ICARDA-145 En

CEREAL IMPROVEMENT PROGRAM

Annual Report 1988

ICARDA

CEREAL IMPROVEMENT PROGRAM

Annual Report 1988

International Center for Agricultural Research in the Dry Areas

P.O. Box 5466, Aleppo, Syria

CONTENTS

1. Program Overview

The diverse projects carried out by the Cereal Improvement Program were oriented towards assisting national programs to increase productivity and yield stability of barley, durum wheat, and bread wheat, particularly in rainfed areas. The commodity focus of projects within the Program was maintained, but the importance of the unique farming systems present in WANA were considered as each project was formulated. One of the Program's strong points is the multi-disciplinary approach employed in cereal improvement. Breeding, agronomy, crop physiology, pathology, entomology, grain quality, biotechnology and interaction with national programs are welded together into an integrated team. In addition, other ICARDA programs such as the Genetic Resources Program, the Farm Resource Management Program, the Food Legume Improvement Program, and Computer Services contributed in various ways to the Cereal Program's research effort.

A major 1987/88 activity for the Cereal Program, as well as for the rest of ICARDA, was the second evaluation by an external review panel called in TAC terminology the External Programme Review (EPR). Over the past year a select panel of TAC appointed scientists examined the Program's activities, achievements and projections. Their review effort culminated in an intensive series of discussions at Tel Hadya in June 1988 with scientific and management staff. We in the Cereal Program greatly appreciated this opportunity to review in-depth our activities and to receive constructive suggestions for further endeavors. We were especially gratified that the panel recognized the full sweep of Cereal Program contributions to cereals research and training, encouraging staff and management to continue for the most part in the direction already charted. We have embraced the EPR panel's major recommendation to define and strengthen our current collaborative project with CIMMYT with the aim of providing NARS with the benefits of two complementary international centers. A new agreement has subsequently been reached between ICARDA and CIMMYT for collaboration in cereal improvement in the WANA region. The agreement will allow the efficient use of CGIAR resources for increased benefit to NARSs. The agreement includes the posting of a third CIMMYT wheat scientist at ICARDA and the implementation of a new system of wheat germplasm distribution in WANA. Wheat germplasm derived from ICARDA Aleppo, and CIMMYT, Mexico, will be pooled in joint screening nurseries to be distributed from ICARDA to NARSs in WANA.

The major achievements of the Cereal Program in 1987/88 are highlighted hereafter.

-The Program continued to refine breeding philosophy and approach based on the idea that germplasm for specific stresses is difficult to identify unless the material under selection is exposed to those stresses. Among the findings of the Program were: 1) selection progress can be made even in harsh environments, 2) the identification of physiological and morphological traits associated with higher yields under stress conditions, and 3) water use efficiency can be both genetically and agronomically manipulated.

-Selection techniques and methodologies were developed and refined. Examples are the different time of sowing used to expose material under selection to different stresses at different phonological stages and the increased use of experimental designs better suited to handle environmental variation. Another example is the use of multi-location testing and selection to identify suitable genotypes for different environments and to develop genetic material with increased yield and production stability.

-In meeting the challenge of harsh environments the Program increasingly used landraces and wild relatives, with a strong focus on the preservation and utilization of their variability. New accessions of Hordeum spontaneum were evaluated, some of which hold promise for stressed environments. Efforts on evaluation, documentation, and utilization of durum landraces and primitive forms of wheat expanded to cover wild relatives of wheat such as Aegilops and other members of Triticeae. Selected trait-specific germplasm of durum wheat was provided to evaluators in national programs through a network of cooperating institutions.

-The effectiveness of CP breeding strategies were proven by the increasing frequency of germplasm selection by NARS for different agroecological conditions and farming systems, particularly in WANA. Approximately 32 barley, 26 durum wheat, and 30 bread wheat varieties are known to have been released by NARS by using CP germplasm (Table 1). The release of Cham 3 (Korifla), a durum wheat identified by Syria as an improved variety for the B zone where a locally adapted landrace, Haurani, has been successfully grown for many centuries, was a major achievement and indicates the success of CP breeding philosophy for severely stressed environments.

-During 1987/88, stress physiology research was considerably strengthened with the objective of supporting breeding programs in selection methodologies for abiotic stresses. Work on gas-exchange of barley and wheat genotypes under drought consistently showed that barley has a higher water use efficiency than wheat. A strong positive correlation between C-13 discrimination and yield was found for barley genotypes grown under severe stress. This technique is being further assessed as a screening tool for cereal improvement in dry areas. An international symposium, "Improving Winter Cereals Under Temperature and Salinity Stresses," October 26-27, 1987 was organized in Cordoba, Spain.

-The evaluation of about 2500 barley genotypes in three contrasting environments confirmed for the third consecutive cropping season that there may be a trade off between yield potential in favorable conditions and yield under stress conditions. The breeding strategy followed by the barley project, which is based on different plant characteristics for stress and moderately favorable conditions, has therefore been consolidated.

-Results in durum wheat breeding showed that drought tolerance can be improved without reducing yield potential. Under dry conditions, a longer peduncle length appeared to be a desirable trait. In bread wheat breeding, the use of a modified bulk method coupled with multilocation testing allowed a strong selection pressure for disease resistance in early segregating generations. As a result the level of stem rust and yellow rust resistance in advanced lines has been considerably upgraded.

-Work on haploid breeding using anther culture and the H. bulbosum technique was initiated in collaboration with advanced institutions in France and Japan. Facilities for in vitro techniques were developed. An H. bulbosum nursery initially comprised of 206 accessions was established.

-A breeding technique based on primordium development and other screening methods for cold and drought tolerance was developed to generate improved germplasm for high altitude areas. An International Symposium on Winter Cereals and Food Legumes Production in High Elevations Areas of West and Southeast and North Africa was held at Ankara, Turkey in July 6-10, 1987. National program participants from countries with major high altitude areas agreed to develop and participate in a network of cereal improvement for such areas.

-Several barley and wheat germplasm pools resistant to a major disease, such as yellow rust, bunt, septoria or scald were developed. Genotypes with multiple disease resistance were identified and made available to NARS. Seedling screening techniques were developed to detect partial resistance to scald and barley leaf stripe. Work on seedling screening for disease is being expanded with the availability of controlled environment chambers.

-Genetic stocks possessing resistance to wheat stem sawflies, aphids and Hessian fly were assembled for use in crossing programs. Networking efforts with national program scientists in the Nile Valley, North Africa, Sub-Saharan Africa, and West Asian countries were improved.

-The evaluation of quality parameters (for food, feed, and straw) was considerably refined and strengthened. Methodologies were standardized and made available to NARS.

-The demand for international nurseries continued to increase as the quality and types of nurseries substantially improved over the last five seasons. Nursery reports became more sophisticated and informative, and were made available to the cooperators much earlier than before. Promising lines nominated by national scientists were included in observation nurseries for the first time. Cluster analysis and regressions were carried out on grain yield data from regional yield trials to further aid breeders target their varieties to specific environments.

-During the season, ICARDA cereal scientists trained over 150 national program participants in specialized short courses, individual non-degree or graduate research training, and in in-country and residential courses. In addition, scientists from the region visited the Program for various periods. During the last five years, over 400 NARS researchers participated in various cereal training courses. As a result of these training activities, national scientists are increasingly becoming partners in research and technology transfer, and there is an increasing rate of adoption of our research products, i.e. methodologies, techniques, and germplasm, by NARS.

-The Program developed subregional networks that concentrate on problems unique to each subregion. Such networks develop leadership and responsibility in the national programs and foster a collaborative atmosphere among them and with ICARDA. For example, Cyprus is taking the lead in identifying early barley and durum wheat lines for areas with mild winters and low rainfall. Egypt assumes specific responsibility for identifying aphid resistant germplasm, and Turkey is capable of assuming greater responsibility in high elevation cereals research. North African, West Asian, Nile Valley, Arabian Peninsula and highlands regional networks were initiated or strengthened.

-There was a marked increase in CP publications, and increased requests for Program Scientists to contribute to international conferences. The Program itself organized several workshops and international symposia. As a result there is an increasing international recognition of CP's scientific contributions in WANA and in the scientific community at large.

The remainder of this document reports detailed research results from each project, concentrating on those derived during the 1987/88 cropping season. This report therefore constitutes an inventory of the Program's activities over the past season as well as describes in-depth a few selected topics. The Program's collaborative activities with NARS and institutions outside WANA are also described.

Staff Changes

During 1987/88 Dr. Philippe Lashermes, formerly with the Plant Breeding Department of INRA-France, joined the Cereal Program on a biotechnology special project supported by the French Ministry of Foreign Affairs and the Ministry of Research and Technology. Dr. Mohammed Tahir, the Program's wheat breeder for high elevations, left for a one year sabbatical at Colorado State University in Fort Collins, Colorado, USA. Dr. Ardeshir B. Damania, durum germplasm scientist, was appointed in charge of a new project on the evaluation of wild progenitors and primitive forms of wheat. Ms. Rosella Franconi was also appointed to assist in the laboratory work of this project in Viterbo, Italy.

J.P. Srivastava

Table 1. Cereal varieties released by national programs as of Nov. 1988.

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
China	1986	Gobernadora
Cyprus	1980	Kantara
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
Jordan	1984	Rum (6-row)
	1988	Petra
		Maru
		Amra
		ACSAD 75
Mexico	1986	Mona/Mzq/DL71
Morocco	1984	Asni
		Tamellat
		Tissa
	1988	Tessaout
		Aglou
		Rihane
Nepal	1987	Bonus
Pakistan	1985	Jau-83
	1987	Jau-87
	1987	Frontier 87
Peru	1987	Una 87
		Nana 87
Portugal	1982	Sereia
	1983	CE 8302
Qatar	1982	Gulf
	1983	Harma
Saudi Arabia	1985	Gusto
Spain	1987	Rihan
Syria	1987	Furat 1113
Thailand	1987	Semangl IBON 48
	1987	Semeng2 IBON 42
Tunisia	1985	Taj
		Faiz
		Roho
	1987	Rihane"S"
Yemen AR	1986	Arafat
		Beecher

Table 1. (cont'd)

Durum Wheat		
Algeria	1986	Sahl
		Waha
	1982	ZB S FG'S'/IUKS GO
	1984	Timgad
Cyprus	1982	Mesoaria
	1984	Karpasia
Egypt	1979	Sohag I
	1988	Sohag II
		Beni Suef
Greece	1982	Selas
	1983	Sapfo
	1984	Skiti
	1985	Samos
	1985	Syros
Jordan	1988	Korifla = Petra
	1988	Cham 1 = Muru
	1988	N-432 = Amra
	1988	Stsork = ACSAD 75
Lebanon	1987	Belikh 2
Libya	1985	Marjawi
		Ghuodwa
		Zorda
		Baraka
		Qara
		Fazan
Morocco	1984	Marzak
Pakistan	1985	Wadhanak
Portugal	1983	Celta
		Timpanas
	1984	Castico
	1985	Heluio
Saudi Arabia	1987	Cham 1
Spain	1983	Mexa
	1885	Nuna
Syria	1984	Cham 1
	1987	Cham 3
		Bohouth 5
Tunisia	1987	Razzak
Turkey	1984	Susf bird
	1985	Balcili

Table 1. (cont'd)

Bread Wheat		
Algeria	1982	Setif 82
		HD 1220
Egypt	1982	Giza 160
	1988	Giza 162
		Giza 163
		Giza 164
		Sakha 92
Ethiopia	1984	Dashen
		Batu
		Gara
Greece	1983	Louros
		Pinios
		Arachthos
Iran	1986	Golestan
		Azadi
	1988	Darab
		Saludan
		Quds
Jordan	1988	Nasma = Jubeiha
		L88 = Rabba
Libya	1985	Zellaf
		Sheba
		Germa
Morocco	1984	Jouda
		Merchouche
Pakistan	1986	Sutlej 86
Portugal	1986	LIZ 1
		LIZ 2
Sudan	1985	Debeira
	1987	Wadi El Neel
Syria	1984	Cham 2
	1986	Cham 4
	1987	Bohouth 4
Tunisia	1987	Byrsa
Yemen AR	1983	Marib 1
	1987	Mukhtar
	1988	Aziz
	1988	Dhumran
Yemen PDR	1983	Ahgaf
	1988	SW/83/2

2.1. Barley Breeding

Barley is the most important cereal crop in unfavorable environments. In developing countries it is grown on about 17 million ha, of which 75% are in West Asia and North Africa (WANA). According to "Agriculture: Towards 2000", it is expected that WANA will be characterized by a gradual shift from direct to indirect consumption of cereals. As a consequence while the demand of cereals for food will increase at the same rate as population growth, the demand for feed (mostly barley) will increase at twice the rate of population growth. Barley area in WANA is expected to increase from 12.7 million ha (1983) to 15.5 million ha by the year 2000 (Table 2). About 50% of the area planted to barley will still be in environments where insufficient moisture is the main limiting factor. An additional 25% of barley hectarage will be planted where excessive water and/or unsuitable soils are the main yield limiting factors. This leaves only one quarter of the total barley area where potential yields per unit area may be attained. The relatively favorable area now contributes almost 33% of the total barley production in WANA (Table 3), and by the year 2000 is expected to contribute more than 37%.

Outside of WANA barley is an important crop in the Andean Region of Latin America, in the Himalayan countries, in the Indian subcontinent, in China and Korea. In all those countries barley is mostly grown for human consumption. In Latin America, barley is one of the few crops adapted to cultivation in the extensive highlands of the Sierra. It has considerable frost tolerance and is adapted to high altitudes and poor soils. In the Sierra, barley is grown by poor subsistence level farmers and is utilized as a basic food staple by their families. Barley contributes 20% of the total caloric intake of these people, second only to potatoes (21%), as shown in some Peruvian economic surveys.

The overall objectives of the barley improvement project are: to increase barley production and to assist the national programs in WANA and beyond. To achieve these objectives two major approaches are followed:

1. Development and dissemination of germplasm and/or research methodologies,

2. Continuous strengthening of research capabilities of national programs (NARS).

The two approaches are complementary to each other, and depending on the status of the barley research in different countries, different combinations of both approaches are often needed. We expect that, as national programs will become more self-reliant, our assistance and interaction will be oriented towards the transfer of methodologies and the development of increasingly specific germplasm. During 1987/88 we began to modify our interaction with national programs including those of Syria, Morocco, Pakistan and Ethiopia by encouraging the development of national barley breeding programs.

2.1. Barley Breeding

Barley is the most important cereal crop in unfavorable environments. In developing countries it is grown on about 17 million ha, of which 75% are in West Asia and North Africa (WANA). According to "Agriculture: Towards 2000", it is expected that WANA will be characterized by a gradual shift from direct to indirect consumption of cereals. As a consequence while the demand of cereals for food will increase at the same rate as population growth, the demand for feed (mostly barley) will increase at twice the rate of population growth. Barley area in WANA is expected to increase from 12.7 million ha (1983) to 15.5 million ha by the year 2000 (Table 2). About 50% of the area planted to barley will still be in environments where insufficient moisture is the main limiting factor. An additional 25% of barley hectarage will be planted where excessive water and/or unsuitable soils are the main yield limiting factors. This leaves only one quarter of the total barley area where potential yields per unit area may be attained. The relatively favorable area now contributes almost 33% of the total barley production in WANA (Table 3), and by the year 2000 is expected to contribute more than 37%.

Outside of WANA barley is an important crop in the Andean Region of Latin America, in the Himalayan countries, in the Indian subcontinent, in China and Korea. In all those countries barley is mostly grown for human consumption. In Latin America, barley is one of the few crops adapted to cultivation in the extensive highlands of the Sierra. It has considerable frost tolerance and is adapted to high altitudes and poor soils. In the Sierra, barley is grown by poor subsistence level farmers and is utilized as a basic food staple by their families. Barley contributes 20% of the total caloric intake of these people, second only to potatoes (21%), as shown in some Peruvian economic surveys.

The overall objectives of the barley improvement project are: to increase barley production and to assist the national programs in WANA and beyond. To achieve these objectives two major approaches are followed:

1. Development and dissemination of germplasm and/or research methodologies,

2. Continuous strengthening of research capabilities of national programs (NARS).

The two approaches are complementary to each other, and depending on the status of the barley research in different countries, different combinations of both approaches are often needed. We expect that, as national programs will become more self-reliant, our assistance and interaction will be oriented towards the transfer of methodologies and the development of increasingly specific germplasm. During 1987/88 we began to modify our interaction with national programs including those of Syria, Morocco, Pakistan and Ethiopia by encouraging the development of national barley breeding programs.

Table 2. Barley Area (1000 ha) in WANA in 1983 and in 2000 (From: "Agriculture: Towards 2000").

Agroecological zones*	No. of Growing Days	1983 Area	1983 %	2000 Area	2000 %
Low or Uncertain Rainfall (Arid and Semi-Arid)	up to 179	6693	52.7	7289	47.1
Problem Areas (Dry sub-humid)	>269 (120-296)+	2311	18.2	3132	20.2
Naturally Flooded (Moist sub-humid)	n.a.	675	5.3	1129	7.3
Good Rainfall (Humid)	180-269	1552	12.2	2066	13.4
Irrigated	n.a.	1470	11.6	1854	12.0
Total		12701		15470	

* As defined by FAO Agro-ecological Zone Study
+ Areas with soils only marginally suitable
n.a. = not available.

Table 3. Barley production (1000 t) in WANA in 1983 and in 2000.

Agroecological zones*	No. of Growing Days	1983 Prod.	1983 %	2000 Prod.	2000 %
Low or Uncertain Rainfall (Arid and Semi-Arid)	up to 179	5931	43.7	9577	36.6
Problem Areas (Dry sub-humid)	>269 (120-269)+	2593	19.1	5525	21.1
Naturally Flooded (Moist. sub-humid)	n.a.	609	4.5	1280	4.9
Good Rainfall (Humid)	180-269	2590	19.1	5287	20.2
Irrigated	n.a.	1858	13.7	4485	17.2
Total		13581		26144	

* As defined by FAO Agro-ecological Zone Study
+ Areas with soils only marginally suitable
n.a. not available.

In the interaction with national programs it is important to generate and offer good and durable products. Frequently germplasm (as a product) is not locally adopted, while techniques, methodologies and strategies, if adequately tested, are both applicable and durable. It is therefore important to maintain a strong, solid research program able to generate both germplasm and methodologies.

To cope with the diversity of environmental conditions where barley is grown, the barley improvement project aims at technology development for:

1) moderate rainfall,
2) low rainfall,
3) high elevation with continental climate,
4) high elevation at low latitudes.

The activities of all four components have two major features: 1) they are geared to the improvement of a commodity crop in a farming system context, and 2) they are oriented towards generation of both germplasm and methodologies.

Results obtained during the 1987/88 cropping season will be presented in five sections:

1) Performance of barley germplasm within and outside WANA.
2) Evaluation and development of germplasm.
3) Breeding for moderate rainfall areas.
4) Breeding for low rainfall areas.
5) Breeding for high elevation areas at low latitudes.

The activities related to high elevation areas with continental climate will be reported in section 2.4.

1. Performance of barley germplasm within and outside WANA.

A number of barley lines have outyielded the national checks in Regional Yield Trials for both moderate and low rainfall areas.

The average yield of the lines included in the Regional Yield Trials for moderate rainfall areas was 3% lower than the long-term check (Beecher) in 1985/86 and was 5% higher in 1986/87 (Table 4). This indicates that a larger number of lines possess a higher yield potential. The lines shown in Table 4 significantly outyielded ($P<0.05$) the national check in countries such as Iran, Iraq, Jordan, Lebanon, Syria, Algeria, Egypt, Morocco, Tunisia, Korea and Pakistan.

In the Regional Yield Trials for low rainfall areas the average yield of lines evaluated in 1985/86 was 15% lower than the long-term check (Beecher) but was 1.5% higher in 1986/87 (Table 5). The lines shown in Table 5 significantly outyielded ($P<0.05$) the national check in countries such as Iran, Jordan, Syria, Morocco, Algeria, Egypt, Greece and Pakistan.

In addition to the lines shown in Tables 4 and 5 a number of other lines outyielded the national check. A summary of the performance of barley lines in different countries is given in Tables 6 and 7 which show that the number of lines outyielding the national check in the moderate rainfall areas is larger than the number of lines outyielding the national check in low rainfall environments. It should be noted that a number of lines performed well outside the WANA region, in countries such as China and Korea.

Table 4. Performance of barley lines in the regional yield trials 1985/86 and 1986/87 for moderate rainfall areas.

Cross/Pedigree	Average Yield*	
	1985/1986	1986/1987
As46/Aths*2 Sel, 2L-1AP-3AP-2AP-1AP-1AP	4286	5448
CI 08887/CI 5761 SEA, 0013-24S-3S-0S	-	5399
Iris/Nopal'S' CMB 77A-0056-1AP-0AP	3819	5037
Long-term check	3707	4612
Average of all lines	3589	4860

* 18 locations in 1985/86 and 22 locations in 1986/87.

Table 5. Performance of barley lines in the Regional Yield Trials 1985/86 and 1986/87 for low rainfall areas.

Cross/Pedigree	Average Yield*	
	1985/1986	1986/1987
Mr25-84/Ahiki CYB-0165-14A-2A-1A-0A	3421	4677
Roho/Mazurka ICB77-0170-1AP-1AP-0AP	3387	4431
Roho/Mazurka ICB77-0170-4AP-1AP-3AP-1AP-0AP	3436	4440
Long-term check	3856	4045
Average of all lines	3289	4104

* 25 locations in 1985/1986 and 22 locations in 1986/1987.

Table 6. Number of barley lines in the Regional Yield Trials for moderate rainfall areas which outyielded significantly the national check in 1986/1987.

Country	Number of locations	Number of lines	Best line(s) Cross	Pedigree
Algeria	3	13	As46/Aths*2	Sel, 2L-1AP-3AP-2AP-1AP-0AP
			CI 08887/CI 5761	SEA-0013-24S-3S-0S
Egypt	4	9	Soufara-03	
			As46/Aths*2	Sel, 2L-1AP-3AP-2AP-1AP-0AP
Lybia	1	2	Comp. Cr. 229//As46/Pro	ICB78-0752-1AP-1AP-0AP
Morocco	2	2	CI 08887/CI 5761	SEA-0013-24S-3S-0S
Tunisia	1	1	"	"
Iraq	1	1	M64-76/Bon//Jo/York..	CMSWB-77A-0164-2AP-0AP
Iran	2	7	Lth/3/Nopal'S'//Pro/11012-2	CMSWB-78A-0044-3AP-7AP-0AP
			WI2291/4/11012-2/70-22425/..	ICB78-0035-1AP-0AP
Jordan	1	9	CI 08887/CI 5761	SEA-0013-24S-3S-0S
			Cq/Cm//Apm/3/12410/4/	
Lebanon	3	6	"	"
Syria	3	20	As46/Aths*2	Sel, 2L-1AP-3AP-2AP-1AP-0AP
Turkey	1	1	"	"
Korea	1	11	Iris/Nopal'S'	
Pakistan	3	13	Soufara-03	
			As46/Aths*2	
			Harma-01	
Ethiopia	2	6	Iris/Nopal'S'	CMB 77A-0065-1AP-0AP

* Excluding the checks.

Table 7. Number of barley lines in the Regional Yield Trials for low rainfall areas which outyielded significantly the national check in 1986/87.

Country	No. of locations	No. of lines	Best line(s)* Cross	Pedigree
Algeria	1	2	WI2291/WI 2269	ICB78-0594-8AP-1AP-0AP
Egypt	3	5	Roho/Mazurka	ICB77-0170-1AP-1AP-0AP
Morocco	5	10	Mr25-84/Akiki	CYB-0165-14A-2A-1A-0A
			WI 2269	
Iran	3	3	Harmal-04	
			Mr25-84/Akiki	CYB-0165-14A-2A-1A-0A
Jordan	1	1	Mr25-84/Akiki	"
Syria	4	5	Mr25-84/Akiki	"
			Roho/Mazurka	ICB77-0170-1AP-1AP-0AP
China	1	1	Deir Alla 106/Cel	ICB77-0091-4AP-0AP
Pakistan	3	2	Roho/Mazurka	ICB77-0170-1AP-1AP-0AP

* Excluding the checks.

2. Evaluation and development of germplasm.

The type of germplasm evaluated during 1987/88 at the Aleppo-based project is summarized in Table 8.

Table 8. Barley breeding material evaluated during 1987/88.

Materials	No. of Entries	Locations
F1's	1832	Tel Hadya
Segregating Populations (F2-Fn)	10817	Tel Hadya (*F2), Bouider (F2-F3)
Initial Yield Trials	1650	Bouider, Breda,Tel Hadya
Preliminary Yield Trials	720	Bouider, Breda, Tel Hadya
Advanced Yield Trials	400	Bouider, Breda, Tel Hadya*, Athalassa, Terbol, Merchouch, Le Kef, Perugia
Crossing Blocks	940	Bouider, Tel Hadya, Athalassa
Observation Nurseries	308	Bouider, Tel Hadya, Athalassa, Terbol, Perugia, Catania
Regional Yield Trials	60	Bouider, Breda, Tel Hadya, Athalassa, Terbol, Perugia, Catania

* two planting dates.

As indicated in the Table the project used the same sites as in the past years. Most of the early generation work is conducted in the Aleppo province (Bouider, Breda and Tel Hadya), while the more advanced material is tested in a progressively larger number of locations. Other locations, reported in the Pathology Section, provide information on reaction to diseases.

Three major climatic events characterized the 1987/88 cropping season in the three sites in Aleppo province: 1) the unusually high rainfall, 2) a cold spell at tillering stage, with minimum temperatures ranging from -7.4^{o}C at Tel Hadya to -11.5^{o}C at Bouider, and 3) terminal drought and heat stress caused by hot winds during the last week of April.

The first event had negative effects on the work for low rainfall areas, which were partly compensated in the advanced lines by information generated by late planting (April 16, 1988) at Tel Hadya. The second event was useful to screen for cold tolerance at early stages of growth, although it did not seriously affect yield. The third event, which led to premature desiccation of a number of genotypes, made it impossible for the first time in the last four years, to harvest the yield trials at Breda.

Some methodological changes were either introduced or implemented in 1987/88. These include:

a) the bulk pedigree method of selection has been modified as indicated in the 1987 Program Report (pg. 25).

b) the technique of late planting at Tel Hadya was further improved by delaying the planting date to April 16. Furthermore, whereas this technique was previously used only for advanced lines, it has now been extended to the F_2 segregating populations. This allowed the identification of spring habit segregants in spring x winter crosses.

c) the modified augmented design, previously used for the Initial Yield Trials at all three locations (see Table 8), was substituted by a 9 x 9 simple lattice design at Bouider.

d) a much wider use was made of the summer nursery at Terbol, not only for segregating populations, but also for rapidly increasing head selections in the bulk pedigree method.

e) we started to implement a system by which in the near future we will have a full selection history for each line reaching the advanced yield trials. This should further improve our ability to compare the efficiency of different selection criteria.

f) a new nursery, the "Barley Breeding Stocks" was established which includes about 550 genotypes divided in 13 groups according to one major characteristic (e.g. earliness, yield potential, drought tolerance, cold tolerance, resistance to specific diseases, etc.).

The purpose of this nursery is to provide NARS with lines possessing a high expression of a given character as parental material. The nursery, or specific groups within the nursery, will be distributed upon request. The composition of the nursery will be changed as new genotypes with better expression of a particular character become available.

Three points of note in the evaluation and development of germplasm were:

a) The improved characterization of photoperiod response and vernalization requirement

b) The identification of genotypes combining prostrate growth habit and earliness

c) Identification and utilization of genotypes resistant to Barley Yellow Dwarf Virus (BYDV).

Photoperiod response and vernalization requirement

The characterization of the barley germplasm for both response to photoperiod (PR) and vernalization requirement (VR) is an important step in tailoring breeding material for specific agroecological zones. The aim of this characterization is to know both PR and VR before promoting genotypes to international nurseries, rather than to select for photoperiod insensitivity and spring types. National programs located in high elevation with continental type of climate or in dry areas with cold winters can usefully exploit the photoperiod sensitive and winter types germplasm pool.

Barley is a quantitative long day species (responding to short nights) which is affected by short-day-vernalization, and therefore the assessment of PR can be done only in relative terms unless a specific evaluation is conducted covering a wide range of photoperiods.

Our preliminary information on PR and VR of lines evaluated in the Advanced Yield Trials was derived from the late planting (April 16, 1988) at Tel Hadya, and from Ciano (Mexico) at 27° 29'latitude. Mean temperatures at Tel Hadya after April 16 were never below 9°C and therefore genotypes with some degrees of VR were not expected to head. At Ciano there are about 35 days with minimum temperatures below 5°C with an absolute minimum of -1°C (H. Vivar, pers. communication) and therefore genotypes with VR are expected to head unless they have some degree of photoperiod sensitivity. The comparison of days to heading between Tel Hadya late planting and Ciano was used to classify the advanced barley lines into four groups (Table 9).

Within the limitations of this classification it was found (Table 10) that 81.4% of the advanced lines are spring types and that 18.6% are winter types. Furthermore 67.5% of the lines are photoperiod insensitive and 32.5% are photoperiod sensitive.

Table 9. Classification of advanced barley lines in relation to photoperiod response (PR) and vernalization requirement (VR).

PR	VR	Heading at Tel Hadya late planting(1)	Heading at Ciano(2)
Insensitive	-	Early	Early
Insensitive	+	Late	Early
Sensitive	-	Early	Late
Sensitive	+	Late	Late

(1) Late genotypes are those that remained in vegetative stage or produced few heads per plot.
(2) Late genotypes are those with more than 95 days to heading.

Table 10. Photoperiod response and vernalization requirement of all advanced barley lines (n=360) and of those selected in 1987 under severe stress conditions (n=112).

Vernalization requirement	Reaction to photoperiod	N	%	Selected in 1987 under stress conditions	
				N	%
Winter Type	Sensitive	48	13.3	12	10.7
Winter Type	Insensitive	19	5.3	8	7.1
Spring Type	Sensitive	69	19.2	10	9.0
Spring Type	Insensitive	224	62.2	82	73.2
Total		360		112	

Table 10 also shows that selection under severe stress conditions (selection for grain yield at Bouider in 1986/87) did not alter the frequencies of spring (81.2%) vs. winter types (17.8%). However the 112 lines selected in 1986/87 at Bouider had a lower frequency of photoperiod sensitive genotypes (19.7%) than the total population of advanced lines (32.5%). Therefore there is no evidence that the use of Bouider as a selection site for stress conditions, might alter the composition of ICARDA's barley germplasm towards types that are photoperiod sensitive and require vernalization.

Early and prostrate genotypes

In most of the barley germplasm early heading is associated with erect growth habit while prostrate habit is found associated with late heading, often with a vernalization requirement. In environments with cold winters and terminal drought stress, genotypes combining a prostrate growth habit and early heading could have an advantage. A prostrate growth habit, if associated with early growth vigour, would allow a rapid ground cover and consequent reduction of the amount of water lost by evaporation, while early heading would ensure a drought escape mechanism.

In the 1987/88 we identified 10 genotypes (three in the Advanced Yield Trials, and 7 in the Initial Yield Trials) that combined prostrate growth habit and early heading (Table 11) when compared with the prostrate landrace Arabi Aswad and the very early cultivar Harmal.

Table 11. Barley genotypes combining prostrate growth habit and early heading in the advanced (BAT) and initial (BIT) barley yield trial 1987/88.

Material	Days to Heading	Growth Habit(1)	Growth Vigour(1)	Cold tolerance(1)
3BAT-LINES	119.7	3.9	2.9	3.7
Harmal	118.8	2.9	2.2	4.4
A. Aswad	125.2	4.4	3.5	1.5
7BIT-LINES	119.0	4.0	3.1	2.5
Harmal	120.1	2.6	2.2	2.9
A. Aswad	126.0	3.4	2.9	1.4

1 = erect (or good vigour or cold tolerant) -5 = prostrate (or poor vigour, or cold susceptible).

The three lines identified in the Advanced Yield Trials (0.8%) also had a growth vigour intermediate between A. Aswad and Harmal, although they are cold susceptible. These three lines headed in the late planting at Tel Hadya and also headed in Ciano (Mexico) and Holetta (Ethiopia, 9^{o} latitude) indicating that they are photoperiod insensitive and do not require vernalization. The seven lines identified in the Initial Yield Trials (0.4%) had a better growth habit-earliness combination and were close to A. Aswad for both growth vigour and cold tolerance. No information is yet available on either vernalization requirement or photoperiod response of these lines.

BYDV resistance

Through collaboration with Dr. K. Makkouk (Germplasm Resources Program) and of Dr. A. Comeau (Canada) 8 barley lines were identified as reliable and consistent sources of BYDV resistance. Four of these lines were included in the Barley Crossing Block for 1989 and have already been used to produce 30 F_1 during 1987/88. F_2 segregating populations derived from those crosses will be artificially inoculated at Tel Hadya and also grown in a "hot spot" in Morocco to increase the frequency of BYDV resistant plants with different genetic background.

S. Ceccarelli

2. Breeding for moderate rainfall areas

Breeding barley for moderate rainfall areas has four major components:

1) Breeding for disease and insect resistance,

2) Breeding for lodging resistance,

3) Breeding for high grain and straw yields,

4) Breeding for tolerance to short term fluctuations in environmental conditions.

Breeding for disease and insect resistance

Three major diseases, powdery mildew, scald, and net blotch, constitute the backbone of the disease resistance breeding efforts. Selection for other diseases such as rusts (yellow, black, and brown), smuts, barley stripe, and BYDV is also practiced whenever it's possible.

Plans for breeding for insect resistance, in cooperation with the cereal entomologist, have been developed. Wheat stem sawfly and Hessian fly will be the two major insects to breed for. Lines showing resistance to wheat stem sawfly will be included in the crossing block this season.

Powdery mildew

Data from the Advanced Yield Trials as well as from F_3 families (2308 families) show that two-row barleys are more resistant to powdery mildew than the six-row barleys (Figs. 1 and 2). Additional efforts will go into upgrading the six-row barleys for powdery mildew resistance.

Scald

Figure 3 shows that six-row barleys are more resistant to scald than two-row barleys. In this case, the two-row barleys will receive more attention for scald. Data from F_3 families (Fig. 4) which were artificially inoculated (see Pathology Section for details) showed that the early families are more resistant to scald than late or medium maturing types. Table 12 gives the pedigrees of the earliest and the most resistant families. These early resistant families will be examined in more detail in 1988/89 in the F_5 generation (F_4 generation was carried out in the summer nursery).

Table 12. Pedigree of the earliest and most resistant F_3 families to scald.

Cross	Pedigree
ID/CM67//Asse/Nacta/3/As46/Aths*2	ICB05-0042-2AP
Bal.16/Mq/3/M67-18/M14//Ds/Apro/4/ Iris/5/ROD586/Nopal's'	ICB85-0064-4AP
Cr.115/Por//Deir Alla 106/3/As46/Aths*2	ICB85-0068-3AP
Cr.115/Por//Deir Alla 106/3/Matnan-05	ICB85-0071-2AP
Cr.115/Por//Deir Alla 106/3/Matnan-05	ICB85-0071-3AP
Comp.Cr.229//As46/Pro/3/Arar	ICB85-0157-1AP
Giza 121/CI 06248/4/Apm/IC65//11012-2/3/ Api/CM67//Ds/Apro/5/Aths	ICB85-0177-2AP
Api/CM67//Mona/3/DI//Asse/CM65-IW-B/4/ Assala-02	ICB85-0225-2AP
Arabi Aswad/3/OP/Zy//Alger/Union, 385-2-2	ICB85-0261-1AP
Arabi Aswad/3/OP/Zy//alger/Union, 385-2-2	ICB85-0261-2AP
Arabi aswad/3/OP/Zy//Alger/Union, 385-2-2	ICB85-0261-4AP
MD Atl/cm59-3w-B//Arar	ICB85-0582-2AP
Arar/Rihane-03	ICB85-0624-1AP
Arar/Rihane-01	ICB85-0636-3AP
Cbg (CI 10114)/Bongie//Arar	ICB85-0818-4AP
Badia/4/ID601810/Julia/Cmn/3/Mich62-201-44/ CI 02274/5/Badia//CM67/Gva	ICB85-1144-2AP
Aths/As46	ICB85-1224-1AP
Rihane-03/4/Lth/3/Nopal//Pro/11012-2	ICB85-1323-1AP
Arar//Bc/Bgs	ICB85-1595-3AP
Arar/3/Comp.Cr.229//As46/Pro	ICB85-1601-3AP
Arar/3/Comp.Cr.229//As46/Pro	ICB85-1601-4AP
Arar/6/Cq/CM//Apm/3/Egypt 20/4/11012-2/ 70-22425/5/Ager	ICB85-1602-2AP

Net blotch

Data on net blotch from Cyprus (Fig. 3) indicate that additional breeding effort for net blotch resistance is justified as the best yielding lines in Cyprus show some susceptibility to this disease.

The disease situation of the Advanced Yield Trials is summarised in Tables 13, 14 and 15. It appears that a number of lines combine resistance for at least two diseases. Among these lines, the highest yielding are included in the crossing block to upgrade disease resistance (Table 16).

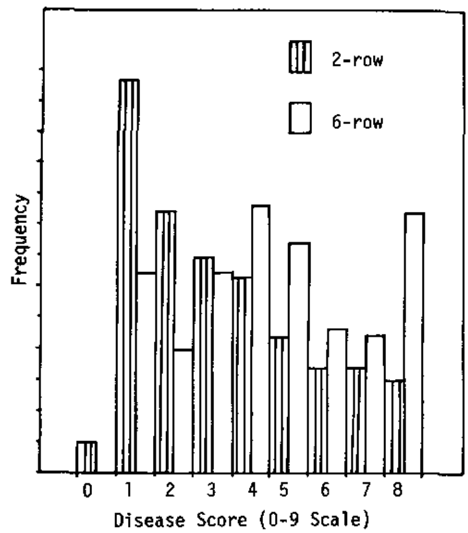

Fig. 1. Reaction to powdery mildew of the advanced yield trials (360 entries). Data collected in the greenhouse at Tel Hadya.

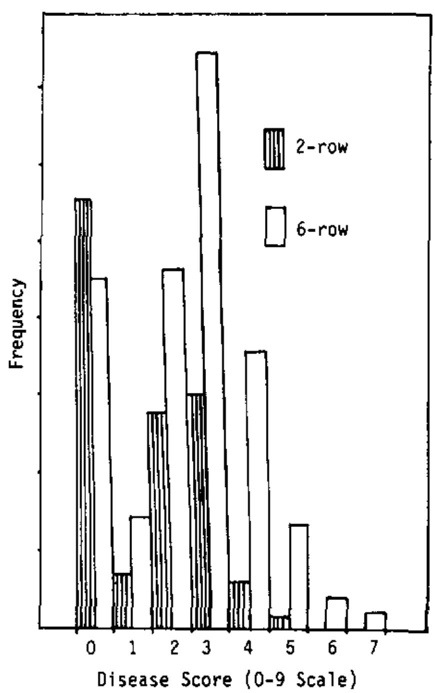

Fig. 2. Reaction to powdery mildew of F_3 families (2308 families) at Tel Hadya.

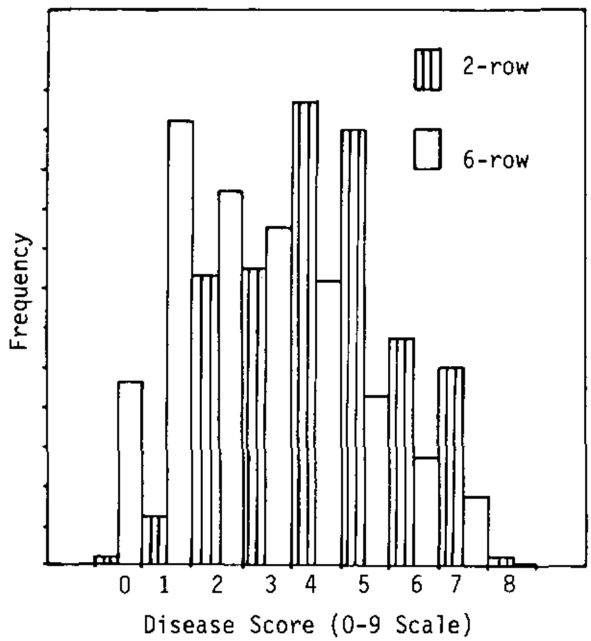

Fig. 3. Reaction to scald of the advanced yield trials (360 entries) at Tel Hadya

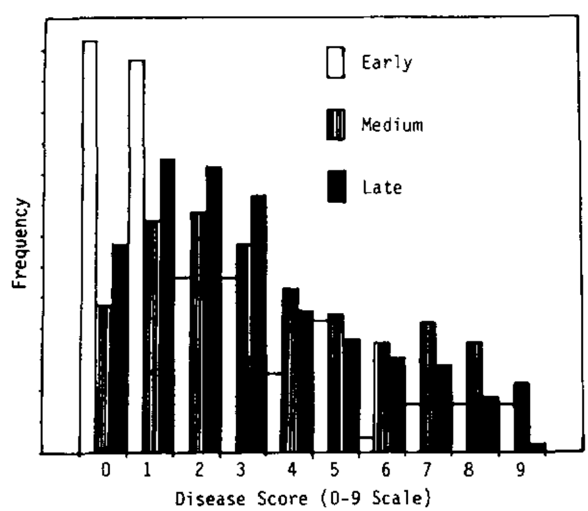

Fig. 4. Reaction to scald of the F_3 families (2308 families) as grouped by maturity. Tel Hadya.

Table 13. Disease performance of the Advanced Yield Trials (360 entries). Number and % of lines with a score of 3 or less (on a 0-9 scale) at different locations.

Diseases	Locations	No. Lines	%
Powdery mildew(PM)	Greenhouse (GH) & Tunsia (TUN)	145	40
Scald (SC)	Tel Hadya (TH) & TUN	75	21
Net blotch (NB)	Cyprus 1 & Cyprus 2 (CY1&CY2)& TUN	103	29
PM	GH, TH, CY1, CY2, & TUN	97	27
SC	GH, Breda, CY1, CY2, & TUN	56	16
PM & SC	All locations	7	2
PM & NB	All locations	21	6
SC & NB	All locations	11	3
PM, SC, & NB	All locations	3	0.8

Table 14. Disease performance of the selected parental lines from the KLDN (% of the selected lines with a score of 3 or less on a 0-9 scale).

Diseases	%
Powdery mildew	75
Scald	75
Net blotch	83
Powdery mildew and scald	47
Powdery mildew and net blotch	37
Powdery mildew, scald and net blotch	23

Table 15. List of the highest yielding and most disease resistant lines from the advanced yield trials.

Cross	Pedigree
Arizona 5908/Aths/Lignee 640	ICB81-0210-1AP-9AP-0AP
Arizona 5908/Aths//Asse/3/F208-74	ICB82-1287-3AP-4AP-0AP
Lignee 527/Sawsan//Bc	ICB82-0426-0SH-1AP-0AP
Lignee 527/Arar	ICB82-0850-7AP-0AP
Emir/Harmal	ICB83-0835-3AP-0AP
Mo.B1337/WI2291	ICB81-2606-2AP-0AP-0AP
ER/Apm//AC253	ICB82-0707-2AP-0AP
Lignee 640/Harma-01	ICB82-0862-10AP-0AP
5604/1025//Arabi Abiad /3/Harmal-02	ICB82-0617-5AP-0AP
Lignee 1242/Harmal-02	ICB82-0757-10AP-0AP
Lignee 527/Badia//Alg.1179 El.973/3/	
Lignee 527/Sawsan//Bc	ICB83-1038-10AP-0AP
Atem/Roho//Katade	ICB82-0557-6AP-0SH-0AP

Table 16. List of the selected lines from the advanced yield trials with resistance to powdery mildew, scald and net blotch.

Cross	Pedigree
ER/Apm//Lignee 131	ICB82-0702-10AP-4AP-0AP
WI2198/lignee 131	ICB82-0832-3AP-3AP-0AP
Lignee 640/Harma-01	ICB82-0862-10AP-0AP
Atem/Roho//Katade	ICB82-0557-6AP-0SH-0AP
Lignee 640/Lignee 527	ICB81-0628-0SH-2AP-0AP-0AP

Diseases and yield performance of selected parents

Thirty lines were selected from the Key Locations Disease Nursery (see Pathology Section) to be included in the crossing block for upgrading disease resistance of the barley germplasm. Both the disease performance and yield levels were considered during the selection of these parents. Powdery mildew data were collected from the greenhouse and the field at Tel Hadya, from two locations in Cyprus, and from Tunisia. Scald data were collected from Tel Hadya, Breda, two locations in Cyprus, and Tunisia. Net blotch data were collected from two locations in Cyprus, and from Tunisia. Yield data were collected from the Advanced Yield Trials (Tel Hadya, Bouider, Cyprus, Terbol, and Morocco with data from Morocco based only on a visual selection). *Among these lines, 74% had a yield equal to or* superior to that of Rihane-03 in at least one location. Seventeen percent produced as much as or better than Rihane-03 in two locations.

Breeding for lodging resistance

One of the major problems of the barley production under relatively favorable growing conditions is lodging. Stiff straw and short stature are the two major traits used to breed for lodging resistance. Both of these traits can affect straw feeding quality and/or total biomass production, and therefore these two traits need to be manipulated taking into account the value of barley straw to farmers in WANA. Depending on when it occurs during the growing season, lodging can reduce yield, decrease quality, and make mechanical harvesting difficult. Lodging resistant parents were included in crosses to be evaluated as F_2 families in 1988/89. The Advanced Yield Trials were also screened for lodging resistance in both Tel Hadya and Morocco and the lines for the observation nursery for the moderate rainfall areas were selected among the most lodging resistant ones.

In segregating populations (F3-F6), the tall lodging prone families were eliminated. Most of the selected families were among those presenting an intermediate height.

Yield potential and high biomass production

In the moderate rainfall areas grain and straw yield determine the success or the failure of a new variety. High yielding lines should always make a sizeable component of parental stocks. Selection for high biological yields and high harvest indices, or selection for *higher biological yields while maintaining harvest indices constant* will result in higher grain and straw yields. For 1988/89, 15% of the F2 families are labelled as high biomass families. Efforts were made to combine high tillering capacity with lodging resistance. Also 33% of the F2 families are labelled as having high yield potential, disease resistance, mainly against powdery mildew and scald, and good adaptation. These families resulted from crosses between selected lines from the international nurseries for high yield capacity across a wide range of environments and the disease resistant parents (selected from KLDN).

Breeding for short term fluctuations in environmental conditions

Moderate-rainfall areas have a less variable rainfall pattern than drier areas. However, there are always chances of having fluctuations in the environmental conditions (drought, heat, cold, etc.). The breeder should always try to find a way to cope with these types of fluctuations.

Although the knowledge in this area of research is rather limited, cooperation with the crop physiologist will be helpful. From the breeding point of view, utilization of traits such as tillering plasticity, height stability, as well as using the best lines from the international nurseries and some of the landraces as sources of tolerance to these fluctuations are being considered in the program. At the present stage of the program, four of the best performing lines across a wide range of environments (Rihane-03, ER/Apm, Assala-04 and Ar46/Aths*2) were used in crosses to try to incoporate tolerance to short term fluctuations in the environment. This is based on the idea that these lines, given the wide range of environments to which they were exposed, must have experienced some stress at certain stages of their development.

The Rihane story

Rihane-03, a well performing barley line across different environments, has been evaluated on on-farm yield trials in Syria for three years (Table 17) and has proved to be an outstanding line. In 1987/88 Rihane-03 had a grain yield ranging from 3800 to 5940 kg/ha across ten locations in Syria. The average yield was 4660 kg/ha.

Table 17. Grain yield (kg/ha) of Rihane-03 in comparison with Arabi Abiad.

