CEREAL IMPROVEMENT PROGRAM

Annual Report for 1990

ICARDA

CEREAL IMPROVEMENT PROGRAM

Annual Report for 1990

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

This year's Cereal Program Report is dedicated to the memory of Dr. Ahmed Zahour who died in an automobile accident on 8 July 1990 in Morocco. During his three years as a visiting scientist - barley breeder at ICARDA, Dr. Zahour contributed significantly to ICARDA's barley breeding project and gained the respect and friendship of the ICARDA and international community.

TABLE OF CONTENTS

1. PROGRAM OVERVIEW

Introduction

Cereal research and training activities during the 1989-1990 season were geared to strengthen ICARDA's partnership with NARS within and outside WANA with the objective of enhancing cereal production in target stress-prone areas. The close partnership with NARS enables the Program to formulate and update its priorities and strategies in accordance with changing technological and socioeconomical needs. Particular attention is paid to the sustainability of production systems in these areas.

Program activities include breeding - the major program thrust - physiology, pathology, entomology and biotechnology. These are carried out by a multi-disciplinary team of CIMMYT and ICARDA scientists in collaboration with NARS scientists. These activities were bolstered by smooth collaboration between CIMMYT and ICARDA and their determination to improve the efficiency of their joint efforts in WANA and elsewhere. Scientists of the two Centers discussed the distribution of joint spring wheat screening nurseries from Aleppo for the 1991-1992 season. A CIMMYT consultant team visited ICARDA in June 1990 within the framework of a mission to review CIMMYT work on winter wheat as it relates to CIMMYT/ICARDA winter and facultative cereal breeding work.

During the 1989-1990 season, drought plagued large areas of North Africa and West Asia including parts of Algeria, Tunisia, Libya, Syria, Lebanon and Jordan. In Syria, cereal crops in many areas were subjected to prolongated cold during the winter, severe frost at heading, and terminal drought and heat stress at grain filling. The unusual late frost at Tel Hadya (Fig. 1) was particularly damaging as it impaired plant development and caused high sterility in early or normal plantings of spring types. Because such severe spring frost is rare in the spring-cereal growing areas of WANA, little useful information could be gained from many of the spring cereal field experiments. On the other hand, late-planted material and slow-growing winter types suffered less, and breeders screened this germplasm for tolerance to terminal drought and heat stress.

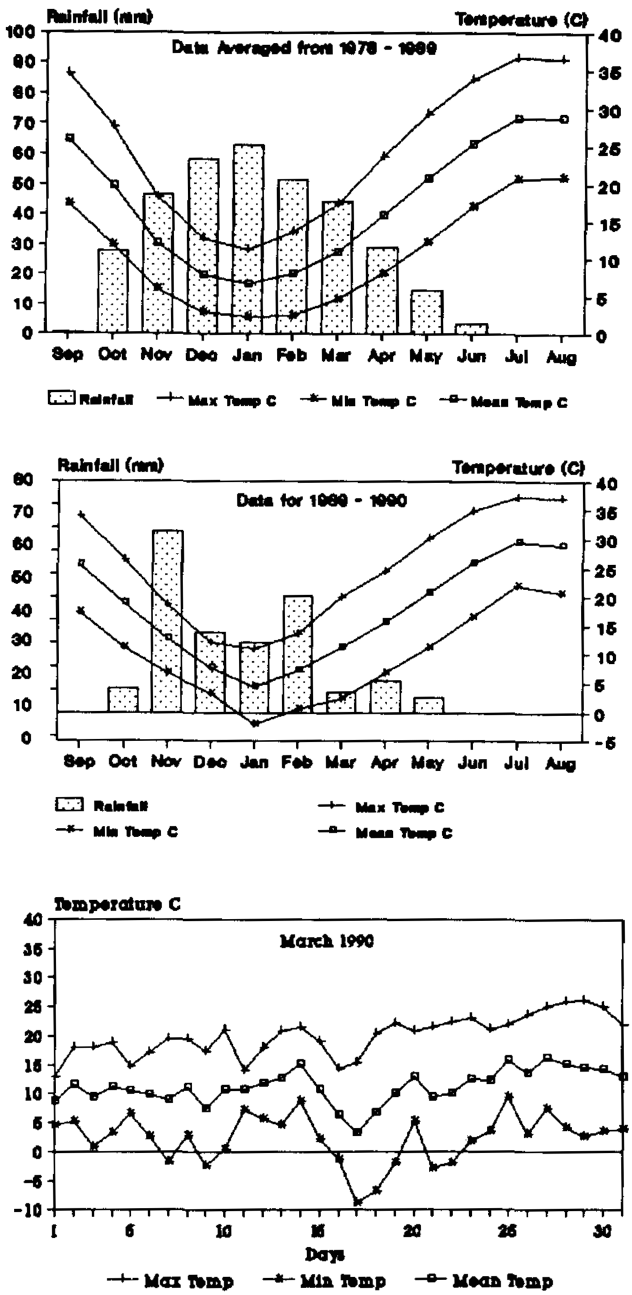


Figure 1. Monthly rainfall and temperature during 1978-1989 and 1989-1990, and daily temperature during March 1990 at Tel Hadya, Syria.

Spring Barley Breeding

Accumulated research results in spring barley showed that germplasm selected under stress conditions performs better under stress than germplasm selected under stress-free conditions. The value of local gemrplasm in barley breeding for marginal environments was confirmed by joint research conducted by ICARDA in collaboration with NARS in Syria, Ethiopia and Nepal. The performance of genotypes under drought could not be attributed to a single trait and results from combinations of traits including growth habit, tolerance to low winter temperatures, early growth vigor, and time to flowering. Studies have shown that low-input barley cultivars can be bred that, in combination with proper crop management, improve sustainable barley production in dry areas. High yield potential, earliness, resistance to diseases and Russian wheat aphid were incorporated in newly-developed germplasm for the Latin American countries, China and Ethiopia. A hull-less nursery was furnished to North African countries marking the initiation of collaborative work on food barley with NARS in these countries. Promising advanced breeding lines were selected by collaborators in several countries and 12 new barley cultivars were released in 1989-1990.

Spring Durum Wheat Breeding

To broaden the genetic base of macaroni wheat and incorporate resistance to abiotic and biotic stresses, durum wheat cultivars were crossed to land races from within and outside WANA, and to wheat relatives including Triticum monococcum, T. dicoccoides, T. carthlicum, T. compactum, T. dicocum and several Aegilops species. Of the 1,000 crosses made this season the single seed descent method was used on 100 crosses in the greenhouse with the objective of increasing the frequency of disease resistance genes in genetically-fixed selection populations. Targeting of material to different agroecological zones in WANA was further refined to separate drought tolerant germplasm into specific material for drought-cum-cold and drought-cum-heat stress areas. Investigations were undertaken to uncover desirable combinations of attributes for improved performance under prevailing stresses in WANA.

Spring Bread Wheat Breeding

Breeding efforts in spring bread wheat focused on low rainfall areas of WANA. Land races from the WANA region were evaluated during two consecutive seasons at the dry site of Breda and were used in crossing programs to enhance germplasm for adaptation to the region's major stresses. Around 1,400 crosses are annually made at ICARDA. Segregating material is regularly introduced from CIMMYT, Mexico to widen the germplasm pool for improved yield potential, disease resistance, and photoperiod insensitivity. The cultivar 'Nesser' confirmed its superiority in large-scale testing in Syria, Jordan, Algeria and Morocco. Seed of the Algerian release 'Zidane 89' was increased for distribution to farmers in the country. Promising material identified in regional testing include 'Gamam' for the low yield (1.5t/ha) environments and the line 'Tsi/Vee' for the high yield (4t/ha) environments of WANA.

Winter Cereal Breeding

Over 10,000 entries of winter and facultative wheat and barley were evaluated for cold and drought tolerance at several sites in Turkey and Syria. Laboratory tests for cold tolerance were also assessed for use as additional tool to field screening, and greenhouses were used to perform crosses and raise 3 winter barley generations during the 1989-1990 season. A new site was acquired at Maadar, a high elevation area (1500 m.a.s.l.), near Damascus, Syria, to test the breeding material for performance under severe winter conditions. Complementarities of the CIMMYT/ICARDA and Turkey/CIMMYT programs were reviewed to recommend a future strategy for improved integration of CIMMYT and ICARDA efforts and more efficient utilization of resources for the improvement of winter cereals.

Physiology - Agronomy

Physiological and agronomic studies confirmed that successful 2-row barley cultivars in cold, low rainfall Mediterranean environments possess slow winter and rapid spring growth and development. Growth habit, response to frost, leaf color, and heading date seem promising selection criteria for improved barley yield in such environments. Research also showed that early sowing and reduced row spacing increased durum wheat yield under drought.

Pathology

Pathology work was strengthened by greater collaboration with NARS in North Africa, Syria and Ethiopia and the establishment of scientific links with research institutions in Europe and North America. Research at Headquarters focused on germplasm evaluation for resistance to major wheat and barley diseases, virulence analysis, and crop loss assessment.

Entomology

Entomological research continued on stem sawflies, aphids, Hessian fly and wheat ground beetle. A survey of Russian wheat aphid in four WANA countries was conducted with collaborating institutions in WANA and USA to identify environments of infestation and natural enemies of the pest for future use in biocontrol. A collaborative project on integrated control of sunn pest in Syria was initiated with Aleppo University.

Biotechnology

Around 700 double-haploid lines of bread wheat and barley were produced in 1990 using anther culture and crosses with Hordeum bulbosum or maize. Preliminary work on RFLP and PCR techniques in barley revealed a high degree of polymorphism among 5 ICARDA genotypes, warranting further studies on DNA marker-assisted selection for adaptation to Mediterranean environments.

International Nurseries

A total of 1027 sets of regular wheat and barley nurseries (crossing blocks, segregating populations, observation nurseries, and yield trials) and 186 sets of specific-trait nurseries were furnished to 104 cooperators in 51 countries, with 70% of the requests emanating from within WANA. Increasingly, greater emphasis is placed on specific germplasm for particular environments including biotic and abiotic stress-prone areas. In-depth data analysis was used to aid in better fitting the germplasm to target environments.

Collaborative Research and Training

Collaborative research in cereal improvement with NARS in WANA was enhanced with the onset of special projects on cereal and legume diseases and technology transfer in North Africa and on barley, pastures and sheep in Mashreq countries. Wheat yield and production in Sudan and Egypt were substantially increased following adoption of improved technology and encouraging policies. Linkages with Latin America, USSR, China, and India were initiated or strengthened through workshops, visits and exchange of germplasm.

A total of 147 researchers participated in headquarters or outreach courses and workshops or received individual training tailored to their needs, including students conducting thesis research at ICARDA. Over 150 visitors were hosted for short periods for orientation or discussion of collaborative work. Thirteen visiting scientists spent longer periods at the Center to work with Program scientists on research topics of mutual interest. Because long-term visits proved effective in enhancing the exchange of scientific information and the undertaking of joint research, it is planned to further expand this component of collaboration.

Detailed information on the different Program activities is presented on the following pages.

Acknowledgements

The contribution of NARS scientists to the work reported in this document cannot be overemphasized. Comments on the manuscript by Dr. A. van Schoonhoven and reviews by Drs. B. Curtis and R. Miller are greatly appreciated. Thanks are also extended to Ms. Samira Maksoud for word processing and preparing the camera ready copy of the manuscript, and to Ms. Nahed Sammani and Ms. Najla Nakshbandi for word processing.

H. Ketata

2. BREEDING

2.1. Spring Barley Breeding

2.1.1. Introduction

The overall objective of the barley improvement project is to contribute, together with National Program scientists, to increase the production of barley.

Although the major emphasis of the project is on germplasm enhancement, research activities differ in relation to agroclimatic environments, uses of the crop and expertise available in different countries.

In relation to agroclimatic environments, for areas in more favorable conditions (yields higher than 2.5-3.0 t/ha) more emphasis is given to the development of new germplasm, while for areas affected by severe abiotic stresses (cold, drought and heat) relatively more emphasis is given to the development of breeding methodologies.

Priority is given to the use of barley as animal feed. This affects the choice of germplasm and has stimulated during 1990 the interest in establishing collaboration with scientists in advanced institutions to initiate a systematic evaluation of straw quality. In addition to animal feed there is a growing interest in a number of countries to develop barley germplasm suitable as human food, malt, or green forage.

New initiatives in the areas of straw quality, barley as human food, malting quality and as green forage were taken during 1990. They are:

1. The possibility of introducing the technique of "grinding energy" as a selection criterion to evaluate barley germplasm for one of the factors affecting palatability.
2. Distribution of hull-less barley lines to Morocco and Algeria for a preliminary evaluation as potential sources of the naked character.
3. Crosses between six-row naked barleys from Nepal and six-row ICARDA lines as a first step to introduce the naked character in some of the best germplasm already available.

4. Contacts have been established with the Scottish Crops Research Institute to begin the evaluation of ICARDA's advanced breeding lines for "milling energy" as a preliminary test for malting quality. The technique is interesting because it uses a mill which, with minor modification, could also be used to measure "grinding energy".
5. Exchange of germplasm has been established with Uruguay with specific emphasis on malting quality.
6. A closer cooperation has been established with China (through the visit of Prof. Lou) to respond to the increased interest of that country for barley germplasm.
7. Lines with good characteristics to be used as green forage (or hay) have been selected in Morocco together with Dr. M.S. Mekni and distributed as a special group in the Barley Crossing Block 1990-91.

In relation to the cooperation between the base program and national program scientists concrete steps were taken towards decentralizing, initially in Morocco and Tunisia, some of the germplasm enhancement activities for North Africa. This initiative is particularly important in relation to disease resistance in view of the possible rapid changes in race virulence. Cooperation with Ethiopia, Egypt and Syria continues at a steady pace, while the cooperation with Nepal has changed towards the development of specific germplasm. During 1990, we have supplied barley lines for on-farm testing in Libya.

The barley project maintains and develops cooperation with institutions in developed countries such as Germany, Australia, Italy, the Netherlands, Great Britain and U.S.A. Among East-European countries, in addition to the existing cooperation with U.S.S.R., germplasm exchange has been initiated with the barley breeder at ICCPT in Fundulea, Romania.

S. Ceccarelli, A. Zahour, S. Grando

2.1.2. Performance of Barley Lines in International Trials

The performance of barley lines distributed to different countries through international nurseries is shown in Tables 2,3 and 4 for the Regional Yield Trials for low and moderate rainfall areas and for high elevation areas, respectively. Each table shows the most promising entries, the total number of locations and the countries in which the lines outyielded the national check, and the average yield advantage (in %) over the national check.

As expected, yield levels in the regional trial for moderate rainfall (Table 3) are higher than either the regional yield trials for low rainfall or high elevations. Regrettably, the material developed for low rainfall areas continues to be evaluated under conditions of higher yield levels (Table 2) than those occurring in the areas they are targetted for. It is likely that the testing conditions affected the relative performance of this type of germplasm.

The number of lines significantly outyielding the national check is larger in the regional yield trials for moderate and low rainfall areas than for high elevation areas. Germplasm development for high elevation areas clearly needs to be strengthened as indicated by the very low number of lines performing well in Turkey and Iran even if the testing sites in these two countries are not always representative of the mountains areas.

On the other hand a number of lines outyielded the national check in countries such as Greece, Spain, Korea and China, in which ICARDA barley germplasm showed poor adaptation in the past. Results of barley for highlands and cold areas are reported in Chapter 2.4.

2.1.3. Performance of Breeding Lines in Yield Trials

During 1990 a total of 3248 barley lines were evaluated in yield trials. Of these 2208 were tested for the first year (initial yield trials) at Tel Hadya and Bouider; 760 were tested for the second year (preliminary yield trials) at Tel Hadya and Bouider: these were lines selected in 1989 from the initial yield trials; and 280 lines were

Table 2. Barley lines[1] in the Regional Yield Trials for Low Rainfall Areas 1989-90 (data from 47 locations) outyielding the national check in various countries.

Line	No. of loc.	Mean yield	Countries[2]	% over national check
Aw Black/Aths	20	2612	IQ*,JO*,TK*,AL,EG* LI,MO,IT*,SP*,CH*, KO*,PK*	34.9
Man/4/Bal.16/Pro//Apm/-	20	3292	IQ*,IR*,JO,SY*,EG* MO*,TU,GR*,IT,CH*, KO,PK*	33.2
Pld10342/Cr.115/Por/3/-	13	3837	SY*,EG*,MO,TU*,GR*, IT,CH*,KO*,PK	27.7
Bal.16/Api/Deir Alla 106	21	3466	IR*,SY*,JO,AL,EG*, LB,MO*,TU,IT*,CH, KO*,PK	20.1
WI2197/Cr. 272-3-4	17	3919	IR,SY*,JO,MA*,EG* TU,GR*,CN,KO*,PA US	27.5
Comp.Cr.229//Bco.Mr/-	16	4026	IR*,SY*,EG*,MA,GR IT*,SP,CN*,KO*,PA US	25.4
Deir Alla 106/DL71/-	15	3254	IQ,IR,JO,SY*,AL, EG*,LB,MA,TU*,IT* CN,KO	28.9

1 excluding the checks.
2 country codes are the same as in the ICARDA International Nurseries Report.
* indicates that differences with national check were significant (P<.05).

tested for third year (advanced yield trials) in Tel Hadya, Breda, Bouider, Lebanon and Cyprus: these were lines selected in 1988 from the initial yield trials and reselected in 1989 in the preliminary yield trials. Most of the trials planted at Bouider were not harvested due to the extremely severe conditions. Although total rainfall was 151 mm, only 107 mm were received after planting which was done in dry soil.

Table 3. Barley lines[1] in the Regional Yield Trials for Moderate Rainfall Areas 1989-90 (data from 49 locations) outyielding the national check in various countries.

Line	No.of loc.	Mean yield (kg/ha)	Countries[2]	% over national check
WI 2291/3/CI 03309/Attiki //Hja33	21	3510	IQ,JO,SA,SY*3,AL*, EG*,MA,TU*,PR,SP* CN,KO*,PA	25.1
Comp.Cr.229//As46/Pro	15	4949	CY*,LE,SA,SY*,AL* EG,MA*,GR*,SP*,KO*	26.2
WI 2197/Mazurka	23	4068	JO,QA,SA,SY,AL*,EG* MA,TU,GR*,IT,SP,CN KO*.,PA,US	16.8
CM67/Apro//Sv.02109/Mari	18	4866	CY,QA,SY,AL*,EG* MA*,TU,GR,IT,PR, SP*,CN,KO*,PA,US	18.5
CM67/Apro//Sv.02109/Mari	16	4492	CY,SY,AL*,EG,MA* TU,GR,PR,SP*,CN* KO*,PA	21.5

1 Excluding the checks.
2 country codes are the same as in the ICARDA International Nurseries Report.
* indicates that differences with national check were significant (P<.05).

Figure 2 shows rainfall distribution and maximum and minimum tested temperatures at Bouider during three dry seasons (1986/87, 1988/89 and1989/90). It is only by considering the combined effects of minimum temperatures in winter and rainfall distribution rather than the total amount of rainfall that it is possible to explain the crop failures of 1986/87 and 1989/90 and an average yield of 642 kg/ha in 1988/89.

The comparison between the three groups of lines gives some information on the relative performance of barley germplasm developed in successive years. The comparison is made possible by use of the same check cultivars in the three levels of yield testing (initial, preliminary, and advanced).

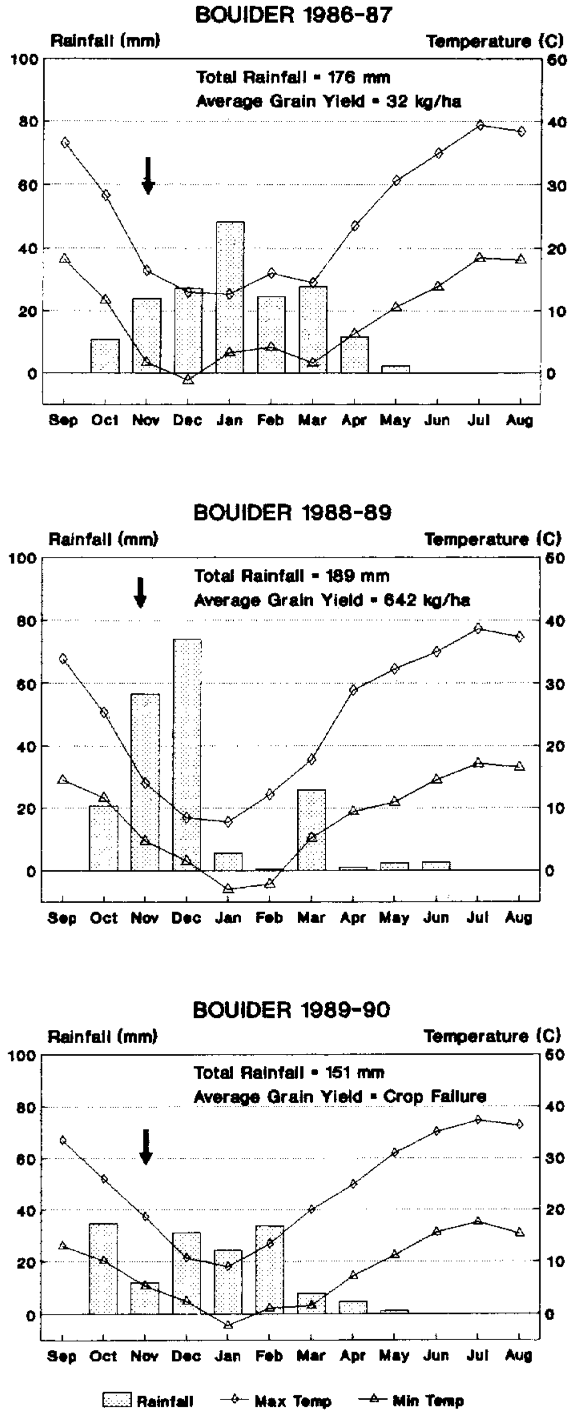


Figure 2. Rainfall, maximum and minimum temperatures at Bouider in 1986/87, 1988/89 and 1989/90. The arrows indicate the planting date.

Table 4. Barley lines[1] in the Regional Yield Trials for High Elevation Areas 1989-90 (data from 20 locations) outyielding the national check in various countries.

Line	No.of loc.	Mean yield (kg/ha)	Countries[2]	% over national check
Leb71/CBB37//Leb71/CBB29	8	3482	IR*,SY,AL*,TU*, MA,GR,KO,	38.8
Dijon 3-2-5	7	3246	IR,SY,AL,CN,KO,PA	16.3
Rihane-08	8	3635	IR,LE,SY,TR,MA,KO PA,ET	20.8
Lignee 527	5	3137	IR,TR,,AL*,KO	35.9
WI 2291/3/SP(2h)//Cr.115/	6	3166	IR,SY,AL*,MA,KO	5.1

1 excluding the checks.
2 country codes are the same as in the ICARDA International Nurseries Report.
* indicates that differences with national check were significant (P<.05).

The yields of the checks in the three types of trials (Table 5) indicate that 1) there is generally good agreement between the relative performance of the checks in the different trials, and 2) grain yields are lower in the third level of testing (plot size of 9 m^2) than in the other two levels (plot size of 4.5 m^2). The best check in the first and second level of testing was Mari/Aths*2, a new check added for the first time this year because of its imminent release in Cyprus. By comparing these yield levels with those reported in previous reports it is obvious that 1989-90 was one of driest years experienced at ICARDA's main experimental station. However, as already mentioned in the introduction, the low rainfall was only partly responsible for the low yields which were caused also by an exceptionally late and severe frost.

Table 5. Grain yield (kg/ha) at Tel Hadya (234 mm rainfall) of the five barley cultivars used as checks in yield testing during 1989-90.

Level of testing[1]	Rihane-03	Mari/Aths*2	Harmal	A.Aswad	A.Abiad
IYT	885	1310	1229	1118	1189
PYT	914	1238	1116	1117	1047
AYT	609	970	943	863	1021

1 IYT = initial yield trials; PYT = preliminary yield trials; AYT = advanced yield trials.

Table 6 compares the grain yield at Tel Hadya (the only location from where data on all the three levels of trials were available in 1990) of the best 10% of the lines and of the top yielding line at each level of testing both in actual kg/ha and in % of the best check. It appears that under the conditions of Tel Hadya in 1990, the newest germplasm (IYT) performed better than both the material at the second

Table 6. Grain yield at Tel Hadya (234 mm rainfall) of the best barley lines in the initial (IYT), preliminary (PYT) and advanced (AYT) yield trials. Lines in the IYT are subdivided according to their origin (Tel Hadya, 1989-90).

Level of testing	No. of lines	Grand mean	best 10%		top line	
			kg/ha	% best check	kg/ha	% best check
IYT	2208	1004	1511	115.3	2038	155.5
USA	50	7231	311	100.1	1678	128.1
Cyprus	48	966	1524	116.3	2038	155.5
Turkey	40	555	963	73.5	1072	81.8
Mexico	131	791	1204	91.9	548	118.2
ICB*	1939	1036	1521	116.1	1942	148.2
PYT	760	1040	1419	114.6	1780	143.8
AYT	280	789	1113	109.0	1270	124.4

* ICB = lines developed at ICARDA, Aleppo.

and third level of testing (PYT and AYT, respectively). Almost 90% of the material evaluated in the first level of testing was developed at Aleppo: the remaining includes germplasm developed in other countries such as U.S.A., Cyprus, Turkey, and by the Mexico-based project. The break-down of the germplasm in the first level of testing shows that the material developed at ICARDA-Aleppo (indicated as ICB) and in Cyprus was, on the average, the highest yielding, although few high yielding lines were identified among the USA and Mexico germplasm. The breeding material introduced from Turkey was the least adapted with the best lines of this material yielding around 20% less than the best check.

Differences in earliness in the IYT (Table 7), partly explain the yield differences observed in Table 6. Turkey germplasm was the latest to head, with the earliest lines heading 18 days after the earliest check (Mari/Aths*2). This also explains why the barley increasingly early, has performed poorly when evaluated in Turkey.

Table 7. Days to heading (as difference with the earliest check) of the earliest check and of the earliest barley lines in the initial (IYT), preliminary (PYT) and advanced (AYT) yield trials. Lines in the IYT are subdivided according to their origin (Tel Hadya, 1989-90).

Level of testing	No. of lines	Days to heading (from emergence)		
		earliest check*	earliest 10%	earliest line
IYT	2208	102.0	+ 0.4	- 15.1
USA	50		+ 8.4	+ 6.9
Cyprus	48		+ 0.4	- 0.9
Turkey	40		+ 18.3	+ 18.0
Mexico	131		+ 6.1	+ 4.1
ICB	1939		+ 2.1	- 15.1
PYT	760	102.0-	0.2	- 6.0
YT	280	102.9	- 1.5	- 4.5

* Mari/Aths*2

The Cyprus and ICARDA germplasm were the earliest, while the material from Mexico, which is usually early, was severely affected by the late frost. Comparison of the earliest entries (10%) at each level of testingindicates that the new material is, on the average, slightly less early than the material in the third level of testing. On the other hand, the comparison of the earliest lines indicates that a few extremely early lines are being generated. This extremely early material is expected to be useful both as parents and as potential cultivars for areas with very mild winters and low rainfall.

One character of particular interest is plant height under dry conditions. Tall plants under drought are very attractive to farmers in dry areas because straw yield can be higher if tillering is not decreased, and because of the advantages in mechanical harvesting. Recently there have been indications (Santamaria et al., 1990) that the character may be the expression of turgor maintenance, and hence of a higher osmotic adjustment. The conditions of 1990 made it possible to assess whether progress has been made in improving plant height under drought, since the character has been used as one of the selection criteria during the last three cropping seasons. The data of Table 8 indicate that the average plant height of the tallest 10% of the breeding lines, as percent over the tallest check (Mari/Aths*2), increased from 109.8% to 115.5% to 117.5% in the third, second and first level of testing, respectively.

In the first level of testing, the tallest material was the U.S.A. germplasm (26.6% taller than the tallest check and almost 48% taller than Arabi Aswad). In spite of its poor tillering some of this germplasm has been retained as parental material.

The frequency of lines with a better expression of grain yield and plant height than the best check (Table 9) increased from the third to the second level of testing and then decreased in the first level of testing, presumably as a result of the presence of ill-adapted germplasm. Days to heading shows the opposite trend possibly due to a relaxation of the intense selection pressure applied during the last few years.

Table 8. Plant height (cm) under stress* of the tallest barley lines in the initial (IYT), preliminary (PYT) and advanced (AYT) yield trials. Lines in the IYT subdivided according to their origin (Tel Hadya, 1989-90).

Level of testing	No. of lines	Plant height (cm) Tallest check	A.Aswad	Tallest 10% cm	% of tallest check	Tallest line cm	% of talles check
IYT	2208	36.1	30.9	42.4	117.5	59.2	164.0
USA	50			45.7	126.6	50.6	140.2
Cyprus	48			44.5	123.3	46.2	128.0
Turkey	40			41.4	114.7	43.1	119.4
Mexico	131			43.5	120.5	48.9	135.5
ICB	1939			42.1	116.6	59.2	164.0
PYT	760	32.9	27.6	38.0	115.5	44.6	135.6
AYT	280	36.3	31.8	39.8	109.8	42.7	117.8

* Plant height at Tel Hadya in 1990.

Table 9. Frequency (%) of barley lines with higher grain yield, earlier and taller than the best check in the initial (IYT), preliminary (PYT) and advanced (AYT) yield trials.

Level of testing	No. of lines	Better than best check for grain yield	days to heading	plant height
IYT	2208	15.2	2.9	26.3
PYT	760	18.3	4.6	31.1
AYT	280	11.1	7.9	19.6

S. Ceccarelli, A. Zahour, S. Grando

2.1.4. Breeding for Stressful Conditions

The development of barley germplasm for stress conditions aims both at the development of germplasm and at the development of breeding methodologies (type of germplasm, selection strategies, identification of selection criteria, etc.) that, with the necessary adjustments, could be tested and validated under the different "stress syndromes" which affect many barley growing areas within and outside WANA.

Our major target environment continues to be the dry areas of Syria: the objective is not only to develop germplasm capable to increase yield and yield stability in one type of stress environment, but to understand if superior germplasm has been generated by design or by chance. If generated by design the germplasm may still be unsuitable to other stress conditions, but the design can be proposed to NARS as a possible strategy.

During 1990, we completed the analysis of the breeding lines evaluated during 1986-1988 (332 lines) and during 1987-1989 (234 lines). As a measure of their performance under stress conditions, we used the average grain yield in the lowest yielding environments (sites and years) during the evaluation period (Table 10). Forty-one lines in the first group and 28 in the second gave a higher yield than the local landrace A. Aswad. The pedigrees and the yields of some of these lines are given in Table 11. Repeated selection under stress consisting of low winter temperatures, reduced available moisture and poor soil fertility can therefore generate lines with a better performance than the local landrace. A point of interest is that the yield of these lines under high yielding (4.0-5.0 t/ha) conditions is always lower than Rihane-03. If our selection and testing for grain yield was conducted only at Tel Hadya, these lines would have been discarded. Another interesting point is that only one of the best lines is related to Syrian landraces and that two of the parents (Roho and Athenais) present in the pedigrees of some of the best performing lines were previously identified as sources of drought resistance (Cereal Program Annual Report for 1989, pp. 110). This suggests that at least some of the differences in performance under stress conditions are genetically controlled.

Table 10. Mean yields in locations and years used to calculate YP (yield under high yielding conditions) and YD (yield in low yielding conditions).

High yielding environments Location/Year	YP	Low yielding environments Location/Year	YD
	1986-1988		
Tel Hadya 1986	4887	Bouider 1986	1181
Tel Hadya 1988	4420	Bouider 1987	48
Cyprus 1988	5027	Breda 1987	454
	1987-1989		
Tel Hadya 1988	4288	Breda 1987	759
Cyprus 1989	5824	Bouider 1989	687
		Ksabyia 1989	373

Table 11. Highest grain yield in low yielding conditions (YD) and their yield in high yielding conditions (YP) of barley lines in the Advanced Yield Trials 1987/88 and 1988/1989.

Line	YP*		YD*	
	kg/ha	% of A.Aswad	kg/ha	% of Rihane
1987/88				
Harmal-02//Esp/1808-4L	1446	213.3	4445	80.2
Aths/Lignee 686	1246	183.8	4409	79.5
Harmal-02/Lignee 131	1243	183.3	4284	77.3
Roho/Arabi Abiad	1200	177.0	5002	90.2
1988/89				
Mari/Aths*2	1101	124.1	4795	85.8
Deir Alla106/Cel/3/Bco.Mr/-	1076	121.1	3208	57.4
Harmal//Kv/Mazurka	1076	121.1	4698	84.1
Arimar/Aths	1060	119.5	3350	60.0

* YD and YP are mean grain yields of each line in the locations/years indicated in Table 10 as low and high yielding environments, respectively.

If this is confirmed we may investigate to which extent the presently used and expensive technique of multi-year/multi-environment testing to identify reliable sources of "drought resistance" can be replaced by some of the equally expensive but faster and more reliable screening techniques based on the use of molecular markers.

In addition to the data presented in Tables 10 and 11, further information on progress in breeding for stress conditions was derived from the Advanced Yield Trials grown at Breda in 1990. Since the same lines were also grown in 1989 in the preliminary yield trials at Bouider, it was possible to analyze the performance of the lines in two extremely stressful environments. The average grain yield of the 280 lines in Breda was 471 kg/ha. The best check cultivar, Harmal (649 kg/ha) yielded slightly more than Arabi Aswad (525 kg/ha). Thirty-eight lines outyielded Harmal, averaging 724 kg/ha, or 11.6% more than Harmal. Twenty-eight of these also outyielded Arabi Aswad at Bouider in 1989. Most of these 28 lines require vernalization (remaining in the vegetative stage when planted at Tel Hadya in April) and have a prostrate growth habit. Five lines were pure spring types although their growth habit was between semi-prostrate and prostrate. The best "winter" types (all Syrian landraces) and the best spring types are shown in Table 12. Two of the spring types are particularly interesting for their plant height.

These data also show the advantages of using a very dry testing site with a very high probability of severe moisture stress. The use of such a site in breeding for stress conditions is equivalent to the technique of artificial inoculation in breeding for disease resistance.

The role of adaptation

The term "adaptation" is not easy to define. We use the term to describe the complex of characteristics found in the local landraces. By our definition "adapted germplasm" is equivalent to landraces, while the term "improved" identifies lines or germplasm resulting from our breeding work but unrelated with local landraces. The analysis of the performance of different germplasm types conducted during the last few

Table 12. Grain yield (kg/ha) and plant height (cm) of some of the barley lines which outyielded the best checks[1] both at Bouider in 1989 and at Breda in 1990.

Line	Bouider 1989		Breda 1990			
	Yield	Height	Yield	Height	VR[2]	GH[3]
SLB 5-96	1241	24.1	911	20.4	+	4.8
SLB 4-71	1278	25.0	788	18.6	+	4.0
SLB 1-67	1289	25.2	741	20.4	+	4.7
SLB 5-07	1126	22.6	899	21.2	+	4.5
ER/Apm/3/Kv//Alger/Ceres,362-1-1	1193	22.3	747	24.9	-	3.8
DMR/WI 2197//ER/Apm	1038	24.3	730	18.3	-	3.0
JLB 70-2	1202	27.8	685	24.6	-	3.8
Bi/Guaj/3/B1//Mari/Coho	1107	28.2	662	23.6	-	3.8
Arabi Aswad	904	25.3	525	20.9	+	4.7
Harmal	785	24.7	649	23.4	-	1.6

1 Arabi Aswad in Bouider (1989) and Harmal in Breda 1990.
2 VR = Vernalization requirement (+ winter types, - spring types)
3 GH = Growth habit (1 = erect; 5 = prostrate)

cropping seasons has shown that adaptation plays an important role in the performance of genotypes under stressful conditions (Cereal Program Annual Reports 1986, 1987, 1988 and 1989). A similar comparison between different types of germplasm was made using the data from the yield trials conducted in 1990.

In the advanced yield trials of 280 entries tested for the third year, a data set of 254 entries was complete for 8 different environments. The 254 entries were divided into three groups according to the type of germplasm: improved material (155 entries) unrelated to Syrian and/or Jordanian landraces, lines extracted from Syrian or Jordanian landraces (77 entries), and entries from crosses between improved material and the two Syrian landraces or lines extracted from them (22 entries). The average grain yield under stress conditions (YS) of the 77 lines extracted from landraces was 788 kg/ha ranging from 486 to 1076 kg/ha (Table 13).

Table 13. Grain yield under stress (YS), grain yield under non-stress (YNS) and average grain yield ($\bar{Y}$) in kg/ha of barley breeding material classified according to the type of germplasm in Advanced Yield Trials, 1990.

Type of germplasm	N[1]	YS[2]		YNS[3]		$\bar{Y}$[4]	
		yield	range	yield	range	yield	range
Improved	155	488	0- 893	3901	2310-4981	2136	1280-2726
Landraces	77	788	486-1076	3413	2398-4610	2115	1637-2587
Land.x Improv.	22	617	164- 838	3474	2545-4783	2015	1480-2540
Best check[5]		717		4147		2303	

1 Number of entries
2 Average of Bouider 1989 and Breda 1990
3 Average of Tel Hadya 1988, Tel Hadya 1989, Terbol 1990
4 Average of Tel Hadya 1988, Breda 1988, Tel Hadya 1989, Bouider 1989, Tel Hadya 1990, Breda 1990, Cyprus 1990, Terbol 1990
5 Harmal for YS, Rihane-03 for YNS and $\bar{Y}$

In the case of improved germplasm the average YS was 488 kg/ha, ranging from 0 to 893 kg/ha. A total of 73 entries outyielded the best check (Harmal) for YS of which 55 were lines from landraces, 12 improved material and 6 derived from improved x landraces crosses. As a group, the landraces had a lower yield under non-stress conditions (YNS) than improved material although six of the 59 entries outyielding the best check (Rihane-03) in YNS were lines from landraces.

A similar analysis was conducted with the data of the initial yield trials (Fig. 3). In these trials, the type of adapted germplasm is different, excluding lines from landraces which are now being evaluated in separate trials with the Syrian national program (see next section). Among the 2208 lines tested 1466 were unrelated to locally adapted germplasm. The adapted germplasm was represented by 655 lines derived from crosses between improved germplasm and landraces, by 40 lines derived from crosses between landraces-lines and by 47 lines derived from crosses involving Hordeum spontaneum. The lines derived from crosses in which both parents were extracted from landraces had the highest grain yield (Figure 2), were among the earliest in heading (this is probably due to their better frost tolerance) and were very short (25.9 cm as average plant height). The improved germplasm was the

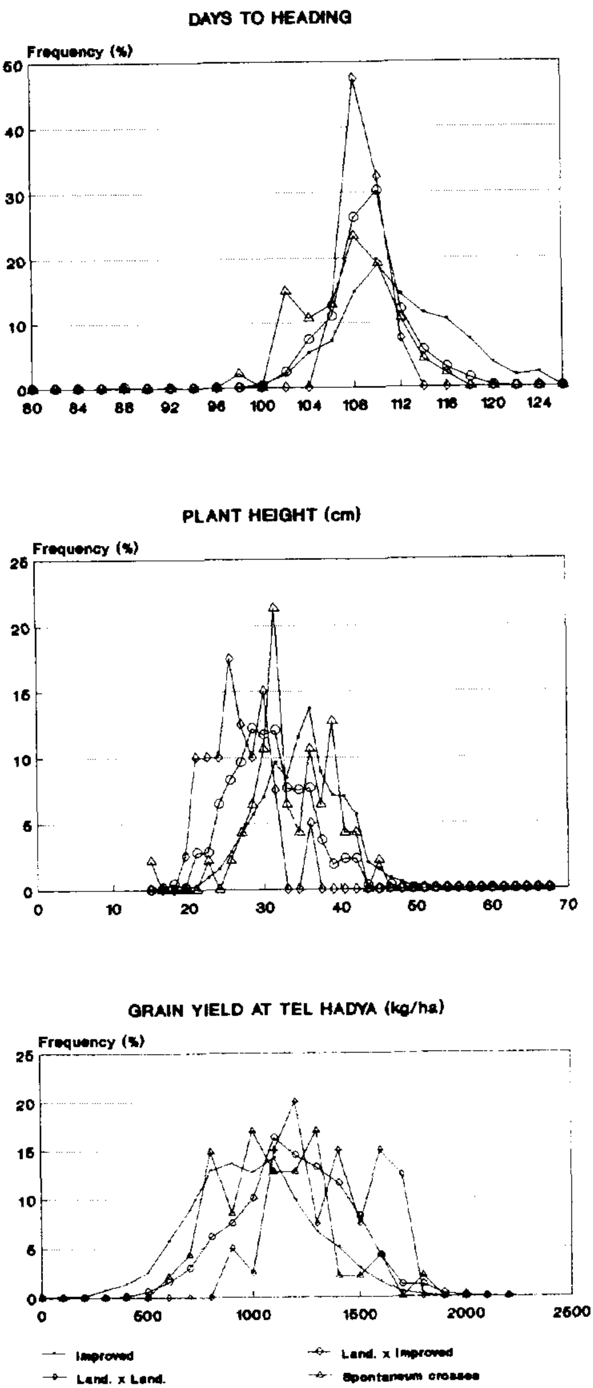


Figure 3. Frequency distribution of plant height, days to heading and grain yield at Tel Hadya for four different germplasm types in the initial yield trials 1990.

tallest (34.0 cm on average) but its average grain yield was the lowest (937 kg/ha). Lines derived from crosses between improved and adapted germplasm were intermediate for plant height (29.8 cm), heading date (108 days) and grain yield (1133 kg/ha). Material derived from crosses with H. spontaneum was the earliest (106 days), had a plant height close to the improved germplasm (32.4 cm) and a grain yield of 1041 kg/ha.

These data show the value of adapted germplasm in breeding for higher and more stable yields under stress conditions and stress the need for National Programs to preserve their adapted germplasm for incorporation in their breeding program. There are at present three countries, Syria, Ethiopia and Nepal, with which the barley project is collaborating in the evaluation and selection of locally adapted germplasm.

Evaluation of adapted germplasm in Syria

In 1988 the Syrian national program began to conduct most of the activities related to evaluation and selection of pure lines extracted from Arabi Abiad and Arabi Aswad in collaboration with ICARDA. In 1988-89, 750 lines arranged in 10 trials (9x9 simple lattice with 75 lines and 6 checks each) were evaluated in two locations (Hassake and Karahta). A total of 148 lines were selected, 44 for grain yield in Karahta, 82 for grain yield in Hassake and 22 for average grain yield. The selected lines were evaluated in two trials conducted during the 1989-90 cropping season in three locations (Karahta, Bouider and Hassake). Only Hassake provided yield data due to the very dry season.

A total of 34 lines were selected for a third year evaluation in 1990-91 (grain yield of the best 10 is shown in Table 14) out of which 24 performed better than the best check in each of the three environments (Arabi Abiad in Karahta 1989, Arabi Aswad in Hassake 1989 and Tadmor in Hassake 1990). Most of these lines are progenies of single heads collected in the area between Raqqa and Palmyra (area of origin for Tadmor), indicating the importance of the area as source of germplasm with special adaptation to stress conditions.

Table 14. Grain yields of the best barley lines extracted from Syrian landraces and derived from two cycles of selection (1989 and 1990) under stress conditions (data from Jamal Baha, Ahmed Balle, Fateh Alla Jajan and ICARDA Staff).

Line	Karahta 1989 g/plot*	Hassake 1989 g/plot*	Hassake 1990 kg/ha
SLB 9-62	123	150	1125
SLB 5-29	109	171	1077
SLB 2-09	118	178	1072
SLB 2-44	129	176	981
SLB 5-07	133	168	968
SLB 2-11	122	176	961
SLB 2-17	145	157	932
SLB 1-90	160	206	931
SLB 3-49	110	178	913
SLB 1-88	135	166	909
Best check	109 (A.Abiad)	149 (A.Aswad)	788 (Tadmor)

* plot size: two rows 2.5 m long

Evaluation of adapted germplasm in Ethiopia

The evaluation of locally adapted germplasm in Ethiopia began in 1988 with the testing of 180 populations available in the Plant Genetic Resources Center in Addis Ababa. These were evaluated in three locations (Holetta, Sheno and Bekoji) and a random sample of individual heads was collected from the best performing populations at each location. Head-rows were grown in the belg season (February-April 1989) for seed multiplication, and the pure lines together with the corresponding populations (630 entries) were evaluated during the cropping season 1989-90 in 10 8 x 8 simple lattices at the three locations.

Thirty-two lines were selected (grain yield of the best 10 is shown in Table 15) which outyielded the local check by 84.7% in Holetta, 39.7% in Sheno and 42.5% in Bekoji. Although the work is still in a preliminary stage these first results are encouraging and could represent an example of transfer of methodology.

Table 15. Grain yield (g/plot[1]) of the best barley lines extracted from Ethiopian landraces and evaluated during 1989-90 in three locations (* indicates the location of selection). Data from: Mr. Yetbarek Semeane, Fekadu Alemayehu and Kiflemariam Mengistu.

