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CEREAL IMPROVEMENT PROGRAM

Annual Report for 1987

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Annual Report 1987

International Center for Agricultural Research in the Dry Areas

Box 5466, Aleppo, Syria

Contents

1. Program Overview

Cereal Improvement Program (CP) activities are oriented to assist NARS to improve yield and production dependability of barley, durum wheat, and bread wheat in the drier, predominantly rainfed areas of the ICARDA region, but also with a wider mandate in developing countries in the case of barley. The overall objective is to achieve greater stability and improved yields over seasons by moderating the effects of environmental stress rather than to simply maximize production in the more favorable environments. This will improve the income and quality of life of a vast population whose livelihood depends on barley/livestock or other cereal-based farming systems. Projects within the Cereals Program have a commodity focus with farming systems perspective and multi-disciplinary research and training in agronomy (together with FRMP), breeding, crop physiology, pathology, entomology, grain quality, and transfer of technology integrated into a strong team approach. Breeding remains the core but more resources are directed to the supporting sciences. The Program works closely and derives valuable support from other programs and units at ICARDA.

The three cereal crops on which the Program is working are barley, durum wheat, and bread wheat. The three crops account for about 70% of the area planted to annual food crops in North Africa and West Asia (WANA). All three have their centers of genetic diversity in WANA.

Cereals are of immense importance in the local diet, the consumption of wheat per person being the highest in the world at about 150 kg/year compared with an average of 58 kg/year in developed countries. Total wheat consumption in the countries of North Africa and West Asia has increased at an average rate of 4.5 percent per annum against an average population growth of 2.4 percent, so that per capita consumption has increased by about 2.1 percent per annum. Barley is the main source of animal (mainly small ruminants) feed, however it is also used as human food (up to 50% in some countries) and to some extent for malt.

Cereal production in the region must be seen against a background of chronic and acute deficiency (Table A). The gap between demand for cereals and the capacity of the region to satisfy it is widening under the combined influences of population growth and an increasing requirement for animal products which, in turn, are largely dependent on the consumption of straw and feed grain.

Projected population growth by the year 2010 is estimated to be as high as 3.7% per annum in certain countries of the region, against a world average of 1.19%. A recent analysis of projected trends in population growth, income and food requirements (Khaldi, 1984) in the Middle East and North Africa led to the following conclusions:

1. If past trends continue, the demand for food commodities will continue to surpass projected output, resulting in a gap of about 52 million tons by the end of the century.

2. The wheat deficit, traditionally the largest component of the region's gap in basic staple foods is expected to decline from the total deficit in 1980 to the year 2000. Meanwhile, the gap in coarse grains (mostly barley) is expected to expand rapidly, eventually reaching 36 million tons by the year 2000.

3. Policies to encourage coarse grain production, especially barley and sorghum, in the major food producing countries (Afghanistan, Morocco, Sudan, Syria, Tunisia, and Turkey) would help to adapt production to the rapidly rising demand for animal feed, and narrow the grain gap. Policies to promote the application of yield-increasing technology on drier land could reduce the trade imbalance in coarse grain without affecting wheat production.

Table A. Imports (million metric tonnes) of wheat and barley in the ICARDA region.

	1969-71*	1984-86**
Wheat		
N. Africa	4.0	14.2
W. Asia	4.1	10.6
Barley		
N. Africa	0.2	1.0
W. Asia	0.4	6.5
Total	8.7	32.3

Source:

* FAO Trade Yearbook, Vol. 28, 1974 (grain + flour)

** FAO monthly Bulletin of Statistics Vol. 10, No. 10, 1987.

Barley

Barley is the world's fourth most important cereal crop after wheat, maize, and rice. It is grown on more than 78 million hectares, with a production of more than 175 million metric tonnes, and with an average yield of 2.2 t/ha.

About 22% (or almost 17 million hectares) of the barley is grown in Asia, Africa and South America (Table B) where yields are about 60% of those obtained in North America and about 30% or less than those in Europe.

Table B. Barley area and yield in major regions of the world. (FAO Monthly Bulletin of Statistics).

	Area (million ha)		Yield (t/ha)	
	1969-71	1984-86	1969-71	1984-86
Developed countries				
USSR	21.8	29.7	1.61	1.55
Europe	16.4	18.9	2.95	3.96
North America	8.7	9.5	2.28	2.64
Oceania	2.1	3.2	1.24	1.64
Developing countries				
Asia	12.5	11.2	1.16	1.53
Africa	4.3	5.1	0.88	1.05
South America	1.0	0.6	1.05	1.34

In less developed countries (LDC), the largest barley growing areas are in Asia (66.4%) and Africa (30.2%), while only 3% is grown in South America. The largest barley growing countries in Asia and Africa are China, India, Turkey, Iran, Syria, Korea, Iraq, Afghanistan and Pakistan in Asia, and Morocco, Algeria, Ethiopia, Tunisia, Libya and Kenya in Africa. In the last fifteen years yields have shown only modest increases, or have remained stagnant in almost all the countries with the exception of Turkey, where yields have increased from 1.43 t/ha to 1.98 t/ha.

Of the three cereal crops handled by ICARDA, barley is the only one for which the Center has a global research responsibility from the CGIAR.

Durum Wheat

Durum wheat is a major basic food crop in the North Africa and West Asia region which accounts a significant proportion of the total world production (Table C).

Table C. Area and percentage of durum wheat in different agroecological zones in the ICARDA region.

Area	Irrigated	Well watered (400-550mm)	Semi-arid (<400mm)	Total
Million ha	0.5	3.9	4.7	9.1
%	5.0	43.0	52.0	100

About 8 percent of the total production of wheat in the world is estimated to be durum wheat, occupying approximately 30 million hectare of which about 11 M ha are in developing countries. Of the area planted to durum in the developing countries, which produces approximately 10 M t annually, an overwhelming proportion (80%) is grown in the mandated regions of the Middle East and North Africa with South-East Asia and Latin America together accounting for little more than 20 percent. With the exception of Egypt and Saudi Arabia almost all of the crop is grown without irrigation.