	1985/86 (8 locations)	1986/87 (7 locations)	1987/88 (10 locations)	Average
Rihane-03	2302	2636	4659	3199
Arabi Abiad	2124	2211	3716	2684

Rihane-03 ranked first in eight out ten locations and second in the other two locations. On the average, Rihane-03 produced 125% of the yield of the local check Arabi Abiad, and 117% of the yield of Furat 1, an improved check. Rihane-03 is also used as a reference line in segregating populations and yield trials. All data collected thus far on this line indicate that Rihane-03 is an outstanding line. Seed requests for this line were received from different countries in the region, and it is being considered for release by different programs.

A. Zahour

3. Breeding for low rainfall areas

The major objective in breeding for low rainfall areas is to stabilize yield in those environments where barley is the only possible crop, and where barley planted in conjunction with livestock husbandry (mainly small ruminants) is the major and often only possible farming system.

Two main breeding methods are being used in this component: the bulk-pedigree method to handle improved x improved, improved x landraces and landraces x landraces crosses, and pure line selection within landraces. In addition we are also evaluating the role of mixtures to assess the role of genetic heterogeneity as a genetic mechanism to stabilize grain yield over time.

Three major sources of germplasm are being used, namely improved genetic material, local landraces and *Hordeum vulgare* ssp. *spontaneum* (= *Hordeum spontaneum*). The results of the 1987/88 season will be summarized under the following headings:

a) Effect of selection under dry conditions on yield potential,
b) Evaluation and utilization of landraces,
c) Evaluation and utilization of *Hordeum spontaneum* germplasm.

Effect of selection under dry conditions on yield potential

Results obtained during the previous three cropping seasons have indicated that yield potential (defined as yield in a nonstress environment) is a poor selection criterion to identify useful germplasm for stress environments. This applies to other crops such as durum wheat (Nachit, in press) and pearl millet (Bidinger *et al*., 1987).

The unusually high rainfall during 1987-88 offered the possibility of further verifying this finding by analyzing the yield potential of barley lines that were selected during 1986/87 (a very dry season) for grain yield under stress conditions.

The 360 lines in the advanced yield trials (Table 18) gave the highest average yield in Cyprus (5008 kg/ha), and the lowest at Bouider (2910 kg/ha).

Table 18. Average grain yield (kg/ha) of 360 barley lines evaluated at five locations in 1987/88.

Location	Average*	Range
Bouider	2910 e	964-4686
Tel Hadya	4388 b	2403-6849
Cyprus	5008 a	1928-8120
Terbol	3730 c	1469-5252
Perugia	3539 d	1933-5881

* Figures followed by the same letter are not significantly different ($P < 0.05$ based on L.S.D. test).

The top individual yields were recorded at Cyprus and Tel Hadya with 8120 kg/ha and 6849 kg/ha, respectively. Therefore the yields at these two locations were assumed to be a good estimate of the yield potential of the material in the advanced stage of yield testing. Table 19 shows the comparison between those lines in the advanced yield trials that were selected in 1986/87 on the basis of different selection criteria, namely earliness, grain yield at Bouider or grain yield at Breda.

Table 19. Effect of different selection criteria on yield potential (Barley Advanced Yield Trials, 1988).

Material	No. of lines	Grain yield (kg/ha) at			
		Tel Hadya		Cyprus	
		Mean	Range	Mean	Range
Selected at Bouider in 1987	112	4659	2524-6320	5070	1928-7876
Selected at Breda in 1987	92	4240	2745-6251	4965	1948-8044
Earliness in 1987	97	4905	2830-6848	4970	1948-8120
Top 5% for grain yield in 1988	18	6084	5828-6849	7445	7112-8120
Best check*		5446		5678	
Population mean	360	4388	2402-6849	5008	1928-8120

* Rihane-03 at Tel Hadya and Harmal at Cyprus.

The lines selected at Bouider in 1987 had a wide range of grain yield both at Tel Hadya and Cyprus and they included a number of lines which were in the top 5% highest yielding lines. Although as a group lines selected under severe stress conditions have a relatively low yield potential under high rainfall conditions, the reduction in yield potential varies greatly from line to line. Out of the lines selected in Bouider during 1986/87, about 30% yielded more than 5t/ha at Tel Hadya, and 25% yielded more than 6 t/ha at Cyprus in 1987/88 (Table 20).

Earliness is often referred to as a mechanism to escape both drought and yield. However, some of lines selected in 1987 for earliness had the highest grain yields at either Tel Hadya (where they escaped the effect of hot winds during grain filling) or Cyprus during 1987/88. The pedigree of the lines which were selected at Bouider in 1986/87 and where among the top yielders in Cyprus in 1987/88 is given in Table 21 together with their grain yield compared with three improved checks.

These results indicate that selection for grain yield under severe stress and for early heading does not necessarily reduce yield potential. Because of the climate during 1987/88 it was not possible to assess the actual performance under stress conditions of the lines selected at Bouider or Breda in the previous cropping season.

Table 20. Frequency distribution of grain yield under favorable conditions of barley lines selected in 86/87 under severe stress.

Classes (kg/ha)	Tel Hadya		Cyprus	
	n	%	n	%
>7000	-	-	6	5.4
6000 7000	3	2.7	22	19.6
5000 6000	31	27.8	33	29.5
4000 5000	51	45.5	30	26.8
3000 4000	26	23.2	15	13.4
2000 3000	1	0.8	5	4.5
<2000	-	-	1	0.8

Table 21. Barley advanced lines selected at Bouider in 1986/87 with high yield potential (Grain yield at Cyprus).

Cross/Pedigree	Grain yield (kg/ha)	Type
Lignee 131/Arabi Abiad ICB81-0642-10AP-5AP-0AP	7182	Winter
Harmal-02/Arabi Abiad ICB82-1022-3AP-0SH-0AP	7876	Winter
Harmal-02/3/OP/Zy//Alger/Union, 385-2-2 ICB83-1552-0AP	7172	Winter
Bante 025/Arabi Abiad//Iris/CI 01507 ICB82-0313-4AP-0AP	7234	Spring
Impala/Julia//Api ICB78-1085-2AP-2AP-1AP-2AP-0AP	7389	Spring
Roho/Arabi Abiad ICB81-0431-1AP-0AP-0AP	7109	Winter
Rihane-03	5390	
Kantara	5509	
Harmal	5678	

Evaluation and Utilization of Landraces

The main objective of this activity was to develop and test work models with locally adapted cultivars which might be used by national programs with their own adapted germplasm.

Landraces are still widely grown in many dry areas where they appear to be well adapted to local conditions, are relatively stable and in areas where both grain and straw are used as animal feed, are utilized by farmers for their feeding quality.

The initial step in the evaluation and utilization of landraces was to assess the amount of variation for morphological and agronomic characters as well as for disease resistance and to determine the extent the genetic diversity available within landraces is useful for breeding purposes. Activity was mainly concentrated on the two widely grown Syrian landraces, Arabi Abiad and Arabi Aswad.

In 1984/85 a sample of 420 single-head progenies (out of a collection of 7000 lines) was evaluated at Breda, and the results showed that the two landraces grown in Syria are highly variable. In fact a large diversity was observed both between and within collection sites for morphological characteristic (Ceccarelli et al., 1987) and for disease resistance (van Leur et al.).

The information generated led to proposals on how to utilize adapted germplasm in a breeding program in different ways, (Ceccarelli, 1984):

1) release of the highest yielding lines as varieties, after testing their stability in different environments (locations and years),

2) utilization of superior lines as parents in the crossing program to introduce additional desirable characters in an adapted genetic background,

3) evaluation of multi-lines built with a variable number of pure lines to achieve a better understanding of relationship between genetic heterogeneity and stability,

4) evaluation by the cereal physiologists of lines showing extreme expressions of specific attributes but similar for others to quantify the adaptive role of specific morpho-physiological traits in a given combination with other traits, in stress environments.

All the four approaches have been implemented during the last four years, although the first meaningful results of the multiline approach will be available only at the end of 1989.

The first approach is obviously the quickest way to utilize readily available genetic diversity and to identify superior genotypes for stressful environments. An example of the potential of this approach is given by Tadmor, a pure line selected from a sample collected at Taibe, near Palmyra. Table 22 summarizes the results of three years testing in the on farm verification trials in the third stability zone of Syria (< 250 mm annual rainfall) where Tadmor has outyielded A. Aswad espcially under highly stress conditions. Tadmor will be evaluated again during 1988/89 in the on-farm verification trials for zone C in Syria.

Table 22. Grain yield (kg/ha) of Tadmor compared with Arabi Aswad.

Material	1985/86 (6 locations)	1986/87 (6 locations)	Mean of 1986/87	1987/88 (9 locations)	Mean
Tadmor	2206	866	1536	2459	1748
Arabi Aswad	1941	798	1370	2430	1665
L.S.D. 0.05	142	ns	119	ns	ns

Since the results generated from the evaluation of a small sample of the whole collection were encouraging it was decided to exploit the genetic value of the 5444 lines still available from the original collection. So far 2408 lines from landraces have been evaluated (Table 23).

Table 23. Number of lines extracted from landraces and evaluated and utilized since 1984/85.

	84/85	85/86	86/87	87/88
Evaluation of pure lines	400	1379	609	-
Selection and yield testing				
- Initial Yield Trials			656	609
- Preliminary Yield Trials		173		372
- Advanced Yield trials			87	8
Utilization in crosses				
- Crosses	86	168	682	
- F_1	62	86	168	682
- F_2	24	62	86	168

In 1987/88 372 lines were tested in Preliminary Yield Trials and 609 in Initial Yield Trials. An additional 1336 lines were planted at Tel Hadya to increase seed.

As already mentioned unusually high rainfall in 1987/88 exerted a negative effect on the work for low rainfall area. Therefore only results on cold tolerance and yield potential will be presented.

In the Preliminary Yield Trials (Table 24) 59% of landrace lines were cold tolerant (scored 2 or less) compared with 0.6% in improved germplasm.

Table 24. Frequency of cold tolerant lines in two different types of germplasm (Barley Preliminary Yield Trials-Bouider 1988).

Type of germplasm	No.	Frequency of cold tolerant lines*
Improved	326	0.6
Landraces	373	59.0

* Lines with an average score of 2 or less in a 1-5 scale.

In the Initial Yield Trials (Table 25) adapted germplasm had an average score of 1.8 ranging from 1.0 to a maximum of 3.8, while the improved germplasm was in general more cold susceptible with an average score of 3.0.

Table 25. Cold damage (mean and range) at Bouider of improved germplasm and landraces in the barley initial yield trials 1987/88.

Material	n	Cold damage	
		Mean	Range
Improved	1041	3.0	1.0-5.0
Landraces	609	1.8	1.0-3.8
Rihane-03		2.8	
Harmal		2.9	
A. Aswad		1.4	
A. Abiad		1.5	

Landraces collected in Syria had a higher level of cold tolerance (Table 26) than Jordanian landraces. Within Syrian landraces the highest frequency of cold tolerant lines was found in samples collected in the Gezira area and in the steppe. Those results clearly indicate that Syrian landraces are important sources of cold tolerance.

The use of landraces in breeding programs has been neglected on the basis that they are susceptible to diseases and have low yield potential. This may be true when landraces are evaluated as populations, but not when single lines extracted from landraces are evaluated.

Yield data from the Preliminary Yield Trials (Table 27) and the Initial Yield Trials (Table 28) indicate that the average yield of landraces as group was lower than the grain yield of conventional germplasm, but that it was possible to identify lines from landraces that outyielded the best check in Tel Hadya.

Table 26. Frequency distribution for cold damage score* in landraces collected from different areas of Syria and from Jordan (Barley Preliminary Yield Trials. Bouider 1987/88).

Area of Origin	n	Percent of tolerant	Percent of med. tolerant	Percent of susceptible
Gezira	144	92.4	7.6	0.0
Central	15	46.7	46.7	6.7
North West	53	60.4	35.9	3.8
South	23	34.8	56.5	8.7
Steppe	34	82.4	17.7	0.0
Jordan	82	1.2	20.7	78.1

* tolerant (score = 1-2)
medium tolerant (score = 2.5-3.0)
susceptible (score = 3.5-5.0)

Table 27. Grain Yield (mean and range) at Tel Hadya and Bouider of improved germplasm and of landraces in the barley preliminary yield trials 1987/88.

Material	n	Tel Hadya Mean	Tel Hadya Range	Bouider Mean	Bouider Range
Improved	272	4132	763-5934	3099	973-5272
Landraces	288	3933	882-6217	2617	220-4775
Rihane-03		5214		3812	
Harmal		4819		3834	
A. Aswad		3445		2589	
A. Abiad		4585		2782	

Table 28. Grain yield (mean and range) of improved germplasm and of landraces in the barley initial yield trials at Tel Hadya and Breda, 1987-88.

Material	n	Tel Hadya Mean	Tel Hadya Range	Breda Mean	Breda Range
Improved	1041	4388	455-7852	3151	845-6584
Landraces	609	3606	623-6600	3070	1385-5002
Rihane-03		5109		3986	
Harmal		4811		3502	
A. Aswad		3217		3178	
A. Abiad		4366		3807	

Evaluation and Utilization of Hordeum vulgare ssp. spontaneum

Hordeum vulgare ssp. spontaneum is the wild progenitor of cultivated barley. In barley breeding the use of the species as source of resistance to powdery mildew, rust and scald has been reported by many authors. It has been indicated that the species also can contribute useful genes for other attributes.

Although H. spontaneum might be expected to have a potential in contributing useful genes in barley breeding for dry areas, as suggested by its distribution in the driest areas of the Fertile Crescent, the species has never been investigated as a source of genetic variation for drought resistance mechanisms. Since a large variability for a series of characters has been found between as well as within accessions, the use of the already available collections of H. spontaneum should go through the following steps:

1) extraction of pure lines,
2) evaluation of pure lines for agronomically useful characters and identification of promising genotypes,
3) use of selected lines in crosses with cultivated barley,
4) utilization of segregating populations in conventional or non conventional methods.

A collection of 215 lines (5 lines for each of 43 accessions of H. spontaneum was evaluated under controlled conditions for the following characters: coleoptile length, number of seminal roots, maximum length of seminal roots. A large variability was observed for these characters (Table 29).

Table 29. Some morphological differences between Hordeum vulgare and Hordeum spontaneum

Characters	H. spontaneum (n=215)		H. vulgare (n = 10)	
	Mean	Range	Mean	Range
Coleoptile length(mm)	58.9	40.0- 81.7	58.8	46.4- 69.2
Root number	4.4	3.2- 5.9	5.9	5.0- 7.3
Root length (mm)	88.7	56.7-123.6	70.0	51.2-109.8

The importance of a long coleoptile has been reported by Acevedo (1986) and it is interesting to note that although the average coleoptile length of H. spontaneum does not differ from cultivated barly, there were lines of H. spontaneum with very long coleoptiles (up to a maximum of 81.7 mm).

H. spontaneum had less and longer seminal roots than cultivated barley. It is known that manipulation of the root system has also been proposed as a possible avenue in breeding for tolerance to severe moisture stress. In barley as in other cereals seminal roots are responsible for the initial absorption of moisture and may function throughout the life of the plants. Under drought or other stress conditions the adventitious roots often do not develop and plants may reach maturity growing only on their seminal roots. Passioura (1972) has shown that in wheat growing predominantly on stored water a high hydraulic resistance in the seminal root system, obtained by decreasing the number of seminal root axes, is an advantage. With this in mind, H. spontaneum can be an useful source of a low number of seminal roots.

A subset of 55 lines for the same collection was also evaluated at Bouider during the 1987/88 cropping season in plots of 6 rows at 30 cm spacing, 2.5 m long, using a simple lattice design 8 x 8 (55 lines + 9 H. vulgare checks) with two replications. Data were recorded for the following characters: cold damage, growth vigour, days to heading, culm length, peduncle length, peduncle extrusion, straw yield, and protein content.

Table 30 shows the means and ranges for the characters observed on the 55 lines of H. spontaneum and the 9 barley cultivars. In general H. spontaneum had lower early growth vigour than cultivated barley, although lines with good growth vigour were also present. Earliness evaluated as days from sowing to spike extrusion indicates that on average H. spontaneum did not differ from H. vulgare, but that within the species very early types are available. Nine lines significantly earlier than Harmal (the earliest check) were identified. A positive association between peduncle length and grain yield under stress conditions has already been found in durum wheat (Nachit, 1986). It was therefore interesting to find a large number of lines with an exceptionally long peduncle as well as with a high portion of the peduncle outside the flag leaf.

Table 30. Differences between Hordeum vulgare and Hordeum spontaneum (Bouider 1987/88).

Characters	H. spontaneum (n=55) Mean	Range	H. vulgare (n = 9)* Mean	Range	Best H. vulgare
Cold damage	3.0	1.0- 5.0	3.7	1.5- 5.0	Tadmor
Growth vigour	2.9	1.0- 5.0	1.6	1.0- 2.5	Tadmor
Days to heading	141.8	131.5- 152.5	141.1	138.5- 145.5	Harmal
Peduncle length	44.2	32.8- 50.3	23.5	20.3- 32.1	Rihane-03
Peduncle extru.	18.4	8.2- 26.3	4.4	1.0- 10.5	Rihane-03
Straw yield (t/ha)	4.4	2.8- 6.5	5.1	4.1- 6.1	Tadmor
Straw protein (%)	5.1	2.7- 7.0	3.5	2.8- 4.7	A. Abiad

* Harmal, Rihane-03, Kantara, Arta, Tadmor, SLB 39-10, SLB 39-60, Arabi Aswad, Arabi Abiad.

For the first time we evaluated both straw yield and straw protein content. Compared with the best checks (Tadmor for straw yield and A.

Abiad for straw protein content), some lines of Hordeum spontaneum had either a slightly larger straw yield or an unexpectedly high straw protein content. Although very preliminary, these data may offer additional justification to the use of H. spontaneum.

S. Grando

4. Breeding for high elevations at low latitudes

Among several factors that contribute to low barley production in the region outside of WANA, the most frequent problems are poor agronomic practices and susceptibility of commercial varieties to prevalent diseases.

Large-scale barley producers in Ecuador and Colombia often cultivate barley for the malting industry. They use two fungicide applications to control stripe rust and leaf rust. The cost of the chemical is equivalent to 20% of the total cost of production. Small-scale peasant farmers do not use chemical control due to his high cost and to limited access to credit.

During the past five years, the ICARDA/CIMMYT Barley Program has incorporated genetic resistance to six diseases into barley germplasm: stem, leaf, and stripe rusts, scald, net blotch, and barley yellow dwarf virus (BYDV).

The introduction of multiple disease resistance followed a stepwise approach, where first a template was built with material resistant to scald and leaf rust, with subsequent resistances being incorporated later.

In 1988, Ecuador and Bolivia, two countries of the Andean Region, are yield-testing promising barley lines that showed multiple disease resistance in national trials.

Preliminary results in Ecuador showed that three sister lines originated from the cross, Lignee 640/Kober//Teran (L/K//T), were among the top five yielders in the national test. One sister line is a firm candidate for release as a variety after another year of national testing. One ha of seed is being increased this fall.

The development of the Lignee/Kober/Teran (L/K//T) lines clearly shows major aspects of the methodology used in the program:

1. a combination of high-yield and disease resistance traits,

2. multiple disease resistance. The L/R//T lines are resistant to three diseases: scald, stripe rust, and leaf rust,

3. superior levels of resistance were obtained by pyramiding different resistance genes for a given disease, for example stripe rust resistance genes originated from all the three parents (Lignee 640, Kober and Teran). Scald resistance genes could be traced back to Kober and Teran,

4. combination of high yield and multiple disease resistance with tolerance to acid soils,

5. close cooperation with national programs. The lines were selected as F_5 by Ecuadorian barley workers from germplasm sent from Mexico,

6. the lines are currently being crossed to enhance the resistance to stem rust.

Breeding Procedures

There are *four factors* that have played *a big role in* the development of high-yielding, disease resistant barley germplasm.

1. The wide use of the top cross method which allows the combination of several disease resistances,

2. The availability of locations that have favorable agro-climatic conditions for diseases development,

3. The ability to develop artificial epidemics of different diseases under field conditions that allow for effective selection,

4. Two generations of breeding per year where alternate selection is done in the field. For example, during the winter cycle, plants resistant to leaf and stem rust are selected. These plants are then planted during the summer cycle where plants resistant to scald, net blotch, and stripe rust are selected.

As a result of this breeding effort, there are now different sets of advanced lines with multiple disease resistance available (Table 31). This germplasm is currently being sent upon request to cooperators.

National programs are interested in barleys developed by the ICARDA/CIMMYT Program because they have found that the disease resistance in the germplasm has solved their particular problems. A couple of examples illustrate this.

Nepal barley production is at risk mainly due to stripe rust. Nepalese barley workers have found stripe rust resistant lines readily available from the ICARDA/CIMMYT Program.

Chinese scientists have found an increased number of lines with good resistance to scab and Barley Yellow Mosaic (BYM), both important barley diseases in the Yang-Ze Basin

Most encouraging, however, are the results obtained by national barley workers, who reported on the yield performance of some advanced lines sent to them in the 9th International Barely Yield Nursery. The results confirm previous data showing that barley lines developed for Latin America have a wide spectrum of adaptation at yield levels of 3.5 t/ha and above, outyielding, in most locations, the best national check (Table 32).

Table 31. Frequency of multiple disease resistance in 1275 advanced barley lines from ICARDA/CIMMYT, Mexico.

Disease combination	No. resistant lines
Three Diseases:	
PG - PS - PH	543
PG PS RS	227
PG PS PT	111
Four Diseases:	
PG PS PH RS	210
PG PS PH PT	108
PG PS RS PT	52
PG PH RS PT	77
Five Diseases:	
PG + PS - PH - RS - P	44

PG = Puccinia graminis
PS = P. striiformis
PH = P. hordei
RS = Rhynchosporium secalis
PT = Pyrenophora teres

Table 32. Yield performance of Gloria/Copal "S" lines in the 9th IBYT as compared to national checks during 1987.

Country	Yield (t/ha)		
	Gloria/Copal	Local Check:	Name
Mexico	9.3	9.3	Gloria/Copal
Spain	10.1	6.4	Dobla
Cyprus	6.7	4.1	Kantara
Turkey	5.1	4.2	
Tunisia	7.4	5.2	Rojo
Algeria	8.6	4.9	Saida 183
Ethiopia	3.8	2.6	Iar H 485
Pakistan	4.1	3.2	Jau-83
Norway	6.9	6.0	Pernilla
China	3.6	2.4	

Variety release

Five varieties were released in three countries as direct introductions. Selections were made in segregating generations and sent directly by the Program.

Pakistan	Jau-87
Peru	Nana 87, Una 87
Thailand	Semang 1, and Semang 2

Yield testing of barley lines on a national scald in Bolivia, Tanzania, Ecuador, and Vietnam will result in the release of varieties in the near future.

Traits to enhance barley adoption

Hull-less barley

The production of hull-less, disease resistant barleys with large grains was rapidly obtained by using the single-seed descent method. In 1988, F_6s with large, white kernels and thousand-kernel weights up to 68 are available. The hull-less lines were field-screened for resistance to stripe rust, BYD, and scald. Unfortunately, these selections showed susceptibility to leaf rust.

H. Vivar

References

Acevedo, E., 1986. ICARDA. Cereal Improvement Program. Annual Report.

Bidinger, F.R., V. Mahalakshmi, and G.D.P. Rao, 1987. Aust. J. Agric. Res. 38, 49-59.

Ceccarelli, S., 1984. Rachis 3(2): 8-11.

Ceccarelli, S., S. Grando, and J.A.G. van Leur, 1987. Euphytica 36: 389-405.

Nachit, M.M., 1986. ICARDA. Cereal Improvement Program. Annual Report.

Passioura, G.B., 1972. Aust. J. Agric. Res. 23: 745-752.

Van Leur, J.A.G., S. Ceccarelli, and S. Grando, 1989. Plant Breeding (in press).

2.2. Durum Wheat Breeding

The durum wheat (Triticum turgidum L. var durum) breeding project at ICARDA is a joint venture between ICARDA and CIMMYT for the dry areas in the West Asia and North Africa Mediterranean region (WANA). The objective of the project is to assist WANA countries to enhance durum wheat production by developing improved germplasm, improving crop management, upgrading of manpower capabilities and developing efficient research methodologies. Four major agroclimatic zones were identified to meet the needs of the various dryland areas in the WANA region and an improved durum wheat breeding methodology was devised to meet the agroclimatic challenges of the region (Annual Reports, 1985/86, 1986/87).

In 1987/88 severe intermittent drought and terminal drought and heat stresses affected cereal production in Tunisia and Algeria while Morocco and the Middle East region recorded favorable rainfall. However, only Morocco has a bumper cereal crop. Syria and other Middle Eastern countries experienced heat during the wheat grain filling period. This reduced grain weight and size, and consequently yield. In addition to abiotic stresses, wheat stem sawfly infestations were very high in the Middle East, while Hessian fly, septoria and leaf rust occurred in Morocco and the Western parts of Algeria.

Notable progress in increasing dryland durum wheat yields were achieved. This is reflected in the performance and releases of advanced and promising durum wheat lines in the dry areas. Korifla was released under the name Cham 3 in Syria, and Belikh 2 in Lebanon. In Jordan Korifla was also released for the dry areas under the name Petra while Cham 1 was released under the name Maru. In Tunisia and Algeria Om Rabi 9 and Kabir 1 are under large scale testing.

Breeding Methodologies

a) Broadening the genetic base of durum wheat

The genetic base of improved commercial durum wheat varieties is narrow, particularly, with regard to biotic and abiotic stresses, quality parameters, and earliness. Therefore, following strategies were utilized to broaden the genetic base. These are:

Utilization of landraces

Thirty six crosses with landraces from North Africa and 178 from West Asia were conducted to upgrade resistance to drought, cold, premature desiccation, common bunt and septoria tritici.

Utilization of wild emmer

One hundred fifty six crosses were made between wild emmer (T. dicoccoides) and durum wheat for improving nutritional quality, resistance to yellow rust and septoria tritici. Back crossing to durum wheat was done to suppress undesirable traits.

Utilization of wheat relatives

Several crosses with T. monococcum, T. aegilopoides, T. carthlicum T. uranicum, T. compactum, T. beocticum, T. urartu, and T. persicum were made.

Recurrent selection population

A population using the recurrent selection method was established. It is comprised of parental material with high yield stability, and multi-biotic and abiotic stress resistance.

b) Genetic studies

Vitreousness

The estimate for heritability of vitreousness was moderate (0.489 ± 0.097). Results also indicate that cytoplasmic inheritance is important in kernel vitreousness (Nachit and Asbati, 1988).

Crosses with dicoccoides

This activity is done in collaboration with the faculty of Agriculture of the University of Amman, Jordan. Results indicate that characters studied in dicoccoides x durum wheat crosses are quantitatively inherited and influenced by both additive and non-additive gene action. Transgressive segregation was also observed for kernel weight. Broad sense heritabilities were estimated for fertile tillering ability (0.78 to 0.93), thousand kernel weight (0.74 to 0.94) and protein content (0.24 to 0.82). Crosses derived from dicoccoides x durum wheat show high grain protein content and a high number of fertile tillers.

c) Gradient selection

A cluster analysis of testing sites supports the use of double gradient (moisture, temperature) selection technique developed in the durum wheat project (ref. previous annual reports). Table 33 shows the distribution of double gradient testing sites in the different clusters. Early planting environment has clustered with group 1, while late planting and Breda clustered with group 2 where moisture stress and terminal stresses predominate. Terbol station clustered with the high yielding environment. Tel Hadya rainfed normal planting was grouped with sites having continental climatic conditions.

d) Haploid breeding

Crosses with bread wheat cytoplasm, Aegilops and T. dicoccoides were conducted for future study on regeneration of haploid plants through anther culture and Hordeum bulbosum techniques.

Table 33. Clustering of 38 testing sites using grain yield of 23 durum wheat lines (average linkage with correlation as distance measure).

Cluste	Site
I	Darab (Iran), Sids (Egypt), **Tel Hadya/Early Planting (Syria)**, El Marg (Libya), Mallawi (Egypt).
II	Karaj (Iran), Debre Zeit (Ethiopia), Maru (Jordan), Tabuk (Saudi Arabia), Zahle (Lebanon), Merchouch (Morocco) Settat (Morocco), Jerez (Spain), Beja (Tunisia) Islamabad (Pakistan), **Tel Hadya/Late Planting (Syria)**, **Breda (Syria)**, Tessaloniki (Greece).
III	Farobroman (Iran), Cassacia (Italy), **Terbol, (Lebanon)** Bajadoz (Spain), Obregon (Mexico), Izmir (Turkey), S. Bel Abbes (Algeria), Moushker (Jordan), Viterbo (Italy) Santa Engracia (Spain), Hohenheim (Germnay).
IV	**Tel Hadya/Normal Planting (Syria)**, Gellin (Syria) Sids (Egypt), Le Kef (Tunisia), Alentejo (Portugal), Shandweel (Egypt).
V	Khroub (Algeria), Cassacia (Italy).

Biotic Stresses

Disease resistance breeding

In 1987/88 the following targeted crosses for disease resistance were conducted; 90 crosses for yellow rust, 19 for leaf rust, 100 for stem rust, 62 for septoria tritici, 56 for common bunt , 21 for barley yellow dwarf virus (BYDV), 18 for powdery mildew and 107 for multiple disease resistance.

At Tel Hadya/early planting, segregating populations were screened for yellow rust resistance. F5, F6 and F7 generations showed a high percentage of resistant populations compared with the early segregating populations. Similar trends at Lattakia for septoria tritici resistance was noticed, 78% of the F6 and F7 generations showed resistance to septoria tritici. However, in the case of septoria tritici, the percentage of resistant populations in the F3, F4 and F5 was low if compared with the yellow rust resistance levels. Nevertheless, the F2 generations exhibit a high level of resistance to septoria tritici. This is a result of continually upgrading resistance through the incorporation of resistant parental material from landraces and <u>dicoccoides</u> into advanced durum wheat germplasm.

For stem rust, and root and foot rot resistance the segregating populations were screened in Terbol during the summer planting. Around 30% of the segregating populations showed resistance to both diseases.

Breeding for insect resistance

Crosses for insect resistance were performed as follows: 21 for heat stem sawfly, 17 for aphid resistance and 47 for Hessian fly. Hessian fly resistance crosses were made with Hessian fly Bread wheat resistant lines in Morocco and need several back-crossings to durum wheats.

Most of the advanced lines of durum wheat exhibit medium to high resistance to wheat stem sawfly under natural infestations at Breda. Resistance to wheat stem sawfly is apparently not confined to stem solidness in durum wheat. However, several durum wheat landraces from Morocco were found to possess solid stems and are now used in the crossing program for wheat stems sawfly resistance. Incorporation of resistance to wheat stem sawfly from different sources and with different resistance mechanisms are combined to develop stable resistance to this insect for the dry areas of WANA region. Wheat stem sawfly resistance was moderate, and positively associated with plant vigour (+.25), tillering (+.23), number of days to heading (+.56) and grain protein content (+.39). It was negatively correlated with plant height (-.57), peduncle length (-.47) . The linkage between wheat sawfly resistance and lateness needs to be broken in order to develop early, resistant lines.

Crosses with aphid resistant lines and Hessian fly resistant lines are still in the early segregating generations. However, adequate Hesian fly screening sites near ICAPDA's base breeding programs are still lacking. Sites at Lattakia and Terbol are presently in use.

Abiotic Stresses

Breeding for drought resistance

In this season, drought limited durum wheat production in WANA particularly in the eastern Maghreb. Grain yield reduction due to low moisture and premature desiccation during the grain filling period was estimated at 50% in Algeria and 80% in Tunisia.

Rainfall at ICARDA's dry site research stations (Breda and Bouider) was very high compared with the long-term average precipitation. Breda's precipitation in 1987/88 was 408 mm. This is an increase of 67% compared with 1986/87, and was more than double the normal at Bouider (117%). However, intermittent drought stress did occur at both sites and a high evapotranspiration demand was observed near the end of March.

Grain yield at Breda and Bouider was above average. Table 34 shows grain yield (kg/ha) and precipitation (mm) at Breda for 3 consecutive seasons.

Table 34. Grain yield (kg/ha) of durum wheat in advanced durum yield trials (ADYT) at Breda for 3 years (1986, 1987, and 1988).

Season	Rainfall (mm)	Grain Yield(kg/ha) ADYT Mean	ADYT Max.	Haurani
1985/86	218	1224	1697	1014
1986/87	145	1127	2500	1066
1987/88	408	3608	4372	3026

The line Om Rabi 17 was identified in 1986/87 for its good performance under stress conditions, and was included in farmers field verification trials of the low rainfall areas (Table 35).

Table 35. Performance of Om Rabi 17 and Haurani under dryland conditions in experimental stations and farm field verification trials, 1987/88.

Entry	Bouider	Breda	FFVT
Om Rabi 17	2420	4372	3469
Trial Mean	1930	3608	3400
Haurani (check)	1521	3022	2828
LSD (0.05)	628	539	160
CV	12.8	7.8	9.3
Om Rabi 17 / Haurani x 100	159.1	144.7	123.0

FFVT = Farmers Field Verification Trials, 10 sites,
B-Zone = Low rainfall areas with less than 350 mm

Om Rabi 17 is adapted to low rainfall areas with continental climates, while Cham 3, a stress tolerant line is adapted to low rainfall areas with mild winters.

By comparing the water use efficiency (WUE) of the stress tolerant high yielding lines, the stress tolerant nursery mean and the stress tolerant landrace Haurani, we found that the WUE by Haurani was 4.6 kg/mm in 1986/87, while in 1987/88 it was 7.4 kg/mm, the 67% above normal precipitation in 1987/88 resulted in an increase of 3 kg per mm water for Haurani while in the case of the stress tolerance nursery it was 4.2 kg/mm, and in the stress tolerant and highest yielding lines, it was 4.6 kg/mm.

The percentage of selection gain in WUE was 28.6% for the stress tolerance nursery and 34.8% for the highest yielding entries under dry conditions. Input responsiveness and stress tolerance are important components of varietal development for the low rainfall durum wheat areas of the Maghreb and Middle East region.

Table 36 shows the successful combination of stress tolerance and input responsiveness. Both Mrb 17 and Daki combine higher stress tolerance with yield potential.

Table 36. Grain yield (kg/ha) and 'stability' of newly developed durum wheat lines for low rainfall areas.

Entry	Mean Yield	Reg. Coeff.
Daki	3656.3	1.19
Mrb 17	3469.0	0.98
Korifla	3440.1	0.93
Haurani	2828.0	0.69

Traits associated to grain yield under moisture stress conditions:

Fertile tillering ability is by far the most potent predictor of durum wheat grain yield under moisture stressed conditions. It accounted for 32.3% (Breda) and 24.2% (Bouider) of the variability in grain yield. These results corroborate last years findings (AR 1985, 86, 87).

Spike fertility and number of days to heading (earliness) contributed to grain yield at Bouider by 5.3% and 4.1%, respectively. At Breda increases in spike fertility and the number of days to heading were insignificant. However, grain yield was associated to plant height, length of the peduncle and early plant vigour and accounted for 6.0, 6.6% and 2.2%, respectively. The Bouider nursery suffered from moisture stress at anthesis, and the Breda Nursery from high evapotranspiration following anthesis.

The breeding methodology, developed for moisture stress breeding is now paying dividends not only reflected in identification of durum wheat genotypes with high stress tolerance and good performance for the low rainfall areas of West Asia, but also for the Maghreb region, particularly Algeria (Fig. 5). Future research activities in this areas will continue to upgrade drought tolerance through further use of durum wheat landraces and wild relatives.

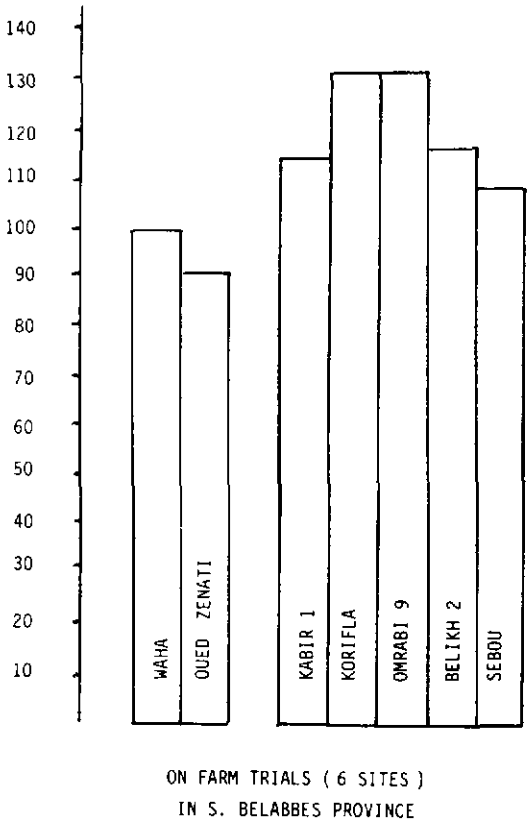

Fig. 5. Yield of durum wheat lines in percent of Waha's yield.

Breeding for heat and terminal stresses

High temperature during the growing season and/or during grain filling frequently occurs in the Mediterranean dry areas of the region

Durum wheat grown in some areas of WANA this season were exposed to high temperature during the grain filling period, particularly in Tunisia and West Asia. Although the 1987/88 season was favorable in precipitation in the West Asia (particularly Syria) yields were average to below average. The causes for this may be the occurrence of high temperatures during the grain filling period. However, it was also observed that nitrogen fertilization was not adjusted to the favorable rainfall conditions.

Intermittent high temperature during the growing season also increased water stress. This phenomena is found in wheat areas with littoral climate and other areas with mild winters. Wheat grown on light textured soils and/or without fallow is particularly prone to moisture and high temperature stress.

The durum wheat project has developed a testing techniques for heat, high evapotranspiration and premature desiccation stresses. Selection for heat is conducted under summer planting techniques at Terbol where maximum temperatures are above 30°C and minimum temperatures do not go below 20 °C during the vegetative growth. Late planting techniques at Tel Hadya are applied to simulated stresses caused by high evapotranspiration demand and premature desiccation.

At Tel Hadya temperature rises from mid-April onward, causing high evapotranspiration, and normally coinciding with a rapid rainfall decreases. Hot and dry winds also occur during this period. Terminal stress nurseries are sown at the *beginning* of April. Germination concurs with the dry and high temperature climatic conditions when soil moisture is rapidly depleted.

Results achieved through late planting and heat tolerance screening are high-lighted by the performance of the cultivar Daki. Daki is also tolerant to terminal stresses.

Table 37 substantiates the selection gain made 1987/88 in heat and terminal stress tolerance and corroborates the results of previous years.

Table 37. Grain yield performance of terminal stresses/heat tolerance nursery, in 1986/87 and 1987/88.

Group/Cultivars	1986/87		1987/88	
	kg/ha	%	kg/ha	%
Nursery mean	888	161	1297	222
Highest yielding lines (5%)	1172	213	1738	298
Maximum yield	1548	281	1850	317
Checks: Haurani	550	100	583	100
Cham 1	765	139	1593	273
Stork	658	120	993	171
LSD (0.05)	469	-	508	-
CV (%)	15.1	-	12.7	

Morphophysiological traits associated to adaptation to terminal stresses conditions.

Relationships between morphophysiological characters and grain yield under terminal stress conditions were analyzed by regression techniques. Table 38 shows simple correlations between several morphophysiological traits and grain yield under terminal stress conditions.

Table 38. Correlation of grain yield with some morphophysio-logical traits under terminal stress/heat conditions, Tel Hadya, 1987/88.

Morphophysiological Traits									
PV	DH	DM	PH	FTA	PL	SF	LT	LERO	TKW
.189*	-.337**	-.048ns	.626***	.603***	.44***	.612***	.209**	.281**	-.224*

GY = Grain yield; NS = Not significant; *, **, *** : Significant at 5, 1, 0.1 % respectively. TKW = Thousand kernel weight.
PV = Plant vigour; DH = No. of days to heading;
DM = No. of days to maturity; PH = Plant height;
FTA = Fertile tillering ability; PL = Peduncle length;
SF = Spike ferility; PL = Peduncle length;
LT = Leaf temperature; LERO = Leaf rolling;

Under late planting conditions grain yield mainly correlated with early plant vigour, earliness, plant height, fertile tillering, peduncle length, spike fertility, leaf rolling and seed size. All contribute through various physiological mechanisms to yield.

Yield variability under terminal stress was explained for 75% by the above-mentioned morphological traits. Plant height alone accounted for 39.2% while 21.6% was accounted for by fertile tillering ability and 9.2% by spike fertility.

Breeding for cold and frost damage

In the continental mediterranean dryland and plateau areas of WANA, durum wheat yields are often reduced, because of cold at the vegetative growth stage and/or frost at anthesis.

Meteorological data revealed that the continental areas of WANA region are cold and dry (Annual Reports, 1986, 1987). The cold and frost incidence increased with increased latitude and altitude.

The continental areas are also characterized by drought, and terminal stresses. Evapotranspiration demand during the vegetative stage is low. However, during the grain filling stage it increases very quickly and soon exceeds precipitation.

Cold and frost damage on winter cereals were reported this season in Algeria and on the Lebanon plateau. Cold damage shown in the field by the reduction of dry matter production and tillers per unit area, whereas frost damage is displayed through impaired spike fertility.

Gradient selection techniques use early planting as a tool to test durum wheat breeding material for cold and frost tolerance. In 1987/88 insignificant cold damage was observed. However, slight frost damage was recorded. Lines with high spike fertility were also those with high yields. Spikelet number per spike was the largest contributor to yield among spike fertility parameters. In the cold and frost testing environment 44.12% of the total yield variability was explained by the fertile tillering ability.

Breeding for Grain Quality

In 1987/88 45 crosses were made to increase industrial quality and 156 for nutritional quality. Korifla and Haurani are currently the best sources for industrial qualities, while T. dicoccoides is used to increase grain protein content in durum wheat grain. The technique of zero-nitrogen screening (Nachit and Asbati, 1988) is now generating promising results. Table 39 shows the distribution for protein content, kernel vitreousness, kernel weight and pigment content. Zero-nitrogen screening technique scattered distribution of durum wheat genotypes for quality traits enabling a better selection of lines with high grain quality. The range for grain protein content was 8% to 16%, for vitreousness 10% to 100%, for thousand kernel weight from 31 to 62, and from 3 ppm to 7 ppm for pigment content.

Table 39. Quality traits in different environment, RCB 1987/88.

Environment	PC (%)		VTR (%)		CC (ppm)	
	Mean	Range	Mean	Range	Mean	Range
Rainfed/TH	12.3	9.0-16.3	91	55-100	5.2	4.0-7.0
Early/TH	10.7	8.3-13.5	83	34-100	5.7	4.5-7.0
Breda	11.9	9.6-14.8	95	66-100	5.5	4.0-7.0
Zero-N technique.	10.8	8.2-15.0	59	3- 97	4.2	3.0-6.0

PC (%) = Protein content
VTR (%) = Vitreousness (%)
CC (ppm) = Carotene content in parts per milliliter

Stability

Stable varieties are necessary to achieve reliable production in dry areas. Grain yield and associated traits such as early plant vigour, plant height, spike fertility and tillering ability are investigated.

Early plant vigour

The highest expression of early plant vigour was obtained in the early and late planting nurseries, while the lowest expression was found in Breda and Bouider. Table 40 shows the early plant vigour of ADYT-trials in different environments.

Associations between stressed and favorable environments were low. This indicates the importance of G x E interactions and highlights the need for developing durum wheat material with consistent and stable early vigour.

Table 40. Expression of early plant vigour (1-9 scale) in ADYT in different environments, 1987/88.

Environment	Bouider	Breda	T.Hadya Late P.	T.Hadya Early P.	T.Hadya Rainfed
HYL (5%)	7.2	7.3	8.0	8.3	6.0
ADYT-Mean	5.2	4.8	6.3	6.9	5.6
Haurani	5.0	5.0	7.0	8.0	6.0
Cham 1	6.0	6.0	7.0	9.0	6.0
Stork	2.0	6.0	7.0	8.0	6.0
LSD (0.05)	0.87	0.72	0.56	0.75	0.63
CV (%)	11.5	7.8	10.3	8.9	9.7

HYL = high yielding lines

Plant Height

The largest plant height was obtained in the rainfed environment (T. Hadya) where the ADYT mean for plant height was 112.3 cm. For Tel Hadya/early planting and Breda the ADYT means were 97.9 and 95.7 cm, respectively, while at Bouider plant height was 78.1 cm. Late planting drastically reduced plant height (43.8 cm) to almost half. Table 41 shows the correlation coefficients between plant heights in different environments. The high correlation coefficients obtained between environments indicate low G x E interactions for plant height.

Table 41. Relationship between plant heights from different environments, 1987/88.

Environment	Bouider	Breda	T. Hadya Late P.	T. Hadya Early P.	T. Hadya Rainfed
Bouider		0.769***	0.427***	0.617***	0.838**
Breda		-	0.426***	0.839***	0.917***
TH/Late P.			-	0.465***	0.427***
TH/Early P.				-	0.799***
TH/Rainfed					-

n = 87, *** = significant at 0.1 %
Early P. = Late planting
Late P. = Early planting
TH = Tel Hadya

Spike Fertility

Spike fertility was negatively affected by terminal stresses and drought. This effect is particularly prevalent under late planting and at the Bouider station. At Tel Hadya (early planting, rainfed) and Breda, spike fertility was similar. Spike fertility of durum wheat genotypes was much influenced by late planting (Table 42). This suggests the imprtance of using late planting environment to select high and stable spike fertile durum wheat.

Table 42. Relationship between spike fertility from different environments, 1987/88.

Environment	Bouider	Breda	T. Hadya Late P.	T. Hadya Early P.	T. Hadya Rainfed
Bouider	1.000	0.320**	0.071*	0.058*	0.489***
Breda		1.000	0.215*	0.528***	0.455***
TH/Late P.			1.000	0.263*	0.427**
TH/Early P.				1.000	0.422**
TH/Rainfed					1.000

n = 87; *, **, *** = significant at 5,1 and 0.1 % respectively;
Late P. = Late planting; Early P. = Early planting

Fertile tillering ability

The nursery means for fertile tillering were similar in all environments. However, Tel Hadya/Late planning reduced the number of fertile heads per unit area. Low correlation between environments for fertile tillering ability was observed (Table 43). This means that the G x E interaction for fertile tillering ability is large. The need to incorporate stability to this trait is implicit, particulary when several other studies (ICARDA Cereals Program Annual Report, 1984, 1985, 1986, 1987) have demonstrated the importance of fertile tillering with regards to grain yield under dry conditions.

Table 43. Relationship between tillering from different environments, 1987/88.

Environment	Bouider	Breda	T. Hadya Late P.	T. Hadya Early P.	T. Hadya Rainfed
Bouider	1.000	0.266*	0.088	0.084	0.161
Breda	-	1.000	0.014	0.294***	0.245*
TH/Late P.			1.000	-0.044	0.129
TH/Early P.				1.000	-0.065
TH/Rainfed					1.000

n=87; *,**,*** Significant levels at 5;1; and 0.1 % 001 respectively.
Late P. = Late planting; Early P. = Early planting

Multilocation testing in WANA

The most promising lines in the advanced durum wheat material are included in the regional observation nurseries. These nurseries are targeted to two major environments: those with moderate rainfall (DON-MR) and those with low rainfall (DON-LR). Table 44 shows the most promising durum entries in comparison with regional checks.

Table 44. Grain yield and agronomic traits of the highest yielding entries in the DON-LR, 26 locations in WANA region, 1986/87.