Line	Holetta	Sheno	Bekoji	Average
4-57	380*	895*	401*	559
8-17	308*	565	526*	467
4-45	335*	629*	407*	457
5-33	349*	551	391*	430
5-32	311*	555	413*	426
4-56	248*	581	378*	402
6-32	253	602*	339	398
5-56	308*	511	369	396
4-16	197	639*	343	393
4-33	224	628*	320	391
Local check	166	426	263	

1 plot size: two rows 2.5 m long

Evaluation of adapted germplasm in Nepal

In Nepal, there has been in the past a strong interest in the improvement of local germplasm which has led to the development of a number of breeding lines. The interest was then replaced by intense activities on introduced germplasm based on the assumption that most of the local germplasm is susceptible to diseases. Field observations conducted during the training workshop held in 1989 suggested that, as already observed in Syrian landraces, there was scope to screen for disease resistance within the extremely variable local germplasm. As previous collections were no longer available, a new collection of individual heads was made during 1989 with the objective of starting a program of evaluation and selection similar to the one described for Ethiopia. At the same time, a number of crosses were made at Aleppo and El Batan between promising Nepalese lines and improved ICARDA germplasm. The F_1 seed was sent to Nepal to establish a first nucleus of targeted segregating populations. The national program scientists will concentrate their efforts on this new type of germplasm and no international nurseries were sent to Nepal for 1991.

S. Grando and S. Ceccarelli

Hordeum spontaneum

Pure lines of Hordeum spontaneum identified as potential sources of "drought tolerance" in 1987 at Bouider (Cereal Program Annual Report, 1987) have been used in a number of crosses with both pure lines from landraces and improved germplasm. A total of 1765 F_3 families were evaluated at Bouider in 1989 and 475 were selected for further evaluation (Cereal Program Annual Report, 1989). In 1990, 74 F_4 families with non-brittle rachis and with a sufficient amount of seed were tested in plots of 4.5 m^2 using a 9 x 9 simple lattice design at Bouider. All the other selected families were evaluated in 2-rows plots at Bouider and grown at Tel Hadya for seed multiplication. The poor crop development made it impossible to take meaningful notes on this material except for total biological yield which was measured following hand harvesting.

Table 16. Total biological yield (kg/ha) of selected F_4 families Hordeum vulgare x Hordeum spontaneum and of the best lines selected from landraces in Bouider (107 mm effective rainfall, 1989-90).

Type of material	Biological yield (kg/ha)
H. spontaneum 41-1 x Tadmor (5320)	347
H. spontaneum 41-5 x SLB 45-40 (6001)	324
H. spontaneum 41-1 x Tadmor (5227)	312
SLB 56-83	330
SLB 45-40	291
Arta	132
Tadmor	101
Zambaka	110

Some of the best F_4 families gave a total biological yield which, although very low, was three times that of lines such as Tadmor, Arta and Zambaka (Table 16). However, some lines from landraces (SLB 56-83 and SLB 45-40) performed as well as the best F_4 families.

Despite the very low yield levels it was possible to detect a specific effect of some parents on the performance of their progenies (Table 17).

In general, the progenies of crosses with H. spontaneum 41-1 and H. spontaneum 41-5 performed better than progenies of crosses with other lines of H. spontaneum. Exceptions are the F_4 families derived from the crosses H. spontaneum 41-1//ER/Apm (134 kg/ha), H. spontaneum 41-1/WI2291 (151 kg/ha), and H. spontaneum 39-2/Tadmor (190 kg/ha), indicating that the more useful crosses were those involving landrace-derived lines and selections from H. spontaneum populations.

Table 17. Total biological yield (kg/ha) of F_4 families Hordeum vulgare x Hordeum spontaneum grouped according to the Hordeum spontaneum parent (Bouider, 107 mm effective rainfall, 1989-90). N = number of families.

Type of material	Number of families	Biological yield (kg/ha)
H. spontaneum 41-1/Tadmor	11	234
H. spontaneum 41-1//ER/Apm	4	134
H. spontaneum 41-1/WI 2291	2	151
SLB 45-40/H. spontaneum 41-1	10	209
SLB 39-39/H. spontaneum 41-1	4	216
H. spontaneum 41-5/SLB 39-60	2	177
H. spontaneum 41-5/Tadmor	10	167
SLB 45-40/H. spontaneum 41-5	8	181
SLB 56-83/H. spontaneum 41-5	5	221
SLB 37-74/H. spontaneum 41-5	4	202
SLB 39-39/H. spontaneum 41-5	2	217
SLB 37-74/H. spontaneum 28-3	4	128
SLB 39-39/H. spontaneum 28-3	1	36
H. spontaneum 39-2//ER/Apm	1	86
H. spontaneum 39-2/Tadmor	4	190
Tadmor/H. spontaneum 64-1	2	83

S. Grando

Collaboration with the University of Perugia

Three major research activities were conducted at the Institute of Plant Breeding of the University of Perugia (Italy) in the framework of the collaborative project "Improving Yield and Yield Stability of Barley in Stressful Environments" supported by the Government of Italy. The activities included a) evaluation of barley lines under low inputs, b) evaluation of barley lines under field conditions and under rain-shelters, and c) evaluation of genetic differences for growth rate at low temperatures.

a. Evaluation of Lines under Low Inputs

These trials were conducted without fertilizer application or weed control, two practices largely used and often abused in Italy. In the first trial 18 barley lines selected from nurseries sent from Aleppo were compared with 7 commercial varieties recommended for Central Italy. The grain yield of the best commercial variety (Barberousse) was 5870 kg/ha. Four ICARDA lines outyielded Barberousse with grain yields of 6610, 6315, 6160 and 6040 kg/ha, respectively. In a second trial 190 ICARDA lines were compared with 6 commercial varieties recommended for Central Italy. The best commercial variety (Fleuret) yielded 5985 kg/ha while the best 13 ICARDA lines yielded between 5994 and 6698 kg/ha. While there is a growing concern of the environmental hazards associated with high input agriculture, these encouraging results indicate some scope in exploiting genetic differences at levels of input much lower than those presently used.

b. Evaluation of Lines under Rain-Shelters

This trial was conducted to test whether simulated drought, through the use of rain-shelters, could determine differences similar to those observed in the dry sites of northern Syria. The lines tested belong to three types of germplasm: commercial cultivars, ICARDA lines unrelated to Syrian landraces and Syrian landraces. The trial, conducted at Perugia both under field conditions (368 mm rainfall) and under rain-shelters (140 mm rainfall) confirmed the information generated at ICARDA headquarters over a number of years (Table 18). Under field conditions commercial varieties outyielded ICARDA lines by 3% and Syrian landraces by 33%. Under rain-shelters Syrian landraces outyielded ICARDA lines by 37% and commercial varieties by 41%.

Table 18. Grain yield (kg/ha) of 6 commercial varieties, 12 ICARDA lines and 7 Syrian landraces under field conditions and under rain-shelters (140 mm rainfall), Perugia, 1990.

Material	Field conditions	Rain-shelters
Commercial varieties	6816	962
ICARDA lines	6621	985
Syrian landraces	5123	1355

c. Growth Rate at Low Temperatures

One of the strategies to improve cereal production in mediterranean environments with cold winters is to maximize growth in winter when the most common limiting factor is temperature rather than moisture. Six barley genotypes (Tadmor, Alger/Ceres, Arar, SLB 39-60, Harmal and WI 2291) were used both in field trials and in growth cabinet experiments. The trials, although not yet completed, indicated that SLB 39-60, a selection from Arabi Abiad, has a consistantly higher growth rate at low temperatures. Tadmor, a selection from Arabi Aswad has a growth rate comparable to SLB 39-60 in the growth cabinet but not in the field. There is some evidence of a possible genotype x temperature x available moisture interaction in determining the growth rate. These preliminary results suggest that genetic differences for growth rate at low temperatures do exist, and that the plant ability to grow at low temperatures can be another facet of adaptation to mediterranean-continental climate.

A. Grillo and R. Petti

2.1.6. Breeding for High Yield Potential

This sub-project deals mainly with germplasm development for those areas where yields are not severely limited by climatic stresses and where biotic stresses are relatively more important.

A total of 412 new crosses, specifically designed for these areas were made during 1990. In addition, the first double-haploid plants were produced by the biotechnologists and these will be multiplied during 1991.

During 1990, the yield levels in all testing sites with the exception of Terbol (Lebanon) were too low to provide a measure of yield potential. Therefore, we have used data from the highest yielding environments (Table 10) and from two sets of breeding materials. The first set was evaluated in the Advanced Yield Trials 1987-88 and the second in the Advanced Yield Trials 1988-89. The highest yielding lines in the first set had a yield advantage between 14% and 18% over Rihane-03 while in the second set the yield advantage was between 20% and about 25% (Table 19). This indicates that progress is made in

Table 19. Barley lines in the Advanced Yield Trials 1987/88 and 1988/1989 with the highest grain yield in high yielding conditions (YP) and their yield in low yielding conditions (YD).

Line	YP*		YD*	
	kg/ha	% of Rihane	kg/ha	% of A.Aswad
1987/88				
NK1207/3/Api/CM67//Mona	6577	118.6	277	40.8
U.Sask.1766/Api//Cel/3/Weeah	6555	118.2	602	88.8
CI08887/CI05761//Lignee 640	6370	114.9	617	91.0
Cam/B1//CI08887/CI05761	6333	114.2	485	71.5
1988/89				
Lignee 527//Bathim/DL71/-	6962	124.6	515	58.1
Mo.B1337/WI2291	6760	121.0	485	54.7
CI08887/CI05761//Cerise	6717	120.2	316	35.6
ER/Apm/3/Arr/Esp//Alger/Ceres-	6691	119.8	480	54.1

* YD and YP are mean grain yields of each line in the locations/years indicated in Table 10 as low and high yielding environments, respectively.

harsher environments which has not detracted from development of germplasm for more favourable conditions. In both sets, lines selected for high grain yield under high yielding conditions yielded less than the local check in low yielding conditions, although the reduction varied considerably among lines and ranged between 10% and 64%. These data confirm therefore those presented in Table 11 as well as those presented during the last four years in indicating that breeding for high yield potential negatively affects performance under drought. It is also worth noticing that the pedigree of the lines with the highest yield potential has little (if any) in common with the pedigree of the lines with the highest yields under drought.

The analysis of these data reveals that some lines combined good grain yield under both high and low yielding conditions (Table 20). These lines were used extensively in the 1990 crossing program and some of the segregating populations will be advanced by the SSD method to verify whether it is possible to increase the frequency of this type of breeding material and select desirable homozygous lines.

Table 20. Barley lines in the Advanced Yield Trials 1987/88 and 1988/1989 combining high grain yield in high yielding conditions (YP) and high grain yield in low yielding conditions (YD).

Line	YP*		YD*	
	kg/ha	% of Rihane	kg/ha	% of A.Aswad
1987/88				
Roho/Arabi Abiad	5899	106.4	1172	172.9
5604/1025//Arabi Abiad	5916	106.7	878	129.5
INRA55-86-2/Rabat 1701	6098	110.0	962	141.9
Mo.B1337/WI 2291	6317	113.9	888	131.0
1988/89				
Mari/Aths*2//M-Att-73-337-1	6294	112.7	979	110.4
Api/CM67//Aths*3	6053	108.3	926	104.4
Mari/Aths*2//Avt/Attiki	5909	105.8	944	106.4
Soufara-02/3/RM1508/Por//WI 2269	5843	104.6	931	105.0

* YD and YP are mean grain yields of each line in the locations/years indicated in Table 10 as low and high yielding environments, respectively.

A. Zahour

2.1.7. Research Methodologies

Under this heading we present results which represent contributions to methodological aspects mostly related to breeding for difficult environments. These results were derived from the analysis of data collected in the breeding material evaluated in the course of the breeding cycles and not from experiments designed only to evaluate methodologies.

Selection Environment and Performance of Breeding Material

As indicated previously, we have recently completed a study conducted with two sets of 332 and 234 breeding lines evaluated in 10 and 9 environments, respectively, to investigate the role of the selection environment on the performance of breeding material in low or high yielding environments. Results obtained in this study (S. Ceccarelli and S. Grando: Environment of selection and type of germplasm in barley breeding for low-yielding conditions, submitted for publication) indicated that selection for high grain yield under relatively favorable conditions has generated breeding material yielding about 18% less than the local landraces grown by the farmers in environments with average yields of 1 t/ha or less. The inferiority of this material is even more apparent (between 33% and 38%) when compared to entries selected for high grain yield under unfavorable conditions (Table 21), a comparison which is often missing in the literature.

This study confirms results obtained in stress environments for barley (Ceccarelli, 1989; Ceccarelli and Grando, 1989), for bread and durum wheat (Ceccarelli et al., 1987b), and in different environments for other crops (Simmond, 1984; Lawn, 1988; Atlin and Frey, 1989).

The results also indicate that selection in environments with intermediate stress is not an efficient strategy to improve grain yield in low yielding environments. This is expected in the case of a crossover type of genotype x environment interaction when selection is conducted at or near the crossover point. The results did not prove that selection for grain yield in a low yielding environment is

Table 21. Grain yield in low- (YL), and high yielding conditions (YH), and average grain yield (Y) of two groups of barley entries classified according to the selection environment (modified from: Ceccarelli and Grando,1990).

Selection Year 1	Environment Year 2	No. of entries	YL (kg/ha)	YH (kg/ha)	Y (kg/ha)
				1986-1988	
Stress	Stress	108	855 a	4643 c	2904 b
Non stress	Non stress	10	522 c	5420 a	3084 a
				1987-1989	
Stress	Stress	30	781 a	5178 b	2631 a
Non stress	Non stress	32	396 c	5719 a	2454 b

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

Table 22. Selection history of the breeding material tested during 1986-1988 and 1987-1989 and outyielding the best checks* for yield in low- (YL), or high yielding conditions (YH). (modified from: Ceccarelli and Grando, 1990).

Selection criteria** Year 1	Year 2	Number selected	Number and % of lines outyielding A.Aswad N	%	YL	YH	Number and % of lines outyielding Rihane-03 N	%	YL	YH
					1986-1988					
GYS	GYS	108	28	25.9	979	4582	5	4.6	805	5725
GYNS	GYNS	10	0	-	-	-	2	28.6	610	5929
					1987-1989					
GYS	GYS	30	7	23.3	960	5153	5	33.3	713	5959
GYNS	GYNS	32	0	-	-	-	16	50.0	384	6136

* A.Aswad for YS, Rihane-03 for YNS

** GYS = grain yield under stress, GYNS = grain yield in absence of stress.

efficient in increasing yield for low yieldingconditions because of the use of the same data in both the selection process and in the measure of grain yield under stress (YL). However, there is little doubt that selection for grain yield in any other combination of environments would produce entries poorly adapted to low yielding conditions (Table 22).

S. Ceccarelli and S. Grando

Genotype x Management Interaction

Genotype x management interaction is one aspect of genotype x environment interaction and is one particular case of the more general problem of selection made in environments differing from the target environment. In most breeding programs, selection work is conducted within experimental stations where management often differs considerably from that used on farmers' fields with respect to fertilizer, rotations, soil preparation, etc. If differences among genotypes are affected by one or more management factors in the sense that the ranking of genotypes can be altered, the efficiency of selection can be considerably reduced.

During 1990, in collaboration with the Farm Resources Management Program, we conducted a set of 12 trials, each consisting of 20 barley lines, without and with fertilizer (40 kg/ha of nitrogen and 60 kg/ha of P_2O_5). The 20 barley lines consisted of two groups, the first group included 10 lines recommended for the second stability zone in Syria (zone B, or moderate rainfall zone), the second included 10 lines developed specifically for stability zone 3 in Syria (zone C, or lower rainfall zone). Eleven trials were sown using an Oyjord planter in farmers' fields and 1 in Breda station. Plot size was 25 m^2 in a RCB design with two replications.

The very dry conditions of 1990 in all the sites, did not allow to obtain a wide range of yield levels. Grain yield could not be measured in all locations, but total dry matter yield was determined in all sites. Fertilizer application had a large effect on yield despite the very dry conditions. Yield increases due to fertilizer were 72.4% and 63.3% in the lines for wet and dry environments, respectively. In the absence of fertilizer lines for dry environments had a yield advantage of 18.4% over the lines selected for wet environments (Table 23). When fertilizer was applied the yield advantage was 12.1%. Among the lines for dry environments, Tadmor was the highest yielder without fertilizer and also the highest yielding when fertilizer was applied. This would indicate that, within this range of yield levels, germplasm derived from landraces does respond to fertilizer.

The trial will be repeated during the next cropping season.

Table 23. Total dry matter yield (kg/ha) of 10 barley lines adapted to wet environments and 10 barley lines adapted to dry environments with and without fertilizer (means of 12 locations).

Environment of adaptation	Line	Dry matter yield	
		no fertilizer	with fertilizer
Wet	Rihane-03	845	1440
	ER/Apm	757	1229
	CI08887/CI0576	1808	1341
	Giza121/....	609	1006
	Cm/3/Api/...	784	1362
	Pitayo/.....	605	1260
	Roho/Mazurka	865	1348
	Salmas	679	1050
	As46/Aths*2	857	1597
	A.Abiad	699	1312
	mean	751	1295
Dry	Harmal	726	1432
	Tadmor	1006	1605
	Arta	973	1584
	SLB 39-60	936	1531
	SLB 39-10	994	1460
	WI 2291	860	1332
	WI 2269	757	1294
	Wadi Hassa	802	1274
	Deir Alla 106/..	886	1489
	A.Aswad	949	1524
	mean	889	1452
L.S.D. (0.05)			
Lines x Fertilizer		177	
Groups x fertilizer		56	

A number of barley genotypes were also tested for their response to supplementary irrigation. The results of this work are reported in the Farm Resources Management Program Annual Report.

M. Jones and S. Ceccarelli

Analytical Breeding

The role of analytical breeding as one of the avenues to increase the efficiency of empirical breeding has been discussed in a paper submitted for publication (S. Ceccarelli, E. Acevedo and S. Grando: Analytical breeding for unpredictable environments: single traits, architecture of traits, or architecture of genotypes?).

The major conclusions of the paper are:

- genetic differences in yield and yield stability under conditions of low winter temperatures and moisture stress are associated with differences in morphological and developmental traits such as growth habit, cold tolerance, early growth vigour and time to flowering, among others.
- the interaction among these, and certainly with other traits, plays a key role in determining the differences in overall performance rather than the expression of any one of them taken in isolation.
- because of the interactions among traits, different combinations of traits are expected to produce the similar effect in terms of final yield.
- the role of each individual trait, even within one type of stress environment (rainfed, mediterranean - continental) depends on the frequency, timing and severity of stresses, and on the type of stress; therefore, efforts to identify individual traits causally associated with yield stability under stress is unlikely to be successful.
- in this type of stress environment "drought resistance", defined in terms of yield under stress, is a genetic abstraction as much as yield in general.
- long-term and sustainable improvements of yield stability should probably be based on populational buffering as achievable with mixtures of genotypes representing different, but equally successful, combinations of traits, as occurs in landraces.

S. Ceccarelli and S. Grando

Barley Improvement and Sustainable Agriculture

A number of issues, mostly related to the selection environment and the type of germplasm used in the barley improvement program are related to sustainability. They have been recently discussed at a Symposium on Sustainability organized by ICARDA. Two of these issues, namely a) high input or low input varieties and b) genetic uniformity or genetic variability have been discussed in the preceding sections. Here we only discuss their relationship to sustainability.

There is an alarming increase in evidence of the environmental damage that agricultural development based on the continued heavy use of inputs can cause. Such damage ranges from direct effect on the environment to depauperation of both physical and biological resources.

In marginal areas, particularly in dry areas, gains in productivity have been relatively modest. There is a widespread belief that big breakthroughs are going to come more through crop management and resources management than by breeding. While there is little doubt that both crop management and resource management can increase yields and preserve physical and biological resources, the role of breeding has been seldom put in the correct context for the following reasons:

- breeding for unfavourable (climatically or agronomically or both) environments has been based on the assumption that increases in yield potential would automatically generate, as a "residual effect", increases in yield under "stress" conditions.
- research on drought resistance has been almost invariably addressed to find a simple character, either morphological, physiological or biochemical, which explains genotypic differences for yield under stress conditions. This research has failed to produce substantive findings because it ignores that field stress conditions are varying widely in type, intensity, timing and duration.
- many scientists in developing countries have been trained on these two concepts and, even now, in many research stations within and beyond WANA, regrettably, an impressive amount of crop improvement work is conducted under optimum growing conditions.

The combination of these three factors has generated a great deal of sceptisism on what breeding can do in unfavorable conditions.

The indications which have emerged during the development of barley germplasm in the last six years suggest that:

- it is possible to identify consistent and repeatable genetic differences under unfavorable environmental conditions only if selection is conducted under the variable conditions typical of these environments.
- yield potential, or even yield under sub-optimal conditions, is not an efficient selection criterion to identify superior genotypes for unfavorable conditions. The trade-off between yield potential and yield under stress varies with the crop and with the definition of stress.
- stress physiology research has confirmed that there are genetic differences in barley for yield under drought not accounted for by either phenology or yield potential.
- there is experimental evidence in other crops, both at ICARDA and elsewhere confirming these results and suggesting the need for separate breeding programs for favorable and unfavorable conditions.

This suggests that plant improvement can indeed provide one of the factors which can promote sustainable agriculture in areas where the efficient use of energy consuming and environmentally hazardous resources is critical. The type of breeding technology which is likely to increase productivity in a sustainable manner includes:

- maintainance of genetic diversity: a large number of varieties should be grown at a given time rather than the very few, often closely related varieties, which have allowed large yield increases in favorable conditions. This is because stress environments often differ largely in the predominant stress factor.
- utilization of plant genetic resources such as landraces and wild relatives in crop improvement programs: it is unlikely that this type of germplasm can contribute more than a few genes to improve production in high input agriculture and in favorable environments. However, in unfavorable environments where the strategy of improving production by a different partitioning of the biomass has been unsuccessful and is not necessarily acceptable by farmers, the incorporation of landraces and wild relatives in breeding programs has already proved to be a valuable tool. Their adaptation to the

fragile farming systems of dry areas is the product of centuries of natural selection. The components of this close adaptation are, or should be, instructive to plant breeders trying to replace them with improved cultivars. An important aspect of this adaptation is the stability of landraces under the wide range of stresses commonly found over years at a single site with a low annual average rainfall.
A conspicuous feature of landraces is their within-population variation (Ceccarelli et al., 1987; van Leur et al., 1989) which may explain their yield stability through population buffering (Allard and Bradshaw, 1964). There is considerable evidence from cereals and food legumes that genetically heterogeneous populations are more stable yielding than genetically homogeneous populations (Simmonds, 1979). In addition to the exploitation of the variability existing within Syrian landraces, the barley project aims at the evaluation of mixtures of superior genotypes in comparison with both the constituent pure lines and the cultivated landrace.
Eventually, in collaboration with both Montana State University and the University of Hohenheim, the barley project will attempt to evaluate the role of possible limited amount of heterozygosity in the complex population structure of landraces.

S. Ceccarelli

2.1.8. ICARDA-CIMMYT Barley Project

The activities of this project, targetted for high rainfall areas, were carried out during the winter of 1989-90 at CIANO located in northwestern Mexico (32 masl) and during the summer of 1990 at El Batan and Toluca located in Central Mexico (2200 and 2600 masl, respectively). The segregating barley populations were screened for their disease reactions under artificial epidemics of leaf and stem rust at CIANO, leaf and stripe rust at El Batan, and scald and stripe rust at Toluca.

Multiple Disease Resistance

The prevalence of diseases in the target high rainfall areas served by the program had made the incorporation of disease resistance into the germplasm a priority. In Bolivia and Peru, the barley germplasm must have resistance to stripe and leaf rust. In Colombia, Ecuador, and Chile, scald and barley yellow dwarf virus (BYDV) are two additional diseases that limit barley production.

Since 1975, stripe rust (race 24) has been the most damaging disease of barley in Latin America. The presence of this race in Mexico has caused considerable losses for barley producers in the Central High Plateau. In 1989 alone, the cost of fungicide application (Tilt and Folicur) in Mexico was estimated to be US$4 million.

One hundred advanced lines carrying multiple disease resistance were sent for yield testing to Colombia, Bolivia, Ecuador, and Peru. Lines performing better than the national checks will be selected for further testing in national or regional trials.

Nearly 1100 F_6 lines were sent to Ecuador's Sta. Catalina Experiment Station where they were screened for BYDV and other diseases; 217 of these lines were classified as BYD-resistant or tolerant and will be included in yield trials throughout the Andean region next year.

Hull-less Barley

Farmers in the Andean Region, North Africa, and the Himalayas frequently grow hull-less barleys because the hull-less kernels are particularly suited for human food preparation.

Advanced hull-less barley lines with multiple disease resistance were yield tested in Mexico (CIANO), Bolivia, Ecuador, and Peru. Thousand kernel weight and test weight were also recorded in Mexico (Table 24). An important characteristic of these lines is the large grain size, a main attraction for farmers in the Andean Region, who receive higher prices for large-kerneled durum wheats and barleys.

Table 24. Test weight, 1000 kernel weight, and yield of hull-less barleys at CIANO, northwestern Mexico, 1989-90.

Cultivar	Test weight (kg/hl)	1000 kernel weight(g)	Yield (t/ha)
Six-row			
CMB 86A. 2044-A	70	32.0	6.5
CMB 86A. 2044-J	80	32.5	6.0
CMB 86A. 2042-Y	80	34.5	5.8
Two-row			
Viringa'S'	80	52.8	5.5
Viringa'S'	80	54.4	5.3
Viringa'S'	80	61.5	4.3

The high yield potential of "Bermejo", an early hull-less barley line, was confirmed for the second year at CIANO; it was comparable to the best early hulled barleys (Table 25). Bermejo's excellent yield indicates that hull-less barleys are not necessarily low yielders. This implies that breeding for high yielding hull-less barleys could be a worthwhile effort. During this cycle, we made several crosses involving hull-less Viringa lines, especially those with large grains, and Aruop, a high yielding two-row barley.

Table 25. Agronomic and field performance of Bermejo (hull-less) and Encino (the top yielding hulled, early barley) at CIANO, 1989-90.

Cultivar	Days to heading	Height (cm)	Physiological maturity (days)	Yield (t/ha)
Bermejo	68	85	106	8.4
Encino	68	70	106	8.9

LSD 5% for grain yield = 1.1 t/ha.

Early Maturing Barleys

Early maturing barleys have proven their merit in many countries where they are exposed to different growing conditions. In China and Vietnam, for example, two crops of rice and one of barley are grown in 1 year, allowing for more intensive land use. In Western Australia, an early variety is being recommended for late planting when farmers cannot meet normal planting dates. The early maturity trait currently is being combined with various combinations of disease resistance-depending on the target environment:

- Barley yellow mosaic virus and scab resistance for the Yangtze River Basin in China.
- Helminthosporium sativum resistance for Thailand and Vietnam. Crosses to incorporate spot blotch were made for these countries.
- Stripe rust, scald, and leaf rust for the Andean Region.
- Leaf and stem rust resistance--in addition to a genetic modification of the awn (hood)-- is desirable where mixtures of rye grass and barley are grown for cattle grazing.

Fifty early advanced barley lines were yield-tested at CIANO during 1989-90. Yields of the Encino'S' lines were among the highest recorded for this group, and were significantly different from the all-time check Mona/MZ9//DL71 (Table 26). Although the Encino lines are often short, most of the tested lines were tall--height is an important trait for rainfed conditions, especially if the crop is handharvested.

Table 26. Performance of Encino lines compared to the early barley check.

Cultivar name	Days to heading	Height (cm)	Days to phys. maturity	Yield (t/ha)
Encino's'	68	85	104	8.9
Encino's'	68	70	106	8.9
Encino's'	70	75	106	8.7
Mona/Mzq//DL71	60	65	106	7.5

LSD (5%) for grain yield = 1.1 t/ha.

Multiple disease resistance in early maturing barleys has been assembled in a step-wise form. Resistances to two diseases are first put together; once advanced lines are obtained, these lines are crossed to add the resistance to a third disease. Table 27 presents the disease reactions of some early maturing barley to different diseases.

Table 27. Disease reaction of early maturing barley lines.

Cultivar Name	Stripe rust	Leaf rust	Scald	BYDV
Encino's'	5S	R	S	R
Gloria/Come//Lignee 640/3/Superprecoz	R	R	MR	
Superprecoz/5/Hja A33/ ID601810//11012.2/ Steudelli/3/Egypt20/4/ Pye'S'/6/Abn	10S	R	R	

Germplasm for China

The variety Gobernadora, released in China in 1986, has expanded to seven Chinese provinces: Heilongjiang, Anhui, Zhejian, Fujian, Hubei, Hunam, and Jiangsu. It is cultivated at these locations for its high yield, tolerance to BYMV, and excellent resistance to scab.

In Shanghai, where Professor Liu Zongzhen identified the variety in germplasm sent from Mexico, new early lines derived from Gobernadora crosses, with the same resistances (scab - BYMV), are ready for release. The most outstanding lines are:

. Hlla/Gob//Hlla

. Henry/Gob/3/Clld/CI12010//Pue

. Magnif 102/Gob

These new early lines have the yield potential of Gobernadora. Their high yield and early maturity make them attractive to Chinese farmers in the Yangtze basin. However the release of these cultivars will depend on seed production in the Province.

In the Zhejian province, two promising lines were identified by Liang Xunyi from 66 F_2 populations sent from Mexico to China in 1984. Four Chinese lines, sources of resistance to BYMV and scab, identified in Shejian, are being incorporated into our crossing scheme. In Sichuan province, the variety V-24 and an Indian line selected from the International Barley Yield Trial (IBYT) were planted on some 300 ha.

Early lines developed for China were sent to Vietnam for observation. The susceptibility of this germplasm to Helminthosporium sativum, the causal agent of spot blotch, will probably prevent much utilization. Crosses were made during the winter with several sources of spot blotch resistance--including the BRB2 from Thailand and NDB112 from USA.

A new germplasm pool with spot blotch resistance must be developed for countries such as Thailand and Vietnam, where this disease is most prevalent.

Resistance to the Russian Wheat Aphid (RWA)

The RWA has become one of the most important insect pests in USA during recent years and has caused severe losses in small grains. In 1989, losses attributed to RWA in Texas were estimated at US$140 million.

RWA was identified in Mexico in 1980. Although present in farmers' fields, the aphid has not caused economic losses to Mexican farmers in the barley belt of central Mexico. Crosses among the best tolerant lines identified on the first screening (1984) and some winter lines (Barberrouse) observed with fewer symptoms under a natural epidemic have resulted in several advanced lines that have some RWA resistance under field conditions.

The mechanism of resistance in some of the best lines was studied in the greenhouse. In the lines Gloria/Come (CMB81-294-5B-3Y-3M-1Y-4M-0Y) and Ase/2CM//B.7.6.B.B., the resistance mechanism was determined to be antibiosis. Tolerance has also been observed, where plant height and weight were measured in comparison with the susceptible check. After aphid inoculation, Gloria/Come develops under infestation levels that practically eliminate the susceptible check.

Crosses between resistant and susceptible cultivars were made during the winter at CIANO to study and determine the mode of inheritance of resistance.

The resistant parents (Gloria/Comme and Ase/2CM//B.7.6.B.B.) and the susceptible parents (Shyri and Esperanza) were crossed in both directions to test for maternal effect. The F_1 and F_2 will be studied in the field and greenhouse separately. In both cases, the inoculation will be done with greenhouse-reared aphids.

Some of the RWA-resistant lines are resistant to diseases such as stem, leaf and stripe rust and scald. Gloria/Come has been extensively yield tested around the world with good results. All our germplasm is available upon request.

The RWA work reported is the result of collaborative work of CIMMYT researchers L. Gilchrist, P. Burnett, S. Calhoun. and J. Robinson.

Resistance to Dwarfing of Narino and BYDV

In southern Colombia and northern Ecuador, a unique problem to barley production is the presence of Narino dwarf, transmitted by a leaf hopper Cicadulina pastusae. The causal agent has not yet been determined precisely. However, resistant barley material has been identified in Colombia; these lines were introduced in the program for crossing to combine several traits lacking in the original parental material such as: resistance to BYD, stripe rust, and leaf rust and stiff straw. BYDV is also important in Latin America and other parts of the world.

Purdue University, has conducted a survey on biotypes of the luteo virus present in Latin America. The results showed the MAV type is present in Bolivia, Colombia, Ecuador, and Peru, while the PAV strain is prevalent in Chile. Both MAV and PAV are controlled by the Yd2 gene, extensively used in our crossing. With P. Burnett, CIMMYT BYD specialist, we identified 67 advanced lines resistant to MAV and PAV in artificial inoculation tests of 280 advanced lines currently being tested for their yield potential. From these 280 lines, only those with higher yield will be included in the International Barley Observation

Nursery (IBON). However the 67 BYD-resistant lines, as a group, will be distributed worldwide in the CIMMYT BYD screening nurseries (BYDSN). A major advantage of these new materials is that they carry multiple disease resistance.

Medic-barley Rotation

Barley is generally grown in the high plateau of Mexico in a monoculture, which results in high incidence of foliar diseases caused by volunteer barley plants and infected straw that remains on the ground.

The presence of medic (Medicago polymorpha) plants in farmers' fields is common. During the summer of 1989 on 1 ha of a farmer's field, 30 kg of P_2O_5 were applied to stimulate the growth of the medic plants. Wild oats were controlled with one application of fusilade herbicide; broad leaf weeds were sliced on the top with a rotary mower twice during the growing cycle. The medic plants developed into good stands and were not grazed so that seed would be produced. A total of 25 kg of pure seed was harvested from the dry medic plants for next year's planting. The adjacent barley field (1 ha) was planted with a stripe rust-resistant line that produced 4.5 t/ha of grain.

A medic-barley rotation looks promising, but field experiments should be conducted with farmers who own animals. Next year medic will be established at a Mexican Experimental Station where research on sheep management is underway.

Variety Release

Four National Programs have recently released barley varieties originating from ICARDA-CIMMYT germplasm:

. Australia: Yagan, an early maturing barley.
. Chile: Centauro, a hull-less variety.
. Brazil: Acumai, a hull-less variety.
. Peru: Bellavista.

H. Vivar

References

Allard, R.W. and Bradshaw, A.D., 1964. Implications of genotype-environment interaction in applied plant breeding. Crop Sci., 4: 503-508.

Atlin, G.N., and K.J. Frey. 1989. Predicting the relative effectiveness of direct versus indirect selection for oat yield in three types of stress environments. Euphytica 44:137-142.

Ceccarelli, S. 1989. Wide adaptation: How wide? Euphytica 40:197-205.

Ceccarelli, S., M. Nachit, G.O. Ferrara, M.S. Mekni, M. Tahir, J.A.G. van Leur, J.P. Srivastava. 1987b. Breeding strategies for improving cereal yield and stability under drought. In "Drought tolerance in winter cereals" (J.P. Srivastava, E. Porceddu, E. Acevedo, and S. Varma, Eds.) pp. 101-114. John Wiley and Sons, New York.

Ceccarelli, S. and S. Grando. 1989. Efficiency of empirical selection under stress conditions in barley. J. Genet. and Breed. 43:25-31.

Ceccarelli, S. and Grando, Environment of selection and type of germplasm in barley breeding for low-yielding conditions (under internal review).

Cereal Program Annual Report, 1987 pp. 110.

Cereal Program Annual Report, 1989 pp. 32-34.

Lawn, R.J. 1988. Breeding for Improved Plant Performance in Drought-prone Environments. In "Drought Research Priorities for the Dryland Tropics (F.R. Bidinger and C. Johansen eds.), ICRISAT, Patancheru, India:213-219.

Santamaria, J,M., Ludlow, M.M. and Fukai, S. 1990. Contribution of Osmotic Adjustment to Grain Yield in Sorghum bicolor (L.) Moench under Water-limited Conditions. I. Water Stress before Anthesis. Aust. J. Agric. Res., 41:51-65.

Simmonds, N.W., 1979. Principles of Crop Improvement. Longman, London, 408 pp.

Simmonds, N. W. 1984. Decentralized selection. Sugar Cane 6:8-10.

Van Leur, J.A.G., Ceccarelli, S. and Grando, S., 1989. Diversity for disease resistance in barley landraces from Syria and Jordan. Plant Breeding, 103 (4): 324-335.

2.2. Spring Durum Wheat Breeding

2.2.1. Introduction

The main objective of the CIMMYT/ICARDA durum wheat project is to enhance durum production in WANA by developing germplasm resistant to abiotic and biotic stresses, improving dryland research methodologies, and upgrading national research capabilities.

Intermittent drought combined with cold and terminal stress affected the cereal production of the WANA region in the 1989/90 season. In addition, Hessian fly, BYDV, leaf and stem rusts affected several wheat growing areas.

The release of stress tolerant durum wheat lines has increased yields in WANA. Increases in durum yields in dryland areas are achieved mainly by improving germplasm tolerance to the various abiotic and biotic stresses.

2.2.2. Breeding Methodology

Broadening the Genetic Base

The genetic base of durum wheat is narrow, and to broaden it crosses were made with landraces from different WANA countries and with wild relatives.

Crosses with landraces from the Ibero-Maghreb region were given high priority this season; 270 crosses were made with parents carrying resistance to diseases, wheat stem sawfly, and Hessian fly.

Twenty-one crosses were made in the 1989/90 season between wild emmer (T. dicoccoides) and advanced durum wheat lines to improve grain quality and to increase resistance to septoria leaf blotch and yellow rust. More than 50% of the F_1 crosses were back-crossed to durum wheats to more rapidly eliminate the effects of undesirable traits. Several backcross generations to durum will be needed to improve spike threshability.

Eighty-seven crosses were made with Triticum monococcum to enhance earliness, rust resistance and early plant vigor in durum wheat. Sixty-three of 87 crosses were backcross combinations. Twenty-four crosses with different *Aegilops* species were made with high yielding and stable durum genotypes to increase fertile tillering ability and abiotic stress tolerance. Several crosses were also made with *T. carthlicum*, *T. compactum*, and *T. dicoccum*.

Recurrent Selection Populations

Three durum populations were developed using recurrent selection. Parental material for these populations came from landraces (Haurani, Jennah Khetifa and Kyperounda) and advanced durum lines with high yield stability and multiple biotic and abiotic stress resistance. The Haurani population was handled at Aleppo, Syria, while Kyperounda population was managed in collaboration with NARS of Cyprus under mild winter conditions. The Jennah Khetifa population is crossed and multiplied, and will later be sent to Maghreb NARS for local evaluation and selection.

Single Seed Descent (SSD)

Four generations per year are grown for each of 100 crosses in the greenhouse. The SSD method is used to rapidly incorporate leaf rust and septoria leaf blotch resistance.

Selection and Screening Techniques

The gradient selection technique is our major selection strategy for multiple stress tolerance in durum wheat (Cereal Program Annual Reports 1987, 1988 and 1989). Emphasis, however, is now placed on the combinations of drought and heat, and drought and cold. Disease resistance has attained an acceptable level for the most important diseases in the region. Several populations and entries have been developed with the combination of tolerances to drought-cold and drought-heat stresses. In the 1989/90 season, individual plant selection was made under extremely dry conditions (Breda, 179 mm, and Tel Hadya rainfed, 234 mm). Although individual plant selection was made at Breda to pyramid genes for drought tolerance, selection was also made under supplementary irrigation to identify populations combining stress tolerance and high yield potential.

2.2.3. Breeding for Biotic Stress Resistance

Disease Resistance

Targeted crosses for disease resistance were made during the 1989/90 season, including 36 crosses for septoria leaf blotch, 31 for common bunt, 147 for leaf rust, 89 for stem rust, 12 for BYDV and 27 with multiple disease resistant lines. All crosses involved at least one parent resistant to yellow rust.

At Lattakia segregating populations were screened for septoria leaf blotch resistance. Segregating and advanced generations showed a high percentage of resistant populations. This is a result of continually upgrading resistance by incorporating resistance from landraces from the Maghreb/Iberia region and from T. dicoccoides, and backcrossing of resistant advanced material to high and stable yielding lines.

For combined resistance to septoria leaf blotch, yellow rust, leaf rust and stem rust, segregating populations were screened at Terbol during the summer for leaf and stem rusts, for yellow rust at Tel Hadya using early planting, and at Lattakia for septoria leaf blotch.

Insect Resistance

Thirty five crosses were made to incorporate resistance to wheat stem sawfly. Of these 27 were made with solid stem landraces from Morocco. All advanced material and segregating generations were screened against natural attacks of wheat stem sawfly at Breda and Tel Hadya. Several durum advanced and segregating generations showed acceptable levels of resistance.

Twenty-nine crosses were made this season for resistance to Hessian fly, using resistant durum varieties from the Iberian Peninsula, such as Javardo. Interspecific crosses with resistant bread wheats were also made to incorporate the many available genes for Hessian fly resistance into durum wheat germplasm.

Because of the limited sources of resistance only five crosses for aphid resistance were made this season. Collaboration with the Egyptian NARS emphasized identifiying resistant sources. Selection for the Russian wheat aphid was made in segregating populations during the summer at Terbol, Lebanon. Preliminary results suggest the possibility of selecting resistant material in durum wheat.

2.2.4. Breeding for Abiotic Stress Resistance

Drought Resistance

This season rainfall in Syria was only two thirds of the long term average. Low rainfall was combined with severe cold and drought during the vegetative stage, frost during anthesis, and a long period of hot weather during the reproductive stage. Intermittent drought stress occurred and high evapotranspiration demand was observed near the end of April. Mean grain yield at the dry site (Breda) was below average. Table 28 shows the average grain yield (kg/ha) in the advanced durum yield trials and the precipitation (mm) at Breda for 5 consecutive seasons.

Average grain yields of the advanced yield trials in 1989/90 were only 34.3% of the 5-year average with yields ranging from 35 to 1420 kg/ha. Severe drought and cold during the months of January and February caused crop failure at the Bouider station.

Table 28. Grain yield (kg/ha) of durum wheat lines in advanced yield trials (ADYT) and annual rainfall (mm) at Breda for 5 years.

Season	Rainfall	Grain yield		
		Mean	Max.	Haurani
1985/86	218	1224	1697	1014
1986/87	245	1127	2500	1066
1987/88	408	3608	4372	3066
1988/89	186	758	1237	503
1989/90	179	494	1420	695
Mean	248	1442	2245	1269

Drought Resistance and Productivity

Table 29 shows the performance of the newly identified genotype Omrabi 17 over three seasons. In 1987/88, when climatic conditions were favorable

Table 29. Performance of Omrabi 17 and Haurani under dryland conditions in experimental stations and farm field verification trials (FFVT) in 1987/88, 1988/89 and 1989/90 in Syria.

Variety	1987/88			1988/89	1989/90
	Bouider	Breda	FFVT*	FFVT*	FFVT*
Omrabi 17	2420	4372	3469	1118	1161
Haurani	1521	3022	2828	981	1050
Omrabi 17/ Haurani (%)	159	144	123	114	110
LSD (0.05)	628	539	160	113	-
CV (%)	13	8	9	17	-
No. of sites	1	1	10	8	10

* FFVT's are conducted in low rainfall areas with less than 350 mm in 1987/88, and less than 250 mm in 1988/89 and 1989/90.

and yields were above average, Omrabi 17 outyielded Haurani. Omrabi 17 also outyielded Haurani, a widely grown landrace in dry areas, in the less favorable seasons of 1988/89 and 1989/90 when cold and drought affected plants during the vegetative stage. In the 1989/90 season frost occurred during anthesis and heat and drought occured during later reproductive stages. The performance of Omrabi 17 suggests a successful combination of moisture stress tolerance and responsiveness to favorable conditions.

Trait Association and Heritabilities under Dry Conditions

Under Mediterranean continental dryland conditions grain yields were highly related to earliness, fertile tillers, peduncle length and number of spikelets/spike for the last two consecutive years (Table 30). These results corroborate earlier findings (Nachit and Jarrah, 1986). Correlations between grain yield, number of kernels/spikelet, and leaf rolling, however, varied from season to season.

The contribution to grain yield variability was predicted largely by fertile tillers for the 1987/88 and 1988/89 seasons, and by peduncle length in 1989/90 (Table 31). Under moisture-stress and across all seasons plant height, number of kernels/spikelet, days to anthesis, and early plant vigor were the best yield predictors.

Table 30. Correlations between grain yield under dry conditions and some morphophysiological traits in two seasons, Breda.

Trait	Correlation Coefficient	
	1988/89	1989/90
Plant vigor[1]	0.51 ***	0.11 n.s
Days to anthesis	-0.53 ***	-0.53 ***
Days to maturity	-0.36 **	-0.09 n.s
Fertile tillers[1]	0.33 **	0.64 ***
Peduncle length[1]	0.27 *	0.67 ***
Spikelets/spike[1]	-0.23 *	0.48 ***
Kernels/spikelet	0.01 n.s	0.51 ***
Leaf rolling index[1]	0.44 ***	0.02 n.s
Plant height (cm)	0.02 n.s	0.60 ***
1000-kernel weight (g)	0.01 n.s	-0.08 n.s

1 scale 1-9, 1 = low, 9 = high
n.s: not significant at 5%, *,**,*** significant at 5, 1, and 0.1% levels, respectively, n = 210.