Durum wheat is used to make different products throughout the world. In the WANA region durum wheat is mainly used for bread, burghul, frekeh, couscous, spaghetti, macaroni and other pasta products which have similar grain quality parameters except for bread. Research on durum wheat is conducted as a joint ICARDA/CIMMYT project and is targeted to arid and semi-arid areas of WANA.

Bread Wheat

As one of the world's most important food crops, bread wheat is also the major cereal grown in the ICARDA region. In the period 1984-86, 49.9 M t of wheat were produced in the countries of West Asia and North Africa, of which it is estimated that approximately 75 percent was bread wheat. This represents approximately 10 percent of total world production of wheat. About 77 percent of the bread wheat grown in the ICARDA region is rainfed and approximately 43 percent of the area receives less than 400 mm of rain (Table D). Irrigated bread wheat production within the region is largely concentrated in Egypt, Sudan, Saudi Arabia, and parts of Pakistan, Afghanistan, and Iran.

Table D. Area* and percentage of bread wheat in different agroecological zones in the WANA region.

Area	Irrigated	Well watered (400-550mm)	Semi-arid (<400mm)	Total
Million ha	3.9	5.7	7.3	16.9
%	23.0	34.0	43.0	100

*Excluding Pakistan
Source: Byerlee and Winkelmann, 1981.

On a world basis in comparison with durum wheat and barley, bread wheat is grown under higher rainfall conditions or under irrigation. There are 7.3 million hectares of bread wheat grown under less than 400 mm rainfall in the WANA region. It is for these areas, characterized by stresses such as drought, cold, heat, salinity as well as biotic stresses, that the Bread Wheat Project at ICARDA is a joint project between ICARDA and CIMMYT.

There are considerable areas of wheat and barley grown in the high altitude zone under rainfall of 250-500 mm. The cereals in these areas suffer due to severe cold, moisture deficiency and biotic stresses. The Cereal Program is engaged in the development of suitable germplasm of wheat and barley which will adapt and withstand the severe stresses contributing to present low yield levels in high elevation areas of WANA.

The Environment

The three cereal crops are grown in distinct, although to some extent overlapping, environments defined in terms of growing days (Table E) which integrate rainfall and temperature considerations.

Barley is the dominant crop in areas where rainfall is too low (less than 300 mm) and unpredictable to raise a wheat crop. Wheat is mostly grown in areas receiving between 300-500 mm rainfall. It overlaps with barley at lower end of this range, and with bread wheat at the upper end. Because the moderate to low rainfall areas are characterized by large seasonal fluctuations in precipitation and other climatic and environmental factors, most of the barley and durum wheat grown is at risk and low yields or crop failures are common.

Table E. The main agroecological zones of West Asia and North Africa.

Zones	Rainfall mm/annum	Crop Growing Days	Crop Duration Days
Very dry	< 300	60-140	100-200
Dry	300-400	110-170	130-210
Moderate rainfall	400-500	140-200	150-220
High Rainfall	> 500	170-200	180-240
Highlands	250-500	70-180	200-360

Note: The growing day period concept considers limitation by temperature and water.

Strategy and Accomplishements

The Cereal Program emphasizes the need for a better understanding of yield limiting factors imposed by various environmental and biotic factors in major agro-ecological zones of the ICARDA region. The Cereal Program cooperates with FRMP in this activity and this information is particularly useful to "tailor" genotypes to fit the targeted environment and farming practices. During the last few years research increasingly turned to less favored environments where increased and stable production requires stress tolerant varieties whose phenology must closely match temperature and moisture availability.

The Program increasingly made use of multi-location testing and selection to identify suitable genotypes for different microenvironments and to develop genetic material with increased yield and stability of production. Selection techniques and methodologies have been developed and refined. Examples are the different time of sowing to expose the material under selection to different stresses at different phenological stages and the increased use of experimental designs better suited to handle environmental variation. The impact of this strategy is now being realized in the conspicuous and increasing proportion of entries giving evidence of better adoption under stress conditions in nurseries and comparative yield trials in the region.

These methodologies have allowed the development of a breeding philosophy based on the principle that germplasm for specific stresses is difficult to identify unless the material under selection is exposed to those stresses. Among the most recent achievements of the Program are 1) the increasing evidence that 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) the emerging evidence that water use efficiency can be both genetically and agronomically manipulated.

To meet the challenge of the harsher environments the Program made an increasing use of landraces and wild relatives with a strong focus on the preservation and utilization of the variability harbored by these genetic resources. Stresses commonly encountered within the ICARDA region include drought, heat, cold, insects and pathogens. To help national scientists utilize their resources more efficiently, germplasm developed at ICARDA is distributed in the form of international nurseries targeted for different agroecological zones or stresses commonly encountered in the region. During 1986-87 the proportion of genetic stocks, trait specific or special purpose nurseries, and segregating populations supplied to national programs considerably increased and the supply of finished lines was reduced.

International nurseries were further tailored for low and moderate rainfall areas (in lowlands) and for high altitude areas. The Heat Tolerance Observation Nursery, one of a series of trait specific nurseries, was assembled. Promising lines nominated by national scientists were included in the observation nurseries for the first time. The proportion of field books returned from cooperaters reached a record level: 59% for observation nurseries and 67% for yield trials. Cluster analysis and regression were carried out on the grain yield data of the 1985/86 regional yield trials to further aid breeders target their varieties to specific environments.

The Cereal Program (CP) aims to deploy genetic resources locally adopted landraces and, especially wild types, more effectively, to concentrate efforts on the production of genotypes more resistant or tolerant to stresses for the drier zones and harsher environments of high altitude areas, and to understand the underlying mechanisms that contribute to improved farming systems. A closer matching of new cereal varieties with livestock requirements is underway, as shown by work on total biological yield and straw quality in barley.

Through cooperation and training an increasing part of the development of varieties and the matching of genotypes to differing environments is being undertaken by the more advanced NARS, especially in the more favorable rainfall areas. The Program is encouraging development of 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 lines for areas with mild winters and low rainfall, Egypt assumed specific responsibility to identify aphid resistant germplasm and Turkey is capable of assuming greater responsibility in high elevation cereals research. In such networks, ICARDA brings scientists together, discusses direction to research, and assists the transfer of results among national programs.