No.	Cross/Name	GY	HD	DM	PH
40	Ch 67/Cando	3580	114	159	88
38	Syrica 3	3473	113	159	83
37	Karasu	3465	113	155	83
33	USDA 575/Ente//Erp/Ruso	3405	113	154	85
90	Dades	3384	112	154	73
10	Awali	3347	111	155	86
112	Daki	3316	110	151	76
18	Lahn	3287	119	157	77
32	Om Rabi 6	3210	109	152	86
109	Om Rabi 9	3200	113	156	86
Haurani (Reg. check)		2424	116	1591	92
Cham 1 (improved, Reg. check)		2768	108	149	78
No. of Locations		25	39	19	30

GY = Grain yield (kg/ha)
HD = No. of days to heading
DM = No. of days to maturity
PH = Plant height (cm)

The data and analyses of the multilocation tests in WANA for 1986/87 has been sent to durum wheat scientists in the region. The most noticeable results are the confirmation of the yield potential and stability of Dades and Daki. They have been tested for several years in the regional durum yield trails (RDYT-LR) intended for the low rainfall areas in the region (Table 45). Similar results for the entries Scoflag and Oronte 6 were obtained in yield trials targeted for the moderate rainfall areas (RDYT-MR) (Table 46).

Table 45. Performance of high and stable durum wheat lines in the RDYT-LR, for 3 years (1984/85 to 1986/87 WANA region).

No.	Entry	Grain yield (kg/ha)	Stability (AR) 1984/85	1985/86	1986/87
9	Dades	4059	-	7.7	7.1
16	Daki	4082	7.8	8.9	8.0
12	Cham 1	3627	11.7	10.6	10.7
	Trial mean	3627			
	LSD (0.05)	307			
	CV (%)	17.3			
	No. of sites	42			

AR = Average rank

Table 46. Performance of high and stable durum wheat lines in the RDYT-MR, (1986/87, WANA region).

No.	Entry	Grain yield (kg/ha)	Stability parameters AR	SDR
6	Scoflag	5093	9.5	6.76
4	Oronte 6	4944	10.0	5.95
12	Cham 1	4910	12.6	6.78
1	Stork	4534	15.3	7.49
	Trial mean	4733		
	LSD (0.05)	275		
	CV (%)	16.1		
	No. of sites	39		

AR = Average rank, SDR = Standard deviation of rank.

M. Nachit

Special studies

The experiment on selection strategy was continued this year. Forty F_4 bulk families were tested in both rainfed and irrigated (30 mm irrigation on 9 May) fields in replicated trials and in a space planted experiment to allow individual plant selection in the F_4 generation.

Visual scores were taken on all the material with respect to disease reaction, maturity, plant height and homogeneity. Grain yield was also determined in the yield trials. The top yielding F_4 bulks in the rainfed field were also high yielding in the irrigated field. High rainfall during this season may partly explain this finding. There was also concordance between selection (of top 10%) based either on grain yield or on other traits recorded visually. Therefore visual selection among F_4 bulks was a good indicator of their yielding ability.

Additional material including F_4 lines were grown in plant rows according to the pedigree scheme for selection under both rainfed and irrigated conditions.

In another study, two durum wheat cultivars, Haurani and Cham 3, were grown in plots with varying interplot distance (20, 30, 100 and 150 cm) with the same interrow distance (20 cm) within plots. Results showed a strong border effect on the two outer rows for the 100 and 150 cm distances and on only the outmost row for the 30 cm inter-plot distance. No significant border effect was detected when the inter-plot distance was 20 cm. These results indicate that the usual procedure of leaving a one-row border on each side of a plot is not recommended for plots situated at the ends of a block, as it gives an upward bias to the yield in these plots. It is suggested to leave two-row borders in these plots or to include an additional "non-treatment" plot at each end of a block.

H. Ketata

2.2.1. Evaluation of Durum Wheat and Germplasm Development

The cooperative project between ICARDA and Italian institutions on Evaluation and Documentation of Durum Wheat Germplasm has completed the field evaluation of ca. 18,000 accessions from the ICARDA Collection as well as samples received from several germplasm collection missions in the region.

The project has identified a number of landraces from various origins possessing tolerance to major biotic and abiotic stresses prevalent in the dry areas as well as having good industrial quality.

During 1987/88, the third season of the project, 3359 accessions representing the final part of ICARDA's durum germplasm collection were planted at Tel Hadya and Breda, the moderate and low rainfall testing sites. These two locations are characterized by long-term average rainfall of >350 and <275 mm respectively. However, this season's total precipitations were 503 and 408 mm. The experiments in salt tolerance at Hegla could not be undertaken this year due to partial flooding by the waters from Lake Jabboul.

Results of screening for tolerance to yellow rust (Puccinia striiformis), carried out in collaboration with wheat pathologists, was successful in identifying 11% of the lines as resistant, 25% as moderately resistant, 26% as moderately susceptible, and 38% as susceptible. The higher precipitation this season also encouraged a natural infection of yellow rust in large plots used for agro-morphological evaluation. The experiment for screening against common bunt (Tilletia caries and T. foetida) in the isolation fields was delayed due to incessant rains.

This did not encourage the establishment of the infection and therefore a second replicate was planted in February. The results on the basis of both replicates were as follows: 4.5% of the accessions were found to be resistant, 10% were moderately resistant, 20% were moderately susceptible and 65% were susceptible. Accessions resistant to yellow rust and common bunt will be retested next year in consultation with wheat pathologists to confirm these characteristics.

Out of a total of 2478 accs. of durum wheat screened for stem solidness, a desirable trait for resistance to European wheat stem sawfly (Cephus pygmaeus), 220 lines were found to be solid stemmed (Fig. 6). A cut in the mid-section of three second uppermost internodes selected at random was considered for scoring stem solidness. When these lines were further tested, in collaboration with cereal entomologists, nearly 75% were found to be resistant. These observations were based on 60 stems selected at random per line.

Selected lines from previous season were retested for resistance to yellow rust (Puccinia striiformis) and common bunt (Tilletia caries and T. foetida) in close consultation with wheat pathologists. Eighty percent of these lines confirmed their resistance for yellow rust. Similarly, out of 83 selected lines retested for resistance to common bunt 40% maintained their resistance in the second year's screening. These lines have been recommended to the breeders for further evaluation and utilization.

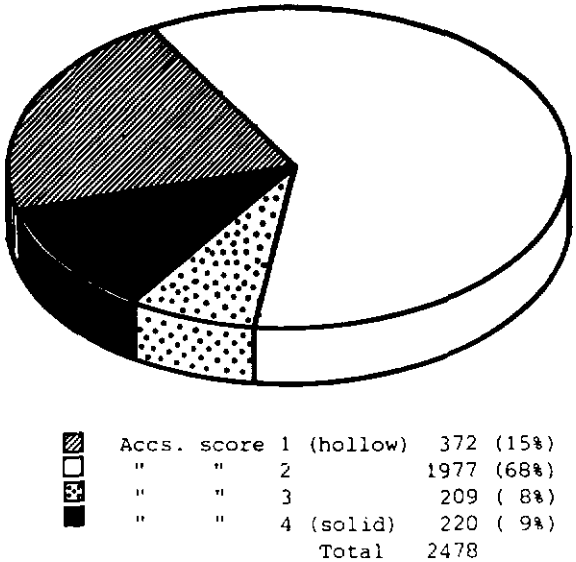

Fig. 6. Results of screening for stem solidness of durum landraces. Scores 1 to 4 based on visiual observations on three randomly selected stems from different plants.

Evaluation for Cooking Quality and Other Traits at University of Tuscia, Viterbo, Italy.

The research group in Italy, headed by Professor E. Porceddu, analyzed electrophoretic banding patterns of 2644 accessions of durum germplasm harvested in the 1986/87 season at Tel Hadya. Electrphoretic profiles were compared with the Italian durum wheat cultivar "Karel," which is known for its high yield and good pasta cooking qualities. The presence or absence of band with relative mobility of Rm 45 was once again used as a genetic marker for good pasta cooking quality. A further 3359 accessions, representing the final part of ICARDA's durum wheat world collection has been sent to the University of Tuscia at Viterbo for analysis. Simultaneously, grain quality characteristics such as 1000-KW and protein content are being analyzed at the Cereal Grain Quality Laboratory at Tel Hadya.

Evaluation Network for Selected Durum Germplasm

Following a durum germplasm consultation meeting, a set of 200 selected accessions were sent to the national programs of eight cooperating countries. Results of evaluation for seven economically important characters have been received from Ethiopia (Debre Zeit), Pakistan (Islamabad), Tunisia, (Mornag) and partially from Canada (Swift Current). The characters were: days to heading, days to maturity, plant height, 1000-kernel weight, reaction to yellow rust (Puccinia striiformis), reaction to Septoria and an agronomic score based on visual observation. In addition, Ethiopian evaluators were also able to record reaction to stem rust (Puccinia graminis f.sp. tritici) and leaf rust (P. recondita), i.e. 34 accessions were resistant to stem rust and 65 to leaf rust.

When comparing selected accessions on the basis of performance at Tel Hadya and Breda, it was found that there was no difference in their agronomic score in Pakistan, but under Ethiopian drought affected conditions the accessions selected in Breda had a significantly higher agronomic score than those selected on basis of performance at Tel Hadya. Similarly, germplasm selected for resistance to Septoria maintained the resistance on an overall basis in Pakistan. The same nine accessions had a high agronomic score in Tunisia and Ethiopia and three accessions in Tunisia and Pakistan. However, none of the 200 accessions distributed performed identically at all three locations. This may be due to the highly contrasting temperature, rainfall and general difference in environment of the evaluation sites.

Out of 200 accessions evaluated at Mornag, Tunisia, a low rainfall site with seasonal precipitation of 280 mm, 26 accessions were drought tolerant, 106 were affected by the drought but survived and 68 were susceptible. Out of the first two categories fourteen accessions were identified by Tunisian evaluators for inclusion in their breeding program on the basis of a high agronomic score and high 1000-KW (Table 47). These lines were also better or equivalent in performance to their local check "Karim." Twenty-two lines out of the 53 accessions selected in Breda and sent to evaluators in Swift Current, Saskatchewan, Canada, had low (desirable) rates of water loss from excised leaves. There is, therefore, evidence to support the theory of a linkage between low water loss rate and good yields under dry conditions (J. Clarke, pers. comm.). Further testing is in progress. Additional results and data are expected from India, Kenya, Italy and Turkey. In the meantime Australia, F.R. Germany and United States of America have joined the network.

Based on past four years of work and the information emanating from the evaluation of selected germplasm at the national programs of co-operating countries in the network an elite germplasm has been developed possessing the following traits: drought tolerance, salinity tolerance, frost tolerance in the vegetative phase, short duration, high protein content, good industrial quality, disease resistance, solid stem, and resistance to certain insect pests. This germplasm is available on request with pass-port information and meteorological data of the evaluation sites.

A.B. Damania, J.P. Srivastava, and L. Pecetti

Table 47. Fourteen promising accessions of durum wheat to be further tested in Tunisia in 1988/89.*

IC. NO.	Drought resistance**	1000-Kernel weight(g)+	Plant height (cm)
6020	I	60.56	72
6140	I	70.80	65
6190	I	63.26	70
6201	R	60.19	80
6223	I	60.00	81
12748	I	61.96	63
12768	I	59.29	50
12795	I	59.60	43
17120	I	63.40	44
17498	I	73.05	50
17553	I	63.04	63
18076	I	68.23	58
18457	I	64.19	57
18796	R	60.92	48

+ Based on weight of grains/spike
* Data based on report received from INAT, Tunisia
** Drought resistance category:
R = No evidence of stress
I = Somewhat affected by the stress, but not in danger

2.3. Bread Wheat Breeding

Two significant events happened during the 1987/88 crop season: a) the amount of rainfall was unusually high at most of our experiment stations in Syria and b) the joint Bread Wheat Project was reviewed by the external program reviews of CIMMYT and ICARDA. We therefore concentrate in this report in presenting results from our driest sites in Syria and from other dry locations in West Asia and North Africa. We describe progress made in understanding and describing the target environment, identifying genetic stocks with tolerance to different stresses, developing breeding methodologies, increasing germplam adaptation and giving support to National Programs by jointly identifying and releasing promising cultivars.

Production Zones

Bread wheat comprises approximately 70 percent of the total wheat (bread wheat + durum) grown in West Asia and North Africa (WANA). In WANA bread wheat is grown in three different agro-climatological zones based on moisture availability and temperature regimes. These are:

a) areas of low rainfall associated with low temperature,
b) areas of moderate rainfall with moderate to high temperature and,
c) irrigated areas.

The area and percentage of bread and durum wheat grown in these production zones are presented in Table 48. There are 7.3 million ha of bread wheat grown under less than 400 mm rainfall. Together with the 5.7 million ha grown under 400-600 mm, this represents 77 percent of the total wheat grown under rainfed conditions in WANA.

These rainfed environments are characterized by being highly variable and unpredictable in terms of moisture (amount and distribution), temperature and other biotic stresses. These production zones may be described as follows:

a) areas of low rainfall associated with low temperature

Approximately 7.3 million hectares, or 43% of the total wheat grown in WANA, is planted in these environments. This production zone includes the continental areas of Morocco, Tunisia, Algeria, Iran, Iraq, Afghanistan, Turkey and Syria. It is characterized by being highly variable and unpredictable in terms of moisture availability and temperature regimes.

In these areas bread wheat is grown and harvested under significant temperature fluctuations. Typically, bread wheat is sown in the fall where early growth and development occurs during the coolest months and grain ripening occurs during the warmest months. Extreme cold and heat are common abiotic stresses encountered during the crop season and frequently a complex interaction between them and moisture deficits develops. Biotic stresses such as common bunt, loose smut, Hessian fly, sawfly and sunni bug are also important constraints to wheat production. Crop management is frequently poor and yields are low (less than 1 t/ha).

b) areas of moderate rainfall with moderate to high temperatures

Approximately 5.7 million ha, representing 34% of the total bread wheat grown in the region is planted in this production zone. These areas are represented by the costal-Mediterranean environments of the region as found in Morocco, Algeria, Tunisia, Turkey and Syria. Beside foliar diseases, other seed-born diseases such as common bunt and loose smut, affect yield and stability of yield. Insect pests such as Hessian fly, sawfly and aphids infest the crop, and with high temperatures, jointly affect wheat near the end of the season. In these areas, the lack of good agronomic practices such as weed control, seed density, seed treatment, fertilizer use and seeding time are the main management factors reducing yield. Grain yields are between 1 and 2 MG/ha.

Table 48. Area and Percentage of bread wheat and durum wheat in different agroecological zones in WANA region, 1981.

	Irr.	Well Watered (400-600 mm)	Semi Arid (<400 mm)	Total
Bread Wheat				
Area	3.9	5.7	7.3	16.9
%	23	34	43	100
Durum Wheat				
Area	0.5	3.9	4.7	9.1
%	5	43	52	100

Source: Bayerlee and Winkelmann, 1981
World wheat facts and trends.

c) irrigated areas

Irrigation covers 3.9 million ha, or approximately 23% of the total wheat in the region. Countries possessing this type of environment include Egypt, Sudan, Yemen PDR, Yemen AR, Saudi Arabia, Pakistan, and a few other countries in the region. Foliar diseases, especially yellow rust and septoria are by far the most important biotic constraints in these areas. Insect pests such as aphids can reduce yields by up to 20 percent and there are no tolerant varieties yet available. Heat stress, both at the early stages of plant growth and at the reproductive stage, is the most important abiotic factor reducing grain yield. Although good, high yielding bread wheat varieties have been developed and released in these areas, improved agronomic practices have not been widely adopted. This serious problem can be solved only by a sustained effort by national governments within the region to improve wheat production practices and to breed high yielding, disease and insect-resistant varieties.

The joint ICARDA/CIMMYT bread what breeding project focuses its efforts on identifying, developing and distributing improved germplasm for the first two rainfed agroecological zones of WANA, while CIMMYT-Mexico produces wheat technology for the irrigated and high rainfall areas.

Identification of genetic stocks with tolerance to different stresses

One of the project's breeding objectives is to identify genetic stocks with tolerance to the biotic and/or non-biotic stresses prevailing in the rainfed environments of the region. The breeding strategy to meet this objective is based on the basic principle that stress tolerant material is difficult to identify unless it is exposed and selected under those stresses. The overall strategy is based on four factors. These are:

a) continuous evaluation of potential parents,
b) targeted crosses,
c) multilocation selection and testing and,
d) targeted distribution of improved germplasm to national programs in the region.

Multilocation testing, the project's most important strategy for selecting and identifying material tolerant to different stresses, occurs at two levels: (1) international multilocation testing, in which data from 50 to 75 locations in the region is obtained through the ICARDA/CIMMYT International Nurseries System, and (2) regional multilocation testing, consisting of five different environments in Syria and Lebanon. The latter constitutes the hub of the screening program in which segregating populations and advanced lines are selected and tested under different moisture and temperature conditions.

Table 49 presents six promising lines identified through the international multilocation testing system. These lines were tested under low moisture (200-350 mm) conditions in locations in WANA as well as at a dry location in Mexico. The yield percentage of these lines over the national checks (which is a widely grown commercial variety at each particular location) ranged from 114% to 179%. These lines are now under extensive testing by each national program, and some have been used in their breeding programs to further incorporate this characteristic into their crossing material.

At the regional level, several lines have been identified that combine qualities for drought and cold tolerance. Five of the most promising lines identified in this manner are presented in Table 50. The average grain yield of these lines at three dry locations in Syria over three years ranged from 2787 to 3235 kg/ha. The moisture levels where these lines were tested ranged from 230 to 381 mm. The 1984/85 season was characterized by extremely low temperatures (-12^{o}c for more than 25 days). Low temperatures were also registered during the 1983-84 and 1987/88 seasons. These lines have been distributed to national programs in the region.

Table 49. Highest yielding entries in the Regional Wheat Yield Trials Low-rainfall Areas 1987/88 compared to the improved national check variety in certain dry locations of West Asia and North Africa.

Location	Pedigree of Highest Yielding Line	Yield (kg/ha) Line	N.C.	%of N.C.
Hammam (Iraq)	TRM/K 253.18 CM46127-1AP-OAP-2AP-1AP-1AP-OAP	1058	588	179
Zahle (Lebanon)	F//68.44/NZT/3/CUC 'S' SWM 6637-2AP-OAP-3AP-1AP-3AP-OAP	3383	1929	175
Ramtha (Jordan)	C.182.24/C.168/.3/CNO*2/7C//... SWM 6828-6AP-2AP-6AP-1AP-2AP-OAP	3648	2680	136
Beja (Tunisia)	MAYA 74'S'/ON/1160.147/3/BB/GLL.. CM 58924-1AP-1AP-2AP-OAP	2880	415	119
Obregon (Mex)	Cc//CAL/SR/3/KAL/BB ICW 79-0820-2AP-4AP-1AP-1AP	3953	3416	116
Bouider (Syr)	Yr/SPRW 'S' L 825-4AP-4AP-1AP-2AP-1AP-OAP	2266	1983	114

N.C. = National Check

Table 50. Grain Yield of the top yielding bread wheat lines under 230-381 mm rainfall at three dry locations* in Syria averaged over three growing season; 1983/84, 1984/85 and 1987/88.

Cross and Pedigree	X Yield (kg/ha)	% over MXP
AI Fong #1/Pew's' SWM 11420-2AP-3AP-1AP-OAP	3212	120
Ald/4/Napo/Tob//8156/3/Kal/Bb ICW 79-0728-1AP-1AP-2AP-OAP	3235	121
Tsi/Vee's' CM 64335-3AP-1AP-1AP-OAP	2850	104
Nesser	2787	121
Inia/Napo/3/Inia//Tob/Napo ICW 78-0001-1AP-1AP-2AP-1AP-OAP	2953	107

* T. Hadya 1983-84 (230 mm); Breda 1984-85 (227 mm); Bouider 1987/88 (381 mm). MXP = Mexipak (Local Check).

Developing Breeding Methodologies

The ICARDA/CIMMYT breeding project pays special attention in developing breeding methodologies that will help in the identification and selection of improved germplasm, but that also have the potential for adoption by national programs of the region. The overall breeding strategy of the bread wheat breeding project, to cater for the region's unpredictable rainfall and frequently harsh environments, has been described in previous annual reports and published elsewhere. The methodology used by the project to identify parental material with tolerance to temperature (cold and heat) stresses was also published at the Proceedings of the International Symposium on Improving Winter Cereals Under Temperature and Salinity Stresses, Cordoba, Spain, 26-29 October, 1987. These methodologies, which are based in the principle that stress tolerant germplasm is difficult to identify unless the material under selection is exposed to those stresses, has already been adopted and implemented by certain national programs in the region (Morocco, Tunisia, Sudan, Egypt, Syria, Algeria, Turkey, and Jordan).

Beside these methodologies, the ICARDA/CIMMYT breeding project has developed a breeding methodology which allows breeders to enhance disease resistance, adaptation and especially that allows the efficient use of multilocation testing of segregating populations. This methodology was presented at the 7th International Wheat Genetics Symposium, Cambridge, England, July 12-19, 1988. A modified bulk method of selection, which comprises the desirable characteristics of the pedigree and bulk methods of selection, has been used by the project during the last six years. F_6 lines which were derived from both, the modified bulk and the pedigree methods, were compared for grain yield, disease resistance and adaptation at three locations. In the comparison, these two methods also represented two approaches to plant selection; the modified bulk involving multilocation testing and the pedigree with continuous selection at one location. The results of this study are presented in Tables 51 and 52. The average grain yield over locations in Table 51 indicate that eight of the first ten top yielding lines represented the modified bulk (MB) method of selection. The higher frequency of MB lines in the top yielding places plus the higher average range yields of the MB lines in comparison to the pedigree (P) lines is a reflection of the higher level of disease resistance in the MB lines at each location. Only three MB lines were among the ten lowest yielding entries, and in most cases, the higher level of susceptibility to one or more diseases was perhaps the responsible factor for the lower yields in all ten lowest yielding lines.

Eight MB lines yielded more than the national (NC) and regional (RC) checks. This reflects the level of adaptation in these lines, since the NC is a widely grown commercial variety at each particular location. Table 52 confirms these results. Four MB lines (entries (entries no. 15, 21, 22 and 23) yielded among the ten top ranking entries and substantially more than the NC. None of the P lines ranked among the top entries at all four locations, and only two P lines (entries No. 10 and 12) yielded among the ten top entries at three locations. Five MB lines and only one P line were among the ten top lines at two locations.

The results presented in Tables 51 and 52 suggest that the MB method is an effective and efficient selection method to enhance disease resistance and adaptation in rainfed wheat. This method of selection has also been adopted by national programs in the region (Morocco, Egypt, Sudan, Tunisia, and Syria).

Table 51. Overall summary for yield, rank and disease resistance of the 24 entries in the comparative wheat yield trial, grown at four locations during 1986/87.

Entry No.	Overall Yield (kg/ha)	Method	Tunisia ST	Syria ACI YR	ACI IR	Mexico ACI SR
22	4367	MB	2.4	2	2	1
20	4043	MB	Tr	6	1	2
17	3935	MB	2.3	2	1	1
15	3879	MB	Tr	1	3	1
21	3847	MB	2.2	1	1	2
23	3840	MB	1.4	2	1	2
18	3745	MB	4.3	1	2	2
2	3715	P	3.2	4	2	4
10	3699	P	Tr	2	3	2
19	3583	MB	Tr	1	2	1
4	3576	P	5.2	80	10	40
8	3449	P	4.2	100	50	20
1	3448	RC	8.4	80	100	60
24	3440	NC	9.9	30	4	2
13	3368	MB	6.4	1	2	1
3	3359	P	7.5	4	40	4
16	3312	MB	5.3	1	4	3
7	3283	P	8.2	48	10	10
14	3282	MB	Tr	2	70	10
6	3254	P	Tr	60	20	10
12	3119	P	5.2	40	50	4
11	3077	P	6.4	2	70	10
5	3023	P	3.1	50	4	4
9	2865	P	Tr	4	70	30

MB = Modified bulk; P = Pedigree; RC = Regional check;
NC = National check; ST = Septoria tritici; YR = Yellow rust;
IR = Leaf rust; SR = Stem rust; ACI = Average coefficient of infection

Table 52. Performance of the ten top ranked entries in 4 locations. Comparative wheat yield trial 1986/87.

Mexico			Tunisia			Breda			Tel Hadya		
Entry No.	Meth.	Yield kg/ha	Entry No.	Meth.	Yield kg/ha	Entry No.	Meth.	Yield kg/ha	Entry No.	Meth.	Yield kg/ha
22	MB	4236	22	MB	5400	23	MB	1488	22	MB	6433
23	MB	4200	17	MB	5184	22	MB	1400	20	MB	6111
10	P	4154	20	MB	5155	16	MB	1388	18	MB	5666
17	MB	4124	21	MB	4881	12	P	1366	12	P	5533
2	P	4116	15	MB	4657	24	NC	1300	15	MB	5511
15	MB	4072	10	P	5463	21	MB	1288	16	MB	5433
21	MB	3940	13	MB	4500	15	MB	1277	2	P	5355
19	MB	3908	23	MB	4350	8	P	1266	23	MB	5322
1	RC	3870	19	MB	4324	4	P	1266	21	MB	5288
18	MB	3861	12	P	4321	10	P	1266	11	P	5266
LSD (5%)	=	456			931			312			1091
CV (5)	=	7			13			15			13
Loca. X	=	3552			4261			1212			5063

MB = Modified Bulk;
P = Pedigree;
RC = Regional Check;
NC = National Check

Enhancing Disease Resistance

Multilocation testing and the use of the modified bulk selection method described above has allowed breeders in the ICARDA/CIMMYT project to increase the level of disease resistance in bread wheat germplasm. Table 53 presents the percentage of susceptible or resistant families to two of the main foliar diseases in the region, yellow rust and _Septoria tritici_. Selection pressure for these diseases has resulted in increased levels of disease resistance.

Similar results can be observed in Table 54. Comparing the progress made by the project in enhancing the disease levels during the last five years (1983-1988), data in this table suggests that substantial progress has occurred in increasing levels of yellow rust, _Septoria tritici_, and stem rust resistance. Leaf rust resistance levels have remained the same over the years.

Table 53. Percentage of resistant or susceptible bread wheat families to yellow rust at Tel Hadya and Septoria tritici at Lattakia, Syria, 1987/1988.

Generation	YR at T. Hadya		ST at Lattakia	
	%R	%S	%R	%S
F_2	21	79	45	55
F_3	25	75	43	57
F_4	57	43	58	42
F_5	78	22	64	36
F_6	65	35	60	40
F_7	86	14	64	36
F_8	91	9	71	29

YR = Yellow rust (Artificial Inoculation)
ST = Septoria tritici (Natural Conditions)

Table 54. Progress made during the last five years (1983-1988) in increasing the levels of resistance to certain foliar diseases in the bread wheat germplasm.

ACI Class	NO. OF ENTRIES*								Class
	YR		SR		LR		ST		
	1983	1988	1983	1988	1983	1988	1983	1988	
0- 5	46	56	16	71	69	39	0	4	1
6-10	21	19	12	15	28	24	3	28	2
11-15	18	5	13	6	18	7	16	25	3
16-20	17	8	18	1	9	14	21	15	4
21-25	14	6	20	2	2	4	49	22	5
26-30	7	2	16	3	5	2	27	4	6
31-35	7	1	19	3	0	3	15	2	7
36-40	2	2	9	1	3	2	3	1	8
>40	4	3	13	0	2	7	2	1	9

ACI = Average coefficient of infection; ST = Septoria tritici,
YR = Yellow rust; SR = Stem rust; LR = Leaf rust.
* = Wheat Observation Nurseries.

Improved Adaptation of Bread Wheat Germplasm

Results of ten years of Regional Wheat Yield Trial data (1978 to 1987), indicate that the adaptation of bread wheat germplasm in the region has increased over the years (Figure 7). Although the number of test locations of this trial remained constant over the years, the number of lines selected by national programs in the region based on their statistical superiority over the national check variety has increased. This is a modest but significant achievement considering that the national check at each location is usually a well adapted, widely grown commercial variety. It is interesting to note that the yield gap between the top bread wheat line and the national check has widened to approximately one ton/ha during the last four years.

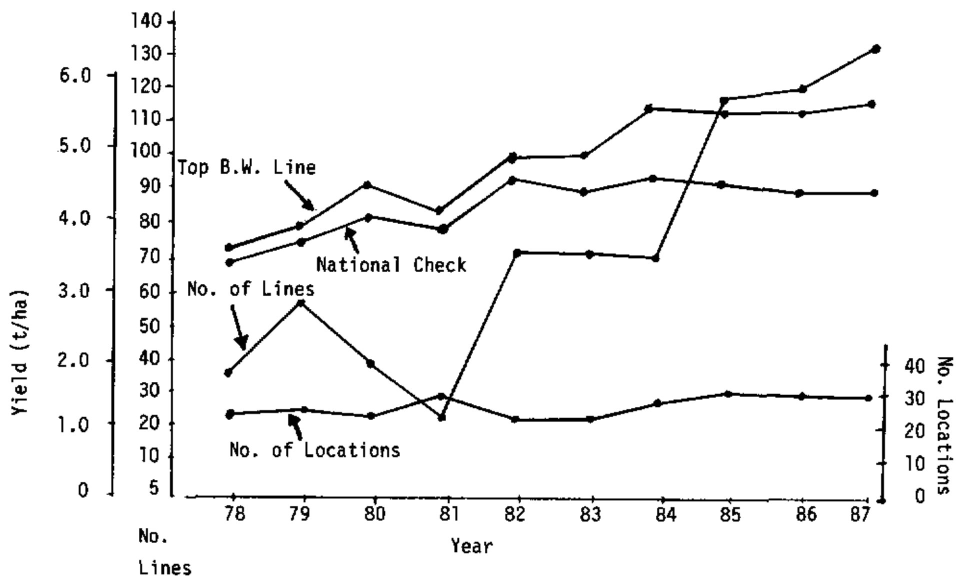

Fig. 7. Number of bread wheat lines significantly (P < 0.05) outyielding the national checks in 21 countries of West Asia and North Africa (1978-87).

One of the project's breeding strategies is to distribute germplasm to targeted areas in the region. Table 55 presents results of the adaptation of bread wheat germplasm in two agroecological zones: areas with moderate moisture and moderate to high temperatures, and areas with low rainfall associated with low temperatures. Data from ten years (1978 to 1987) of the Regional Wheat Yield Trial indicate that there has been a steady adoption of bread wheat germplasm. This adoption has been more consistent in the low rainfall environments of the region. The number of entries selected by national programs based on their statistical superiority (P < 0.05) over the national check varieties has been more consistent in this last production zone, ranging from 35 in Iraq to 97 in Jordan.

Table 56 shows 4 promising bread wheat lines that have superior yield and adaptation over the national checks and the improved bread wheat checks across 54 locations in WANA. One of these lines, Nesser 'S', is currently under seed multiplication in Syria, and has been considered for release in other countries of the region.

Table 55. Adaptation of bread wheat germplasm in selected countries of West Asia and North Africa. RWYT 1978 to 1987.

	Environment		No. sel.	No.	
	Moisture	Temp.	entries	locations	Rate
Saudi Arabia	H	H	68	20	3.4
Egypt	H	M-H	51	32	1.6
Yemen PDR	H	H	28	8	3.5
Pakistan	H	M-H	39	22	1.8
Iraq	L	L	35	7	5.0
Jordan	L	M-L	97	18	5.4
Syria	L	L	60	14	4.3
Algeria	L	L	38	9	4.2

M = Moderate, H = High, L = Low

* Selected by national programs based on their statistical superiority ($P < 0.05$) over the National Check varieties.

Farmers Field Verification Trials

The bread wheat project places special emphasis in developing germplasm with adaptation to the low rainfall environments of the region; in this way, it complements the breeding work of CIMMYT-Mexico. Results from these efforts indicate the possibility of making breeding progress in these marginal areas as regards moisture stress. Figure 8 shows the yield potential of barley, bread wheat, and durum in the low rainfall (250-350 mm) areas of Syria. Results of five years of farmers field verification yield trials grown in this production zone indicate that barley has the highest yield potential, followed by bread wheat and then durum wheat.

Table 56. Top performing bread wheat entries in the regional wheat yield trail 1986/87. 54 locations in West Asia and North Africa.

Cross/Pedigree	Yield kg/ha	Rank	Frequency* Top 5	>N.C.	>I.C.
Trm//Kal/Bb CM 49744-1AP-4AP-1AP-6AP-OAP	4327	1	22	11	8
Kvz/Cgn Se 1066-9S-3S-4S-0S-1K-Ok	4260	2	22	13	12
Nesser's'	4259	3	24	10	15
Chr/5/Tp//Cno/Inia/3/5x/4/Hork CM 46943-4AP-2AP-4AP-1AP-OAP	4235	4	16	10	8
National Check (NC)	3953	14	15	0	11
Improved Bread Wheat Check (IC)	3873	16	8	7	0

* Total No. of times that each entry ranks fifth or less or exceeds a check (LSD test, P = 0.05, 1 sided test).

On-farm verification trials started in Syria nine years ago. These are jointly conducted by the Ministry of Agriculture and Agrarian Reform and ICARDA. Similar activities have been extended to other countries in WANA including Algeria, Morocco, Sudan, Lebanon, Turkey, and Yemen AR.

Figure 9 show the performance of the promising bread wheat line Nesser in Farmers Field Verification Trials of Syria. Three years data of these trials show that Nesser had an average yield advantage of 14% over the local check Mexipak 65 under low rainfall conditions (250-350 mm).

Results of large scale testing of Nesser under low rainfall (250-350 mm) and in farmer's fields confirms the yield superiority of this promising bread wheat line over the local check Mexipak 65 (Table 57). It is interesting to note that Mexipak 65 is a widely grown variety still in use by farmers in these production zones of Syria and the region. Considering the yield advantage of Nesser over Mexipak 65, the national program of Syria is considering releasing this bread wheat line as a commercial variety for the low rainfall areas of the country. Other national programs such as Morocco and Algeria have this line under extensive testing as well.

Results of farmers' field verification trials carried out in Algeria during the last two years are shown in Table 58. Promising bread wheat lines such as Gv/Ald 's' and Cham 4 show an average yield advantage of 14% and 10% over the local check variety Mahon Demias. These on-farm trials were carried out in the low rainfall (200-300 mm) areas of the country. These two lines are under extensive testing and are being multiplied for possible release as commercial varieties.

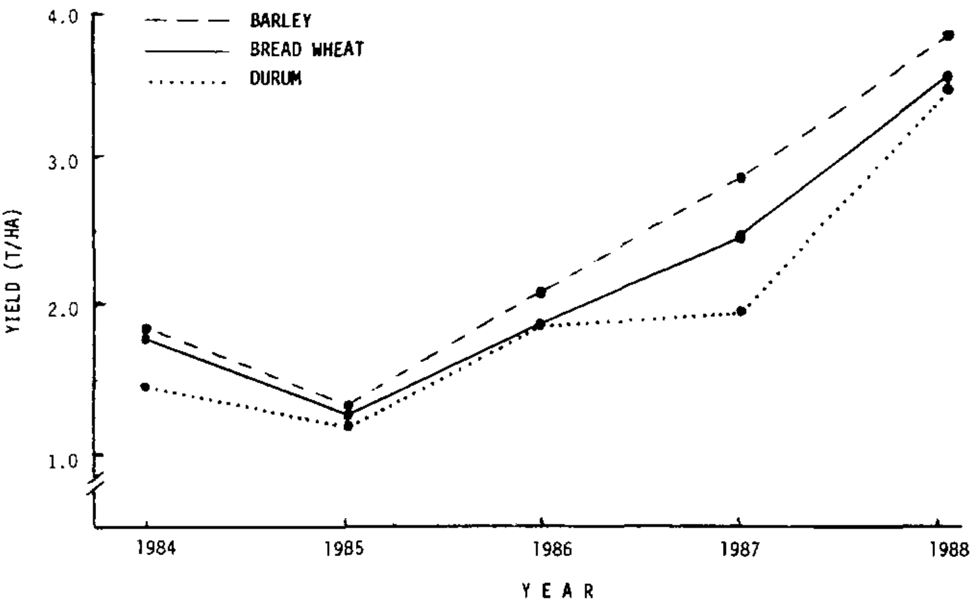

Figure 8. Yield Potential of bread wheat, barley and durum in the low-rainfall areas (Zone B) of Syria. Farmers field verification trials, 1984-1988.

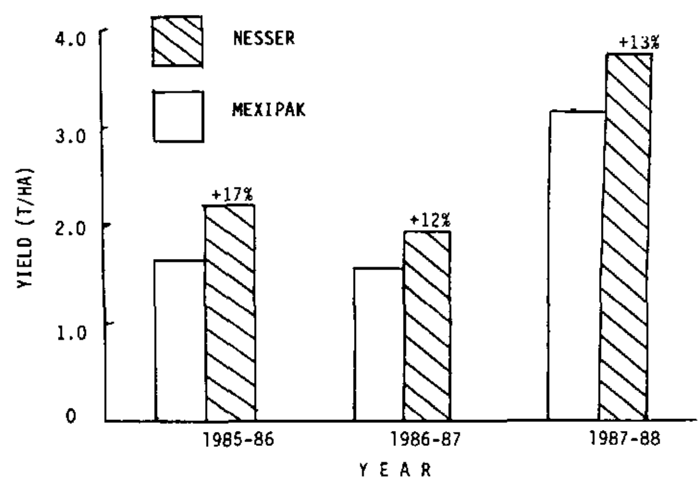

Figure 9. Performance of Nesser, promising bread wheat line, under low-rainfall (250-350 mm) conditions in Syria. Farmer's field verification trials, 1985/86 to 1987/88.

Table 57. Results of large scale testing of promising bread wheat line Nesser under low rainfall (250-350 mm) farmer's field conditions of Syria. 1987/88.

Variety	Izraa Yield kg/ha	Breda Yield kg/ha	Average Yield	% Over Mexipak 65
Mexipak 65	1628	1770	1699	100
Nesser	1805	2360	2088	123

Table 58. Performance of promising bread wheat cultivars under low rainfall (200-300 mm) farmer's field verification trails in Algeria, 1986/87 and 1987/88.

	1987		1988		Average	
	Yield (kg/ha)	%> MD	Yield (kg/ha)	%> MD	Yield (kg/ha)	%> MD
GV/ALD'S' L882-1AP-OAP-2AP-OAP	2141	125	2334	105	2238	114
Cham 4	2118	124	2200	100	2159	110
Mahon Demias (Check)	1711	100	2226	100	1968	100
Neelkant CM40454-11M-4Y-2M-3Y-OM	1943	114	1905	861	924	98
Cham 2	1850	108	1886	851	868	95
ACSAD59	1932	113	1690	761	811	92
Zargoon	1233	72	1835	82	1534	78
No. of locations		4		6		10

MD = Mahon Demias (local check)

G. Ortiz-Ferrara

2.4. Breeding for High Elevation

The high elevation areas in WANA comprise 40% of the total land where winter cereals (wheat and barley) constitute the backbone of farming systems used by resource poor farmers. Improving the productivity of high elevation cereals will alleviate economic hardships for these farmers. A large number of biotic and abiotic factors affect the production of cereals (ICARDA Annual Report 1987). The Cereal Program has a collaborative project to improve wheat and barley productivity in cooperation with national programs by:

A. Develop and disseminate improved germplasm with resistance or tolerance to biotic and abiotic stresses.

B. Strengthen research capabilities of national program scientists.

Expansion of the Genetic Base

The genetic base of wheat and barley is enriched and expanded by sharing new materials with other national and international programs.

Eight different wheat and barley nurseries (Table 59) comprised of 1908 accessions were evaluated under rainfed conditions at Tel Hadya. Sixteen percent of the entries were selected for further evaluation for direct or indirect use in developing new germplasm for high altitude environments in WANA. Selections were based on agronomic score, disease and drought tolerance and yield.

Table 59. International germplasm evaluation.

Nursery	Total	Selected No.
Turkish Winter Wheat Screening Nursery	276	76
3rd Int. Winter Wheat Nursery Turkey/CIMMYT	78	29
20th Int. Winter Wheat Performance Nursery	30	8
15th Int. Winter X Spring Wheat Nursery	113	22
Winter Type Feed Barley Elite Lines-Oregon	24	7
Winter Type Quality Barley elite Lines-Oregon	26	8
Turkish Wheat Observation Nursery	860	60
Turkish Winter Barley Observation Nursery	501	102
	1908	312

Germplasm Development

The major part of the breeding program focuses on the extraction and utilization of desireable gene(s) from divergent sources to combat the most prevalent stresses. Due to divergent climatic conditions in the high altitude areas targeted crosses were primarily made by using locally adapted landraces. Germplasm from other sources was employed to incorporate various types of stress tolerances. In total, 593 single, double or top crosses were made in bread wheat, and 250 and 213 cross combinations in durum wheat and barley were also achieved.

Because of the importance of utilizing all of the available genetic diversity, the genetic variability in wild species of Triticum and Aegilopes was exploited. Last year 314 crosses involving wild species were made with bread and durum wheat. This year only top or back crosses (126 combinations) were made with the durum or bread wheat parent.

Table 60. Selections out of segregating populations and preliminary screening nurseries at Tel Hadya during 1987/88.

	Bread Wheat		Durum Wheat		Intersp. Crosses	
Generation	Total	Selection	Total	Selection	Total	Selection
F_2	630	464	175	150	390	260
F_3	580	358	439	380	277	160
F_4	714	375	563	310	250	220
F_5	442	270	360	274	283	187
F_6	164	84	142	82	383	183
PSN	234	114	202	129	-	-
Total	2867	1665	1879	1325	1583	1010

Segregating Populations and Preliminary Screening Nurseries

The selections carried out in different segregating populations (F_2-F_6) are given in Table 60. The selection pressure on F_2 populations was only for disease resistance and plant height. Secondly, information on the performance of these F_3 populations from the high altitude sites of the region was used to advance or discard a population. Maximum selections were carried out of those populations which were performing well at more than one site. Maximum disease pressure was exerted on F^3, F_5 and F_6 populations, and populations showing susceptibility to yellow rust were discarded. In total, 1665, 1325 and 1010 populations of bread wheat, durum wheat and interspecific crosses, respectively, were retained for further selection and evaluations. The selected lines out of Preliminary Screening Nurseries will be yield tested next year.

M. Tahir

Table 61. Number of selections from winter cereal nurseries at Ankara, Turkey.

Nursery	Bread Wheat		Durum Wheat		Barley	
	Total	Selected	Total	Selected	Total	Selected
Crossing Block	258	140	209	75	183	112
PSN*	234	114	202	90	-	-
F2	630	175	175	57	126	40
F6	164	79	728	55	309	-
Total	1286	508	728	277	309	152

*PSN = Preliminary Screening Nursery.

Screening of Winter Cereal Nurseries at Ankara, Turkey

Under a collaborative arrangement between the Field Crop Improvement Center, Ankara, Turkey and ICARDA's Cereal Improvement Program, cereal germplasm developed at ICARDA is evaluated for its agronomic performance and resistance to biotic and abiotic stresses at Haymana. The number of lines in the three winter cereal species tested and the selections made out of them are listed in Table 61. Out of a total of 2323 lines/families, 937 were selected mainly on the basis of agronomic score, cold tolerance and disease resistance. The screening of crossing blocks is helpful in deciding the parental lines for future germplasm development, whereas the screening of material from crosses at Ankara is instrumental in deciding the material to be advanced and sent to high altitude areas resembling the Central Anatolean Plateau.

M. Tahir and B. Yilmaz

Screening of Winter Cereal Nurseries at Sarghaya

Sarghaya, Syria, is a useful site for screening new wheat and barley lines segregating populations for cold tolerance, yellow rust resistance, barley yellow dwarf virus and altitude affect. A total of 2473 lines and crosses of wheat and barley were planted at Sarghaya. The number of selected entries from each nursery are given in Table 62. The information on the better performing lines is used in the crossing program at Tel Hadya. The choice of material for Ankara is made on the basis of its performance at Sarghaya due to similarities between the two sites. The overall selection frequency among the new material has risen to 54%. The high selection frequency from the Preliminary Wheat Screening Nursery and advanced segregating populations at Sarghaya, where the temperature was -22°C for two consecutive days, indicate the high level of cold tolerance in the material generated at Tel Hadya.

Table 62. Screening of Cereal Nurseries at Sarghaya 1988-89.

Nursery	Total	No. selected
Barley Observation Nursery - HAA	125	50
Barley Screening Nursery - HAA	137	81
Winter Feed Barley	24	7
Winter Quality Barley	26	11
Barley Crossing Block - HAA	183	112
F^2 Barley Seg. Pop. - HAA	126	52
Bread Wheat Obs. Nurs. - HAA	150	39
Prelimin. Bread Wheat Screen. Nurs.- HAA	233	155
F^2 Bread Wheat Seg. Pops. - HAA	630	392
F^6 Bread Wheat - HAA	170	108
DON - HAA	150	84
PDSN	202	72
F^2 DW Seg. Pop. - HAA	175	122
F6 DW - HAA	142	57
Total	2477	1342

Screening from International Nurseries at High Altitude Sites

Observation nurseries regional yield trials, F_3 segregating populations of durum wheat, bread wheat and barley were dispatched to cooperators in the region. The number of entries in each nursery and the selection frequency (%) at each site is given in Table 63. The overall selection frequency has increased from less than 10% in 1980 to over 30%. The biggest achievement has been made in durum wheat due to low cold tolerance.

Table 63. Frequency of selection out of international nurseries at high altitude sites, 1988-89.

Nurs.	Total	Syria	Turkey		Pak.	Moroc.	Algeria	
	Ent.	Sarg.	Ankara	Konya	Sariab	Annac.	Setif	Tiaret
DON-HA	150	53	52	19	14	15	27	14
WON-HA	150	47	31	29	27	10	27	NA
BON-HA	125	43	30	15	24	NA	16	24
WYT-HA	24	-	NA	17*	38	25	13	21
BYT-HA	24	-	NA	-	NA	NA	-	46
F_2 BW	150	62	29	-	14	15	-	-
F_2 D^W	150	69	33	-	11	12	-	-
F_2 B	126	41	31	-	-	NA	-	-

* Selected at Diyarbakir; DON = Durum Wheat Observation Nursery - High Altitude; WON-HA = Bread Wheat Observation Nursery - High Altitude; BON = Barley Observation Nursery - High Altitude; WYT = Regional Wheat Yield Trial; BYT = Regional Barley Yield Trial.

A large number of lines (52%) were selected from the Durum Wheat Observation Nursery and 33% out of F^2 segregating populations. The high frequency of selection at Ankara is due to: a) the parents employed in generating these materials were screened at Ankara and in many cases these materials have locally adapted germplasm in their parentage, b) some of the material such as observation nurseries have undergone a cycle of selection at Sarghaya before their evaluation at Ankara.

The most striking performance of wheat and barley observation nurseries was recorded at the International Winter Cereal Research Institute, Konya-Turkey, where all national and international nurseries were planted in a salinity-affected field. Almost all the national and international nurseries were killed due to the high salinity, whereas a large number of lines from ICARDA's high altitude nurseries were selected. Stress tolerance is a complex character to incorporate into new material. Most of the parental lines in the past were screened under high soil pH at Quetta-Pakistan. Therefore, it is likely that the genes for high pH tolerance were transferred into new material with drought and cold tolerance. Selected wheat and barley lines will be tested on a large scale at the Konya Research Institute.

Interspecific Hybridization

For the introgression of desirable genes from wild species of Triticum to broaden the genetic base of T. durum, the following three species were used in the crossing program during 1980-81.

Triticum turgidum var. dicoccoides = AABB (2n = 4x = 28)

Triticum kotschyi = CuCu S_1S_1 (S_1 = B?) (2n = 4x = 28)

Triticum zhukovski = AAAAGG or AAAAB'B' (2n = 6x = 42)

The crossing program was organized in such a way that cultivated durum wheat varieties were used as female parents and the selected accessions of the three wild species were employed as male parents. One or two backcrosses were carried out with the female durum wheat parent (Fig. 10 a-c) to rapidly achieve genetic homozygosity. In subsequent segregating populations single plant selections were carried out. Cytological studies were made in the F^4 to determine chromosome number and configuration. Genetically homozygous lines were evaluated for various agronomic traits.