Table 32 shows the broad sense heritability and expected genetic advance for grain yield and other traits in two seasons at Breda.

High values for both parameters were found for peduncle length, fertile tillers and spikelets/spike. Days to anthesis had high heritability but low genetic advance.

Performance at Breda of Promising Durum Wheat Entries in the Maghreb Region.

Promising entries in the Maghreb region had an average grain yield at Breda of 460 kg/ha compared to 494 kg/ha for promising lines in West

Asia. Association of grain yield with other traits was similar in both groups (Table 33).

Table 31. Trait contribution (%) to grain yield variation under dry conditions, Breda.

Trait	% contribution		
	1987/88	1988/89	1989/90
Fertile tillers	32.34	38.10	5.94
Peduncle length	6.63	0.72	40.51
Plant height	5.99	10.52	0.40
Spikelets/spike	0.51	3.78	0.00
Kernels/spikelet	5.27	1.37	3.25
Days to anthesis	4.26	1.50	4.50
Days to maturity	1.48	2.28	1.43
Plant vigor	2.17	2.04	0.72
Leaf rolling - a.m.	1.59	0.03	0.03
Leaf rolling - p.m.	1.07	0.00	0.00
1000 kernel weight	0.94	0.02	0.43
Leaf temperature	0.78	0.01	-
Total	63.03	60.28	57.23

Table 32. Heritability and expected genetic advance (%) of grain yield and other traits under dry conditions in two consecutive seasons at Breda.

Trait	Heritability*		Expected Genetic Advance (% of population mean)	
	1988/89	1989/90	1988/89	1989/90
Plant vigor	0.71	0.69	18.23	24.21
Days to anthesis	0.92	0.72	5.17	1.89
Fertile tillers	0.64	0.54	31.08	55.33
Peduncle length	0.71	0.77	56.23	90.16
Spikelets/spike	0.52	0.65	21.78	65.27
Kernels/spikelet	0.24	0.25	9.96	19.61
Grain yield	0.56	0.51	10.98	46.22
Leaf rolling index	0.39	0.75	19.81	26.39
Plant height	0.56	0.58	8.24	26.62

* Broad sense heritability.

However, when the contribution of each trait to yield was analyzed (Table 34), grain yield of promising lines in the Maghreb region could be accounted for by fertile tillers and early plant vigor. In the case of promising lines in West Asia, peduncle length, tillering and number of days to anthesis were the most important predictors of grain yield. Although sufficient genotypic variability in both populations exists and traits differ in their contribution to actual grain yield, no major yield differences were found between the two populations (Table 34). More data over sites and years are needed to verify these results.

Table 33. Correlation at Breda of grain yield with some morphophysiological traits in Maghreb- and West Asia-selected lines, 1989/90.

Trait	Region of selection: Maghreb (n = 40)	Region of selection: West Asia (n = 56)
Leaf color	0.06 n.s	-0.01 n.s
Plant vigor	-0.27 n.s	0.11 n.s
Days to anthesis	-0.49 **	-0.53 ***
Days to maturity	-0.39 *	-0.14 n.s
Plant height	0.55 ***	0.60 ***
Fertile tillers	0.68 ***	0.64 ***
Peduncle length	0.52 ***	0.64 ***
Leaf rolling - a.m	-0.09 n.s	0.02 n.s
Leaf rolling - p.m	0.13 n.s	-0.03 n.s
Spikelets/spike	0.58 ***	0.48 ***
Kernels/spikelet	0.66 ***	0.51 ***
Growth habit	0.01 n.s	0.09 n.s

n.s = not significant at 5%; *, **, *** significant at 5, 1, and 0.1 % levels, respectively.

Table 35 shows comparative values for trait expression under rainfed conditions at Tel Hadya (234 mm) and Breda (179 mm) in 1989/90. Most traits were affected by moisture stress. Leaf color and leaf rolling were increased by the onset of moisture stress, while plant vigor, number of days to anthesis and maturity, plant height, fertile tillers, peduncle length, spike components, and grain yield were reduced by increased moisture stress.

Table 34. Contribution of different traits (%) to grain yield in Maghreb and West Asia selected lines, Breda, 1989/90.

Trait	Contribution (%) Maghreb (6 sites)	Contribution (%) West Asia (6 sites)
Fertile tillers	46.77	5.94
Plant vigor	15.27	0.72
Days to anthesis	2.86	4.50
Day to maturity	0.35	1.43
Spikelets/spike	2.10	0.00
Kernels/spikelet	0.79	3.25
Leaf rolling - a.m	1.27	0.01
Leaf rolling - p.m	0.54	0.00
Peduncle length	0.23	40.51
Plant height	0.10	0.42
Leaf color	0.00	2.35
Growth habit	0.07	0.88

Trait Association and Heritabilities under Cold Conditions

Grain yield under cold conditions was associated with fertile tillers, cold tolerance score, plant height and spikelets/spike (Table 36) with fertile tillers making the greatest contribution to yield variability in 1987/88, 1988/89 and 1989/90. Cold tolerance ratings showed high heritability (0.92 in 1988/89 and 0.76 in 1989/90) which compared well with those of actual yield under cold (0.92 in 1988/89 and 0.82 in 1989/1990). Sufficient genetic variability exists in the advanced durum wheat populations to permit substantial improvement by selecting superior genotypes for cold conditions.

Joint studies between the durum breeding project at Aleppo and the University of Hohenheim show that spike development closely related to winter temperature patterns. Slow spike development in winter shows a strong association with cold and frost tolerance.

Table 35. Comparison of trait expression at dry sites in Breda (179 mm) and Tel Hadya (234 mm), 1989/90.

Trait	Mean Tel Hadya Rainfed	 Breda	Change %
Leaf color	5.24	5.51	+5.15
Plant early vigor	6.46	6.15	-4.80
Days to anthesis	123.10	116.94	-5.00
Days to maturity	150.31	141.46	-5.89
Plant height	41.60	32.13	-22.80
Fertile tillers	3.23	1.87	-56.43
Peduncle length	1.75	1.68	-4.00
Leaf rolling - am	1.47	4.47	+202.72
Leaf rolling - pm	5.18	6.46	+24.71
Spikelets/spike	1.75	1.51	-13.71
Kernels/spikelet	1.25	1.12	-10.40
Grain yield	1.25	1.12	-10.40

Breeding for Heat and Terminal Stress

High temperatures frequently occur in the Mediterranean dry areas of the region during the growing season. Durum wheat of WANA is exposed year after year to high temperatures during the grain filling period in some areas. Drought effects are frequently aggravated by high temperatures. Fertile tillers, early plant vigor and days to anthesis appear the best predictors of grain yield after 3 years testing for heat stress (Table 37). There is sufficient genetic variability for important selection traits in our germplasm (Table 38) to anticipate yield improvement through selection under heat stress.

2.2.5. Breeding for Yield Stability

Stable varieties are a prerequisite for achieving reliable production in WANA. The Mediterranean dryland conditions in WANA are characterized by high year-to-year and site-to-site variation, particularly with respect to precipitation and temperature extremes (Nachit and Ketata, 1986). Climatic fluctuations within an environment

Table 36. Correlation of grain yield with some morphophysiological traits under cold conditions.

Trait	Correlation coefficient	
	1988/89	1989/90
Cold tolerance	0.827***	0.459 ***
Days to anthesis	0.073 n.s	0.373 ***
Days to maturity	0.191 *	0.374
Plant vigor	0.159 *	0.184 **
Plant height	0.417 **	0.508 ***
Fertile tillers	0.714 ***	0.807 ***
Spikelets/spike	0.371 **	0.561 ***
Kernels/spikelet	0.077 n.s	0.430 ***
1000-kernel weight	0.158 *	0.173 *
Peduncle length	-0.086 n.s	0.545 ***

n.s.: not significant at 5%; *, **, *** significant at 5,1 and 0.1% levels, respectively.

oscillate from stressed to very favorable conditions. Stress tolerance must be considered in variety development for the Mediterranean dryland and simultaneously responsiveness to environmentally favorable seasons is necessary (Nachit, 1989). Genotype performance over a range of environments provides a measure of yield stability. Several breeding lines have performed well in regional yield trials across WANA (Table 39). The performance of 5 lines selected for improved yield and yield

Table 37. Correlation of grain yield with some morphophysiologial traits under heat conditions, Tel Hadya, late planting.

Trait	Correlation coefficient		
	1987/88	1988/89	1989/90
Early plant vigor	0.52 ***	0.41 ***	0.72 ***
Days to anthesis	-0.53 ***	-0.61 ***	-0.31 **
Spikelets/spike	0.19 *	0.40 ***	0.36 **
Kernels/spikelet	0.42 ***	0.46 ***	0.38 **
Fertile tillers	0.71 ***	0.67 ***	0.62 ***
Peduncle length	-0.16 n.s	0.36 **	0.63 ***
Plant height	0.15 n.s	0.21 *	0.62 ***
1000-kernel weight	-0.02 n.s	0.07 n.s	0.10 n.s

n.s: not significant at 5%; *, **, *** significant at the 5, 1 and 0.1% levels, respectively.

stability across the region is shown in Table 40. The lines Brachoua, Omrabi 5, Belikh 2 and Daki possessed grain yields similar to Cham 1, a regression coefficient close to one, a small deviation from regression and a high coefficient of determination.

Table 38. Heritability and expected genetic advance (EGA) of grain yield and other traits under heat stress conditions, Tel Hadya, late planting.

	Heritability		EGA (5%)	
	1989/90	1989/90	1989/90	1989/90
Grain yield	0.59	0.18	21.26	12.03
Fertile tillers	0.75	0.12	30.15	06.55
Plant vigor	0.76	0.68	19.07	30.40
Days to anthesis	0.98	0.51	35.19	04.00
Plant height	0.97	0.46	33.20	16.61

Yield stability under low rainfall was associated mainly with drought tolerance. This is reflected by the performance of Omrabi 5 under varying climatic conditions. Yield stability is also associated with plant vigor, leaf rolling mechanisms, tillering, earliness, leaf temperature, peduncle length, plant height, number of spikelets/spike and grain yielding ability. These results suggest the utility of the analytical approach for selecting varieties for dry areas.

In the moderate rainfall areas of the Maghreb region, where a total of 9 trials were grown by national programs, the cultivars Cham 1, Omrabi 3, Cham 3/Tell 76 and Omrabi 5 were the most promising durum genotypes. In West Asia Omrabi 5, Sabil 1, Brachoua and Gedifla were the highest performing genotypes among the entries included in the RDYT-MR. Several new promising genotypes for both dry and moderate rainfall areas were also selected by NARS from the durum observation nurseries.

Table 39. Performance of durum wheat lines in different environments and countries of WANA, regional durum yield trials-low rainfall (RDYT-LR), 1988/89.

Site/Country	Highest yielding entry (kg/ha)	Site mean yield (kg/ha)	Site check yield (kg/ha)	LSD (kg/ha)	No. of entries yielding higher than site check
Talafar (Iraq)	1005	714	504	199	13
Diyarbakir (Turkey)	1444	1073	875	376	5
S.Bel-Abbes (Algeria)	1604	781	892	685	2
Geleen (Syria)	4119	3351	2439	498	21
Marchouch (Morocco)	4444	3479	2778	640	11
Athalassa (Cyprus)	5566	4534	4054	666	10
Ahwas (Iran)	5589	4471	3831	527	14
Derna (Libya)	6666	3700	1633	1320	11

Omrabi 5 is being tested on large scale in Tunisia, Algeria, and Syria and has been released in Morocco due to its high yield and good stability. In Syria the cold tolerant genotype Lahn has exceeded a yield of 9 t/ha in large scale on-farm testing in high rainfall and irrigated areas of the country.

Table 40. Yield performance and stability of durum wheat lines in the WANA region, RDYT-LR, 1988/89.

Entry	Mean yield (kg/ha)	Regression coefficient	Deviation from regression	Coefficient of determination
Brachoua	3230	1.059	146179	0.926
Omrabi 5	3374	1.143	273270	0.905
Belikh 2	3299	1.127	270368	0.903
Daki	3286	1.048	243995	0.897
Cham 1	3303	1.066	615238	0.812

References

Cereal Program Annual Report, 1987, ICARDA.

Cereal Program Annual Report, 1988, ICARDA.

Cereal Program Annual Report, 1989, ICARDA.

Nachit, M.M. and Jarrah, M. 1986. Association of some morphological characters to grain yield in durum wheat under Mediterranean dryland conditions. Rachis 5(2): 33-34.

Nachit, M.M. and Ketata, H. 1986. Breeding strategy for improving durum wheat in Mediterranean rainfed conditions. International Wheat Conference, May 2-9, Rabat, Morocco.

Nachit, M.M. 1989. Moisture stress tolerance and yield stability in durum wheat (*Triticum turgidum* L. var. *durum*) under Mediterranean dryland conditions. *In* Science for Plant Breeding, XII Eucarpia Congress, Feb. 27 - March 4, 1989. Gottingen, Germany.

M. Nachit

2.3. Spring Bread Wheat Breeding

2.3.1 Introduction

Weather at Tel Hadya during the 1989-90 crop season is reported in the introduction of this Annual Report. Extensive damage by drought, cold and frost were also reported in other dry areas of West Asia and North Africa. Because of this, we present data on progress made in developing and identifying germplasm with tolerance to these and other important abiotic stresses and also in enhancing disease and insect pest resistance in our germplasm. Described are additional breeding techniques incorporated into the program to enhance breeding for rainfed Mediterranean environments. Finally, progress is reported toward identifying germplasm with the national programs of West Asia and North Africa and the potential impact of this germplasm on crop sustainability within the region.

2.3.2. Research Priorities for Bread Wheat Improvement

During 1990, the CIMMYT/ICARDA spring bread wheat breeding project emphasized the development of improved, adapted germplasm for the variable and unpredictable environments of West Asia and North Africa, with special attention to rainfed and low-rainfall areas (less than 400 mm annual rainfall). Table 41 presents the list of research priorities by agroecological zone and according to the importance of the stresses found in each area. A detailed description of these two zones was reported in ICARDA's 1988 annual report and includes geographical area, production, and the major stresses responsible for reduced yields. The low rainfall environments of the region receive highest priority.

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

Attention was also given to developing and verifying breeding methodologies. The single seed descent (SSD) method was introduced to rapidly improve resistance to specific qualitative traits such as yellow rust and Hessian fly. Multilocation testing continues to be a useful selection strategy, and emphasis was placed on the selective exploitation and use of exotic material including landraces.

Table 41. List of research priorities for bread wheat improvement.

Research activity	Production zone	
	MRT	LRT
Breeding		
Yield	H	VH
Yield stability	H	VH
Stresses		
Drought	H	VH
Cold	M	VH
Heat	H	M
Methodology		
Selection methods	H	H
Multilocation testing	VH	VH
Landraces	L	VH
Pathology		
Foliar diseases	VH	M
Seed borne diseases	M	VH
Entomology		
Insect pests	H	M
Agronomy	M	L
Physiology	L	H
Quality	H	H

MRT = moderate rainfall with moderate temperature
LRT = low rainfall with low temperature
L = low; M = medium, H = high; VH = very high.

In close collaboration with the physiologists and agronomists, special efforts were made to evaluate the amount of genetic variation for desirable agronomical or physiological traits available within bread wheat landraces. Cooperation also continued with other disciplines within the Cereal Program such as biotechnology and grain quality.

2.3.3. Identification and Distribution of Genetic Stocks

The breeding strategies used in our program have been published elsewhere (Ortiz Ferrara, G. and Deghais, M., 1988. Ortiz Ferrara, G., et. al., 1989). The project has identified genetic material with tolerance to various stresses which is made available to the national programs of the region for use in their own breeding programs.

Table 42 presents the number of bread wheat lines identified and distributed as crossing blocks to national programs in WANA during the last five years; the objectives are being to decentralize our breeding activities and allow national programs to take more responsibility in generating sources of genetic variability.

Table 42. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last five years.

Characteristics	1986	1987	1988	1989	1990	Total
High yield and stability:	35	36	36	36	36	179
Abiotic stress resistance:						
Terminal drought	12	25	25	27	22	111
Cold	9	7	9	18	12	55
Terminal heat	7	5	18	19	12	61
Biotic stress resistance:						
Yellow rust	16	15	11	14	16	72
Leaf rust	13	12	5	11	8	49
Stem rust	5	6	5	3	2	21
Septoria leaf blotch	12	12	20	13	8	65
Common bunt	10	7	8	9	12	46
Wheat stem sawfly	8	13	15	17	16	69
Hessian fly	-	-	-	-	3	3
Selected landraces:	-	-	-	6	18	24
Bread making quality:	8	9	7	8	9	41
Total	135	147	159	181	174	796

2.3.4. Germplasm Development

Targeting crosses is a fundamental strategy of the spring bread wheat breeding project. Table 43 presents the number and type of crosses made during the last two years, averaging about 1400 crosses each year, to cope with the various agroclimatic conditions of WANA with special attention to stresses prevalent in the low-rainfall areas.

During the last two years, 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 collected in the region which had been evaluated for two consecutive years under terminal drought, cold and disease pressure. Genetic variability was high among these landraces for several morphological or physiological traits evaluated under terminal stress conditions. Similar results were obtained by Acevedo (1989), working with durum wheats. We feel that this type of germplasm can be exploited to develop lines with higher level of stress resistance.

Segregating populations originating at CIMMYT/Mexico are also utilized. Around 600 to 800 F2's of three different types (F2 Optimal Environments, F2 Semi Arid, and F2 Spring x Winter), are received from Mexico every year, providing additional sources of genetic variability, especially for traits such as grain yield potential, disease resistance, and photoperiod insensitivity.

2.3.5. Breeding for Abiotic Stress Resistance

Terminal drought, cold, and terminal heat are the main abiotic stresses responsible for reduced yields in the rainfed, Mediterranean environments of the region. In selecting and identifying germplasm with tolerance to these stresses, multilocation testing is utilized at two different levels: (1) international multilocation testing, in which data from 50 to 75 locations in the region is obtained through the CIMMYT/ICARDA international nurseries system, and (2) regional multilocation testing, consisting of five different environments in Syria

Table 43. Number and type of crosses made for the last two years in the bread wheat crossing program.

Purpose of the cross	1989 No. of crosses	1989 % of total	1990 No. of crosses	1990 % of total
Abiotic stress tolerance		36.7		36.8
Terminal drought	192		204	
Cold	146		230	
Terminal heat	139		105	
Biotic stress resistance		35.2		36.0
Yellow rust	125		106	
Leaf rust	42		152	
Stem rust	39		30	
Septoria leaf blotch	112		120	
Common bunt	54		45	
Wheat stem sawfly	86		75	
Bread making quality	98	7.5	102	7.0
Special purpose				
Selected landraces	268	20.6	296	20.2
Total	1301	100.0	1465	100.0

and Lebanon. The latterconstitutes the hub of the screening program in which segregating populations and advanced lines are tested and selected under different moisture and temperature conditions.

The yield levels of 216 advanced bread wheat lines tested for two consecutive years in three of these environments are shown in Table 44. Both years were extremely dry at Breda (BR-less than 200 mm rainfall) a location used to screen germplasm for terminal drought resistance under low fertility conditions. Similarly, high temperatures and moisture availability were also constant in both years at the environment Tel Hadya Late Planting (TH-LP), a simulated environment used to screen for terminal heat stress during the reproductive period. For both BR and TH-LP the grain yield of the top performing line, the mean of the best ten lines and the mean yield of all the lines in the trials were substantially higher during 1990 while the mean yield of the local checks were only slightly higher than the previous year. This suggests that progress is made to improve yield under terminal drought and heat stress.

The yield levels of the 216 lines evaluated at the cold-prone environment Tel Hadya Early Planting (TH-EP), are also shown in Table 44. The yield levels, including that of the local check, were substantially reduced in 1990 over the previous year. As mentioned in the introduction, the crop, especially early maturing germplasm suffered frost damage from three days of subzero temperatures during the reproductive period. This rare event, occurring once every 50 years or less, coupled with the fact that the trials were grown under less moisture than the year before, explain the sharp drop in yield level.

In spite of frost damage, several lines were identified that had higher yields than the local and improved checks. Table 45 presents two promising lines showing a yield advantage of 5 to 12% over the local check, and of 9 to 18% over the improved check. These and other lines have been included in the crossing blocks for further use in the crossing program.

Table 44. Trends in yield levels of 216 advanced bread wheat lines over two years and three environments: Terminal drought (BR); Terminal heat (TH-LP); and cold stress (TH-EP). Advanced wheat yield trials 1989 and 1990.

	Grain yield (kg/ha)											
	Highest yielding line			Ave. of best ten lines			Ave. of all lines			Ave. local check		
Year	BR	TH-LP	TH-EP	BR	TH-LP	TH-EP	BR	TH-LP	TH-EP	BR	TH-LP	TH-EP
1989	925	1785	5575	855	1619	5375	585	1044	4243	614	1124	4256
1990	1983	2100	2166	1545	1843	2080	682	1102	1345	648	1146	1417
% of 1989	214	118	39	181	114	39	117	105	32	105	102	33

BR = Breda (< 200 mm in both years); TH-LP = Tel Hadya late planting (supplementary irrigation, 300 mm); TH-EP = Tel Hadya early planting (supplementary irrigation, 480 mm in 1989 and 350 mm in 1990).

Table 45 Top performing bread wheat lines under cold/frost stress conditions in comparison to the local and improved checks. Preliminary and advanced yield trials 1989 and 1990, Tel Hadya, Syria.

Pedigree	Grain yield (kg/ha) 1989	1990	Avg.	% L.C.	% L.C.
ALD/PVN//SERI 82 CM 83453-04AP-300AP-300L- -2AP-300L-0AP	5166	2166	3666	112	118
VEE/NKT CM 73825-08AP-300AP-1AP- -300L-1AP-300L-0AP	4850	1975	3413	105	109
Mexipak (Local check)	4691	1833	3262	100	104
Cham 4 (Improved check)	4799	1441	3120	96	100
Trial average	4515	1417	2966		
$LSD_{.05}$	786	728			
CV (%)	8	24			

Tables 46 and 47 present five promising bread wheat lines with yield advantage over the local and improved checks under terminal drought and heat stress. The top line in each table is a candidate for testing in on-farm verification yield trials in Syria. Nesser, an advanced bread wheat line used as the improved check in our drought trials and a candidate for release for the low-rainfall areas of the country, was identified through this breeding scheme.

The new candidate lines were developed following the modified bulk method of selection used for the last 8 years by the program (Ortiz Ferrara, G. and Deghais, M. 1988), suggesting an advantage for this approach.

Table 46. Grain yield of a promising bread wheat line under terminal drought conditions (< 200 mm). Preliminary and advanced yield trials 1989 and 1990, Breda, Syria.

Pedigree	Grain yield (kg/ha) 1989	1990	Avg.	% I.C.	% L.C.
VEE/GH 's' CM 77894-06AP-300AP-2AP--300L-2AP-300L-0AP	783	1983	1383	116	138
Nesser (improved check = I.C)	716	1666	1191	100	119
Mexipak (local check=L.C)	750	1250	1000	84	100
Trial mean	643	1206	924		
$LSD_{.05}$	300	876			
CV (%)	22	25			

Table 47. Performance of promising bread wheat lines under terminal heat stress and reduced moisture conditions (< 300 mm). Advanced wheat yield trials Tel Hadya late planting, 1990.

Pedigree	Grain yield (kg/ha)	% I.C.	% L.C.
FLK/HORK/6/WA 4767/391//56D.81-14.53 /3/1015.6410/4/W22/5/ANA ICW 84-0074-09AP-300L-1AP-300L-8AP-0L	2100	137	225
KVZ//CNO 67/pj 62/3/VEE ICW 84-0320-02AP-300L-2AP-300L-1AP-0L	1983	129	213
PVN/SPRW//KEA ICW 85-0665-02AP-300AP-300L-2AP-0L	1666	109	179
KEA/4/KV2/3/Cc/INIA//CNO/EL GAU//SN 64 ICW 84-0300-08AP-300L-3AP-300L-2AP-0L	1600	104	171
Debeira (Improved check=I.C)	1533	100	164
Mexipak (local check=L.C)	933	61	100
Trial mean	1270		
$LSD_{.05}$	745		
CV (%)	28		

2.3.6. Enhancing Disease Resistance

Evaluation of disease reaction is based on the use of multilocation testing, the modified bulk method of selection, artificial inoculations under close cooperation with plant pathologists. The disease resistance level in bread wheat germplasm has improved with most entries in the wheat observation nursery for moderate rainfall areas now having increased resistance to the main foliar diseases found in the region (Table 48). Further efforts are needed to raise the level of septoria tritici blotch resistance. More information is presented in the pathology section of this report.

Table 48. Levels of disease resistance in the CIMMYT/ICARDA wheat observation nursery - moderate rainfall areas (WON-MR) 1988-89.

	Rusts			Septoria leaf blotch	
Class	No. of entries			No. of entries	
ACI	YR	LR	SR	Class	ST
0-5	94	82	54	0	0
6-10	2	7	21	1	0
11-15	0	5	7	2	0
16-20	2	1	7	3	9
21-25	0	4	4	4	45
26-30	0	0	0	5	36
31-35	0	1	1	6	10
36-40	0	0	2	7	0
> 40	2	0	4	8	0
				9	0
No. of locations	1	7	4		5

ACI = Average coefficient of infection. YR, LR, SR = yellow, leaf and stem rust respectively. ST = septoria leaf blotch.

2.3.7. Evaluation of Non-conventional Material for Stress Resistance Breeding

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. Moss et. al., 1974, indicated that information to guide plant breeders in developing higher yielding varieties by selecting for specific physiological traits controlling stress resistance was not available. They recommended close cooperation between physiologists, physical scientists and plant breeders in defining stress related traits, in discovering genetic variability for these traits and in incorporating desirable traits into new varieties.

The breeding/physiological approach to abiotic stresses, including techniques followed by the project to identify easily measurable traits associated with yield under stress conditions and the amount of genetic variability available for those traits, was presented in Ortiz Ferrara et al. (1989). In that study, 11 morphological, physiological and/or

Table 49. Genetic variation among bread wheat landraces for several morphological and physiological characters evaluated under terminal drought stress (183 mm). Landraces yield trial 1989-90, Breda, Syria.

Character	Maximum	Minimum	Mean	GCV (%)
Grain yield (kg/ha)	1177	133	585	35.7
Growth habit (GH)	5	1	3.3	14.2
Seedling vigor (SV)	5	1	3.0	20.9
Leaf rolling (LR)	5	1	3.2	22.3
Days to heading	159	138	150	1.5
Days to maturity	185	167	176	0.8
Plant height (cm)	50	25	35	18.9
Frost resistance score (FRS)	5	2	4.0	12.1
Leaf temperature (°C)	37	32	34.9	3.2

n = 96. GCV = genotypic coefficient of variation. Scale for SV, LR, and FRS: 1 = low, 5 = high. GH: 1 = erect, 5 = prostrate.

phenological traits were used to evaluate 84 advanced bread wheat lines under terminal drought, terminal heat and cold stress conditions. Increased leaf rolling, longer peduncle length, increased plant height, early heading and maturity and possibly higher number of tillers/m2 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. They also concluded that the 84 lines have sufficient variability for these traits to warrant further studies for their use as selection tools.

During 1990, special efforts were made to evaluate and identify additional sources of genetic variability for stress-related traits available in bread wheat landraces collected in West Asia and North Africa. Tables 49 and 50 confirm that enough variability exists among this type of material to guarantee its exploitation and use for stress resistance breeding. As mentioned earlier in this report, about 20% of our crossing program is involved in this improvement aspect.

Table 50. Genetic variation among bread wheat landraces for several morphological and physiological characters evaluated under cold stress. Landraces yield trial 1989-90, Tel Hadya, Syria.

Character	Maximum	Minimum	Mean	GCV (%)
Grain yield (kg/ha)	3555	133	1788	29.9
Growth habit (GH)	5	1	3.1	13.2
Seedling vigor (SV)	5	1	3.5	14.0
Leaf rolling (LR)	5	1	2.9	23.7
Days to heading	194	165	177	1.2
Days to maturity	229	211	218	1.0
Plant height (cm)	90	55	69	10.4
Frost resistance (FRS)	5	1	2.9	13.9
Leaf temperature (°C)	33	19	24.6	5.2
Tillering (1 mtr)	280	49	96.2	28.1
Peduncle length (cm)	56	19	30.4	20.2

GCV = genotypic coefficient of variation. GH: 1 = erect, 5 = prostrate n = 96. Scale for SV, LR, and FRS: 1 = low, 5 = high.

Table 51 confirms that careful and selective use must be made of this type of genetic material due to high levels of yellow rust susceptibility exhibited by most accessions both in the seedling stage (plastic house) and at the adult stage under field conditions.

Table 51. Levels of yellow rust resistance/susceptibility in 76 bread wheat landraces evaluated under plastic house (seedling) and field (adult plant) conditions. Tel Hadya, Syria, 1989-90.

Disease reaction	No. of entries	
	Plastic house	Field
Resistant	1	5
Moderately resistant	2	12
Intermediate	6	2
Moderately susceptible	14	27
Susceptible	53	30

2.3.8. Breeding for High Yield and Stability

Table 52 presents four promising bread wheat lines that have performed well across 16 dry locations (200 to 350 mm) in eight different countries of WANA. Nesser, the improved bread wheat check, continued to show good adaptation and is currently under large scale testing and/or multiplication in Jordan, Syria, Algeria, and Morocco.

Gamam, a cross between an Australian (WW 33) and a Mexican (Veery 's') line, was selected, evaluated, and distributed to regional national programs through this system. Table 53 shows its performance in eight different dry locations. Gamam shows an overall mean yield advantage of 38 % over the national check, a widely grown commercial variety at each location. Its yield superiority over the national check ranged from 9 % in Rabbah, Jordan, to 108 % in Diyarbakir, Turkey. Basis earlier performance, Gamam was promoted to on-farm verification yield trials in Syria last year. It shows a substantial yield advantage over the local check Mexipak under both rainfed and irrigated conditions and a slight yield superiority over the improved check Cham 4. It also has better leaf and yellow rust resistance than Cham 4, making it more acceptable to farmers.

Table 52. Mean relative yield (*), rank and standard deviation of promising bread wheat genotypes in two geographical regions. Regional wheat yield trial - low rainfall areas (RWYT-LR), 1988/89.

Pedigree	West Asia Mean	R	SD	North Africa Mean	R	SD
Nesser (bread wheat check)	1.147	2	.147	1.156	2	.079
Gomam = WW33/Veery's' SWM 11619-2AP-4AP-1AP-2AP-0AP	1.053	5	.135	1.212	1	.085
INIA/R 14220//7C/3/YR/..... ICW80-0745-4AP-1AP-3AP-0AP	1.083	3	.167	1.090	5	.111
Sawari SWM 11133-9AP-4AP-1AP-0AP	1.153	1	.366	.867	23	.131
Mexipak (long term check)	1.035	6	.188	.920	19	.143

* Mean relative yield = entry yield divided by trial mean yield and then averaged over trials. R = rank (n = 24); SD = Standard deviation. West Asia = 10 locations in Iran, Iraq, Syria, Turkey. North Africa = 6 locations in Algeria, Libya, Morocco, Tunisia.

Table 53. Grain yield of Gomam, bread wheat advanced line, in comparison with the national checks at eight dry, (< 300 mm) locations of West Asia and North Africa. Regional wheat yield trial low-rainfall areas (RWYT-LR) 1988/89.

Country/location	Grain yield (kg/ha) Gomam	Natl. check (NC)	Site mean	% NC	LSD 0.05	CV %
West Asia:						
Jordan (Rabbah)	2908	2659	2508	109	577	17
Syria (Breda)	767	667	697	115	292	24
Turkey (Diyarbakir)	1042	500	985	208	263	19
Pakistan (Quetta)	1492	861	850	173	328	28
North Africa:						
Algeria (Tiaret)	802	725	768	111	109	10
Libya (El Marj)	1511	935	1221	162	353	21
Morocco (Sidi El Aidi)	4436	3156	3495	141	692	14
Tunisia (Siliana)	1097	700	879	157	275	23
Overall mean	1757	1275	1425	138		

Table 54 presents data on yield and yield stability of another two promising bread wheat lines across 60 locations in the region. Although they are not significantly different from the local and improved checks in terms of stability, the trend appears toward a slight yield advantage over these checks and a much better performance when compared against the national check. These two lines have already been identified by national programs in the region for further testing in farmer's fields.

Results from the regional wheat yield trial for the moderate rainfall areas of the region are shown in Table 55. The adaptation of Tsi/Vee, the top performing line in Table 54, covers a wide geographical area in the moderate rainfall and irrigated locations of the region, where diseases and insect pests are important constraints to wheat production. This line showed an overall mean yield advantage of 32 % over the national check across all locations, with a yield superiority ranging from 22% in Tabuk, Saudi Arabia, to 52% in Bahawalpur, Pakistan.

Table 54. Overall performance for grain yield and stability of promising bread wheat lines in 60 locations of West Asia and North Africa. Regional wheat yield trial - moderate rainfall areas (RWYT-MR) 1988/89.

Pedigree	Mean yield (kg/ha)	Reg. coef.	Top 5*	> NC
TSI/VEE CM 64335-3AP-3AP-1AP-2AP-0AP	3976	1.085ns	26	18
CHILERO CM66684-B-1M-6Y-1M-1Y-1M-1Y-0M	3959	1.054ns	19	13
CHAM 1 (Durum check)	3910	0.997ns	13	9
CHAM 4 (Bread wheat check)	3887	1.039ns	17	15
Mexipak (long-term check)	3884	1.005ns	16	11

* Total number of times that each entry ranks fifth or less. > NC = Number of times that the entry exceeds the national check (LSD test, P = 0.05, 1-sided test). ns = Not significantly different from 1.0 at $P < 0.05$.

Table 55. Grain yield of Tsi/Vee, promising bread wheat line, in comparison to the national checks in eight moderate-rainfall (> 350 mm) or supplementary irrigated locations of West Asia and North Africa. Regional wheat yield trial - moderate rainfall areas (RWYT-MR) 1988-89.

Country/location	Grain yield (kg/ha) Tsi/Vee	Natl. Check	Site mean	% NC	LSD 0.05	CV %
West Asia:						
Iran (Sari)	5811	4644	4992	125	692	10
Saudi Arabia (Tabuk)	7648	6271	6252	122	908	11
Pakistan (Bahawalpur)	3389	2222	2963	152	344	8
Lebanon (Zahle)	4900	3911	4204	125	827	14
North Africa:						
Morocco (Merchouch)	4333	3333	3833	130	567	11
Morocco (Fes)	2944	2111	2567	139	588	17
Egypt (Giza)	5571	3810	4958	146	-	-
Algeria (K. Miliana)	5897	4278	5295	138	967	13
Overall mean	5062	3823	4383	132		

2.3.9. Performance of Bread Wheat Germplasm in Farmers' Fields.

Tables 56 and 57 show the grain yield potential of improved vs local varieties of three cereal crops grown under farmers field conditions in two geographical areas, West Asia (Syria), and North Africa (Algeria). The combined data from both tables indicate that barley has the highest yield potential, followed by bread wheat and then durum wheat. Data from national programs indicate that there are approximately 450,000 ha of wheat grown under less than 350 mm rainfall in Syria, and approximately 200,000 ha of wheat in the dry areas in the West of Algeria (Sidi Bel Abbes). The bread wheat improved varieties shown in Tables 56 and 57 have been tested for more than three years in farmers fields in each country. They are currently under demonstration and extensive seed multiplication by respective national programs.

Table 56. Grain yield potential of three cereal crops in the low-rainfall (< 300 mm) areas of Algeria. Farmer's demonstration trials (*) 1989-90. Sidi Bel Abbes.

Crop	Cultivar	Grain yield (kg/ha) Tessala (282 mm)	Zidane (277 mm)	Mean	% LC
Bread wheat	M. Demias (LC)	1500	650	1075	100
	Zidane 89 (IC)	1660	870	1265	118
Barley	Saida (LC)	1513	610	1061	100
	Rihane 03 (IC)	1646	820	1233	116
Durum wheat	O. Zenati (LC)	1066	530	798	100
	Waha (IC)	1106	440	773	97

* Plot size = 0.5 ha. LC = local check. IC = improved check.

Table 57. Grain yield potential of three cereal crops in the low-rainfall (< 300 mm) areas of Syria. Farmer's field verification yield trials 1989/90.

Crop	Cultivar	Average grain yield (kg/ha)	% LC
Bread wheat	Mexipak (LC)	1224	100
	Nesser (IC)	1402	115
Barley	A. Aswad (LC)	1855	100
	Rihane (IC)	1833	99
Durum wheat	Haurani (LC)	1133	100
	Cham 3 (IC)	1121	99
No. of locations		9	

LC = local check; IC = improved check.

References

Acevedo, E. 1989. Cereal Improvement Program Annual Report, ICARDA, Aleppo, Syria. p. 89 - 109.

Moss, D.M., Wolley, J.T., and Stone, J.F. 1974. Plant modification for more efficient water use: the challenge. Agric. Meteorol. 14: 311 - 320.

Ortiz Ferrara, G. and Deghais, M. 1988. Modified bulk: a selection method for enhancing disease resistance and adaptation in rainfed wheat. In: Proceedings of the Seventh International Wheat Genetics Symposium, Cambridge, England. p. 1149 - 1153.

Ortiz Ferrara, G. 1988. Cereal Improvement Program Annual Report, ICARDA, Syria. p. 58 -70,.

Ortiz Ferrara, G., Yau, S.K., and Mousa, M.A. 1989. Identification of agronomic traits associated with yield under stress conditions. In: Proceedings of the International Symposium on Physiology/Breeding of Winter Cereals for stressed Mediterranean Environments. July 3-6, 1989, Montpellier, France. (In press).

G. Ortiz Ferrara

2.4. Winter and Facultative Cereal Breeding

2.4.1. Winter and Facultative (W&F) Bread Wheat Breeding

2.4.1.1. Introduction

Following the posting of a CIMMYT winter wheat breeder at ICARDA in 1989, the high elevation cereal improvement project has been divided into two projects: 1) bread wheat and 2) barley and durum wheat. This section covers only bread wheat.

Because background information for winter and facultative wheat breeding was presented in several past ICARDA Cereal Improvement annual reports and remains little changed, it is not addressed here. CIMMYT and ICARDA are continuing to study how best to combine the respective Center efforts for the most efficient use of resources in improving winter and facultative wheat germplasm for the WANA Region. A concerted effort was made in the 1989-90 season to initiate the unification by expanded germplasm and information exchange and scientific visits between the Turkey/CIMMYT program in Turkey and the CIMMYT/ICARDA project in Syria. Moderate success was achieved but one or two more seasons will be required to determine the best approaches to follow in the unified program.

2.4.1.2. Nurseries Grown in 1989-90

ICARDA Originated Germplasm: Shown in Table 58.

Tel Hadya Grown Nurseries from Turkey/CIMMYT.

W&F nurseries sent by Turkey/CIMMYT to ICARDA and planted at Tel Hadya (isolation area) include:

Crossing Block (CB), 1 set of 140 entries (1988-89 nursery).
6th International Winter Wheat Candidate Nursery (6IWWCAN), 400 entries.
Turkey Observation Nursery (TON) - 1 set of 198 entries.
Segregating Populations - 1 set of 574 entries.
5th International Winter Wheat Screening Nursery (5IWWSN) - 2 sets of 160 entries each.

Table 58. Locations and nurseries originating from ICARDA.

Gen.	Entries	Location	Size	Irr/Rf*
F_1	296	Tel Hadya	1-row, 2.5m	Irr
F_2	475	Haymana	6-row, 5m	Rf
	475	Breda	ditto	Rf
	475	Tel Hadya	ditto	Rf
	475	Sarghaya	1-short row	Rf
	159	Izmir	ditto	Irr
F_3	314	Tel Hadya	4-row, 2.5m	Irr
F_4	503	Tel Hadya	ditto	Rf
F_5	230	Tel Hadya	ditto	Rf
F_6	172 Bulk	Tel Hadya	4-row, 5m	Irr
	172 Bulk	Breda	ditto	Rf
	172 Bulk	Sarghaya	1-short row	Rf
F_6	177 S. plant	Tel Hadya	4-row, 5m	Irr
F_7	25 S. plant	Tel Hadya	ditto	Irr
WON	150	Tel Hadya	2-row, 2.5m	Irr
	150	TH Isolation	4-row, 2.5m	Irr
	150	Breda	ditto	Rf
	150	Sarghaya	1-short row	Rf
	150	International locations		
CB	258	Tel Hadya	2-row, 2.5m	Irr
	240	Breda	ditto	Rf
	240	Sarghaya	1-short row	Rf
	240	Ankara	ditto	Rf
	240	Eskisehir	ditto	Rf
PWSN	390	Tel Hadya	4-row, 10m	Irr
	280	Breda	ditto	Irr
	280	Haymana	ditto	Rf
	280	Sarghaya	1-short row	Rf
	280	Izmir	ditto	Irr
	280	Ankara	ditto	Rf
	280	Eskisehir	ditto	Rf
RWYT	24	Tel Hadya	6-row, 2.5m	Irr
	24	Breda	ditto	Rf
		International locations		
PWYT1	24	Tel Hadya	ditto	Irr
PWYT2	24	Tel Hadya	ditto	Irr

* Irr: irrigated, Rf = rainfed.

Other Introduced Material

From Oregon State University:

F_4's from F3 bulked head rows - regular - 1910 entries.

F_4's from F3 bulked rows - early material - 114 entries.

From CIMMYT/Mexico - Warm Area Environment Lines, 24 entries; From China - 12 entries.

2.4.1.3. Crossing Methodologies Followed in 1989-1990

Since CIMMYT and ICARDA have maintained separate W&F breeding programs it seemed prudent to intercross heavily among the improved winter lines from each program. Even though the respective programs have had similar breeding objectives, quite different germplasm was utilized to attain these objectives. This offered opportunity to cross "good with good" germplasm of dissimilar inheritance from the two programs. However, fewer than desired number of such crosses were made due to quarantine restrictions which delayed planting of Turkey material, preventing synchrony of heading or "nicking" of parents. Such crosses will receive attention in the 1990-91 season.

Since the top cross approach of winter x spring F_1 crossed with another winter had been strongly adopted in the Turkey/CIMMYT W&F program and to some extent in the ICARDA program to take advantage of improved traits from spring wheat breeding, a vigorous top crossing effort was undertaken this year. Advanced improved stress resistant lines from the CIMMYT/ICARDA spring wheat program were parents for crosses to both CIMMYT and ICARDA improved winter wheat lines to provide single cross F_1's for top crossing to winters next season. In this case, the spring wheats were grown alongside the Turkey/CIMMYT material under isolation and nicking was satisfactory. The Turkey/CIMMYT W&F top crossing effort has largely utilized spring wheats derived from CIMMYT/Mexico, thus the effort undertaken this season using CIMMYT/ICARDA derived springs taps yet another spring wheat gene pool. Additional top crosses were made using Turkey/CIMMYT winters onto Aleppo F_1's from varied winter x spring combinations.

The number of crosses made this year include 292 top crosses, 578 winter x winter and 140 winter x spring simple crosses for a total of 1010 different combinations. The top crosses and winter x winter simples will be field grown to produce seed for F_2's and the winter x spring simples will enter the greenhouse crossing block for top crossing in 1990-91.

From the 1989-90 Winter Wheat Crossing Block (WCB) of 283 entries, 50 were retained for a new and revised WCB of 224 entries. Incorporated were several drought tolerant selections made in 1990 along with introductions from the Turkey/CIMMYT program and other countries that grow winter wheat. Twenty-five Chinese lines were added for their apparent rapid grain fill and early maturity traits. The 20 improved stress-resistant lines from the CIMMYT/ICARDA spring wheat program mentioned above were included as well.

2.4.1.4. Breeding for Drought Tolerance

The screening technique used to breed for drought tolerance at ICARDA has involved growing the segregating generations alternatively under rainfed and supplementary irrigation conditions in successive years at Tel Hadya. Supplementary drought data are obtained from a sub-set of F_2's and advanced lines grown at the drier Breda site and from international multi-location testing of advanced lines in observation and yield nurseries. The alternate generation method has merit but in very dry years, e.g. 1989 and 1990, seed production under rainfed is reduced such that flexibility for subsequent plantings is much too restricted. Further, it reduces opportunity to select for other traits. To avoid these problems, duplicate nurseries of all segregating generations will be grown, starting with the 1990-91 season, under both rainfed and irrigated conditions at Tel Hadya. This should increase selection efficiency and not be too costly providing the program remains at its current reasonable size.