Over the years approximately 26 barley, 26 durum wheat, and 30 bread wheat releases have been made by various national programs (Table F) in the region. However, the results of research for drier areas have started to pay dividends. Sham 1, a durum wheat first released by Syria in 1983-84, has experienced a logarithmic increase in production by the Syrian national seed production organization, which started out with 20 tons of seed supplied by ICARDA in 1984 and distributed 9000 tons of that variety in 1986-87. A similar situation is occurring for barley varieties jointly developed by ICARDA and the Tunisian National Program. The release of Sham 3, (Korifla) a durum wheat identified by Syria as an improved variety for the B Zone where locally adapted land cultivar, Haurani, has been successfully grown for many centuries, is a major achievement and indicates the success of breeding philosophy for severely stressed environments.

The evaluation of about 2500 barley genotypes in three contrasting environments has 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. 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 progenitors for wheat such as Aegilops and other members of Triticae, selected trait-specific germplasm of durum wheat were provided to evaluators based at national programs through a network of cooperating institutions.

In collaboration with advanced institutions in France and Japan work on haploid breeding using anther culture and H. bulbosum technique was initiated. Facilities for in-vitro techniques are being developed. An H. bulbosum nursery initially comprised of 206 accessions was established. Further accessions are being added and evaluated for agronomic traits and potential use in haploid breeding of barley and wheat.

Two high yielding bread wheat lines, ICWH81-1610 and ICWH81-1781, with a high level of cold tolerance and a phenology suited to high altitude environments of Pakistan and Iran were identified for national testing. A breeding strategy based on primordium development and other screening methods for cold and drought tolerance has been developed to generate improved germplasm for high altitude environments. An international symposium on cereal production in high altitude areas was held at Ankara, Turkey. The national program participants from countries with major high altitude areas agreed to develop and participate in a network of cereal improvement for such areas. Six main ecological zones with major research stations were identified.

During the season, stress physiology research was considerably strengthened with the objective of supporting breeding programs in methodologies of selection for abiotic stresses. Work on gas-exchange of barley and wheat genotypes under drought consistently showed that barley has higher leaf transpiration efficiency. Furthermore, barley genotypes continued to photosythesize at stress levels at which the stomata of wheat are fully closed. At a crop level, below 300 mm, 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 potentially powerful screening tool for cereal improvement in dry areas.

Several barley and wheat germplasm pools for major diseases such as yellow rust, bunt, septoria and scald have been developed and are available to breeders. Seedling screening techniques were developed to detect partial resistance to scald and barley leaf stripe. Genotypes with multiple disease resistance were identified and made available to NARS. Work on seedling screening for diseases increased with the availability of controlled environment chambers.

Similarly, genetic stocks possessing resistance to wheat stem sawflies, aphids, and Hessian fly were assembled and are being used by breeders in crossing programs. Cooperative efforts with national program scientists in the Nile Valley region and North Africa were consolidated. Future work will concentrate on developing integrated management strategies for farmers for specific cereal pests using data generated at ICARDA and by collaborating scientists.

The training offered this year was diversified to meet the changing needs of national programs in cereal improvement. During 1986-87 ICARDA cereal scientists trained over 150 research workers from the region. In addition to the regular residential course and the in-country training courses in Algeria and Ethiopia, four specialized short courses were conducted at ICARDA in barley improvement, cereal diseases, cereal landraces and wild relatives, and statistical data analysis. Emphasis was also placed on individual training both for nondegree participants as well as graduate students from national universities. Visits of regional scientists to the program are contributing to better communication and further enhancement of ICARDA's collaboration with the national programs.

Program and national program scientists, participated in and organized international symposia and workshops. This is a natural consequence of the evolution of the Program from essentially an applied plant breeding project to a center of training and expertise on improving barley and wheat through strategic research for a region in which physical and biotic environment is often harsh and challenging. During 1986/87 need for collaborative research with advanced institutions in areas of basic research was emphasized and several working partnerships were established.

A dynamic crop improvement program must be able to gradually adjust its priorities to the changing needs of the clients. Over the past several years both as a result of internal reassessment of priorities and of external suggestions, a number of activities were terminated (work on triticale and dual purpose barley, activities in Pakistan after they resulted in the implementation of the AZRI Project, and activities in Jordan), other activities were reduced (presence of scientists in Tunisia, work on standard agronomic practices). Some activities were emphasized (cooperation with North Africa, Turkey, Iran, Ethiopia, breeding for earliness in Cyprus, breeding for dry areas, use of landraces and primitive forms of germplasm, cooperation with advanced Institutions) and training. Some new activities were initiated, insect pest management in the region, stress physiology research, use of new techniques and non-conventional germplasm. The policy of adjusting Cereal Improvement Program activities according to the evolving needs and capabilities of NARS, and to the availability of new advanced technologies will continue.

Major findings from the Program's diverse projects are presented on the following pages. Also included is an inventory of the Program's collaborative activities during 1986/87. Much of this report's content is being further refined for publication in scientific journals.

J.P. Srivastava

Table F. Cereal varieties released by national programs.