The agronomic performance of 22 tetraploid wheat lines derived from the above mentioned crosses F_5 generation) is given in Table 64. None of these lines gave significantly higher yield than the improved durum wheat check variety Cham 1. However all 22 lines were superior to the variety Hourani. With the exception of two entries (nos. 11 and 12) all had superior protein content as compared to check varieties.

One of the major problems in durum wheat has been the lack of cold tolerance. Field observations indicate that these derivatives have better cold tolerance, especially lines (nos. 1,4,5) derived from the crosses with T. kotschyi and T. zhukovski with a semi-prostrate growth

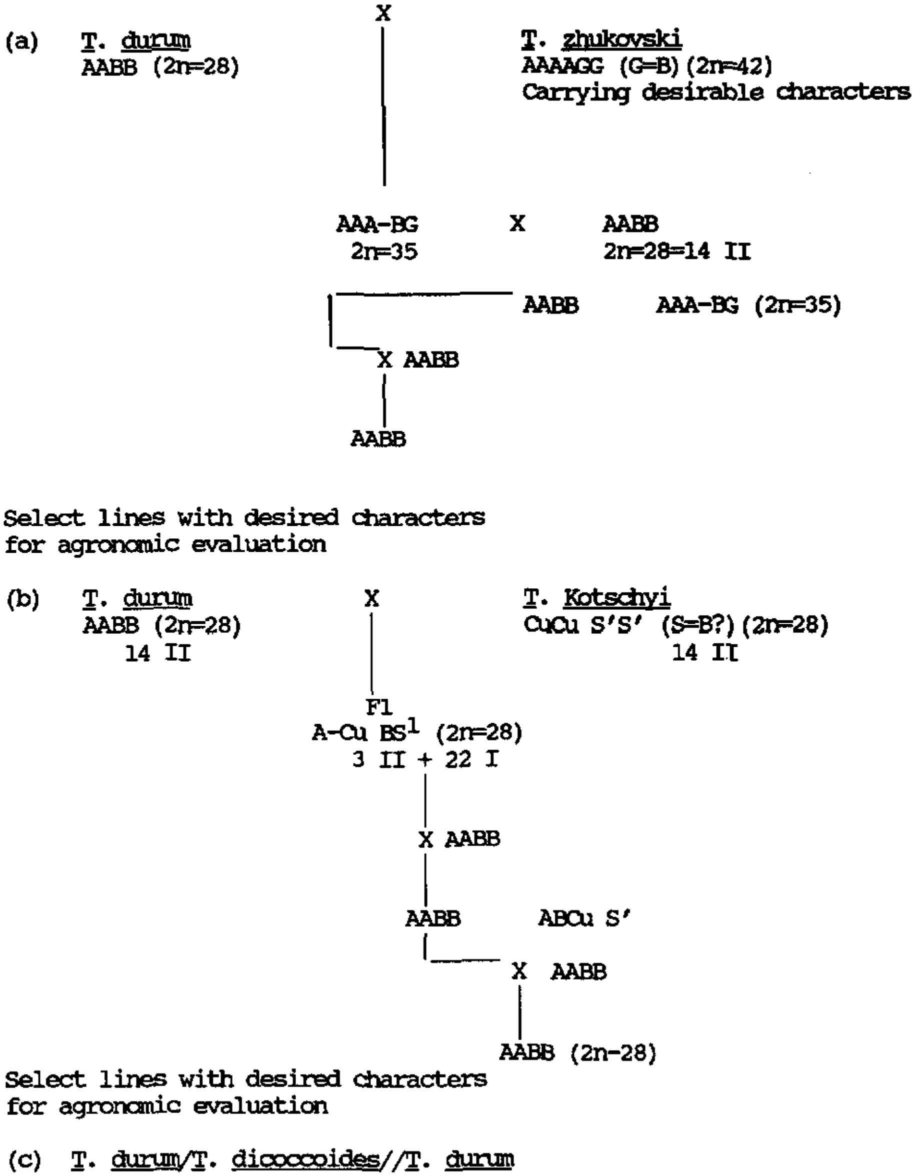

Fig. 10 (a-c) Schematic presentation of interspecific crosses

Table 64. Performance of derivatives from interspecific hybrids.

Entry No.	Character Cross	Growth habit	PH	DH	DM	YR	Prot. %	TKW	Yield kg/ha
191	Hourani/Kotschyi-SY20224/Hour. ICI81-0047	3	145	159	203	R	16.1	37	3170
104	Raspinegro/T.Zhuk.WR13//2* Waha = " ICI81-026-13	1	110	155	192	R	13.9	35	3090
98	" ICI81-026-8	1	110	152	192	R	14.8	36	2950
101	" ICI81-026-10	2	130	150	191	R	14.9	35	2900
106	" ICI81-026-15	2	120	152	192	R	13.5	39	2850
5	BD272/SY2010/Waha = IC183-0010-1	2	100	153	193	R	14.3	36	3200
54	Rubio Tandeal/T.dic-WR33//Ente'S'/Stk'S' = ICI83-0017-16	1	95	152	192	R	14.4	34	3100
30	" ICI83-0017-1	1	155	152	198	R	15.7	33	2950
45	" ICI83-0017-7	1	100	152	192	R	14.6	34	2850
56	" ICI83-0017-18	3	100	165	204	R	16.2	31	2800
59	Rubio Tandeal/T.dic.WR42//Ente'S'/Stk'S' = " ICI83-0020-2	1	140	155	191	R	11.5	40	2800
67	" ICI83-0020-8	1	95	157	193	R	11.5	36	2790
78	SY20017/Renode Granada//Waha = ICI83-24-6	1	90	157	194	R	14.3	37	3400
82	" ICI83-24-6-5	1	110	157	193	R	13.2	40	3320
79	" ICI83-24-6-3	1	100	155	193	R	13.6	41	3250
80	" ICI83-24-6-4	1	105	155	191	R	13.0	44	3250
75	" ICI83-24-4	1	100	165	204	R	13.5	36	3160
87	" ICI83-24-9	1	105	153	194	R	13.2	38	3000
88	" ICI83-24-10	1	110	155	192	R	13.6	33	3000
76	" ICI83-24-5	1	110	157	192	R	13.4	39	2900
83	" ICI83-24-6-6	1	100	167	197	R	14.5	36	2830
173	BD272/SY20017//Waha = ICI83-0063.2	1	130	157	198	R	15.0	34	2830
	Cham 1-Check	1	90	153	191	R	11.8	41	3406
	Hourani-Check	2	130	155	198	MS	13.0	41	1736
	CV								16.15
	LSD at 0.05								425.34

habit. Growth habit is generally correlated with cold tolerance even through erect types (spring types) may possess high cold/frost tolerance.

In breeding semi-dwarf wheats (bread and durum wheat) the source of dwarfing genes has been Norin 10, which carries Rht 1 and Rht 2 genes located on homologous chromosomes 4A and 4D respectively. In bread wheat, one of the major dwarfing genes is located on the D-genome chromosome. Since durum wheats lack the D-genome, breeders were incorporating only the Rht 1 gene and all breeding lines had uniform plant height. Interspecific crosses of derived lines show a considerable range (90-155 cm) in plant height. There are at least 5 lines which measured 110 cm. We feel that wild species can be useful in the genetic manipulation of plant height and other agronomically important traits.

M. Tahir

Cold Tolerance Studies: Relationship between Freezing Resistance and Primordia Development in Wheat

Early primordia development and internode elongation in wheat causes freezing injury in winter and frost injury in spring. The control of the initiation of primordia development and internode elongation is required to avoid freezing and frost injury. In 1987/88, primordia developmental stage, internode elongation and other growth characters were investigated in divergent wheat lines/cultivars. The relation between freezing resistance and primordia development was studied and is discussed here.

Thirty one leading cultivars and breeding lines from the ICARDA region (Table 65) were planted in two row, 2.5 m long plots on 5th November 1987. Primordia developmental stage and length of internode were observed on 18th January and 8th February according to the criteria of Inamura et al. (1955). Growth habit (1 very erect-8 very prostrate) was determined on 18 January, and plant height and tiller number on 8 February for five plants per cultivar. The initiation of internode elongation (Table 66) was determined by continuous observations from January to the end of February.

The same cultivars were used for artificial freezing tests. Plant materials were sampled for freezing tests on 11 and 18 January after hardening under natural field conditions. Crowns were prepared by removing all plant parts 3 cm above and 1 cm below the crown and were washed in water to remove soil. Excess water was removed from the crown with dry tissue paper and crowns were placed in plastic bags for freezing. Freezing temperature treatments and duration were as follows: 2 hrs at 0°C and 3 hrs at -2°C as pre-treatment, followed by 15 hrs at -4°C, -5°C, -10°C, -12°C respectively. Post-freezing treatments were: 2hrs at -2°C, 2 hrs at 0°C, and 1 hr at 4°C. After freezing treatments, crowns were washed with water, transplanted in sand and grown at 15-25°C in a plastic house. Two replications of 10 crowns each were prepared for every cultivar and each freezing treatment.

Leaf survival ratios on 10th and 15th day after transplanting were determined as follows:

0 : Lethal, all leaf sheets became brown (dead)
2 : Leaf regrowth not occurred, leaf colour became yellow green
5 : Little leaf regrowth, leaf colour was yellow green

Root survival was calculated as % of root regrowth on the crown 15 days after transplanting. The curve representing the relations between the survival (%) and freezing temperature was S-shaped for most cultivars. Probit analysis was used to calculate LT 50 temperature.

Table 67 shows primordia developmental stage, length of culm, growth habit, earliness of internode elongation and other growth indicators of wheat cultivars and breeding lines. Four cultivars (nos. 1, 5, 23 and 28) which did not initiate primordia development and internode elongation on 8 February are winter type and may be late in heading and maturity. Eleven cultivars/lines (entry nos. 3,4,6,7,11, 20,22,24,25,26 and 31) had primordia development stages VI-VIII.

Table 65. LT50 for leaf and root regrowth of wheat cultivars and breeding lines.

Entry No.	Cultivar/line	Leaf-regrowth 10 days	Leaf-regrowth 15 days	Root-regrowth 15 days
1	Bezostaya 1	-10.2 (100)	-9.1 (83)	-9.3 (73)
2	Kvz/Cut 75	-6.2 (30)	-5.3 (14)	-4.4 (0)
3	Bolal	-8.1 (67)	-5.1 (41)	-8.0 (30)
4	Vratza	-7.8 (85)	-6.6 (64)	-6.4 (50)
5	CA8055	-8.9 (61)	-7.0 (46)	-8.7 (30)
6	Au/4/Ch53/N10B/3505/3/093.44/5/...	-8.0 (38)	-7.2 (13)	-6.8 (0)
7	Kavkaz	-8.4 (83)	-8.3 (71)	-8.1 (30)
8	Mexipak	-8.5 (6)	-4.9 (3)	-3.8 (0)
9	Katya Al	-7.4 (77)	-6.0 (60)	-6.1 (20)
10	Zaminder	-6.2 (24)	-4.6 (7)	-4.2 (0)
11	Avalon	-7.2 (50)	-6.1 (24)	-5.4 (5)
12	Zargoon	-5.9 (11)	-4.5 (5)	-4.5 (0)
13	Cham 2	-6.7 (5)	-5.6 (1)	-5.9 (0)
14	Au/Tob66/5/K338/Edch//Koudiat 17/.../3/3/WC/4/Ogn	-5.7 (12)	-4.7 (7)	-4.3 (5)
15	Tr.aest (Rom)//Tob'S'/8156/3/Tx69A460-1/...	-6.0 (1)	-5.1 (1)	-5.5 (0)
16	Cllf/Pch//P101/Vogaf-Swd71452/3/Inia 66(r)//...	-7.6 (23)	-6.0 (10)	-5.0 (0)
17	Au/3/Hork/Ymh//Kal/Bb	-7.6 (56)	-5.9 (31)	-4.8 (15)
18	F3.73/Nkt'S'	-7.7 (52)	-5.9 (37)	-4.6 (10)
19	Tr.aest(R)//Tob'S'/8156/3/Tx69Aa460-1/4/Emu'S'	-5.9 (2)	-4.7 (1)	-4.5 (0)
20	Lom10/3/2010/171-2//234-3819/4/Naya74'S'/Moncho'S'	-6.7 (36)	-6.4 (29)	-5.8 (15)
21	Chambord/5133//Mt/3/Kkc/4/Lfn//ND/2*P101/5/Rom/..	-6.7 (32)	-5.8 (14)	-5.5 (5)
22	Dacia//Cofn/ND/3/Bez/Tob/8156	-7.5 (54)	-5.9 (25)	-5.7 (20)
23	Bez//Tob/8156/4/On/3/6*Th/Kf//6*Lee/Kf/5/...	-7.5 (44)	-6.4 (29)	-6.8 (5)
24	Au//2*Yt54/N10b/3/Codr'S'An//Codr'S'/Mus'S'	-7.4 (57)	-6.6 (39)	-6.4 (25)
25	Chambord/5133/Mt/3/Kkc/4/Lfn//HD/2*P101/6/...	-7.7 (48)	-6.8 (58)	-5.8 (50)
26	Loml1/Son64/4/Pj'S'/Gb55//093/3/Stw597947/...	-9.3 (72)	-8.2 (51)	-8.6 (30)
27	Chambord/5133//Mt/3/Kkc/4/Lfn//Nd/2*P101/5/...	-6.6 (41)	-5.7 (11)	-4.4 (0)
28	Bez//Tob/8156/4/On/3/6&*Th/Kf//6*Lee/Kf/5/...	-8.0 (27)	-6.9 (11)	-7.1 (0)
29	T.aest (Rom)//Tob'S'/8156/3/Tx69A460-1/4/...	-6.6 (38)	-5.2 (12)	-5.0 (0)
30	Au//2*Yt54/N10B/5/2*Rfn//Pj'S'//Pjh/3/2*jn/...	-7.3 (53)	-6.1 (15)	-6.3 (0)
31	Quilamapu 25-77	-7.2 (-)	-6.8 (-)	-6.8 (-)

() Figures in parenthesis indicate survival (%) at 3 leaf stages.

Table 66. Criteria for earliness of internode elongation.

Score	Earliness of internode elongation	
2	Very early	before 10 Jan.
3	Early	before 15 Jan.
4	Moderate early	before 20 Jan.
5	Moderate	before 30 Jan.
6	Moderate late	before 10 Feb.
7	Late	before 20 Feb.
8	Very late	after 30 Feb.

Most of these lines headed at the same time. Two cultivars, Avalon (Entry no. 11) and Quilamapu (no. 31) were very late in heading as well as in maturity. One would expect these two entries to be frost/cold resistant due to their slow primordia development but actually their LT50 was higher than -8^{o}C. It seems that these two entries are photoperiod sensitive as their development throughout the crop season was slow and they were last in maturity. These 11 cultivars were expected to avoid cold and frost damage more than the others since their internodes are shorter than 2 mm and are underground. Seven cultivars out of these 11 may be high-yielding and also have winter hardiness. Their tiller number was higher than other cultivars, and at the same time the degree of unsynchronization was also greater. A compensation effect on spike number may also be expected, when main stems are damaged by freezing and frost.

Growth habit and primordia development are negatively correlated. Cultivars with primordia developmental stage over VIII were erect (growth habit 2 or 3) on 18 January and may be susceptible to winterkill. Cultivars with primordia developmental stage below VIII on 8 February, range from moderate to prostrate. Lines possessing moderate or prostrate growth habit must be selected to bread resistant cultivars for cold/frost damage. One of the erect breeding lines (entry no. 6) showed primordia developmental stage VIIe on 8 February. It seems that efforts at ICARDA to incorporate cold tolerance in spring type wheats through slow primordia development have been successful.

To investigate the relationship between primordia development and freezing resistance, 50% lethal temperature for the same cultivars (except cv. Quilamapu 25-77) were studied by artificial freezing treatment Table 67). Date on leaf regrowth (Table 68) shows that the most resistant lines were, nos. 1, 7 and 26 which tolerated temperatures lower than -8$_{o}$C. However the root regrowth studies show that two other lines, i.e. nos. 3 and 5 in addition to entry no. 1, 7 and 26, resisted temperatures lower than -8^{o}C.

Table 67. Primordia development stage and growth performance of wheat cultivars.

Entry No.	Growth habit	Earlin. intern. elonga.	Primordia dev. stage 18, Jan	8, Feb	Length of internode 18, Jan (mm)	8, Feb (mm)	Plant height (mm)	Tiller No.	DH	DM
1	6	8	V	V	3	3	28	7.0	170	206
2	3	3	VIII	IXI	25	93	53	4.0	150	204
3	5	6	V-VI	VIIe	3	9	32	5.2	162	205
4	5	6	VI	VIII	5	8	37	7.8	161	201
5	6	8	V	V	3	3	22	12.2	160	200
6	3	7	V	VIIe	3	5	37	8.2	163	199
7	6	7	V	VIIe	3	4	28	6.4	159	203
8	2	3	IXe	X	30	147	61	4.8	150	201
9	4	5	VIIe	IXm	6	33	43	5.6	154	205
10	2	2	IXe-1	X-X1	55	135	52	4.0	146	203
11	7	7	V	VII	3	4	29	10.8	181	223
12	3	3	VII-I	IXI	20	106	50	4.6	152	201
13	2	2	IXe	X	17	149	57	4.2	151	203
14	3	3	IXe	IXI	20	123	63	3.6	153	202
15	3	3	VII-I	IXI	17	113	52	4.0	152	199
16	3	5	VII	VIII	8	38	42	4.2	164	208
17	4	4	VIIe	IXe	6	67	54	3.8	158	204
18	3	4	VIIIe-I	IXe	6	51	53	4.2	158	202
19	2	2	VII-I	X	35	137	53	5.4	146	196
20	5	5	VIIe	VIII-IXe	6	16	41	6.4	161	193
21	4	4	VII-I	IXe-1	7	49	45	4.4	157	201
22	4	6	VI	VII-I	8	11	38	9.8	162	197
23	4	8	V	V	3	4	31	6.8	163	198
24	4	7	VI-VIIe	VIIe	6	9	42	6.6	164	198
25	4	5	VIIe	VIII	7	19	45	3.0	173	204
26	7	7	V	VII	3	4	33	9.2	164	200
27	3	5	VIIe	VIII	7	5	46	3.8	161	203
28	4	8	V	V	3	4	33	6.0	162	203
29	3	2	VI-VIIe	IX-1	7	118	55	3.6	146	201
30	3	4	VIIe	IXe	7	64	52	3.6	157	203
31	7	7	VIIe	VIIe	4	4	33	9.4	150	218

Primordia developmental stage and length of internode are roughly correlated with LT50. Only three cultivars i.e., nos. 1, 7 and 26, show lower LT50 than -8°C which is the critical temperature for freezing resistance in this region. These cultivars also did not initiate primordia development (below VI) and had internode elongation (below 5 mm). All cultivars which initiated primordia development and internode elongation are susceptible to freezing. The LT50 ranged from -5.4°C in cultivars which did not initiate primordia development and internode elongation. These results indicate that primordia development and freezing resistance are different physiological characters. The same results were obtained in the freezing tests using plants at the 3-leaf stage. The entries which did not initiate primordia development and internode elongation (Table 68) were not resistant to freezing. The earliness of plant development did not correlate with the freezing survival ratio. To develop early cultivars with cold/frost resistance in high-altitude areas, it is essential to have a plant development which would avoid cold, frost and terminal moisture stress. This is shown by the performance of entry nos. 23, 26 and 28 which had slow primordia development during early stages of plant development and later rapidly developed. This is a desirable character for avoiding terminal moisture stress. Freezing resistance is also an important character which can be transferred and achieved by effective selection. Six lines/cultivars (Entry nos. 1, 4, 7, 9, 25 and 26) expressed high freezing resistance, and are useful for the breeding program. These results conform with earlier studies and these lines have been extensively employed in the crossing program to develop new germplasm.

N. Kawada and M. Tahir

Regional Yield Trials

The most advanced breeding lines/cultivars performing well against various stresses under controlled conditions and at a number of key locations in the region are provided to cooperators in high altitude areas yield trials. The results from a few locations are presented here.

Bread Wheat Yield Trials, Kabul-Afghanistan, Mashhad-Iran, and Setif-Algeria, 1986/87

This trial was comprised of 24 entries with one long term check (cv. Bezostaya 1), an improved check, Cham 2, and a national check variety. The results of the five top yielding lines at Kabul along with the check varieties are given in Table 68. The yield increase in the top five lines ranged from 32-49% over the national check variety. Entry no. 5 (Pls 70/3/Fln/Acc/An .....), which is one of the top yielding lines at Kabul, was also top yielding at Setif-Algeria.

Table 68. Top yielding lines from the Regional Wheat Yield Trial for High Altitude Areas at Kabul-Afghanistan, 1986-87.

Entry No.	Name/Cross	Rank	Head days	Mat. days	Yield kg/ha
9	Dj/Bza//Wa-II-5204	1	203	247	2578
20	TW238/TW269//TW238/Timmo	2	207	249	2378
10	GD-27-262	3	198	246	2344
5	Pls 70/3/Fln/Acc/An	4	195	244	2289
13	Nir 264/3/NP 852/Pj62	5	199	245	2283
1	Cham 2 (Spring Type Check)	16	194	244	1856
12	Bezostaya	19	200	246	1744
24	National Check				
	Grand Mean	198	246	1991	
	CV	198	8	7	27
	LSD (P = 0.05)		20	20	729

At Kabul 19 lines outyielded the national check and 15 entries gave better yield than all three check varieties. All of the top yielding lines are of facultative type derived from winter x spring crosses. The spring and winter type check varieties ranked 16 and 19. The better performance of facultative types and poor yields of spring and winter types suggests that the most suitable material for the Kabul region should be an intermediate type possessing adequate cold tolerance. Furthermore, the overall grand mean yield was better than the national check variety indicating that germplasm developed at Tel Hadya is suitable for Afghanistan.

Mashhad-Iran is a high input environment compared to Kabul with high yields. One of the most widely grown cultivars is the winter wheat variety Bezostaya. Nine entries gave higher yield than the long term winter wheat check variety Bezostaya 1. Twenty two entries outyielded the national check variety and the overall experimental mean yield was significantly larger than the check variety. Although a large number of entries gave yield significantly better than the national check the data presented in Table 69 indicate an increase of 42% in the top five lines/cultivars. Four of the lines, i.e. cv. Zargoon, Trakia, Lom 10/3/2810/171-2//234-3816/4/..; and Chambord/5133//Mt/3/KKC/4/Lfn//.... were also among the top yielding lines at Tehran in the previous year. The variety Zargoon and entry no. 3 seemed to possess wider adaptability.

Table 69. Top yielding lines out of the Regional Wheat Yield Trial for High Altitude Areas at Mashhad, Iran, 1986-87.

Entry No.	Name/Cross	Rank	Head days	Mat. days	Plant height	TWK	Yield kg/ha
6	Zargoon	1	158	199	81	40	6696
7	Trakia	3	157	200	82	41	6089
2	Lon 10/3/2810/171-2//..						
1	Cham 2 (Check)	2	158	200	78	34	6163
12	Bezostaya (Check)	10	163	204	92	42	5422
24	National Check	23	170	210	105	43	3674
	Grand Mean		162	204	80	40	5091
	CV		11	9	84	39	17
	LSD (P = 0.05)		27	22	92	21	1197

No significant differences were observed in days to heading and maturity, but all top yielding lines matured at least 10 days earlier than the national check. Due to the better performance of the variety Zargoon at a number of sites in the region, 50 kg seed were requested and supplied to Iran for large scale testing.

At Setif, algeria none of the top five entries significantly outyielded the national check. However data indicate that facultative material or spring types with strong cold tolerance may be successfull in these environment.

Two of the entries, i.e. cv. Zargoon and no. 5, are widely adapted lines and have yielded consistently better in Afghanistan, Pakistan, Iran and Algeria. They are therefore worth testing in larger areas.

1. Regional Bread Wheat trial at Annaceur (Morocco), Breda, and Tel Hadya (Syria).

Data from Annaceur have shown the superiorty of entry No. 3 (Soty/Sut//Ler/4/2 Rfn/3/Fill....Trakia) as compared to the checks and other entries. The four top yielding lines have been developed through winter and spring crosses using cold tolerant varieties. At Breda, 11 lines significantly outyielded the two checks, Bezostaya and Zargoon. The average yield was higher at Breda than at Annaceur (3166 kg/ha vs 1095 kg/ha). This trial data at Tel Hadya confirm previous findings that facultative wheat types perform well in Tel Hadya. This also confirms the suitability of this station for evaluation of winter x spring crosses.

2. Regional durum wheat yield trials at Annaceur (Morocco) and Breda (Syria).

Three lines (entries 3, 16 and 6) outyielded the check Cham 1 at Annaceur, but only one line (entry 3) was superior to this check at

Breda. Entry 3 (9045/Loogl'S') ranked first at Breda and third at Annaceur and was selected in both sites. However, performance of durum wheat lines over sites suggests that durum wheat has a narrower adaptation as compared to bread wheat.

The selection frequency from various high altitude nurseries indicates a generally-good performance of our germplasm at various high altitude sites in WANA. The small number of advanced lines selected at more than one location shows the specificty in performance of the top yielding lines to particular sites. This is due primarily to agroclimatic diversity in the high altitude areas.

A network of research stations in high elevation areas will be developed to enhance the interflour of research material, and promote exchange of information through scientific visits, workshops and conferences.

M. Tahir

3.1. Physiology/Agronomy

Introduction

The physiology/agronomy project, now in its third season of activities, has the following goals:

a. Identification of specific plant and crop attributes representing traits that confer survival and productivity to cereals under stress.

b. Characterization of a wide range of genotypes in terms of morphological and physiological attributes of importance for physically stressed environments. Establish that sufficient genetic variability exists to be exploited.

c. Search for simple (integrative) parameters representing the physiological attributes that correlate with the plant responses to stress.

d. Prove that selection and recombination of characters is possible.

The following pay off is expected: improved efficiency of selection for stressed environments, and faster improvement of yield and yield stability.

The agronomy component aims to explore crop establishment practices, canopy architectures and the matching of genotypes to the medium (350 mm) and low (200 mm) rainfall spectrum of rainfed Mediterranean environments.

Previous reports (Cereal Improvement Program Annual Reports 1986 and 1987) have presented the materials and methods used, the description of the environments, evaluation of morphological traits according to their relation to yield, gas exchange patterns in relation to stress, comparative stress physiology between and within winter cereal species and agronomic tools for improving variety performance under stress. Emphasis has been given to drought, the major physical stress of concern. Some screening techniques have been explored.

In this report a brief environmental description of the season is given. The major part of the report addresses a detailed description of some morphophysiological traits of two row barleys and the problem of heat stress in wheat.

Environments

The rainfall in the 1987/88 season was above average in northern Syria. Fig. 11 shows the total and monthly rainfall for two seasons at two representative sites.

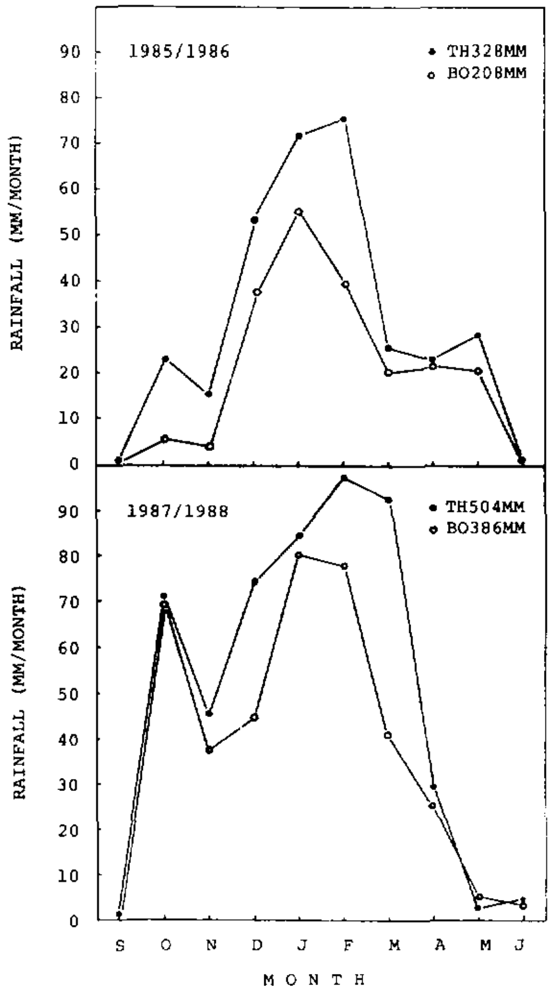

Fig. 11. Monthly rainfall at Tel Hadya and Bouider, northern Syria.

The 1985/86 season was below but close to the long term average. Seasonal rainfall was reflected in soil water profiles for the two years. While during 1985/86 the wetting front at Bouider did not reach below 70 cm in the soil profile and consequently soil water uptake was confined to this depth. In 1987/88 the soil was recharged to 140 cm and the roots grew to this depth. At Tel Hadya the two seasons allowed root growth and soil water uptake down to 170 cm in the soil.

Table 70 shows the total above ground biomass obtained in the three seasons of study and at the three testing sites. The biomass yields correspond to the genotypes of the cereal physiology nurseries

(72 barleys and 40 wheat). Table 70 shows that wheat outyielded barley at Tel Hadya, the higher rainfall site, while at the two drier sites the opposite occurred, except for Breda in the 1987/88 season. In 1987 barley had a higher rainfall use efficiency than wheat. Barley also had a higher transpiration efficiency but a lower photosynthesis and stomatal conductance at the wetter site than wheat, which presumably lead to a lower seasonal transpiration. Fig. 12 indicates that in a wet season at Tel Hadya (504 mm rainfall), the evapotranspiration efficiency of barley was higher than wheat but total biomass production was 27% lower. This result is in agreement with the gas exchange data discussed in previous reports.

Table 70. Total biomass (MG/ha) of barley and wheat across seasons.

Site	Season	Rainfall (mm)	Barley	Wheat	B/W
Tel Hadya	86	316	7.91	8.02	0.99
	87	343	5.73	6.68	0.86
	88	499	12.64	17.23	0.73
Breda	86	218	3.39	3.13	1.08
	87	245	3.34	2.63	1.27
	88	408	8.78	10.73	0.82
Bouider	86	205	3.80	2.89	1.31
	87	174	0.78	0.40	1.95
	88	382	9.82	8.60	1.14

Genotype characterization

This was the third season of characterization of the barley and wheat physiology nurseries. In this report partial results are presented, corresponding to detailed field studies undertaken in 25 two-row barley entries. Twenty of the twenty five were chosen to represent relatively well adapted genotypes based on earliness and grain yield. The remaining five entries are late and have had low yields in previous seasons. Results presented include apex development, number of leaves on the main shoot, tiller number, leaf colour, growth habit, vernalization requirement, potential and realized kernel number and grain filling rate and duration. Most emphasis was placed on the Breda site.

Apex development. Two development apex periods appear to be of major importance in barley: a vegetative period (VP), corresponding to leaf initiation, considered here from plant emergence (E) to the double ridges stage (DR), and the ear initiation period (EIP) spanning from double ridges until the maximum number of spikeletes (TS) is formed. The code number described by Kirby and Appleyard, 1984 (Cereal Development Guide, 96 p.) will be used; in this code DR is given the number 2 and TS the number 7.

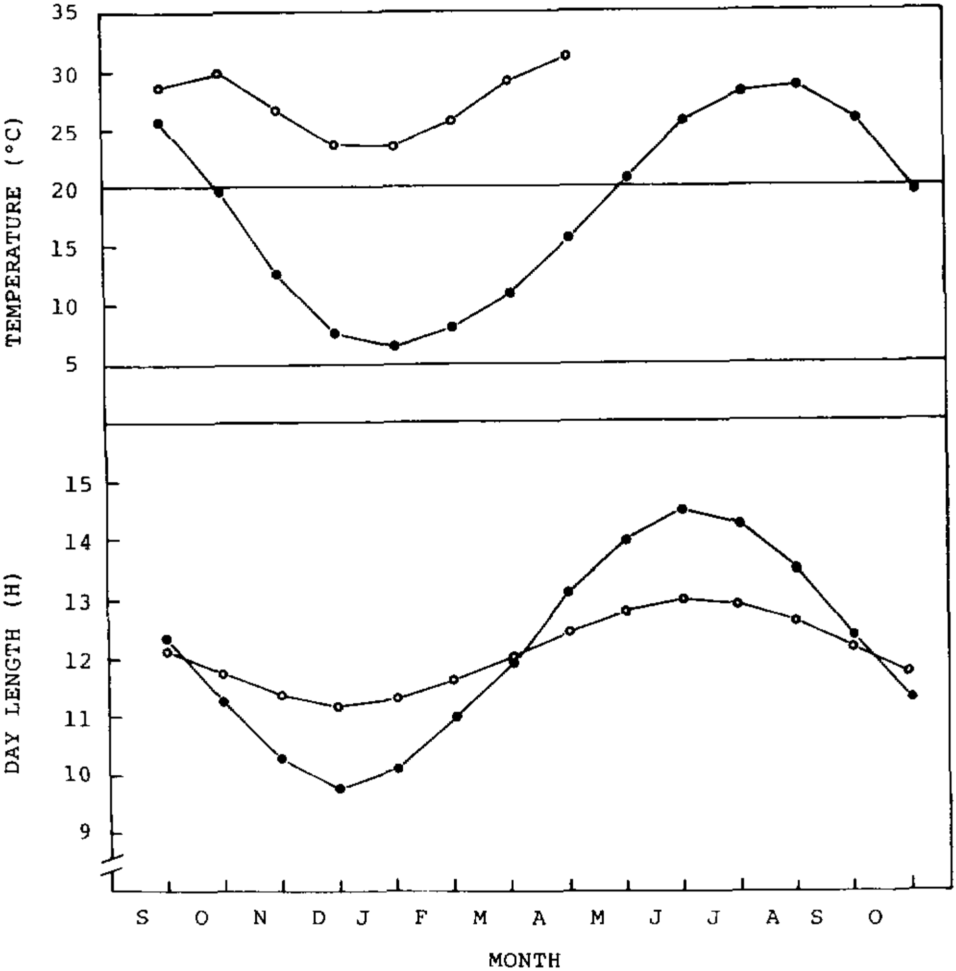

Fig. 12. Water use-efficiency of wheat and barley, and mean temperature, at Tel Hadya, through 87/88 season. Arrows indicate mean heading time. Date of emergence: 25/11/87.

Four plants from replicated plots (3) were taken every two weeks during the period January-March 1988. The rate of development of the apex was expressed in thermal time (accumulated mean daily temperatures above 0°C from emergence).

The study of the time course of apex development (Fig. 13) suggested a grouping of the genotypes to facilitate the analysis. Five groups were established:

- Fast developing entries, including WI 2291, WI 2198, WI 2269, WI 2291/WI 2269. This group is referred as WI entries.
- Slow VP and fast EIP: Tadmor, Arabi Abiad and Arabi Aswad. The group is referred as Tadmor type entries.
- Slow VP and slow EIP: Atem, Lignee 131, Alger/Union and BON 27. Referred as unadapted entries, being too late for the Mediterranean environments with terminal stress under study.
- Intermediate behaviour between the Tadmor type and the WI entries. This group includes Syrian landraces barleys (SLB).
- Other entries: Wadi Hassa, Roho/Masurka, Roho and SBON 96.

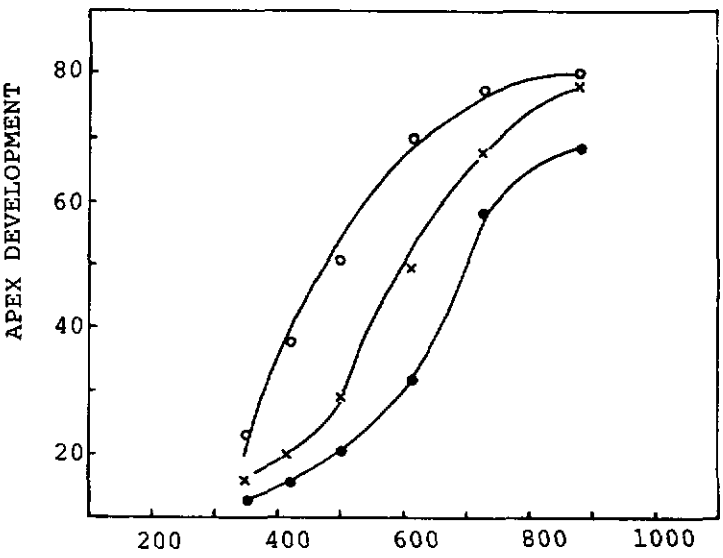

Fig. 13. Apex Development during the season for 3 entries WI 2269, early (open symbols); Tadmor, naturally adapted (crosses) and Lignee 131, non adapted (closed symbols).

Table 71 shows the thermal time required for each of the above entry groups for a given developmental phase. The range is given in parenthesis. The Tadmor type entries had the longest vegetative period (E-DR), and the shortest EIP (DR-TS). The longer time to heading of these genotypes as compared to the WI entries is caused by the longer E-DR period, since the EIP and spike growth period (TS-H) are the shortest. The WI entries had a relatively short EIP and a long ear growth period but they headed earliest. Late heading of the unadapted entries is the result of a long EIP and a long spike growth period. Three of the non grouped entries, SBON 96, Wadi Hassa and Roho had a short E-DR period (340, 345 and 360 °CD respectively), while Roho/Masurka has 400 °CD and a short EIP (280 °CD).

Table 71. Thermal time (°CD) required for various developmental phases. Two row barleys (n=20) 1987/88 season. Breda. The range of the group is given in parenthesis.

	Development Phases			
Barley group1/	E-DR	DR-TS	TS-H	Heading
Tadmor, A. Aswad A. Abiad (3)	478 (435-510)	272 (205-285)	397 (375-430)	1147 (1140-1152)
SLB (7)	381 (365-390)	306 (275-345)	434 (415-445)	1121 (1104-1153)
WI (4)	348 (335-360)	300 (270-315)	444 (420-485)	1093 (1062-1123)
Unadapted (5)	418 (365-560)	350 (335-365)	455 (390-530)	1224 (1155-1302)
Harmal	370	245	445	1062

1/ Numbers in parenthesis refer to the number of entries included in the group.

Number of leaves in the main shoot. The number of leaves in the main shoot and leaf appearance rate or phyllochron period (interval in °CD between the appearance of 2 leaves) are important genotype characteristics as they are contributors to the formation of the early canopy structure. Fully expanded leaves of the main shoot were counted in 12 plants per genotype (4 plants x 3 replicated plots) at each sampling time. The phyllochron period was constant for a particular entry. Fig. 14 shows the linear relation between leaf number and thermal time. Two contrasting entries as well as the mean of the 25 under study are given in the figure.

Table 72 gives the total number of leaves in the main shoot and the phyllochron period (calculated as the regression of thermal time onto number of leaves).

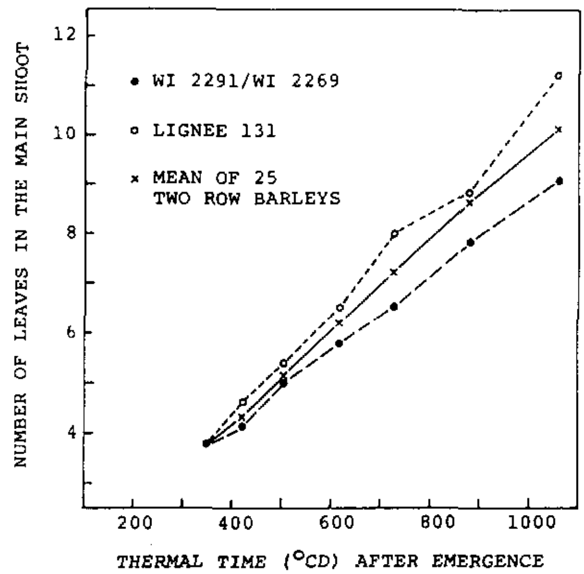

Fig. 14. Number of leaves on the mainshoot as a function of thermal time from emergence. Source: PCB Breda 87/88 points are means of 12 observations/entry.

The Tadmor type and SLB group had a higher number of leaves in the main shoot and generally shorter phyllochron period than the WI group. The total number of leaves in the main shoot was significantly correlated to the thermal time from emergence to double ridges ($r = 0.98$, $P < 0.01$, $n = 25$), and the phyllochron period was negatively correlated to this thermal time interval ($r = -0.58$, $P < 0.01$, $n = 25$), i.e. a long E-DR in general implied more leaves in the main shoot appearing faster. The correlation between leaf number and phyllochron period was -0.67 ($P<0.01$). This last correlation was strong enough to predict the final number of leaves on the main shoot on the basis of the phyllochron period within the limits of a 5% confidence interval.

Plants with more leaves on the main shoot have more potential sites for tillers (Kirby, 1988, in press). A positive correlation between maximum number of leaves in the main shoot and maximum number of main shoot tillers was found, ($r = 0.6$, $P < 0.01$, $n = 25$). Table 73 shows the maximum number of main tillers and number of leaves on the main shoot at various development stages for four groups of entries.

In general, entries with a shorter E-DR period had a lower number of leaves in the main shoot which appeared at a lower rate (longer phyllochron period) and a lower maximum number of tillers. Fast and abundant early growth and earliness have been found to be correlated with yield in the dry Mediterranean environments of northern Syria. This implies a long E-DR period and, as will be shown later, some degree of vernalization.

Table 72. Total number of leaves in the main shoot and phyllochron period of 25 two-row barley genotypes. Values in parenthesis are the 5% confidence interval. Breda 1987/88.

	Final leaf number on main shoot	Phyllochron period (°CD)
Tadmor	10.6	95.1 (66.0-124.1)
A. Abiad	10.3	109.7 (95.2-124.2)
A. Aswad	11.3	93.2 (60.1-126.5)
WI 2291	9.5	119.8 (109.1-130.6)
WI 2198	9.4	116.1 (100.1-132.1)
WI 2269	9.2	107.5 (94.1-120.9)
WI 2291/WI 2269	9.1	129.2 (118.1-140.3)
SLB 39-99	10.0	112.7 (98.8-126.5)
SLB 62-35	10.2	116.4 (111.0-121.8)
SLB 62-99	10.3	98.3 (82.8-113.8)
SLB 8-6	10.3	102.7 (85.1-120.3)
SLB 60-2	10.1	113.7 (106.2-121.1)
SLB 39-43	10.7	107.3 (98.4-116.2)
SLB SLB 8-84	10.3	103.4 (89.9-116.8)
Atem	9.8	116.1 (99.6-132.6)
Lignee 131	11.5	100.8 (84.6-116.9)
Alger/Union	11.3	104.1 (89.8-118,3)
Kervana/Masurka	9.9	103.0 (86.6-119.4)
BON 27	10.5	104.8 (94.8-114.8)
Harmal	9.7	95.3 (79.0-111.7)
ER/Apm	10.4	97.4 (77.4-117.3)
Wadi Hassa (SLB 8-89)	9.6	119.2 (102.3-136.1)
Roho/Masurka	11.3	92.6
Roho	10.2	97.9 (87.9-107.9)
SBON 96	9.8	122.6 (115.2-130.0)

Table 73. Leaf number at various development stages and maximum main shoot tillers. Values in parenthesis are ranges.

Entry group	Leaf No. at DR	Leaf No. at TS	Final Leaf No.	Maximum MS tillers
Tadmor type	5.3	7.9	10.7	3.1
	(4.9-5.8)	(7.5-18.5)	(10.3-11.3)	(2.9-3.4)
SLB	4.1	6.9	10.3	2.8
	(3.7-4.5)	(6.3- 7.3)	(10.0-10.7)	(2.5-3.0)
WI	3.7	6.2	9.3	2.4
	(3.6-3.8)	(6.0- 6.3)	(9.1- 9.5)	(2.2-3.0)
Unadapted	4.3	7.6	10.6	2.7
	(3.4-6.0)	(6.5- 9.4)	(9.8-11.5)	(2.1-4.0)
Harmal	3.8	6.3	9.7	

Leaf colour. We reported (Cereal Improvement Program, Annual Report 1987, p:125) that light green colour is positively related to grain yield under drought in durum wheat and information on barley colour during the growing season is provided here. Chlorophyll information and its possible relation to plant colour has been provided by Dr. R.B. Austin from the Plant Sciences Institute of Research, Cambridge.

Chlorophyll in plants occurs only in chloroplasts in the form of chlorophyll containing proteins. These proteins are constituents of the two photosystems, PSII and PSI, located on the thylakoid membranes in the chloroplasts. Each photosystem particle (a mesophyll cell of bread wheat contains about 150 chloroplasts and each chloroplast will contain at least a thousand photosystem particles) contains a "core complex" of several different chlorophyll proteins. It is within this core that the photochemistry (water splitting by charge separation in PSII and generation of reducing power and ATP in PSI) takes place.

Most chlorophyll in leaves is in the form of complexes called light harvesting chlorophyll proteins (LHCII and LHCI for the two photosystems). LHCII and LHCI form "antennae" for intercepting photons which are then passed on to the core complexes where photochemistry takes place.

Antenna chlorophyll has an a/b ratio of 1-1.3 while that in the core complexes is mainly chlorophyll a. In low light environments there is relatively more antenna chlorophyll than in high light environments (i.e. low a/b ratio), which ensures a sufficient delivery rate of excitons to reaction centers to keep them working efficiently. In high light, too much antenna chlorophyll can overload the core PSII complex. If electron transport through PSII is inhibited by feed back mechanisms due to low demand for the products of photosynthesis (e.g. at low temperatures or in drought), proteins in the core of PSII are damaged and photosynthesis subsequently is impaired (a phenomenon known as photoinhibition).

During the initial part of the season, roughly through the beginning of stem extension, solar radiation is limiting in northern Syria (8 $MJm^{-2}d^{-1}$) increasing to values above 20 MJ m^{-2} d^{-1} during stem extension, heading and grain filling (28 MJ m^{-2} d^{-1}). At the high levels of radiation it is very likely that photoinhibition will occur, particularly if the plants are subject to drought or heat stress.

Fig. 15 shows the evolution of plant colour throughout the season of four groups of barley genotypes at Bouider, a dry testing site. The naturally adapted genotypes (landraces), Tadmor, Arabi Aswad, Arabi Abiad (Tadmor group) and pure lines isolated from landraces (SLB group) show a distinct colour pattern as compared to a Waite Institute set of entries (WI) and European entries which have been shown to be poorly adapted to the northern Syria environments. Most interesting, the Tadmor and SLB groups show a dark green colour early in the season when radiation is low, which changes to pale green as radiation increases.

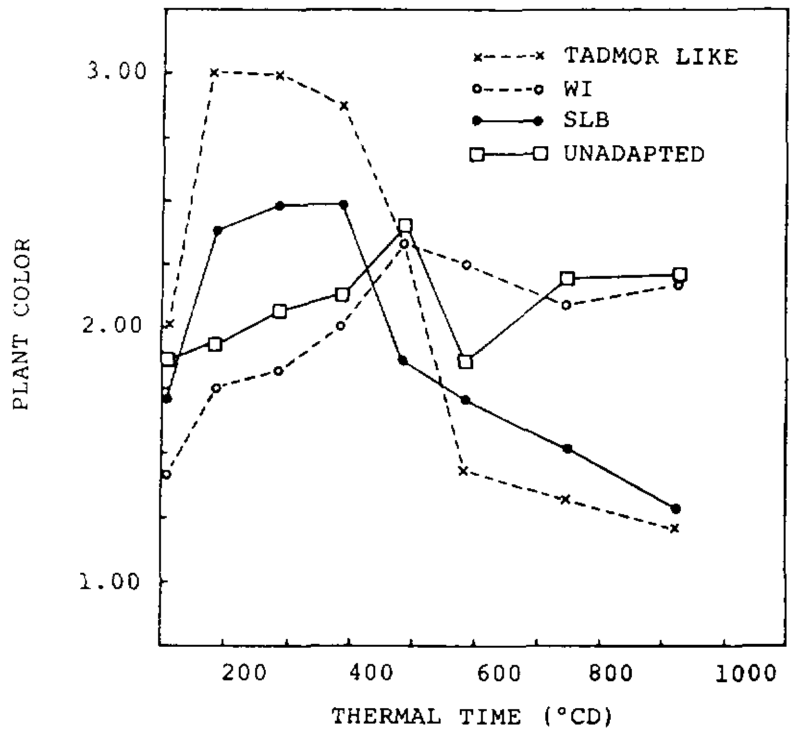

Fig. 15. Plant colour during the season as a mean for four groups of entries. Source: PCB Bouider 1987/88. Score: 1 = light green; 3 = dark green.