In 1990-91, all segregating nurseries from CIMMYT/ICARDA, Syria will be grown in Cumra, Turkey as a part of the Turkey/CIMMYT/ICARDA program. This will allow breeders in Turkey to know the CIMMYT/ICARDA material better.

A majority of the segregating and advanced line Turkey/CIMMYT material grown in the 1989-90 Tel Hadya isolation nurseries will be grown both under rainfed and irrigation conditions at Tel Hadya in 1990-91 to study traits not possible to evaluate last season.

Tel Hadya F_2, F_4 and F_5 rainfed nurseries, although extremely droughted, were ideal to select for genotypes to withstand drought. The drought effect was most uniform with only plants at the end of rows next to the alleyways showing border effect and approaching normality. Some might consider these conditions too severe for selection since several lines such as Bezostaya failed to head. Nevertheless, the opportunity was taken to select only the best families under these conditions. Some otherwise good genotypes may have been eliminated but the price was small to pay considering that such uniform conditions are seldom available to isolate drought tolerant genotypes. The border effect did allow some evaluation of other traits and was particularly useful for selection of individual heads.

Although ideal for evaluation, harvesting was difficult because of small brittle plants and few tillers. As a result, only head selection and bulk harvest was possible. Had the material been duplicated under irrigation, plant selections could have been made there using the drought data from the same families under rainfed.

Selection under rainfed conditions was based on drought tolerance, exemplified by plant vigor, spike exertion, general appearance and seed grade. Selection intensity was as follows:

Generation	No. Populations	No. Selected	% Selected
Rainfed			
F_2	520	105	20
F_4	503	163	32
F_5	230	73	32
Supplemental irrigation			
F_3	314	118	36
F_6	348	91	26
F_7	30	3	10
PWSN	396	55	14
INWON (intro.)	250	41	16

The 1990-91 nurseries from 1989-90 rainfed plots will include space-planted F_3's from bulk harvested F_2's and F_5 and F_6 head-rows (from F_4 and F_5) to be grown under supplementary irrigation as well as bulk plots of each respective generation under rainfed conditions. In the 1989-90 supplementary irrigated nurseries the amount of irrigation that could be applied under the extreme dry conditions was limited and some selection for drought tolerance could also be practiced but to a much lesser degree than for rainfed.

2.4.1.5. Breeding for Winter Hardiness

Winter hardiness refers to the ability of plants to withstand the rigors of winter to include low temperatures combined with dehydration from drought, wind and other ill effects. For the WANA region a multi-location evaluation program in Turkey and Iran will be required to adequately screen germplasm for winter hardiness. Good information on winter hardiness was obtained in the Ankara, Turkey area for both CIMMYT and ICARDA 1989-90 W&F nurseries. Unfortunately, not all the important nurseries of ICARDA were planted there and hopefully, such shortcomings can be avoided once the CIMMYT and ICARDA programs are fully integrated.

A component of winter hardiness in winter wheat are the vernalization genes. The literature suggests that the major vernalization genes, thought to be about four to five in number, and winter hardiness level have a high positive correlation, although not complete. To study the vernalization requirement of W&F lines distributed internationally by CIMMYT and ICARDA in 1989-90, the WON HAA and 5IWWSN nurseries were field planted in mid-July, 1990 at Tel Hadya. The first irrigation was July 23 and approximately each 10 days thereafter. By October, 4 some plots were near ripe with an estimated yield level of about 2-3 tons/ha. Percentage heading readings made on October 4 are shown in Table 59.

Interestingly, both programs have distributed a predominance of lines with heavy vernalization requirement (not headed), Turkey/CIMMYT more than ICARDA. Of note is that the 5IWWSN contains much introduced material from other winter wheat areas such as the USA and eastern Europe whereas most of the ICARDA material was developed from crosses in Syria. For the arbitrary classes of 70-90% to 1-9% headed, one could surmise that these are facultative wheats having one, two, three and four genes for vernalization,

Table 59. Percent and number of lines with various degrees of heading on October 4 from a July 23 planting date, Tel Hadya, 1990.

Percent Headed	ICARDA WON HAA (150 lines)		CIMMYT 5IWWSN (156 lines)	
	No.	%	No.	%
100	20	13.3	12	7.7
70-90	10	6.6	7	4.5
40-69	9	6.0	7	4.5
10-39	6	4.0	6	3.8
1-9	9	6.0	3	1.9
0	96	64.0	122	78.2

respectively. Lines that headed 100% could be classed as spring wheats but probably with some level of cold tolerance since they were selected under the same conditions as the winter types. However, the 1989-90 winter hardiness data from Turkey showed the fully headed lines in the 5IWWSN summer nursery to be low-temperature susceptible and had the conditions under which they were selected been as severe as 1989-90, they would probably have been eliminated due to freeze damage. This emphasizes the vagaries of selecting for winter hardiness even over several sites for several years.

The Tel Hadya winter had near normal temperatures except for an abnormally cold period March 17 which severely damaged many spring wheats. The winter and facultative wheats at Tel Hadya were much less affected.

2.4.1.6. Selecting for Rapid Grain Fill (RGF)

At anthesis, 10 spikes from each of the 160 entries in the 5IWWSN were tagged and harvested 21 days later at approximately physiological maturity. The heads were dried, threshed and 1000-kernel weight computed. The Bezostaya and Seri 82 check varieties, repeated 4 times in the nursery, varied greatly in kernel weight suggesting something was wrong. At maturity a strong wind revealed that there had been a heavy but non-uniform infestation of the wheat stem sawfly that produced the erratic results. The data were discarded as being non-usable.

2.4.1.7. Breeding for Disease Resistance

Only minimum progress was made in selection for disease resistance in the 1989-90 season at Tel Hadya. The extreme dry conditions were detrimental to stripe rust infection, even in the irrigated areas. Common bunt developed well under inoculated conditions, however only the Turkey/CIMMYT 5IWWSN nursery was evaluated.

In the 5IWWSN, common bunt infection ranged from 0 to 75% with 27 (19%) entries, excluding 17 check varieties, having 5% or below infection. Because common bunt is a major disease of the winter and facultative wheat areas, this low percentage of resistance demands intensification of common bunt resistance breeding. Thus in the 1990-91 season, more of the advanced lines coming from Turkey and Syria will be evaluated for common bunt resistance. Unfortunately, a shortage of seed precludes testing of the 7IWWCAN at Tel Hayda in 1990-91. ICARDA W&F materials reportedly have more resistance because of systematic common bunt evaluation over the years.

2.4.1.8. Should Northern Syria and Southeast Turkey Grow Winter Wheat?

The latitude and analyses of weather conditions of Syria and winter wheat varietal responses at Tel Hadya for several years would suggest that northern Syria might well be growing winter rather than spring wheat. The crop loss caused by the heavy damage from the March 17, 1990 freeze may not have occurred had the farmers been growing winter wheat. This year the winter wheats growing on the Tel Hadya station were much less affected whereas spring wheats in the same nurseries sustained heavy freeze damage.

The latitude of Aleppo is 36° N and the winter temperatures are sufficiently low to vernalize even the hardiest of winter wheat as attested by the evaluation of thousands of winter wheat lines from many parts of the world at Tel Hadya since 1980. One probable reason for winter wheat not being considered as a crop until now was the apparent lack of adapted materials. Now, after ten years of ICARDA breeding at Tel Hadya and with new winter lines available for the Turkey/CIMMYT program, the probability of winter wheat lines adapted to northern Syria and southern Turkey appears likely. Several lines grown at Tel Hadya in 1989-90 showed much promise.

A major concern about winter wheat is the question of whether they will mature early enough to escape drought and heat in the finishing stages of the crop. With the emphasis that has been placed on the "rapid grain fill" trait by both CIMMYT and ICARDA, this may be a smaller problem than suspected. Support for this hypothesis is that about 70% of the Syrian barley landraces have been found to have a winter growth habit (personal communication with Salvatore Ceccarelli). His data (Table 60) shows the yield superiority of the barley land races having a high vernalization requirement over improved barley lines that have little vernalization requirement when grown under drought stress conditions in northern Syria.

Table 60. Average score in 1988 and 1989 for vernalization requirement* and grain yield under drought** for Syrian barley landraces and for 165 barley lines unrelated to Syrian landraces (improved).

Material	No. of lines	Score Mean	Score Range	Yield under drought (kg/ha)
Syrian landraces	76	2.95	2 - 3	791
Improved	165	1.45	1 - 3	459

* 1 = normal heading, 3 = no heading in trials planted at Tel Hadya in the third week of April.
** Means of Bouider 1988 and Breda 1990.

An experiment designed to test the above hypothesis will be conducted in the 1990-91 crop season. An 8 x 8 triple lattice design of 44 winter and 20 spring wheat lines will be grown at five Syrian locations including Tel Hadya, Hasseke, Kamishly, Edlib and a mountainous location in the south. The plan for a trial at Diyarbakir, Turkey was scrapped since the Turkish scientists at that location are away for graduate training. Although largely representative of the available germplasm, the 44 winter wheat lines selected are not necessarily the best due to lack of seed supplies of others resulting from heavy demand. The 20 spring lines are considered the best stress resistant lines from the CIMMYT/ICARDA spring wheat program and are the same spring lines used heavily in winter x spring crosses for the top cross program.

Byrd C. Curtis

2.4.2. Breeding Winter and Facultative Barley and Durum Wheat

Work on barley and durum wheat for high elevation areas was focused on the development and distribution of adapted germplasm as a means of sustaining cereal production in WANA. The work was also geared to strengthen the technical competence of NARS so that suitable germplasm is developed locally.

2.4.2.1. Germplasm Development

Research efforts were increased to develop improved winter and facultative barley germplasm with adequate level of cold tolerance. To enrich and expand the narrow genetic base of ICARDA winter barley, 751 accessions were introduced from various parts of the world. These accessions, along with the existing material were evaluated for various agronomic traits at Breda (drought), Sarghaya (cold and BYDV), Ankara (cold) and Tel Hadya (diseases and other agronomic characteristics) for future use in the breeding program. The number of lines selected at various sites from exotic and locally developed germplasm are given in Table 61. Within the high elevation areas there are regions where cold tolerant, early maturing material will fit better than winter types; 338 advanced lines of spring barley were also evaluated for cold/frost resistance. Fifteen lines survived to varying degrees the severe cold at Ankara. These lines can be a valuable source for developing new cold tolerant early maturing germplasm.

Breeding Sustainable Barley Cultivars

In breeding barley for harsh environments it is essential to develop new improved cultivars that maintain the yield gains achieved through previous cultivars. The new varieties must have the following characteristics:

a) Fit into existing farming systems
b) Fit into existing cropping patterns
c) Fit the farmers economic conditions

Table 61. Evaluation of winter and facultative barley germplasm 1989/90.

Source*	Total No. of Entries	No. of entries selected at			
		Breda	Sarghaya	Ankara	Tel Hadya
OSU	75	-	-	41	62
Turkey	500	62	76	-	65
GRU	176	-	-	-	155
ICARDA	242	-	111	-	210
ICARDA-SB	338	-	45	15	-

*OSU: Oregon State University, USA. GRU: Genetic Resources Unit of ICARDA.
SB = Spring barley.

d) Maximize net profitability with minimum investment; and

e) Provide safeguard against uncertainties caused by abiotic & biotic stresses

f) and meet quality requirements.

The winter and facultative barley germplasm being developed through pedigree and bulk pedigree methods is listed in Table 62. For keeping the inflow of improved germplasm, 222 new single and top-crosses were made between local landraces from NARS and improved winter lines carrying one or more desirable traits (e.g. stress tolerance to abiotic stress, disease resistance, and better grain quality). Part of the durum wheat material tested and selected is also listed in Table 62.

Table 62. Number of winter barley and durum wheat germplasm selections made in 1990 - Tel Hadya.

Nursery	Barley		Durum wheat	
	Total	Selected	Total	Selected
Crossing Block	89	72	205	190
F_0	222	-	-	-
F_1	324	302	157	150
F_2	204	352	230	161
F_3	297	252	240	144
$F_4 - F_n$	-	-	3528	2346
Elite Lines	650	504	350	220
PSN*	600	504	420	252
PYT	48	28	48	30

*PSN : Preliminary Screening Nursery.

To rapidly generate new winter barley germplasm for cold areas, four different methods have been employed, i.e. traditional pedigree method, bulk pedigree method, haploid breeding and accelerated breeding. Out of 324 F_1 crosses of last year, 38 were provided to biotechnologists/breeders working at ICARDA and Oregon State University for doubled haploid production. Over 300 doubled haploids from those crosses will be available for further evaluation during 1990/91 crop season.

However to achieve homozygosity rapidly the generation advance was accelerated under controlled and green house conditions. In spring barley, it is possible to raise two generations every year by planting at a suitable site during summer. However, this is not feasible in winter barley because of vernalization requirement and longer life cycle. Secondly, the use of dihaploids to obtain the size of populations needed at an international center requires huge resources. Therefore an alternate procedure as outlined in Table 63 was followed to advance progenies of 90 F_1 crosses, which enabled us to raise three generations in 1989/90.

A portion of seed from these F_1s was kept for the regular pedigree approach to make a comparison of the two procedures. The 1400 single plant derived F_4 progenies will be evaluated in the field during the coming season.

2.4.2.2. Breeding for Cold Tolerance

Cold and frost cause serious damage to barley in a number of ways; such as: partial to complete killing of plants, foliar damage, partial to complete head damage, spikes sterility. There is no single precise method available to evaluate and screen cereals (barley & wheat) for cold/frost tolerance. At ICARDA we are screening the materials in the field and using the freezing test in the lab. We are also investigating new methods and tests for more reliable, and repeatable screening. The results on germplasm development for cold tolerance follow.

a) <u>Field evaluation and screening</u>

Most of the breeding material is evaluated for its cold tolerance (survival %) at cold/frost prone sites i.e. Ankara, Haymana and Konya (all in Turkey) under a collaborative arrangement with NARS in Turkey.

Table 63. Accelerated Breeding of Winter Barley during 1989/90.

Date	Generation	Procedure
August 15	F_1	Planting of 90 new crosses in Petri dishes. Imbided seeds were vernalized for 6 weeks at 1-4°C.
Sept. 1		Seedlings transplanted in greenhouse and kept at 20/10°C day/night temperature (16 hrs/ 8hrs).
Dec. 15	F_2	10-15 heads in each cross were harvested 20 days after heading and dried at 40°C for 48 hours. Two seeds from each head were taken and bulked; and sown in petri dishes for vernalization. The remaining seeds were planted in the field for progeny evaluation.
Feb. 1		The vernalized seedlings were transplanted in the greenhouse as in the previous generation.
March 17	F_3	15-20 heads from each progeny were harvested and handled like F_2 on Dec. 15.
April 5		The vernalized seedlings were transplanted in the greenhouse and handled like on Sept. 1.
July 30		Seeds from selected single plants (10-15) in each progeny were harvested for field planting and evaluation.
Oct. 25	F_4	Field sowing for evaluation of single plant progenies (1400).

Ankara (Caimara)

Three different types of Barley Observation Nurseries meant for cold low rainfall areas (BON-LRA cold), moderate rainfall areas (BON-MRA) and High Altitude Areas (BON-HAA) along with Barley Segregating Populations (F_2), Crossing Block and Barley yield Trial (BYT-HAA) were planted at Field Crops Research Center, Caimara in the last week of September, 1989. The temperature during January and February was -20°C for several days. The data on survival (%) were recorded at the end of March. The number of entries and percent survival are given for each nursery in Fig. 4. These data indicate that the Observation Nurseries for Low Rainfall Cold Areas and for Moderate Rainfall Areas and the Barley Segregating Populations were almost completely killed. The only barley nursery from ICARDA which had reasonable survival at Caimara was the Observation Nursery for High Altitude Areas. This precarious condition for cold tolerance in barley germplasm became abundantly clear with a very high level of mortality (92%) in the crossing block where only 7 lines out of 84 showed partial (1-40%) survival.

Based on this screening, the crossing block for winter barley will be restructured to include more lines possessing an adequate level of cold tolerance.

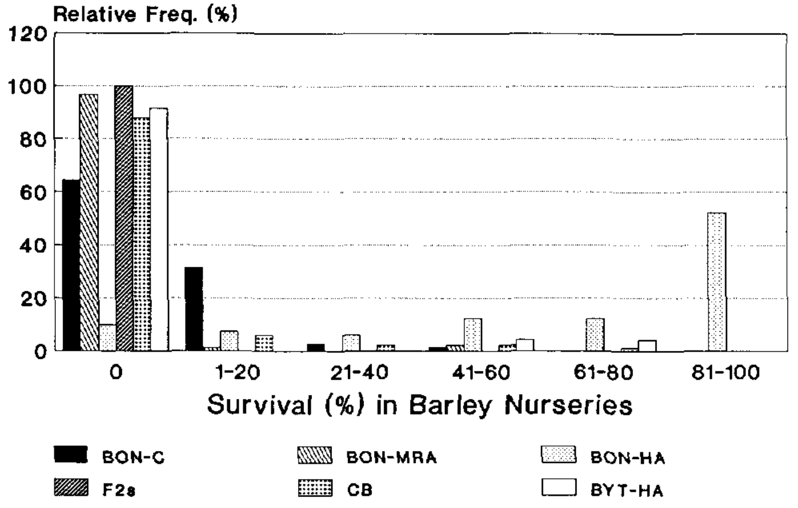


Fig. 4. Cold tolerance in barley nurseries at Ankara.

Haymana and Konya

Six nurseries, including 184 F_2s (F_2-HA), 58 F_5's (F_5-HA), 110 Barley Elite Lines (BEL), Crossing Block for High Altitudes (CB-HA) with 75 entries, Barley Observation Nursery for High Altitudes (BON-HA) with 82 lines and Barley Crossing Block (CB-B) with 84 lines were evaluated and selection made on the basis of cold/frost survival (%) at Haymana and Konya in Turkey. The relative selection frequency at these two sites is represented in Fig. 5.

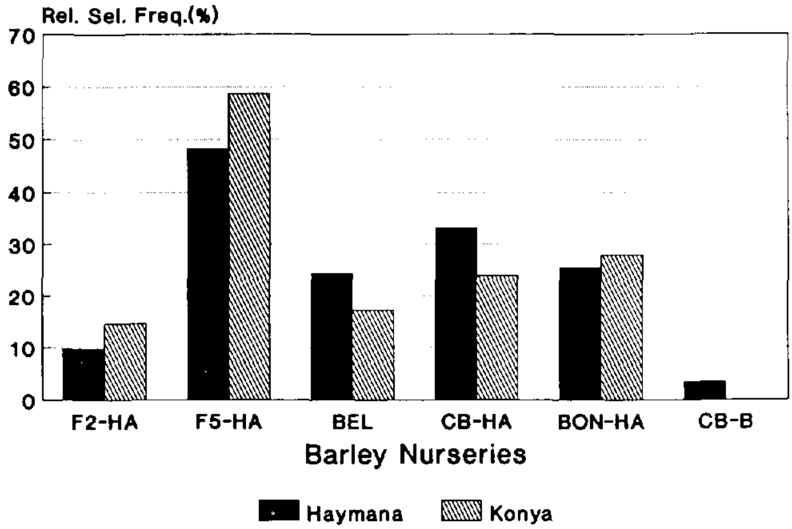


Fig. 5. Relative frequency (%) of barley lines selected for winter survival at 2 sites in Turkey.

Survival was generally above 20% except in the F_2's and the Barley Crossing Block (CB-B). The total death of all entries at Konya recorded in the CB-B may be due to : (1) the spring growth habit of all entries, the saline and water-logged soil at this site.

Cultivar Tokak (the local check) experienced a 50% damage which demonstrates the cold severity during the season. Quantification of cold and reliable screening of germplasm for cold and frost-tolerance under field conditions need to be complemented with laboratory screening for more precise evaluation.

b) <u>Laboratory Screening for Cold Tolerance</u>

The estimation of primordia development stage and its relationship to cold has been employed at ICARDA to identify cold tolerant varieties on a limited scale because it is laborious and time-consuming.

The second method which is more commonly used is crown freezing test. However there are two drawbacks to this method: a) It is applied on the seedlings only and it is difficult to measure cold tolerance after stem elongation; b) it is time consuming as the survival rate is determined by regrowth of leaf or root after exposure to low temperature, therefore evaluation of survival needs 10-15 days after freezing treatment.

Therefore an experiment was carried out to estimate freezing survival by treating barley with TTC (Triphenyl Tetrazolium Chloride) solution. In this experiment reaction of barley primordia and other parts to TTC was observed and investigated. TTC produces insoluble Triphenyl phormazan (red colour) when it is reduced in living tissue. So if the tissue is alive, it becomes red in TTC solution otherwise not.

Five barley varieties (Table 64) were sampled from the field. The intact plants were subjected to -10°C for 18 hours. Two replications of three plants each were prepared for each variety. After the freezing treatment, three main primordia from each plant were excised and immersed in the TTC solution. The colour of the primordia was checked after 24 hours using a 1-5 scale where 1 = white or pale green and 5 = dark red. Tiller number, culm length, plant height, stage and length of primordia were also observed. The killed culms remained green whereas the living ones became reddish, and the excised primordia which were not killed also turned red. Some of the primordia turned red with score 5 while others remained pale green, or became partially red. Only those culms and primordia scoring 4 or 5 were considered alive. These data showed clear genetic differences for cold tolerance level among the tested barley genotypes.

This method has the advantage of enabling to test the cold tolerance of plants at or after stem elongation, a test which is not possible with the crown freezing method.

Relationship of Guard Cell Size to Cold Tolerance

Limin and Fowler (1989) reported significant correlation between size of guard cell and LT50 (cold tolerance) but we did not find such a correlation in barley or wheat where an array of different ploidy levels of wheats and barley were tested hence the technique cannot be tested for cold tolerance work without further investigation.

2.4.2.3. Breeding for Drought Tolerance

Barley and wheat productivity is directly linked to moisture availability in the high altitude areas where moisture becomes a constraint in two different ways, i.e, a) scanty surface water due to low and variable rainfall, b) the water on the soil surface and in the soil profile may be frozen, and hence not available to the plants. The problem of moisture stress in high altitude areas therefore may be more serious than in lower elevations.

Table 64. Developmental traits and reaction to cold[1] of 5 barley cultivars.

	Cultivar				
	ICB 105959	Schuyler	ICB 107879	ICB 102907	ICB 104005
No. of tillers	6.3	14.0	7.2	15.0	11.2
Culm length (cm)	12.7	20.3	8.5	4.9	2.3
Plant height (cm)	25.3	30.9	21.9	19.6	18.3
Primordia length	7.6	7.7	3.3	2.7	2.3
Primordia stage					
Range	X->X	>X	IXm-X	IXe-IXl	IXe-X
Mode	>X	>X	X	IXl	IXm
Reaction to cold					
Score[1]	No. of plants				
1	5	8	12	15	18
2	11	1	0	0	0
3	0	2	0	0	0
4	0	4	0	0	0
5	2	3	6	3	0

[1] Reaction to cold is measured by a score quantifying the color of plant parts treated with TTC following the freezing test; score : 1 = white or pale green (very susceptible); 5 = dark red (very resistant).

Screening for drought tolerance of winter barley and winter durum wheat was carried out at Breda where the total rainfall during the crop season was 183mm with erratic distribution. In total 663 entries of winter barley and 1147 of winter durum were evaluated of which 266 (40%) barleys and 544

(47.6%) durum wheat entries were selected, on the basis of an agronomic score. The total number of entries and the selections made in various nurseries are given in Table 65. Since the moisture stress was too severe, yield was not considered in screening. The information on drought tolerance was used to advance the material at Tel Hadya. More than 50% of those selected lines were also found to be cold tolerant at Sarghaya and Turkey suggesting association of these two traits. Further studies will be carried out to confirm this association.

Table 65. Screening of winter barley and durum wheat for drought tolerance at Breda, 1989/90.

Nursery	Winter Barley		Durum wheat	
	Total	Selected	Total	Selected
Crossing Block	84	19	205	125
Observation Nursery	-	-	150	75
F_5 - WB	58	31	-	-
F_2 - Seg. Pops	204	126	230	132
DW - F_6	-	-	230	109
Prel. Screen. Nursery	245	65	140	48
DON	-	-	120	28
Preliminary Yield Trial	48	15	48	17
Regional Yield Trial	24	10	24	9

2.4.2.4. Heat Tolerance

High temperatures in the initial stages of plant development and at grain filling cause considerable damage to winter cereals. To obtain scientific evidence on the heat resistance of bread and durum wheat, a study based on the thermostability of the cell membrane, estimated as the percentage damage (electrolyte leakage) was carried out. Two hundred and four bread wheat lines, and 94 durum wheat lines/cultivars originating from different wheat growing countries of WANA were studied. The cumulative distribution of heat tolerant lines in Triticum aestivum and T. durum (Fig.

6) shows that bread wheat in general is more heat tolerant than durum wheat. The probability of having tolerant lines with less than 20% damage in the two wheat groups showed significant superiority of bread wheat over that of durum wheat. These studies indicate that bread wheat will be more successful in the heat prone areas as compared to durum wheat. This tolerance is probably due to the higher ploidy (AA BB DD) level of bread wheat. The D-genome has also been found to contribute toward drought, cold and salt tolerance. It will be interesting to study further the effect of D-genome on heat tolerance in wheat which may lead us to develop multiple stress tolerant germplasm in the future through manipulation of genes located on this genome.

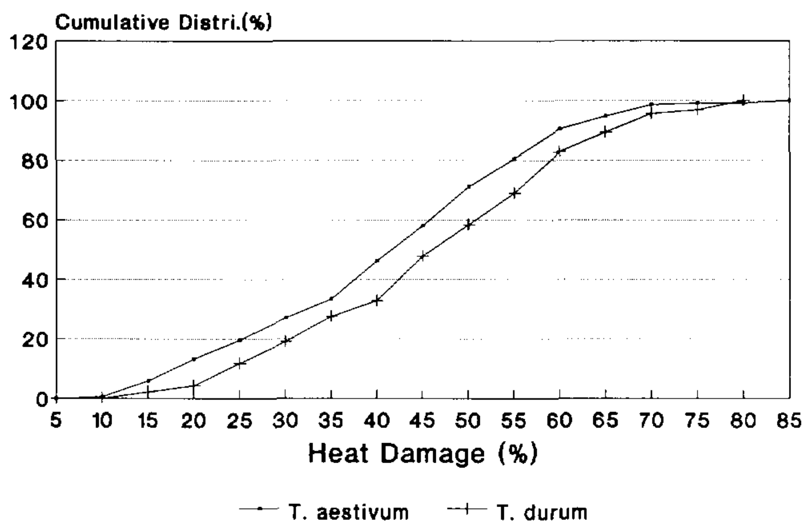


Fig. 6. Cumulative distribution of heat tolerant lines in _T. aestivum_ and _T. durum_.

2.4.2.5. Breeding for Grain Quality

The work on winter and facultative barley is still in its initial stages and we are still in the process of determining the priority areas so far as quality is concerned. However, two characters, i.e. grain protein and kernel size (1000-kernel weight) are important in feed and food barley, and are therefore recorded on the advanced material. Eighty lines/cultivars of the

Winter Barley Crossing Block (WBCB) and 242 Barley Elite Lines (BEL) were evaluated for protein content and thousand-kernel weight and results are shown in figures 7 and 8. A higher level of protein content is found in the elite lines as compared to the crossing block lines, which demonstrates the effectiveness of selection for this trait. Certain varieties grown by NARS possess low protein content. Hybridization with high protein lines would improve the feed and food quality of these varieties. Thousand kernel weight ranged between 25 and 60g with larger values more frequent among the elite lines in comparison with the WBCB lines.

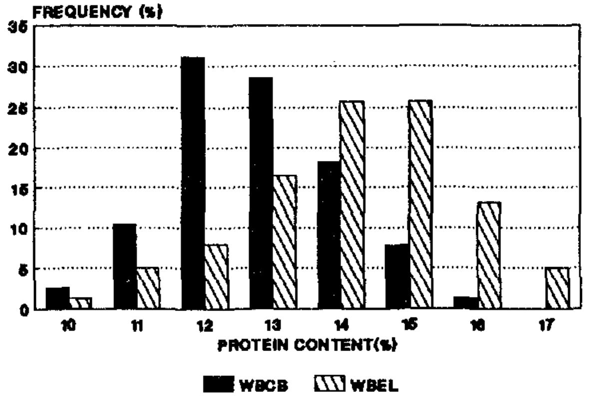


Fig. 7. Distribution of protein content in winter barley (WBCB = crossing block; WBEL = elite lines), Tel Hadya, 1989-90.

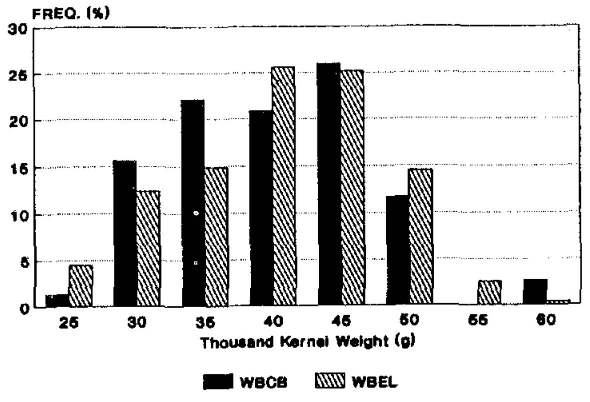


Fig. 8. Thousand kernel weight (g) in winter barley (WBCB = crossing block; WBEL = elite lines), Tel Hadya, 1989-90.

2.4.2.6. International Testing

The newly developed germplasm has to cope with the variable and diverse agroclimatic conditions in the high altitude areas of WANA and cold areas elsewhere. Segregating populations and genetically homozygous materials of winter barley and durum wheat are supplied in Observation Nurseries and Regional Yield Trials. Results from a few sites are summarized below.

Barley Observation Nursery (High Altitude)

The nursery was supplied to a large number of cooperators in the NARS, but results returned only from nine locations are summarized in Table 66. The average yield of all the lines at each location along with yield of 25th ranking entry and national check varieties show that a very large number of entries at each location outyielded the national check variety except in Ethiopia.

A critical analysis of the data revealed that in most locations the lines selected were different which not only strengthened our strategy to develop germplasm for specific adaptibility but also indicated that there is adequate genetic variability in this nursery to serve the needs of the diverse agroclimatic conditions in the region.

Durum Wheat Observation Nursery (High Altitude)

Grain yield data from nine locations are summarized in Table 67. A range in the mean yield of 325 - 5442 kg/ha across the nine locations indicates the diversity in the agroclimatic conditions. At every location, a number of entries outyielded the national check variety. At four locations (IR14, A107, GR01 & IN18) the top yielding lines had 90-250% higher yields than the national check varieties.

In India and Greece more than 25 lines outyielded the national check varieties and in the highest yielding environment of Terbol some of the lines yielded more than 9 t/ha as compared to 7.8 t/ha for the improved check variety. In the harsher conditions of Setif-Algeria and Sararoud-Iran, a very large number of lines outyielded the national check.

Table 66. Grain yield of the 25* highest yielding lines in the Barley Observation Nursery - High-Altitude, 1988-89.

Yield (kg/ha)	Location								
	IR08	IR23	LE01	AL06	AL07	GR01	UR03	KO01	ET01
Average	8528	738	6531	4222	1960	3630	3836	3582	995
Minimum	1666	33	2466	1568	233	1384	2222	937	160
25th value	10666	1066	8133	5280	2500	4461	3777	4356	860
Nat. check	12000	518	8166	3544	3000	3793	3839	3304	4360
Maximum	16666	2566	10333	7024	3900	7307	6666	6262	4360
St. dev.	2314	548	1694	1200	675	1061	815	950	841

*) Out of a total of 128.
IR08 = Zargan (Fars-Iran); IR23 = Arak-Iran; LE01 = Terbol-Lebanon; AL06 = Setif-Algeria; AL07 = Tiaret-Algeria; GR01 = Thessaloniki-Greece; UR03 = Krasnodar-USSR; KO01 = Suwon-Korea; ET01 = Holetta-Ethiopia.

Table 67. Grain yield of the 25* highest yielding lines in the Durum Wheat Observation Nursery, High-Altitude, 1988-89.

Yield (kg/ha)	Location								
	IR02	IR13	IR14	LE01	SY11	AL06	AL07	GR01	IN18
Average	3380	4801	325	5442	2792	1268	605	3106	2492
Minimum	866	3033	33	2400	1200	480	200	1846	106
25th value	4400	5500	513	6600	3333	1680	933	3692	3866
Maximum	6866	7233	993	9133	6000	2400	1333	4923	6000
Nat.check	5658	4760	393	7833	3719	2270	666	2596	3633
St. dev.	1030	812	226	1310	706	354	291	1398	-

*) Out of a total of 150.
IR02 = Karaj-Iran; IR13 = Fardbroman-Iran; IR14 = Sararoud-Iran; LE01 = Terbol-Lebanon; SY11 = Tel Hadya-Syria; AL06 = Setif-Algeria; AL07 = Tiaret-Algeria; GR01 = Thessaloniki-Greece; IN18 = Ranichauri-India.

Regional Durum Wheat Yield Trial (High Altitude)

The results on yield performance of the top five lines at five high altitude sites are summarized in Table 68.

In Afghanistan and Iran the best bread wheat cultivars were used as check varieties. These data show that the grand experimental mean in Afghanistan was more than the yield of the national check variety. Three lines, i.e. entries no. 4 (BD272/5/B. Bal ... = ICDHA82-241), no. 13 (BD1658/458(F_6) = ICDHA 82-2178) and no. 8 (Mahmoudi/Valselva = ICDHA82-2193) with mean yields of 2150, 1861, and 1851 kg/ha, respectively gave significantly higher yields than the national check cultivar Ciano's' (1342 kg/ha).

In Farubruman two lines, i.e. entry no. 17 (ICDHA81-1667 = 9045/Loogh) and entry no. 18 (ICDHA81-1829 = Ruff's'/Jo's'//Cr's'/3/Cham 1) with respective yields of 6567 and 6600 kg/ha, significantly outyielded the national check variety Yavaros (5600 kg). In Lebanon though five entries gave higher yield than the national check, this increase was nonsignificant.

However, in Turkey five entries outyielded the national check but only one entry (no. 4) did so significantly (2073 kg/ha vs 1643 kg/ha). This entry was also the highest yielding line in Afghanistan.

These results show the scope of generating germplasm adapted to the high altitude areas of WANA.

Table 68. Yield performance (kg/ha) of the top five lines of the Regional Durum yield Trial (High Altitude), 1988-89.

Country (site)	Yield			Local Check		
Mean	Expt.	Average of 5 top lines		Name	Rank	Yield
Afghanistan (Darul Aman)	1356	1800	(3*)	Ciano's'	11	1342
Iran (Farubruman)	5365	6277	(2*)	Yavaros	10	5600
Iran (Ardabil)	1014	1222	(ns)	Sabalan	1	1317
Lebanon (Terbol)	4040	4887	(ns)	Sebou	3	4856
Turkey (Haymana)	1335	1726	(1*)	Unknown	3	1643

(*) = Number of lines significantly outyielding the national check.

Reference

Limin A.E., and Fowler, D.B. 1989. The influence of cell size and chromosome dosage on cold-hardiness expression in the Triticeae. Genome 32: 667-671.

M. Tahir

3. BREEDING-RELATED RESEARCH

3.1. Physiology/Agronomy

3.1.1. Genotype Characterization in Durum Wheat

There are two main objectives of this work. First, the assessment of morphological and physiological traits of a diverse collection of durum wheat genotypes and their importance in the determination of adaptation and yield in stressed rainfed Mediterranean environments. Second the development of selection criteria for these environments. The experiment was grown for the second season at Tel Hadya which represents the moderate rainfall area, and at Breda as a dry site.

Eighty one durum wheat genotypes, representing wide genetic variability for adaptation to the environments of North Africa and West Asia, were used in the study including some landraces, and improved and advanced genotypes. These genotypes were assumed to present a high diversity in morphophysiological traits and adaptation to various agroecological zones in the WANA region. The basal and experimental treatments are summarized in Table 69. The field design was a 9x9 simple lattice with a plot size of 6 rows, 5 m long and 20 cm apart.

Table 69. Details for the durum wheat characterization experiment, 1989/1990.

Variable	Tel Hadya	Breda
Nitrogen rate (kg/ha)	40+40	20+20
P_2O_5 rate (kg/ha)	60	60
Weed Control	Brominal + (at tillering stage)	Brominal + (at tillering stage)
Fungicide	-	Bayleton
Seed rate (kg/ha)	120	120
Sowing date	5/11/1989	3/10/1989
Emergence date	27/11/1989	9/12/1989
Harvest date	3/6/1990	29/5/1990
Total rainfall (mm)	233+70*	183

* Two supplementary irrigations (70mm) were applied during the season.

The studied variables, the scale used, and the abbreviations are summarized in Table 70. Observations were limited to visually scored morphological traits, yield and yield components.

Table 70. Measurements, abbreviations and scale.

Variables	Abbreviation	Scale
1. Plant number/m^2	PNM	at 2 leaf stage
2. Ground Cover*	COV	1-10 increasing
3. Growth vigor*	VIG	1- 5 increasing
4. Cold damage*	FRO	1- 5 increasing
5. Growth habit*	GH	1= erect, 3=prostrate
6. Leaf posture*	LP	1= erect, 3=horizontal
7. Plant color*	PLC	1= light, 3=dark
8. Leaf rolling*	ROL	1-3 increasing
9. Zadok's score*	ZAD	Zadoks et al.
10. Leaf number in main shoot	LMS	along with Zadoks
11. Main tiller number	TNO	" " "
12. Days to ear emergence	DH	percentage (50%)
13. Days to physiological maturity	DPM	dry peduncle, yellow spike
14. Days to maturity	DM	days to hard grain
15. Plant height	PH	centimeter
16. Peduncle length	PL	centimeter
17. Leaf senescence**	SEN	1-5 increasing
18. Biological yield	BYM	Grams/m^2
19. Head number/m^2***	HNM	-
20. Grain yield	GYM	Grams/m^2
21. 1000 kernel weight	TKW	Grams
22. Hectoliter weight	HLW	kg/hl
23. Straw yield	STY	calculated
24. Harvest index	HI	calculated

* every 10 days
** during grain filling period
*** at harvest

The results of this experiment will be presented in terms of the effects of crop establishment, growth variables, yield components, grain and biological yield.

Table 71 shows the simple correlations of mean ground cover, and growth vigor with four different variables related to yield and yield components at different plant growth stages. The results show a highly significant correlation between ground cover and growth vigor with each variable at different growth stages at Tel Hadya and Breda. At Tel Hadya, ground cover along with growth vigor, between tillering stage (stage 20) to flowering stage (stage 60), are positively correlated with plant number/m² (PNM), heads number/m² (HNO), grain (GY), and biological yield (BYM). Such correlations reflect the importance of the continuity of early ground cover and good growth vigor for a longer period through the growth cycle (stages 22-70). On the other hand at the drier site in Breda, the most critical stage for achieving high ground cover and growth vigor is apparently early in the season (stage 20) which leads to better crop establishment, increased light interception, reduced direct soil water loss, and consequently increases WUE and yield.

Table 71. Simple correlation between mean ground cover (COV) and growth vigor (VIG) with crop establishment and yield components, 1989/90.

Variable[1)]	Tel Hadya		Breda	
	COV	VIG	COV	VIG
	(growth stage 21-22 to 60-69)		(growth stage 21-22 to 73-75)	
PNM[1)]	0.50***	0.35***	0.53***	0.46***
HNM	0.33***	0.29***	0.21**	0.19*
BYM	0.27***	0.25***	0.16*	0.14
GYM	0.22**	0.22**	0.02	0.03

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

1) PNM= plant no., HNM = head no., BYM = biological yield, GYM = grain yield.

Plant number/m² was highly correlated with ground cover (GC) at Breda (especially at early growth stages), and at Tel Hadya, and showed consistent correlations across growth stages (Table 72). Initial good ground cover and good crop vigor results mainly from increasing plant number/m² or tiller number. In fact, there are contradicting reports on which particular physiological processes are the major determinants of cereal yield and on which stage is critical in the crop growth cycle. Our results showed that a good crop establishment was critical at both sites indicating the importance of developing durum wheat genotypes with consistent and early ground cover.

Table 72. Simple correlation between plant number/m^2 (PNM) and ground cover in different growth stages.

Site	GC1 (12-13)	GC2 (21-22)	GC3 (22-23)	GC4 (23-24)	GC5 (30)	GC6 (37)
Tel Hadya	0.46***	0.59***	0.46***	0.42***	0.44***	0.18*
Breda	0.73***	0.64***	0.51***	0.44***	0.35***	0.01

* P < 0.05, *** P < 0.001
GC = ground cover at different growth stages (Zadoks scale).
PNM = plant number per m^2.

The correlations between other morphological and physiological attributes with grain and biological yields are shown in Tables 73 and 74 for Tel Hadya and Breda. Grain and biological yields under stress environments were negatively correlated with days to heading and positively correlated with number of heads/m^2, plant height, and peduncle length.

The association between heading date and grain yield at the dry site (Breda) clearly indicates the importance of earliness under dry conditions. Also, peduncle length appears to be a good predictor for performance of genotypes under moisture stress.

In the wetter site (Tel Hadya) both tillers and fertile tillers were positively correlated with both grain and biological yields while at the dry site (Breda) only fertile tillers was correlated with grain yield (r = 0.45***) and biological yield (r = 0.68***). Therefore, the ability for fertile tiller production is viewed as an important predictor of durum wheat grain yield under moisture stress conditions.

Leaf Color

Consistent with the findings of previous seasons, dark leaf color during winter at the wetter site in Tel Hadya (stage 20) and light leaf color at spring (stage 60-70) for the drier location (Breda) correlated positively with grain and biological yields (Tables 73 and 74). It is postulated that lightly colored leaves late in the season are likely to be less susceptible to photoinhibition of the photosynthetic system, have higher rates of electron transport, and

Table 73. Durum wheat physiology nursery 89/90. Simple correlations between plant and crop attributes and yield (81 genotypes). Tel Hadya (233 mm rainfall plus 70 mm irrigation).

Crop attribute (Zadoks)	Score	Mean (range)	Phenotypic standard deviation	Correlation coefficient GYM	Correlation coefficient BYM
Tiller no./plant					
(22)		1.5 (0-3)	0.67	0.30***	0.30***
(30)		3.4 (2-5)	0.53	0.1	0.04
(32)		2.7 (2-4)	0.49	0.20**	0.21**
Plant color	1-3				
(24)		1.9 (1-3)	0.64	0.25**	0.17*
(60)		2.3 (1-3)	0.64	0.13	0.12
Frost damage	1-5				
(22)		2.2 (1-3.9)	0.75	-0.14	-0.18*
(30)		1.8 (1-3.5)	0.41	-0.30***	-0.25**
(60)		1.78 (1-3)	0.40	-0.16*	-0.15*
Leaf rolling	1-3				
(12-13)		1.0 (0.5-1.5)	0.32	0.21**	0.29***
(23)		1.57 (1-2.5)	0.43	0.24**	0.27***
(32)		1.55 (1-2)	0.36	0.15	0.21**
Senescence	1-5	1.95 (1-3)	0.35	-0.24**	-0.18*
Plant height (cm)		63.9 (42-94)	9.5	0.38***	0.11
Peduncle length (cm)		26.7 (13.7-40)	5.2	0.39***	0.47***
Days to heading		141.2 (134-304)	13.5	-0.008	0.18*
Days to maturity		178.6 (173-186)	2.4	0.08	0.14
Head no./m²		151.8 (66-273.8)	37.1	0.48***	0.67***
Biological yield (g/m²)		361.0 (150-606)	89.2	0.82***	-
Straw yield (g/m²)		250.9 (109-443.8)	62.2	0.56***	0.93***
Harvest Index		0.30 (0.13-0.42)	0.06	0.70***	0.19*

n = 81, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 74. Durum wheat physiology nursery 89/90. Simple correlations between plant and crop attributes and yield (81 genotypes). Breda (183 mm rainfall).

Crop attribute (Zadoks)	Score	Mean (range)	Phenotypic standard deviation	Correlation coefficient GYM	Correlation coefficient BYM
Tiller no./plant					
(22)		1.6 (0-3)	0.73	-0.06	0.15
(30)		2.4 (2-4)	0.58	0.04	
(60)		2.7 (2-4)	0.70	-0.19*	0.21**
Plant color	1-3				
(21-22)		2.0 (1-3)	0.85	0.003	0.08
(23-24)		2.4 (2-3)	0.48	0.05	0.13
(69-70)		2.4 (2-3)	0.49	-0.19*	-0.16*
Frost damage	1-5				
(22)		0.94 (0-2.5)	0.65	-0.22**	-0.26**
(30)		1.2 (1-2)	0.29	-0.23**	-0.09
(60-70)		1.5 (1-3.5)	0.50	-0.40***	-0.10
Leaf rolling	1-3				
(12)		1.1 (0.5-2)	0.45	-0.03	0.11
(31)		1.5 (1-2.5)	0.38	0.15	0.11
(69-70)		1.9 (1.5-2.5)	0.34	-0.18*	-0.04
Senescence	1-5	3.7 (2-5)	0.54	-0.0	-0.03
Plant height (cm)		38.9 (22-63)	7.5	0.61***	0.67***
Peduncle length (cm)		11.1 (5.5-19.7)	3.1	0.61***	0.52***
Days to heading		131 (123-159)	4.5	-0.42***	-0.18*
Days to maturity		163 (159-169)	2.0	-0.12	0.02
Head no./m^2		111 (12.5-230)	34.5	0.45***	0.68***
Biological yield (g/m^2)		175.2 (56-462)	64.3	0.66***	-
Straw yield (g/m^2)		146.2 (34-338)	52.8	0.40***	0.95***
Harvest Index		0.16 (0-0.45)	0.09	0.77***	0.11

n = 81, * P < 0.05, ** P < 0.01, *** P < 0.001

possibly higher water use efficiency and yield enhancement. More details on the relation between leaf color and genotype performance can be found in previous cereal program annual reports (1987, p. 125, and 1988, p. 94).