Country	Year of release	Variety
Barley		
China	1986	Gobernadora
Cyprus	1980	Kantara
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
Jordan	1984	Rum (6-row)
Mexico	1986	Mona/Mzq/DL71
Morocco	1984	Asni
		Tamellat
		Tissa
Pakistan	1985	Jau-83
	1987	Jau-87
	1987	Frontier 87
Portugal	1982	Sereia
	1983	CE 8302
Qatar	1982	Gulf
	1983	Harma
S. Arabia	1985	Gusto
Spain	1987	Rihan
Syria	1987	Furat 1113
Tunisia	1985	Taj
		Faiz
	1987	Rihane"S"
Yemen AR	1986	Arafat
		Beecher
Durum wheat		
Algeria	1986	Sahl
		Waha
	1982	ZB S FG'S'/LUKS GO
	1984	Timgad
Cyprus	1982	Mesoaria
	1984	Karpasia
Egypt	1979	Sohag
Greece	1982	Selas
	1983	Sapfo
	1984	Skiti
	1985	Samos
	1985	Syros

Lebanon	1987	Belikh 2
Libya	1985	Marjawi
		Ghuodwa
		Zorda
		Baraka
		Qara
		Fazan
Morocco	1984	Marzak
Portugal	1983	Celta
Saudi Arabia	1987	Sham 1
Syria	1984	Sham 1
	1987	Sham 3
	1987	Bohouth 5
Tunisia	1987	Razzak
Bread wheat		
Algeria	1982	Setif 82
		HD 1220
Egypt	1982	Giza 160
Ethiopia	1984	Dashen
		Batu
		Gara
Greece	1983	Louros
		Pinios
		Arachthos
Iran	1986	Golestan
		Azadi
Libya	1985	Zellaf
		Sheba
		Germa
Morocco	1984	Jouda
		Merchouche
Portugal	1986	LIZ 1
		LIZ 2
Sudan	1985	Debeira
	1987	Wadi El Neel
Syria	1984	Sham 2
	1986	Sham 4
	1987	Bohouth 4
Tunisia	1986	Snb'S'
Yemen AR	1983	Marib 1
	1988	Mukhtar
	1988	Aziz
	1988	Dhumran
Yemen PDR	1983	Ahgaf

2. Germplasm Development

2.1. Barley Breeding

Introduction

Barley is the fourth most important cereal crop, after wheat, maize, and rice, and is one of three crops for which ICARDA has global responsibility among IARCs.

Barley is utilized in three ways, as animal feed, as human food, and for malting. It is used directly in the human diet in South America, some African countries (such as Morocco and Ethiopia) and Asia (Pakistan, India and China), while in many other underdeveloped countries it is mainly grown as a source of animal feed. In these countries straw yield is a very valuable crop output, and straw quality is an important attribute of a successful crop.

Based on the most frequent climatic stresses limiting crop yields, five major agroclimatic zones can be identified where barley is grown in developing countries. Although in the following classification the term of reference for drought is the average annual rainfall, it must be emphasized that rainfall distribution is at least as important, if not more important, than the total amount of rainfall. On this basis the major agroclimatic zones where barley is an important crop are:

a) Areas with low (less than 250 mm) average annual rainfall and where low temperatures in winter and high temperatures during grain filling, represent the "stress package" responsible for low crop yields and frequent crop failures. Examples of such areas are many countries of West Asia, and the continental part of many North African countries. It is estimated that almost 4 million hectares (or 25% of the total barley growing area in developing countries) fall in this category (Ceccarelli and Mekni, 1985).
b) Areas with moderate (between 250 and 350 mm) annual rainfall, where temperatures in winter are milder, and soil fertility is usually higher than in the areas under a). Examples of such areas are the coastal regions of north-east African countries. Although occasionally dry years may cause substantial yield losses, the major production constraints in these areas are the susceptibility to lodging and diseases, and the low yield potential of the traditional cultivars still widely grown.
c) High elevation areas with a continental-mediterranean type of climate. Those areas are characterized by long cold winters, and hot, dry springs. About 5.8 million hectares of barley are grown in this ecological area, both in North Africa (Morocco and Algeria), and in West Asia (Turkey, Iran, Iraq, Afghanistan, and Pakistan). The major production constraints are moisture deficit (200-300 mm annual rainfall), poor soil fertility, and very low temperatures in winter. With the exception of the Central Anatolian Plateau of Turkey very few,

or no research efforts have been made to increase barley productivity in these resource-poor farming systems.

d) areas with a subtropical type of climate, where the single major yield limiting factor is disease and pest susceptibility. Examples of these areas are in South America, Central Africa, and the Himalayan belt. Although the total area is not very large (1.5 million hectares), in those areas barley is a typical crop of poor, subsistence farmers who use the grain in their diet, and the straw as animal feed. In those areas barley is an essential crop to the farmers, and factors affecting barley production have serious effects on farmers' life. An example is offered by the massive urbanization of Andean farmers after the epidemics of yellow rust on barley in the late 70s. Barley improvement for these areas is a specific responsibility of the CIMMYT-ICARDA Barley Project, based in Mexico.

e) Areas where barley is grown on moisture stored in the soil from a previous rainy period. Examples of those areas are most barley growing areas in the Indian sub-continent.

China, which grows about three million hectares of barley, fits in areas b), c), and d), since barley is grown in a multitude of environments which differ for both elevation and rainfall.

The structure of the barley breeding project at ICARDA (Fig. 1) reflects the main agroecological environments (hereafter referred to as macro-environments) where barley is grown. Activities of the Aleppo-based barley project are mostly addressed to three macro-environments: areas receiving less than 250 mm rainfall (dry areas), areas receiving between 250 and 400 mm (moderate rainfall areas), and high elevation areas with a continental-mediterranean type of climate. The Mexico-based barley project addresses high elevation areas in a subtropical climate, with Latin America receiving regional priority. In terms of germplasm development the Mexico-based project is strongly oriented towards short-season barleys, adapted mostly to mild winter environments. Therefore barley lines developed by the Mexico based project are well adapted also outside Latin America.

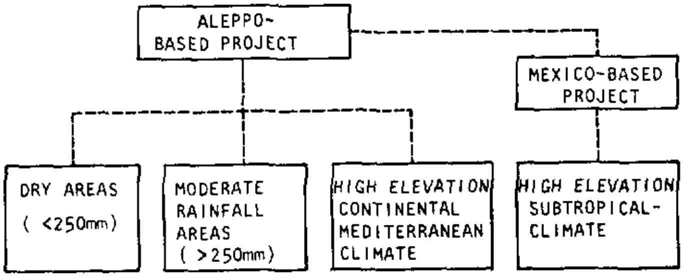

Fig. 1. The structure of the barley breeding project at ICARDA and target environments.