Dr. N. Watanabe, working on chlorophyll proteins at the Institute of Plant Sciences, Cambridge Laboratory, measured the chlorophyll content and a/b ratios in a set of genotypes with either light green or dark green leaves. Measurements were done early in the grain filling period on samples from irrigated plots at Cambridge. The flag leaf-1 in replicated plots was analyzed. A summary of the results is given in Table 74. Light green genotypes consistently had a higher a/b ratio than dark green ones but there was no consistent difference between groups in their chlorophyll content per unit leaf area. The observed difference in a/b ratio is similar to that between high-photosynthesis diploid wheat species and bread wheat. In diploid wheat, the high a/b ratio is associated with a smaller ratio of chlorophyll in the antenna to that in the core complex of photosystem II and with a higher capacity for photosynthetic electron transport, particularly at light saturation. These associations need to be investigated in barley. Present efforts of Dr. Watanabe at IPSR seek to separate chlorophyll proteins by gel electrophoresis to measure the antenna/core complex ratio of the light and dark leaf colour barley genotypes.

The light leaf colour of the adapted barley genotypes is associated with a consistently higher chlorophyll a/b ratio, and this is likely to be a measure of a reduced amount of antenna chlorophyll in proportion to that in the cores of PSII and PSI. This may confer (a) a high rate of photosynthetic electron transport, possibly resulting in a lower Ci and hence a high transpiration efficiency, and (b) reduced susceptibility to photoinhibition. The colour pattern of the adapted barley genotypes may be a useful selection criteria for barley improvement for dry environments similar to those northern Syria.

Table 74. Leaf colour, chlorophyll content and chlorophyll a/b ratio of dark green (n=6) and light green (n=7) barley genotypes. Measurements done during grain filling[1/].

Genotype group	Leaf colour score[2/]	Chl. content mmol m^{-2}		Chl. a/b ratio	
		Occasion		Occasion	
		1	2	1	2
Dark	2.50	236	408	3.762	3.481
Light	1.04	253	382	3.892	
3.729					
LSD 0.05 (one side test)		26	26	0.136	0.040

[1/] Data provided by Dr. R.B. Austin.
[2/] Score: 1=light green; 3=dark green.

Growth habit. An early prostrate growth habit, before stem extension, has been correlated to yield under drought in the Mediterranean environments of northern Syria (Acevedo, 1987. In: Drought Tolerance in Winter Cereals pp:303-320). A plausible explanation lies in an increased ground cover and light interception by the crop at a time when radiation is low, resulting in an increased water use efficiency. Fig. 16 shows that the adapted entries, Tadmor, Arabi Aswad and Arabi Abiad, are prostrate early in the season. Other Syrian landrace barleys (SLB group) show a similar but less pronounced pattern. The WI group is completely erect through the growing season and the European unadapted entries are also erect except for Lignee 131 which is prostrate. Within the SLB group, a range is found with SLB 60-2 being Tadmor-like to SLB 8-84 being WI-like.

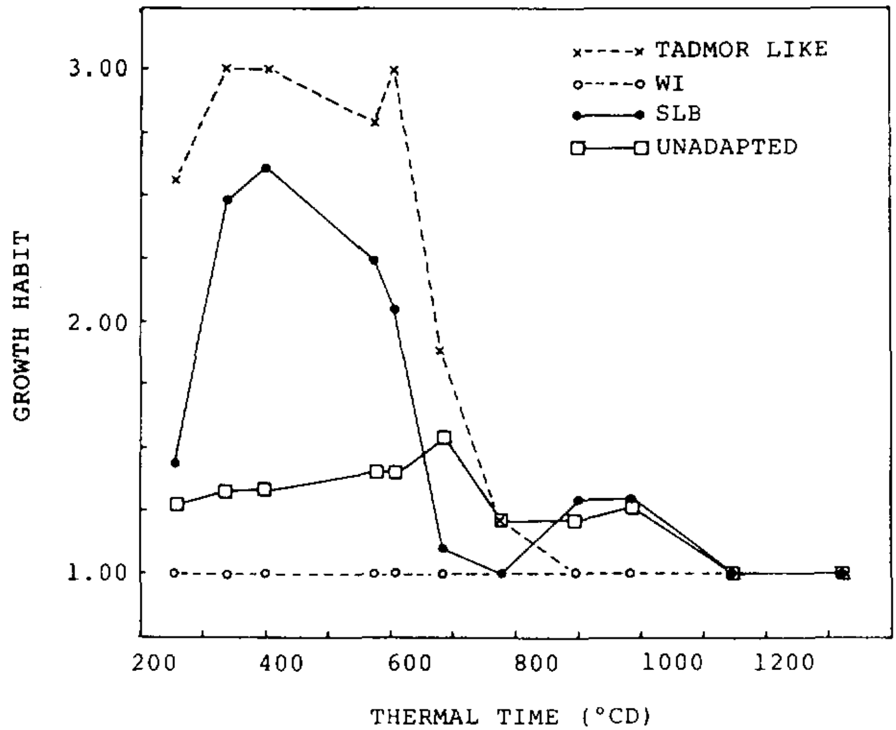

Fig. 16. Mean growth habit during the season for four groups of entries.(PCB, Tel Hadya 1987/88. Score: 1 Erect;3 Prostrate).

The initial prostrate growth habit of the Tadmor-like and SLB group changed to erect between 600 and 800 °CD at Tel Hadya, between 500 and 700 °CD at Breda and between 400 and 600 °CD at Bouider. At Breda, where detailed information on apex development was obtained, the change from prostrate to erect habit occurred during ear initiation, i.e. between double ridges and maximum number of spikelets, and may be related to the vernalization requirement of the entries. If his is the case, the change in growth habit would be a good field indicator that vernalization requirements have been met in those entries requiring devernalization. Internode elongation, which would be an obvious indicator, did not necessarily coincide with the change in growth habit.

Vernalization requirements. The reproductive development of barley and consequently the time to ear emergence and maturity is influenced by vernalization or cold requirement for ear initiation and by photoperiod and temperature response during growth. As part of the collaborative program of the Cereals Physiology Project of ICARDA with the Institute of Plant Science Research (IPSR), Cambridge, UK., the vernalization requirement of 50 two-row barleys, including 30 of the genotype characterization trials, was determined at Cambridge.

The results (Table 75) show that the majority of genotypes examined were spring types, i.e. genotypes in which vernalization treatment did not hasten time (degree days) to ear emergence. This group included Japanese and European genotypes, 3 genotypes from Turkey, one from each Pakistan, Morocco and Iran, and the genotypes of the barley characterization physiology nursery of ICARDA except for the local landraces. Of the remaining genotypes in which time to ear-emergence was hastened by vernalization (i.e. winter types), only Lignee 131, a genotype from Montpellier in France, required more than two weeks vernalization. This group included all the landraces examined, two genotypes from Iran and one each from Iraq and Turkey. The Tadmor type and SLB entries which are well adapted to northern Syria require vernalization.

Table 75. Classification of 2-row barleys into spring-type (vernalization did not hasten time (day-degrees) to ear-emergence) or winter-type (2 weeks vernalization did hasten ear-emergence). Day-degrees to ear-emergence in the 0 week treatment and the effect (+ = earlier, - = later) of 2 weeks vernalization are shown.

Spring type Genotype	°C days to ear emergence No vernalization treatment	Difference in °C days between no vernalization and 2 weeks vernalization*	origin
Bankuti Korai	1116	+54	
Shunsei	1109	+110	
Nirakei 19	840	+8	Japan
Satsuki	1024	+64	
Amaji Nijo	836	0	
Proctor	1234	+45	
Maris Mink	1136	+39	
Triumph	1046	+34	Europe
Georgie	1003	-24	
Kenia	1028	+23	
Harmal	727	+72	Barley
WI 2291	720	-13	characterization
WI 2198	780	+111	trial.
Er/Apm	764	+41	Landraces
Atem	999	+44	excluded
Alger/Union	818	+76	
WI 2291/BG-5	769	+35	
WI 2291/EH 70-F3-AC	897	-50	
A16//2728/SV. Mary	782	+62	

Table 75. (cont'd).

Spring type Genotype	°C days to ear emergence No vernalization treatment	Difference in °C days between no vernalization and 2 weeks vernalization*	origin
Roho/Masurka	825	+74	
WI 2291/WI 2269	753	+61	
Jer. Barbelisse/ C110836	741	+46	
Kervana/Masurka	1090	+46	
Roho	787	+84	
Swannek	772	+5	
Cytris	941	+43	
S. Bon 89	1020	+53	
S. Bon 29	921	+27	
S. Bon 27	1020	+88	
S. Bon 4	843	+110	
S. Bon 96	737	0	
Drusp	896	-6	Pakistan
Esperance	786	-14	Morocco
L-28-98 53	949	-85	Iran
Ankara Tokak 14	916	-5	
Guzak	924	+24	Turkey
Smyrnakorn	1125	-52	
Arabi Abiad	1686	+700	
Arabi Aswad	1294	+383	
Tadmor	1702	+722	Syrian
ELB 51 = SLB 60-2	1738	+605	Landraces
ELB 75 = SLB 39-43	1670	+661	or derived
ELB 80 = SLB 39-99	1667	+581	genotypes
ELB 11 = SLB 8-6	901	+230	
W. Hassa = SLB 8-89	1123	+233	
I. Asadabad	1452	+394	Iran
L-34-15 20	1614	+703	
Mosul 72	1583	+707	Iraq
Aklidar	1817	+818	Turkey
Lignee 131	1861	+519[1]	France
S.E.D.	50.4		

* A positive number greater than 100 indicates a vernalization requirement.

[1] 6-weeks vernalization.

Potential and realized kernel number. Results of previous seasons indicated that the number of grains per spike was the yield component most affected under the driest environments. Table 76 shows the average decrease in yield and yield components at Breda and Bouider with respect to Tel Hadya for the 1985/86 and 1986/87 seasons.

Table 76. Yield and yield structure as affected by stress. (Breda, Bouider). Percentage with respect to Tel Hadya. 85/86; 86/87.

	Barley		Wheat	
	2 row	6 row	Durum	Bread
Grain Yield	-52	-57	-77	-70
Spikes/area	7	3	6	7
Grains/spike	-43	-44	-64	-60
Grain mass	-25	-24	-40	-30
Straw	-45	-44	-54	-50
HI	-7	-16	-34	-50
DH	-5	-5	-10	-11
DM	-7	-7	-11	-9

HI = harvest index, DH = days to heading, DM = days to maturity.

As mentioned previously, the 1987/88 season was wet at Tel Hadya, Breda and Bouider and the kernel number of the twenty five two-row barleys under study was little affected at the drier sites, 11.4% on the average as compared with the wettest site (Tel Hadya).

Counting of the potential number of kernels was done at the maximum number of spikelets stage. Counting was repeated between heading and anthesis (developed kernels) and during grain filling (fertilized kernels). Results are summarized in Table 77. At Tel Hadya and Breda unadapted entries had a higher number of potential, developed and fertilized kernels, the means for the WI and Tadmor groups were lower and the SLB group presented a wide range with an intermediate mean. Because barley spikes are indeterminate, a positive correlation between the ear initiation period (DR-TS) and potential kernel number would be expected. At Breda the correlation was 0.49 ($P<0.05$) and the EIP explained 24% ($P<0.05$) of the variation in potential kernel number. The entries with the lowest relative number of fertilized kernels were WI 2291 and SBON 96, both early heading and with higher scores of frost damage around anthesis. The relative lateness in anthesis of the Tadmor and SLB groups resulting from a long E-DR period and relatively short EIP and spike growth period may have evolved to combine a high vegetative growth and escape to possible spike frost and drought damage.

Table 77. Kernel number of the ears of the main shoot at three stages of ear development (see text). Values are means of 3 replications and four measurements per plot. Values in parenthesis give the kernel number as a percentage of the potential.

Site/entry group	Kernel number		
	Potential	Developed	Fertilized
Tel Hadya			
Tadmor	42.7	25.9 (60.8)	25.6 (60.0)
SLB	42.0	25.6 (61.0)	24.5 (58.3)
WI	42.0	25.6 (61.0)	24.5 (58.3)
Unadapted	45.8	32.1 (70.1)	29.4 (64.3)
Breda			
Tadmor	40.1	24.6 (61.3)	22.0 (55.0)
SLB	40.4	25.0 (61.8)	23.9 (59.3)
WI	39.1	23.1 (59.2)	22.0 (56.4)
Unadapted	43.4	27.6 (63.6)	26.2 (60.5)

Grain filling of barley genotypes. The grain filling rate and duration of 27 two-row barley genotypes was studied to identify cultivars best adapted to terminal stresses (drought and heat). Use was made of this particularly high rainfall season at Bouider (381.8 mm) to assess the effect of accelerated leaf senescence on grain filling.

The experiment was performed in replicated plots (2.4 x 5 m) which at the time of anthesis were split longitudinally. One half of the plot was sprayed with a solution of potassium iodide (4 gr/l) 10 days after the yellow anther stage to accelerate senescence (N.C. Turner, personal communication). The equivalent to 2500 l/ha or 0.25 l/m^2 of KI solution was sprayed to fully wet the plants, ears included. The effectiveness of the KI treatment was assessed by measuring photosynthetic rate in the flag leaf-1 in treated and untreated plants, four and eight days after the treatment. On average, net photosynthesis was reduced by 40 and 50% at the two measurement occasions in the treated as compared to the untreated plants. Leaf conductance however was affected only by 8.5%.

Ten spikes per sub-plot were randomly sampled immediately after the treatment with KI and at 5 days interval through hard grain stage. At each sampling the grains were dried in a ventilated oven at 75°C for 48 h., counted and weighed. Observations on plant senescence were also taken using a 1 to 5 score.

Fig. 17 shows the mean kernel weight through the grain filling period of the treated and untreated plants. The KI treatment decreased kernel weight significantly ($P<0.01$) at maturity. Varieties differed at $P<0.01$ in final kernel weight while the variety x treatment interaction was insignificant. Table 78 shows the mean values of kernel weight for the treated and untreated plants.

Table 78. Mean and range of final kernel weight of plants treated with a KI solution at 4% 10 days after anthesis (Means obtained from 10 plants x 3 reps x 27 entries).

	Kernel weight (mg)	
	Treated	Untreated
Mean	32.6b	35.6a
Range	24.9-41.1	29.0-43.3
LSD (0.05)	5.5	6.0

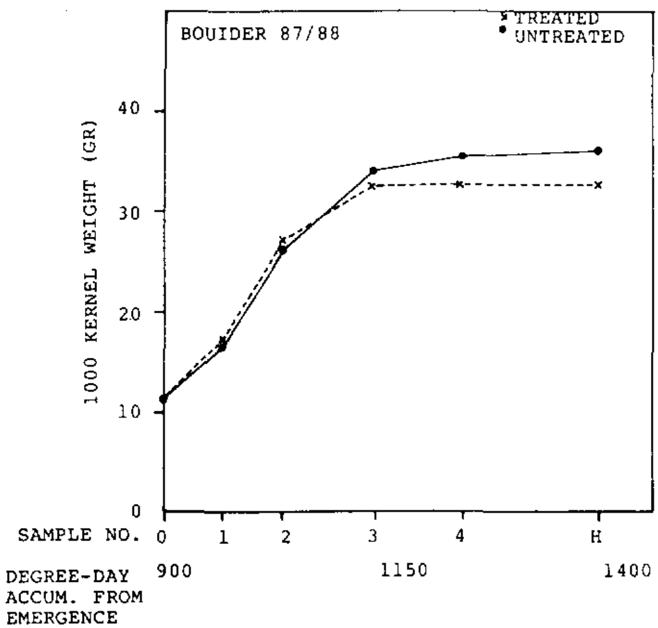

Fig. 17. Effect of KI treatment on 1000 kernel weight. Average for 27 barley lines.

It was important to identify varieties having similar final kernel weight for treated and untreated plants since this can be interpreted as the ability of the genotypes to fill grain despite decreased photosynthesis during grain filling. Table 79 lists genotypes with the values of the kernel weight and the effect of the treatment. Genotypes are ranked from low to high differences in kernel weight.

Table 79. Final kernel weight (mg) of treated and untreated genotypes (LSD 0.05 for the difference between two genotypes=5.6)

Genotype	Untreated	Treated	Difference
WI 2198	34.4	36.3	-1.9
SLB 8-6	32.0	32.7	-0.7
Alger/Union	41.3	41.1	0.2
SLB 60-2	38.0	37.6	0.4
SLB 8-89	39.4	39.0	0.4
Tadmor	31.2	30.7	0.5
Swanneck	31.0	30.5	0.5
Lignee 131	33.6	32.6	1.0
BON 27	29.0	27.7	1.3
WI 2291/WI 2269	35.6	34.2	1.4
Roho/Masurke	36.6	34.9	1.7
WI 2291	35.7	33.9	1.8
A. Abiad	37.3	35.1	2.2
SLB 39-43	35.8	32.9	2.9
Cytris	37.0	33.9	3.1
Harmal	37.8	34.6	3.2
SBON 96	40.3	36.9	3.4
SLB 62-35	29.0	25.6	3.4
Roho	38.7	34.9	3.8
A. Aswad	31.4	26.7	4.7
Atem	26.8	21.2	5.6
SLB 62-99	34.0	28.4	5.6
SLB 8-84	38.2	32.4	5.8
WI 2269	38.5	32.6	5.9
Kervana/Masurka	32.3	24.9	7.4
ER/APM	43.3	34.8	8.5
SLB 39-99	42.4	30.1	12.3

A small difference in kernel weight indicates that in spite of reduced net photosynthesis and accelerated senescence (the senescence score was on the average 1.32 times higher in the treated plants 20 days after anthesis), the genotype was able to fill the grains. The KI treatment did not affect the grain number per spike.

Regression analysis showed that there were no treatment effects on grain filling rate between the treated and untreated plants. Grain filling duration, assessed by the inflexion point of the plateau in the kernel weight versus time curves, was significantly longer in the untreated plants of only six varieties, WI 2269, Roho/Masurka, SLB 39-99, SLB 8-84, SLB 8-6 and Atem. Four of these varieties are within the group of 25% higher difference in kernel weight between treatments.

Photosynthetic rate was checked by 40 to 50% of controls four to eight days after the KI treatment. Grain number per spike was the same between treatments, there were no differences in grain filling rate and the grain filling duration between treatments was similar in 21 out of the 27 varieties tested. The lack of difference in kernel weight between treated and untreated varieties was largely due to retranslocation to the grain of stored assimilates prior to the KI treatment. The differences in variety behaviour are more completely illustrated in Fig. 18 where the varieties Wadi Hassa (SLB 8-89) and Roho are contrasted.

The correlation coefficient between final kernel weight and days to anthesis was -0.53 (significant at P<0.01) for the untreated plants.

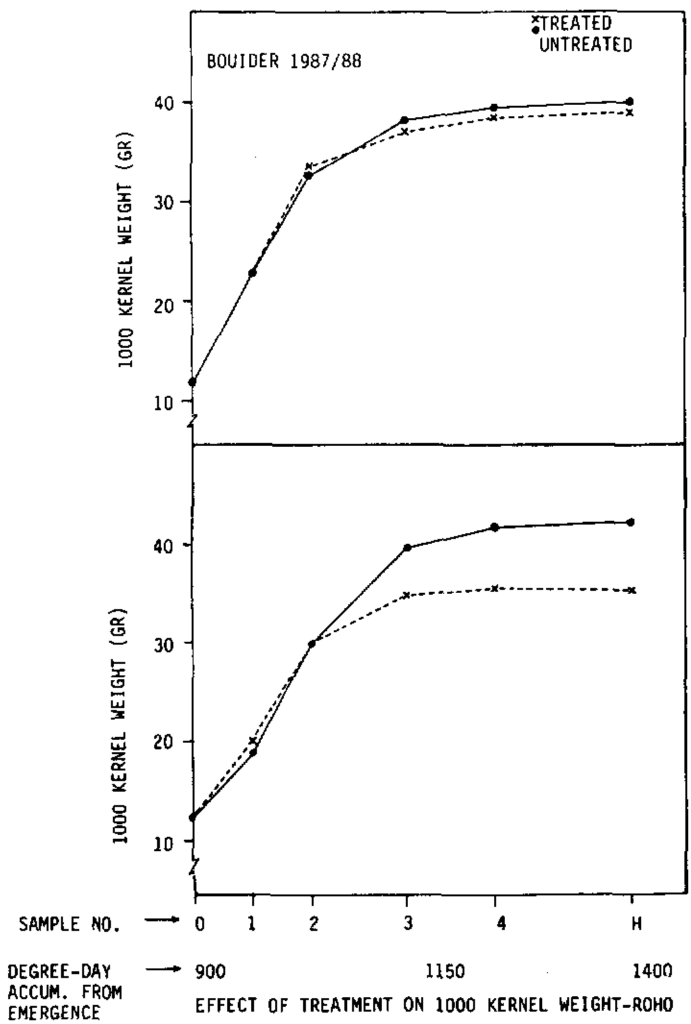

Fig. 18. Effect of KI treatment on 1000 kernel weight. a) W. Hassa (SLB 8-89) and b) Roho.

For the treated plants r was negative but insignificant (r =- 0.36). The significant negative correlation between heading date and kernel weight in the untreated plants indicate that the late heading plants were subject to terminal stress. In fact, a heat wave accelerated the maturity of the untreated plants such that the senescence scores beyond 30 days after anthesis became equal for the two treatments.

Heat Stress in wheat

Cereal yields are essentially determined by management, variety and environment. Winter cereals are cool season crops. Among various climatic factors, high temperature is a major production constraint. High temperatures may occur throughout the growing season as in the lowland tropics or as terminal heat affecting the crop during the grain filling period in Mediterranean environments and highlands. In Sudan wheat grown between 14 ^{o}N and 16 ^{o}N latitude and 350 m elevation yields 0.75 MG/ha. In this case the growing season is short and with high temperature throughout.

In this work we aim at investigating crop responses to high temperature stress and identify morphophysiological and phonological traits related to temperature tolerance. The traits related to temperature tolerance of wheat and barley can be evaluated by assessing the effects of temperature at each growth stage and on final yield. For analysis purposes, and due to physiological plant responses, the development of a winter cereal may be conveniently divided into three major phases: from emergence to double ridge (GS1), from double ridges to anthesis (GS2) and from anthesis to maturity (GS3). Temperature has an effect on each of these phases.

Experimental. The study is being approached by exposing a set of wheat genotypes to various planting dates in the Mediterranean climate of Tel Hadya.

Twenty one bread wheat and three durum wheat fixed lines representing various stages of selection for heat stress were studied. Planting dates were December 1st, 1986 (normal, N), March 23, 1987 (terminal heat stress, THS) and July, 15, 1987 (heat stress early in the season, EHS). An additional planting was done on May, 20, 1987 to expose cultivars to heat stress during the whole growing period (HS). Heavy root rot attack in this planting allowed obtain only partial information. On November 15, 1987 the cultivars were planted at Wad Medani, Sudan (14^{o}, 24'N, 380 m elevation) on the Gezira University Farm in collaboration with Professor J. Sirag. At this site entries were exposed to the normal heat stress of the dry lowland tropics throughout the season.

The experimental design at each site or date was a randomized complete block with three replicates. For analysis purposes four or five environment levels were available (five when variables from HS are included). Plot size varied according to site, being 1.8 m wide (6 rows, 30 cm apart) and 5 m long at Tel Hadya (Oyord planted) and 1.8 m wide (3 rows, 60 cm) and 6 m long at Wad Medani (hand planted in ridges). The sowing rate was 110 kg/ha in all the experiments.

Crop husbandry other than planting method was the same in all environments and corresponds to that usually used at ICARDA. Irrigations were given to replace crop evapotranspiration every 7 or 8 days during the rainless season at Tel Hadya (spinkler) and every 10 days at Wad Medani (surface irrigation). The observations included crop emergence and establishment, growth, development and yield.

Environments. Fig. 19 shows long term average temperatures and daylength for Tel Hadya and Wad Medani, and Fig. 20 shows the actual temperature for the various plantings.

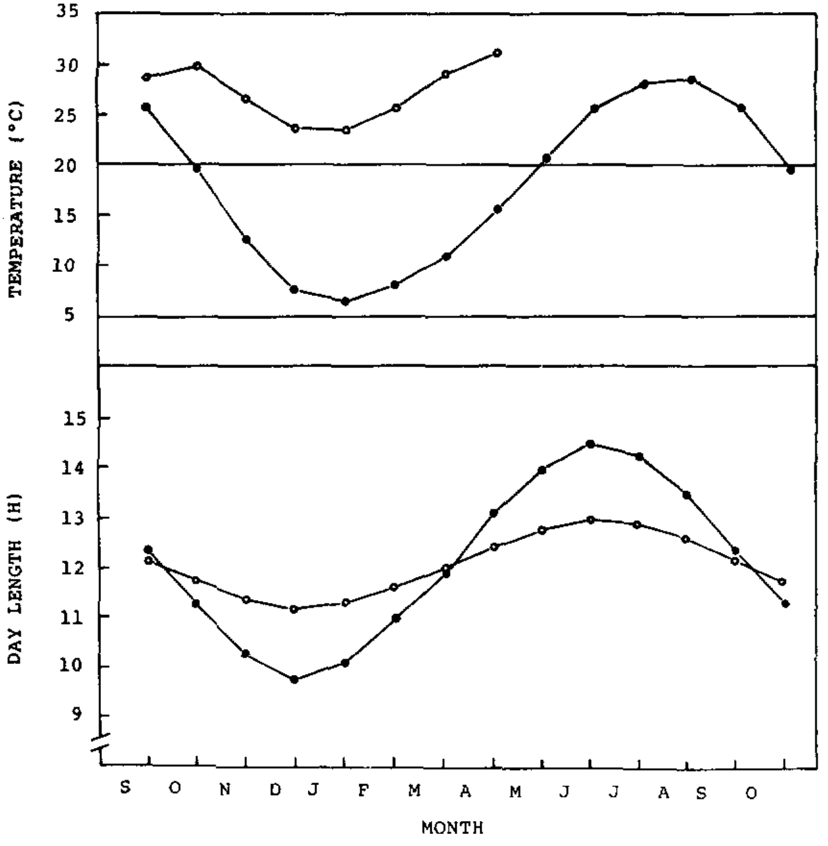

Fig. 19. Monthly mean temperature for Tel Hadya (closed circles), 8 years average and Wad Medani (open circles), 30 years average. Day length was approximated by the maximum number of sunshine hours for the respective latitudes.

The temperature regime is supraoptimal (>20°C mean temperature) for wheat growth at Wad Medani throughout the season while at Tel Hadya it stays above 20°C from early May through the end of October. Daylength fluctuates throughout the year at Tel Hadya, from a minimum of 9.8 h in December to a maximum of 14.5 h in June, while at Wad Medani it oscillates from 11.2 h to 13 h. Daylength fluctuation for the growing season at Wad Medani (November through March) is smaller, from 11.4 h to 12 h.

It is not possible to mimic the temperature and daylength regime of Wad Medani by field planting at Tel Hadya. While a June planting at Tel Hadya will have relatively similar mean temperatures than Wad Medani, daylength will be approximately 2.5 h longer. This implies that photoperiod sensitivity of the germplasm in this experiment is confounded.

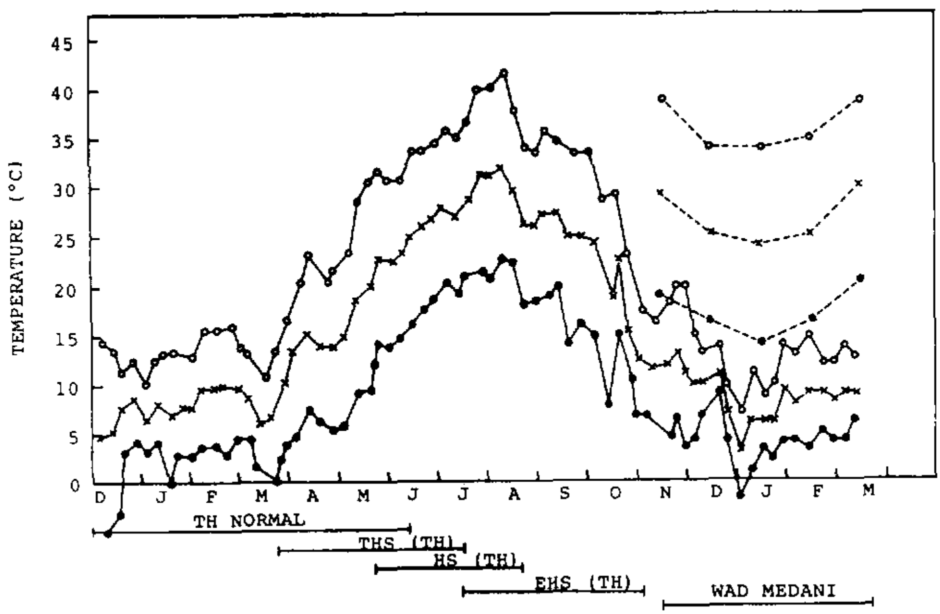

Fig. 20. Maximum (open circles), minimum (closed circles) and mean (x) temperatures at various planting dates. Tel Hadya (solid lines) and Wad Medani (broken lines). 1987/88 season.

The plant material at Tel Hadya was subjected to one month (Fig. 20) of heat stress at the end of the grain filling period (15 May-15 June) in the normal planting. The terminal heat stress was increased to two months by planting by mid March. The crop was subjected to thermal stress throughout the season by planting in mid May and to predominately early heat stress by planting early in July.

Yield and Yield Components. Environmental effects on yield are presented in Table 80, the values are average for the nursery under study. Grain yield was drastically reduced by heat stress, the biggest reduction occurred when heat stress was present throughout the season at Wad Medani. At Tel Hadya the heat stress early in the season had the most negative effect, not significantly different than the effect at Wad Medani. Total above ground biomass, though affected at Wad Medani, was not as severely decreased as the early heat stress at Tel Hadya, probably due to higher temperatures at the latter site.

Table 80. Environmental effects on grain yield, total above ground biomass and harvest index. Means of 24 wheat cultivars. The percent value in comparison to to Tel Hadya normal planting (100%) is also given.

Environment	Grain yield		Above ground biomass		Harvest index	
	$MGha^{-1}$	%	$MGha^{-1}$	%		%
TH normal	3.56a	100.0	9.41a	100.0	0.38ab	100.0
TH terminal heat stress	1.57b	44.1	4.21b	44.7	0.36b	94.7
TH early heat stress	1.20c	33.7	2.98c	31.7	0.40a	105.3
Wad Medani	0.96c	26.9	3.95b	42.0	0.24c	63.2
LSD (0.05)	0.30		0.74		0.03	

Numbers followed by a different letter in the same column differ at $P<0.05$.

Correlation coefficients for grain yield in the various environments were not significant except for normal planting at Tel Hadya and Wad Medani where low ($P<0.05$) correlations were found. The general lack of correlation in grain yield is indicative of significant genotype x environment interactions.

Table 81 presents the effect of environments on yield components. Grain number per unit area and mean grain mass are the grain yield determinants. Delaying planting at Tel Hadya reduced mean grain mass by an average of 24.8% while at Wad Medani the reduction was of 30.1% with a similar number of kernels per spike than the normal planting at Tel Hadya. The major reduction in grain yield is the result of decreased grain number, particularly by decreased spikes per unit area. The reduction in spikes per unit area was associated mainly with early heat stress and accounted for about 55% of yield loss at high temperatures. The number of kernels per spikelet (a/b in Table 79), though low does not seem to have been greatly affected by either THS or EHS while the number of kernels per spike was reduced from 9.6% at Wad Medani to 28.8% for THS at Tel Hadya. All yield components listed in Table 80 had a significant genotype x environment interaction (P<0.01). Grain number per unit area also differed significantly (P<0.05) for environments, genotypes and their interaction. The important contribution of reduced number of spikes per unit area on grain yield reduction for early heat stress should be examined in terms of crop establishment and tillering. There was a drastic reduction in crop establishment associated to early heat stress (20 to 30% with respect to normal planting). In spite of an increase of spike number per plant compensating for low plant density the decrease in crop establishment appeared as the main yield reduction cause. On a single trait analysis the problem is to select for varieties able to germinate and emerge under heat stress. This trait can be screened under controlled conditions. It is important that in this study significant differences in crop establishment between genotypes within environments were found (P<0.001) and the GxE term of the analysis was also significant at the same level, giving scope for selection for this character.

Table 81. Yield components of wheat as affected by environments differing in heat stress. Means of 24 cultivars. The percent value with respect to Tel Hadya normal planting (100% is also given.

Environment	Spike No. (m^{-2})		Kernels per spike (a)		Spikelets per spike (b)		a/b	Mean grain mass (mg)	
TH normal	349.2a	100.0	27.1a	100.0	15.9a	100.0	1.7	39.5a	100
TH terminal heat stress	292.9b	83.9	19.3b	71.2	12.3c	77.4	1.6	28.9b	73.2
TH early heat stress	163.2c	46.7	22.1b	81.5	13.4b	84.2	1.6	30.5b	77.2
Wad Medani	145.6c	41.7	24.5a	90.4	N.a.	-	-	27.6c	69.9

Numbers followed by a different letter in the same column differ at $P < 0.05$

Phenology. Days from sowing to emergence were significantly reduced by increased temperature, from 25 days in the normal sowing to 9 and 13 days in the THS and EHS at Tel Hadya to 4 days at Wad Medani. Soil water was not limiting for any of the planting dates at germination time. Table 82 shows values for thermal time and average 5 cm soil temperature in the germination-emergence period. The highest temperature for EHS at Tel Hadya was particularly detrimental to germination and emergence.

Table 82. Days to emergence, thermal time (base temperature = 0°C) and mean soil temperature at 5 cm depth during the sowing-emergence period.

Environment	Days to emergence	°CD	Soil temperature °C
TH Normal	25	172.3	9.6
TH Terminal heat stress	9	101.5	15.1
TH Early heat stress	13	408.0	37.8
Wad Medani	4	123.0	35.4

Table 83 shows the mean duration and range for the development stages GS1, GS2 and GS3 along with the accumulated thermal units base 0°C during the phase. Heat stress shortened the duration of GS1 and GS2 as compared to normal planting in all environments. The duration of GS3 was the same across environments, probably because all sites had some level of heat stress during this period. Similar thermal units were required for GS1 in all environments, except THS which had an abnormally low value. The thermal units required for GS2 were the same in all environments. For GS3 the thermal units increased with increase in mean temperature except for Tel Hadya late heat stress which had a lower number of °CD than expected. Table 84 shows that within the nursery there was a wide range of duration (days) for each developmental phase.

Phenology was also assessed by Zadoks visual score and was highly correlated with the apex development in spite of changes in development rate under heat stress as compared to normal planting (Table 83).

Environmental effects on growth. Plant breeders usually use plant height and peduncle length as indicators of plant growth. Both traits were reduced by heat stress when compared with normal planting, the greatest reduction occurred when early heat stress was predominant at Tel Hadya. Leaf area per plant developed faster under high temperature but maximum leaf area per plant was higher in the normal planting. When the values were expressed on a unit soil surface area (leaf area index, LAI), it was observed that wheat under THS barley covered the soil surface (LAI<3.0) while at Wad Medani the LAI reached a maximum (at anthesis) of about 0.5, a reflection of the planting method. The leaf area density or specific leaf weight (leaf weight per unit area) was significantly higher around anthesis under high temperatures, indicating that expansive growth was affected. Average leaf size was smaller in the heat stressed treatments (15, 11 and 8 cm^2 per leaf for the normal, THS and Wad Medani environments respectively).

Table 83. Mean duration and range of three major wheat development phases as affected by environment. The thermal units (°CD) presented are calculated above a threshold of 0°C.

	Environment									
	Normal		THS		HS		EHS		Wad Medani	
Phase	Days	°CD	Days	°CD	Days	°CD	Days	°CD	Days	°CD
GS1	55.9a	459a	13.9c	185b	22.1b	513a	20.4b	576a	22.2b	56.2a
	(60-52)		(29-10)		(33-12)		(44-8)		(39-12)	
GS2	73.8a	827ab	48.9b	883ab	28.6d	782b	32.4d	893ab	38.5c	938a
	(80-64)		(72-33)		(50-13)		(56-13)		(54-22)	
GS3	28.5a	606c	29.4a	770b	28.8	894a	26.5a	586c	30.5a	748b
	(39-22)		(42-14)		(43-8)		(42-10)		(43-20)	
Crop duration	158.2a	1892	92.2b	1838	79.5c	2189	79.3c	2055	91.2b	2248

Means in a row for a given variable followed by the same letter do not differ at $P < 0.05$.

Phenotypic effects. Genotypes tested had no significant differences in grain yield and total biomass within most environments in spite of differences in yield components, except for early heat stress at Tel Hadya where the grain yield differed at $P<0.01$ and total biomass at $P<0.05$. The differences in harvest index between genotypes were significant ($P<0.01$) in all environments. The mean, range and phenotypic standard deviation of the nursery under study are given for each site in Table 84.

The association between grain yield within environment and the two determinants, grain number per m^2 and mean grain mass is shown in Table 85, the relative contribution to yield of each factor as determined by multiple regression is also given by the % of the total sum of squares reduced.

Genotypes producing high number of kernels per m^2 had smaller and lighter grains while those with high number of spikes per m^2 produced fewer grains per spike an smaller grains. Thus compensation in yield components in all but one environment were translated into lack of significance in grain yield.

Within any given environment the correlation across genotypes between grain weight per plant and GS1, GS2 and GS3 were insignificant, except for Wad Medani where a longer GS2 was positively correlated to grain yield per plant. At Tel Hadya, however at the very late planting (EHS), a long GS2 was negatively correlated to yield.

The analysis will not be pursued further here other than indicating that the highest ratio between the five top and bottom yielding entries in yield components was observed at the EHS environment, and that variability in developmental phases and grain filling rate was best expressed in the HS and EHS environments.

Table 84. Nursery mean, range and phenotypic standard deviation at each environment for grain yield, biological yield and harvest index (n=24).

	Environment							
	TH Normal		THS		EHS		Wad Medani	
	Mean	PSD	Mean	PSD	Mean	PSD	Mean	PSD
Grain Yield g/m^2	356 (280-480)	77	157 (121-196)	37	120 (0.0-219)	45.5	96 (51-151)	43
Biological Yield g/m^2	941 (787-1210)	203	421 (306-545)	95	298 (163-497)	109	396 (280-542)	93
Harvest Index	0.38 (0.34-0.43)	0.02	0.38 (0.32-0.46)	0.04	0.40 (0.0-0.51)	0.05	0.24 (0.12-0.31)	0.06

Table 85. Association between grain yield and its major components (n=24).

Environment	No. kernels/m^2		Mean grain mass	
	r	%	r	%
TH Normal	0.80**	63.6	0.11	35.7
THS	0.82**	67.4	-0.14	28.4
EHS	0.95**	90.5	0.69**	3.7
Wad Medani	0.93**	85.9	-0.08	12.4

** P<0.01

Conclusions

There is no planting date at Tel Hadya that would match the environmental conditions (temperature and day length) presented in the dry lowland tropics of the Sudan. Even though at times temperatures may be similar, day length is significantly longer at Tel Hadya. The genotype x environment interaction is significant for all the planting dates tested. Grain yield was decreased up to about 70% under hot environments. A similarity in grain yield decrease at Tel Hadya and Wad Medani was obtained when the wheat crop was planted during the first half of July at Tel Hadya, i.e. when the crop was exposed to predominantly early heat stress.

- The high reduction in grain yield at the hottest environments was mainly the result of a decrease of grain number per unit area (about 70%). This was associated to a reduction in crop establishment and spikes per unit area were reduced in about 55% Kernels per spikelet was not sensitive to the heat stress environments. Significant genotype x environment interactions were found for the yield components investigated.

- Crop establishment at high temperature had an overriding effect on spikes per unit area. Compensatory increase in tiller number and in spike number per main shoot tiller though present could not overcome the effect of low plant density. Selection for genotypes able to germinate and emerge under heat stress appears desirable, the variability between genotypes in this trait is high.

- The GS1 stage (days from emergence to double ridges) was decreased by 62% while GS2 (days from double ridges to anthesis) was decreased by 55% by heat stress early in the season and heat stress through the growing period. GS3 (anthesis to maturity) was equal for all environments. As a result total crop duration was reduced by 47%. This resulted in decreased growth: plant height, peduncle length, leaf area per plant, leaf area index and increased specific leaf weight. Kernels per spike were affected between 10 and 20% and mean grain mass between 20 and 30%. Significant genotype x environment interactions were present.

- The best environment to select for physiological traits postulated to confer heat tolerance appears to be Tel Hadya early stress (early July planting).

Several researchers contributed to the information in this report. These include graduate students working in the project , Mr. Adil Deifalla, Mr. Pedro Perez-Marco and Mr. Erik van Oosterom; the collaboration of Dr. R.B. Austin and Dr. P.C. Craufurd from PSIR, Cambridge, Prof. J. Siraq from the Gezira University, Sudan and regular staff of the Cereal Physiology/Agronomy Project, Mr. Issam Naji, Mr. Riad Saccal, Mr. Mufid Ajami and Mr. Salem Farrouh.

E. Acevedo

3.2. Pathology

3.2.1. Wheat diseases

The most feasible control measure for wheat diseases in the WANA region is the use of resistant cultivars. The main tool used at the Center to up-grade the resistance level of the developed germplasm is screening for resistance to diseases in sites where high disease pressure prevails, "hot-spots". This helps in discarding susceptible lines and in identifying sources of resistance.

At the principal station, T. Hadya, and sub-station Lattakia, in Syria, techniques and methods are well established for the diseases, yellow rust (Puccinia striiformis), leaf rust (P. recondita), septoria tritici blotch (Mycosphaerella graminicola) and common bunt (Tilletia foetida and T. caries). Additional information on the above diseases are obtained through multilocation testing system, also including the diseases stem rust (P. graminis), tan spot (Pyrenophora- trichostoma-repentis) and powdery mildew (Erysiphe graminis).

Resistant lines to one specific disease precipitating from screening procedures are usually pooled in special purpose disease nurseries, repeatedly tested for 3-4 years and selected for acceptable agronomic characteristics and non-targeted diseases. The seed of such pools is multiplied and distributed for use in crossing programs and by NRPs. For 1988/89 the following pools have been dispatched to NARS: Germpalsm Pool for Yellow Rust Resistance, durum and bread wheat; and Bread Wheat Germplasm Pool for Common Bunt and Yellow Rust Resistance.

Screening for disease resistance

Tables 86 and 87 give an overview of durum and bread wheat germplasm screened for resistance to major wheat diseases in 1987/88. A collection of Triticum sp. from GRU/ICARDA was included in the screening. Other germplasm screened came from collaborative programs with Syria, Algeria, Tunisia and ACSAD; European Leaf Rust Nursery/Yugoslavia; CIMMYT/Mexico; and USDA-ARS.

The highest percentage (70%) of durum germplasm screened was resistant to yellow rust (Table 86). Also high, 49%, was the number of durum lines showing resistance to stem rust. However, this is based on information obtained from one site and needs verification. For septoria 21% of the screened lines showed resistance. Low percentages of resistant lines were observed for powdery mildew, common bunt, and leaf rust: 8%, 8%, and 12%, respectively. More emphasis should be put on up-grading resistance level for these diseases in durum germplasm.

Sixty four percent of bread wheat germplasm screened was resistant to stem rust and powdery mildew (Table 87). Also relatively high was the number of lines resistant to leaf rust and yellow rust. Only 9% of the lines tested were resistant to common bunt and this comes mainly from the Repeat Testing Bunt (RTB) Nursery (39%).

The number of lines selected for special purpose disease nurseries was low (135) in the durum germplasm and reasonable good (236) in bread wheat germplasm. Selection of these lines is based not only on the primary disease but also on their performance to other non-targeted diseases.

Table 86. Screening of durum wheat germplasm for resistance to yellow rust (YR), leaf rust (LR), stem rust (SR), septoria tritici blotch (ST), powdery mildew (PM) and common bunt (CB); 1987-88 season.

Germplasm	Tested	No. of Entries Resistant						Select.
		YR	LR	SR	ST	PM	CB	
Aleppo C.B.	189	140	0	-	10	-	3	0
APCB		(74)	(0)	-	(5)	-	(2)	(0)
Crossing Block	219	96	-	-	-	-	26	7
DCB-HAA		(44)	-	-	-	-	(12)	(3)
Observation Nursery	143	105	-	-	-	-	18	15
DON-HAA		(73)	-	-	-	-	(13)	(11)
Preliminary Disease	114	93	4	-	31*	-	-	2
Nursery PDN		(82)	(4)	-	(27)	-	-	(2)
Key Loc. Disease	160	133*	39*	-	43*	13	10	35
Nursery KLDN		(83)	(24)	-	(27)	(8)	(6)	(22)
Yellow Rust Nursery	81	60	-	-	-	-	-	60
DYR		(74)	-	-	-	-	-	(74)
Leaf Rust Nursery	45	38	14	-	-	-	-	11
DLR		(84)	(31)	-	-	-	-	(24)
Septoria Nursery	45	32	9	22	25*	-	-	5
DST		(71)	(20)	(49)	(56)	-	-	(11)
Entries Total tested		966	553	45	508	160	710	Sel.
Entries Total resistant		697	66	22	109	13	57	135
Entries % resistant		70	12	49	21	8	8	

Resistant: 0-10MR severity and reaction type for rusts;
0-6 score, on 0 -9 scale for septoria and powdery mildew;
0-15% infected heads for common bunt.

( ) = % resistant lines; checks excluded

* : Based on data obtained from multilocation testing.

Table 87. Screening of bread wheat germplasm for resistance to yellow rust (YR), leaf rust (LR), stem rust (SR), septoria tritici blotch (ST), powdery mildew (PM), and common bunt (CB); 1987-88 season.

Germplasm	Tested	No. of Entries Resistant						Sel.
		YR	LR	SR	ST	PM	CB	
Aleppo C. B.	199	80	129	-	27	-	4	17
APCB		(40)	(65)	-	(14)	-	(2)	(8)
Crossing Block	256	138	-	-	-	-	49	16
WCB-HAA		(54)	-	-	-	-	(19)	(6)
Observation Nursery	142	75	-	-	-	-	29	7
WON-HAA		(53)	-	-	-	-	(20)	(5)
Observation Nursery	113	45	-	-	-	-	0	0
WON-LR		(40)	-	-	-	-	(0)	(0)
Observation Nursery	134	50	-	-	-	-	4	4
WON-MR		(37)	-	-	-	-	(3)	(3)
Regional Yield Trial	20	7	-	-	14	-	2	8
RYT-LR		(35)	-	-	(70)	-	(10)	(40)
Regional Yield Trial	20	8	-	-	15	-	1	7
RYT-MR		(40)	-	-	(75)	-	(5)	(35)
Preliminary Disease	309	99	196	-	25*	-	-	25
Nursery PDN		(32)	(63)	-	(8)	-	-	(8)
Key Location Dise.	198	53*	77*	-	78*	130	4	43
Nursery KLDN		(27)	(39)	-	(39)	(66)	(2)	(22)
Yellow Rust Nursery	90	58*	-	-	-	-	-	58
WYR		(64)	-	-	-	-	-	(64)
Leaf Rust Nursery	45	35	42	-	-	-	-	32
WLR		(78)	(93)	-	-	-	-	(71)
Septoria Nursery	45	38	28	29	28*	25	-	12
WST		(84)	(62)	(64)	(62)	(56)	-	(27)
Repeat Testing Bunt	29	23	-	-	-	-	9*	7
RTB		(79)	-	-	-	-	(39)	(24)

		YR	LR	SR	ST	PM	CB	Sel.
Entries	Total tested	1600	796	45	791	243	1111	Sel.
	Total resistant	709	472	29	187	155	102	236
	% resistant	44	59	64	24	64	9	

Resistant : 0-10 MR severity and reaction type for rusts;
0- 6 score, on 0-9 scale for septoria and powdery mildew;
0-15 % infected heads for common bunt.