Leaf Rolling

Leaf rolling (assessed as the number of leaf turns), early in the season positively correlated with grain yield (r = 0.21**), and biological yield (r = 0.29***) at Tel Hadya. While it was positively correlated only with plant number/m^2 (r = 0.22**), and heads number/m^2 (r = 0.20**) at Breda. The fact that genotypes showing this trait without experiencing much drougth stress at Tel Hadya, suggests that this trait may be constitutive in wheat. In the less stressed environment (e.g. Tel Hadya, 1989/90) leaf rolling might play a more pronounced role in yield maintenance. However, under the severely stressed environment of Breda, such avoidance mechanism had less effect on yield maintenance and other physiological processes would have contributed more to the observed yield variations among genotypes.

Frost Damage

In Mediterranean environments, frost can happen at any time during the growing season. The results show that frost damage during early stages (stage 22), as well as at flowering time (stage 60) were very important at the dry site (Breda). Early frost greatly affected early season ground cover making it very difficult for the plants to recover completely, given the subsequent suboptimal environmental conditions that prevailed. At flowering time florets are more susceptible to frost damage. For both cases of frost damage grain yield was negatively affected. At Tel Hadya late frost (stage 50-60) seemed to have had more pronounced effects on yield than early frost. This may be the result of the more favorable environment enabling plants to recover more fully and to sustain greater damage. These results reemphasize the importance of frost resistance in cereal genotypes for Mediterranean environments.

Plant Height

The range of plant height attained at Breda was 22-63 cm while at Tel Hadya it was 42-94 cm; the correlations between plant height and grain yield were positive for both Breda and Tel Hadya. However, the association seemed stronger at the drier site ($r = 0.61^{***}$ vs $r = 0.38^{***}$). For biological yield, the association was significant at Breda only ($r = 0.67^{***}$). Such positive correlation at the drier site may be related to the fact that genotypes with taller stature have a better total growth potential and resource utilization under drought, and have a higher amount of reserves which could be retranslocated to the grains at the time of filling when current photosynthetic production is very limited in the drier site.

Genotype Ranking

Tables 75, 76, 77, and 78 show the top and bottom five genotypes in grain or biological yield along with data for water use efficiency (WUE) and other growth parameters for the wet and dry sites. WUE was estimated in terms of grain and biological yield produced per unit of rainfall received ($gr/m^2/mm$). Although not precisely measured, WUE decreased with the reduction of available moisture. In addition, values for grain yield, harvest index, days to heading and days to physiological maturity were higher at the wetter site. The top five and bottom five genotypes for yield were statistically different for all parameters at both locations. The top five genotypes at Breda were different from those showing high grain yield at the more optimal environment in Tel Hadya, suggesting a high genotype by environment interaction. These results are not surprising considering the wide range of genetic variability in the genotypes under study. The high coefficients of variation at both locations, especially at the drier site, was due to the distribution of rainfall at Breda and to the late frost damage that occurred during the reproductive period. In spite of this, the data suggest that WUE could be used as a selection criterion to identify genotypes with good performance under reduced moisture conditions.

Table 75. Top and bottom five genotypes in grain yield, with associated water use efficiency (gr/m²/mm), and other growth parameters. (Breda 1989/1990).

	WUE	GYM	HI	DH	DPM	DM
Top 5 genotypes						
Romanou 2	0.333	61.02	0.30	128	158	163
Cham 1	0.330	60.48	0.25	126	155	161
Haurani Nawawi	0.313	57.20	0.18	130	155	162
M15	0.303	55.39	0.31	128	154	161
Local Iraklion	0.289	52.92	0.24	129	159	164
Bottom 5 genotypes						
Soorsonera	0.040	7.39	0.07	136	160	164
Baladia Hamrra (A)	0.052	9.45	0.04	139	161	166
Ethiopia IC 8373	0.056	10.33	0.05	139	161	166
N. Dakota 86	0.058	10.58	0.08	138	161	166
Belikh 2	0.058	10.61	0.09	134	159	165
C.V.	71.3	71.4	50.1	2.2	0.8	0.7
LSD:	0.23	41.28	0.16	5.8	2.5	2.3
G. mean:	0.16	29.1	0.16	130.8	157.9	163.4

WUE: rainfall use efficiency calculated from total rainfall/GYM.
LSD: for WUE at 0.05 = 0.226

Only two genotypes (Cham 1 and Haurani Nawawi) appear among the top five for both grain and biological yield at the drier site. This may be partially explained by the fact that the increase in WUE for biological yield is associated with an increase of yield when the harvest index is relatively stable. Cham 1 and Haurani Nawawi both had relatively stable HI when compared with their HI at the wetter site in Tel Hadya (0.27 and 0.28 respectively compared with 0.25 and 0.18). In contrast, at the wetter environment of Tel Hadya, four out of five genotypes (Daki, Marjawi, Hamari Ahmar, and Belikh 2) appear among the top yielders both in biological and grain yields. During the previous season Cham 1, Haurani, Belikh2, and Daki were among the five best performing genotypes under the dry Mediterranean environment.

In summary, most attributes identified in the previous season as selection criteria for durum wheat under Mediterranean environments proved important for the second season. These traits include, tall stature, long peduncle, early heading, resistance to frost, high number of fertile spikes, and high straw yield.

Table 76. Top and bottom five genotypes in biological yield, with associated water use efficiency (gr/m^2/mm), and other growth parameters. (Breda 1989/1990).

	WUE	BYM	HI	DH	DPM	DM
Top 5 genotypes						
Hedba 3	1.598	292.5	0.09	133	161	167
Sicilia Lutri	1.399	255.9	0.06	137	159	165
Mavragani-iraklion	1.387	253.9	0.09	127	153	161
Haurani Nawawi	1.346	246.3	0.18	130	155	162
Cham 1	1.305	238.8	0.25	126	155	161
Bottom 5 genotypes						
Chahba 88	0.507	92.8	0.23	130	158	163
Karasu	0.513	93.8	0.15	136	161	166
Bicre	0.592	108.4	0.14	134	160	165
M21	0.598	109.3	0.23	126	157	163
M3	0.598	109.3	0.25	130	158	163
CV	35.9	35.9	50.1	2.2	0.81	0.7
LSD	0.68	125.3	0.16	5.8	2.54	2.3
G. mean	0.96	175.2	0.16	130.8	157.9	163.4

RUE: calculated from total rainfall / BYM
BYM: biolobical yield (gr/m^2)
Rainfall: 183 mm, n = 81.

Table 77. Top and bottom five genotypes in grain yield, with associated water use efficiency (gr/m^2 / mm), and other growth parameters. (Tel Hadya 1989/1990).

	WUE	GYM	HI	DH	DPM	DM
Top 5 genotypes						
Daki	0.631	191.19	0.42	139	170	177
Moundros	0.549	166.48	0.38	138	171	179
Hamari Ahmar	0.516	156.43	0.31	137	171	180
Marjawi	0.492	148.95	0.30	137	169	177
Belikh 2	0.476	144.22	0.29	142	172	178
Bottom 5 genotypes						
Cannizzara	0.148	44.85	0.17	143	172	179
Scorsonera	0.178	53.90	0.18	148	175	180
Sabil 1	0.223	67.71	0.26	148	175	181
Jordan	0.233	70.52	0.24	137	168	177
M 1084	0.246	74.51	0.29	144	175	182
CV	30.0	30.0	13.9	8.8	1.2	1.06
LSD	0.22	65.37	0.08	24.7	4.2	3.8
G. mean	0.36	109.53	0.30	141	172	179

WUE: water use efficiency calculated from total rainfall/GYM.

Table 78. Top and bottom five genotypes in biological yield, with associated water use efficiency (gr/m²/mm), and other growth parameters. (Tel Hadya 1989/1990).

	WUE	BYM	HI	DH	DPM	DM
Top 5 genotypes						
Wakooma	1.663	503.83	0.23	148	173	180
Marjawi	1.618	490.38	0.30	137	169	177
Hamari Ahmar	1.595	483.16	0.31	137	171	180
Belikh 2	1.581	478.92	0.29	142	172	178
Daki	1.513	458.29	0.42	139	170	177
Bottom 5 genotypes						
Sabil 1	0.804	243.64	0.26	148	175	181
M1024	0.842	255.21	0.29	144	175	182
M21	0.847	256.73	0.29	149	173	179
M3	0.867	262.63	0.32	140	171	178
Cannizzara	0.915	277.31	0.17	143	172	179
CV	21.5	21.5	13.9	8.8	1.2	1.06
LSD	0.51	154	0.08	24.7	4.2	8.8
G. mean	1.19	360.9	0.30	141	172	179

WUE: water use efficiency calculated from total rainfall / BYM. Total precipitation = 233 mm + 70 mm irrigation.
LSD: small value for WUE at 0.05 = 0.509, n = 81.

E. Acevedo and I. Naji

3.1.2. Physiology-Breeding in Barley

3.1.2.1. Influence of Plant Architecture upon Yield

In the 1988-89 annual report it was concluded that for high grain yield in the cold and/or dry environments of Northern Syria earliness *per se* is not sufficient, but that it must be combined with a long vegetative period of the apex and a short ear initiation period. This type of apical development, controlled by both a vernalization requirement and a strong photoperiodic reaction, is associated with a prostrate winter growth habit, an initially dark green plant color changing to pale green around the middle of February, and a high level of frost resistance.

The relation between plant architecture and yield was studied in a nursery of 36 two-row barley entries including local landraces, locally selected entries and improved varieties. To simplify the analysis, plant architecture was reduced to one variable, being the first principal component (PC1) of a principal component analysis (PCA). Field observations used for this PCA were growth habit, plant color (expressed as the difference between winter and spring color) and frost damage, scored in the 1987/88 season at Tel Hadya, Breda and Bouider. As input for the PCA a weighed mean across the three locations for each of the three observations was used.

The first principal component explained 78% of the total variation present in the three variables (traits) and was highly correlated ($P < 0.001$) with each of them. Therefore, PC1 was assumed to be representative for all three traits and thus for plant architecture.

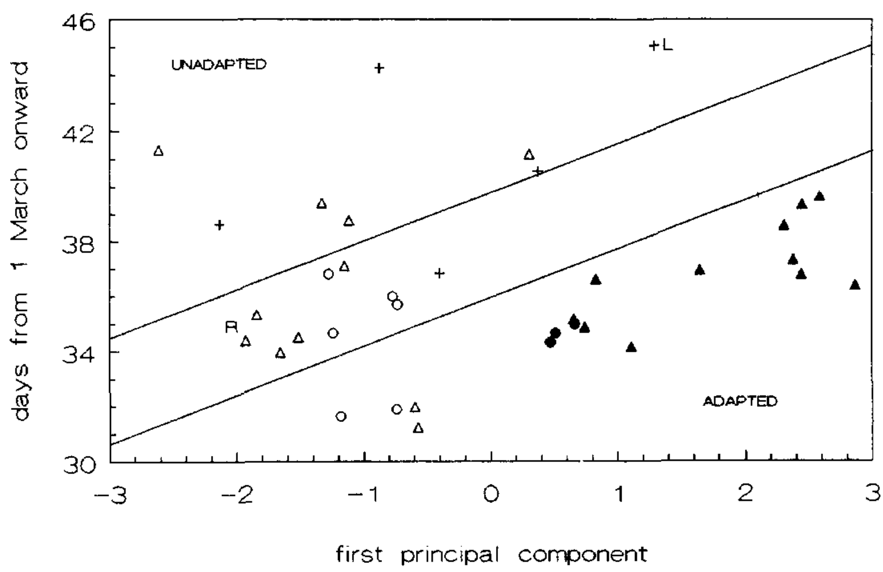


Fig. 9. Scatter diagram of the first principal component PC1 of growth habit plant color and frost damage against heading date, expressed as days from 1 March to heading and averaged over nine environments. A high value for PC1 indicates a prostrate growth habit combined with a clear change in plant color and frost resistance.
Plus sign= barley improved varieties, open triangles = locally selected lines, open circles = WI-entries, closed triangles = Syrian landraces, closed circles = Jordanian landraces.
L=Lignee-131, R=Roho.

Table 79. Proportion of variation in grain yield explained by earliness and plant architecture across nine environments in Northern Syria.

	Environment								
	TH6	TH8	BO8	TH7	BR7	BR6	BO6	TH9	BO9
DH	20.2**	0.4	16.3*	39.9**	56.0**	33.8**	41.8**	44.4**	23.0**
PC1	1.2[a)]	12.1*	8.3	1.3	12.4**	13.0**	1.5	21.8**	27.9**
Grain yield (g/m^2)	331	296	273	246	148	134	133	89	7

DH = days from 1 March to heading (average of nine environments).
PC1 = first principal component representing growth habit, plant color and frost damage.
TH6 = Tel Hadya 1985/86; BO8 = Bouider 1987/88; BR7=Breda 1986/87; etc.
*, ** = significant at 5% and 1% respectively.
a) small value due to a significant negative correlation between grain yield and PC1.

That a landrace type of architecture does not necessarily imply lateness is shown in Figure 9; the correlation between PC1 and heading date was only r=0.17. and non-significant at 5%. Because earliness is known to be strongly correlated with yield, the influence of plant architecture per se upon yield was analysed after removing the effect of heading date by a stepwise regression analysis. The results, presented in Table 79, show that earliness is related to grain yield across the whole range of environments while plant architecture has an additional effect only in the low yielding environments.

The above results suggest that adaptation under dry conditions in northern Syria depend upon two strategies. First, avoidance of terminal stress by earliness which is represented by the four early entries in the left corner of the lower triangle of Figure 9. Earliness can result in good yields in normal dry years, but often subjects plants to damage by late frosts. The second strategy, based on an adaptation to local temperature, photoperiod and irradiation regimes, is pursued by the landraces in the lower triangle of Figure 9. The six landraces with a high value for PC1, referred to as prostrate landraces, represent the latter strategy most clearly. Strategy 2 may not necessarily lead to yields higher than strategy 1, but may improve yield stability, especially under harsher conditions. Entries not following one of these strategies and are late or have a non-landrace type of plant architecture, i.e. the eight entries in the upper triangle of Figure 9, are unadapted to the dry environemnts of northern Syria.

3.1.2.2. Yield Stability

Yield stability has been measured as the slope of the linear regression of entry mean yield per environment on environmental mean yield. Since the genotype x environment interaction for grain yield is multiplicative rather than additive, data were log-10 transformed prior to analysis.

Figure 2 shows the relation between the regression coefficient and the transformed mean yield per entry across environments. The eight environments included were the same as those mentioned in Table 79 with the exception of B09, not included because the low yield of that environment may have a disproportional influence upon the regression slope. In Figure 10, four distinct response patterns can be distinguished:

(1) A high regression coefficient in combination with a low average yield, typical for entries not adapted to dry conditions. In Figure 9 entries showing this pattern were in general situated in the upper triangle.

(2) A medium regression coefficient in combination with a moderate to high mean grain yield. This pattern, indicating a medium yield across the whole range of environments, was represented by entries scattered between the two triangles of Figure 9.

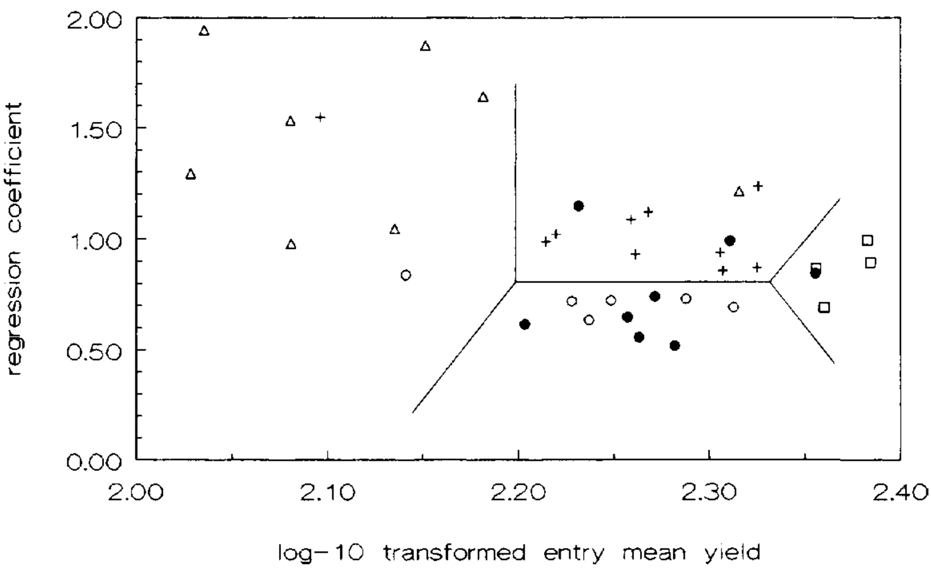


Figure 10. Regression coefficient of the linear regression of entry mean yield per environment on environmental mean yield vs. log-10 transformed entry mean yield (g/m^2) across eight environments in northern Syria.

open triangles	=	unadapted entries (8 entries in upper triangle in Figure 9).
open circle	=	prostrate landraces (6 entries in the upper corner of the lower triangle in Figure 9).
closed circle	=	other landraces (8 entries in the middle of the lower triangle in Figure 9).
open squares	=	early entries (4 entries in the left corner of the lower triangle in Figure 9).
plus symbols	=	entries without a specific adaption (10 entries between the two triangles in Figure 9).

(3) A low regression coefficient combined with moderate to high mean grain yields indicating special adaption to the drier environments. Local landraces, found in the upper corner of the lower triangle in Figure 9, mainly showed this type of response pattern.

(4) A medium regression coefficient combined with a high mean grain yield, characteristic of good performance in all the environments tested. The four early entries in Figure 9 had this wide range adaptation.

The above results suggest that entries identified in Figure 9 as being adapted to dry conditions indeed show two types of adaption mechanisms, either by earliness or by plant architecture. Table 80 shows that early entries have a yield advantage over the prostrate entries across the whole range of environments. However, the relative yield advantage of the latter group under drier conditions as compared to wetter conditions is clear. Under wet conditions the unadapted late entries performed better than the prostrate ones.

Table 80. Difference in grain yield between groups of entries across a range of environments (referred to in Table 79). To compare the individual environments, for each of them, grain yields have been standardized to a mean of zero and a standard deviation of one. Values presented are means of three successive environments after ranking for mean grain yield. Details about groups of entries are given in section 3.1.2.1. Parentheses show numbers of entries in each group.

	Contrast*		
Environments	early(4) vs prostrate(6)	early(4) vs unadapted(8)	prostrate(6) vs unadapted(8)
TH6, TH8, BO8	1.64	1.30	-0.34
TH8, BO8, TH7	1.39	1.33	-0.06
BO8, TH7, BR7	1.30	1.76	0.67
TH7, BR7, BR6	0.92	1.96	1.26
BR7, BR6, BO6	0.98	2.06	1.29
BR6, BO6, TH9	0.78	2.17	1.39
BO6, TH9, BO9	0.41	2.05	1.64

* A positive value indicates that the first group has the highest yield.

The hypothesis, put forward in the previous section, that prostrate landraces are more stable than the early entries, especially under very harsh conditions, is illustrated in Table 81. Across three dry sites, ranging in average grain yield from 133 to 148 g/m^2, prostrate landraces have a higher standard deviation than early entries. After addition of the two lower-yielding environments however, the standard deviation of these landraces becomes smaller than that of the other groups.

Similarities between the results of this and the previous section suggest that earliness and plant architecture together can give a reasonable prediction of the expected grain yield response across a range of environments in northern Syria. Traits included in Figure 9 can easily and quickly be scored in the field and are correlated to yield under dry conditions. In addition, if they possess a high heritability (i.e. stable expression across environments) they can be appropriate indirect selection criteria in breeding.

Table 81. Mean standard deviations of grain yield for three groups of entries across sets of dry environments. To adjust for differences in yield level, log-10 transformed data have been used. Data in parantheses are relative values.

Group[1]	Number of dry environments		
	3[a]	4[b]	5[c]
Early	0.0402 (35)	0.0669 (63)	0.5738 (119)
Prostrate	0.1151 (100)	0.1068 (100)	0.4807 (100)
Unadapted	0.0947 (82)	0.2078 (195)	0.9443 (196)

1) Details about the groups are given in section 3.1.2.1.
a) BR6, BR7, BO6, b) TH9 added, c) BO9 added.

3.1.2.3. Selection for Morphological Traits

In order to investigate the above hypothesis, experiments were initiated to study selection effects of plant architecture variations upon yield under drought. Each experiment contains F_2-bulked progenies of a cross between two parents differing widely in the traits mentioned before. This year, emphasis was put upon two crosses: Lignee-131/Roho (F_3) and WI-2291/Roho//Tadmor (F_4), both planted at Tel Hadya in four experiments following an 8x8 modified augmented design. The primary aim of this year's experiments was an assessment of the variation available in each cross and the selection of groups of lines with contrasting morphology or phenology. Results from the cross Lignee-131/Roho are illustrated.

Figure 11 shows frequency distributions of the F_2 derived F_3 lines for traits measured in 1989/90. For most traits the parents showed a contrasting expression (see also Figure 9). Although the curves were similar to a normal distribution, they showed significant deviations from normality, perhaps due to slight differences among the four experiments. The clearest deviation from normality appeared for winter frost damage, where the distribution was significantly ($P < 0.001$) skewed to the right for all four experiments, indicating some dominance of frost resistance over frost susceptibility. Skewness is absent in the distribution of growth habit implying that resistance to early frost is not necessarily associated with prostrate growth habit. The relative good growth vigor of the progeny might be a result of the better early vigor of Roho (in absence of frost) combined with the better frost resistance of Lignee-131. Heading date also had a skewed distribution, being significant at ($P < 0.001$) in three out of four experiments. Almonst all of the progenies were earlier than Lignee-131. The relative late heading of Roho was caused by severe frost damage which also accounted for its short plant stature.

One prerequisite of using morphological traits as indirect selection criteria in a breeding program is high heritability. Table 82 shows that early (January) frost damage, plant color, growth habit and heading date have the highest heritabilities (broad sense) which are exactly the four traits making up the model presented in Figure 9. The low plant height values for in the first two experiments is due to some field heterogeneity. The high heritabilities for grain yield are remarkable. The smaller plot size in experiment 4 increased the environmental variance of growth habit and heading date, resulting in lower heritabilities. It can therefore be concluded that unless the plot size is very small, the heritability of the traits mentioned in section 3.1.2.1 is not a limiting factor for their usefulness in breeding work.

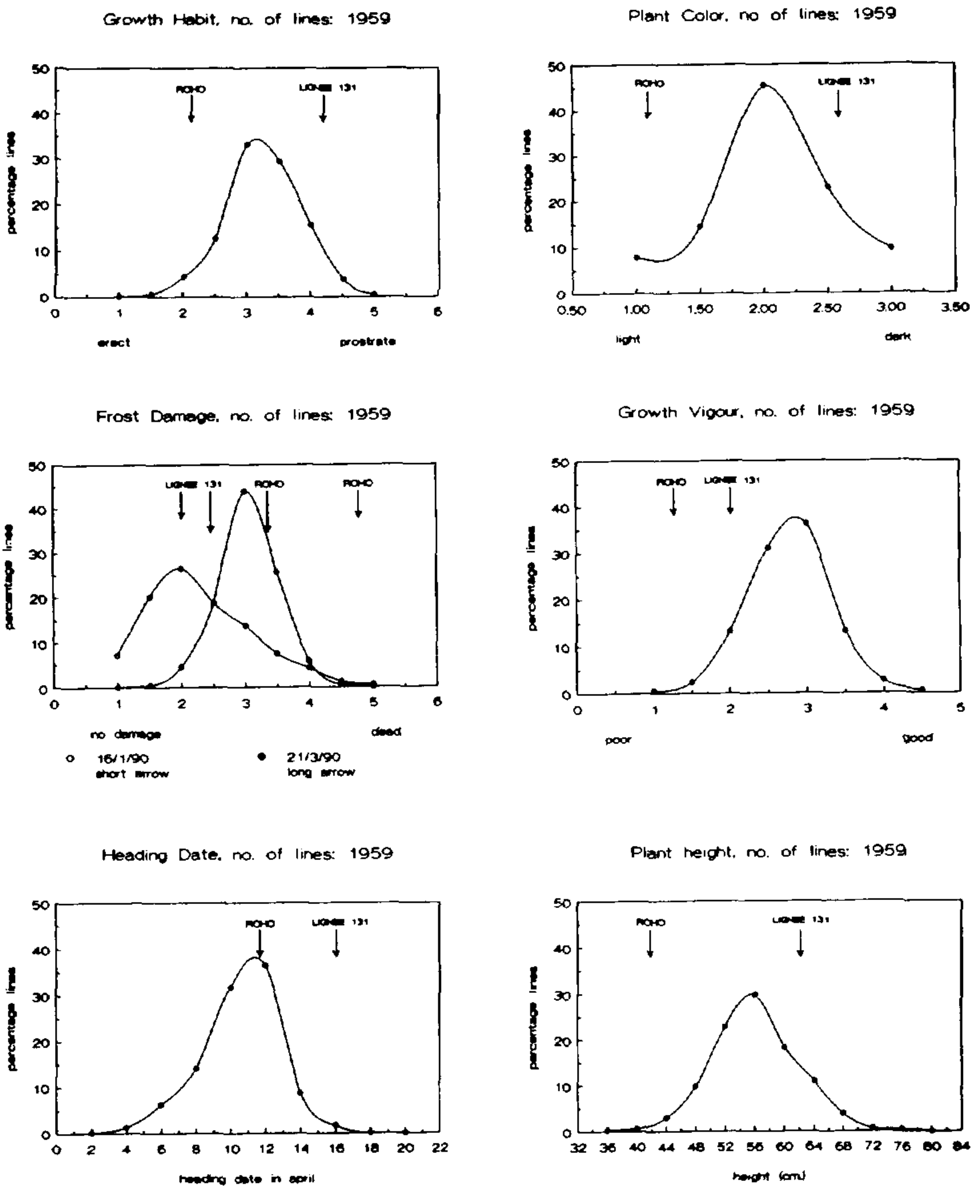


Figure 11. Frequency distribution for the traits measured on the F_2-bulked progenies of the cross Lignee-131/Roho.

The effect of selection based on plant architecture on plant response to late frost, heading date, plant height and grain yield was assessed using the 10 lines with the highest or lowest PC1-values in each experiment, where PC1 represented growth habit, winter plant color and winter frost damage. Table 83 shows that although the differences between the two groups are not always significant, they are consistent across sets. Of significance is that the lines with a high value for PC1, the "landrace types", have a lower score for late frost damage which supports the hypothesis put forth in section

Table 82. Broad-sense heritabilities of traits measured in four individual experiments. Values are based on unadjusted observations for the progeny. Environmental variance is estimated as the mean of the variance of the eight checks included in each design.

Trait	Experiment 1[a]	2[a]	3[a]	4[b]
Frost damage (Jan)	0.84	0.85	0.85	0.74
Plant color	0.72	0.61	0.69	0.56
Growth habit	0.70	0.73	0.64	0.41
Growth vigour	0.49	0.44	0.48	0.35
Frost damage (March)	0.35	0.46	0.25	0.43
Days to heading	0.75	0.74	0.64	0.36
Plant height	0.36	0.47	0.68	0.33
Grain yield	0.63	0.70	0.60	0.69

a) plot size 0.6 x 1 m^2
b) plot size 0.3 x 1 m^2

3.1.2.1 that this type of plant architecture is less susceptible to harsh environments. Differences in heading date are small confirming the low association between PC1 and heading date noted previously. The small plot size and the three 40 mm irrigations given to the plots around the beginning of March, and the beginning and middle of April, may explain the relatively high yield levels. Nevertheless, lines with a high PC1 yielded consistently higher than those with a low PC1.

Table 83. Mean performance in each of 4 experiments of the ten lines with the highest and lowest value for the first principal component based upon growth habit, plant color and early frost damage.

Trait	group	Experiment 1[a]	2[a]	3[a]	4[b]
Late frost damage[1]	high PC1	2.5	2.8	2.6	2.8
	low PC1	3.4	3.3	3.4	3.4
	difference	-0.9**	-0.5*	-0.8**	-0.6*
Heading date[2]	high PC1	11.0	10.1	10.9	10.2
	low PC1	12.3	11.1	11.7	11.8
	difference	- 1.3	- 1.0	- 0.8	- 1.6*
Plant height (cm)	high PC1	60.0	61.1	55.9	55.2
	low PC1	55.7	55.5	50.5	54.2
	difference	4.3	5.6	5.4	1.0
Grain yield (g/plot)	high PC1	491	459	376	185
	low PC1	363	314	285	145
	difference	128*	145**	91**	40

1) scored on 21 March after cold spell; scale 1-5 (1 = no damage, 5 = dead)
2) 1 April = day 1; a) plot size $0.6 \times 1 m^2$; b) plot size $0.3 \times 1 m^2$
*, ** significant at 5% and 1% respectively.

Next season, lines selected for contrasting plant architecture and heading date will be studied in more detail at Tel Hadya and Breda. Variability in expression of the individual traits is available in the Lignee-131/Roho cross and the preliminary results presented here support the hypothesis that selection for plant architecture is beneficial and that, in combination with heading date, it might be a suitable criterion for indirect yield selection in early generations.

E. van Oosterom and E. Acevedo

3.1.3. Agronomy

In continuation of last season's experiment (Annual Report, 1989) three selected durum wheat genotypes with similar phenological development and varying in coleoptile length, namely Om Rabi 14 (long coleoptile), Korifla (medium) and Sebou (short), as determined in a germination chamber, were planted at 10, 20 and 40 cm row spacings at 3, 7 and 10 cm sowing depths and at three planting dates (early, medium and late). The experimental design was a 3^4 factorial with a single replication (blocks of 9 units with 4 factor interactions confounded) with 81 plots. The experiment was repeated at Tel Hadya, ICARDA's main station in northern Syria (36°N, 37° E, 300 m elevation with a long term average annual rainfall of 332 mm) and Breda (35°55'N, 37° 10'E, 350 m elevation with a long term average annual rainfall of 278 mm). Prior to planting the soil was fertilized with 40 kg of nitrogen/ha and 60 kg of P_2O_5/ha at Tel Hadya and 20 kg/ha of nitrogen and 60 kg of P_2O_5 at Breda in the form of ammonium sulfate and triple superphosphate. Additional nitrogen was applied at mid tillering at both sites, 40 kg/ha at Tel Hadya and 20 kg/ha at Breda. The preplanting fertilizers were broadcast and incorporated into the soil with the last harrowing operation. Seed rate was 120 kg/ha. The plot size was 1.2 m wide and 2.5 m long, and consisted of 12, 6 and 3 rows according to the row spacing treatment. The planting and emergence dates for Tel Hadya and Breda are presented in Table 84.

The following traits were measured: plant number/m^2 (PNM) at Zadoks stage 11-12, ground cover (GC4) at ten days interval, plant vigor (VIG), plant height (PH), peduncle length (PL), head number/m^2 (HNM), tiller number/m^2 (TNM), biological yield (BYM), grain yield (GYM), head weight (HW), number of days to heading (DH), days to physiological maturity (DPM) and, days to maturity (DM). Straw weight (STY) and harvest index at harvest were calculated. Total rainfall during the growing season was 233 mm at Tel Hadya plus two sprinkler irrigations (35 mm each) one at tillering stage (Zadocks 22) and the other at the flag leaf stage (Zadocks 37) and 183 mm at Breda.

Table 84. Planting and emergence date at Tel Hadya (TH) and Breda (BR).

Planting treatment	Sowing date		Emergence date	
	TH	BR	TH	BR
Early	15/10/89	17/10/89	23/11/89	10/12/89
Medium	22/11/89	20/11/89	11/12/89	10/12/89
Late	20/12/89	27/12/89	07/01/90	28/01/90

The results of this experiment are primarily presented in terms of main effects for crop establishment, growth and yield attributes at each site.

Crop establishment, assessed in terms of plant number per unit area and ground cover at late tillering (Table 85) indicated that longer coleoptile had a significant positive effect ($P < 0.05$) on the number of plants per m^2 (PNM) at Tel Hadya but had no effect on any of the traits at the drier site of Breda. The genotype (Sebou) with the shorter coleoptile had the higher number of emerged plants at Tel Hadya. Early planting and narrow row spacing significantly favored stand establishment at both sites. Sowing depth had no effect and early sowing increased the number of plants per m^2 at Tel Hadya and Breda. Narrowing row spacing and early planting had a significant effect ($P < 0.01$) on ground cover at both sites, the best spacing being 10 cm.

Table 85. Effect of variety, row spacing, planting date and depth on crop establishment and ground cover.

Factor	Variable: Tel Hadya		Breda	
	PNO (pl/m²)	GC4 (1-10)	PNO (pl/m²)	GC4 (1-10)
<u>Variety</u>				
Om Rabi 14 (L)	186 b*	4.0 a	108 a	4.3 a
Sebou (S)	207 a	3.9 a	109 a	3.9 a
Korifla (M)	189 b	3.9 a	110 a	4.1 a
<u>Row Spacing</u>				
10 cm	209 a**	5.0 a**	229 a**	5.2 a**
20 cm	192 b	3.9 b	217 a	4.4 b
40 cm	181 b	2.9 c	192 b	2.8 c
<u>Planting date</u>				
Early	206 a**	5.1a**	199 b**	5.0 b**
Medium	216 a	4.1 b	226 a	5.7 a
Late	160 b	2.6 c	68 c	1.7 c
<u>Sowing depth</u>				
3 cm	188 a	3.9 a	114 a	4.1 a
7 cm	201 a	4.0 a	105 a	4.1 a
10 cm	193 a	3.9 a	107 a	4.2 a

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

Visual observations were used to assess ground cover GC4 using a scale 0-10, where 0 indicates no plants and 10 means 100% ground cover.

These results indicate that crop establishment for durum wheat is favored by short coleoptile varieties, early planting, and with narrow spacing (10 cm) at Tel Hadya. Close row spacing (10 cm) and early planting will in general improve ground cover by the crop and hence increase the transpiration component of evapotranspiration. In general deep sowing shows no advantages for crop establishment even at the drier site.

Table 86 shows the main effect of the treatments on biological and grain yields at Tel Hadya and Breda during the last two seasons (1988/1989 and 1989/1990). The results indicate a consistent positive effect ($P < 0.01$) of early planting except for biological yield at Tel Hadya in 1989/1990. This is the result of a better performance of the crop through the season as judged by the effects of early planting on crop establishment and ground cover (Table 85) and on growth attributes (data not shown). Sowing depth had no effect on grain yield at either site. Close row spacing had a highly significant effect on biological yield and grain yield at both sites, with the narrowest row spacing giving the highest yields.

Varieties affected biological yield at the drier site during the 1989/90 season where OmRabi 14 (long coleoptile) outyielded the other varieties.

Table 86. Effect of varieties, row spacing, planting date and sowing depth on yield (t/ha), at Tel Hadya (TH) and Breda (BR) in 1988/1989 and 1989/1990.

Factor	1988/1989				1989/1990			
	TH		BR		TH		BR	
	BYM	GYM	BYM	GYM	BYM	GYM	BYM	GYM
Variety:								
Om Rabi14(L)	4.8b**	1.6a	1.6a	0.4a	4.9a	1.5a	2.3a**	0.4a
Sebou (S)	5.3a	1.9a	1.7a	0.4a	4.9a	1.7a	2.1b	0.4a
Korifla (M)	5.1ab	1.7a	1.8a	0.5a	4.7a	1.6a	2.0b	0.4a
Row spacing:								
10 cm	5.7a**	2.5a**	2.1a**	0.6a**	5.3a**	1.8a*	2.5a**	0.4a**
20 cm	5.0b	2.3a	1.6b	0.4b	4.9a	1.5b	2.1b	0.5a
40 cm	4.6c	2.0b	1.4b	0.3b	4.3b	1.5b	1.8c	0.3b
Planting date								
Early	6.7a**	2.4a**	3.9a**	0.7a**	4.6	1.6b**	2.2b**	0.5a**
Medium	4.3b	1.5b	1.9b	0.5b	4.6	1.8a	2.4a	0.4a
Late	4.4b	1.3b	0.3c	0.0c	5.0	1.5b	1.9c	0.3b

n = 81, * $p < 0.05$, ** $p < 0.01$.

Conclusions

From the two year results, the following conclusions can be drawn:

1. Sowing between October 15 and November 15 is recommended for maximum grain yield. During this period adequate precipitation occurs which enables good seed germination and better plant establishment. Delaying the sowing date up to mid December will reduce grain yield significantly by up to 60% at Breda (dry site), and up to 17% at Tel Hadya.
2. Reduced row spacing improves early ground cover which in turn is related to fertile tillers and yield. The effect of row spacing was highly significant for grain yield and biological yield at both sites. It is clear that 10-20 cm spacing is preferable to 40 cm.

3. Sowing depth (3-10 cm) did not have an effect on any of the growth attributes measured at Tel Hadya and Breda. However deep (7-10 cm) sowing with early planting tend to be a good agronomic practice in the dry areas and these advantages tend to disappear in high rainfall areas.

E. Acevedo and I. Naji

3.2. Pathology

3.2.1. Wheat Pathology

3.2.1.1. Development of Germplasm Pools for Sources of Resistance

In the process of enhancing germplasm with resistance to the major wheat diseases in the WANA region, the Cereal Improvement Program has developed several germplasm pools with sources of resistance to these diseases. These pools include bread and durum wheat lines with sources of resistance to yellow rust, septoria tritici blotch, and common bunt and combined resistance to common bunt and yellow rust. Two hundred and ten sets of these pools were distributed to NARS and other collaborators for testing during 1988/89, 1989/90 and 1990/91. Some of these pools were evaluated under central Californian conditions (USA) and were exposed to different pathotypes of yellow rust and septoria tritici blotch. A good number of lines in these pools maintained their resistance to both diseases there and work on these pools will continue to identify resistance sources/genes in each pool. Seed of these pools is preserved at the Genetic Resources Unit of the Center.

New germplasm pools will be made available by the coming season, 1991/92 and will include lines with resistance to yellow rust, leaf rust, stem rust and and common bunt.

3.2.1.2. Screening for Resistance to the Major Wheat Diseases

Data on the multilocation testing of the KIDN-89 were completed in Dec. 1989. Usefull information on the Durum Wheat KIDN were received from 1 location for each of yellow rust (Puccinia striiformis) and common bunt (Tilletia foetida and T. caries), from five locations for each of leaf rust (P. recondita) and septoria tritici blotch (Mycosphaerella graminicola), and from 3 locations for each of stem rust (P. graminis) and barley yellow dwarf virus. The number of lines with resistance to one or more of these diseases are shown in Table 87.

Table 87. Number of durum wheat lines* found resistant** to one or more major diseases. KLDN-89.

Disease	No. of resistant lines
Yellow rust	165
Leaf rust	20
Stem rust	72
Septoria blotch	74
Barley yellow dwarf	166
Common bunt	30
Septoria and barley yellow dwarf	59
Yellow rust and common bunt	24
Three rusts	16

* Total number tested 216, checks excluded.
** Selection criteria: yellow rust CI = 1, leaf and stem rust ACI = 10; septoria blotch and barley yellow dwarf average 0-5 on a 0-9 scale; common bunt 0-3% head infection.

There were 165, 20, 72, 74, 166, and 30 lines with resistance to yellow rust, leaf rust, stem rust, septoria blotch, barley yellow dwarf, and common bunt respectively. Out of this multilocation screening, 16 lines were resistant to all three rusts, 59 to septoria blotch and barley yellow dwarf combined and 24 to yellow rust and common bunt (Table 87). Six of these lines also showed combined resistance to the three rusts, septoria blotch and barley yellow dwarf virus and their performance for common bunt (% head infection) was acceptable (Table 88).

Table 88. Name and performance* of six durum wheat lines for major diseases in multilocation testing, KLDN-89.

		Disease					
Ent no	Name/Cross	Yellow rust	Leaf rust	Stem rust	Septoria blotch	Barley dwarf	Common bunt(%)
42	Mrb16/3/Ato//Ibis/Fg	0.8	7.8	8.3	4.6	5.0	5
46	Ru/Mrb15	0.0	2.5	3.5	4.5	5.0	21
59	Chahba88/Mrb11	0.8	2.6	7.5	5.0	4.7	28
68	Mrb16/Guerou 1	0.8	2.0	0.9	4.0	5.0	13
86	Guerou 1	0.4	9.5	8.5	4.8	4.7	11
147	Jo/Cr//Gs/AA/3/FG/4/ USA IIIC/Gs//Cr/Cit/3 3/D67.2	0.0	8.6	4.1	4.2	5.0	20

* Selection criteria: yellow rust CI = 1, leaf and stem rust ACI = 10; septoria blotch and barley yellow dwarf: average= 0-5 on a 0-9 scale.

Usefull information on the Bread Wheat KIDN-89 were received from 1 location for each of yellow rust and common bunt, 2 for each of stem rust and barley yellow dwarf, 3 for leaf rust, and 5 for septoria blotch. The number of lines with single or multiple resistance to these diseases are shown in Table 89. There were 162, 73, 90, 63, 1, and 19 lines resistant to yellow rust, leaf rust, stem rust, septoria blotch, barley yellow dwarf and common bunt respectively. Fourty four of these lines were resistant to the three rusts, 1 to septoria blotch and barley yellow dwarf and 16 to yellow rust and common bunt.

Table 89. Number of bread wheat lines* found resistant** to one or more major wheat diseases, KIDN-89.

Disease	No. of resistant lines
Yellow rust	162
Leaf rust	73
Stem rust	90
Septoria blotch	63
Barley yellow dwarf	1
Common bunt	19
Three rusts	44
Septoria and barley yellow dwarf	1
Yellow rust and common bunt	16

* Total number tested 180, checks excluded.
** Selection criteria: yellow rust CI = 1, leaf and stem rust ACI = 10; septoria blotch and barley yellow dwarf: average 0-5 on a 0-9 scale; common bunt 0-3% head infection.

3.2.1.3. Crop Loss Assessment

The Cereal Program has completed the third year of crop loss trials to assess the actual losses due to yellow rust and septoria tritici blotch. Trials on yellow rust were conducted at the principal station, T.Hadya/Aleppo, whereas trials on septoria blotch were conducted at the Center's sub-station in Lattakia. The cultivars used were those under verification from the Collaborative Research and Training Program with the Syrian NARS. These cultivars are usually promosing lines or candidates for release.

There were two treatments , chemical treatment, with Bayfidan EC 250 (500ml/ha) to prevent or suppress yellow rust and septoria development and the second treatment left unprotected for best development of the disease after artificial infection. The trials are planted in a split plot arrangement with three replicates.

In the 1989/90 season there were 15 cultivars, comprising 10 durums and 5 bread wheats (Tables 90 and 91). The season was characterized by

Table 90. Effect of yellow rust (Puccinia striiformis) on grain yield and yield components of different durum wheat cultivars (Tel Hadya, Syria 1990).

Cultivar	Treatment	Yellow rust Score/	ACI	Yield kg/ha	No.tillers per m	No.seeds per spike	1000KW (g)
Gezira 17	infected	3R-MR	1.0	1613.2	74	33	33.5
	controlled	3R	0.6	2093.8	82	31	33.6
Haurani 27	infected	25M-MS	19.7	2165.6	79	18	36.0
	controlled	2MR	0.9	1693.4	71	19	33.2
Cham 1	infected	2R-M	0.7	2021.4	78	25	28.8
	controlled	2R-MR	0.5	1675.7	77	25	28.2
Cham 3	infected	22M-S	18.3	2073.1	87	24	39.8
	controlled	1R-M	0.5	2367.1	76	26	36.6
Sabil 1	infected	4R-MR	1.1	1646.2	83	22	37.3
	controlled	3R-MR	0.7	1553.4	84	24	35.0
Brachoua	infected	1MR-MS	0.6	1875.0	77	23	33.4
	controlled	3R	0.6	1580.4	77	27	31.6
Om Rabi 5	infected	10M-MS	6.3	2134.5	92	24	32.6
	controlled	1MR-M	0.5	2393.0	88	36	35.6
Om Rabi 17	infected	2MR-MS	1.6	2065.7	82	25	31.6
	controlled	1R-MR	0.3	1824.6	86	23	29.6
Douma SH-149	infected	4R-M	1.2	2409.5	67	31	34.0
	controlled	5R	1.0	2297.7	83	31	33.1
Douma H-300	infected	12MS-S	10.7	1674.2	61	22	44.2
	controlled	3R-MS	1.1	1508.5	54	22	41.0

drought, severe frost and high temperature in May and the crop was much affected by these unusual environmental conditions. Results obtained from these trials may not represent the actual loss due to the disease and should be repeated next season. Obvious reduction in the yellow rust score was observed on the durum wheat cultivar with relatively high score of infection, i.e., Haurani and Cham 3 (Table 90). However, significant differences between treatments for the same cultivar were found in Haurani, Cham 3, Om Rabi 5, and Douma H-300. No significant differences were found between treatments for the same cultivar in grain yield or yield components. For bread wheat (Table 91) significant differences of yellow rust score were found between treatments within the same cultivar for all bread wheat cultivars except Douma 9457. No significant differences in yield or yield components were found between treatments for the same cultivar.