With the exception of areas with moderate rainfall, barley is mostly grown under stress, frequently severe. The major stresses are climatic (drought, cold, and heat), biotic (diseases and insect pests), and edaphic (problem soils, poor soil fertility, low-input crop management). In areas with moderate rainfall climatic and edaphic stresses are usually not as severe as in other macro-environments while biotic stresses are more important.

Remarkable progress in raising barley yields has been made in mildly stressed environments through joint efforts between breeding and agronomy. However, in less favourable environments where yield is limited by a number of stresses and where it is difficult to improve agronomic practices due to inherent low productivity, very little (if any) yield increase has been achieved in the last 20-30 years (Fig. 2). Yet in these unfavourable conditions barley is the most dependable and often the only possible crop.

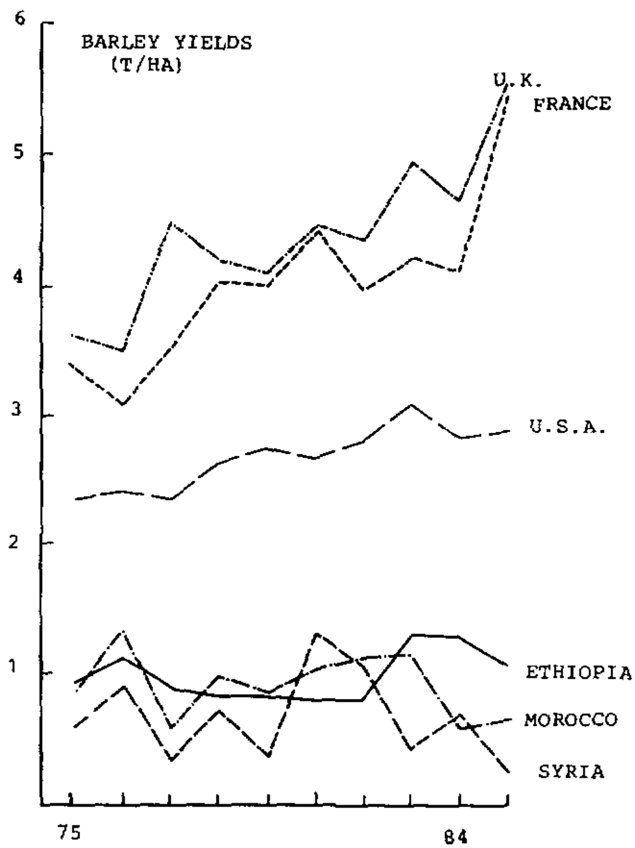

Fig. 2. Barley production (t/ha) during 1975-1984 in three developed and three developing countries.

The overall objective of the barley breeding project is "to assist national programs to increase barley production through the development and dissemination of improved germplasm and production technology, and more efficient research methodologies."

To reach this objective the following areas of research are being pursued:

1. Continuous upgrading of the level of resistance to diseases and insect pests.
2. Development and refinement of selection methodologies to improve selection efficiency, especially for severe stress conditions.
3. Development and free dissemination of widely diverse genetic stocks including lines with high diastatic power (malting), and with high protein and lysine (food) to meet the differing requirements of national programs.
4. Training of national program scientists.

Breeding Strategy

The strategy followed by the barley breeding project is to select genotypes for their stability of performance (grain yield and/or total biological yield, depending on the specific macro-environment) within a given macro-environment irrespective of their performance across different macro-environments (Fig. 3). The information generated during 1984/85 and 1985/86 in dry and moderate rainfall areas, has indicated a higher scope for genetic improvement by selecting for yield and stability within macro-environments rather than across them. This is supported by data showing that maximum yield in dry areas and in moderate rainfall areas is associated with different morphological and mostly physiological characters (see also Section 7.2. Physiology/Agronomy). Furthermore, it has been shown that selection for performance across macro-environments almost systematically leads to discarding the top yielding genotypes within macro-environments.

This approach is based on the belief that it is irrelevant to breed genotypes for environmental conditions having a very low probability of occurrence. For example, the conditions (rainfall amount and distribution, temperature pattern in winter, soil fertility, agronomic practices) conducive of yields of above 3 t/ha are rare events in areas with a long-term average rainfall below 250 mm.

In dry areas efforts to reduce the frequency of crop failures seem more justified than efforts to incorporate a high yield potential which will be rarely (if ever) expressed.

In moderate rainfall areas, where yields of 2.5 - 3.0 t/ha are not uncommon in farmers' fields, efforts to raise yield potential and increase resistance to diseases and to lodging appear to have a priority over breeding for the ability to cope with severe levels of physical stress.

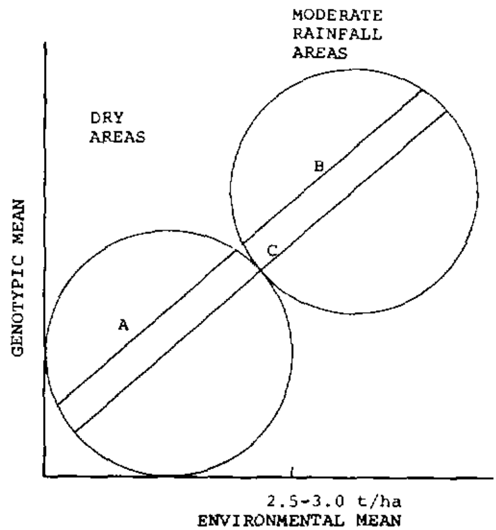

Fig. 3. Genotypes with high yield and stability within macroenvironments (such as A and B) are selected regardless of their performance across macroenvironments. Genotypes such as C are in general less productive than A in dry areas and less productive than B in moderate rainfall areas.

Breeding Methods

The breeding methods used in the barley breeding project are:

1. The bulk-pedigree, mostly for dry areas.
2. The pedigree, mostly for more favourable environments.
3. Pure-line selection, used only within locally adapted germplasm, such as landraces.
4. Back-cross, for the transfer of specific characters into desirable genetic backgrounds.

Most of the breeding work is based on the empirical approach, i.e. selection for either grain yield or total biological yield under field conditions. Because it is impossible to rely on one year-one location results due to the variability in the timing and severity of both moisture and temperature stresses the genotypes under selection are exposed to a multitude of environments (locations and years) which can provide the spectrum of variation to which the future variety is likely to be exposed.