( ) = % resistant lines; checks excluded

* : Based on data obtained from multilocation testing.

Variability of wild relative, <u>Triticum turgidum</u> var. <u>dicoccoides</u> for major wheat diseases

Collection, characterization and utilization of wild progenitors/relatives of wheat is an important research component in the program. Knowledge on the resistance/susceptibility of these species is of great importance to collector and user. Screening <u>T. dicoccoides</u> for major wheat diseases started in 1986/87 (Cereal Improvement Program; Ann. Report. Page 132, 1987). This season, 200 accessions were screened in the Center's regular disease sites (Table 88). They originated from Jordan (78), Turkey (54), Syria (53) and USDA (15). Results show the great variability of these accessions for common bunt, septoria blotch, yellow rust and leaf rust. Out of the 200 accessions tested, 62, 129, 77, and 32 showed resistance to common bunt, septoria, yellow rust and leaf rust, respectively. Combined resistance to septoria and yellow rust was shown in 67 accessions; to septoria blotch and yellow rust and leaf rust in 22 accessions. Combined resistance to all four diseases was found in 8 accessions. Lines with combined resistance to three and four diseases will be retested the next season.

Table 88. Variability in <u>Triticum dicoccoides</u> for common bunt <u>Tilletia foetida</u> and <u>T. caries</u>), septoria tritici blotch (<u>Mycosphaerella graminicola</u>), yellow rust (<u>Puccinia striiformis</u>), and leaf rust (<u>P. recondita</u>); season 1987/88.

Disease**	No. Accessions *						
	S	MS	MR	R			
Common bunt	81	21	36	62			
Septoria blotch	40	16	15	129	67		
Yellow rust	94	18	11	77		22	8
Leaf rust	151	4	13	32	22		

S = susceptible : rusts > 15% severity; septoria > 6;
common bunt > 15% infected heads.

R = resistant: rusts 0-5% severity; septoria 0-3;
common bunt 0-5% infected heads.

* Total no. accessions tested: 200 (JOR 78, TUR 54, SYR 53, USDA 15)

** Screening sites:
Common bunt and yellow rust in T. Hadya (art. inoculation);
Septoria in Lattakia (art. inoculation)
Leaf rust in Lattakia (nat. infection)

The number of resistant lines according to country of origin is given in Table (89). Excluding the group from USDA, we found the highest percentage (50%) of resistant accessions to common bunt in the Turkish group. The highest percentage of resistant accessions for septoria (77.4%), yellow rust (90.6%) and leaf rust (30.2%) was found in the dicoccoides group from Syria. These findings should be considered in any future collecting expeditions to locate areas of wild relatives and progenitors with genetic variability for wheat disease reaction.

Table 89. Percentage of resistant* Triticum dicoccoides accessions to four major wheat diseases.

Disease	No. and origin of tested accessions				
	Jordan 78	Syria 53	Turkey 54	USDA 15	Total 200
Common bunt	11.5	32.1	50.0	60.0	31.0
Septoria blotch	53.8	77.4	70.4	53.3	64.5
Yellow rust	7.7	90.6	37.4	20.0	38.5
Leaf rust	11.5	30.2	11.1	6.7	16.0

* resistant: 0-5 % severity for rusts
0-3 score, on 0-9 scale, for septoria
0-5 % infected heads for common bunt

Partial infection in common bunt

Common bunt of wheat, as a rule, affects all kernels in the spike. However, some researchers attribute the loss factor as 0.77 or 0.9 of disease incidence. This indicates that not all kernels in one spike are always affected.

In our investigation of the problem, 144 naturally infected bunted spikes collected from different countries of the WANA region and 244 bunted spikes from artificial inoculation collected from the Common Bunt Nursery (I) at T. Hadya, season 1987/88 were used (Table 90). Bunted spikes in both collections are from durum and bread wheat. Results show that not all bunted spikes have all kernels affected by the disease, whether they originate from natural infection or artificial infection. Out of the 144 naturally infected spikes, 102 spikes (70.8%) were completely affected. The remaining 42 spikes (29.2%) exhibited different degrees of infection ranging from 12.1% to 98.4% kernels/spike. In the bunted spike collection originating from artificial inoculation only 123 spikes (50.4%) out of the 244 studied exhibited complete infection. The remaining 121 spikes (49.6%) showed different degree of infection ranging from 2 to 98.2% infected kernels/spike.

These findings have not been yet studied. Whether this phenomenon is a kind of partial resistance for common bunt or simply an environmental influence is not clear and needs further investigation. It is, however, of great importance for the epidemiology and control of the pathogen. Experimental trials are planned for the season 1988/89.

Table 90. Percentage affected kernels/wheat spike by common bunt (Tilletia foetida and T. caries) in 144 naturally and in 244 artificially infected bunted spikes.

Category	% affected kernels/spike					
	<40	40-59	60-79	80-99	100	Total
	Natural infection *					
Range	12.1-35.9	46.5-55	62.5-76.4	82.6-98.4	-	-
Mean	24.1	50.8	69.8	88.2	100	92.5
No. spike	4	2	14	22	102	144
% Spike	2.8	1.4	9.7	15.3	70.8	100
	Artificial infection **					
Range	2-39.3	40-57.1	61.1-78.3	79.4-98.2	-	-
Mean	18.7	50.5	71.5	91.1	100	85.1
No.	20	13	29	59	123	244
% Spike	8.2	5.3	11.9	24.2	50.4	100

* = 144 Collected from Syria (65), Jordan (27), Turkey (20), Lebanon (9), Tunisia (8), Iran (7), Pakistan (6) and Morocco (2)

** = 244 Collected from Common Bunt Nursery I. at T. Hadya, 1987/88

Table 91. The effect of yellow rust (Puccinia striiformis) on grain yield and yield components of different wheat cultivars (Tel Hadya, Syria 1988).

Cultivar	Treatment	YR Score/ACI		Yield kg/ha	No. tiller /m^2	No. Seeds /spike	1000KW (g)
Haurani	Inf	33MR	17.3	3166	347	38	45.3
	Cont	5R	1.0	3632	350	35	39.3
Lahn	Inf	2R	0.5	5780	297	43	53.7
	Cont	1R	0.2	5220	307	41	51.4
Belikh 2	Inf	15MR	4.0	4827	327	37	44.4
	Cont	1R	0.2	5440	383	45	41.5
Hazar	Inf	4MR	1.1	5417	390	38	44.4
	Cont	4R	0.7	4808	370	35	44.4
Om Rabi 9	Inf	8MR	3.3	4771	397	38	39.4
	Cont	2R	0.5	5072	410	37	43.0
Douma 6102	Inf	8MS	5.3	5771	370	43	42.4
	Cont	4R	0.7	5516	350	45	42.4
Douma 6065	Inf	5MS	2.3	5014	343	40	45.6
	Cont	5R	1.0	5525	393	39	45.1
Mexipak	Inf	73S	69.0	3574	353	40	32.1
	Cont	10R	2.0	5048	440	44	34.1
Nesser	Inf	65S	65.0	4425	463	37	30.9
	Cont	2R	0.5	5477	557	35	31.2
Douma 6914	Inf	52MS	34.3	5705	390	40	37.2
	Cont	4R	0.7	5607	450	42	37.2
LSD (0.05) between treatments for the same cultivars				*913*	*103n.s*	*6.9n.s*	*7.9n.s*

Figures = mean of 3 rep., each 6.3 m2; harvested 3.6 m^2
Experimental design = split plot (treatments as main plot factor)
Infected = artificial inoculation applied once
Controlled = Bayfidan EC 250 (Triadimenol) 2 L/ha applied twice

Crop-loss assessment

A trial to assess crop-loss induced by yellow rust of wheat was conducted in the 1987/88 season for the first time at Tel Hadya, Syria. Ten promising lines of wheat, 7 durum and 3 bread wheat, were tested using a chemical treatment (Bayfidan EC 250, Triadimenol 2 L/ha) to keep control plots free of the disease (Table 91). The objective of this trial was to determine the actual losses in each cultivar, since yield in wheat cultivars is affected differently even at the same level of yellow rust infection.

Analysis of variance revealed significant cultivar effects on all traits and significant treatment effects (infected vers controlled) and cultivar x treatment interaction on grain yield only. The susceptible cultivar Mexipak suffered 29% loss in grain yield due to the disease. This yield decrease may be the result of reduced number of tillers/m^2 (21%), seed/spike (9%) and kernel weight (6%) though decreases were not statistically significant. Nesser, also a susceptible cultivar, suffered a 19% loss from a lower degree of infection. Haurani, Belikh, Douma 6102, and Douma 6914, seemed to tolerate the disease differently as indicated by their Average Coefficient of Infection (ACI) of 17.3, 4.0, 5.3 and 34.3, respectively. The remaining cultivars, Lahn, Hazar, Om Rabi, Douma 6056 were found to be resistant with ACI<4.

Although results are preliminary, they clearly indicate that yellow rust can drastically affect yield in susceptible cultivars.

O.F. Mamluk

3.2.2. Barley pathology

Cooperation in the region

Collaboration with National Agricultural Research Systems (NARSs) can substantially aid studies on disease resistance as virulence genes of pathogens may change from one region to the other. A number of joint projects with pathologists in the region are established; ranging from an interchange of nurseries for field screening to the identification of differences in virulence between pathogen strains in different countries, and training. In this year's report two research activities are highlighted.

Field screening of breeding material

The testing of ICARDA's nurseries in 'hot spots' for different diseases in and outside the region is the most established of the collaborative activities and has helped the breeding program through the years selecting lines with adequate resistance to major diseases. National program scientists each year screen all lines of ICARDA's Advanced Yield Trials through the Key Location Disease Nursery. The results of this nursery are discussed in the barley breeding section of this report. In return, ICARDA, on request of National Programs, screens their material for resistance in the disease nurseries at Tel Hadya. Table 92 summarizes tests of 237 lines from 5 different countries for 3 diseases during 1987-88 season.

Table 92. Level of resistance to 3 diseases of material from 5 barley improvement programs in different countries[a)]

Country	Scald			Pow. Mild.			Cov. smut			total
	R	MR	S	R	MR	S	R	MR	S[b)]	
Syria[c)]	29	72	0	-	-	-	81	18	1	192
Ethiopia	50	50	0	23	69	8	18	39	43	28
Algeria	29	43	28	43	43	14	0	86	14	7
Turkey	33	60	7	22	52	26	27	45	28	180
Morocco	14	57	29	57	43	0	71	29	0	7
USSR	13	47	40	53	20	27	73	20	7	14

a) Data are percentages of the total number of lines in each of three categories.

b) R = <5%, MR = 5-25%, S = >25% diseased leaf area (scald and powdery mildew) or affected plants (covered smut).

c) Syrian material was sowed two weeks later, resulting in a lower scald and little powdery mildew development.

Screening for resistance to Barley Leaf Stripe

Barley leaf stripe (caused by *Pyrenophora graminea*) is a seed-borne disease requiring special efforts in resistance screening. In last year's report we described a seedling test enabling testing lines in the greenhouse or growth chamber. As the environment plays a large role, not only on the infection by the pathogen during seed formation, but as well on the expression of the disease in the plant during the following season, seedling tests alone are not sufficient to classify lines as susceptible or resistant. Presently we are collaborating with the Ecole Nationale d'Agriculture in Meknes (Dr M. Boulif), while the University of Aleppo (Dr A. el Ahmed) is involved in screening at Tel Hadya. In both locations the same set of advanced breeding lines was planted after artificial inoculation with local strains of the pathogen. Data from both locations were obtained on a total of 145 lines. In Tel Hadya the average percentage of stripe affected plants was 67%, in Meknes the average was 48%. A highly significant correlation (r=0.30) was found between results obtained in Syria and those in Morocco. In Table 93 lines are listed that showed a low level of disease in both locations. In addition results from a seedling test, carried out with the same mono-spore isolate used in the field screening at Tel Hadya, are given.

Table 93. Lines showing a low level of disease after artificial seed inoculation by barley leaf stripe in field testing in Tel Hadya, Syria and Meknes, Morocco.[a]

Name	Field testing		Seedling[b] test
	Tel Hadya	Meknes	
WI 2269	0	0	20
Moroc 9-75	0	0	23
Porthos (B)	0	0	60
Harmal	0	2	100
Kantara	0	2	100
Harmal-02	0	4	45
Alger/Ceres,362-1-1	0	6	0
Quin	0	6	90

a) Data are percentages of barley leaf stripe affected plants.
b) Seedling test carried out in plant growth chamber, Tel Hadya.

Although there was a significant correlation between the results of the field tests both in Tel Hadya and Meknes and the seedling test (r=0.30 and 0.14, resp.), some lines showed a far higher susceptibility in the seedling test than in the field. An explanation for this could be that in certain early varieties, like Harmal and Kantara, the mycelium growth in the plant is slower than the development of the growing point. Seed of low and moderately stripe affected lines has been harvested and will be sown during the coming season to check the natural infestation of this pathogen.

Screening for scald resistance

The two most important leaf diseases of barley are probably scald, caused by the fungus Rhynchosporium secalis, and powdery mildew. The first disease has a slightly lower optimum temperature than the second and is therefore of greater importance in regions with a continental climate like the barley growing areas of West Asia and those in the higher altitudes. Together with the Helminthosporium leaf blotches, scald is as well the predominant pathogen of the tropical highlands in East Africa. Powdery mildew becomes more important in the regions with milder winters like North Africa. Although both diseases are favoured by a high humidity, high disease levels can frequently be recorded in the dry areas. The development of scald depends strongly on management practices, earlier sowing and fertilizer application favouring the disease. Intensification of the cultivation of barley will also result in more scald as the pathogen survives on the stubble of the previous year's crop.

Resistance breeding is the most feasible way of controlling the disease. All newly developed material and all lines used in ICARDA's crossing program pass through the scald screening nurseries at the base program. Through the years we have improved our screening methods. The presently used methodology allows a reliable estimation of the level of resistance to the local Syrian pathogen strains we use to inoculate our screening nurseries.

Although numerous sources for resistance are available, progress in resistance breeding is hampered by the notorious variability of Rhynchosporium secalis. Before being used in crosses, potential parental material must be tested against as many different scald strains as possible. One way of doing so is by sending material to different countries, to be tested in locations where heavy development of the disease occurs naturally. However, disease development in the field can vary strongly between years. The environment as well has a strong influence on the expression of the disease, while the occurrence of other, non-target, diseases can mask the presence of resistance. To overcome these complications a seedling screening technique was developed that shows a reasonable affinity with the performance under natural epidemics of scald (see last year's report). The technique was further improved during the past year and is capable not only of detecting high levels of resistance, but can as well differentiate between moderate levels of resistance. As the testing is done in growth chambers, and plants are destroyed by autoclaving after readings are taken, foreign isolates can be included in these tests. Table 94 shows the results of a comparison of eight scald strains, four isolated from cultivars grown in the disease nurseries at Tel Hadya, four isolated from the same cultivars in a disease nursery at Beja, Tunisia. Two of the cultivars were rated as highly resistant in Syria, one as moderately resistant and one as susceptible. The strains were tested against the same cultivars from which they were isolated and on four more lines with a different level of resistance.

The results clearly show the danger of selecting genotypes in a single location; the cultivars 'Atlas 46', 'Gaines/Oregano' and 'Alger/Ceres' (the last one being of Tunisian origin) are highly resistant to Syrian strains but susceptible to the Tunisian strains. Interesting is the performance of the two Syrian landrace-lines 'Tadmor' and 'Arta': both lines are moderately-resistant in Syria, and showed the same resistance to the Tunisian isolates. Also the moderately susceptible Jordanian cultivar 'Deir Alla 106' showed little variation in its performance. 'WI2291 and 'JLB 6-35' (a Jordanian landrace-line) were highly susceptible to all scald strains tested. Differences among pathogen strains within a location exist, but a specialization on specific cultivars could not be shown within the material tested.

Table 94. Response of eight cultivars to eight mono-spore isolates[a] originating from four different cultivars, grown in Tel Hadya, Syria and Beja, Tunisia.

	Isolate origin: Country / Cultivar								
	Syria				Tunisia				
Cultivar	Gn/Or	As46	D106	WI..	Gn/Or	As46	D106	WI..	Mean
Gaines/Ore	0a[b]	0a	0a	0a	100f	100f	33bc	95f	41B[c]
Atlas 46	0a	5a	10a	0a	100f	100f	55cd	55cd	41B
Deir Alla 106	55cd	35c	36c	55cd	50cd	80ef	69de	61de	55C
WI 2291	100f	95f	85ef	95f	90f	90f	95f	100f	94D
Tadmor	20a	0a	5a	39bc	6a	16a	21ab	0a	13A
Arta	15a	20ac	18ac	24b	5a	18a	20ab	15a	17A
Alger/Ceres	5a	6a	5a	0a	85f	95f	100f	85f	48BC
JLB 6-35	100f	90ef	73e	92ef	100f	100f	100f	100f	94D
Isolate mean	37A[d]	31A	29A	38A	67BC	75C	62B	64B	

LSD values ($p=0.05$): between isolates; 9.5
between cultivars; 8.0
between cultivars for a given isolate; 22.6
between isolates for a given cultivar; 23.2

a) Percentage of scald affected plants 19 days after inoculation by single drop of 10^5 sp/ml per plant, data are means of 4 replicates, each replicate having 5 plants.
b) Means followed by the same letter in each row and each column are not significantly different (LSD test, $p=0.05$).
c) Cultivar means followed by the same capital letter are not significantly different (LSD test, $p=0.05$).
d) Isolate means followed by the same capital letter are not significantly different (LSD test, $p=0.05$).

The same type of test, using the most virulent of the Syrian and Tunisian isolates was used for screening breeding material under advanced yield testing and being considered for inclusion in the international nurseries of the coming season. A number of lines were identified with adequate resistance to both strains.

Crop loss studies

Our research in past years has focused on the development of fast and reliable methods to quantify differences between cultivars in disease resistance. Differences in resistance will lead to differences in severity of disease under farming conditions and, depending on the timing of pathogen development and on the conditions of the host plant, to differences in production. Rarely does newly developed germplasm have complete resistance to all the pathogens that can affect the plant. The decision to recommend a new line for release must therefore not only be based on the expected gain in production, but as well on the vulnerability of the genotype to losses caused by pests and diseases. Special concern is justified when resistance screening has shown that the new line is more susceptible to a disease as the cultivar it is expected to replace.

During the past season we studied the effect of scald on yield and yield components of ten cultivars grown in ICARDA's main station at Tel Hadya. Six of these lines were advanced breeding lines while the remaining were landrace-lines, all selected for their different reaction to this disease. The experiment was planted in a split-plot design with two main treatments (inoculation versus fungicide-spray), cultivars in sub-plots and three replications. Each subplot consisted of 6 rows of 3.5 m. An inoculation was carried out twice with local scald strains, multiplied on artificial media. After the inoculations the plots were covered by plastic to ensure adequate moisture for spore penetration. The non-inoculated plots were twice sprayed with Bayfidan, a fungicide highly effective against both scald and powdery mildew. The percentage of disease-affected leaf tissue was estimated about two weeks before harvest. To avoid border effects 0.25 m was cut from the side of the plots before harvesting the four center rows.

Two yield parameters were measured: grain weight and thousand kernel weight (Table 95). A significant yield reduction was found for four varieties; three susceptible cultivars; 'SLB 37-74', 'WI2291' and 'Faiz', and one moderate susceptible line 'SLB 39-60'. The yield of the susceptible cultivar Harmal was not affected by the disease. Also the moderately susceptible cultivar 'Deir Alla 106' did not show a significant yield reduction. The 20% yield reduction caused by heavy powdery mildew development on the two landrace-lines 'Tadmor' and 'SLB 56-79' was not significant in this experiment. However, a single spray of the systemic fungicide Bayleton in late February on large seed increase plots of 'Tadmor'(2 plots of 500 m^2 each), resulted in a highly significant yield gain of the same magnitude as in the experiment (183.5 vs 153 kg/plot).

The disease levels measured in this experiment were comparable to those observed in non-inoculated plots of scald susceptible cultivars in yield trials in ICARDA's experimental stations and in the Farmers' Field Verification Trials. However, these levels are rarely found in commercial fields sown with local cultivars. Studies on the resistance structure of local Syrian germplasm (see as well this reports' previous section) have shown that scald resistant genotypes occur with a high frequency within landrace populations. Moreover, the high degree of heterogeneity within the landraces will have a positive effect on slowing down disease epidemics and might act against the development of highly virulent strains. Replacement of these heterogeneous mixtures by pure lines without adequate resistance, either 'improved' breeding material or selections from landraces might result in substantial losses due to scald and other pathogens.

Table 95. Comparison of 10 cultivars between disease-free plots and plots affected by scald and/or powdery mildew.

Cultivar	% scald	Yield			1000 kernel weight a)		
		-	+	%	-	+	%
Lignee 131	0	51	47	92	45	45	100
Tadmor	0 b)	42	35	83	37	32	86 c)
SLB 56-79	0 b)	39	31	79	36	33	92
Rihane-03	16	49	56	114	44	46	105
SLB 39-60	43	49	36	73 c)	48	40	83 c)
Deir Alla 106	52	45	39	87	39	36	92
Harmal	75	45	47	104	47	43	91
SLB 37-74	77	42	30	71 c)	48	40	83 c)
WI2291	78	54	36	67 c)	41	38	93
Faiz	80	60	45	75 c)	46	41	89 c)
LSD (5%)							
between treat. for a given cult.			10.1			4.3	
between cult. for a given treat.			9.0			4.4	

a) Percentage scald: Percentage leaf area affected by scald averaged over the tree inoculated plots.
Yield: x 100kg/ha.
1000 kernel weight: grams.
-: sprayed with fungicide, not inoculated.
+: inoculated with scald, not sprayed with fungicide.
%: percentage of sprayed as compared to inoculated.

b) The cultivars Tadmor and SLB 56-79 showed an average of resp. 60% and 67% leaf area affected by powdery mildew in the plots not sprayed with fungicide.

c) Cultivars with significant difference between the two treatments.

It is planned to extend our studies on crop losses during the coming season. Our objectives will be not only to test differences in genotypes in their response to diseases, but as well to gain a better understanding of the influence of changing agronomic practices and abiotic stresses on losses caused by diseases. Similar experiments will therefore be planted in two sites, one with a favorable environment and one where drought stress is expected to occur, using two different sowing dates.

Root rot studies

Dry-land root rot can be caused by both Cochliobolus sativus and by Fusarium sp.. Both fungi are supposed to be 'weak' pathogens, having little competition power and little infection-power in normal conditions. However, the disease can be severe in dry areas, most probably because of decreased activity of other micro-flora in the soil and because of the poor condition of the host plant. The pathogens attack all root parts, but the most conspicuous is the discoloration of the sub-crown internode. In serious cases this part of the plant can be severely damaged, resulting in a decrease of the water flow from the seminal roots to the plant. Deep sowing, a practice recommended for the drier zones, favors the infection of the sub-crown internode by these fungi.

In order to study the importance of root rots in different environments and to develop rapid varietal screening techniques it is useful to have varieties with contrasting levels of resistance and adapted to the environment in which our experiments are conducted. As we did not have information about differences in resistance to root rots within ICARDA's barley germplasm pool so far, a field survey of a selected number of lines from the breeding project was undertaken. Two sets each of 25 lines of the Advanced Yield Trial were chosen. One consisted of lines selected for their earliness and in the second a number of landrace lines were present. Both sets were grown in the experimental station at Breda, Syria, where previous sampling had shown a relatively high occurrence of root rots. Each set of 25 entries (20 entries under testing and five check varieties) was planted in a lattice design with two replications. Each plot consisted of 6 six rows of 5 m long, seeded by Oyjord experimental planter with a row distance of 30 cm and a seed-rate of 120 kg/ha. The land on which the experiments were grown was kept fallow during the 1986/87 season, and received a fertilizer application of 20 kg N and 40 kg P_2O_5 before the seeding in November 1987.

On May 5, when most lines were in DC 87-91 the two border rows in each plot were uprooted and a minimum of 50 plants with a sub-crown internode of at least 1 cm were taken. The sub-crown internode was cut off by scissors, taken to the laboratory and scored on the extent of its discoloration according to the scale used by Grey and Mathre (1988), 0 = no discoloration, 1 = pinpoint lesions, 2 = extended linear lesions; 4 = more than 50% of the sub crown internode discolored. Analysis of the results showed a significant difference among entries for both sets. The most susceptible lines rated 8-9 times as high as the least affected, a difference in rating which is far larger than reported in similar studies in North America. Isolations from the sub-crown internodes, made by Mr W. Grey (Montana State University), showed Cochliobolus sativus to be predominant and Fusarium sp. to be far less frequent.

Table 96. Mean ratings for root rot infection measured by discoloration of the sub-crown internode (0-4 scale) in un-inoculated field plots and in inoculated growth chamber experiments.

Variety	Field	Growth chamber		
		Exp 1	Exp 2	Mean
Tadmor	-	0.3	0.1	0.2a[a)]
Arizona 5908/Aths//Lignee 640 ICB81-0210-1AP-4AP-0AP	0.9	0.9	0.9	0.9ab
Arabi aswad	1.6	1.3	0.7	1.0ab
SLB 39-60	1.0	1.3	1.7	1.5abc
ER/Apm//Belle/Maf102 ICB82-1367-0SH-2AP-0AP	0.9	1.8	1.6	1.7bc
Sawsan/Lignee 527//Arar ICB82-0076-1AP-3AP-0AP	2.9	2.7	0.7	1.7bc
Kervana/Mazurka ICB77-0369-4AP-1AP-0AP	-	3.1	1.3	2.2bc
JLB 6-38	2.1	2.7	2.5	2.6c
MEAN		1.8	1.2	1.5

a) Mean rating averaged over two growth chamber experiments, means followed by the same letter are not significantly different (p=0.05).

As a large sample size is needed in field testing because of the strong influence of the conditions of plant and soil on the development of the disease, this type of testing is not suitable for screening a large number of entries. We have tried to confirm the results obtained in the field test by using a seedling test, carried out under controlled environmental conditions. This test, developed by our collaborators of Montana State University, was modified to give fast results in a short time. Eight cultivars were selected for the seedling test, 6 of which showed a contrasting performance in the field survey, while 2 were selected from preliminary experiments. Although a large difference was noted between two successive seedling tests, a distinction could be made between highly resistant and highly susceptible lines (Table 96). The local Syrian cultivar for the drier areas, 'Arabi aswad', is among the more resistant entries. It is tempting to relate this resistance to the low incidence of root rot found in Syria. The landrace-line 'Tadmor', a selection from a black seeded population has a very high resistance, while a number of improved lines and the Jordanian landrace-line 'JLB 6-38' gave a susceptible reaction.

The differences in resistance found in ICARDA's germplasm pool and the changes in farming practices in West Asia, which are expected to promote the development of root rots, justifies an increase of research efforts on these pathogens. A number of experiments are planned for the coming season to measure the impact of root rot on yield in different environments, as well as research on varietal differences in resistance to root rot.

J.A.G. van Leur

3.3. Entomology

Introduction

The Cereal Program Entomology Project seeks to develop the research capabilities of national program scientists in countries falling within the ICARDA mandate, conduct research beyond the present capabilities of the national programs, and train technicians, scientists, and students in current entomological techniques and theory. A summary of current projects is contained in Table 97.

Table 97. Cereal Program entomology projects during 1987/88.

Project/Description	Location
Wheat Stem Sawflies	
1. Resistance screening-to identify resistant germplasm for breeders.	Tel Hadya, SYRIA
2. Factors affecting sawfly resistance in wheat (with Tischrin University)	Tel Hadya, SYRIA
3. Chemical analysis of WSS resistant plants (with Canadian Grain Commission) -to identify chemicals playing a role in WSS resistance.	Tel Hadya, SYRIA
4. Field trials of resistant lines -to field test materials from caged screening trials.	SYRIA, MOROCCO
Sunn Pest	
1. Resistance screening-to identify sources of sunn pest resistance in wheat	Azaz, SYRIA
Hessian fly	
1. Resistance screening-to identify and verify sources of HF resistance in wheat and barley (with INRA/MIAC)	MOROCCO
2. Biotype identification-to identify HF biotypes in the region using the Uniform Hessian Fly Nursery (with INRA/MIAC)	MOROCCO, ALGERIA, TUNISIA, SYRIA, TURKEY, LEBANON
Aphids	
1. Resistance screening-to identify and verify sources of resistance in wheat and barley (with national programs of Egypt, Sudan, Ethiopia)	EGYPT, SUDAN, ETHIOPIA
Ground Pearls (*Porphyrophora tritici*)	
1. Biological studies-to describe the life cycle ecology of *P. tritici* (with FRMP)	Bouider, SYRIA
2. Effects of crop rotation-to examine the effects on *P. tritici* populations of using a barley-vetch-fallow rotation (with FRMP)	Bouider, SYRIA

The development of networks between countries sharing common insect pest problems constitutes the foundation for many of the entomology project's activities. Insects identified for work by each subregional network constitute a major economic threat to stable cereal production in each of the countries involved. ICARDA seeks to facilitate cooperative efforts between participating countries and to provide international contacts as needed by the respective project to insure the flow of new technologies from more advanced countries to those less developed. The participating countries and ICARDA form a partnership dedicated to utilizing all economically and technically feasible pest management techniques in an integrated effort to reduce pest depredations. This report will deal primarily with those insect problems researched in 1987/88 at research stations in northern Syria (sawflies, sunn pest, ground pearls), Egypt, Ethiopia, and Sudan (aphids), and in North Africa (Hessian fly).

Wheat Stem Sawfly

About 270 lines each of barley, bread wheat, and durum wheat were screened under cages at Tel Hadya in replicated trials. Identical trials were planted in a sawfly "hotspot" 7 km southeast of Tel Hadya. Because of the unexpectedly high natural population of sawflies throughout northern Syria in 1987/88 an additional 827 durum, 1185 bread wheat, and 1800 barley lines were evaluated for susceptibility to WSS by the Cereal Program's Pathology Unit. Similarly, the Durum Germplasm Evaluation team rated another 3584 durum lines for WSS. While none of the lines rated by the Pathology Unit proved resistant, 90 lines were recommended by the Durum Evaluation team for inclusion in caged WSS screenings in 1988/89. Most of these lines evidenced some degree of pith accumulation in the stem, suggesting the importance of solid stems in imparting resistance to WSS in wheat. Barley, durum, and bread wheat lines that performed well in screening trials in 1986/87 and 1987/88 are shown in Table 98. Because of the high 1987/88 WSS populations in uncaged areas, only those lines exhibiting less than 10% infestation rates when data from caged and uncaged trials were pooled were selected. Arabi Aswad (barley), Mexipak (bread wheat), and Haurani (durum wheat) checks were all highly infested and not included in Table 98. Regressions of percent WSS infestation onto percent mean stem solidness were significant for both durum and bread wheat, although more variation in infestation was noted in plants with stem solidness indices near 60%.

This trend was repeated in the study testing the effects of plant spacing on WSS resistance and may indicated factors other than stem solidness in durum wheat that play a role in WSS resistance. In this study WSS infestation was significantly related to the distance between plants rather than to the performance of the respective varieties in previous resistance trials (Table 99).

Table 98. Promising barley, durum wheat, and bread wheat lines screened for wheat stem sawfly resistance in 1986/87 and 1987/88.

Name	Pedigree	Soure	No.	% Infestation 1987	% Infestation 1988
Barley					
FB73-075	-	BAB85	(14)	0.83	2.08
Durum Wheat					
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-0AP	DCB87	(37)	0.83	5.00
Bit/Creso	CD34346-2TR-2AP-1AP-0AP	DCB87	(11)	1.25	7.92
A63040/Sty//Lds/3/Win/4/Erp/Ruso	CD35072-C-5Y-1M-0Y	DCB87	(123)	0.83	8.33
Can2101/Magh//Stk/3/Wlls 65150	CD15111-3S-2AP-2AP-3AP-0AP	DCB87	(19)	0.83	8.75
Bit/Creso	CD34346-2TR-2AP-1AP-0AP	DCB87	(20)	0.83	9.58
D-2/Bit	CD20796-4AP-6AP-2AP-0AP	DAT87	(116)	1.66	9.58
21563/Jo//D.dwarfS15/Cr	L0414-3L-1AP-1AP-4AP-0AP	DAT87	(608)	1.66	10.00
Bread Wheat					
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-1Y-1B-0Y	WCB87	(72)	2.91	5.00
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-2Y-2B-0Y	WCB87	(71)	0.83	5.42
Rmn F12-71/Jup//S	CWM76 584-01H-1H-1S-05	WOL86	(89)	4.58	7.08
Y50E/Kal*3//Rg'S'/Soty 3Sx/Wc/4/Hork	CM39867-2S-1AP-0AP-3AP-2AP-2AP-0AP	WCB87	(159)	5.41	7.50
Rbs/Ti Resel	SWM4781-2S-3AP-0AP-1AP-0AP	WCB87	(43)	5.00	8.75
Gll/Ti/3/Kvz//Kal/Bb/4/Kal/3/Cno/Chr//On	CM54580-3AP-1AP-2AP-0AP	WCB87	(33)	3.75	8.75
Bol'S'/Pvn'S'	CM58696-5AP-2AP-1AP-1AP-0AP	WON87	(42)	2.91	10.00

Table 99. Sawfly infestation rates of durum wheat and bread wheat screened under natural infestations (N) and under cages (C) at Tel Hadya during 1987/88.

Durum Wheat

Variety	Plant Spacing	
	Wide spaced	Closed spaced
Resistant[1]	2.3 N	14.4 N
	0.0 C	2.2 C
Non Resistant[2]	2.4 N	38.8 N
	0.6 C	34.4 C

Bread Wheat

Variety	Plant Spacing	
	Wide spaced	Closed spaced
Resistant[3]	1.1 N	8.3 N
	1.0 C	5.0 C
Non Resistant[4]	1.1 N	16.7 N
	3.0 C	17.2 C

1) Fta/W71//Imuris; CMH80A-276-1B-2Y-1B-2Y-2B-0Y; WCB87(78)
2) Mexipak
3) Po; 19539-D-1Y-1AP-0AP; DAT 87 (802)
4) Haurani

As shown in previous work (ICARDA Cereal Program Report-1986/87), stem solidness also increased in plants spaced 40 cm apart and decreased when spaced 3 cm apart (Table 100). Similarly, Zadoks development (Table 101) and plant height (Table 102) varied with plant spacing, with wide spaced plants developing slower and not growing as tall as close spaced plants. These results corroborate previous conclusions that different sowing rates, which result in different stand densities in the field, may negate the effect of solid stem resistance to WSS. Further studies will be conducted to examine the role of drought stress in affecting stem solidness, and to see if lines with partial stem solidness are affected to the same degree as completely solid stem varieties.

A senior thesis project conducted by several students in agriculture at the University of Aleppo, with ICARDA assistance, revealed that wild grasses surrounding farmer's cereal fields may provide significant numbers of sawflies. They observed infestations of 22% in wild grasses in Idlib Province as compared to 30% in barley, 25% in Mexipak wheat, and 14% in Haurani wheat. This suggests that sanitation of field borders may be important in an integrated management program for WSS. These students also collected Hymenoptera emerging form stubble collected for the caged WSS screenings. Identification by the British Museum of Natural History (Table 103).

Table 100. Mean stem solidness of durum wheat and bread wheat entries screened under natural infestations (N) and under cages (C) at Tel Hadya during 1987/88.

Durum Wheat

	Variety	Plant Spacing	
		Wide spaced	Closed spaced
	Resistant[1]	98.2 N	57.2 N
		94.3 C	57.3 C
Variety			
	Non Resistant[2]	85.1 N	46.5 N
		87.2 C	45.2 C

Bread Wheat

Variety	Plant Spacing	
	Wide spaced	Closed spaced
Resistant[3]	97.2 N	76.5 N
	84.6 C	66.5 C
Non Resistant[4]	96.9 N	66.8 N
	97.8 C	55.7 C

1) Fta/W7//Imuris; CMH80A-276-1B-2Y-1B-2Y-2B-0Y; WCB 87 (78);
2) Mexipak; 3) Po; 19539-D-1Y-1AP-0AP; DAT 87 (802); 4) Haurani

Table 101. Zadoks development of durum wheat and bread wheat screened under natural infestations (N) and under cages (C) at Tel Hadya during 1987/88. Julian dates of measurements given.

Durum Wheat

Variety	Plant Spacing					
	Wide spaced			Close spaced		
	JD114	JD145	JD160+	JD114	JD145	JD160+
Resistant[1]	44 N	71 N	96 N	50 N	73 N	99 N
	47 C	71 C	99 C	56 C	75 C	99 C
Non Resistant[2]	46 N	72 N	98 N	57 N	79 N	99 N
	45 C	72 C	99 C	58 C	75 C	99 C

Bread Wheat

Variety	Plant Spacing					
	Wide spaced			Closed spaced		
	JD114	JD145	JD160+	JD114	JD145	JD160+
Resistant[3]	38 N	72 N	99 N	69 N	87 N	99 N
	45 C	73 C	99 C	67 C	91 C	99 C
Non Resistant[4]	50 N	70 N	99 N	58 N	82 N	99 N
	45 C	44 C	99 C	57 C	87 C	99 C

1) Fta/W71//Imuris; CMH80A-276-1B-2Y-1B-2Y-1B-2Y-2B-0Y; WCB 87(78)
2) Mexipak; 3) Po; 19539-D-1Y-1AP-0AP; DAT 87(802); 4) Haurani

Table 102. Plant height of durum wheat and bread wheat screened under natural infestations (N) and under cages (C) at Tel Hadya during 1987/88.

Durum Wheat

Variety	Plant Spacing	
	Wide spaced	Closed spaced
Resistant[1]	83.4 N	92.6 N
	92.2 C	96.4 C
Non Resistant[2]	84.4 N	125.0 N
	112.6 C	132.5 C

Bread Wheat

Variety	Plant Spacing	
	Wide spaced	Closed spaced
Resistant[3]	63.5 N	86.4 N
	73.8 C	88.2 C
Non Resistant[4]	69.9 N	85.4 N
	83.3 C	82.5 C

1) Fta/W71//Imuris; CMH80A-276-1B-2Y-1B-2Y-2B-0Y; WCB 87(78)
2) Mexipak
3) Po; 19539-D-1Y-1AP-0AP; DAT 87(802)
4) Haurani

provides a more accurate picture of the sawfly species composition of northern Syria, and also indicates that naturally occurring WSS parasites may play an important role in regulating WSS populations.

Counts of ichnuemonid and braconid parasites from collected stubble indicate that Collyria spp. may parasitize 17% of WSS, while Bracon terebella accounts for 5% parasitism. Counts of the sawflies inserted into the cages in 1988 reveal that Cephus pygameus comprised 85% of the 9864 WSS used in the caged screenings, with Trachelus judaicus providing 15%.

Sunn Pest

Six hundred wheat lines were screened for sunn pest, Eurygaster integriceps (Scutelleridae), near Azaz in northern Syria. Lines selected for retesting next season experienced less than 3% infestation (Table 104). Little correlation was found between percent sunn pest infestation and kernel damage ratings, the latter of which will no longer be used to make selections. The check lines Mexipak and Haurani had infestation rates of 15% and 8% respectively.

Table 103. Hymenoptera from 1987 Tel Hadya collections identified by British Museum of Natural History.

CEPHIDAE (Sawflies)
Cephus pygmaeus L.
Trachelus libanensis Andre
Trachelus judaicus Konow
Trachelus spp.
Calamenta idolon Rossi
ICHNEUMONIDAE (Sawfly parasitoid)
Collyria coxator Villers
Collyria orientator Aubert
BRACONIDAE (Sawfly parasitoid)
Bracon terebella Wesmael

Aphids

As in past years, nurseries assembled at ICARDA were screened against Schizaphis graminum and Rhopalosiphum padi in laboratory trials in Egypt and in field trials in Sudan. Lines derived from crosses between commercial Egyptian varieties and Bushland/Amigo derivatives showed S. graminum resistance in the laboratory but were heavily infested by S. graminum in the third of three scoring periods in field tests in Sudan late in the season. However, they had remained relatively free of aphids during the previous two scoring episodes earlier in the growing season, suggesting that they may indeed carry resistance to Sudanese aphids but cannot cope with the extremely high populations normally encountered near the end of Sudan's winter cereal season. The incorporation of these resistance genes into backgrounds suitable for the unique conditions of the Sudan, may prove effective in maintaining aphid populations at subeconomic levels if used in an integrated management program with other pest control strategies.

Four lines of Hordeum vulgare spp. spontaneum (Hordeum spontaneum) were found resistant to S. graminum, and 2 different H. spontaneum lines were resistant to R. padi. This is the first instance of any barleys tested in the aphid screening program showing aphid resistance. These results are being verified. Additionally, a collection of wild barleys obtained from Sweden was increased at Tel Hadya and is scheduled to be screened for aphid resistance in Egypt in 1988/89.

The Russian wheat aphid, Diuraphis noxia, reportedly caused 41% to 71% crop losses in high elevation barley in Ethiopia according to results from small plot studies conducted by Ethiopian entomologists. A number of natural predators and a fungal disease of D. noxia have been described. Linkages are now being established between the Ethiopian national program and ICARDA, and the Nile Valley aphid network to

Table 104. Promising bread wheat and durum wheat lines screened under natural infestations of *E. integriceps* at two sites in northern Syria in 1987/88.

Name	Pedigree	Source	No	% INF 1	% INF 2	Grade 1	Grade 2
Ahgaf		WCB8	(2)	1	3	1	2
Nkt'S'	CM40454-33Y-4Y-1M-0Y	WCB87	(11)	3	2	1	1
Ww33/Vee'S'	SWM11619-12AP-7AP-1AP-0AP	WCB87	(18)	1	3	1	2
Prl'S'	CM25988-8Y-3Y-2Y-1M-1Y-0B	WCB87	(36)	1	3	2	1
Mtl'S'	CM47634-I-2M-3Y-1M-2Y-1Y-2M-0Y	WAC87	(68)	3	2	1	2
II58-57/4/Maya74'S'/ Ogn/3/Cc/Inia/Cal	CM40742-27M-1Y-2M-3Y-3M-1Y-0B	WCB87	(91)	2	3	2	2
Pvn'S'/Pam'S'	CM61832-1Y-2M-4Y-1M-0Y	WAC87	(91)	1	3	2	1
Wa476/3/391//56D-81-14-53/ 1015.6410/4/W22/5/Ana	SWM6525-1AP-0AP-1K-0AP	WRT86	(21)	3	3	1	1
F//68.44/Nzt/3/Cuc'S'	SWM6637-2AP-0AP-3AP-1AP-3AP-0AP	WOL86	(35)	1	1	1	2
Cham 1	CM17904-B-3M-1Y-0SK-0AP	DAB87	(161)	2	3	1	3
Sabil 1	ICD79-I437-25AP-1AP-0AP	DCB87	(80)	3	3	2	1
Om Rabi 6	L0589-3L-1AP-2AP-1AP-0SH	DAT87	(713)	2	3	2	2
Gallareta	CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y	DAT87	(923)	2	3	1	1
Ruff/Ru	ICD80-1419-1AP-3AP-2AP-0AP-0JB	DPT87	(1422)	3	1	1	1
Plc/Cr//Stk/3/Dom//Dack/ Kiwi	CD27748-B-2M-2Y-1Y-0Y	DRL86	(10)	3	1	2	1
Om Rabi 5	L0589-4L-2AP-2AP-2AP-0AP	DAT87	(207)	3	3	3	3
Gran	CD40150-14B-1Y-2M-0Y-14Y-0B	DAT87	(922)	1	3	1	3
Haurani (Local Check)	-	DAT87	(101)	2	3	1	2
Zincirli/4/Kkz/3/Nai60// Staring/2*Cmn/5/Dove'S'	ICW-HA81-1545-1AP-1AP-3AP-0AP	PWSN87	(341)	3	3	1	1
Rmn F12-JI/Jup'S'	SWM765784* OR 8300226	PWSN87	(728)	3	3	2	1

expedite the screening of lines for resistance to D. noxia and the development of other management strategies. The training of Ethiopian entomologists at the Giza aphid screening laboratory and in biocontrol techniques now being developed in Sudan will form a key component of Ethiopia's participation in the aphid subregional network.

Hessian fly

The Uniform Hessian Fly Nursery, containing known genes for HF resistance in wheat, was planted in western Syria and in the Bekaa Valley of Lebanon (Terbol Station). Low populations of HF in these ares, possibly related to the wet spring experienced throughout the eastern Mediterranean region this year, precluded identifying HF biotypes. This nursery will again be planted in 1988/89, with additional sites in Turkey and Algeria to be included. A survey of HF in Tunisia was jointly conducted by ICARDA, Moroccan, and Tunisian scientists in May 1988. HF was observed on wheat and barley. Most infestations on wheat ranged from 0 to about 20% while barley infestations were higher, ranging from 0 to 80%. A survey of HF in the three Maghreb countries is scheduled for 1988/89 in conjunction with an entomology training workshop to be held in Morocco.

R.H. Miller

3.4. Cereal Quality Evaluation

During the nine years of its existence the ICARDA's cereal quality laboratory has established a solid reputation throughout the region for efficiency and flexibility of laboratory output.

A large number of barley as well as durum wheat genotypes now can be easily evaluated for processing and nutritional quality. This applies for early generations where several thousands of samples and a few grams of seed are available. Developing a new method for measurement protein strength of bread wheat is under investigation. Preliminary work on this aspect showed the possibility of using near-infrared technique. The cereal quality laboratory conducted over 46000 tests during 1987-88, which are summarized in Table 105.

Table 105. Number of tests carried out at ICARDA cereal quality laboratory, 1987/88.

Project	TKW[a]	VKC	PSI	SDS	YP	FM	FAR	KSD	DP	PROT	TOTAL
Barley	2638	-	-	-	-	-	-	500	910	2763	6811
Bread Wheat	1896	-	1080	-	1896	46	46	-	-	1896	6860
Durum Wheat	1900	1900	-	672	1900	42	42	-	-	1900	8356
Durum Germplasm	2546[c]	2546	-	-	2546	-	-	-	-	2546	10184
High Elevation	1733	810	427	810	810	46	46	-	-	1733	6415
FFVT[b]	544	222	161	-	222	383	383	-	-	544	2479
Other	2444	180	-	-	-	-	-	60	-	2265	4949
Total	13711	5658	1668	1482	7374	517	517	560	910	13657	46054

a. TKW = Thousand kernel weight, VKC = Vitreous kernel count, PSI = Particle size index, SDS = Sodium Dodecyl Sulphate sedimentation, YP = Yellow pigment, FM = Flour milling, FAR = Farinograph, KSD = Kernel size distribution, DP = Diastatic potential.
b. Farmer's field verification trials.
c. Colour test carried out by visual evaluation of external seed coat only.