Table 91. Effect of yellow rust (Puccinia striiformis) on grain yield and yield components of different bread wheat cultivars (Tel Hadya, Syria 1990).

Cultivar	Treatment	Yellow rust Score/	ACI	Yield kg/ha	No.tillers per m	No.seeds per spike	1000KW (g)
Mexipak 65	infected	53S	53.3	1429.9	78	27	27.4
	controlled	6MR-S	5.3	1651.5	82	24	28.8
Cham 4	infected	40S	40	1882.5	102	28	26.0
	controlled	1MR-MS	0.6	2059.5	94	23	28.2
Douma 8815	infected	32MS	25.3	1680.0	69	30	27.5
	controlled	2R-M	0.5	1681.6	68	28	27.8
Bohouth 4	infected	18MS-S	16.7	1940.2	75	29	30.4
	controlled	3R-M	0.7	1863.2	84	23	30.3
Douma 9457	infected	5R	1.0	1699.0	88	21	24.9
	controlled	3R-M	0.7	1606.3	104	29	24.2

Tables 92 and 93 show the results obtained on losses due to septoria tritici blotch. The infected plots in all durum cultivars (Table 92) showed high score (7-8) for vertical disease development, (first digit of the score), and the fungicide treatment suppressed completely the disease development. Disease severity, (second digit) was also affected by the chemical treatment. No significant differences were found between treatments for the same cultivar for grain yield and yield components. In the bread wheat group (Table 93), Cham 4 and Bohouth 4 scored low in the infected treatment both for vertical disease development and severity. On the other hand, in the fungicide-treated plots, the disease was completely suppressed. However, no significant differences between treatments for the same cultivar were found for grain yield and yield components.

Table 92. Effect of septoria tritici blotch (Mycosphaerella graminicola) on grain yield and yield components of different durum wheat cultivars (Lattakia, Syria 1990).

Cultivar	Treatment	Septoria score	Yield kg/ha	No.tillers /m	No. seeds /spike	1000KW (g)
Gezira 17	Infected	8/5	5204.1	86	51	46.6
	controlled	3/1	6258.1	95	44	45.6
Haurani 27	Infected	8/5	4818.7	109	34	48.2
	Controlled	1/1	4632.9	103	35	52.7
Cham 1	Infected	8/3	5960.8	112	43	47.0
	Controlled	0/0	7006.3	121	43	47.2
Cham 3	Infected	8/4	6284.6	111	39	54.0
	Controlled	1/1	6738.1	110	33	55.0
Sabil 1	Infected	8/4	5916.9	97	38	56.0
	Controlled	0/0	5408.6	112	33	54.6
Brachoua	Infected	8/3	5404.8	111	41	51.1
	Controlled	0/0	6665.9	117	43	51.2
Om Rabi 5	Infected	7/2	6262.9	122	49	49.8
	Controlled	0/0	5941.2	114	43	48.6
Om Rabi 17	Infected	8/3	6605.2	118	53	46.2
	Controlled	0/0	6273.2	108	46	46.7
Douma SH-149	Infected	8/4	6170.6	103	50	48.1
	Controlled	0/0	5222.2	106	50	49.5
Douma-H-300	Infected	8/5	5641.2	83	44	60.0
	Controlled	0/0	6712.9	90	45	61.1

Table 93. Effect of septoria tritici blotch (*Mycosphaerella graminicola*) on grain yield and yield components of different bread wheat cultivars (Lattakia, Syria 1990).

Cultivar	Treatment	Septoria score	Yield kg/ha	No.tillers /m	No. seeds /spike	1000 KW (g)
Mexipak	Infected	8/7	7002.0	128	55	39.3
	controlled	0/0	6120.0	102	51	40.4
Cham 4	Infected	5/2	6181.2	163	39	40.6
	Controlled	0/0	7010.6	166	39	39.9
Douma 8815	Infected	8/8	5541.3	122	42	39.9
	Controlled	1/1	6736.4	113	47	42.7
Bohouth 4	Infected	5/2	6170.0	125	40	44.4
	Controlled	0/0	7125.1	123	41	44.2
Douma 9457	Infected	8/5	5013.6	133	42	37.5
	Controlled	0/0	6562.4	137	40	37.4

Omar F. Mamluk

3.2.2. Barley Pathology

3.2.2.1. Introduction

So far the most economical way of controlling cereal diseases in developing countries is to incorporate disease resistance. Testing barley germplasm for disease resistance has been and remains the most important activity of the barley pathology project. Most testing is conducted in the field, at Tel Hadya or at a substation near the Syrian coast. The advantages of field testing are that the performance of the germplasm can be judged over the whole growing season and interactions of environmental conditions, plant growth habit and plant age with disease resistance may be observed. The main disadvantages are that only indigenous strains of the pathogens can be used and that the success of the testing depends to a large extend on the climate during the season. At the base program, field screening for resistance is done for scald and powdery mildew, the most important leaf diseases in WANA, and for barley leaf stripe and covered smut, the most prominent seed-borne diseases. In the past season, the early planted screening nurseries for scald and powdery mildew were affected by frost in March 1990, making later readings unreliable. Through the recent acquisition by the project of greenhouses and growth chambers, some screening under controlled conditions will be feasible, while also pursuing investigations on the genetic basis of resistance becomes possible.

To select for broad-based disease resistance, we rely on a network of collaborators in and outside the WANA region. As the results of our International Screening Nurseries have been discussed in previous Annual Reports, only special collaborative projects will be highlighted in this report.

New barley pathology projects are undertaken that aim at better understanding the importance of diseases in low-input barley cultivation. An example of this new research thrust is the work on dry-land root rot. Although symptoms of this disease can be observed on barley throughout Syria, no loss estimates have yet been made. Research on this disease was initiated in collaboration with Montana State University and we plan to extensively survey Syrian barley growing areas this season in collaboration with the University of Aleppo.

ICARDA is situated within the center of origin of barley, which makes it an ideal location to conduct studies on diversity in resistance within host plant and variance of virulence within pathogen populations. In this report, some data are presented from studies on resistance of local landraces and wild barley populations. Other data are presented of a small project on the evaluation of fungicides for control of seed-borne diseases.

3.2.2.2. Cooperation with Other Institutes

International centers have extensively used their international nursery systems to expose germplasm to different diseases and to wide ranges in virulence of specific pathogens. Multi-location field testing is very useful to identify material with high levels of resistance, especially if the nurseries are planted in locations where severe disease epidemics occur every season. However, to identify resistance genes the germplasm has to be tested against strains with known virulences.

Results of two collaborative projects in barley pathology will be highlighted in this report, one relating to field screening at a testing site with a high disease pressure, and the other to an in-depth analysis of disease resistance.

Screening for Resistance to Scald in Ethiopia

Barley is a traditional crop of the Ethiopian highlands where it is grown across a wide range of environments. Temperature and rainfall during crop growth are favorable for the development of most barley diseases. Differences in altitude cause planting and harvesting dates to differ considerably among sites, even within a relatively short distance. The lack of a sufficiently long crop-free period (in some regions two barley crops per year are grown) results in an abundance of inoculum for most pathogens and pests. This combined with a favorable climate, results in frequent epidemics. However, the continuous selection pressure of numerous pests and diseases has resulted in local germplasm with high variability for many characteristics and high disease resistance. The Ethiopian Institute for Agricultural Research has started an extensive testing program of its local germplasm in collaboration with ICARDA, aimed at using superior lines as sources for disease and stress tolerance.

The importance of Ethiopia as a source for disease resistant germplasm and as a testing site for disease resistance is illustrated in Table 94.

Table 94. Performance of selected Ethiopian germplasm lines for scald at Holetta, Ethiopia and Tel Hadya, Syria, 1990.

		Holetta* Date and score			Tel Hadya*
No	PI-number	25/8	14/9	28/9	percent infection
1	PI 385629	42	74	73	-
2	PI 382368	52	85	85	0.5
3	PI 386731	42	41	41	2.5
4	PI 386770	31	64	85	0
5	PI 382523	75	86	87	-
6	PI 382946	42	52	82	-
7	PI 383069	63	86	86	1.0
8	PI 383181	53	53	85	5.0
9	PI 386771	31	42	82	3.0
10	PI 386825	31	74	86	-
11	PI 386880	86	87	88	3.0
12	PI 386908	31	63	83	-
13	PI 386966	42	52	84	3.0
14	PI 387096	63	85	99	4.0
15	PI 387117	42	84	86	2.0
16	PI 382375	74	86	88	0

* Notes in Ethiopia (data from Mr Yitbarek Semeane) taken in 'double digit' score (first digit indicates vertical spread of disease, second the percentage leaf area affected, <10%=1, 10-20%=2 etc.), at Tel Hadya notes are taken as percentage leaf area affected.

The sixteen lines in Table 94 are Ethiopian accessions from the USDA world germplasm collection, reported to possess a very high level of resistance to scald (Rhynchosporium secalis) in the field (Webster, 1980) and in seedling tests (Starling, 1980). Both researchers used the most virulent USA strains of this pathogen. Seed of these lines was requested from the USDA germplasm bank, increased at Tel Hadya and field-tested by Mr. Yitbarek Semeane of IAR at Holetta, Ethiopia, one year later. The same lines were tested against Syrian isolates at Tel Hadya. While the lines were nearly immune to scald in Syria, only one (PI 386731) kept its resistance in Ethiopia. These results demonstrate the high virulence of the Ethiopian scald population, and the importance of testing germplasm for disease resistance in the area of origin.

Through the evaluation of new accessions of Ethiopian germplasm a number of lines have been identified with high levels of scald resistance. These lines are likely to maintain their resistance to less virulent pathogen strains in other countries. This testing program is therefore important to Ethiopia and to other breeding programs dealing with scald resistance.

Identification of Specific Mildew Resistance in Riso, Denmark

The Risø National Laboratory in Denmark maintains a large collection of mildew strains with known virulence genes through which the resistance of barley can be analyzed. In 1990 Dr. J. H. Jørgensen tested a collection of local Syrian and Jordanian barleys against 21 strains of Erysiphe graminis, previously selected for powdery mildew resistance in field tests at Tel Hadya. The barley collection consisted of 29 lines, originating from 8 sites in Syria and Jordan.

Diverse resistance genes were found (Table 95), especially in the Jordanian material. However, mildew resistance was also identified in material originating from sites with little or no disease pressure such as Qasr El Heir. No specific resistance genes were present in lines from the wetter site Sheikh Ali, even though these lines showed incomplete resistance during field testing in Syria. Lines with superior resistance will be used in barley breeding projects for Syria and for areas with similar climatic conditions.

Table 95. Variability in resistance genes for <u>Erysiphe graminis</u> within and among collection sites for Syrian and Jordanian barleys (data from J.H. Jørgensen).

Site	number of lines with identified resistance genes
Madaba (Jordan	1 line : Ml-a6 (Pallas-03) + additional resistance 2 lines: Ml-k (Pallas-24) + additional resistance
Qatrana (Jordan)	1 lines: resistant to all isolates (Ml-p?) 2 lines: susceptible to all isolates
Jerash (Jordan)	1 line : resistant to all isolates (Ml-p?) 1 line : Ml-a6 (Pallas-03) + additional resistance 1 line : Ml-k (Pallas-16)
Madaba (Jordan)	1 line : resistant to all isolates (Ml-p?) 1 line : unidentifiable resistance 1 line : susceptible to all isolates
Um Zeitoun (south Syria)	7 lines: Ml-a6 (Pallas-03) + additional resistance 1 line : unidentifiable resistance
Sayaa (south Syria)	3 lines: Ml-a6 (Pallas-03) + additional resistance
Sheikh Ali (west Syria)	3 lines: susceptible to all isolates
Qasr el Heir (central Syria)	2 lines: Ml-k (Pallas-24) 1 line : susceptible to all isolates

3.2.2.3. Root Rot Testing

Research on dryland root rot within the barley pathology project was begun two years ago when initial survey results suggested its importance in Syria. Lack of a suitable inoculation method caused difficulties in quantifying losses and in testing for disease resistance. Because the pathogens that cause dryland root rot (<u>Cochliobolus</u> <u>sativus</u> and <u>Fusarium graminearum</u>) are nearly always present in soil under cereal cultivation, artificial inoculation only increases inoculum levels. Disease-free controls are nearly impossible to realize under field conditions. For the yield loss experiments reported in last year's annual report, the standard inoculation method for soil-borne diseases was used. The fungus was grown on sterilized oat kernels, placed in furrows along with barley seed. We failed to obtain consistently higher infection levels in the inoculated plots using this method.

A new inoculation method was developed in 1989/90, based on techniques used by microbiologists to inoculate legume seed with nitrogen fixing bacteria. Spores of Cochliobolus sativus, grown on PDA, were mixed with peat and cellulose gum. This mixture was applied to barley seed just prior to planting. The tested material consisted of lines considered for release in Syria, lines previously identified as varying in root-rot resistance, and two local checks. A split-plot design was used, with inoculation vs check as main plots and varieties as sub-plots. Each plot consisted of six 3 m rows, sown at 0.3 m spacing. The two border rows of each plot were uprooted at maturity and the discoloration of the sub-crown internode was rated using a 0-5 score (0 = no discoloration, 5 = completely brown). The four middle rows were harvested.

Table 96 shows the effect of inoculation on disease score and yield parameters. Data analysis revealed a significant effect of the inoculation on the discoloration of the sub-crown internodes. The only variety not responding to the inoculation was Tadmor. Tadmor's resistance was already identified in previous year's experiments. The ranking of the other varieties, however, was not similar to those of the preceding season. Late frost severely affected the experiment and was a likely cause for the lack of a consistent reduction in yield.

We will start a variety testing program during the coming season, using the new inoculation method, through which we expect to identify varieties with contrasting reaction. Having lines with contrasting resistance will facilitate future research on the effect of root rot on yield and yield components.

Table 96. Effect of inoculation with <u>Cochliobolus</u> <u>sativus</u> on discoloration of sub-crown internode (0-5 score), yield (kg/ha) and thousand kernel weight (g) of eight barley cultivars.

No	Name	Score		Yield		Kernel weight	
		check	inoc.	check	inoc.	check	inoc.
1	Arabi Abiad	2.3	3.4	1959	1962	33.5	32.3
2	Arabi Aswad	2.6	3.2	1979	1642	31.0	30.1
3	Tadmor	2.4	2.6	2146	2511	35.3	34.1
4	JLB 6-38	2.8	3.4	1851	1767	38.1	38.5
5	Arizona	2.1	2.9	1858	1334	28.1	26.0
6	WI2291	2.8	3.2	2309	1965	30.3	30.3
7	Arta	2.7	3.5	2309	1983	33.8	35.6
8	Furat 653	1.9	2.6	1372	959	35.1	40.5
	Average	2.5	3.1	1973	1765	33.2	33.4
	Significance of treatment	***		*		ns	
	Lsd (0.05) between treatments for one variety	0.36		481			

***; *; ns = significant at 0.001; at 0.05 and non-significant at 0.05 respectively.

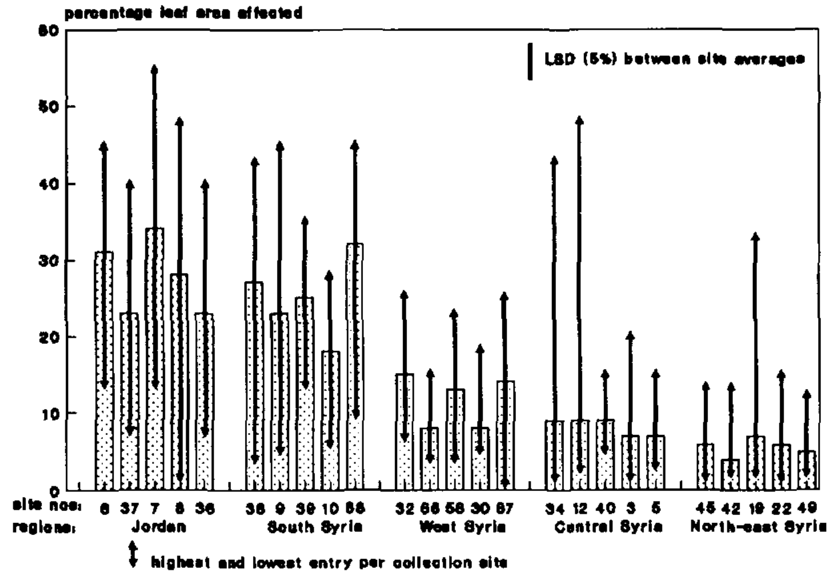
3.2.2.4. Evaluation of Syrian and Jordanian Local Germplasm for Disease Resistance

In 1984, the ICARDA barley project began a systematic evaluation of barley landraces from Syria and Jordan. Single head progenies of a large number of collection sites were evaluated for agronomic characteristics and for disease resistance. A high diversity in all characteristics studied was found among and within collection sites. Initial results indicated that differences in resistance for some diseases existed between regions, possibly associated with differences in the local environment. Field tests were conducted during the 1989-90 season to investigate differences between regions, with lines from collection sites from 5 regions: (i) southern Jordan, (ii) northern Jordan and southern Syria, (iii) north western Syria, (iv) central Syria and (v) north eastern Syria. Each region was represented by 5 collection sites and each site represented by 20 single head progenies. The five regions have distinct environmental characteristics. Winter temperature decreases from south to north, while rainfall is highest in north western Syria and lowest towards central Syria. The collection was evaluated for resistance to scald (Rhynchosporium secalis) and covered smut (Ustilago hordei) in separate nurseries, facilitated by artificial inoculation with a mixture of indigenous strains. Powdery mildew occurred naturally and notes on this disease were taken in the scald nursery. Sets were planted in a split-plot design in which the collection sites formed the main plots and the single head progenies the sub-plots. This design was chosen to enable a better distinction of differences in resistance within collection sites.

A relationship between the environmental conditions of the region and the level of disease resistance of the germplasm collected was shown for powdery mildew and scald, but not for covered smut (Figure 12). Powdery mildew resistance was more frequent in the warmer areas of Jordan and southern Syria, where the pathogen is more frequent. Scald resistance was more frequent in germplasm from northern Syria. Our survey data showed that scald was more frequent in the northern part of the sampled area. A large difference was noticed among lines between and within collection sites.

It is not possible to detect differences in resistance genes using field tests with mixtures of pathogen strains. Preliminary results of seedling tests under controlled conditions using distinct strains of Rhynchosporium secalis confirmed the resistance detected in field tests and indicated that resistance was effective against highly virulent strains. From the southern part of the sampled area, landrace lines resistant to strains of powdery mildew with a wide range of virulences were found (see section 3.2.2.2.). These results indicate that the resistance of the Syrian and Jordanian lines is based on a variety of genes. However, plant reaction to scald and powdery mildew seems to indicate that combined resistance to both diseases is rare (Table 97). The negative correlation between scald and mildew scores is caused by the large regional differences and was found nonsignificant when collection sites were analyzed separately. Hence, a careful evaluation of a large sample of the local germplasm could yield lines with resistance to both pathogens.

Rhynchosporium secalis



Erysiphe graminis

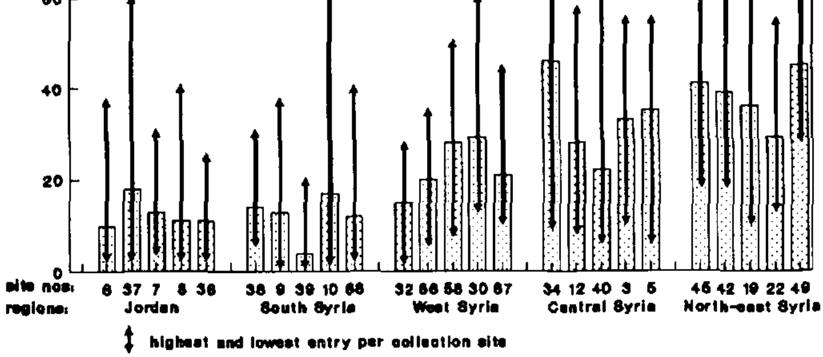


Figure 12. a) Reaction to two diseases (Rhynchosporium secalis and Erysiphe graminis) of barley landraces collected from 25 different sites. The graphs show the highest, lowest and average readings of 20 single head progenies per collection site.

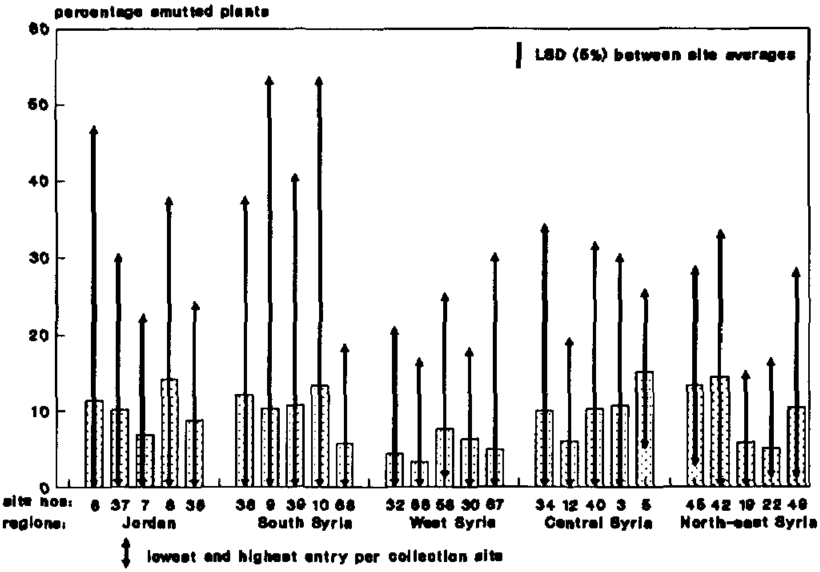


Figure 12. b) Reaction to Ustilago hordei of barley landraces collected from 25 different sites. The graphs show the highest, lowest and average reading of 20 single head progenies per colletion site.

Table 97. Reaction* of 500 barley landrace lines to powdery mildew and scald.

Powdery mildew	Scald	No. of lines
Resistant	Resistant	14
Resistant	Susceptible	126
Susceptible	Resistant	215
Susceptible	Susceptible	145

* Disease reaction was based on 2 replicate average of the percent leaf area affected. Resistant = % leaf area affected ≤ 10, and susceptible = % leaf area affected > 10.

3.2.2.5. Evaluation of Wild Barley (Hordeum spontaneum) for Disease Resistance

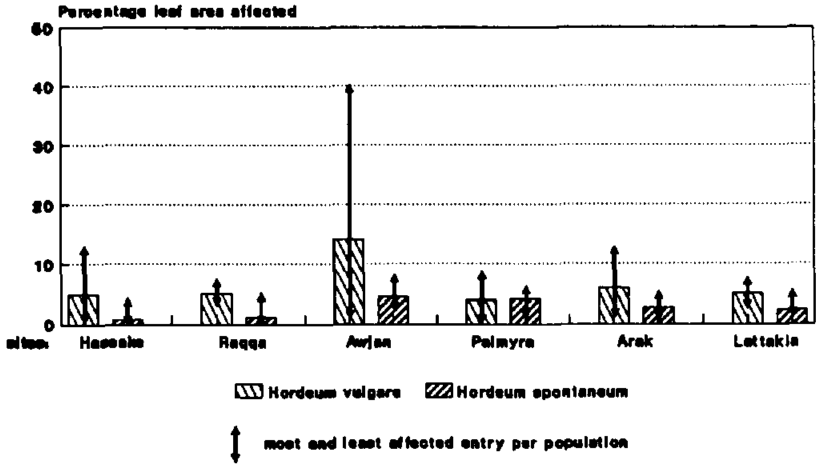
Wild progenitors of cultivated species may be a possible source for diversity in resistance genes. In barley, the wild species (Hordeum spontaneum) is well suited as it readily crosses with Hordeum vulgare. It has been used worldwide and a number of genes for disease resistance have been successfully extracted, especially for leaf rust and for powdery mildew. Although H. spontaneum grows throughout Syria, no systematic investigation of the potential of Syrian germplasm as a donor for disease resistance has yet been made. In collaboration with ICARDA's Genetic Resources Unit, we started to evaluate a number of H. spontaneum populations for three barley diseases. H. spontaneum populations were compared to cultivated barleys collected from the same site to distinguish the potential value of the wild barley versus the cultivated species. Simultaneous testing of both species may also give an indication on the level of intercrossing and whether similar selection forces act on both populations.

Six populations were tested, two from northeastern Syria (Raqqa and Hassake), two from central Syria (Palmyra and Arak), one from the coastal region (Lattakia) and one from a mountainous region near Damascus (Awjan). Each collection site was represented by 10 single head progenies from H. spontaneum and 10 from H. vulgare. Populations were tested for scald, powdery mildew and covered smut similarly to the local landraces as described in the previous section. Results are presented in Figure 13. Because of lack of seed, only four populations were tested for resistance to covered smut (Figure 14) and barley leaf stripe (Figure 15). Resistance to barley leaf stripe was tested in a growth chamber on seven single head progenies per species and per site. An artificial seed inoculation with the Syrian monospore isolate Pg8710-C was made, as described in the Annual Report of 1989. It is not possible using this method to determine whether the non-emergence of seed is caused by the pathogen or by other factors. Figure 15 shows both the average percentage of striped plants and the percentage of non-emerged seed.

Analysis showed that H. spontaneum is significantly more resistant to scald than H. vulgare. However, the opposite was true for covered smut. No significant difference between the 2 species was observed for powdery mildew and barley leaf stripe. These results do not lend support to any general statement on a difference between both species in disease resistance. Highly significant interaction existed between species and collection site for each of the diseases tested, while the difference among sites (both species combined) was non-significant (for mildew, smut and barley leaf stripe) or of low significance (for scald). Disease resistance within populations of both species are therefore unlikely to be subjected to the same selection pressure throughout the country.

Although the number of lines tested is small, there are no indications that the wild species is a more promising source for resistance to any of the tested pathogens. The highly significant differences found among selections within collection sites show that a careful evaluation may yield disease resistant lines in both species. The H. spontaneum population from Lattakia appeared to have near complete resistance to powdery mildew, a type of resistance which is not found within local barley landraces. However, the same population was highly susceptible to barley leaf stripe and covered smut. It is important to consider the drawbacks of using wild or unimproved material as a source for disease resistance. Landraces, grown under low-input conditions and buffered by their high level of heterogeneity, may not have been subjected to selection pressures comparable to those of homogeneous varieties grown in modern farming systems. New genes for disease resistance may be found in unimproved germplasm, but a thorough examination of this germplasm for resistance to other diseases is necessary before using it in a crossing program. If not, susceptibility to other diseases may be incorporated. Use of H. spontaneum is even more risky for the same reasons. Selection pressure is even lower on wild populations than on land races. H. spontaneum populations grow rarely over large areas and plant density is not comparable to that found in a farmers fields. Considering the abundance of resistance within local landraces, research resources are probably more efficiently utilized by evaluating and using landraces, rather than H. spontaneum.

Rhynchosporium secalis



Erysiphe graminis

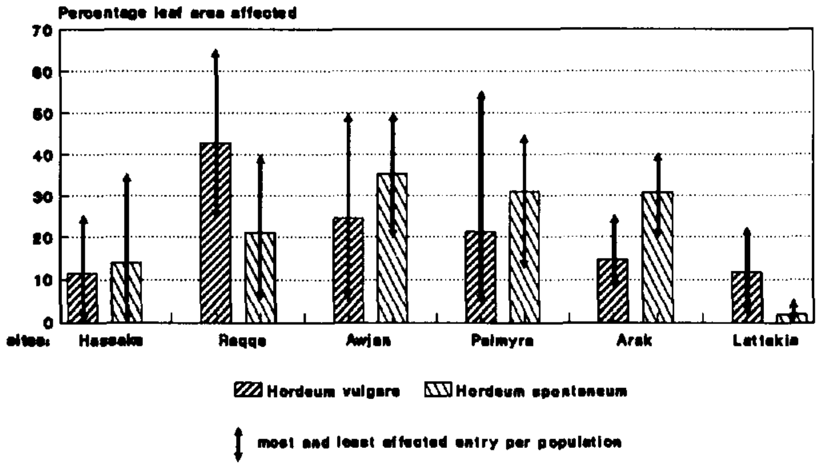


Figure 13. Reaction of Hordeum vulgare and H. spontaneum populations from six collection sites to two barley diseases (Rhynchosporium secalis and Erysiphe graminis).

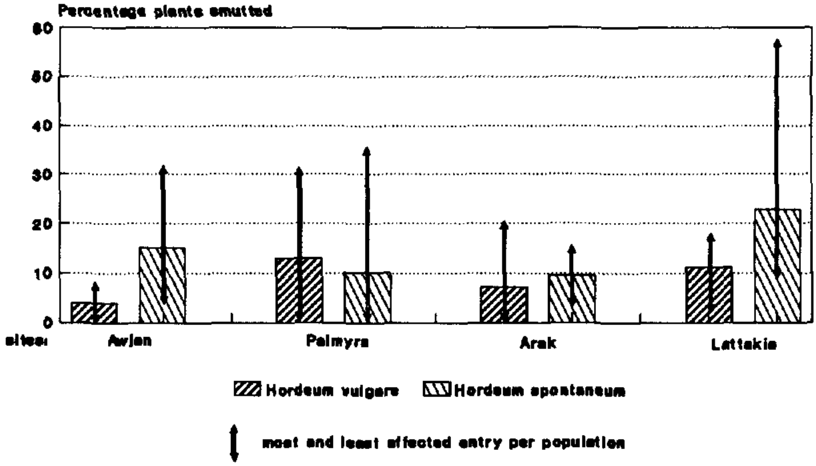


Figure 14. Reaction of Hordeum vulgare and H. spontaneum populations from four collection sites to Ustilago hordei.

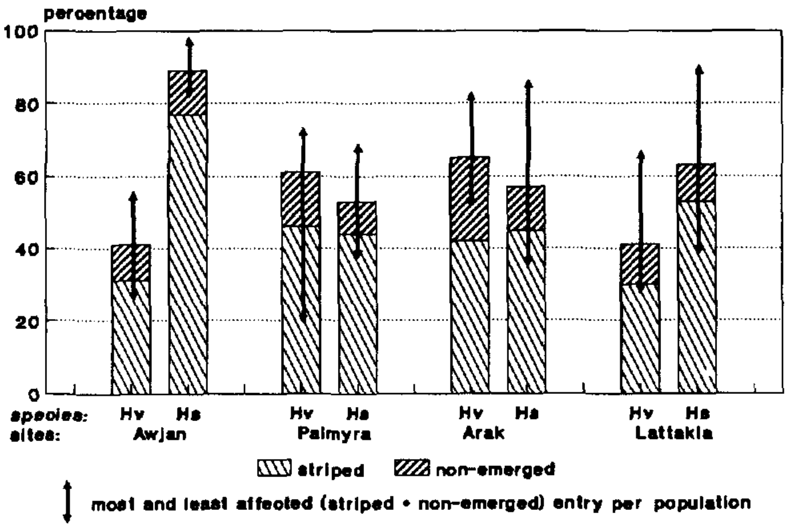


Figure 15. Reaction of Hordeum vulgare and H. spontaneum populations from four collection sites to Pyrenophora graminea.

3.2.2.6. Use of Fungicides for Seed Treatment

Because of the relatively low yields in the ICARDA region, it is questionable whether chemical control of leaf diseases will ever play a significant role in barley cultivation. Controlling diseases by seed application of fungicides, however, is relatively cheap and poses less threat to the environment. Seed treatment was used in the past only to control seed-borne diseases like smuts and bunts. Some of the newer systemic fungicides control other pathogens as well, such as mildew and scald, during early plant growth stages. A limited research effort in ICARDA's pathology projects is justifiable, as these chemicals may be used in the future within improved farming systems in WANA. Testing fungicides as a seed treatment is also important to ICARDA, as a large part of its impact is based on international seed exchange, where seed-borne diseases cannot be tolerated.

The efficiency of two new chemicals, Raxil and Baytan Combi, was compared with Vitavax, which is used for the seed dressing of ICARDA's international nurseries. Four barley varieties were examined; two of these varieties ('Roumi' and 'Local Bawabieh White') originated from farmer fields heavily infested with the seed-borne diseases barley leaf stripe and covered smut respectively. One landrace line ('JLB-08') was increased at ICARDA and was lightly infested with barley leaf stripe. The fourth variety ('Arta') was disease free and included as a check. The experiment was planted in a randomized complete block using plots of six 3m rows (0.3m row spacing) and six replicates. Data were collected on seedling emergence, cold damage, yield and disease occurrence.

The level of disease in this nursery was rather low, even though the seed was harvested from fields with a high disease infestation. An average of 25 stripe infested and 5 smutted plants per plot were counted for the untreated variety 'Roumi'. Less than one infested plant per plot infested was counted for the untreated plots of 'Local Bawabieh White' and 'JLB-08'. All three chemicals completely controlled smut, but only Baytan completely controlled stripe. Both Raxil and Vitavax seem satisfactory for commercial purposes. Less than one plant per plot showed symptoms on the treated variety 'Roumi'.

Data on cold damage were taken on 10 January, after the early frost period, and on 20 March after the heavy late frost. The first note taking clearly showed an effect of the fungicides on cold damage (Figure 16). Plots treated with Baytan and (to a lesser extent) Raxil showed less cold damage than the untreated ones, while plots treated with Vitavax showed more cold damage. The protecting effect of Raxil and Baytan was especially clear on the frost susceptible lines 'JLB-08' and 'Roumi'. Both these lines originated from areas (Jordan and Syria's Ghab valley respectively) where frost occurs infrequently. The effect of Vitavax was most clear on the frost tolerant local line originating from the village Bawabieh, near Tel-Hadya.

A small laboratory experiment was conducted in order to check the effect of these fungicides on seedling vigor. Seeds were germinated within rolls of filter paper at 20°C in the dark. Seedling length was measured 1 week after germination. There was no significant difference between Vitavax and the check, while seed treated with Raxil gave significantly smaller seedlings, and seedlings from seed treated with Baytan were again significantly smaller than those treated with Raxil. Part of the differences in cold tolerance found in the field could therefore have been caused by a delay in germination or a slower growth rate.

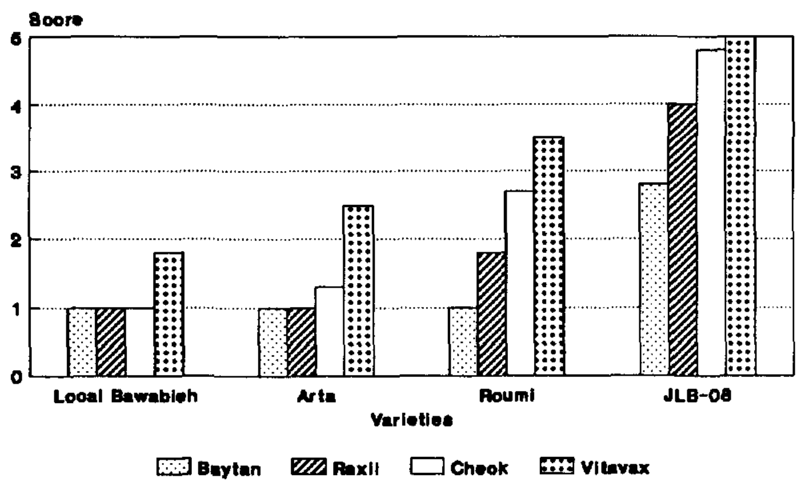


Figure 16. Effect of seed treatment by three different fungicides on cold damage of four barley varieties (lower score indicates less damage).

No differences between treatments were noted in the field after the second frost period in March. The late frost severely affected the experiment. No differences in cold damage score were observed and no significant yield differences were found among treatments or varieties.

Even though Vitavax seems to give a satisfactory control of smut and barley leaf stripe, the effect of this fungicide on plant characteristics like seedling vigor and cold tolerance justify a reconsideration of its use in yield trials and further studies on fungicides.

References

Webster R.K., 1980. Sources of resistance to Rhynchosporium secalis, Plant Disease 1:88-90.

Starling T.M, and Roane, C.W. 1980. Barley Newsletter 23, 53.

Joop van Leur

3.3 Entomology

3.3.1. Introduction

The goals of the Cereal Program Entomology Project are to develop the research capabilities of national programs, conduct research in collaboration with national programs, implement integrated pest management programs with national programs, and to train technicians, scientists and students according to national program needs. A summary of projects carried out in 1989/90 is shown in Table 98 of which some results are discussed hereafter.

3.3.2. Project Summaries

The 1989/90 growing season was distinguished by a severe drought during the winter and spring and a severe frost in mid-March. This seriously reduced stem sawfly and wheat ground beetle populations in northern Syria. Plant growth was retarded in plots at Tel Hadya, Breda, and Bouider, and many plants were killed by the late March frost.

Wheat Stem Sawfly

Lines selected in wheat stem sawfly screening trials are shown in Table 99. Some of these lines have been selected for four consecutive years and form the core of a sawfly resistant germplasm pool developed for use in sawfly infested regions of WANA. A 3% infestation level was the approximate cutoff for retaining a line for subsequent testing. This is much lower than in past years (ICARDA 1988,1989) due to the adverse weather encountered during the sawfly flight period and to generally low sawfly populations in this season. Nevertheless relative percentage of suceptible lines versus resistant lines in the material tested was consistent with past seasons. As previously reported, stem solidness was most important in imparting sawfly resistance to bread wheat, less so for durum wheat, and not important for barley (ICARDA 1987). Stem solidness was also generally reduced by drought this season.

Table 98. Cereal Program Entomology Projects, 1989/90.

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[1] (with Tischrin University, preparation of M.Sc. thesis)	Tel Hadya, Syria
3. Field trials of resistant lines[1]	Morocco, Tunisia
4. Studies on sawfly parasites[1] (with University of Aleppo)	Syria
5. Genetics of sawfly resistance in barley[2]	Tel Hadya, Syria
Hessian Fly	
1. Resistance screening-to identify and verify sources of HF resistance in wheat and barley[1] (with INRA/MIAC)	Morocco
2. Biotype identification using differential screening nursery[1,2]	Morocco, Algeria Tunisia, Syria Turkey, Lebanon
Aphids	
1. Resistance screening-to identify and verify sources of aphid resistance in wheat and barley in the laboratory[1,2]	Egypt
2. Field screening of aphid resistant lines in the field[1]	Egypt, Sudan
3. Estimation of yield losses due to aphids[1].	Egypt
4. Survey/collection of Russian wheat aphid and parasites (with Washington State University)	Morocco, Jordan Syria, Turkey
5. Effects of cold stress on BYDV[2]	Tel Hadya, Syria
Wheat Ground Beetle (Zabrus tenebrioides)	
1. Survey of Zabrus infestations in monocultures vs. rotations[1]	Syria
2. Study on the effect of soil moisture on Zabrus infestations[1]	Syria

[1]Conducted in collaboration with the respective national program.
[2]Conducted by ICARDA entomology staff.

Table 99. Promising bread wheat, durum wheat and barley lines for wheat stem sawfly resistance.

Name	Pedigree	Source/No	%Inf87	%Inf88	%Inf89	%Inf90
Bread Wheat						
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-2Y-2B-0Y	WCB87/71	0.83	5.42	1.70	2.08
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	1.25
Fta/W71//Imuri	CMH80A-276-1B-2Y-1B-1Y-1B-0Y	WCB87/72	2.91	5.00	7.10	1.25
Bol's'/Pvn's'	CM 58696-5AP-2AP-1AP-1AP-0AP	WCMB87/42	2.91	10.00	7.50	3.75
Rbs/Ti Resel	SWM4781-2S-3AP-0AP-1AP-0AP	WCB87/43	5.00	8.75	7.90	0.00
G11/Ti/3/Kvz//Kal /Bb/4/Kal/3/Cno/Chr//On	CM54580-3AP-1AP-2AP-0AP	WCB87/33	3.75	8.75	8.33	0.83
Rmn F12-71/Jub//S	SWO76584-01H-1H-1S-05	WOL86/89	4.58	7.08	9.18	3.33
Cham 4 (susceptible check)						13.33
Durum Wheat						
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-0AP	DCB87/37	0.83	5.00	3.35	0.42
Bit/Creso	CD 34346-2TR-2AP-1AP-0AP	DCB87/11	1.25	7.92	5.83	0.42
A63040/Sty//Lds/3/Win /4/Erp/Ruso	CD 35072-C-5Y-1M-0Y	DCB87/123	0.83	8.33	5.83	0.00
Can2101/Magh//Stk/3/ W11s/65150	CD 15111-3S-2AP-2AP-3AP-0AP	DCB87/19	0.83	8.75	6.25	2.92
Bit/Creso	CD 34346-2TR-2AP-1AP-0AP	DBB87/20	0.83	9.85	7.05	0.00
D-2/Bit	CD 20796-4AP-6AP-2AP-0AP	DAT87/116	1.66	9.58	4.58	0.42
Cham 3 (susceptible check)						8.33
Barley						
FB73-075	-	BAB85/14	0.83	2.08	2.03	5.00
Ager//Api/CM67/3/Cel/ WI2269//Ore	ICB81-1275-0SH-1AP-0AP-0AP	BAT88/405	-	7.50	5.03	0.83
Salmas//WI 2198/Emir (susceptible check)						12.50

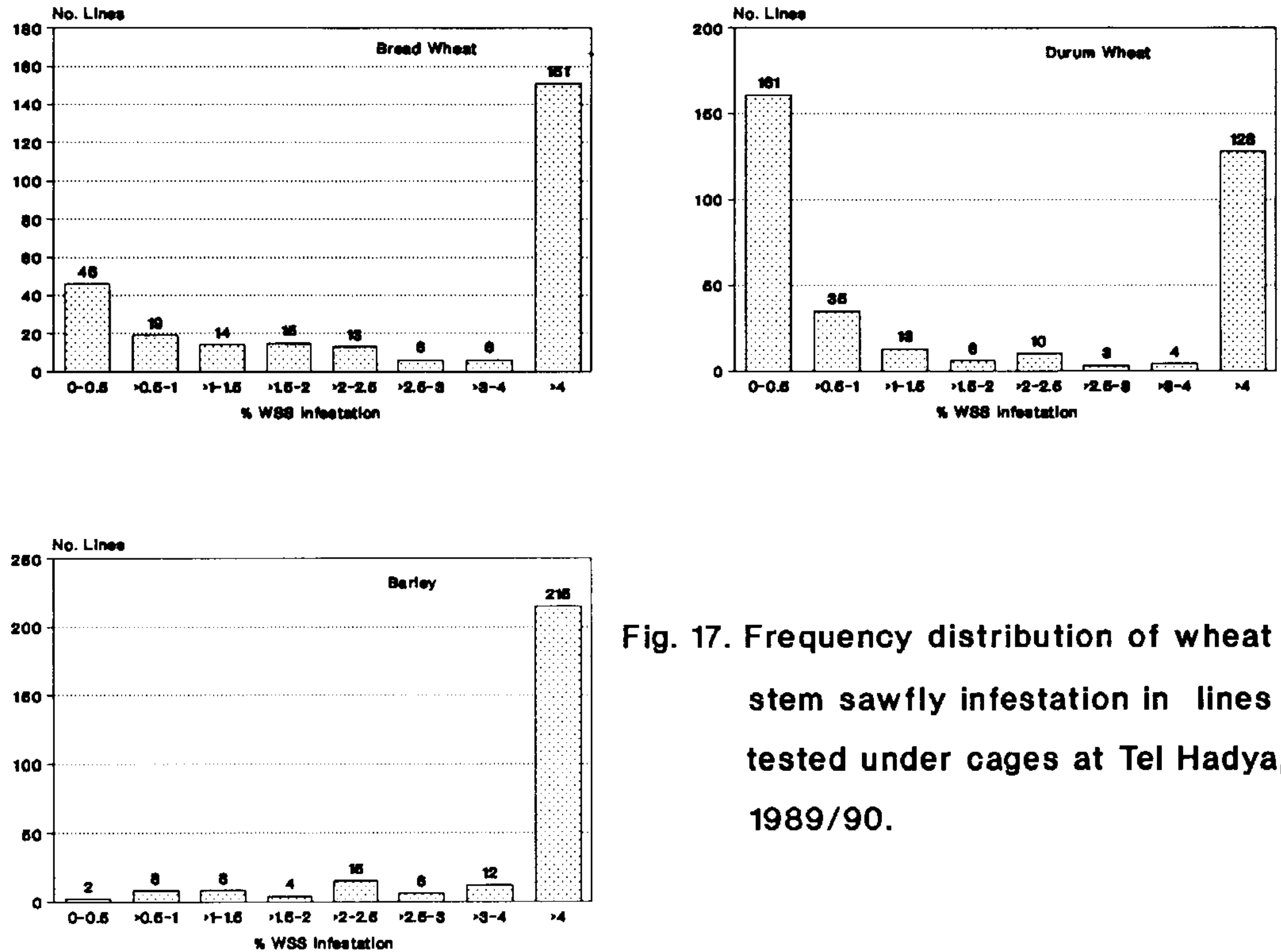


Fig. 17. Frequency distribution of wheat stem sawfly infestation in lines tested under cages at Tel Hadya, 1989/90.