Similar to the previous two cropping seasons, all breeding material was evaluated at three ICARDA stations located within Aleppo province, with the exception of the segregating populations which are followed with the pedigree method. The three stations provide a gradient of rainfall ranging from a long term average of about 350 mm (Tel Hadya), to 240 mm (Breda), to 175 mm (Bouider). The three stations also provide a soil fertility gradient which decreases from Tel Hadya, to Breda and to Bouider, and of winter temperatures, with Bouider generally colder than Breda and Tel Hadya.

The climatic conditions during the 1986/87 cropping season at the three sites were different from the previous two cropping seasons (see ICARDA Annual Report for 1985, and ICARDA Annual Report for 1986). Although the total amount of rainfall was close to the long term average at Bouider (164.0 mm), Breda (244.6 mm), and Tel Hadya (342.9 mm), rainfall distribution was poor and low temperatures in winter imposed an additional, although not unusual stress. After emergence the crop was affected by six weeks of drought (especially severe at Breda and Bouider) followed by a long period of low temperatures (Table 1), which lasted until the end of March.

Table 1. Number of frost days and minimum temperatures at Bouider, Breda and Tel Hadya during 1986/87.

Month	BOUIDER		BREDA		TEL HADYA	
	N of frost days	Min. (°C)	N of frost days	Min. (°C)	N of frost days	Min. (°C)
November 1986	17	-4.0	12	-4.0	7	-2.3
December 1986	17	-8.0	17	-8.0	16	-6.8
January 1987	6	-2.0	8	-2.0	6	-2.1
February 1987	2	-0.6	0	-	0	-
March 1987	10	-5.6	6	-2.7	7	-3.4
Total	52		46		36	

A second dry period occurred during grain filling. The low temperatures during winter, when moisture was not limiting, prevented crop growth to the extent that ground cover at the end of March was poor especially at Bouider. As a result the crop failed, and in most dry areas was grazed by sheep or hand-harvested. Because of this and in spite of the very low yield, we have measured both grain yield and total biological yield on 1 m^2 samples in both the preliminary and advanced yield trials at our driest experimental station (Bouider). In the initial yield trials the 1656 genotypes evaluated at Bouider were scored from 1 (the best) to 5 (the poorest). At Breda and Tel Hadya all trials were combine-harvested.

In addition to these locations, most advanced yield trials were evaluated at Terbol (Lebanon), Athalassa (Cyprus), Le Kef (Tunisia) and Merchouch (Morocco). Data from the last two locations were not available in time to be included in this report. The experimental designs adopted for the yield trials were the modified augmented design (Biometrics, 39: 553-561) for the initial yield trials, and the lattice design for both the preliminary and the advanced yield trials. The use of the lattice design in place of the randomized block design allowed a 23% reduction in the total number of plots (from about 21000 to about 16000) without reducing the total number of genotypes under evaluation and without sacrificing the level of precision. Table 2 shows the type of material evaluated during 1986/87.

Table 2. Barley breeding: materials evaluated during 1986/87 under direct supervision of ICARDA staff (with the exception of Cyprus).

Materials	Locations
F_1	Tel Hadya
Segregating Populations (F_2 - F_n)	Tel Hadya
Landraces	Bouider, Tel Hadya
Initial Yield Trials	Bouider, Breda, Tel Hadya
Preliminary Yield Trials	Bouider, Breda, Tel Hadya
Advanced Yield Trials	Bouider, Breda, Tel Hadya, Cyprus, Terbol, Merchouch, Le Kef
Crossing Blocks	Tel Hadya
Observation Nurseries	Bouider, Breda, Tel Hadya,
Regional Yield Trials	Bouider, Breda, Tel Hadya, Terbol, Cyprus, Perugia

Germplasm Development

During April-May 1987 a total 1872 crosses were made, 1144 at Tel Hadya and 728 at Terbol. The different types of crosses for each type are listed in Table 3.

Table 3. Type and number of crosses made during 1987.

Type of cross	Number of Crosses
1) High yielding x High yielding	318
2) Early x Early	199
3) Early x Drought resistant	136
4) Drought tolerant x Heat tolerant	126
5) Spring x Winter	131
6) Improved x High yielding landraces	402
7) Landraces SC resist. x Landraces PM resist.	81
8) Disease resistance	83
9) Landraces high yield. x landraces high yield.	40
10) High x Low number of seedling roots	16
11) *H. vulgare/H. spontaneum//H. vulgare*	56
12) *H. spontaneum/H. vulgare*	32
13) Three way crosses	38
14) Double crosses	214
Total	1872

Crosses of groups 1, 8, 13, and 14 (653 crosses, or 34.9% of the total) were mostly targetted for moderate rainfall areas. Although the number of crosses specifically designed to either incorporate or combine sources of disease resistance (Group 8) may appear low, one or both parents in many crosses of other groups carry the resistance to one or more diseases. Crosses of groups 2, 3, 4, 7, 11, and 12 (630 crosses, or 33.7% of the total) were mostly targetted for dry areas. Crosses of group 5 (131 crosses, or 7.0% of the total) were specifically targetted for high elevation areas with a continental-mediterranean type of climate. Crosses of groups 6 and 9 (442 crosses, or 23.6% of the total) are expected to generate useful recombinants for the three macro-environments the Aleppo-based project services. The 16 crosses of group 10 were designed to study the inheritance of the number of seedling roots. This is an attempt to genetically manipulate this constitutive character to increase yield stability in severe stress conditions.