Promising Barley from Late Planting

Advanced barley yield trials were planted late (April 1988) at Tel Hadya under rainfed conditions. Some of the lines with a high yield potential in normal planting had a high protein content and a large kernel size under the stress conditions of late planting (Table 106).

Grain quality data of the normal planting season at Tel Hadya show that cereals this season were in general low in protein (6.2-10%) and had large kernel size.

Table 106. Advanced barley lines with good grain quality, at late planting 1987/88.

Entry No.	Grain yield (Normal planting) kg/ha	Protein (%)		TKW (g)	
		NP	LP	NP	LP
306	6849	8.2	14.9	46.8	38.0
204	6080	7.9	15.3	47.2	48.9
511	5976	9.3	17.1	46.6	43.9
702	5899	10.1	16.2	49.8	41.2
513	5828	9.2	16.6	48.1	44.1
Check: Rihane 03	5446	7.9	14.5	47.9	31.5

NP = normal planting; LP = late planting; TKW = 1000 kernel weight

Diastatic Power Test

Since the diastatic power test is essential for screening malting barley, the efforts in cereal quality laboratory result in improving the efficiency of test volume which increased to 50% during 1988.

Total of 192 advanced barley lines (BAT, BYT, Tel Hadya rainfed 1986-1987) were analyzed for diastatic potential. The data obtained showed low values (mean of 71 mg) perhaps because of drought during that season.

Table 107. Bread wheat lines promoted for FFVT 1988-89.

Line	Low rainfall			Irrigated		
	Protein	FST	TKW	Protein	FST	TKW
Nawras	11.3	4.5	31.0	10.3	7.0	33.9
Saker	10.5	6.8	37.4	11.0	5.6	42.6
Zarzour	11.0	7.7	40.4	11.1	4.3	45.4
Mexipak 65	11.2	4.5	27.7	10.0	2.5	30.7
Cham 4	10.6	3.0	29.0	9.3	2.4	32.2

FST = Farinograph stability time (min).
TKW = Thousand kernel weight (g).

New Bread Wheat Lines Promoted for On-farm Trials 1988-89 in Syria

The main objective of the bread wheat improvement program at ICARDA is to develop high yielding, stable varieties, with good nutritional and processing quality. In the grain quality work carried out at Tel Hadya, special consideration is paid to the following quality parameters: protein content, protein strength, kernel hardness and 1000 kernel weight.

During 1987/88, the bread wheat project identified and promoted three new lines for field verification yield trials in Syria. These lines have high yield stability, disease resistance and good grain quality. They also showed good adaptation across 48 locations in West Asia and North Africa. The quality characteristics of these lines are presented in Table 107. Three distinct and desirable characteristics are presented in these lines:

a) protein content ranged between 10.3-11.3% which is close to the protein content obtained under farmers' field conditions. The quality data were obtained from samples grown under low rainfed and under irrigated conditions. This shows that these lines have quality stability. It is expected that they will maintain protein level under farmers' field conditions in years of variable rainfall.
b) these lines have excellent bread making potential (two-layered flat bread). This character is given by the medium gluten strength at protein level of 10.3-11.3 %.
c) grain quality of these lines is superior to the local and improved checks grown in farmers' fields in Syria.

Importance of Protein Strength Measurements for Durum Wheat Evaluation

a. Electrophoresis Studies

Breeders and quality specialists are looking for improved protein content in new varieties to improve the nutritional and processing quality of durum wheat grain. The 1986/87 season showed interesting characteristics in some durum lines. In combination with high variability in protein strength (sodium dodecyl sulfate, or SDS sedimentation range 13-54 ml) the new lines having high protein content but poor protein strength will be rejected as they are not acceptable for the food industry.

37 crosses of high protein lines were analyzed for protein, SDS sedimentation and Farinograph data: correlations between these tests are summarized in Table 108. The results indicate the importance of protein strength as measured by SDS sedimentation index in large scale evaluation of durum wheat germplasm.

Preliminary work on several crosses involving T. dicoccoides has indicated that the presence of electrophoretic band No. 45, hailed as a marker to high quality in durum wheat, may not be fully reliable. Some genotypes with band 45 appear to have inferior gluten strength, while others without band 45 have been found satisfactory. The results are summarized in Table 109. This work is continuing.

b. Influence of irrigation and high rainfall on durum wheat quality

The 1987 farmer's field verification trials of advanced durum selections yielded material with reasonable to low protein content in the irrigated and high rainfall zones, but in most cases poor gluten strength, as indicated by the SDS sedimentation index. This was verified by subsequent Farinograph tests (Table 110). SDS sedimentation indices of 2.5 to 1.5 are designated fairly weak to weak, and were borne out by Farinograph stability values of 3.0 to 0.6 minutes, designated as weak to very weak. Vitreous kernel counts varied from as low as 2%, which indicated the material to be quite unsuitable for semolina milling and bread baking.

The influence of non-stress moisture conditions on wheat strength has been noted previously, and is believed to be due to differences in the pattern of agglomeration of protein, starch, and the oil and cell wall components during the maturation stage of the grain.

These data indicate it is not good policy to grow durum wheat under irrigation, or in areas where rainfall may be high, due to very serious deterioration in milling and baking quality.

Wheat strength (including durum wheat) is a physico-chemical parameter, and is believed to be affected by the pattern of hydration of sites on protein, starch, oil (ester linkages) and cell-wall components, to form a coherent molecular complex. The mechanism of the apparent change in strength may be as follows: single molecules of water produced by enzyme activity during the synthesis of protein, starch and other constituents are available to form hydrogen bonds between hydrophilic sites on the molecules as they are produced. Under conditions of luxury water availability some of these single water molecules preferentially form aggregates with adjacent water molecules, and are therefore not available for hydrogen bonding or hydrogen bridging between the main grain constituents. As a result the overall cellular matrix becomes correspondingly weakened.

Table 108. Correlation coefficients between protein content and protein strength.

	SDS	SDSI	FST	FMT
Protein	-0.06 ns	-0.23 ns	-0.02 ns	0.14 ns
SDS		0.98 **	0.90 **	-0.92 **
SDSI			0.88 **	-0.92 **
FST				-0.88 **

N = 37;Protein range 15.2-19.4;SDS range = 13-54ml;
SDS = Sodium Dodecyl Sulphate sedimentation volume;
SDSI = SDS index;FST=Farinograph stability time (min);
FMT = Farinograph mixing tolerance (Brabender units)
ns = Not significant, **=Significant at level P<0.01

Table 109. Quality of tetraploid genotypes with and without electrophoresis band No. Rm 45.

Line No.	Protein %	% with Rm 45	SDSI	Classification[a]
55	11.3	0	3.00	Strong
170	18.9	25	2.49	Fairly weak
70	18.7	100	1.76	Weak
75	14.0	100	2.07	Fairly weak
62	22.4	100	1.01	Very Weak

Note: a. Classification on basis of dough strength characteristics.

Table 110. Quality characteristics of durum wheat genotypes from irrigated and high rainfall areas.

Location	Variety/ genotype	Protein %	VKC[a] %	SDS Index[b]	Farinograph stability (minutes)[b]	Class
Deir Ezzor	Gezira 17	12.7	99	2.52	2.1	Weak
Raqqa	Gezira 17	14.6	96	2.33	2.3	Weak
El Ghab	Gezira 17	7.8	2	1.79	1.0	Weak
Idleb	Gezira 17	9.9	47	1.41	1.2	Very weak
Deir Ezzor	Cham I	11.4	69	1.32	1.3	Very weak
Raqqa	Cham I	15.0	99	1.33	2.2	Very weak
El Ghab	Cham I	9.6	3	1.40	1.4	Very weak
Idleb	Cham I	10.2	64	1.18	1.5	Very weak
Deir Ezzor	Douma H326	10.5	56	2.00	1.6	Very weak
Raqqa	Douma H326	12.9	88	2.02	1.8	Very weak
El Ghab	Douma H326	8.4	3	1.67	1.1	Very weak
Idleb	Douma H326	10.8	63	1.57	1.0	Very weak
Tel Hadya	Haurani	12.8	92	2.89	4.2	Fairly strong

Notes: a. VKC: Vitreous Kernel Count, SDS = Sodium Dodecyl Sulphate
b. Farinograph stability of 4-7 optimum for 2-layer flat bread barking. SDS index should be as high as possible and certainly above 3.0.

F. Jaby El-Haramein, A. Sayegh and P.C. Williams

3.5. Applied Biotechnology

Introduction

Three aspects of in vitro techniques for use in crop improvement are considered here. These are maintenance, creation, and recombination of genetic resources. Plant tissues can be maintained and propagated as dedifferentiated calli which regenerate to whole plants through organogenesis or embryogenesis. In particular, plant regeneration from gametes results in the production of haploids with no genetic alternation. However, a great deal of somaclonal and gametoclonal variation is generated during the callus phase. The creation of genotypes not found in existing genetic resources is expected in in vitro selection to biotic or abiotic stresses. Wide cross hybridization may be attempted to recombine genetic variations. When interspecific or intergeneric hybrids do not form endosperms, hybrid embryos can be artificially rescued in an early developmental stage. Somatic hybridization is also feasible through protoplast fusion, direct injection of DNA, etc.

These aspects superficially resemble those used in conventional plant breeding and are actually complementary to them. Techniques such as haploidization, in vitro selection, and embryo rescue, are at present available to develop new varieties.

Wheat haploid production

Haploid production is of great value to plant breeders, because if followed by chromosome doubling it is possible to quickly obtain genetically homozygous lines. The production of doubled haploids is the most rapid technique for developing uniform homozygous breeding lines and may complement conventional breeding programs.

Intergeneric hybridization of wheat and wild barley, Hordeum bulbosum, produces haploid wheat embryos because H. bulbosum chromosomes are preferentially eliminated during embryo development from the hybrid zygote. Regeneration from cultured wheat anthers may be also be applied for haploid production. Anther culture has been widely used for the last decade, and has recently contributed to the release of new wheat varieties in China and France.

Crossability between wheat and H. bulbosum

In 1986-87, 206 clones of H. bulbosum were collected in Syria, and maintained in an ICARDA nursery. The crossabilities of primarily Turkish and Iranian wheat cultivars with H. bulbosum clones were examined.

Average seed setting frequency with embryos on 29 wheat genotypes pollinated with 13 clones of H. bulbosum ranged from 0.0% to 18.6% (Table 111). Since some seeds lacked embryos frequencies of seeds with embryos were slightly lower than those of seeds scored according to their external appearance. Two Iranian cultivars, Tabassi and Bisotoon, and four Japanese cultivars were crossable with H. bulbosum. The other two genotypes, Cakmac 79 and Sabalan, produced a few seeds with embryos but were not recognized as crossable because of poor seed setting. All the H. bulbosum clones were crossable with Japanese genotypes at mean frequencies of 2.5%-23.4% seeds with embryos (Table 112). The highest frequency (23.4%) of seed sets with embryos was obtained in the cross with clone SY-111. The frequency of seed set was not associated with morphological characters observed in H. bulbosum clones. Statistical analysis indicates that there were significant differences in frequencies of seeds set with embryos among wheat and H. bulbosum genotypes used for crosses, but with no significant interaction between them.

Table 111. Crossabilities of twenty-nine wheat genotypes with H. bulbosum clones.

Wheat genotype	Origin	No. of florets pollinated	No. of seeds set (%)	No. of embryos produced(%)
1. Bolal	Turkey	336	0	0
2. Gerek 79	"	382	0	0
3. Haymana 79	"	392	0	0
4. Kirkpinar 79	"	424	0	0
5. Atay 89	"	458	0	0
6. Kirac 66	"	406	1 (0.2)	0
7. Cakmac 79	"	424	5 (1.2)	1 (0.2)
8. Kunduru	"	396	0	0
9. Diyarbakir 86-1	"	356	0	0
10. BVD-1	"	364	0	0
11. Roshan	Iran	380	0	0
12. Adl	"	372	0	0
13. Omid	"	400	0	0
14. Rashid	"	352	0	0
15. Bayat	"	404	0	0
16. Bisotoon	"	388	9 (2.3)	6 (1.5)
17. Tabassi	"	376	17 (4.5)	17 (4.5)
18. Darab	"	390	0	0
19. Sabalan	"	359	3 (0.8)	2 (0.6)
20. 1646 Bio Morocco L.	Morocco	364	0	0
21. 2306 Bio Morocco L.	"	390	0	0
22. Nes Bio Morocco L.	"	308	0	0
23. 5/70-32 Bio Morocco L.	"	382	0	0
24. Bouni	N. Yemen	250	2 (0.8)	0
25. Local White	Pakistan	334	0	0
26. Norin 61	Japan	764	158 (20.7)	142 (18.6)
27. Fukuho	"	779	138 (17.7)	120 (15.4)
28. Mikuni	"	786	52 (6.6)	45 (5.7)
29. Aoba	"	784	51 (6.5)	40 (5.1)

Table 112. Frequencies (%) of seeds set with embryos in crosses of four Japanese wheat genotypes with thirteen clones of H. bulbosum

H. bulbosum genotype				Wheat genotype3/				
	Clone	Plant height1/	Heading time2/	Norin 61	Fukuho	Mikuni	Aoba	Mean
1	SY- 18	M	M	37.5	14.8	9.3	6.9	17.1
2	SY- 32	S	E	25.0	17.7	4.4	1.7	12.2
3	SY- 34	M	E	17.2	7.3	5.2	6.9	9.2
4	SY- 39	S	E	3.2	3.4	1.9	1.6	2.5
5	SY-100	S	E	19.6	4.8	6.5	0.0	7.7
6	SY-111	M	M	37.5	30.0	10.0	16.1	23.4
7	SY-119	M	E	26.8	12.5	18.0	6.7	16.0
8	SY-120	T	L	13.8	21.2	3.1	0.0	9.5
9	SY-122	T	L	18.3	25.0	0.0	1.5	11.2
10	SY-127	T	L	18.3	26.8	3.4	17.9	16.5
11	SY-136	M	L	1.6	6.9	4.8	1.5	3.7
12	SY-140	S	L	18.2	21.0	4.5	0.0	10.9
13	SY-176	M	E	8.6	9.1	6.3	8.1	8.0

1/S: Short, M: Medium, T: Tall
2/E: Early, M: Medium, L: Late
3/M.S. for wheat genotypes (3 d.f.) 1297.42**
M.S. for H. bulbosum genotypes (12 d.f.) 288.72**
Interaction (36 d.f.) 88.44

The cross-incompatibility of wheat is genetically controlled by genes Kr1 and Kr2 located on chromosome 5B and 5A respectively. These genes also determine crossability with rye and barley. It is clear that cross-incompatibility genes predominate among Turkish and Iranian wheat genotypes.

H. bulbosum is self-incompatible and can be vegetatively propagated. Populations will therefore be genetically highly heterogeneous in their ability to affect crossability. Outcrossing between different clones of H. bulbosum followed by selection may be used to obtain promising clones with increased crossability. Since strong cross-incompatibility between wheat and H. bulbosum is the main obstacle in applying the H. bulbosum method to haploid production, it is more important to examine a wide range of H. bulbosum genotypes, which may enhance seed setting of wheat genotypes.

Wheat anther culture

This year, 7 F1 wheat genotypes (Exp 1) and 5 breeding lines (Exp 2), grown in field, were used for anther culture. Anthers excised from cold-treated spikes were inoculated on a modified potato medium (Chuang et al. 1978) at a temperature of 28°C. All embryoids emerging from anthers were transferred to a regeneration medium (He and Ouyang 1984).

Inoculated anthers (7974) produced 269 embryoids. These embryos regenerated 36 plants including 12 albino plants, at a frequency of 0.45% (Table 113). This frequency was comparable to those reported by other research workers, though not high. The frequency of haploid production through anther culture greatly varies with the genotypes used, and is generally low. Reliable regeneration from microspores is attractive because a single anther contains many microspores which could be regenerated to haploid plants. Further work is needed to develop the anther culture technique.

Table 113. Numbers of embryoids and plants obtained through anther culture in wheat.

Exp.	No. of anthers inoculated	No. of embryoids produced (%)	No. of plants regenerated (%) Green	Albino	Total
1	5036	128 (2.54)	2	5	7 (0.14
2	2938	141 (4.80)	22	7	29 (0.99)

M.N. Inagaki, M. Tahir

Doubled haploids and *in vitro* culture methods for cereal improvement

In 1988, an additional project was started to develop and adapt biotechnology to ICARDA germplasm and to the specific problems of dry areas. The current techniques present inherent limitations and appropriate activities for the Cereal Improvement Program are being identified. Special emphasis is placed on doubled haploid plant production of barley and of durum and bread wheat through *in vitro* androgenesis. We wish to develop the capacity for large scale production of doubled haploid plants in barley and bread wheat, and overcome the poor response of durum wheat to haploid plant production techniques. Another objective is to develop prerequsites for the combination of *in vitro* selection and doubled haploid plant production i.e. efficient in vitro screening systems by identifying components of complex phenotypes amenable to selection at the haploid cellular level, and powerful culture-regenerating methods using populations of isolated microspores.

P. Lashermes

3.6. Evaluation of Wild Relatives of Wheat and Identification of Useful Traits.

West Asia is the primary center of diversity and origin of wheat. ICARDA's proximity to this area is favorable for collection, evaluation and utilization of genetic resources of wild progenitors, wild relatives and primitive forms of this crop. However, in spite of the potential for genetic improvement of wheat varieties for tolerance to stresses in harsh environments of the region through plant breeding, the utilization of non-conventional genetic resources has been slow. This is perhaps due to two reasons: (1) linkages of undesirable characteristics with favorable traits associated with yield and stress as well as disease tolerance, and (2) lack of information on the genetic variability that such germplasm harbours. This variability of traits is being unmasked through a comprehensive evaluation project incorporating multi-location testing and specialized institutions in developed countries. The project will also eventually establish a regional network of national program cooperators for wider exposure of selected germplasm.

During 1987/88 a major part of ICARDA's Aegilops collection, numbering 662 accessions from 27 different species, was evaluated at Tel Hadya and Breda, ICARDA's moderate (>350 mm long-term average) and low (<275 mm) rainfall sites in NW Syria. The list of species evaluated is given in Table 114. Twelve species were selected for statistical analysis as the others did not have a representative number of accessions.

Table 114. List of species of Aegilops evaluated for six econonomically desirable traits in Tel Hadya and Breda during 1987-88.

Botanical spp.	Ploidy level	Genome	Botanical spp.	Ploidy level	Genome
Ae. bicornis	2X	S	Ae. neglecta *	4X	UM
Ae. biuncialis*	4X	UM	(= Ae.triaristata,4X)		
Ae. caudata	2X	C	Ae. recta*	6X	UMUn
Ae. columnaris*	4X	UM	(= Ae.triaristata,6x)		
Ae. comosa	2X	M	Ae. searsii	2X	S
Ae. crassa	4X,6X	DM,DDM	Ae. sharonensis	2X	S
Ae. cylindrica*	4X	CD	Ae. speltoides *	2X	S
Ae. geniculata*	4X	UM	Ae. squarrosa*	2X	D
(= Ae. ovata)			Ae. triuncialis*	4X	UC
Ae. kotschyi*	4X	US	Ae. umbellulata *	2X	U
Ae. longissima	2X	S	Ae. uniaristata	2X	Un
Ae. lorentii*	4X	UM	Ae. variabilis	4X	US
Ae. mutica	2X	Mt	Ae. vavilovii	6X	DMS
			Ae. ventricosa	4X	DUn

* Species included for statistical analysis.
** Genome symbols after Kimber and Feldman, 1987.

The following characters were evaluated: germination, days to heading, plant height, days to maturity, and number of tillers/plant. In addition, reaction to naturally occurring yellow rust (Puccinia striiformis) infection at both locations was scored (Table 115).

Table 115. Yellow rust infection on Aegilops at Tel Hadya and Breda.

Botanical spp.	% plants infected	
	Tel Hadya	Breda
Ae. biuncialis	8.0	8.3
Ae. columnaris	73.3	69.2
Ae. cylindrica	97.9	100.0
Ae. geniculata (= Ae. ovata)	4.4	3.8
Ae. kotschyi	61.1	42.8
Ae. lorentii	5.5	16.6
Ae. speltoides	7.1	8.0
Ae. squarrosa	78.6	68.8
Ae. triaristata	41.7	50.0
Ae. triuncialis	16.8	16.2
Ae umbellulata	42.8	31.0

Analysis of variance revealed a high variation for all characters between species at both locations. However, this variability was not significant between locations for days to heading and maturity. In other words, the difference in ecological conditions at the two sites were not able to influence earliness or lateness in Aegilops spp.

A formula for the transformation of numerical values into three categories or scores was used (Table 116). Trends for some species were noticed independent of the location. For example, Ae. kotschyi was early heading and maturing whereas Ae. speltoides was late with Ae. geniculata (= Ae. ovata) intermediate. Also Ae. squarrosa (the donor of the D genome to bread wheat) had low tillers/plant.

Evaluation for Disease Resistance

ICARDA's Aegilops collection was tested at the University of Tuscia, Viterbo, Italy, by Dr. Carla Ceoloni under supervision of Dr. E. Porceddu for resistance to powdery mildew (Erysiphe gramini ssp. tritici) and leaf rust (Puccinia recondita). The powdery mildew inoculum was checked for virulence with a set of standard differential

Table 116.Qualitative description of four characters in Aegilops spp.

If $X_i < X$ - s.d. then score = 1	Early Heading Early maturing Short plants Low tillers/plant
If X - s.d. $< X_i < X$ + s.d. then score = 2	Intermediate
If $X_i > X$ + s.d. then score = 3	Late heading Late maturity Tall Plants High tillers/plant

Where: X_i = Observations on individual accs.
X = Overall experiment mean
s.d. = Overall experiment standard deviation

varieties, each carrying a given Pm gene for resistance to this pathogen. The inoculum was subsequently specifically characterized by its ability to attack the normally effective Pm4 resistance gene which is present in several high yielding Italian durum wheat varieties. The inoculum for two leaf rust populations were derived from representative areas for this pathogen one being from central Italy (Rome) and the other from the south (Foggia). The resistance was tested on artificially infected seedlings grown under optimal greenhouse conditions for each of the pathogens. The virulence of the disease was scored on a 0-4 scale.

Approximately 410 accessions from 19 different Aegilops species (diploids and polyploids) have been evaluated for resistance to powdery mildew since the start of the project in January 1988. 264 (or 63%) were found to be fully resistant, 37 as moderately resistant, 102 moderately to completely susceptible and 16 as segregating. Numerous sources of resistance are apparently available, both at the diploid level, including species which carry the S, C, M, Mt, D and U genome, as well as at the polyploid level. Due to the presence of more than one potential donor genome, a larger fraction of the polyploid Aegilops spp. turned out to be resistant as compared to diploid ones. In most cases, they had the genomic constitution UM [Ae. biuncialis, Ae. columnaris, Ae. geniculata (= Ae. orata), Ae. neglecta (= triaristata)], UC [Ae. triuncialis], US [Ae. kotschi, Ae. variabilis] and CD [Ae. cylindrica].

In the case of leaf rust the difference between diploid and polyploid species was less evident. When tested against the pathogen population isolated near Rome a total of 241 (or 70%) out of 345 accessions were highly resistant. Also, ca. 276 accessions were resistant when infected with pathogen from Foggia. Once again, resistant accessions belonged to different species from the diploids to polyploids.

Perhaps the most interesting finding was the combined resistance to mildew and leaf rust in several species, including accessions of Ae. longissima, Ae. mutica, Ae. speltoides and Ae. squarrosa among the diploids and virtually all of the polyploids. It would be practical to transfer both resistances from the same wild donor into cultivated wheat. However, to achieve this goal proper cytogenetical manipulations of the selected genotype to induce chromosomes of the donor strain and recipient lines to pair and exchange genetic material, are needed. Products of such an exchange retaining desired traits from the wild parent will be selected for future evaluation.

While further tests are in progress at the University of Tuscia there seems to be little doubt as to the usefulness of Aegilops. On the basis of first year's results some accessions with promising traits have been given to breeders for further testing and eventual use in crosses.

A.B. Damania, J.P. Srivastava, and L. Pecetti

4. International Cooperation

A. Cooperation with National Programs

Introduction

One of the objectives of the Cereal Improvement Program is to assist national barley and wheat scientists with technology and information to improve cereal production in their countries, while enhancing their skills and abilities. In addition to its role in training, germplasm development, and crop improvement through improved production technologies, the Program plays an important catalytic role. Besides adopting new varieties, national programs are also adopting the improved breeding methodologies for more stable and increased production in stress environments and significant increases in moderately favorable environments.

Within the region, areas with common production constraints were identified, and in addition to the already developed subregional program for the Maghreb countries as well as for the countries in the Nile Valley, it is proposed to establish a program for the West Asian countries which will include Southern Turkey, Syria, Jordan, Iraq, and Lebanon and another for the countries of the Arabian Peninsula. The level of activities in high elevation areas (parts of Pakistan, Afghanistan, Iran, Turkey, Iraq, Algeria, Morocco) was increased. While cereal cooperation in these programs is based on general breeding and training activities, specific networks were initiated or strengthened including those of Hessian fly, aphids, drought, heat tolerance, and barley disease resistance.

Activities were increased with national, regional, and international institutions as well as with research institutions in developed countries that would serve ICARDA's mandate and goals. The highlights of cooperative research with national programs are presented below. The research and training activities reported hereafter are the fruit of joint efforts by scientists of NARSs in the various countries and outreach and headquarters scientists of ICARDA including CIMMYT's scientists posted at ICARDA.

Maghreb Regional Program

Algeria

Drought conditions that prevailed this year had a significant effect on cereal production. Total production would be around 1.5 million tons this year, leaving about another 2.0 million tons to be imported to meet local requirements.

At Sidi Bel Abbes, the total rainfall during 1987/88 crop season was 227 mm, this is 164 mm lower than the annual average of 395 mm. Rain distribution was also poor as 81.3 mm fell during October, November and December, and 40 mm only during February, March and April.

In April and May total rainfall was 20 mm. Full advantage of this drought was made by selecting drought tolerant germplasm. The severe selection pressure was reflected in the limited number of lines selected for resistance/tolerance to drought. On-station yield trials show that in durum wheat the variety Om Rabi 9 yielded 2.9 tons/ha, three times more than the local check O. Zenati. In bread wheat the variety Nesser yielded 1.5 tons/ha compared to Mahon Demias; 0.9 tons/ha.

Off-station testing comprised 6 durum varieties, 5 bread wheats and 8 barleys. These were grown in six locations representing the three different agroecological zones of Sidi Bel Abbes. Within the improved durums, yields ranged from 1.6 to 2.1 tons/ha, for bread wheats 1.6 to 2.3 tons/ha and for barleys the highest yielder was Roho with 3.1 tons/ha compared to the checks ACSAD 176 and Saida 183 that yielded 1.9 and 2.0 tons/ha respectively.

Demonstration plots incorporating improved varieties and production technology were conducted in unreplicated 1/2 ha plots in zones I, II, III and IV of the Wilaya. They included one improved durum variety; Waha, one bread wheat, Flicker-Hork's'and one barley, Rihane-03. Each variety was planted in at least 3 sites in each of the four zones. The results in general demonstrate that the production can easily be doubled even in difficult years and using local varieties. Waha yielded 0.6 tons/ha compared to O. Zenati 1.0 ton/ha with the traditional technology compared to 2.0 tons/ha and 1.9 tons/ha respectively for both varieties with the improved technology. The figures for Mahon Demias were 1.1 tons/h and 2.1 tons/ha compared to Flk-Hork's' 1.0 tons/ha and 2.4 tons/ha, Rihane 0.6 and 1.6 tons/ha and Saida 183, 1.1 and 1.6 tons/ha respectively.

Algerian technicians and researchers participated in various ICARDA, Aleppo and ICARDA North Africa cereal activities examples are participation in Tunisia/ICARDA, Morocco/ICARDA coordination meetings, visits to the base program to acquaint with high elevation cereal research, participation in residential training courses, etc.

Moreover various ICARDA, Aleppo and North Africa staff visited Sidi Bel Abbas as well as the other stations. This was particularly beneficial during planting the off-station trials at Sidi Bel Abbes, and note taking across Sidi Bel Abbes, Tiaret, El Khroub, Setif and Guelma.

1987/88 was the second year for the collaborative project between the Institut Technique des Grandes Cultures (ITGC), Algeria, ICARDA and LECSA/INIA France to improve research production and transfer of technology for winter cereals, food legumes and forages in the Wilaya of Sidi Bel Abbes. The project aims to develop improved varieties and production technologies, to test and verify results on farmer's fields and demonstrate research findings to farmers in the various agro-ecological zones of the Wilaya while evaluating the impact of this technology.

The second coordination meeting for this project was held at ITGC, Algiers, September 10-12, 1988 during which results of the 1987/88 crop season were discussed and 1988/89 plans developed. Training requirements, visits, workshops, seminars etc. for the coming season were also finalized.

Morocco

Work in Morocco in 1987/88 was directed towards the development of partnership in research, training, and transfer of technology.

Unprecedented favorable weather gave Morocco a record cereals crop. Small grain cereal production exceeded 7.5 million tons and allowed the export of barley to other Maghreb countries. Average yields exceeded 1.5 per hectare for barley and reached 2.0 t/ha for bread wheat. High rainfall also favored disease development and lodging. Septoria and the three rusts plagued wheats, while scald and net blotch caused significant losses in barley yields.

The newer bread wheat cultivars Nesma, Jouda, Merchouch 8, Saiss and Mabrouka contributed largely to the high yields while the durum Karim and Marzaq and the barley cultivars Arig 8, Asni, Tissa and Tamellalt covered large areas.

As a result of NARS scientists' dedicated efforts and partnership, the Moroccan National Program has made the following achievements:

- Improved training level of the national workers to carry independent research.

- Adoption of efficient release and seed multiplication procedures.

- Initiation of a high altitude and summer nursery research programs for cereals at Annaceur Atlas Station.

- Introduction and evaluation of wheat and barley germplasm targeted for the main cereal growing areas of Morocco, or having resistance to the predominant cereal diseases.

- Strengthening of large scale on-farm verification and demonstration work on cereal varieties. Fourty three verification trials and 26 demonstration trials were implemented in the favorable, semi-arid and mountainous areas of Morocco.

- Identification and training of junior scientists in agronomy breeding, pathology, germplasm collection and preservation, seed technology and plant physiology. Training was also imparted at ICARDA, Aleppo and in other Maghreb countries.

- Collecting, rejuvenating, cataloguing and preserving cereal national resources in Morocco.

- ICARDA scientists participated in research activities dealing with verification and demonstration trials, selection, disease breeding and field days.

- Identification of several promising lines for registration and demonstration in farmers' field verification trials.

- Strengthening of intra-regional cooperation and the initiation of several networks. For example, production of germplasm with good agronomic characters was generated in Tunisia for the Maghreb while crossing for diseases resistance were done in Morocco. Also germplasm resources under advanced testing from Tunisia were shared with the Moroccan and Algerian national programs. Conversely, lines under advanced testing in Morocco were tested at two locations in Tunisia and another two environments in Algeria.

- A travelling workshop in Morocco in which 26 breeders and pathologists from Algeria, Morocco, and Tunisia participated.

- Coordination meetings for Moroccan cereal workers Sept. 26 and 27.

During the 1988/89 support will be geared to facilitate the rapid transfer of research findings to farmers, to establish multi-disciplinary research teams, to coordinate research activities among Moroccan researchers and with other researchers from the Maghreb, to exploit the germplasm from regional and international organizations, and to analyze research results from previous seasons.

Tunisia

The Tunisia/ICARDA Cereal Project is a collaborative project between the Institut National de la Recherche Agronomique de Tunisie (INRAT) and ICARDA. However other national institutes, such as, the *Institut National Agronomique de Tunisie (INAT) and the Direction de* l'Amelioration de la Production (DAP) of the Office des Cereales, participate in various research activities.

Rainfall during 1987/88 crop season was below average in all cereal growing areas. However the magnitude of the rain deficit varied between zones. In the intermediate zones of Fahs, Medjez, Kef and Siliana the drought was very severe. In the most productive areas of the North West i.e. Mateur, Beja, Jendouba and Krib the deficit in rain was about 30-40%. This season's drought was the most severe recorded in this century.

Total cereal production this year was 0.3 million tons as compared to about 1.7 million tons in a normal year. Seed produced was also of poor quality, most being shrivelled.

The newly released variety Razzak outyielded all commercial varieties under this year's drought conditions. It gave a 15 to 20% yield advantage over the widely grown variety Karim in all stations. In Advanced Yield Trials many lines yielded as much as Razzak but none outyielded it. At Beja many lines outyielded Razzak by 8 to 20%. Some of these lines are various selections of Om Rabi.

As a result of the drought, the bread wheat variety Salambo gave the highest yield and confirmed its adaptation to dry conditions while Tanit was the least productive. The newly released variety Byrsa was severely affected by the drought, confirming that it is adapted essentially to the favorable conditions. Five newly identified lines outperformed all other lines under drought conditions.

In barley the newly released variety Rihane performed well in the dry conditions. Other advanced lines also showed high yield potential in stations at Beja, Hindi Zitoun and Bou Salem.

The grain quality of durum germplasm was determined using 1000 kernel weight, specific weight, vitreousness and protein content. Due to the drought all variables decreased except for protein content. The variety Ben Bechir was particularly higher in 1000 kernel weight than other varieties irrespective of location.

Sixteen lines were drought tolerant and had a 1000 kernel weight higher than Karim of a set of 200 lines selected from the durum world collection.

On-farm verification/demonstration trials conducted by DAP of l'Office des Cereales verified results obtained from farmer's fields. Trials were conducted in various sites for variety performance, response to fertilizer application particularly Potasium, seed rate and weed control. Results generally confirm results from previous years and show the yield superiority of the durum wheat varieties Razzak and Karim, the bread wheat varieties Byrsa and Salambo and the barleys Rihane and Roho.

Pathology research included the evaluation of the breeding material of the three crops to the prevalent diseases, a regional virulence survey to scald and net blotch of barley, the screening of part of the durum world collection to septoria leaf blotch at the seedling stage, a regional disease survey conducted in Morocco and the initiation of a cereal disease monitoring nursery for North Africa.

1905 lines of the durum world collection were evaluated at the seedling stage to septoria leaf blotch. 17% of these lines showed good resistance. Similarly entries of the BON LRA and BCB were inoculated with 6 isolates of each of scald and net blotch. The scald isolates originated from collections made in Tunisia, Morocco and Syria while the net blotch isolates originated from collections from Cyprus, Morocco, Egypt and Syria. The lines showing resistance to a majority of these isolates were selected for further use.

The virulence spectrum of 33 net blotch isolates was evaluated using ten barley cultivars as differential varieties. These isolates originated from collections made from Tunisia, Morocco, Egypt and Cyprus. Results showed that the North African isolates were more virulent than isolates from Egypt and Cyprus. None of the varieties used as differentials was resistant to all isolates.

Due to the drought conditions that prevailed in Algeria and Tunisia the disease survey was conducted this year in only Morocco. The survey was conducted by pathologists from Tunisia, Morocco as well as ICARDA. An insect survey was concurrently conducted in Tunisia and Morocco.

The cereal disease monitoring nursery was grown this year in 24 locations in Tunisia, 2 in each of Morocco and Algeria and one at Tel Hadya. This nursery was further developed into a North Africa/Iberian Peninsula cereal disease monitoring nursery and will be grown this coming season in 15 locations in Tunisia, 7 in each of Algeria and Morocco, 2 in each of Spain and Portugal and one at Aleppo.

Support to Ph.D. and MS thesis research is also continuing in the following areas: breeding methodology for drought resistance, yield loss to net blotch and septoria, and race non-specific resistance to net blotch in barley. An ICARDA supported Ph.D. thesis research, was completed this year by a scientist from INRAT. The thesis identified morphological and physiological characters associated with drought resistance in wheat.

More details are presented in the report of the Sixth Tunisia/ICARDA Coordination Meeting, September 1988.

Nile Valley Regional Project-Egypt, Ethiopia, Sudan.

In Egypt the Program strengthend its collaborative effort on screening for aphid resistance in the laboratory and field and for heat resistance in the field. Increased emphasis was placed on screening landraces and primitive forms. A number of meetings were held with Egyptian scientists in Egypt and at ICARDA headquarters to discuss improving current projects to secure external funding for projects dealing with wheat and barley production in Egypt.

In Ethiopia a workshop was organized to review the barley research and production in Sub-Saharan Africa. A training course for barley researchers was also organized. Scientists from ICARDA visited Ethiopia to assist in germplasm evaluation and to discuss research methodologies with Ethiopian researchers.

In Sudan, the project "Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields," funded by OPEC, resulted in initiating a national coordinated network on wheat; improved wheat varieties and agronomic practices were demonstrated on large scale in farmers' fields.

Trainees from all three countries participated in one or more of ICARDA's cereal training courses.

In 1987, with the full support of ICARDA's Board of Trustees, the Nile Valley Regional Program was developed for each of the three countries covering cereals and cool-season food legumes. SAREC has funded the Ethiopian component of the food legume and part of barley activity; the Dutch Government has agreed to fund the Sudan component; and EEC, has agreed to finance the Egyptian component of the project. Each of the countries has identified national program coordinators and constituted a steering committee comprising national program coordinators and relevant ICARDA staff to review the workplan developed by national programs and oversee the project implementation. Detailed workplans for 1988/89 were developed for each country at a coordination meeting held in Cairo in September 1988.

China

A Chinese delegation visited ICARDA to discuss germplasm exchange; a senior visiting scientist and trainees spend one week to 3 months in the Program. It is planned to increase the cooperation on barley improvement in China. A delegation from the Cereal Improvement Program will visit China to discuss the direction of future collaboration.

Cyprus

A collaborative project to identify early maturing drought tolerant barley and durum lines with the Agricultural Research Institute (ARI) is underway. The project provides ICARDA with sources of earliness in good genetic background and provides Cyprus with high yielding lines which have been released as varieties.

Work on dryland root-rot disease and evaluation of targetted germplasm for rainfed areas with mild winters was emphasized. Cyprus continues to play a role in providing germplasm for the use of other countries with similar agroclimatic conditions. Work on barley development for low rainfall grazing lands continued. Several journal publications have resulted from this cooperative program. Scientists from Cyprus were provided with financial support to attend international conferences related to the project.

India

An agreement between the Indian Council of Agricultural Research (ICAR) and ICARDA was signed during the season and germplasm exchange and visits of scientists increased.

Jordan

The Program has maintained active collaboration with the National Center for Agricultural Research and Technology Transfer (NCARTT), the University of Jordan (UOF), and Jordan University of Science and Technology (JUST). Barley and wheat germplasm were provided and ICARDA scientists visited Jordan to discuss cereal breeding methodologies and joint NCARTT-UOJ on-farm testing and participate in scientific meetings. Five persons from Jordan were trained in various topics relating to cereal improvement.

Latin America

The CP's barley breeder, through the joint CIMMYT/ICARDA barley improvement program, continued to provide disease resistant germplasm suitable to the growing conditions prevailing in countries of the Andean region (Bolivia, Ecuador and Peru) and similar areas.

Lebanon

The Program used the Terbol station both for regular winter planting and as off-season site to speed up the breeding cycle. Breeder seed was provided for improved seed production and subsequent distribution to cereal growers.

Pakistan

Crop experimental fields were installed at various locations through Baluchistan. Although crop research work during the season suffered badly due to lack of rain, interesting observations were made on maturity and cold and drought tolerance of wheat and barley. Germplasm, consultancies, etc. were provided as in previous years. Detailed results on the performance of cereal germplasm is provided in the AZRI-Quetta Project report.

Syria

Cooperative research with the Ministry of Agriculture and Agrarian Reform moved toward true partnership. The CP has exchanged both germplasm and scientific visits with the Directorate of Scientific Agricultural Research (Douma). During the season, 27 Syrian trainees participated in various training activities at ICARDA. Joint on-farm verification trials of wheat and/or barley have been conducted in 31 sites throughout Syria, while large-scale testing for a few varieties has been made in selected sites. The barley line Rihane 03, the bread wheat Nesser and the durum wheat Douma 6056 were among the most promising entries tested in the on-farm trials. Grain yields were not as high as would have been expected from the high seasonal rainfall, perhaps because of diseases and terminal heat stress.

ICARDA scientists along with Syrian colleague scientists, participated in meetings, work groups and field days organized by Syrian institutions. During this season, the Syrian National Program released a new durum wheat variety named Cham 3. Newly released varieties from the joint program occupied large areas, indicating that they have been gradually adopted by farmers in Syria.

Turkey

The collaboration with Turkey remained at a good level. In addition to exchange of germplasm and information, wheat and barley germplasm from ICARDA was tested at Ankara and Haymana through a collaborative arrangement with the Field Crop Improvement Center at Ankara. Five researchers visited ICARDA to attend cereal training courses. The Turkish government organized an International Symposium on the Sunn Pest which was attended by scientists from western and eastern Europe as well as from West Asia. ICARDA is considering strengthening its research activities in high elevation areas. Turkey has offered ICARDA to consider one of its stations as a Regional Coordinating Center for high elevation work.

Yemen Arab Republic (YAR)

During the season several ICARDA staff visited the YAR resulting in a much effective cooperative activity between the YAR and ICARDA. The YAR released three bread wheat varieties (Aziz, Mukhtar, Dhumran). On-farm trials and demonstrations were organized. An "In Country Training Course on Techniques of Cereal Improvement" was held at the Agricultural Research Authority in Dhamar, YAR, supported by the Arab Fund (AFESD). It is proposed to start a regional network for the Arabian Peninsula, and the first Regional Coordination Meeting was held at Sana'a, October 18-20, 1988 with participation of representatives from Saudi Arabia, Kuwait, Yemen PDR, and Yemen AR.

B. Cooperation with Institutions Outside the Region

The Cereal Program has several collaborative research projects with advanced institutions in various countries. Brief notes on each of the following collaborative projects with advanced research institutions are given below:

1. Evaluating Durum Wheat Germplasm for Drought Tolerance.

Collaboration with Agriculture Canada, Research Station, Swift-Current, Canada.

Based on a single-replicate screening of about 4000 durum wheat accessions for excised-leaf water loss rate, 50 lines were selected and were grown at three sites in Syria. These parental lines were of interest for their high yield potential under dry growing conditions and for low rates of exused leaf water loss. Progeny from these crosses will be evaluated for physiological traits the 1988/89 season. — J.M. Clarke, (Wheat physiology; Program Leader), S. Jana, University of Saskatchewan, J.P. Srivastava, M. Nachit, and B.H. Somaroo, ICARDA.

2. Collection, Evaluation and Conservation of Barley and Durum Wheat and Their Wild Relatives.

Collaboration with the University of Saskatchewan, Canada.

Germplasm is being evaluated for a number of morphological and agronomic characters and response of field level drought at ICARDA, the University of Saskatchewan, Saskatoon Canada and Jordan University of Science and Technology. -- S. Jana, University of Saskatchewan, Canada, A. Jaradat, JUST University, Jordan, and J.P. Srivastava, Cereal Improvement Program, ICARDA.

3. Grain Quality and Local Product Evaluation on Barley and Wheat.

Collaboration with Canadian Grain Commission, Winnipeg, Canada.

Work continues on evaluating wheat and barley for cereal grain quality and local food processing. Consultancy for Dr. P.C. Williams is financied by CIDA. — P.C. Williams, Canadian Grain Commission, Canada, and J.P. Srivastava, Cereal Improvement Program, ICARDA.

4. Screening Advanced ICARDA Wheat and Barley Germplasm for BYDV.

Cooperative research with Instituto de Investigaciones Agropecuaries (INIA), Chile, and Laval University, Canada.

The project supports research on BYDV on cereals in North Africa, which includes surveys for BYDV incidence, losses induced by it and testing cereal germplasm for BYDV resistance using artificial inoculation. Most promising lines after testing at Tel Hadya are sent to North Africa (Tunisia and Morocco) for testing. In 1989 some work on BYDV will be initiated in Algeria. IDRC provided US$. 47,700 for the three years from November 1986. — Dr. K. Makkouk, ICARDA.

5. Yield Physiology of Durum Wheat.

Collaboration with Institute of Plant Breeding, University of Hohenheim, Germany. Funded by Vater & Sohn V & S Eiselen Stifturg.

The objectives of this project are: to find new sources for photoperiod insensitivity; to understand linkage between photoperiod insentivity and thermo sensitivity (vernalization); to understand how plants react during different development stages to change photoperiod; to study the inheritance of photoperiod insensitivity; to compare glasshouse trials with field trials. -- P. Ruckenbauer, University of Hohenheim, Federal Republic of Germany, and M. Nachit, ICARDA/CIMMYT.

6. Haploid Breeding of Wheat Using H. Bulbosum.

Collaboration with Tropical Agricultural Research Centre, TARC, Japan.

The project aims to shorten the time required to breed new varieties which are tolerant to stresses. It focusses on the haploid breeding method using the bulbosum technique. — M. Inagaki, TARC, Japan and M. Tahir, J.P. Srivastava, Cereal Improvement Program, ICARDA.

7. Screening for Resistance to Yellow Rust, Septoria, Scald, and Powdery Mildew.

Collaboration with ENMP, Elvas, Portugal. Funded by Government of Portugal.

Collaboration in cereal pathology with ENMP in Elvas continues to be of great value. ENMP has provided excellent data on yellow rust, leaf rusts, scald and septoria tritici blotch, as well as results on the virulence of leaf samples from the region. — E. Barradas, M.J. Concalves, ENMP, Portugal, and O.F. Mamluk, J.v. Leur, Cereal Improvement Program, ICARDA.

8. Barley Stress Physiology.

Collaboration with University of Cordoba, and INIA, Spain. Funded by Government of Spain

Emphasis is given to crop physiological attributes and plant traits of potential use in barley breeding for lowrainfall Mediterranean areas. The work started in the 1986/87 season and is being financed by Spain through two graduate students. — E. Fereres, ITSIA, University of Cordoba, A. Royo, Servicio Investigacion Agraria D.G.A. Zaragoza, Spain, and E. Acevedo, Cereal Improvement Program, ICARDA.

9. Genotype Characterization in Barley.

Collaboration with the Plant Breeding Institute, Cambridge, UK. Funded by ODA.

The aim of the project is to characterize barley genotypes in terms of constitutive and adaptive traits for improved performance in dry Mediterranean environments. Work on specific identified traits such as vernalization requirements, chlorophyll a/b ratio and C-13 discrimination are providing concrete selection criteria and sources of resistance to drought. -- R.B. Austin, PBI, Cambridge, U.K. and E. Acevedo, Cereal Improvement Program, ICARDA.

10. Development of a Metabolic Index of Stress.

Collaboration with University College London, UK. Funded by ODA.

The final report of this three year project was produced. The objective of the project was to examine differences between barley genotypes at the metabolic level in their response to water stress and to explore the possibility of devising a metabolic index for genotype screening.

A metabolic index was developed using the ratio of proline concentration to total amino acids. The index gave a higher value for drought susceptible varieties. The tissue has to be sampled prior to anthesis or may be used with plants grown under controlled conditions but acclimated to drought. Only a limited number of genotypes were used to develop the index and it should be tested on a wider range. No single metabolite correlated adequately with the degree of drought stress experienced by the varieties tested.

Work done on photosynthesis indicated that both stomatal and non-stomatal control occurs and that heading to anthesis might be the best time to sample for varietal differences in photosynthesis provided that drought stress is present.

The stress metabolism of the developing grain was also examined. -- G.R. Stewart, J. Pearson, University College London, U.K. and E. Acevedo, I. Naji, Cereal Improvement Program, ICARDA.

11. Photothermal Responses of Barley.

Collaboration with University of Reading, UK. Funded by ODA.

This project is in its final phase. Its objective is to provide precise information on the effects of temperature and daylength on the development and growth of barley. The study will help scientists better understand how different genotypes of barley adapt to different environments. Current work focuses on how daylength and temperature determine the time of flowering of six diverse barley varieties.-- E.H. Roberts, R.J. Summerfield, University of Reading, UK, J.P. Cooper, FRMP, ICARDA, and E. Acevedo, S. Ceccarelli, CP, ICARDA.