Figure 17 shows the frequency distribution within infestation classes of bread and durum wheat and barley lines tested this season. Both bread wheat and durum wheat had a higher number of lines in the lower infestation classes than did barley. Similarly, more durum wheat lines had low sawfly infestations than bread wheat, a result suggesting that durum wheat may innately possess higher sawfly resistance than bread wheat which is not necessarily related to stem solidness.

Aphids

Russian Wheat Aphid

A survey of the Russian wheat aphid (RWA), Diuraphis noxia Mordvilko, and collection of its natural enemies was conducted during April and May in Jordan, Syria, and Turkey in collaboration with scientists from Washington State University, USA (Pike et al. in press). Additional surveying and collecting in Morocco was conducted by WSU with assistance from MIAC and INRA staff in Morocco. The purpose of the RWA project was to document the occurrence of RWA in the Mediterranean region, collect its natural enemies for further studies and eventual use as biological control agents, and to foster collaborative associations between regional, USA and ICARDA scientists for long-term biocontrol research.

RWA was not widely abundant in any of the countries explored, but sites were located in each with low to moderate RWA infestations and accompanying natural enemies. The best locations were drought-stressed wheat and barley fields with low plant density. Drought-stressed field of center pivot-irrigated wheat was also infested in southern Jordan. In Jordan we suspect that alate RWA may migrate from barley in the lower reaches of the Jordan Valley and Wadi El Arab during April-May to wheat and barley developing later on the eastern highlands.

In Syria, the highest RWA and natural enemy populations were located in sparse barley patches planted in hilly, rocky terraces near Qatura, about 40 km northwest of Aleppo. RWA was also found on Hordeum bulbosum near Qatura. In Turkey RWA was found on the east side of the coastal mountains near Baglama, Kirikhan, and Antakya. RWA was not observed in lush wheat or barley fields, or in fields along the humid Mediterranean coast south of Iskenderun.

Table 100. Natural enemies of RWA from Morocco[1], Jordan, Syria, and Turkey[2] collected in March and April, 1990 (after Pike et al. in press).

Natural enemies	Order/ Family	Type	Date	Site	Aphid host	Plant host
Aphidiine	Hym/Brac	Para	27 Mar	Morocco, Marrakech	Dn,Rp,Sg	Hv
Aphidiine	Hym/Brac	Para	28 Mar	Morocco, Beni Mellal	Rp,Md	Ta
Aphidiine	Hym/Brac	Para	28 Mar	Morocco, Settat	Rp,Md	Ta
Aphidiine	Hym/Brac	Para	29 Mar	Morocco, Annaceur	Dn,Sg	Hv,Ta
Aphidiine	Hym/Brac	Para	3 Apr	Jordan, Rum-Disi	Dn,Pp	Hv,Ta
Aphidiine	Hym/Brac	Para	5 Apr	Jordan, Ash Shunah	Dn	Ta
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Qatura	Dn	Hv
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Qatura	Dn	Hb
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Tel Hadya	Dn	Hv
Aphidiine	Hym/Brac	Para	8 Apr	Syria, Al Bab	Dn	Hv
Aphidiine	Hym/Brac	Para	11 Apr	Turkey, Baglama	Dn	Ta
<u>Coccinella</u>	Col/Cocc	Pred	10 Apr	Syria, Khafsa	Dn,Rm,Rp	Hv
<u>Coccinella</u>	Col/Cocc	Pred	29 Mar	Morocco, Meknes	Rp,Md	Td
<u>Scymnus</u>	Col/Cocc	Pred	29 Mar	Morocco, Meknes	Rp,Md	Td
<u>Leucopis</u>	Dip/Cham	Pred	3 Apr	Jordan, Rum-Disi	Dn	Hv,Ta
Syrphid	Dip/Syrp	Pred	27 Mar	Morocco, Marrakech	Dn,Rp,Sg	Hv

1 Collected by WSU, MIAC, and INRA-Morocco scientists. Material in Jordan, Turkey, and Syria was collected by ICARDA and WSU scientists.

2 Col = Coleoptera, Dip = Diptera, Hym = Hymenoptera, Brac = Braconidae, Cocc = Coccinellidae, Cham = Chamaemyiidae, Syrp = Syrphidae, Para = parasitoid, Pred = predator, Dn = <u>Diuraphis noxia</u>, Md = <u>Metopolophium dihrodum</u>, Rm = <u>Rhopalosiphum maidis</u>, Rp = <u>Rhopalosiphum padi</u>, Sg = <u>Schizaphis graminum</u>, Hb = <u>Hordeum bulbosum</u>, Hv = <u>Hordeum vulgare</u>, Ta = <u>Triticum aestivum</u>, Td = <u>Triticum durum</u>.

RWA were generally found within leaf whorls and in tightly rolled flag leaves and secondary leaves. Damage symptoms included longitudinal white, yellow or purple streaks in the leaves and leaf sheaths, inward rolling of the leaves, and stunting of the plant. Table 100 describes the natural enemies of RWA collected. Parasitoids collected consisted primarily of Aphidiine braconids. A total of 572 parasitoids and predators were collected and sent to Texas A&M University, USA, for processing. Some have since been released against RWA populations in the rainfed wheat region of the Pacific Northwest of the USA, a region with a mild Mediterranean climate.

Aphid Screening in Egypt

Cooperating Egyptian scientists reported that of 270 *Aegilops* sp. lines sent to the Giza Aphid Screening Laboratory, 13 showed resistance to *Schizaphis graminum* (Table 101). Problems with maintaining *Rhopalosiphum padi* in the laboratory precluded screening these lines against that aphid during this study.

From about 700 lines produced from BC3/BC4 of aphid susceptible Egyptian varieties and the relatively resistant Amigo T 101 and Amigo T 105, 4 lines were rated as resistant and 16 lines as moderately resistant to *S. graminum* in the laboratory. When these lines were evaluated in the field against *R. padi* 8 lines derived from Amigo T 101 X Sakha 61 and 4 lines from Amigo T 105 X Sakha 69 were rated resistant. An additional 23 lines from other parents were rated moderately resistant, as were 3 additional lines from Amigo T 101 X Sakha 61 and 20 lines from Amigo T 105 X Sakha 69.

Yield loss experiments conducted at Shandaweel Research Station in Upper Egypt revealed aphid losses due to *R. padi* to average 17.62% with significant differences existing between different cultivars (Mossad et al. 1990). Losses in bread wheat were slightly higher than those of durum wheat, averaging 20.61% with significant differences between cultivars. These results corroborate those reported for 1988/89 (Mossad et al. 1989).

Table 101. *Aegilops* sp. lines showing resistance to *Schizaphis graminum* in laboratory screening tests conducted at the Aphid Screening Laboratory, ARC, Giza, Egypt in 1989/90 (Youssef et al. 1990).

Species	Line identification number
Ae. ovata	118, 119, 122, 132
Ae. speltoides	143, 144, 145, 153, 154
Ae. triaristata	190
Ae. truncialis	290, 239

BYDV and Cold Stress

In a preliminary study to examine the effects of cold stress on BYDV resistance jointly conducted by ICARDA's entomology, virology, and breeding projects, a BYDV resistant line (Corris, Yd2 gene) and a nonresistant line (Harmal) were exposed to different cold treatments in the laboratory and to the PAV isolate of BYDV (Fig. 18). ELISA tests were performed on leaves collected from plants at 3 equally spaced intervals after cold treatment and BYDV inoculation. Results indicate that cold may enhance the reproduction of BYDV in nonresistant plants if the cold stress occurs after the plant is inoculated with BYDV. The pattern of increase of BYDV titres in plants inoculated following a cold treatment resembled those in plants that were not exposed to cold at all. Additional field and environmental chamber tests are planned to verify these results.

Hessian Fly

A number of lines were sent from ICARDA to Jema'a Shaim, Morocco to be tested for Hessian fly resistance under the extremely high natural infestations occurring there. Results of these tests are summarized in this report in the spring bread wheat breeding section.

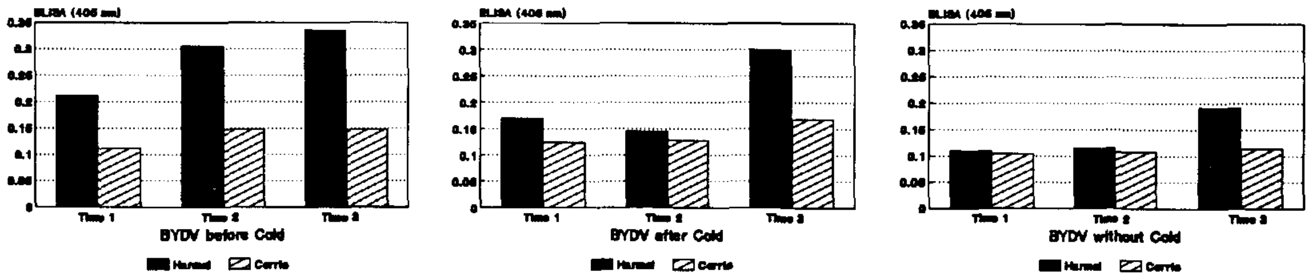
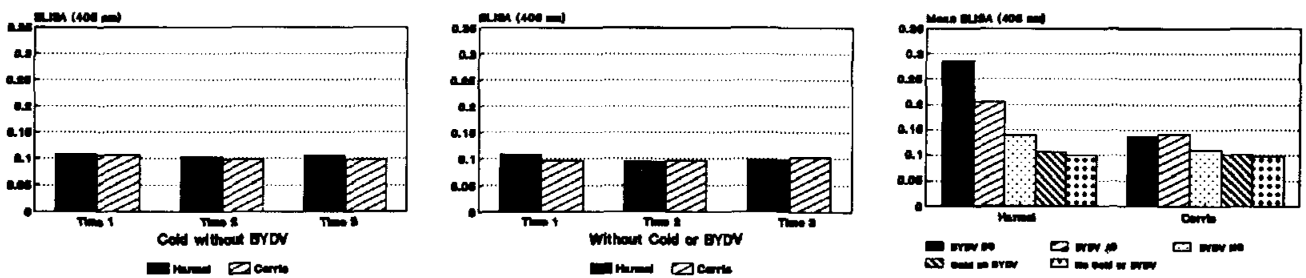


Fig. 18. Effect of cold stress on ELISA values for the PAV isolate of BYDV at Tel Hadya in 1989/90.



The Uniform Hessian Fly Nursery was planted at sites around the Mediterranean region as part of an ongoing study to determine biotype distribution in the area. Nurseries were planted at Terbol, Lebanon; Lattakia, Syria; Erzerum, Turkey; as well as in Morocco, Algeria, and Tunisia. Contacts were made with scientists in Spain, Portugal, Cyprus, and Libya who were willing to plant and monitor this nursery in the future. Results will be presented at a later date.

Zabrus tenebrioides

Baseline data on infestation of Zabrus tenebrioides were collected in collaboration with DASR (Syria) as part of long term studies on the effect of crop rotation and rainfall on Z. tenebrioides populations in northern Syria. The unusually dry winter and spring appeared to negatively affect Zabrus population densities. Results of these studies will be presented following completion of the experiments.

References

ICARDA. 1987. Cereal Improvement Program: Annual Report 1987. ICARDA Cereal Improvement Program, Aleppo, Syria. 206 p.

ICARDA. 1988. Cereal Improvement Program: Annual Report 1988. ICARDA Cereal Improvement Program, Aleppo, Syria. 191 p.

ICARDA. 1989. Cereal Improvement Program: Annual Report 1989. ICARDA Cereal Improvement Program, Aleppo, Syria. 209 p.

Pike, K.S., L. Tanigoshi, R. H. Miller and L. Buschman. 1990. Exploration in Morocco, Jordan, Syria, and turkey for Russian wheat aphid and its natural enemies. Proc. 4th Ann. Russian Wheat Aphid Conf., Bozeman, MT, USA. (in press).

Mossad, M.G., H.G. Enayat, and A.M. Tamm. 1990. Aphid research in Shandaweel. Nile Valley Winter Season Cereals Regional Project Program Report, ARC, Giza. pp. 59-61.

Mossad, M.G., A.A. Shafi, and R.H. Miller. 1989. Aphid damage and resistance in wheat in Egypt. Proc. Int. BYDV Workshop. Rabat, Morocco. in press.

Youssef, G.S., M. El Hariri, A.M. Abdelghani, and A.A. Marzok. 1990. Screening for aphid resistance in wheat and some wild types. Nile Valley Winter Season Cereals Regional Project Program Report, ARC, Giza. pp. 56-58.

Ross H. Miller

3.4. Applied Biotechnology

3.4.1. Introduction

This project aims at developing and adapting techniques and methodologies that could accelerate and improve the efficiency of cereal breeding. Activities are focused on the production of doubled haploid (DH) lines, and on the development and use of DNA molecular markers.

3.4.2. Haploid Plant Production

Haploid plant production followed by chromosome doubling offers the possibility of developing completely homozygous lines from heterozygous parents in a single generation. Regarding crop improvement, the production of doubled haploid lines provides a rapid technique for the incorporation of new characters into agronomically superior germplasm, and higher selection efficiency. Two different methods have been developed: anther culture and interspecific crosses followed by embryo rescue (pollination with pollen from Hordeum bulbosum or maize), and both have become integrated into the cereal breeding programs. The first DH lines were tested under field conditions during the 1989/90 season. Moreover, approximately 700 new DH lines of bread wheat and barley were produced. Those lines will be fed back to the breeding programs for selection.

Attempts were made to improve the anther culture efficiency in bread wheat. Comparison of anther culture responses in barley-starch and agarose gelatinized media was done. The number of responding anthers and plantlets produced were slightly higher in the barley-starch gelatinized medium (Table 102). The consistency of the starch gelatinized medium although varying with the concentration, is generally soft and viscous. Effects of different solidifying or floating agents were tested. As can be seen in Table 103, presence of Gelrite had a negative effect on the percentage of responding anthers and on the number of embryoids produced. Addition of agarose did not significantly improve the production of green plants although the number of embryoids was increased.

Table 102. Comparison of wheat anther culture (cultivar Veery's') in barley starch (60g/l) and agarose (6g/l) gelatinized media*.

Medium	Number of plated anthers	Percent** responding anthers	Number** of embryoids per 100 anthers	Number of plants** per 100 anthers		
				albino	green	total
Agarose	764	9.0a	21.7a	3.4a	5.9a	9.3a
Barley starch	757	12.4b	28.1b	5.5b	7.4a	12.9b

* medium composition: modified MS-nutrient + Sucrose 0.25M + Glutamine 750 mg/l + Myo-Inositol 100mg/l + $AgNo_3$ 5mg/l + 2-4D 1mg/l, filter-sterilized.

** percentages followed by the same letter are not significantly different at the 0.05 probability level, as determined by 't' test of arcsin transformed data.

Table 103. Influence of different texture agents on wheat anther culture response (cultivar Veery 's') in barley starch containing media*.

Medium		Percent** responding anthers	Number** of embryoids per 100 anthers	Number of plants** per 100 anthers		
agent	texture			albino	green	total
Control	semi-solid	21.2a	72.3a	14.6a	10.2a	24.8a
Gelrite (4g/l)	solid	6.0b	25.4b	-	-	-
Agarose (6g/l)	solid	18.5a	149.0c	6.3b	11.3a	17.6b
Ficoll(200g/l)	liquid	13.9c	40.5d	3.7c	10.7a	14.4b

* medium composition: basal medium (see table 102) with 1% activated charcoal, 60 g/l barley starch and 0.083 M maltose in place of sucrose.

** percentages followed by the same letter are not significantly different at the 0.05 probability level, as determined by "t" test of arcsin transformed data. No data were taken on plant production for the Gelrite-based medium.

Ficoll induced a low rate of embryo production, but greatly enhanced plant formation, resulting in a high frequency of direct plant regeneration (i.e. without transfer to a regeneration medium). Finally, an experiment was undertaken to ascertain the influence of silver nitrate ($AgNo_3$) and activated charcoal in barley starch containing media. The results in Table 104 indicate that activated charcoal seemed to reduce the production of embryoids while $AgNo_3$ stimulated the embryo and plant development. An $AgNo_3$ concentration of 5mg/1 and absence of activated charcoal gave an optimal response with regard to the yield of green plants, and can be recommended in association with barley-starch for wheat anther culture.

Table 104. Effect of $AgNo_3$ and activated charcoal on wheat anther culture response in barley starch containing media*.

Genotype	Medium: $AgNo_3$ (5mg/1)	Medium: Charcoal (1%)	Percent** responding anthers	Number** of embryoids per 100 anthers	Number of plants** per 100 anthers: albino	green	direct	total
	+	+	14.0a	30.6a	2.3a	6.0a	8.3a	8.3a
Hodhod	+	-	5.7bc	24.1b	0.7b	10.9b	6.3a	11.6a
	-	+	7.7b	13.5c	0.8b	3.5c	2.3b	4.3b
	-	-	5.0c	28.1b	2.6a	6.6a	3.3b	9.2a
	+	+	7.9a	16.3a	0.0a	5.4a	4.6a	5.4a
Veery's'	+	-	10.0a	66.3b	3.8b	27.9b	18.3b	31.7b
	-	+	7.1a	17.9a	2.5bc	0.8c	0.8c	3.3c
	-	-	7.9a	37.5c	1.3c	9.6a	3.8a	10.9d

* medium composition: basal medium (see Table 102) with 60g/1 barley starch and 0.083 M maltose in place of sucrose.

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

3.4.3. DNA Molecular Markers

Restriction Fragment Length Polymorphism (RFLP) offers a powerful, attractive technique for the identification of molecular markers associated with genes conferring adaptation to biotic or abiotic stresses. The integration of RFLP techniques into plant breeding promises to : (1) speed up the transfer of desirable genes among varieties or from related wild species, (2) make possible the analysis of complex polygenic characters as a group of single Mendelian factors (Tanskley et al., 1989). In this seasons's report we present some preliminary work regarding the development and evaluation of marker-assisted breeding in barley.

Plant material

Seven barley genotypes have been selected for this study. Five of the genotypes are from ICARDA, and two from the American Barley Genome Mapping Project. Names and characteristics of these 7 genotypes are as follows:

- Tadmor: a pure line from a Syrian landrace Arabi Aswad, adapted to drought, 2-row.
- Hordeum spontaneum 41.1: promising accession of H. spontaneum carrying traits of adaptation to dry areas.
- ER/Apm: 2-row variety with high yield potential, susceptible to drought.
- Athenais: 6-row cultivar adapted to drought.
- Gloria's'/Copal's': 6-row line with high yield potential, leaf rust resistance, susceptible to drought.
- Morex: 6-row malting barley variety, (Manchuria germplasm group).
- Steptoe: 6-row high yielding variety, poor malting and feed quality, (American costal type).

Variability at RFLP loci

Thirteen clones were hybridized to restricted genomic DNA from the above set of genotypes to identify informative probe/restriction enzyme combinations. All clones have been isolated and selected by Dr. N. Lapidn of Colorado State University within the framework of the North American Barley Genome Mapping Project. Work was done at MSU laboratory. For each probe two different restriction enzymes, both hexanucleotide cutters, were assayed for the detection of RFLPs. As can be seen in Table 105, polymorphism was easily detected although a limited number of probe/enzyme combinations was tested. Polymorphisms were found for 9 of the 13 clones.

Table 105. Polymorphism detected among seven barley genotypes using different DNA clones* as probes.

Clone number	Restriction enzyme	Polymorphic fragments: +(presence)/ -(absence)	Polymorphic fragments: No. of RFLP patterns
32	Hind III	-	1
	Xba I	-	
50	Hind III	-	
	Xba I	+	2
59	Hind III	+	4
	Xba I	+	
65	Xba I	-	1
71	Hind III	+	2
	Xba I	-	
73	Hind III	+	3
	Xba I	+	
74	Hind III	+	4
	Xba I	+	
83	Hind III	-	1
	Xba I	-	
88	Hind III	+	2
	Xba I	-	
89	Hind III	+	2
90	Hind III	+	2
93	Hind III	-	1
95	Hind III	+	4
	Xba I	+	

* Clones isolated and selected by N. Lapidan of Colorado State University (vector: pGEM; insertion site: Pst I).

Only 4 of the probes detected no RFLPs among the 7 genotypes with the restriction enzymes assayed. Two clones, number 59 and 74, are particularly polymorphic and allow, in combination, the distinguishing of most of the tested genotypes. This considerable diversity among the genotypes tested confirms the previous data showing a high degree of polymorphism detected with these sorts of probes in barley (Shin et al., 1990).

Polymerase Chain Reaction

The polymerase chain reaction (PCR) involves synthesizing multiple copies of a gene, or a region of DNA, from oligonucleotide primers which bind to opposite DNA strands flanking the target sequences. Each cycle in the reaction involves denaturing the DNA, annealing the primers, and extending them across the templates via DNA polymerase. Applications of Taq polymerase-mediated PCR technology are manifold and involve analysis of nucleotide sequence variation (DNA marker) as well as cloning, sequencing or mutagenesis (Saiki et al., 1988). PCR is a fast and simple non-radioactive technique which is more rapid than RFLP analysis, but requires an understanding of the molecular basis of variation between genotypes at specific loci. Thomas Blake (personal communication) from Montana State University (MSU) has identified several loci for which variation can be scored using PCR. Five primer sets developed by T. Blake were tested in his laboratory against the above 7 genotypes. Depending on the set of primers used, single or multiple bands of amplified DNA were obtained (Figure 19). All the sets tested showed distinct patterns among the 7 cultivars (Table 106). However, in some cases, unreproducible results and lack of specificity in the amplification process appeared as an important limitation. An interesting approach is illustrated in Figure 20. Only one segment of DNA is amplified and polymorphism is detected in a second step after restriction of the amplified product. This method still presents the advantage of the PCR and allows to check the specificity of the amplification and to detect polymorphism which is not easily accessible by the conventional RFLP technique.

Table 106. Polymorphism detected among seven barley genotypes analyzed using different PCR primer sets*.

Primer set name	Character/Clone (location)	Informative amplified band +(presence)/-(absence)	Number of distinct banding patterns
TB 13/14	Thionin	+	2
TB 15/16	Ubiquitin	+	2
TB 17/18	Hordothionin	+/-**	2
TB 33/34	aMSU21 (chr2)	+	3
TB 38/39	B Hordein (chr5)	+	2

* Developed by T. Blake (MSU).
** Polymorphism detected only after restriction by Taq 1.

The polymerase chain reaction can be considered as an alternative to RFLP technology capable of efficiently handling the large number of individuals commonly dealt with by plant breeders. Once an informative RFLP locus is identified, it could be converted to a PCR based marker. However, primer design and/or PCR protocol still need to be optimized for use with plant genomic DNA.

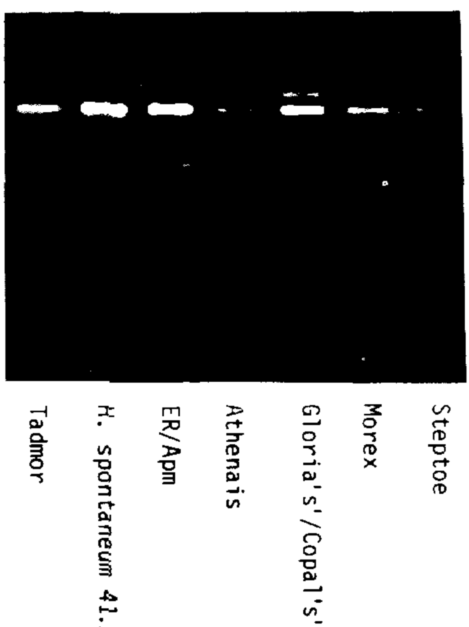


Figure 19. Agarose gel electrophoresis of amplified DNA samples from different genotypes using TB 13/14 PCR primer set.

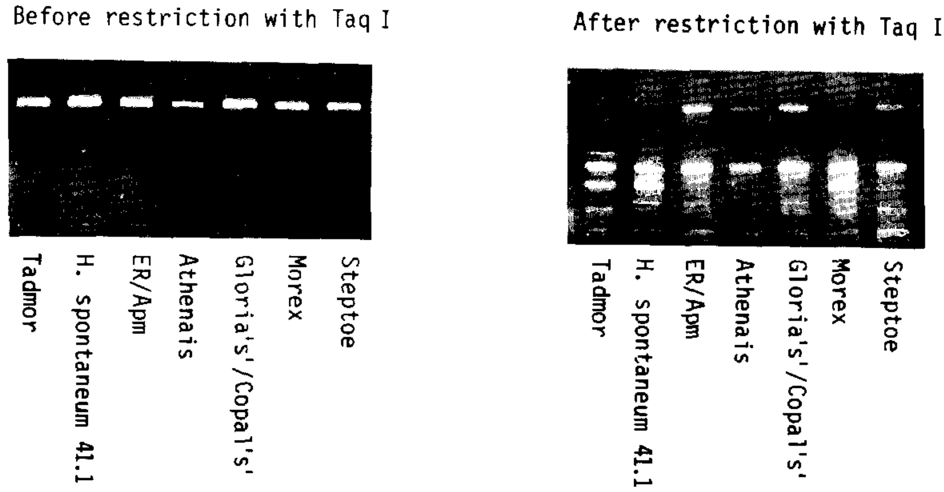


Figure 20. Agarose gel electrophoresis of amplified DNA samples from different genotypes using TB 17/18 PCR primer set.

Cross Selection for RFLP Analysis

Association of RFLP markers with loci affecting a character of interest can succeed only when loci segregating in the cross have a relatively large phenotypic effect. Moreover, development of an RFLP linkage map is obviously facilitated when distant genotypes are used. In consequence, parental lines should be chosen on the basis of 1) variation in trait expression and 2) RFLP divergence. Estimation of the genetic distance between 5 reference genotypes from ICARDA, based on RFLP and PCR markers, is given Table 107. On the average, approximately 50% of the DNA markers thus far tested differ between two genotypes. However, the polymorphism (distance) detected varied between combinations of genotypes. Tadmor and <u>H. spontaneum</u> 41.1 appear relatively close. The 6-row cultivars

Table 107. Genetic distance between five ICARDA reference genotypes based on RFLP and PCR markers.

	H.sp.41.1	ER/Apm	Athenais	Gloria's'/Copal's'
Tadmor	0.23	0.50	0.45	0.54
Hor.Spont.41.1		0.53	0.50	0.64
ER/Apm			0.50	0.40
Athenais				0.25

Distance: ratio of number of polymorphic markers to the number of DNA clones and PCR primer sets tested (13 DNA clones and 3 PCR primer sets).

Athenais and Gloria's'/Copal's' show some closeness while ER/Apm is distant to all other genotypes. Based on these preliminary data, crosses involving ER/Apm (e.g. ER/Apm//Tadmor, ER/Apm//Athenais, ER/Apm//H. Spont. 41.1) as well as crosses like H. spontaneum 41.1//Gloria's'/Copal's' and Tadmor//Gloria's'/Copal's' may be useful crosses to initiate a RFLP analysis study focused on adaptation to mediterranean low rainfall environment.

References

Saiki R.K., Gelfand D.H., Stoffel S., Scharf S.J., Higuchi R., Horn G.T., Mullis K.B., and Erlich H.A. 1988. Primer-directed enzymatic amplification of DNA with a thermostable DNA polymerase. Science 239: 487-491.

Shin J.S., Chao S., Corpuz L. and Blake T. 1990. A partial map of the barley genome incorporating RFLP, PCR, isozyme and morphological marker loci. Genome (in press).

Tanksley S.D, Youg N.D., Paterson A.H. Bonierbale M.W. 1989. RFLP mapping in plant breeding: New tools for an old science. Biotechnology, March: 257-264.

Ph. Lashermes

3.5. Cereal Grain Quality

3.5.1. Introduction

During the 1989-90 season, the cereal quality laboratory conducted more tests on the use of electrophoresis as an additional aid in grain quality assessment. Table 108 shows the number and type of tests carried out during 1989-90 in the ICARDA cereal quality laboratory for the different types of barley and wheat germplasm. Recently, the Chopin Alveograph was introduced for the purpose of evaluating advanced bread wheat material and for training purposes.

Table 108. Number of tests [1] carried out in the ICARDA cereal quality laboratory, 1989/90, for different projects[2].

Project	ELEC	TKW	VKC	PSI	SDS	YP	GC	FM	FAR	PROT	BAK	TOTAL
Barley	-	1450	-	-	-	-	-	-	-	725	-	2175
W	-	1915	-	1915	-	-	1915	-	-	1915	66	7726
DW	637	2097	2097	-	747	2097	-	-	-	2097	-	9772
W/F	-	1046	472	284	472	-	-	-	-	411	-	2685
FFVT	-	477	195	-	195	195	-	136	136	477	-	1811
Other	-	180	1114	45	1124	1114	-	-	-	2393	-	5970
Total	637	7165	3878	2244	2538	3406	1915	136	136	8018	66	30139

(1) ELEC=Electrophoresis, TKW=1000-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, PROT=protein, BAK=baking. (2) BW=bread wheat, DW=durum wheat, W/F=winter/facultative wheat and barley (high elevation), FFVT=farmer's field verification trials, Other=other ICARDA programs.

F.J. El Haramein and A. Sayegh

3.5.2. Red Wheat Functionality for Baking Two-layer Flat Bread

Traditionally, farmers in countries of West Asia and North Africa prefer wheat with white/amber seed. This tradition has been supported by researchers and decision makers in those national programs. They believe that wheats with red seed color will give bread with dark or undesirable color at high flour extraction (75-80%).

Performance data of red and white/amber bread wheat germplasm tested under both rainfed and optimal conditions, show no difference in grain yield and other agronomic characters. In spite of this, some National Programs in WANA still favor material with white/amber seed. As a result, many bread wheat lines with red seed are not considered and receive little attention by several programs in the region.

During the 1988-89 crop season, we evaluated 10 red-seeded and 10 white-seeded bread wheat lines selected from advanced wheat yield trials. These were chosen on the basis of grain yield across three environments: Tel Hayda - rainfed (250mm), Tel Hadya-supplementary irrigation (350mm), and Breda (160mm). Three checks for each seed color were also included in the trial. The following grain quality parameters were measured on all entries grown at the two locations: grain color, kernel hardness (%), protein content (%), 1000 kernel weight (g), test weight (kg/ha), flour yield (%), flour ash (%), flour color (K.J.), farinograph, and 2 layer flat bread baking. The results summarized in Table 109 show that flour of the red seeded cultivars was slightly darker but not significantly different from flour of the white/amber seeded cultivars. The bread color from the two groups was also similar. The study will be repeated in the coming season to confirm these results.

G. Ortiz Ferrara and F.J. El Haramein

Table 109. Quality characteristics of 20 (10 white seeded and 10 red-seeded) high yielding spring bread wheat lines in advanced wheat yield trials at two locations in Syria, 1988-89.

Characteristic	White/amber seed			Red seed		
	Min	Max	Mean	Min	Max	Mean
Breda:						
1000-kernel weight (g)	22.2	29.2	25.2	20.0	29.1	23.6
Protein (%)	13.5	16.9	15.2	14.8	16.7	15.6
Flour yield (%)	73.0	77.0	74.5	72.0	74.0	73.5
Flour color (K.J.U)	0.10	2.05	0.85	0.40	4.80	1.84
Flour ash (%)	0.52	0.71	0.60	0.51	0.71	0.57
Farinog. stability (min)	3.2	16.5	7.3	3.3	11.8	6.9
Bread color* (score)	4.5	5.0	4.8	4.0	4.5	4.4
Tel Hadya - irrigated:						
Kernel weight 1000	25.5	38.3	32.9	25.1	34.5	30.0
Protein (%)	12.9	14.1	13.1	12.5	13.8	13.2
Flour yield (%)	74.0	77.0	75.5	74.0	77.0	75.0
Flour color (K.J.U.)	-0.30	1.70	0.37	0.0	2.95	1.26
Flour ash (%)	0.56	0.74	0.67	0.59	0.69	0.64
Farinog. stability (min)	3.0	7.5	4.2	2.2	7.0	4.8
Bread color* (score)	4.0	4.5	4.07	3.5	4.5	4.0

* Color for 2 layer-flat bread taken on a scale 1-5: 1 = grey-yellow, 5 = pale to light brown.

3.5. Cereal Grain Quality

3.5.1. Introduction

During the 1989-90 season, the cereal quality laboratory conducted more tests on the use of electrophoresis as an additional aid in grain quality assessment. Table 108 shows the number and type of tests carried out during 1989-90 in the ICARDA cereal quality laboratory for the different types of barley and wheat germplasm. Recently, the Chopin Alveograph was introduced for the purpose of evaluating advanced bread wheat material and for training purposes.

Table 108. Number of tests [1] carried out in the ICARDA cereal quality laboratory, 1989/90, for different projects[2].

Project	ELEC	TKW	VKC	PSI	SDS	YP	GC	FM	FAR	PROT	BAK	TOTAL
Barley	-	1450	-	-	-	-	-	-	-	725	-	2175
W	-	1915	-	1915	-	-	1915	-	-	1915	66	7726
DW	637	2097	2097	-	747	2097	-	-	-	2097	-	9772
W/F	-	1046	472	284	472	-	-	-	-	411	-	2685
FFVT	-	477	195	-	195	195	-	136	136	477	-	1811
Other	-	180	1114	45	1124	1114	-	-	-	2393	-	5970
Total	637	7165	3878	2244	2538	3406	1915	136	136	8018	66	30139

(1)ELEC=Electrophoresis, TKW=1000-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, PROT=protein, BAK=baking. (2) BW=bread wheat, DW=durum wheat, W/F=winter/facultative wheat and barley (high elevation), FFVT=farmer's field verification trials, Other=other ICARDA programs.

F.J. El Haramein and A. Sayegh

3.5.2. Red Wheat Functionality for Baking Two-layer Flat Bread

Traditionally, farmers in countries of West Asia and North Africa prefer wheat with white/amber seed. This tradition has been supported by researchers and decision makers in those national programs. They believe that wheats with red seed color will give bread with dark or undesirable color at high flour extraction (75-80%).

Performance data of red and white/amber bread wheat germplasm tested under both rainfed and optimal conditions, show no difference in grain yield and other agronomic characters. In spite of this, some National Programs in WANA still favor material with white/amber seed. As a result, many bread wheat lines with red seed are not considered and receive little attention by several programs in the region.

During the 1988-89 crop season, we evaluated 10 red-seeded and 10 white-seeded bread wheat lines selected from advanced wheat yield trials. These were chosen on the basis of grain yield across three environments: Tel Hayda - rainfed (250mm), Tel Hadya-supplementary irrigation (350mm), and Breda (160mm). Three checks for each seed color were also included in the trial. The following grain quality parameters were measured on all entries grown at the two locations: grain color, kernel hardness (%), protein content (%), 1000 kernel weight (g), test weight (kg/ha), flour yield (%), flour ash (%), flour color (K.J.), farinograph, and 2 layer flat bread baking. The results summarized in Table 109 show that flour of the red seeded cultivars was slightly darker but not significantly different from flour of the white/amber seeded cultivars. The bread color from the two groups was also similar. The study will be repeated in the coming season to confirm these results.

G. Ortiz Ferrara and F.J. El Haramein

Table 109. Quality characteristics of 20 (10 white seeded and 10 red-seeded) high yielding spring bread wheat lines in advanced wheat yield trials at two locations in Syria, 1988-89.

Characteristic	White/amber seed			Red seed		
	Min	Max	Mean	Min	Max	Mean
Breda:						
1000-kernel weight (g)	22.2	29.2	25.2	20.0	29.1	23.6
Protein (%)	13.5	16.9	15.2	14.8	16.7	15.6
Flour yield (%)	73.0	77.0	74.5	72.0	74.0	73.5
Flour color (K.J.U)	0.10	2.05	0.85	0.40	4.80	1.84
Flour ash (%)	0.52	0.71	0.60	0.51	0.71	0.57
Farinog. stability (min)	3.2	16.5	7.3	3.3	11.8	6.9
Bread color* (score)	4.5	5.0	4.8	4.0	4.5	4.4
Tel Hadya - irrigated:						
Kernel weight 1000	25.5	38.3	32.9	25.1	34.5	30.0
Protein (%)	12.9	14.1	13.1	12.5	13.8	13.2
Flour yield (%)	74.0	77.0	75.5	74.0	77.0	75.0
Flour color (K.J.U.)	-0.30	1.70	0.37	0.0	2.95	1.26
Flour ash (%)	0.56	0.74	0.67	0.59	0.69	0.64
Farinog. stability (min)	3.0	7.5	4.2	2.2	7.0	4.8
Bread color* (score)	4.0	4.5	4.07	3.5	4.5	4.0

* Color for 2 layer-flat bread taken on a scale 1-5: 1 = grey-yellow, 5 = pale to light brown.

4. INTERNATIONAL NURSERIES

4.1. Increase in International Nurseries Since 1977

The increase in numbers of international cereal (barley, durum wheat and bread wheat) nurseries available from ICARDA, Aleppo, to national programs from 1977 to 1989 is presented in Fig. 21. From the initial 10 nurseries, the number rised to 33 in 1988 and 1989.

Since 1978, four basic types of nurseries have been prepared for each of the three crops every year. They are crossing blocks, segregating populations, observation nurseries and yield trials. Different types of nurseries have been prepared in order to cater for the needs of the national programs, which have had different levels of infrastructure and technical expertise.

Because global adaptation may cost the plant some yield sacrifice in different environments, materials with specific adaptation to one major environmental zone are desirable. Besides, nurseries containing more targeted materials and less entries are always preferred by national scientists. Starting from 1983, the observation nurseries, yield trials, and eventually the segregating populations were therefore gradually splitted into those for low rainfall areas, and those for moderate rainfall/supplementarily irrigated areas. The three types of nurseries consisting of winter and facultative types for high elevation areas in West Asia and North Africa were made available for barley in 1985 and for wheat in 1986.

Heat stress is a major problem facing cereal production in the more tropical countries under ICARDA's mandate. In 1986, the Heat Tolerance Observation Nursery was assembled. This was the first specific-trait nursery made available to national programs. With the addition of the Heat and Drought Observation Nursery, and the three germplasm pools for disease resistance, the total numbers of specific-trait nurseries increased to five in 1988.

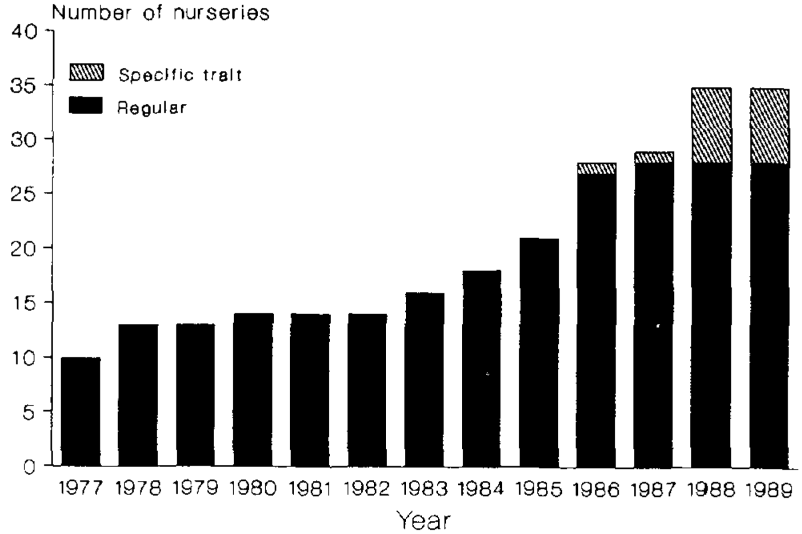


Fig. 21. Number of international cereal nurseries available from ICARDA, 1977 to 1989.

4.2. Types, Numbers and Distribution of Nurseries

International nurseries available for distribution in 1990 are given in Table 110. There were a few changes from last year. One more specific-trait nursery, the Durum Wheat Drought and Cold Tolerance Observation Nursery, was assembled, but the Bread Wheat Yield Trial (High Altitude Areas) was not prepared. The Barley Observation Nursery (High Altitude Areas) was renamed International Winter and Facultative Observation Nursery (IWFVON). The IWFBON was prepared with the cooperation of Oregon State University (OSU), USA, and replaced the International Winter and Facultative Barley Screening Nursery used to be assembled and sent by OSU. The Barley Observation Nursery (Low Rainfall Areas) and the Barley Yield Trial (Low Rainfall Areas) were divided into two: one for the mild winter areas and one for cold winter areas. The three germplasm pools for disease resistance which were first offered last year, were also available.

Table 110. Cereal international nurseries for 1990.

Nursery	Barley	Durum wheat	Bread wheat
Regular Nurseries			
Crossing Block	*	*	*
Segregating Populations			
- Low rainfall areas (LRA)[1]	*	*[5]	*[5]
- Moderate rainfall areas (MRA)[1]	*	*[5]	*[5]
- High altitude areas (HAA)	*	*	*
Observation Nurseries			
- Low rainfall areas (LRA)[1]	*, *[2]	*	*
- Moderate rainfall areas (MRA)[1]	*	*	*
- High altitude areas (HAA)	*[3]	*	*
Yield Trials			
- Low rainfall areas (LRA)[1]	*, *[2]	*	*
- Moderate rainfall areas (MRA)[1]	*	*	*
- High altitude areas (HAA)	*	*	-
Specific-Trait Nurseries			
Bread Wheat Heat Tolerance Observation Nursery			
Durum Wheat Drought and Heat Tolerance Observation Nursery			
Durum Wheat Drought and Cold Tolerance Observation Nursery			
Germplasm Pools for Disease Resistance[4]:			
- Durum Wheat <u>Septoria tritici</u>			
- Bread Wheat <u>Septoria tritici</u>			
- Durum Wheat Common Bunt and Yellow Rust			

[1] LRA & MRA are for lowlands
[2] two sets : one for cold winter areas, and one for mild winter areas
[3] IWFBON
[4] same entries as in 1989
[5] one nursery not divided into LRA and MRA

In 1990, 1027 sets of regular nurseries and 186 sets of specific-trait nurseries were distributed from Aleppo to 104 cooperators in 51 countries upon request. The numbers of sets sent were about the same as those of 1989, but the numbers of cooperators and countries increased. There was a seed shortage, caused by the unusual severe frost experienced in March, and the annually increasing seed requests.

Approximately 70% of all the nursery sets were distributed from Aleppo to countries within the ICARDA region. The number of sets of regular nurseries distributed for barley, durum wheat and bread wheat represented 31%, 32% and 37% of the overall total, respectively. Detailed information on distribution of nurseries for 1990/91 can be found in the booklet "International Cereal Nurseries, List of Cooperators and Nursery Distribution, 1990/91" available from the Cereal Improvement Program. All 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.

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.

4.3. Regression vs Cluster Analyses of Genotypes

The regression analysis made popular by Finlay and Wilkinson, is the most widely used method for quantifying stability. The technique, however, has limitations. The main concern is that a definite model for the expected response function in unnecessary, and may be inadequate or misleading. In rejecting the regression technique, the multivariate cluster analysis was advocated by Mungomery et al. (1974). Instead of measuring stability by a quantitative parameter, genotypes are assigned into qualitative groups based on similarity of responses. Lin et al. (1986) believed that using cluster analysis can avoid the difficulty of the univariate approach.

A study was conducted to compare the regression analysis with cluster analysis in efficacy of explaining the GXE interaction and description of differential responses of elite wheat lines grown in diverse rainfed or supplementarily-irrigated environments. The CIMMYT/ICARDA Regional Bread Wheat Yield Trials were analyzed. Grain yield of the entries (excluding the triticale and national checks) from 14 sites in 1983/84, 25 sites in 1984/85, 24 sites in 1985/86 and 24 sites in 1986/87 in West Asia, North Africa and Mediterranean Europe were used. Before carrying out the regression analysis, the method of Hinz and

Eagles (1976) was followed to find out the appropriate data transformation for reducing the interdependence of site mean yield and error variances, and the range of error variance differences among sites. Only the regression coefficient(b) was considered as the stability measure. A hierarchical, agglomerative and polythetic program was used for the cluster analysis. Data were standarized within each site. Euclidean distance and the average linkage (ie. UPGMA) were employed.