Germplasm Evaluation

Among the most significant findings of the last two cropping seasons was that grain yield under moderate rainfall conditions (about 350 mm) is not a useful selection criterion for identifying genotypes suitable for areas with less than 250 mm rainfall. Although some genotypes can be found which perform well in both macro-environments, their frequency is very low. It was also found that selection for grain yield under severe stress conditions has an efficiency of about 25%, three times higher than that of indirect selection (selection for grain yield in more favourable conditions). Also it was found that the utilization of adapted germplasm, such as landraces and wild relatives such as Hordeum spontaneum, is a promising avenue in barley breeding for dry areas. Because of the impact these results might have on breeding strategies, priorities assessment, and resources allocation, 1986/87 data were primarily analyzed to further test the hypothesis originating from the findings of the the previous two cropping seasons. Furthermore we attempted an evaluation of progress of selection under stress conditions using three years data, because breeding in stress conditions is still highly controversial, and because progress in moderate rainfall areas (>250 mm rainfall) has been fairly rapid. This is shown by release of barley varieties and by the large-scale testing of potential new varieties by a number of countries (see Section 9. International Nurseries). To maintain the necessary continuity in the barley breeding program, 1987 results will be presented within the framework of past years achievements, and will be integrated when necessary with previous results. The order of presentation will be as follows

- Barley breeding for moderate rainfall environments.
- Performance within and across environments.
- Response to selection:
    a) Improved germplasm
    b) Bulks
    c) Landraces
    d) The case of Tadmor
- Mexico-based project.

Barley Breeding for Moderate Rainfall Environments

As mentioned earlier, progress has been fairly rapid in developing suitable germplasm for this type of macroenvironment. After the assembly of different sources of germplasm during 1976-77, a large number of crosses designed to incorporate disease resistance, yield potential, earliness, and resistance to lodging were made. The results of that work began to be evident during the last few years when a number of lines, such as Rihane sister lines, Harmal, ER/Apm, Avt/Aths, have been identified by national programs and released as varieties (for a detailed list see Table A). New lines are being identified in the regional yield trials (see Table 23) which outyield significantly the national check in a number of countries. The development of germplasm for this macroenvironment will continue at the same level as in the past, with an increased emphasis being given to multiple disease resistance (see Pathology Section), and to earliness. In the future an increasing amount of more conventional selection work will be carried out by national programs, while an increasing use of advanced techniques will be made at ICARDA.

The results presented below refer to progress being made both in dry areas and in moderate rainfall areas

Performance of Barley Lines Within and Across Environments

The results which will be discussed in this section are mostly derived from initial, preliminary, and advanced yield trials. The number of genotypes evaluated during 1986/87 in the Initial, Preliminary, and Advanced Yield Trials was 1656, 520, and 400, respectively. The experimental design was a 6X6 modified augmented design (with 276 lines and 48 checks) in the case of the initial yield trials, and the lattice design (triple lattice at Bouider and simple lattice at all other locations) in the case of preliminary and advanced yield trials. There were 6 initial yield trials which were analyzed individually, since no combined analysis is available for the modified augmented design, 26 preliminary yield trials, and 20 advanced yield trials. Fifteen advanced yield trials were also evaluated at Terbol, Cyprus, Tunisia and Morocco.

In all yield trials the following characters were measured:

1. Growth vigour (1=good 5=poor)
2. Cold damage (1=no damage 5=maximum damage). At Bouider this score was taken twice.
3. Plant colour (1=pale 2=intermediate; 3=dark green).
4. Growth habit (1=erect; 5=prostrate).
5. Days to heading (days from emergence to awn appearance).
6. Days to maturity (in days from emergence to complete discoloration of the peduncle).
7. Grain filling duration (difference between days to maturity and days to heading).
8. Agronomic score (1=good 5=poor), taken only in the initial yield trials, in 13 of the 20 advanced yield trials evaluated at Bouider, and at Cyprus.
9. Plant height (in cm excluding the spike).
10. Grain yield (on a 1 m^2 sample in the preliminary and advanced yield trials evaluated at Bouider, and on the whole plot at all other locations).
11. Total biological yield (only in the advanced yield trials evaluated at Bouider and Breda).

Initial Yield Trials

In the six initial yield trials the 164 lines with the best agronomic score at Bouider were compared with the 191 lines with the highest grain yield at Tel Hadya. The lines with the best agronomic score at Bouider had a significantly (P< 0.01) lower agronomic score than the lines selected at Tel Hadya (Table 4). However at Tel Hadya, the lines selected for agronomic score at Bouider always had a significantly (P<0.01) lower grain yield than the lines selected at Tel Hadya. Only 19 of the 191 lines with the highest grain yield at Tel Hadya were included in the 164 lines selected for agronomic score at Bouider.

Table 4. *Agronomic score (1=good; 5=poor)* and grain yield (kg/ha) of 164 barley lines selected for agronomic score at Bouider and of 191 lines selected for grain yield at Tel Hadya. Initial Yield Trials, 1987.

Selection Site	Selection Criterion	TRIALS 1	2	3	4	5	6
				AGRONOMIC SCORE-BOUIDER			
Bouider	Agr.Score	1.43	1.52	1.66	1.66	1.58	1.54
Tel Hadya	Grain Yield	4.09	3.61	3.50	3.34	3.21	2.65
		***	***	***	***	***	***
Population mean		3.65	3.61	3.50	3.34	3.21	2.65
				GRAIN YIELD-TEL HADYA			
Bouider	Agr.Score	2647	2932	2332	3037	2536	2078
Tel Hadya	Grain Yield	3831	3925	3854	3642	3605	3047
		***	***	***	***	***	***
Population mean		2809	2815	2621	2754	2292	2194

***P<0.01, t-test

Preliminary Yield Trials

Both in the preliminary and advanced yield trials grain yields at Bouider were extremely low and could be measured only by hand harvesting a random 1 m^2 sample in each plot (Table 5). Grain yield averaged 56.3 kg/ha (with a maximum of 530.6 kg/ha) in the preliminary yield trials, and 32.3 (with a maximum of 169.5 kg/ha) in the advanced yield trials. Total biological yield averaged 812.8 kg/ha at Bouider (with a maximum of 1958.1 kg/ha), and 1496.2 kg/ha at Breda (with a maximum of 2997.2 kg/ha). These results show that even in an extremely dry season, and in sites with less than 250 mm rainfall it is possible to find a wide range of both grain yield and total biological yield.