12. Collaborative Inter-disciplinary Research and Training Program to Enhance Germplasm of Selected Cereals Grains for Less Favorable Environments.

Collaboration between Oregon State University, USAID, Montana State University, Kansas State University, CIMMYT and ICARDA.

The objective of this project is the enhancement and dissemination of improved wheat and barley germplasm with relevant training and in-country symposia welded together to provide an effective delivery system within the NARSs. The project maintains a strong relevant graduate training program at Oregon State University. W. Krostad, P. Hayes, Oregon State University and J.P. Srivastava, M. Tahir, Cereal Improvement Program, ICARDA.

C. Specially Funded Projects

1. Research and Training on Barley Diseases and Associated Breeding Methodologies.

Collaboration with Montana State University (MSU), USA. Funded by Science and Technology Bureau, USAID, USA.

The project addresses the need to study the major barley diseases in developing countries, particularly in the ICARDA region. The first objective is to create a model of an integrated approach to incorporating disease resistance into adapted, high-yielding barley cultivars through national, university, and international research program cooperation. An equally important objective is to upgrade the national research capabilities of developing countries through long-and short-term training, graduate degree (M. Sc.) training, and seminars and workshops in pathology and plant breeding methodologies.

The project is conducted in collaboration with Montana State University, USA. USAID is providing US$. 381.504 for 1989 out of which US$. 136.862 will be handled by ICARDA and the remainder by Montana State University. — D. Sands, W. Grey, M. Bjarko, Montana State University (MSU), USA and J.v. Leur, O.F. Mamluk, CP, ICARDA.

2. Evaluation and Documentation of Durum Wheat Germplasm (Funded by the Government of Italy)

Collaboration between Cereal Improvement Program, Genetic Resources Program, ICARDA, and University of Tuscia, Viterbo, Germplasm Institute, Bari and ENEA, Rome, Italy.

The project which was initiated in 1985/86 has the following major objectives: to screen durum wheat germplasm collection at ICARDA utilizing an ecogeographical approach, to document, utilize and disseminate information on genetic resources for the use of breeders and other scientists and to identify and test selected lines in cooperation with national programs in other countries to confirm results.

With the data coming from the 1987/88 season the project has evaluated Ca. 18000 accessions during the last four seasons and therefore the bulk of ICARDA's durum wheat world collection has now been evaluated "in-depth" for 29 agromorphological as well as biochemical characters and the information has been entered into ICARDA's central computerized data-bank. In addition, data for seven economically important characters, which were evaluated in different countries under the framework of a network of cooperating evaluators, has also been analyzed. This has led to two beneficial developments viz. the knowledge of the behaviour of germplasm selected at ICARDA under environments in other countries as well as the identification and utilization of the best lines under local conditions by the cooperating national programs. -- J.P. Srivastava, B.H. Somaroo, A.B. Damania, ICARDA and E. Porceddu, Department of Agrobiology and Agrochemical, Univ. of Tuscia, Viterbo, Italy.

3. Improving Yield and Yield Stability of Barley in Stress Environments

Collaboration with University of Perugia, Italy and Experimental Institute for Cereal Research, Ministry of Agriculture, Catania, Italy. Funded by Government of Italy.

The objectives of this project are: to assess the efficiency of the modified bulk in generating materials suited to stress environments; to select barley landraces and other lines for contrasting characters to determine their importance for adaptation to dry areas; to test over a variety of different environments the performance of pure lines compared with mixtures; to determine the importance of genetic heterogeneity in relation to yield stability; to evaluate the performance of crosses between lines selected from landraces and high yielding cultivars; to screen H. spontaneum accessions for resistance/tolerance to drought; and to utilize H. spontaneum in crosses with lines selected from landraces as well as improved cultivars. R. Petti, A. Grillo, University of Perugia, Dr. G. Boggini, Ministry of Agriculture, Catania, S. Grando, S. Ceccarelli, Cereal Improvement Program, ICARDA.

4. Enhancing Wheat Productivity in Stress Environments Utilizing Wild Progenitors and Primitive Forms.

Collaboration with University of Tuscia, Viterbo, Italy.

The project was initiated in 1987/88 and the major objectives are to study the genetic variability in the wild progenitors and primitive forms of wheat, to identify germplasm possessing genes for stress disease tolerance and study their inheritance, to identify and study physiological traits associated with high stress tolerances, to identify easily observable markers linked to these traits, to initiate a prebreeding program to develop genetic stocks, incorporating desirable genes with the aid of biotechnology whenever necessary and to provide training to regional scientists in techniques of evaluating and utilizing non-conventional genetic resources.

A total number of 662 accessions from 27 different Aegilops species were planted at Tel Hadya and Breda in Syria. Sub-samples were also sent to the University of Tuscia, Viterbo, for cytological analysis as well as electrophoretic studies.

Six economically important characters were scored in Tel Hadya and Breda. Variability for these characters was studied in-depth for 12 species which were most promising for utilization in crosses. A number of accessions were identified as resistant to yellow rust at both locations. These selected accessions have been given to the breeders for further testing and eventual use in crossing blocks. The project also provides opportunities for regional scientists to be trained at advanced institutions. -- J.P. Srivastava, B.H. Somaroo, A.B. Damania, ICARDA and E. Porceddu, Department of Agrobiology and Agrochemicals, Univ. of Tuscia, Viterbo, Italy.

5. Haploid Breeding Techniques in Cereal Improvement Using Anther Culture.

Collaborative Project with G.I.S. Moulon, University of Paris South, INRA, France. Funded by the Government of France.

The project emphasizes developing double haploids from targeted crosses of barley and wheat and tests whether anther culture is a more efficient and cost effective breeding method. The project will remain flexible and be open to other new biotechnologies that may be helpful for cereal improvement. A scientist was provided by France in August 1988 to work on this Project. -- E. Picard, University of Paris South, France, P. Lashermes, M. Tahir, J.P. Srivastava, Cereal Improvement Program, ICARDA.

6. Strengthening Barley and Wheat Research and Training in the Nile Valley and the Arabian Peninsula.

The project aims to solve some of the problems facing barley and wheat production in a short period of time in the targeted countries. There are two major research components: (1) On-farm demonstrations, research managed trials and back-up research in Sudan and the two Yemens. (2) Breeder seed of wheat and barley varieties were produced and distributed to several national programs through this project. The methodology and germplasm developed through the project will be disseminated to these participating countries. Training for agricultural research will be provided for all countries of the Arabian Peninsula. It may have also interaction with the Nile Valley Regional Program.

The project with an annual budget of Kuwaiti Dinars 50k is being funded by the Arab Fund for Economic and Social Development for a period of five years starting from 1988/89.

D. North Africa Traveling Workshops

A traveling workshop, jointly sponsored by ICARDA and CIMMYT and organized by ICARDA was held in Mid-May in Morocco. Scientists from

Tunisia and Morocco as well as from ICARDA and CIMMYT visited experimental sites in the rainfed areas of northern, central and southern Morocco (north of High Atlas Mountains), made selections and held discussions concerning germplasm improvement.

E. The following annual coordination meetings were organized with national programs to review the 1987/88 collaborative research activities and to plan for the 1988/89 workplan:

1. Cereal Annual Coordination Meeting in Wad Medani, Sudan, September 4-6, 1988.

2. Cereal Program Coordination Meeting in Algiers, Algeria, September 10-12, 1988.

3. Cereal Program Coordination Meeting in Tunis, Tunisia, September 13-14, 1988.

4. Cereal Nile Valley Regional Program Meeting in Cairo, Egypt, September 22-24, 1988.

5. Cereal Program Coordination Meeting in Rabat, Morocco, September 26-27, 1988.

6. 7th Annual Coordination Meeting with Turkey, April 9-14, 1988.

7. First Regional Coordination Meeting (Barley and wheat) in Sana'a, Yemen Arab Republic, October 18-20, 1988.

F. Visits

During 1987/88 season, 144 scientists from 36 countries visited the Program. CP's scientists spent considerable time working with national colleagues in their research plots and laboratories and discussing problems and research information on crop improvement and priorities. Some national programs requested a review of research activities and solicited suggestions for accelerating cereal production. Some Program scientists visited research centers in advanced institutions.

G. Information Exchange

In collaboration with the Scientific and Technical Information Program (STIP), the Program promoted the exchange of information among cereal researchers, and encouraged national scientists to share useful research findings in Rachis, a barley and wheat newsletter. It published 2 issues of Rachis, in English and Arabic. To reach the larger community of scientists, however, the Program scientists published papers in refereed journals and produced several reports and other publications.

J.P. Srivastava

5. International Nurseries

The international nursery system has three objectives:

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

In 1987/88 much effort was spent on in-depth analyses of the data collected for the previous years' regional yield trials and on the publication of results in scientific journals.

Types, Numbers and Distribution of Nurseries

Subdivision of the regular international nurseries into lowland and high altitude areas, and further into low rainfall or moderate rainfall areas for the lowland, was completed for the 1987/88 season. The types and names of the regular nurseries distributed in 1988 remained the same as in the previous season and are given in Table 117.

Besides the regular nurseries special specific trait nurseries were also distributed. In addition to the Bread Wheat Heat Tolerance Observation Nursery available in the last two seasons, four new nurseries were assembled in 1988 (Table 117).

1987/88 was the second season that national programs were invited to nominate their best lines for testing in the international nursery system. In the observation nurseries distributed in 1988, there were 26 entries nominated by national scientists.

In 1988, 1344 sets of regular nurseries and 156 sets of specific trait nurseries were assembled and distributed from Aleppo to 131 cooperators in 50 countries upon written request. Wheat nurseries were developed through the joint ICARDA/CIMMYT breeding activity at ICARDA. Barley nurseries sent from Mexico through the joint CIMMYT/ICARDA activity at CIMMYT are reported by CIMMYT. Approximately 69% of all the nursery sets were distributed to countries within the ICARDA region. The number of sets distributed for barley, durum wheat and bread wheat represented 40%, 27% and 33% of the overall total, respectively. Detailed information on distribution of nurseries for 88/89 can be found in the booklet "International Cereal Nurseries 1988/89 List of Cooperators and Distribution of Nurseries" available from the Cereal Improvement Program.

Though the demand of international nurseries by national programs has continued to increase over the years, the number of sets distributed were kept to the same level during the last two seasons. This was achieved by carefully considerating the requests on two aspects: whether resources are available for a cooperator to handle the nurseries requested and whether the requested nurseries are suitable to cooperators' environments.

Table 117. ICARDA's cereal international nurseries distributed in 1988.

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

[1] LRA & MRA are for lowlands

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.

Data Analysis and Report

As in the previous two seasons, upon receipt of the yield trial field books from cooperators, data were analyzed and results in the form of computer print-outs were returned to allow cooperators make a more and rapid decision on the germplasm. Annual nursery reports for the 1986/87 barley, durum wheat and bread wheat international nurseries were distributed to cooperators in June-August, 1988, respectively.

The reports retained the features of previous years with improvement in the observation nursery section. New analyses and information incorporated into the reports since 1987 were:

1. Similarity of trial sites and entries obtained by the cluster analysis.
2. Stability of the genotypes provided by the regression technique.
3. The mean relative yield and standard deviation of each entry in each geographical region or cluster of locations.

Classification of Genotypes

Useful information should be extracted from previous international nursery results to let breeders target their germplasm more precisely. The first attempt to achieve this was initiated in 1986/87 when a statistical approach using multivariate cluster analysis was chosen. Cluster analysis is an empirical technique for grouping objects, so that objects within the same cluster are relatively homogeneous and while the group themselves are relatively heterogeneous.

The objective of this study is to investigate phenotypic responses of advanced lines in the regional yield trials to different environments using cluster analysis. Numerous statistical procedures have been proposed to quantify stability. The most widely used method is regression analysis. However, all these techniques follow the traditional approach which transforms multivariate responses to environments into a univariate problem. They thus give only individual aspects of stability. Multivariate cluster analysis avoids this difficulty and has been widely accepted since the 1970s. Instead of measuring stability by a quantitative parameter, genotypes are assigned into qualitative groups based on response similarities.

The BMDP hierarchical, agglomerative 2 M program was employed for cluster analysis of mean yield of each entry from each site. Entries were considered as cases and sites were variables. Standardized Euclidean distance (standardized within each site) and centroid linkage were used.

Data from the 1985/86 and 1986/87 regional yield trials have been analysis. Results were given in the annual reports for ICARDA's cereal international nurseries for 1985/86 and 1986/87, available from the Cereals Program. For demonstration, results of the 1985/86 Regional Bread Wheat Yield Trial, which has been studied in more detail, will be briefly presented here. Grain yield from twenty four trial sites in West Asia, North Africa and Mediterranean Europe were analyzed. These sites were rainfed or under supplementary irrigation and had a C.V. for grain yield less than 32% with yield data for all 4 replicates.

Results of joint regression analyze of variance on grain yield for the 23 entries in 24 sites are presented in Table 118. Entries and entries x sites were highly significant (P<0.001). However, heterogeneity among the linear regressions was not significant and accounted for only 5.2% of the interaction sum of squares.

Table 118. Joint regression analysis of variance in grain yield of 23 wheat cultivars/lines grown in 24 rainfed or supplementary irrigated sites in West Asia, North Africa Mediterranean Europe.

Source	df	SS (x100,000)	MS (x1000)	F+	
Entry	22	74.34	3379	3.22	***
Site	23	5795.08	251960	240	***
Entry x site	506	531.88	1051	3.33	***
Regression	22	27.57	1253	1.20	ns
Deviation from regression	484	504.29	1042	3.30	***
Residual	1584	499.45	315		

***, ns = significant at P<0.001 and non-sig., respectively.
\+ = approximation only, but entry, and entry x site still significant (P<0.10) even when much smaller d.f. were used in presence of heterogeneity of interaction and error variances.
= entry MS or site MS / entry by site MS
= entry by site MS or deviation MS / residual MS
= regression MS / deviation from regression MS

The dendrogram resulted from cluster analysis of the 23 entries based on differential responses across 24 sites is given in Fig. 21. Entries 8, 11, 12, 1, 22, 5 and 19 each formed a single cell cluster separated from the remaining cluster. By examining the pedigrees (Table 119), five of these seven entries were found to be different from the rest. Entry 22 was the only line selected solely at Aleppo, Syria and was derived from a spring x winter cross. Entry 11 was the only line bulked at Patzcuaro, Mexico. Entry 5 was the line selected only in Turkey, entry 1 was an old variety developed in Mexico and entry 12 was a durum wheat. Interestingly, two sub-clusters were noted within the remaining cluster: (A) lines selected mainly under low rainfall conditions at Aleppo, Syria, without selection in Kenya (Entries 2, 3, 4, 9, 10, 13, 15, 18 and 23), and (B) lines selected under favorable conditions outside Syria, ie. high fertility and full irrigation at CIMMYT, Mexico, or in Kenya, or under high rainfall condition at Izmir, Turkey (Entries 6, 7, 14, 16, 17, 20 and 21), except entries 20 and 21, which were screened for only one season in Kenya. Mean entry yield over the 24 sites was not the criterion for clustering and sib lines were grouped together earlier in the clustering process.

S.K. Yau

Table 119 Name/cross and pedigree for each of the 23 entries and their mean relative yield and ranking over 24 sites.

Entry	Name/cross	Pedigree	Mean Relative yield
8	Ymh/Tob//Ron	SE 1756-9S-2S-5S-0S-3K-0K	.961
11	Vee'S'	CM 33027-F-15M-500Y-0M-18B-0Y-0Ptz	1.045
12	Sham 1 (Improved durum wheat check)	-	.998
1	Mexipak 65 (long-term check)	-	.968
22	C182-24/C168-3/3/(Cno/7C)*7C*2//Cc/Tob	SWM 6828-6AP-2AP-2AP-2AP-0AP	.957
5	Kvz/3/Cc/Inia//Cno/Elgau//Sn64	SE 381-4S-1S-1S-0S-2Mb-1Mm-0Mm	.949
19	Bch'S'/3/Bb/Nor67//Cno'S'/7C	CM 35297-1L-3AP-0AP-2K-0AP	.892
Sub-cluster A:			
18	Jup'S'/7/Pch/6/Kt54A/N10B//Kt54B/5/Nar59*2/4/Lfn	SWM 5090-3S-1AP-0AP-3AP-0AP	1.051
10	SD 648.511/SD 648.5/5/8156//Chr//SN64//Kbre/3/Bb/4/Zbz	CM 32670-6S-1AP-1AP-2AP-0AP	.956
3	P106.19//Soty/Jt*3	L 489-2L-2AP-0AP-8AP-0AP	.963
13	Yd'S'/Pci'S'	CM 35044-0L-7AP-1AP-1AP-0AP	.954
4	P106.19//Soty/Jt*3	L 489-2L-1AP-2AP-1AP-1AP-0AP	.993
9	Bb/7C*2//Y50E/Kal*5	CM 29014-7S-2AP-1AP-2AP-0AP	1.046
23	Sham 2 (Improved bread wheat check)	-	.939
15	Maya 74/Cli	CM 39427-14AP-2AP-1AP-0AP	1.005
2	K6290.9/4/Cno/K58N//Tob/Cno/3/We/Sx	L 51-2S-4S-2AP-2AP-6AP-0AP	1.043
Sub-cluster B:			
6	Kvz/Cgn	SE 1066-9S-1S-6S-0S-1K-0K	1.069
17	Hoopoe'S'	SWM 2185-2Y-3M-1Y-2M-0Y-3K-0K	1.028
7	Kvz/Cgn	SE 1066-9S-1S-6S-0S-6K-0K	1.074
16	Kal//Bb/Kal//3/AU//Y50E/Kal*3	CM 48418-A-3M-2Y-1M-3Y-0M	1.061
21	WA476/3/391//56D-81-14-53/3/1015.6410/4/W22/5/Ana	SWM 6525-1AP-0AP-1K-0AP	1.023
20	WA476/3/391//56D-81-14-53/3/1015.6410/4/W22/5/Ana	SWM 6525-1AP-0AP-2K-0AP	.997
14	Condor'S'/Ald'S'	CM 36903-1Y-1M-1Y-0M-3K-0K	1.046

Entry yield divided by site mean yield and then averaged over sites.
Explanation on pedigree: CM - CIMMYT cross; SWM - CIMMYT spring x winter cross; SE - Turkish cross; L - ICARDA cross in Lebanon; AP - Aleppo (Syria); S - Izmir (Turkey); K - Kenya; Sa - Sakha (Egypt); M, Y, B & Ptz - sites in Mexico; Mb & Mm - trials in Turkey.

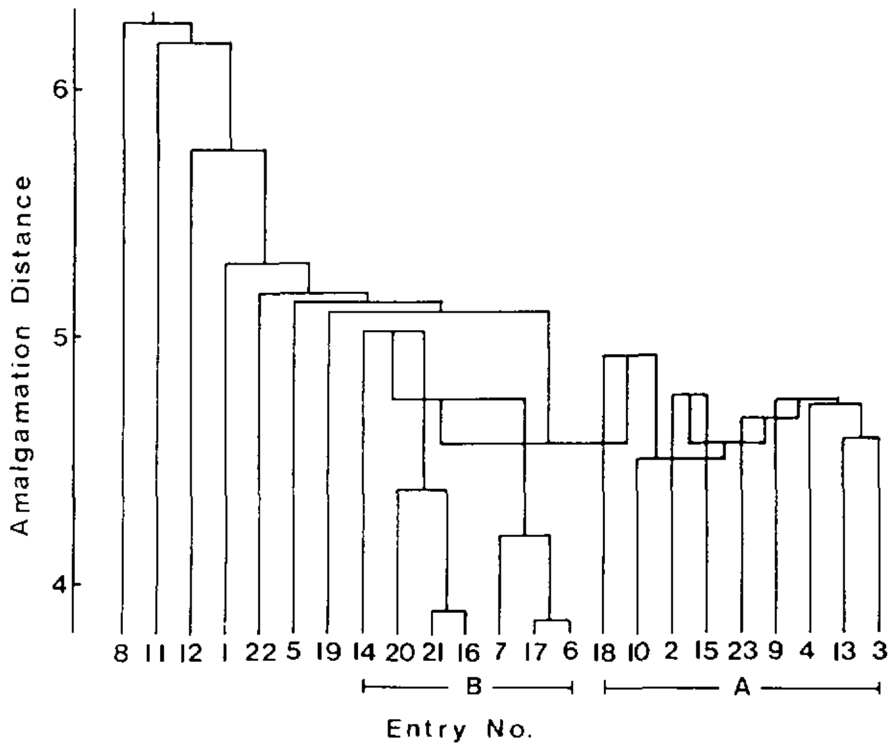

Fig. 21. Amalgamation resulting from cluster analysis of 23 entries based on differential yield responses across 24 sites.

6. Cereal Training

In response to the evolving needs of NARS in WANA, training activities have been intensified, mainly through specialized short courses. During 1987/88 148 persons were trained by cereal scientists at ICARDA or in in-country courses. In addition, a number of scientists from NARS visited the Program for periods of 1 week to 4 months. Table 120 shows cereal training trends during the last 10 years.

Table 120. Number of participants in various training courses 1979-1988.

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

* Number of courses in parentheses

A. Short courses

Four specialized training courses were conducted in 1987-88 at Tel Hadya on: biometrical techniques for cereal breeders, cereal stress physiology, barley diseases and associated breeding methodologies and cereal disease identification and scoring.

Biometrical Techniques for Cereal Breeders

Seven scientists from 6 countries (Table 121) participated in a specialized intensive course held at Tel Hadya, Syria, from 16-23 Feb. 1988. Topics included: heritability, genetic designs, genotype x environment interaction, varietal stability, and selection efficiency. In addition to attending lectures, each participant made a presentation on a particular topic and discussed it with other colleagues. They also had a chance to work on examples using the computer. From the discussions it appears that NARS need software appropriate for geneticists and breeders.

Table 121. Participants in the short course on biometrical techniques for cereal breeders, ICARDA 1988.

Name	Institute/Country
Dr. Raafat Abdel Hamid Mitkees (Ph.D.)	ARC, Giza, Egypt
Dr. P.S.L. Srivastava (Ph.D.)	IARI, New Delhi, India
Ms. Fadwa Mustafa Shqaidef (B.Sc.)	Jordan Univ.,Amman,Jordan
Ms. Nadia Fanek (B.Sc.)	Jordan Univ.,Amman,Jordan
Mr. Mahmoud Deghaies (M.Sc.)	INRAT, Tunis, Tunisia
Mr. Ahmed Ali Khajeh A. Attari (M.Sc.)	SPII, Karaj, Iran
Mr. Iftikhar Ahmed (M.Sc.)	NARC, Islamabad, Pakistan

Cereal stress physiology

Twelve trainees from 9 countries (Algeria, Egypt, Ethiopia, India, Jordan, Morocco, Pakistan, Syria, Turkey) participated in a two-week course at Tel Hadya during 15-28 March, 1988. Course objectives were to explain the mechanisms of interaction between the crop and the environment, to analyze the effects of physical stresses on crop growth and development and to utilize physiological concepts in varietal selection and crop management to minimize the effect of environmental stresses on crop production. Topics included water balance and water stress, water use efficiency, transpiration efficiency, resistance to cold and heat, and breeding cereals for improved resistance to environmental stresses. The course also provided an opportunity for ICARDA and NARS scientists to exchange ideas and information on environmental stresses prevailing in the region, and to establish research links with cereal physiologists from WANA.

Barley Diseases and Associated Breeding Methodologies

This course was offered at ICARDA from 21 March-5 April 1988 by the Cereal Improvement Program, ICARDA and, the Department of Plant Pathology at Montana State University. The objective was to familiarize participants with the major barley diseases, to train them on recognizing these diseases and assessing their severity of their occurrence, and to provide them with methodologies of efficient disease control including breeding for disease resistance.

Fourteen researchers from 10 countries, i.e., China, Egypt, Ethiopia, Morocco, Nepal, Sudan, Syria, Tunisia, Turkey and Yemen Arab Republic participated.

Topics included: disease occurrence and development, life cycle of causal agents, epidemiology, diagnosis and field sampling, scoring disease incidence and severity, crop loss assessment, seed health and control of diseases with emphasis on breeding for disease resistance.

In addition to attending classroom presentations, the participants worked in the laboratory and fields at Tel Hadya, and visited off-station testing sites to observe and evaluate diseases under artificial and natural infections.

Cereal Disease Identification and Scoring

A short intensive course on cereal disease identification and scoring was offered to 8 participants from various research stations in Syria during 18-21 April. The course which took place at Tel Hadya was designed for cereal workers involved in disease note taking. Emphasis was placed on development of diseases, recognition and identification of symptoms and evaluation of the type reaction type and infection severity. The major part of the course was devoted to practical field training.

Because of specificity of the course, it was possible to use the Arabic language in the course, which made communication with trainees more efficient.

B. In-country courses

Saudi Arabia

Based on a request from the national program in Saudi Arabia, one scientist from ICARDA, in collaboration with national scientists, assisted in organizing an in-country course on "identification, diagnosis and control of barley and wheat diseases". The course took place in 2 sites: at Riyadh (2-6 April 1988) and at Unayzah, Qassim (8-12 April 1988). In total 42 persons from different agricultural directorates participated in the course. Three days were devoted to classroom presentations, 1 day to laboratory sessions, and 1 day to field visits.

The course focused on the major diseases infecting wheat and barley in Saudi conditions and emphasized the importance of resistant cultivars as a means of controlling the diseases.

Yemen

A course on cereal improvement was conducted at Dhamar, Yemen Arab Republic (YAR) from 23-27 October 1988. Trainees included 12 participants from YAR (2 from research, 5 from seed multiplication project and 5 from production and extension projects), 2 from Peoples Democratic Republic of Yemen. (1 from seed production and 1 from extension) and one researcher from Oman. Instructors inncluded 3 scientists from ICARDA and 3 from the Agricultural Research Authority in YAR. Classroom presentations covered the development of improved barley and wheat varieties, the occurrence and importance of diseases and insect pests in cereal production, cultural practices and on-farm trials and demonstration fields. A participant from each country gave a brief presentation on cereal research in his own country, followed by discussion. One day was devoted to practical field visits both on-station and on-farm fields.

C. Individual training

In response to increased demands from NARS for training on specific research techniques, the cereal improvement program trained 18 participants from 6 countries for periods of 1 week to 3 months on various topics (Table 122).

Participants who spent a short individual training also involved in other training courses at ICARDA.

Table 122. Specialized non-degree individual training at the Cereal Improvement Program, ICARDA, 1988.

Subject	No. of participants	Duration	Country
Barley breeding	1	3 months	Algeria
Cereal entomology	1	1 months	Syria
Germplasm evaluation	1	3 weeks	Syria
Cereal improvement	1	2 weeks	Syria
Grain quality	1	2 weeks	Syria
Data analysis	2	10 days	Syria
On-farm testing	1	1 month	Tunisia
Grain quality	1	2 weeks	Tunisia
Cereal pathology	1	3 weeks	Tunisia
Cereal pathology	1	8 days	Tunisia
Cereal pathology	2	2 weeks	Ethiopia
Cereal pathology	1	2 weeks	Turkey
Cereal entomology	2	2 weeks	Turkey
Use of the oyjord drill	2	1 week	Jordan

D. Graduate Research Training:

An increased number of graduate students from the region have been accepted to conduct their research work under the co-supervision of ICARDA and NARS scientists. Also, graduate students from outside the ICARDA region have been accepted to carry out their thesis research at ICARDA with external financial support (Table 123).

In addition to supporting graduate students, the Cereal Improvement Program provided training to 4 students from Aleppo University on cereal entomology and 3 students on barley diseases as part of their graduation projects. Groups of third and fourth year students from Aleppo, Tichreen and Deir-ezzor universities visited the program to get acquainted with its various research activities.

A student from Wagenigen University spent 6 months working in cereal physiology as part of the training requirements in his university.

Table 123. Graduate students supported by the Cereal Improvement Program 1987-88.

Name	Degree	Research Area	Country	Source of financial support
Mr. Moncef Ben Salem	Ph.D	Wheat physiology	Tunisia	ICARDA
Mr. Deghaies Mahmoud	Ph.D	Wheat breeding	Tunisia	ICARDA
Mr. Adel Deif Alla	M.Sc.	Cereal physiology	Sudan	ICARDA (GRTP)
Mr. Mohamed S.El-Khatem	M.Sc.	Cereal physiology	Sudan	ICARDA (GRTP)
Mr. Pedro P. Marco	Ph.D	Cereal physiology	Spain	external support
Mr. Hani Ghoshe	M.Sc.	Wheat breeding	Jordan	ICARDA (GRTP)
Mr. Eric van Oosterom	Ph.D.	Wheat breeding/ physiology	Holland	external support
Mr. Peter Stefany	Ph.D.	Wheat breeding/ physiology	F.R. Germnay	external support
Mr. Jamal Abu El-Enein	M.Sc.	Wheat breeding	Jordan UOJ	ICARDA
Mr. Haytham Al Sayed	M.Sc.	Cereal wild species	Syria	ICARDA (GRTP)
Mr. Mohamed S. Hakim	Ph.D.	Wheat breeding/ pathology	Syria	ICARDA
Ms. Samia El Masri	M.Sc.	Cereal entomology	Syria	ICARDA (GRTP)
Ms. Suha Ismail	M.Sc.	Wheat pathology	Syria	ICARDA (GRTP)
Ms. Christa Probst	M.Sc.	Barley breeding	F.R. Germnay	external support

E. Residential Course

The residential course (1 March-16 June 1988) was attended by 18 participants from 11 countries (Table 124). Four trainees, one each from Morocco, PDR Yemen, Saudi Arabia and Syria, were supported financially by AOAD.

The trainees attended classroom presentations in breeding, physiology, agronomy, pathology, entomology, cereals for high elevations, genetic resources, seed production, seed health, grain quality, on-farm testing, field plot techniques, data analysis, and economics.

These classroom presentations were complemented by practical training in hybridization, selection, disease and insect identification and scoring, harvesting, analyzing research data and reporting of results. Practical training covered about three quarters of the entire schedule.

All trainees visited on-farm trials at different sites in Syria (El Ghab, Hama, Idleb, Saraqueb) and participated in selection at off-station research sites.

Table 124. List of trainees in the cereal residential training course (1 March-16 June 1988).

Name	Country	Topic
Mr. Mohamed Bouizar	Morocco	Barley improvement
Mr. Tugrul Ince	Turkey	Barley improvement for high elevation areas.
Mr. Zhou Yang	China	Barley improvement
Mr. Mansour Al Saghir	Yemen AR	Barley improvement
Mr. Mohamed Hamadi	Morocco	Balrey and durum wheat improvement
Mr. Mohamed Abd El Fattah A. Salem	Egypt	Physiology/agronomy
Mr. Fayez Anwar Essa	Egypt	Physiology/agronomy
Ms. Nuray Kilinc		Turkey Physiology/agronomy
Mr. Yousef M. Al Rajab	Saudi Arabia	Bread wheat improvement
Mr. Mohamed S. Al Yamei	Saudi Arabia	Bread wheat improvement
Mr. Ibrahim B. Al Amry	Saudi Arabia	Bread wheat improvement
Mr. Hussein M. Abu Hamza	Syria	Durum wheat improvement
Mr. Ababsa Bel Kacem	Algeria	Durum wheat improvement
Mr. Idris Ali Mohamed	Sudan	Cereal pathology
Ms. Ihsan Ali Abbas		SudanCereal entomology
Mr. Ibrahim Al Khalidi	Syria	Cereal improvement/seed production
Mr. Idrissi Abdel Ouahed	Morocco	Cereal improvement/seed production
Mr. Mool Chand Diwakar	India	On-farm testing.

F. Visiting scientists:

Five research scientists, one each from China, Algeria, Egypt, India, and Sudan visited the program to get acquainted with research work at ICARDA in barley pathology, barley breeding, bread wheat breeding and cereal improvement for high elevation areas. A senior scientist from Peoples Republic of China also visited the program to get general information on our work on wheat and barley improvement with some emphasis on material suitable for high elevation areas.

H. Ketata, and other CP's scientists

7. Publications

Journal Articles

Ceccarelli, S., 1989. Wide adaptation: how wide? Euphytica (In press)

Ceccarelli, S. and Grando, S., 1989. Efficiency of empirical selection under stress conditions. Genetics and Breeding (In press).

Inagaki. M.N. 1987. Variation in plant height of doubled haploid lines of wheat derived from intergeneric crosses with Hordeum bulbosum L. Japan. J. Breed. 37: 275-282.

Inagaki, M.N., Henry, Y. and De Buyser, J. 1987. Comparison of haploid production efficiency through anther culture and intergeneric crossing in three wheat varieties and their $F^1 1$ hybrids. Japan. J. Breed. 37: 474-478.

Inagaki, M.N., De Buyser, J. and Henry, Y. 1988. Occurrence of somatic embryoids in suspension callus cultures initiated from immature haploid wheat embryos. Japan. J. Breed. 38: 103-107.

Ishikawa, N., Hoshino, T. and Tahir, M. 1988. Distribution and ploidy levels of Hordeum bulbosum and H. murinum in Syria. Japan. J. Breed. Vol. 38 (suppl. 1): 438-439.

Lashermes, P., Beckert, M., 1988. Genetic control of maternel haploidy in maize and selection of haploid inducing lines. Theor. Appl. Genet. 76: 405-411.

Lashermes, P., Gaillard, A., Beckert, M. 1988. Gynogenetic haploid plants analysis for agronomic and enzymatic markers in maize (Zea mays L.). Theor. Appl. Genet. 76:570-572.

Williams, P.C., Jaby El-Haramein, F., Nelson, W., and Srivastava, J.P. 1988. Evaluation of wheat quality for the baking of Syrian-type two-layered flat breads. Journal of Cereal Science. 7: 195-207.

Williams, P.C., Jaby El-Haramein, F., Oritz-Ferrara, G., and Srivastava, J.P. 1988. Preliminary observation on the determination of wheat strength by near-infrared reflectance. Cereal Chem. 65(2): 190- 114.

Yau, S.K., Mekni, M.S. and Naji, I. 1989. Effects of green-stage grazing on rainfed barley in northern Syria. I. Tiller production and other agronomic characters. Experimental Agriculture (In press).

Yau, S.K. and Mekni, M.S. 1989. Effects of green-stage grazing on rainfed barley in northern Syria. II. Yield and economic returns. Experimental Agriculture (In press).

Conference papers

Acevedo, E., Perez-Marco, P. and Van Oosterom, E. 1988. Physiology of wheat and barley in stressed rainfed Mediterranean environments. In: Proceedings of the International Congress of Plant Physiology, New Delhi, India 15-20 February 1988. (In Press).

Benedetelli, S., Tomassini, C., Lafiandra, D., Damania, A.B. and Porceddu, E. 1988. Variation in morphological characters in landrace populations of wheat from Nepal. Pages 292-302 In: Proceedings of International Symposium on Winter Cereals and Food Legumes Production in High Elevation Areas of West and South East Asia and North Africa, Ankara, Turkey 6-10 July 1987.

Ceccarelli, S., 1989. Increasing producivity in unfavorable conditions: philosophies, strategies, methodologies. Proceeding of the International Workshop on "Advanced Technologies for Increased Agricultural Production: Actual Situation, Future Prospects and Concrete Possibilities of Applications in the Developing Countries. (S. Margherita Ligure, Italy, 25-29 September, 1988).

Damania, A.B. and Srivastava, J.P. 1988. Genetic resources for optimal input technology-ICARDA's perspectives. In: Proceedings of Third International Symposium on Genetic Aspects of Plant Mineral Nutrition, Braunschweig, FRG 19-24 June 1988. (In Press).

Damania, A.B., Tahir M. and Somaroo B.H. 1988. Improvement of durum wheat Proteins utilizing wild gene resources of Triticum dicoccoides Koern at ICARDA. In: Proceedings of Seventh International Wheat Genetics Symposium, Cambridge, UK 13-19 July 1988. (In Press).

Inagaki, M.N. 1988. Three steps in producing doubled haploids of wheat through the bulbosum technique. Proceedings of Seventh International Wheat Genetics Symposium, Cambridge, U.K. (In Press).

Mamluk, O.F., Haware, M.P., Makkouk, K.M. and Hanounik, S.B. 1988. Occurrences, losses and control of important cereal and food legume diseases in west Asia and north Africa. In: Proceedings, International Symposium on Crop Losses Due to Disease Outbreaks in the Tropics and Countermeasure. Tropical Agriculture Research Center, Kyoto, Japan, Aug. 25-27, 1988 (in press).

Mamluk, O.F. and Nachit, M. 1988. Performance and reaction of some durum wheat genotypes against different isolates of common bunt (Tilletia foetida and T. caries). In: Abstracts of Papers.

5th International Congress of Plant Pathology, Kyoto, Japan. Aug. 20-27, 1988.

Miller, R.H. 1988. Past, present, and future status of sunn pest research at ICARDA. Proc. I. International Sunn Pest Symposium, Tekirdag, Turkey.

Nachit, M.M. and Ketata, H., 1987. Selection for heat tolerance in durum wheat (Triticum turgidum L. var. Durum). In: Proceedings of the International Symposium on Improving Winter Cereals under Temperature and Salinity Stress. Cordoba, Spain, 26-29 October.

Nachit, M.M., Ketata, H. and Yau, S.K., 1988. Breeding durum wheat for environments of the Mediterranean region. In: Third International Symposium on Durum Wheat, Foggia, Italy, 5-7 May.

Nachit, M.M., 1988. Association of yield potential, drought tolerance and stability in durum wheat (T. turgidum var. L. durum. In: 7th International Wheat Genetics Symposium Cambridge, UL, 10-13 July.

Nachit, M.M. 1988. Contribution of drought tolerance to grain yield in durum wheat under low rainfall areas conditions. In: Symposium on Rainfed Field Crops and Farming Systems in Jordan & Neighbouring Countries, Amman, Jordan, 10-14 September.

Ortiz Ferrara, G., Deghais, M. 1988. Modified bulk, a selection method for enhancing disease resistance and adaptation in rainfed wheat. Proccedings of Seventh International Wheat Genetics Symposium, Cambridge, UK July 13-19, 1988. (In press).

Srivastava. J.P. 1988. Physiological approach to winter cereal improvement for dryland farming systems. Presented at the International Congress of Plant Physiology, New Delhi, India, 15-20 February, 1988.

Srivastava, J.P., Damania, A.B. and Pecetti, L. 1988. Landraces, primitive forms and wild progenitors of durum wheat-their use in dryland agriculture. In: Proceedings of Seventh International Wheat Genetics Symposium, Cambridge, UK 13-19 July 1988. (In Press).

Srivastava, J.P., Miller, R.H., and van Leur, J.A.G. 1988. Biotic stresses in dryland cereal production: The ICARDA perspective. Proc. International Symposium on Dryland Agriculture, Amarillo, TX, USA, 14-19 Aug.

Tahir, M. and Hays, P.M. 1987. A synthesis of winter cereal research and production status in high-elevation areas of west Asia and north Africa. Proceed. Int. Symp. on High Altitude, Ankara, Turkey, July 1987.

Tahir, M. 1987. Breeding of cold tolerant early maturing wheat and barley varieties. Proceed. Int. Symp. as thermal stresses held at Cordoba. Spain.

Tahir, M. 1988. Characteristics of cultivated landraces and improved varieties of wheat (T. aestivum L.) in high altitude areas. Proceed. 7th Int. Wheat Genet. Symp. Cambridge, U.K.

Tahir, M., Williams, P.C., Jaby El-Haramein, F., Sayegh, A., and Srivastava, J.P. 1988. Influence of interspecific crossing on quality of durum-type wheats. 73rd Annual Conference American Association of Cereal Chemists, San Diego, CA., U.S.A.

Yilmaz, B. and Tahir, M. 1988. Genetic diversity in Ahlat wheats. Proceed. 7th Int. Wheat Genet. Symp. Cambridge, U.K.

Yau, S.K. and Thurling, N. 1988. Genotypic variation in mechanisms of nitrogen uptake in spring rape (Brassica napus L.). In: 9th Australian Plant Breeding Conference, Wagga Wagga, N.S.W., Australia. June 27-July 1, 1988.

Reports and other Publications

Cereal Improvement Program. 1988. Annual Report for the regional barley yield trials and observation nurseries, 1986-87. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1988. Annual report for the regional durum wheat yield trials and observation nurseries, 1986-87. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1988. Annual report for the regional bread wheat yield trials and observation nurseries, 1986-87. ICARDA, Aleppo, Syria.

Cereal Improvement Program. 1988. International Cereal Nurseries, 1988-89. List of cooperators and distribution of nurseries. ICARDA, Aleppo, Syria.

Damania, A.B. and Somaroo, B.H. 1988. Preliminary screening of wheat germplasm utilizing PAGE - Greek var. Atsiki 1/2/3/4/5 and Italian cv. Capeiti. Rachis 7 (1). (In Press).

Damania, A.B. 1988. Sampling cereal diversity in Morocco. Plant Genetic Resources Newsletter 72: 29-30.

Dominici, L., Grottanelli, A., Tomassini, C., Lafiandra, D., Porceddu, E. and Damania, A.B. 1988. Electrophoretic variability in landraces of durum wheat from Ethiopia. Rachis 7 (1). (In Press).

ICARDA, 1988. Meeting the challenge: Cereal Improvement in Tunisia. ICARDA, Aleppo, Syria, 55 pp.

ICARDA, 1988. Cereal Improvement Program. Achievements and Perspectives.

Miller, R.H. and Haile, A. 1988. Diuraphis noxia Mordvilko on barley in Ethiopia. Rachis (In Press).

Nachit, M.M. and Asbati, A., 1987. Testing for vitreous kernels in durum wheat at ICARDA. Rachis, 6 (2): 41-44.

Yau, S.K. 1987. Comparison of triticale with barley as a dual-purpose crop. Rachis 6 (1): 19-24.

Books

Saxena, M.C., Sikora, R.A, and Srivastava, J.P. (eds.) 1988. Nematodes parasitic to cereals and legumes in temperate semi-arid regions. ICARDA, Aleppo, Syria, 55 pp.

Srivastava, J.P., Saxena, M.C., Varma, S., and Tahir, M. (eds.) 1988. Winter cereals and food legumes in high elevations. ICARDA, Aleppo, Syria. (In Press).

8. Staff List of Cereal Improvement Program

Dr. Jitendra P. Srivastava	Program Leader
Dr. Edmundo Acevedo	Agronomist/Physiologist
Dr. Salvatore Ceccarelli	Barley Breeder
Dr. Ardeshir B. Damania	Germplasm Scientist
Dr. Guillermo O. Ferrara	Bread Wheat Breeder (CIMMYT/ICARDA)
Dr. Habib Ketata	Senior Training Scientist
Dr. Philippe Lashermes	Biotechnologist
Ir. Joop van Leur	Barley Pathologist
Dr. Omar Mamluk	Cereal Pathologist
Dr. Mohamed S. Mekni	Cereal Scientist (Morocco)
Dr. Ross H. Miller	Entomologist
Dr. Miloudi Nachit	Durum Wheat Breeder (CIMMYT/ICARDA)
Dr. Mohamed Tahir*	Cereal Breeder
Dr. Hugo Vivar	Barley Breeder (CIMMYT/ICARDA)
Dr. Stefania Grando	Research Scientist (Barley)
Mr. Masanori Inagaki	Biotechnologist
Mr. Issam Naji	Agronomist
Dr. Sui K. Yau	International Nursery Scientist
Dr. Ahmed Zahour	Visiting Scientist (Barley)
Mr. Luciano Pecetti	Research Associate
Mr. Abdel Jawad El Sabouni	Training Assistant
Mr. Michael Michael	Research Assistant
Mr. Mohamed Asaad Mousa	Research Assistant
Mr. Pierre Asbati	Research Assistant
Mr. Fuad Jabi El-Haramein	Research Assistant
Mr. Mazen Jarrah	Research Assistant
Mr. Adonis Kourieh	Research Assistant
Mr. Mohamed Mushref	Research Assistant
Mr. Munzer El Naimi	Research Assistant
Mr. Henry Pashayani	Research Assistant
Mr. Riad Sakkal	Research Assistant
Mrs. Anette Sayegh	Research Assistant
Mr. George Kashour	Research Assistant
Mr. Rizkallah Abed	Research Assistant
Ms. Sonia Sultan	Senior Technician
Mr. Mohamed Azrak	Senior Research Technician
Mr. Zuhair Murad	Senior Research Technician
Mr. Nicolas Rbeiz	Senior Research Technician (Terbol)
Mr. Mufid Ajami	Research Technician
Mr. Ziad Alamdar	Research Technician
Mr. Haitham Altunji	Research Technician
Mr. Joseph Aziz	Research Technician (Terbol)
Mr. Haitham Kayyali	Research Technician
Ms. Therese Kebbe	Research Technician
Ms. Suzan Khawatmi	Research Technician

Mr. Mohamed Amir Makki	Research Technician
Mr. Mosbahi Mohamed	Research Technician (Tunis)
Mr. Omar Muhandess	Research Technician
Mr. Mohamed Tarakji	Research Technician
Mr. Adnan Ayyan	Research Technician
Mr. Mohamed I. Ghannoum	Research Technician
Mr. Riad Lutfi	Research Technician
Mr. Abdel Rahman Touma	Research Technician
Mr. Zuhair Younis	Research Technician
Mr. Salem Farrouh	Research Technician
Ms. Talin Helvajian***	Research Technician
Mr. Bassam Shammo	Research Technician
Ms. Gisele Dadour	Assistant Research Technician
Mr. Abdullah Steif	Assistant Research Technician
Ms. Rita Nalbandian	Program Secretary
Ms. Magda Khawam	Secretary
Ms. Samira Maksoud	Secretary
Ms. Dia Mufti	Secretary
Ms. Nahed Sammani	Secretary
Ms. Zohra Ben Masoud	Secretary (Morocco)
Mr. Asaad El Ahmed	Labour Foreman
Mr. Obeid El Jasem	Farm Labourer
Mr. Michael Abu Nakad	General Worker (Terbol)
Mr. Hassan El Khatib	General Worker (Terbol)
Mr. Mohamed Charrab	Driver (Morocco)

Visiting Scientists

Dr. Abdel Fattah Ahmed El-Sayed	Barley Breeder, Egypt
Dr. Mohamed Saleh Mohamed	Bread Wheat Breeder, Sudan
Dr. Dalvir Singh	Barley Breeder, India
Dr. Heng Li Wang	Res. Prof. & Wheat Breeder People's Republic of China
Mr. Qu Liang	Barley Pathologist People's Republic of China

Research Fellows

Ms. Loretta Dominici	Durum Wheat (Viterbo)
Ms. Rosella Franconi**	Wild Progenitors (Viterbo)
Ms. Antonella Grillo	Barley (Perugia)
Mr. Angelo Grottanelli	Durum Wheat (Viterbo)
Mr. Rudi Petti	Barley (Perugia)
Ms. M. Aatika**	Biotechnology (Paris)

---

* Left on sabbatical, October 1988
** Joined in 1988
*** Left ICARDA, August 1988

Acknowledgement

As always, this years Cereal Program Report is the result of the efforts of many people. It is impossible to think of anyone in the Program who did not contribute in some way to its preparation. A few groups deserve special mention. First, we extend our appreciation to the staff of Computer Services for not only setting up the microcomputer system on which this report was assembled but for trouble-shooting problems of software and hardware. In this regard we also appreciate the efforts of Ir. J.A.G. van Leur in spearheading the Cereal Program's initial foray into the world of microcomputers and desktop publishing. And last but certainly not least, we express appreciation to Dia Mufti, Samira Maksoud, Magda Khawam, Nahed Sammani, and Basma Talas, the program secretaries who valiantly and rapidly adapted to an unfamiliar new system under the difficult conditions imposed by the preparation of this report.

R.H. Miller - Editor

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

1989