ANOVAs using the transformed data showed that in each season, entry, site, and entry x site effects were highly significant. But the linear regression technique was not helpful in explaining the large GXE in this study. Deviation from regression was significant, but heterogeneity among regressions was not. The latter component accounted for less than 2% of the interaction variances only. When the interactions were regressed against the environmental index, as in Perkins and Jinks (1968), the coefficients of determination were small (r^2= 0.00 to 0.35). For each season, the durum wheat had similar b and r^2 values as the bread wheat entries. Thus it is believed that under the conditions of this study (reduced variability among tested entries, and diverse environments), the linear model was too simple to adequately describe the large deviation from regression.

Using the cluster analysis, nine clusters were formed in 1983/84, eight in 1984/85 and 1985/86, and seven in 1986/87. The durum wheat check was distinct from the bread wheat entries in the four seasons. Though cluster x site, and entries within cluster x site interaction components were both significant, the latter accounted for less than 48% of the total interaction sum of squares. This study showed the usefulness of cluster analysis in explaining the G X E of elite materials grown in diverse environments that cannot be obtained from the regression analysis. A biological interpretation of the results from the cluster analysis on the 1985/86 data is given by Yau et al. (1989).

It is recommended that cluster analysis be used for the investigation of phenotypic responses to different environments among elite lines from a breeding program or when variability among the tested entries has been reduced substantially by selection. Cluster analysis could also complement the commonly used regression analysis when significant differences in the regression coefficient were detected.

References

Hinz, P.N. and H.A. Eagles. 1976. Estimation of a transformation for the analysis of some agronomic and genetic experiments. Crop Sci. 16: 280-283.

Lin, C.S., M.R. Binns and L.P. Lefkovitch. 1986. Stability analysis: where do we stand? Crop Sci. 26:834-900.

Mungomery, V.E., R. Shorter and D.E. Byth. 1974. Genotype x environment interactions and environmental adaptation, I. Pattern analysis - application to soya bean populations. Aust. J. Agric. Res. 25:59-72.

Perkins, J.M. and J.L. Jinks. 1968. Environmental and genotype - environmental components of variability III. Multiple lines and crosses. Heredity 23: 339-356.

Yau, S.K., G. Ortiz-Ferrara and J.P. Srivastava. 1989. Cluster analysis of bread wheat lines grown in diverse rainfed environments. Rachis 8:31-35.

S.K. Yau

5. COLLABORATIVE RESEARCH

Within the framework of the ICARDA global mandate for barley improvement and the CIMMYT-ICARDA joint effort for wheat improvement in WANA, the Cereal Program bases its activities on close collaboration with partner research institutions. These activities focus on barley and wheat improvement in rainfed areas where cereal production is hampered by abiotic and biotic stresses including drought, cold, heat, low soil fertility, salinity, diseases and insect pests.

An important part of Cereal Program research is conducted in Syria, ICARDA's host country, either on ICARDA's stations or in collaboration with Syrian research institutions. Other research activities are conducted in Lebanon and Cyprus. Gradual decentralization of research at ICARDA is facilitated by the establishment of ICARDA-NARS Regional Programs which enable scientists to conduct research in target environments, according with ICARDA's overall breeding strategy.

While research in collaborating countries is carried out by NARS scientists, the Cereal Program's contribution to this collaboration is in the form of back-up technical support, providing of germplasm and information, and covering minor research costs. An important component of Cereal Program resources is allocated to strengthening intercountry scientific links in breeding and breeding-related areas.

Syria

Cereal crops were subjected to drought in most rainfed areas of the country, to prolonged cold during January and February and to late frost in mid-March. In consequence, many barley fields in the driest zone of the country were grazed. Late developing cultivars were less affected by cold and benefitted from late March and April rains.

Advanced barley and wheat lines from the Directorate of Agricultural Scientific Research (DASR) and ICARDA were jointly tested for yield performance and disease resistance in verification trials and large-scale testing plots at 36 sites throughout Syria. Scientists from (DASR) and

ICARDA visited these sites in February and March and participated in an in-country travelling workshop (1-10 May) to observe wheat and barley plots in verification trials and in farmer fields. Promising cultivars included the durum wheats 'Omrabi 5' for Zone A and 'Omrabi 17' for Zone B, the bread wheats 'Douma 9457' for Zone A and 'Nesser' for Zone B, and the barley 'Arta' for Zone B.

Collaborative work included the evaluation of advanced breeding lines from DASR at ICARDA for disease resistance, joint research on wheat ground beetle, evaluation of barley landrace-derived lines, provision of seed and related information for Mashreq project, and training and visits. Eighteen junior researchers attended various training courses at ICARDA. A senior scientist from DASR conducted joint research on durum varietal stability and tolerance to salinity during a 7-month scientific visit to ICARDA and participated in the cereal travelling workshop in Morocco.

Collaboration with Aleppo University included joint supervision of graduate students for MS or Ph.D research and undergraduate students for "graduation projects", and the initiation of a project on integrated control of sunn pest in Syria.

The Program used the Lattakia site to screen germplasm for diseases and acquired a new site at Maadar (1500 m elevation) near Damascus to test winter/facultative cereals for cold tolerance.

Lebanon

Wheat and barley nurseries were grown at Terbol station during the winter for evaluation under favorable conditions, and during the summer for generation advance and screening for vernalization requirement and disease resistance. Plots were irrigated because of very low-rainfall during spring. In summer planting growth was excellent and most nurseries were harvested within 100 days from sowing. Heavy stem and leaf rust infestations appeared in mid-November on late-planted wheat. The frequency of susceptible entries was greater in durum than in bread wheat.

The station was visited by students, researchers and farmers from the Bekaa Valley. Improved seed of cultivars Rihane, Sebou, and Seri 82 was produced, and two students from St. Joseph University were trained in wheat quality and data analysis.

Cyprus

Collaboration within the ICARDA-ARI project on 'Cereal Improvement for Dry Areas' involved joint research and training in barley and durum wheat.

Germplasm from ICARDA was evaluated under the dry conditions of the 1989-90 season at sites receiving between 200 and 300 mm rainfall. The season was particularly dry and hot at grain filling.

Barley germplasm included several hundred entries from ICARDA's international nurseries and from the ICARDA advanced and preliminary yield trials. Lines were selected by ICARDA and ARI staff. The check ER/Apm performed well at Dromolaxia (290 mm of rainfall) and the line Impalia/Julia/Api showed some yield advantage at slightly lower rainfall (260 mm). The cultivar Harmal ranked first in January-planted nurseries. In general, taller genotypes yielded more than short genotypes confirming previous results on the relationship between plant height and yield in dry environments. Segregating barley material from ARI included crosses with wild barley sent to ICARDA for selection under drought or extraction of germplasm for self-regenerating pastures in marginal lands.

Durum wheat germplasm was also exchanged between ARI and ICARDA. Selection in Cyprus emphasized performance under dry mild-winter environments and grain quality. Material exchange included the CIMMYT/ICARDA durum wheat observation nurseries, advanced lines, and crosses made in Cyprus involving local durum landraces, _T_. _dicoccoides_, bread wheat, and high yielding durum cultivars. Among the promising entries selected this year at Cyprus were the lines Omrabi 5, Cit/Sco//Mex and Chen/Altar.

Breeders from ICARDA and ARI exchanged visits and information. The ARI barley breeder and cereal coordinator attended the Eucarpia International Meeting on Fodder Crops (18-22 Nov. 1990 at IAC Wageningen, Netherlands) and lectured at an ICARDA course on barley improvement (3-8 February 1990, Amman, Jordan). The ARI durum wheat breeder visited ICARDA to discuss joint research and attend a workshop on electrophoresis.

Jordan

Collaboration with Jordan included the exchange of wheat and barley germplasm and related information, and training. Jordanian scientists contributed to a regional training course on barley improvement held in Amman. Two graduate students from the University of Jordan (UOJ) conducted MS thesis research in barley or wheat breeding with joint supervision by ICARDA and UOJ scientists.

The bread wheat cultivar 'Nesser' and the barley cultivars 'Arta' and 'Harmal' performed well under low-rainfall in Jordan and several tons of seed of these cultivars were produced by NCARTT in anticipation of future release. A joint meeting is planned for 1991 to review results of past on-farm research and discuss concrete recommendations to improve cereal production in Jordan.

Turkey

Most of the ICARDA-generated winter and facultative wheat and barley germplasm was evaluated at Haymana while selected nurseries were tested at three additional sites near Konya, Ankara and Eskisehir. Winter temperatures at these sites dropped to -20°C with no snow cover, thus providing an excellent test for cold tolerance. Barley was the most seriously damaged crop, followed by durum wheat.

The flow of germplasm between the CIMMYT/ICARDA and the Turkey/CIMMYT projects has increased following the posting of a CIMMYT wheat breeder at ICARDA.

During the season, a senior entomologist from Cukurova University visited the Program to discuss and exchange research information on sunn pest; one senior scientist from Ankara Field Crops Research Institute was sponsored to attend an International Conference on grain quality in Vienna (27 May - 1 June); two students completed their MS thesis research on double haploid production in wheat and three other researchers participated in ICARDA short courses.

Activities planned for 1991 were discussed at the annual Turkey-ICARDA coordination meeting (Ankara, 25-26 October 1990) and included: a) germplasm exchange and testing of ICARDA or CIMMYT/ICARDA material for cold tolerance in Turkey and testing of Turkish material for diseases and drought tolerance at ICARDA; b) joint expedition in cold areas of Turkey to collect winter barley germplasm; and c) joint entomology research.

Iran

Collaboration was maintained in cereal improvement for dry and cold areas within the framework of the current Iran-ICARDA agreement. In 1990, four Iranian researchers attended training courses at ICARDA and a senior scientist visited the Cereal Program in November for 3 months to conduct research on barley and wheat tolerance to cold and heat stress. A new emphasis was placed in Iran on the improvement of cereal production in rainfed areas. Iranian researchers identified high-yielding germplasm and released one bread wheat, 'Falat', and two barley cultivars, 'Kavir' and 'Star.' A delegation of Iranian scientists and officials visited the Cereal Program in conjunction with their visit to ICARDA to sign an agreement for wider collaboration with ICARDA.

Maghreb Regional Program

The Cereal Program continued to assist NARS in the Maghreb in training, germplasm evaluation, and collaboration among scientists. The similarities of environments in the Maghreb and the determination of all parties to work together and share responsibilities has resulted in an effective and viable network of cereal researchers in this region. Network activities were further strengthened by support from an IFAD-funded project on technology transfer, and by a UNDP project on disease surveillance and germplasm enhancement for cereals and food legumes.

Wheat and barley disease and insect surveys were conducted in Algeria, Libya, Morocco, and Tunisia. Germplasm was exchanged through the Maghreb Cereal Observation Nursery (POM). The COM nursery was also grown at several sites in Tunisia, Algeria, Morocco, Libya as well as in Spain, Portugal and Syria to monitor changes in virulences of major cereal pathogens in the region. A travelling workshop in Morocco was attended by scientists from Algeria, Libya, Morocco, Egypt, Syria, Portugal, Spain, Italy, CIMMYT and ICARDA. Research coordinators from Algeria, Libya and

Morocco visited ICARDA during selection time. Coordination meetings were held in each of the Maghreb countries where 1990 results were reviewed and plans of work for 1991 prepared. The Maghreb activities reported hereafter by Dr. M.S. Mekni were conducted by national program staff from each country with support from ICARDA and CIMMYT scientists. Additional information is found in separate annual reports published for each Maghreb country and available upon request.

Algeria

Weather conditions in 1990 were generally unfavorable for cereal production in Algeria. In Sidi Bel Abbas, target area of the ITGC/ICARDA/INRA project (see CP Annual Report 1989), low rainfall (300 mm - 350 mm) coupled with late frost damaged cereal crops in most of the province. In the higher rainfall areas, weeds were a serious problem. Off-station research included the testing of 6 durum wheat varieties, 5 bread wheat varieties and 8 barley varieties. Large scale demonstrations were planted and included improved varieties and production technologies in every agroecological zones. Bread wheat cultivars 'Zidane 89' and 'Nesser', durum cultivars 'Kabir', 'Omrabi 9', 'Sahel', and 'Belikh 2', and barley 'Rihane' and 'Badia' continued to perform well in comparison to older cultivars. Seed for some of these cultivars was delivered to ITGC upon request. Quality seed of improved cultivars is still insufficient to meet NARS needs. Five Algerian researchers visited ICARDA for long or short-term training. ICARDA scientists visited Algeria during the season to participate in planting, note taking and on-site training of junior research staff. During the coordination meeting, it was suggested to decrease the research load on individual research stations and to improve the utilization of resources by a better coordination among the various research stations.

Libya

While rainfall is generally low in Libya and its 660,000 ha of cereals are largely rainfed, irrigated wheat makes a substantial contribution to national production. The 1989-90 season marks the start of closer collaboration between ICARDA and ARC, Libya. A large number of nurseries were requested from ICARDA and CIMMYT and planted in various research stations. A number of entries were selected and will be grown in 1991 for performance verification. A pest survey was conducted which revealed the importance of BYDV, Russian wheat aphid, leaf rust and powdery mildew on wheat and of BYDV, powdery mildew, net blotch and covered smut on barley. Other diseases were less prevalent. Training remained the most significant activity of ICARDA-ARC collaboration in 1990. Six junior researchers received training at ICARDA and 9 others were trained in Libya. Three senior researchers visited ICARDA on an orientation tour to get information on Cereal Program breeding strategies for stress environments. ICARDA outreach or headquarters staff visited Libya for technical support at various times during the season.

Morocco

Favorable growing conditions led to a cereal production exceeding 5.8 million tonnes (M.t) including 2.2 M.t of barley (produced on 2.4 M.ha), 2 M.t of bread wheat (1.4 M.ha) and 1.6 M.t of durum wheat (1.4 M.ha). Widely grown varieties were the same as in the previous season (CP Annual Report 1989).

Moroccan scientists screened indigenous and introduced wheat and barley germplasm for diseases, insect and drought tolerance. Bread wheat lines from crosses NS732/Her and Shi 4414/Crow were found tolerant to Hessian fly and resistant to drought. The highland INRA site of Annaceur was used to test germplasm for cold tolerance during the winter and to speed up generation advance in summer. A travelling workshop in Morocco was attended by scientists from the Maghreb countries, Egypt, Syria, Spain, Portugal, Italy, CIMMYT and ICARDA. Moroccan scientists also participated in diseases and insect surveys in the Maghreb. Emphasis next season will be placed on barley breeding for human consumption, in close collaboration with ICARDA breeders, and on breeding wheat cultivars resistant to Hessian fly, septoria leaf blotch and tan spot.

Tunisia

Drought in 1989-90 was severe in the traditional cereal growing areas of northern and northwestern Tunisia. In contrast, rainfall was relatively good in the large semi-arid areas of central and coastal Tunisia, which contributed significantly to this year's high crop of 1.63 million tonnes (0.90 M.t of durum, 0.22 M.t bread wheat, 0.48 M.t barley and 0.03 M.t triticale). Temperature pattern favored disease development on wheat (e.g. leaf rust, powdery mildew, BYDV, and stripe rust) and on barley (net blotch, powdery mildew, covered smut and BYDV), and insect infestation of both wheat and barley - Hessian fly, Russian wheat aphid and wheat stem sawfly.

Observations this year corroborated those of last year for the cultivars Razzak, Byrsa or Salambo, and Rihane in commercial fields (CP Annual Report, 1989). Promising material selected this year include the durum lines Chen's'/Altar 84, the bread wheat lines Kauz's' and Chilero's' and barley lines Lignee 527/3/Harbing/Avt 3//Aths. The durum selections Omrabi did not perform as expected but the barley selection Deir Alla 106//DL71/Strain 205 performed well despite a high incidence of BYDV and is proposed for release. Pathologists screened breeders' material for major diseases and conducted in-depth studies on scald and net blotch virulence. Emphasis next season will be placed on drought tolerance and on agronomic research for Tunisia's semi-arid areas.

Nile Valley Regional Program

Collaboration between scientists from Egypt, Sudan and Ethiopia increased in 1990. Travelling workshops and annual coordination meetings held once in each country were attended by scientists from all three countries in addition to those from CIMMYT and ICARDA. Such visits enhanced the exchange of germplasm and research results among wheat or barley scientists of the three countries. Research findings for 1990 and plans for 1991 were discussed at the annual national coordination meetings and approval of the plans of work was decided upon by the NVRP Steering Committee Meeting in October 1990 at Addis Ababa.

Egypt

Wheat production in 1990 was estimated at 4.2 million tonnes (M.t) representing 40% self-sufficiency as compared to 3.2 M.t in 1989. Egyptian scientists working with extension staff tested improved production packages in farmer-managed trials in marginal areas of Upper Egypt. Yield increases of 17-63% were achieved using packages involving improved cultivars, adequate sowing, timely irrigation, and control of weeds and aphids. Researcher-managed trials assessed varietal performance under biotic and abiotic stresses. Promising wheat cultivars included Beni Sweif 1, Sohag 2, Sakha 8, Sakha 69, and Giza 164 for drought tolerance and Debeira, Genero 81, and F134-71/Crow's' and Giza 160 for heat tolerance. Barley cultivars Giza 123 and Giza 124 outyielded older cultivars in the low-rainfall areas of the Northwest Coast. The following varieties were released by the National Program in 1990: Gemmeza 1 and Giza 165 (bread wheat), Sohag 3 (durum wheat), and Giza 123 and Giza 124 (barley). Egyptian scientists also identified a number of wheat and Aegilops lines with greenbug resistance for use in crossing programs. Three senior researchers visited ICARDA and 7 junior researchers participated in ICARDA training courses.

Ethiopia

Ethiopian researchers in collaboration with ICARDA scientists tested several land race-derived lines for disease resistance and adaptation in Ethiopia. A SAREC-funded project supporting training in barley research ended in December 1990 and efforts are underway to seek additional funds. Two scientists from IAR visited ICARDA for 2 weeks to analyze data and discuss results of collaborative research with ICARDA scientists. Three junior researchers participated in barley training courses at ICARDA.

Sudan

Favorable policy and adoption of improved technology by farmers led to increased wheat production in 1990 (378,000 tonnes versus 233,000 tonnes in 1989 harvested from 261,000 ha and 177,000 ha respectively).

The increase in production was mainly due to area expansion and only slightly to yield improvement. Low yields were attributed to lack of planting machinery and production inputs, and to biotic and abiotic stresses. In large-scale demonstrations, yields were 50-100 % greater than in farmer fields. Progressive farmers using the improved technology obtained yields of 6 t/ha or more. The advanced lines Vee's' and S948-A-Sel 7 performed well in several areas of Sudan and were submitted for release. Back-up research emphasized the development of germplasm with high and stable yield and tolerance to heat which remains the major abiotic stress in the Sudan. Weeds, aphids, and diseases are important research topics in 1990 and 1991.

Two scientists (a breeder and an entomologist) visited ICARDA for 2 months and one scientist attended an international symposium on Russian wheat aphid in the USA. Four junior researchers attended training courses at ICARDA.

Collaboration with Other Institutions

Barley and wheat nurseries were sent to Arabian Peninsula countries for selection by NARS under drought, heat or salinity conditions. Trainees from Oman and Yemen attended cereal improvement courses at ICARDA while ICARDA staff participated in an in-country course and a travelling workshop in Oman and in an international conference on "High-Salinity Tolerant Plants in Arid Regions" held in UAE.

Collaboration with China was strengthened with the visit of Prof. Shu Zhong Luo, barley coordinator in China and vice-chairman of the Chinese Barley Commission. Prof Luo spent 3 and a half months as a visiting scientist to the Cereal Program and discussed various aspects of collaboration with ICARDA, including the joint organization of a barley conference in 1992. Barley scientists were informed of the good performance of ICARDA germplasm (e.g. Api/CM67//Emir/Nacta/3/MGH/G 355/4/Lignee 686) in Shanxi, Yencheng and Jiangsu provinces.

Scientists from India visited the Cereal Program for orientation and discussion of research topics of mutual interest e.g. breeding, pathology, entomology and selection of barley and wheat germplasm.

Links with USSR were strengthened with the exchange of visits between USSR and Cereal Program scientists. A senior scientist from Saratov Research Center (Elita Povolzhie) visited the Program for 6 months to undertake collaborative research in durum wheat with emphasis on drought tolerance and grain quality.

Collaborative research was also continued with Italy in barley and durum wheat breeding; with France on durum wheat physiology and biotechnology: with Montana State University (MSU) and Oregon State University in barley breeding and biotechnology; with the University of Wageningen in barley breeding and physiology, and with the University of Hohenheim in barley breeding. Results of these collaborative efforts are reported elsewhere in this report.

In connection with the ICARDA-MSU project on Barley Diseases and Associated Breeding Methodologies, a symposium entitled "Biotic Stress of Barley in Arid and Semi-Arid Environments" was held in Big Sky, Montana 31 July - 2 August 1990. In attendance were scientists from the USA, Canada, UK, Denmark, Tunisia, Morocco, Italy, Netherlands and ICARDA.

H. Ketata

6. TRAINING AND VISITS

Specialized intensive training continued to gain strength in 1990 although the long-term course still appeals to National Programs in WANA. Four short headquarters courses and three outreach courses were conducted in addition to the long-term residential course and individual degree- and non degree training. A total of 147 trainees (including 22 females) participated in Cereal Improvement Program training activities during 1990 (Table 111) and in addition, over 150 students and researchers from different countries visited the Program for short or longer periods.

Table 111. Number of participants in various training courses 1979-90.

Year	Type of training: Residential (long-term)	Individual: Non-degree	Individual: Degree	Short*	In-country*
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)
1990	20	23	13	44 (4)	47 (3)

* Number of courses in parentheses

6.1. Headquarters Short Courses

Four specialized courses were offered during 1990, three of which were joint courses with other ICARDA Programs.

Biometrical Techniques for Cereal Breeders

ICARDA scientists from both the Cereal Improvement Program and Computer Services conducted a course on "biometrical techniques for cereal breeders" during 14-22 February 1990 at Tel Hadya. The course reviewed the major experimental designs used by cereal breeders and covered topics on heritability, genotype-environment interaction, varietal stability and other genetic and environmental factors affecting selection efficiency. Part of the schedule was devoted to computer applications. The majority of participants were breeders (Table 112).

Cereal Disease Methodologies

Fourteen trainees from 9 countries (Afghanistan, Algeria, Egypt, Libya, Morocco, Oman, Saudi Arabia, Syria and Yemen) participated in this course during 20 March - 4 April at ICARDA. Instructors included four scientists from ICARDA and one scientist from CIMMYT. The course focused on techniques and methods of assessing disease resistance of cereal germplasm and covered lectures (on epidemiology, diagnosis, scoring, and breeding for disease resistance) laboratory sessions and field visits to research sites in Syria.

Table 112. List of participants in the course "biometrical techniques for cereal breeders", 1990.

Name	Title	Degree	Country
Mr. Hamenna Bouzerzour	Breeder	BS	Algeria
Mr. Mohamed El Hadi Maatougui	Breeder	MS	Algeria
Mr. Assad Ahmed Hamada Ahmed	Breeder	MS	Egypt
Mr. Hossein Amiri	Breeder	MS	Iran
Mr. Fahed Saleh Khatib	Breeder	BS	Jordan
Mr. Ziad Mohamed Hallak	Breeder	BS	Syria
Mr. Gharbi Mohamed Salah	Breeder	MS	Tunisia
Mr. Mohsen Gharbi	Biometrician	MS	Tunisia
Mr. Sevket Kara	Breeder	BS	Turkey

Due to continued demand from national programs, the course will be also offered in 1991.

Insect Control in Food Legumes and Cereal Crops

This course, offered jointly by the Food Legumes and the Cereal Improvement Programs for the second year, was conducted during 9-19 April at ICARDA. Similar to last year (CP Annual Report, 1989. p. 194), the course curriculum included epidemiology and identification of insect pests, scoring of insect infestation, integrated pest management and breeding for insect resistance. There were 13 participants from 11 countries including Afghanistan, Egypt, Ethiopia, Morocco, Libya, Sudan, Syria, Turkey, Tunisia, UAE, and Yemen. Because of it success and the increased demand from national Programs, the course will be offered again in 1991.

Use of Electrophoresis in Cereal Improvement

Within the framework of collaboration between Italian research institutions and ICARDA, a training course on "use of electrophoresis in cereal improvement" was presented on 15-25 October 1990 at ICARDA jointly by the University of Tuscia, Viterbo (Italy), Cereal Improvement Program and Genetic Resources Unit of ICARDA. The course dealt with theoretical and practical aspects of electrophoresis in general and cereal seed proteins in particular. Among topics covered were: techniques of gel casting for wheat and barley; horizontal versus vertical electropheretic systems; SDS-PAGE; RFLPs; use of electrophoresis in taxonomy, genetic variability, and grain quality studies. Over half of the schedule was devoted to practical training where participants used the equipment themselves and discussed the results of analysis with the instructors. To enable effective practical training using 3 available sets of electrophoretic equipment, only a limited number of trainees (Table 113) were accepted to participate in the course. That the course was successful was expressed by both instructors and training participants.

Table 113. Participants in the course "use of electrophoresis in cereal improvement", 1990.

Participant's name*	Title	Qualification (degree)	Country
Dr. Mohamed Moualla	Professor/breeder	PhD	Syria
Dr. Hassan Ghazal	Professor/breeder	PhD	Syria
Dr. Constantine Josephides	Breeder	PhD	Cyprus
Ms. Shaheena Yasmin	Grain technologist	MS	Pakistan
Ms. Zeyneb Denner	Research assistant	BS	Turkey
Mr. Niazali Sephvand	Breeder	BS	Iran

* Two research assistants from ICARDA (Ms. Annette Sayegh and Mr. Haytham Altunji) also attended the course.

6.2. In-Country and Regional Courses

Mashreq

Within the framework of the UNDP/AFESD/ICARDA Machreq project on Barley, Pastures and Sheep, a subregional course on "techniques and methodologies of barley improvement" was held on 3-8 February 1990, in Amman, Jordan. Participants were three researchers from Iraq, four from Jordan and three from Syria; two invited trainees from Egypt also attended. The course, taught by 13 instructors from ICARDA and Jordan, was at a workshop level and included lectures, discussions and field visits. Several breeding and agronomy topics were covered and particular emphasis was placed on yield improvement in low rainfall areas, utilization of barley as a feed crop and technology verification and adoption. The course was well received by participants as judged from their comments and the results of pre- and post- course evaluation.

Libya

An in-country course on "crossing techniques and note taking in cereals" was conducted during 27 February- 4 March 1990 in Tripoli, Libya. Participants were 9 researchers/technicians from Libya and two instructors from ICARDA. Most of the schedule was devoted to practical training on techniques of crossing wheat or barley and on agronomic scoring of field plots at research stations. Although the course met its objectives, it was suggested to complement it with a future course on breeding, agronomy, pathology, entomology, and on-farm research.

Ecuador

A regional (Latin America) course on "barley improvement with an emphasis on disease resistance" was conducted on 2-9 May 1990 at Quito, Ecuador, in collaboration with INIAP (Ecuador), CIMMYT, and Montata State University (MSU). Participants were 13 researchers from Ecuador, 6 from Peru, 3 from Columbia, 2 from Bolivia, 2 from Argentina, and 6 instructors from ICARDA, CIMMYT and MSU. It was a workshop type course and included country presentations on barley research and production in the Andes, lectures on barley diseases and breeding for disease resistance. A two-day field visit was made to Pasto, Columbia where participants had the opportunity to discuss and observe diseases and other problems in farmers' fields. This was the first opportunity for barley researchers in Latin American countries to meet and discuss research issues of common interest. It was suggested that ICARDA further pursue its efforts to support barley research in Latin America where barley plays an important role in the diet of rural communities.

6.3. Individual Training

Twenty three trainees from 12 countries spent periods varying from 1 week to 4 months of training in barley or wheat breeding or related topics totaling 19 person-months (Table 114). Several participants also attended specialized group courses prior to or after the individual training.

Table 114. Specialized individual non-degree training at the Cereal Improvement Program, ICARDA, 1990.

Subject	No. of participants	Duration	Country
Barley breeding	1	4 months	Ethiopia
	1	10 weeks	Syria
Barley pathology	1	2 months	Syria
Cereal improvement	1	1 week*	Algeria
	1	1 week*	Morocco
	1	1 week**	South Korea
	1	1 week*	Turkey
Wheat crossing/selection	2	5 weeks	Sudan
Wheat breeding	1	2 weeks*	Tunisia
Cereal pathology	1	1 week*	Afghanistan
	1	2 weeks*	Algeria
Biotechnology	2	2 weeks***	Turkey
	1	3 months	Syria
	1	2 weeks	Egypt
Data analysis/computer applic.	1	2 weeks	Libya
	1	2 weeks	Syria
Grain Quality	1	2 weeks	Algeria
	2	1 week	Lebanon
	1	2 weeks	Libya
	1	2 weeks	Morocco
	1	2 weeks	Yemen

* Also attended a short course. ** GRU trainee. *** As part of MS research.

6.4. Long-term Course

The long-term residential course continued to form the backbone of cereal training as shown by continuing demand from NARS. This year twenty trainees from 12 countries (Table 115) attended the course. Topics continued to be centered around breeding including breeding-related disciplines of pathology, entomology, grain quality, tissue culture, seed production and experimental design. Most of the schedule was devoted to practical on-job training, making less acute the problem of the English language capacity for communication with trainees. Participants were

Table 115. List of participants in the long-term (residential) training course 1 March - 30 June, 1990.

Participant's name	Country	Topic
Mr. El Hala Mohamed Habibeche	Algeria	Durum wheat breeding
Mr. Kenzi Lyamine Hassous	Algeria	Barley breeding (high elevation)
Mr. Fanggi Guo	China	Barley breeding
Mr. Mahfouz Abdel Hamid Mahmoud	Egypt	Barley breeding
Mr. Hussein Mohamed Mahmoud Zaied	Egypt	Bread wheat breeding
Mr. Salah El din Abdel Halim Ali	Egypt	Durum wheat breeding
Mr. Wondafrash Mulugeta Kabtiymer	Ethiopia	Barley breeding
Mr. Akbar Ghandi	Iran	Bread wheat breeding (high elevation)
Mr. Hussein Akbari Moghadam	Iran	Bread wheat breeding (high elevation)
Mr. Darwish Abbas Noureddine*	Lebanon	Cereal improvement/ seed production
Mr. Mahamed Mansour Wahiba*	Libya	Barley breeding
Mr. Salah El din Ghariani	Libya	Durum wheat breeding
Mr. Lahoucine Hamouch	Morocco	Barley breeding
Mr. Mohamed Marah	Morocco	Cereal pathology
Mr. Ahmed Jamaan Al Marhoon	Oman	Cereal physiology/agronomy
Mr. Ali Zakaria Babiker	Sudan	Cereal physiology/agronomy
Mr. Ali Haydar Abo Racho*	Syria	Durum wheat breeding
Mr. Bade'e Haddou Wardeh	Syria	Durum wheat breeding/ seed production
Mr. Maurice Hanna Kourye	Syria	Bread wheat breeding
Mr. Riad Ahmed Mohamed	Yemen	Bread wheat breeding

* AOAD sponsored trainee.

generally very satisfied and all demonstrated acceptable participation in the various activities throughout the duration of the course. Mr. Salah Eddin Ghariani from Libya received the Outstanding Trainee award for 1990.

6.5. Graduate Research Training

Several students completed their research at ICARDA during 1989-90, (CP Annual Report, 1989) two of whom have already graduated (Hani Ghoshe and Haytham El Sayed). New students supported by the Cereal Improvement Program are listed in Table 116.

Table 116. Students supported by the Cereal Improvement Program, 1990.

Name[1]	Degree	Research area	Country	ICARDA support
Adnane El Yassin	MS	Barley breeding	Jordan	Financial and technical
Shamsuddin Siddiqui[2]	MS	Wheat breeding	Afghanistan	Technical
David Klein	Ir.[3]	Barley breeding/ physiology	Netherlands	Technical
Erik Jansen	Ir.[3]	Barley physiology	Netherlands	Technical

1 New students; other students are listed on p. 199 of CP Annual report, 1989.
2 Enrolled at University of Jordan with FAO financial support.
3 Ingenieur degree, as awarded by Wageningen University.

6.6. Visits

More than 150 visitors came to the Cereal Improvement Program for orientation about Program activities or to discuss collaborative research with Program scientists. Visitors included students, researchers and Officials from Syria, India, Iran, USSR, Morocco, Algeria, Libya, Ethiopia, CIMMYT and FAO. In addition, several research scientists visited the Program for longer periods and worked with their ICARDA colleagues on research topics of mutual interest (Table 117). These visits were particularly useful for strengthening the scientific links with collaborating scientists.

Table 117. Visiting scientists to the Cereal Improvement Program, 1990.

Scientist's name	Country	Duration of visit	Research area
Mr. Ali Shehata	Syria	7 months	Durum wheat breeding
Mr. Brehane Lakew	Ethiopia	2 weeks	Barley pathology
Mr. Yitbarek Semane Mebrate	Ethiopia	2 weeks	Barley pathology
Prof. Luo Shu Zhong	China	3½ months	Barley breeding
Dr. Nabil Suleiman Hanna	Egypt	2 months	Cereal physiology
Dr. Fathi Faraj El Sayed	Egypt	1 month	Bread wheat breeding
Dr. Maher Noaman	Egypt	1½ month	Barley breeding
Dr. Abdel Gader Bushara	Sudan	2 months	Cereal entomology
Dr. Abdel Wahab Abdalla	Sudan	2 months	Bread wheat breeding
Dr. Nikolai Vassilchuk	USSR	6 months	Durum wheat breeding
Dr. J.B.L. Mathur	India	2 weeks	Wheat breeding
Dr. Asha Shivpuri	India	2 weeks	Barley pathology
Dr. V.S. Singh	India	2 weeks	Cereal entomology

H. Ketata

7. PUBLICATIONS

Journal Articles

Berdahl, J.D., Hewitt, G.B. and Miller, R.H. 1990. Recurrent phenotypic selection for low grasshopper food preference in rangeland alfalfa. J. Range Mgmnt. 43: 216-219.

Inagaki, M. and Tahir, M. 1990. Comparison of haploid production frequencies in wheat varieties crossed with Hordeum bulbosum and maize. Japan. J. Breed. 40: 209-216.

Katlabi, H. and Miller, R.H. A survey of wheat stem borer, Oria musculosa Hubner (Lepidoptera: Noctuidae) in Syria (1983-1987). Arab J. Plant. Prot. (in press).

Lashermes, P., Engin G. and Ortiz-Ferrara G. 1990. Anther culture of wheat adapted to dry areas of West Asia and North Africa. J. Genet. & Breed. (in press).

Mamluk, O.F., Al Ahmed, M. and M.A. Makki. 1990. Current status of wheat diseases in Syria. Phytopath. Med. 29: (in press).

Miller, R.H. and Onsager, J. Grasshopper and plant quality relationships in grazed pastures. Env. Ent. (in press).

Ozdemir, E., Inagaki, M.N. and Tahir, M. 1990. Effect of alien cytoplasms on wheat haploid production through crosses with Hordeum bulbosum. Cereal Res. Comm. 18(3): 185-189.

Yau, S.K., Ortiz-Ferrara, G. and J.P. Srivastava. 1991. Classification of diverse bread wheat growing environments based on differential yield responses. Crop Science 3(2): (in press).

Yau, S.K. 1991. Need of scale transformation in cluster analysis of genotypes. J. Genet. & Breed. (in press).

Conference Papers

Acevedo, E., Nachit, M. and Ortiz Ferrara, G. 1990. Selection tools for heat tolerance in wheat - Potential usefulness in breeding. In : Proceedings of the International Symposium on Wheat for the Non Traditional Warmer Areas. July 29 - August 3, 1990. Iguazu Falls, Brazil. (in press).

Ceccarelli, S., 1990. Selection for specific adaptation or wide adaptability. Proceed. of the International Symposium on "Improving Winter Cereals under Temperature and Salinity Stresses". Cordoba (Spain), 26-29 October, 1987 (in press).

Ceccarelli, S. and van Leur, J.A.G., 1990. ICARDA activities in developing barley germplasm. Symposium on 'Biotic Stresses of Barley in Arid and Semi-Arid Environments' Big Sky, Montana, 1990 (in press).

Grando, S., Baha El-Din, J., Balleh, A. and Jajan, F., 1990. Evaluation and selection of lines from Syrian barley land races. 39th Science Week, November 3-8, 1990, Damascus, Syria.

Lashermes, P. 1990. Screening for stress tolerant genotypes via microspore in vitro culture. In : Physiology/breeding of winter cereals for stressed Mediterranean environments, International Symposium. INRA, France. (in press).

Mamluk, O.F., Haware, M.P., Makkouk, K.M. and Hanounik, S.B. 1989. Occurrence, losses and control of important cereal and food legume diseases in West Asia and North Africa. In : Proceedings of the 22nd International Symposium on Tropical Agriculture Research. P. 131-140. 25-27 August 1988. Kyoto, Japan.

McGee, R. and Grando, S. 1990. Future of land Races. Symposium on 'Biotic Stresses of Barley in Arid and Semi-Arid Environments' Big Sky, Montana, 1990 (in press).

Miller, R.H., Yousef, G.S., Shafi Ali, A.M., and El Sayed, A.A. 1990. Host-plant resistance to aphids in three Nile Valley Countries. In: Proc. Int. BYDV Workshop. November, 1990. Rabat, Morocco. (in press).

Mossad, M.G., Abdel Shafi Ali, A. and Miller, R.H. 1990. Aphid damage and resistance in wheat in Egypt. In : Proc. Int. BYDV Workshop. November, 1990. Rabat, Morocco. (in press).

Ortiz Ferrara, G. 1990. Bread wheat in the semi-arid Mediterranean environments: status and breeding strategies. In : Proceedings of the International Symposium on Rainfed Cereals. May 2-6, 1990. Tunis, Tunisia. (in press).

Ortiz Ferrara, G., Curtis, B.C., Saunders, D.A., and Hobbs, P.R. 1989. Wheat: a complementary crop for traditional rice-growing countries of Asia. In : Proceedings of the International Symposium "Rice Farming Systems: New Directions". P. 255-263. Jan. 31 - Feb. 3, 1987. Sakha, Egypt.

Pike, K.S., Tanigoshi, L.K., Miller, R.H., and Bushman, L.L. 1990. Exploration in Morocco, Jordan, Syria, and Turkey for Russian wheat aphid and its natural enemies. In : Proc. 4th Ann. Russian Wheat Aphid Conf. Bozeman, USA. (in press).

Thompson, E.F. and Ceccarelli, S., 1990. Progress and future direction of applied research on cereal straw quality at ICARDA. Workshop on "Production and Utilization of Lignocellulosics: Plant Refinery and Breeding, Analysis, Feeding to Herbivores and Economic Aspects. Reggio Emilia, 16-19 Maggio 1990 (in press).

van Leur, J.A.G. and Ceccarelli, S., 1990. *Subsistence-farmer strategies* in response to drought and biotic stress uncertainty. Symposium on 'Biotic Stresses of Barley in Arid and Semi-Arid Environments' Big Sky, Montana, 1990 (in press).

Weigand, F. and Lashermes, P. 1990. ICARDA's strategy for biotechnology: objectives, organizational structure and areas of research. International Symposium. Options Mediterraneennes. (in press).

Reports and other publications

Cereal Improvement Program. 1990. Annual Report for the International Barley Nurseries, 1988-89. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1990. Annual Report for the CIMMYT/ICARDA Regional Durum Wheat Nurseries, 1988-89. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1990. Annual Report for CIMMYT/ICARDA Regional Bread Wheat Nurseries, 1988-89. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1990. International Cereal Nurseries. List of cooperators and Nursery Distribution 1990-91. ICARDA, Aleppo, Syria.

Inagaki, M.N. and Tahir, M. 1990. Effect of silver nitrate on callus induction and plant regeneration in wheat. Rachis 9(2): (in press).

Pecetti, L., Mamluk, O.F., Damania, A.B. and Srivastava, J.P. 1990. Variability in a world collection of durum wheat for reaction to yellow rust and common bunt. Rachis 8: 8-11.

Yau, S.K., Ortiz Ferrara, G., and Srivastava, J.P. 1989. Cluster analysis of bread wheat lines grown in diverse rainfed environments. Rachis 8(2): 31-35.

Yau, S.K., and Srivastava, J.P. 1989. Demand on ICARDA and ICARDA/CIMMYT international nurseries over the last ten years. Rachis 8(2): 41-42.

Yau, S.K., and Ketata, H. 1990. Types, numbers, and distribution of ICARDA and CIMMYT/ICARDA cereal international nurseries. Rachis 9(2): (in press).

8. STAFF LIST

Dr. Habib Ketata	Senior Training Scientist/Breeder and Acting Program Leader
Dr. Edmundo Acevedo[1]	Cereal Physiologist/Agronomist
Dr. Salvatore Ceccarelli	Barley Breeder
Dr. Byrd C. Curtis	Wheat Breeder - Liaison, CIMMYT/ICARDA (CIMMYT)
Dr. Ardeshir B. Damania[2]	Wheat Germplasm Specialist
Dr. Guillermo Ortiz Ferrara	Bread Wheat Breeder (CIMMYT)
Mr. Masanori Inagaki[3]	Senior Researcher (Japan)
Dr. Philippe Lashermes	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[5]	Durum Wheat Breeder (CIMMYT)
Dr. Mohamed Tahir	Cereal Breeder
Dr. Hugo Vivar	Barley Breeder
Dr. Stefania Grando	Research Scientist (Barley)
Mr. Issam Naji	Agronomist
Dr. Sui K. Yau	International Nurseries Scientist
Dr. Ahmed Zahour[6]	Visiting Scientist/Barley breeder
Mr. Mohamed Assad Mousa	Research Associate
Mr. Luciano Pecetti[7]	Research Associate
Mr. Abdul Jawad Sabouni	Training Assistant
Mr. Michael Michael	Research Assistant
Mr. Nicolas Rbeiz	Research Assistant (Terbol)
Mr. Antointe Pierre Asbati	Research Assistant
Mr. Fuad Jabi El-Haramein	Research Assistant

Mr. Adonis Kourieh	Research Assistant
Mr. Mohamed Mushref	Research Assistant
Mr. Munzer El-Naimi	Research Assistant
Mr. Riad Sakkal	Research Assistant
Mr. Rizkallah Abed	Research Assistant
Mr. Mazen Jarrah	Research Assistant
Mr. George Kashour	Research Assistant
Mr. Henry Pashayani	Research Assistant
Mrs. Anette Sayegh	Research Assistant
Mrs. Sonia Sultan	Research Assistant
Mr. Haytham Kayali	Research Assistant
Mr. Mohamed Ziad Alamdar	Senior Research Technician
Mr. Mohamed Azrak	Senior Research Technician
Mr. Zuhair Murad	Senior Research Technician
Mr. Mufid Ajami	Research Technician
Mr. Adnan Ayyan	Research Technician
Mr. Mohamed Izzat Ghannoum	Research Technician
Mrs. Suzan Khawatmi	Research Technician
Mr. Amir Makki	Research Technician
Mr. Omar Muhandess	Research Technician
Mr. Ahmed Obaji[8]	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
Mr. Riad Lutfi	Research Technician
Mr. Abdalla Steif Abdalla	Assistant Research Technician
Ms. Gisele Dadour[9]	Assistant Research Technician
Mr. Hassan El-Khatib	Assistant Research Technician (Terbol)
Mr. Michael Abu Naked	Assistant Research Technician (Terbol)

Mr. Asaad Ahmed Jasem	Labour Foreman
Mr. Obeid El-Jasem	Farm Labourer
Mr. Ali Zahlout	Farm Labourer/guard (Lattakia)
Ms. Rita Nalbandian	Program Secretary
Ms. Samira Maksoud	Secretary
Ms. Nahed Sammani	Secretary
Ms. Najla Nakeshbandi	Secretary

Research Fellows

Mr. Renato D'Ovidio[10]	Durum Wheat (Viterbo)
Mr. Rudi Petti	Barley (Perugia)
Ms. Antonella Grillo	Barley (Perugia)
Ms. Aatika Mihamou	Biotechnology (Paris)

---

1) Left the Program, May 1990.
2) Moved to GRU, January 1990.
3) Left the Program, June 1990.
4) Returned from sabbatical, September 1990.
5) Left for sabbatical, August 1990.
6) Deceased, July 1990.
7) Left the Program, June 1990.
8) Left the Program, July 1990.
9) Left the Program, November 1990.
10) Left the Program, November 1990.

المركز الدولي للبحوث الزراعية في المناطق الجافة
ايكاردا
ص. ب. 5466 ، حلب ، سورية

INTERNATIONAL CENTER FOR AGRICULTURAL
RESEARCH IN THE DRY AREAS
Box 5466, Aleppo, Syria

ICARDA-198/1300/Feb 1991