The three locations had a mean yield lower than usual. While the lower yields at Bouider and Breda may be attributed to the adverse climatic conditions, the lower yields at Tel Hadya may be attributed to limited fertilizer applications during the last two cropping seasons. This was purposely done to reduce the level of soil fertility at the main station, where grain yields over the last few cropping seasons appeared to be unrealistically high compared with those in farmers' fields.

A number of lines were identified in the preliminary yield trials with a higher grain yield than the local check (Table 6). The lines outyielding the local check at Tel Hadya yielded an average of 3106.3 kg/ha (with a maximum of 4314.9, Table 5), which was almost 1 t/ha more than the lines selected at Bouider. However, the highest yielding lines at Tel Hadya yielded a meagre 53.3 kg/ha at Bouider, slightly less than the mean of all the lines (56.3 kg/ha, Table 5), and four times less than the average grain yield of the lines outyielding the local check at Bouider (220.6 kg/ha).

Table 5. Grain yield (GY) and total biological yield (TBY) in kg/ha of 520 barley lines evaluated in the preliminary yield trials, and of 400 barley lines evaluated in the advanced yield trials at three locations (1986/87).

Location	Rainfall		Preliminary Yield Trials		Advanced Yield Trials	
			Mean	Range	Mean	Range
Bouider	164	GY	56	0-531	32	0-170
		TBY	-	-	813	240-1958
Breda	245	GY	523	0-1136	671	66-1398
		TBY	-	-	1496	552-2997
Tel Hadya	343		2250	905-3526	2655	554-4315

Table 6. Grain yield* (kg/ha) of barley lines outyielding local cultivars at each testing site (Preliminary Barley Yield Trials, 1987).

Selection		Testing site		
Site	N	Bouider	Breda	Tel Hadya
Bouider	43	220.6 a	585.3 b	2173.4 c
Breda	40	88.3 b	871.1 a	2289.2 bc
Tel Hadya	28	53.3 c	572.2 b	3106.3 a

* Values followed by different letters are significantly ($P<0.05$) different, based on t-test.

Only one (3.6%) of the 28 lines selected at Tel Hadya was also selected at Bouider. By contrast the lines which gave the highest yield at Bouider, yielded only 2173.4 kg/ha at Tel Hadya, significantly less than the highest yielding lines at Tel Hadya (3106.3 kg/ha).

Plant colour and days to heading (Table 7) were the only characters for which significant differences were found between the top yielding lines at Bouider and the top yielding lines at Tel Hadya. The top yielding lines at Bouider were paler and headed earlier than the top yielding lines at Tel Hadya.

Table 7. Agronomic characters of the highest yielding lines at Bouider and Tel Hadya in the preliminary yield trials (1986/87).

Character	Testing Site	Highest Yielding Lines at: Bouider	Tel Hadya	Diff.
Cold Tol.(1-5)+	BO	2.91	2.83	n.s.
Cold Tol. "	BR	2.67	2.66	n.s.
Vigour "	BO	2.63	2.84	n.s.
Vigour "	BR	3.03	3.22	n.s.
Vigour "	TH	2.75	2.86	n.s.
Color "	TH	1.88	2.27	***
Heading (days)	BO	168.4	175.9	*
Heading (days)	BR	148.1	150.9	**
Heading (days)	TH	131.9	133.6	**

BO-Bouider; BR-Breda; TH-Tel Hadya. n.s.=not significant
*(P<0.05); ** (P<0.01); *** (P<0.01).
+see pg. 10 for details.

Advanced Yield Trials

Among the 400 genotypes evaluated in the 20 advanced yield trials, 313 were improved lines and F_5 bulks derived from two cycles of selection, and 87 were pure lines selected from Syrian landraces. In the first 15 yield trials (300 genotypes) evaluated at 5 locations there were 226 (75.3%) improved lines and 74 (24.7%) lines derived from landraces.

Advanced Yield Trials at 5 Locations

The average grain yield of the best 30 lines (selection pressure=10%) at each of the five locations where the first 15 yield trials were evaluated ranged from as little as 0.1 t/ha at Bouider to more than 5 t/ha at Terbol (Table 8).

Table 8. Grain yield and total biological yield (in brackets), in kg/ha, at five different locations of the top 30 advanced barley lines. (Selection pressure = 10%).

Selection site	Testing Site				
	Bouider	Breda	Tel Hadya	Cyprus	Terbol
Bouider	100.4 (985.6)	853.3 (1688.7)	2726.3	3280.4	2892.5
Breda	54.4 (826.5)	1002.4 (2036.4)	2603.5	3387.7	2972.9
Tel Hadya	29.8 (865.7)	668.1 (1483.0)	3493.7	3450.4	3328.9
Cyprus	36.8 (825.6)	738.4 (1639.5)	2809.5	4600.2	3532.1
Terbol	24.7 (811.9)	604.1 (1349.6)	2875.6	3381.8	5202.0
best check	67.3 (1246.4)	768.2 (1594.4)	3450.2	4138.8	3482.2
Population Mean	29.9 (811.5)	676.2 (1510.4)	2667.1	3106.3	3092.5

Similar to results of both the initial and the preliminary yield trials, the highest yielding lines under severe stress conditions (Bouider and Breda) had a low yield potential under mild stress conditions (Tel Hadya, Cyprus, and Terbol). As the site mean increases, the difference between the grain yield of the best lines under mild levels of stress and the best lines under severe stress conditions also increases (Table 9).

Table 9. Difference between yield under mild levels of stress and grain yield under severe levels of stress at different yield levels, estimated as site means.

Site Means (means of 260 Lines, kg/ha)	Difference between yield potential and yield under severe stress (kg/ha)
29.9	2792.2
676.2	2918.5
2667.1	3299.1
3092.5	5177.3
3106.3	3495.3

A similar pattern is suggested by regression analysis (Fig. 4). The highest yielding lines at Bouider and Breda had the largest intercepts and the lowest regression coefficients, while the highest yielding lines at Tel Hadya, Cyprus, and Terbol had a negative intercept and a regression coefficient larger than 1. The highest yielding lines at the highest yielding sites were the top yielding even when the environmental mean was around 1 t/ha, a much lower value than the 2.5-3.0 t/ha found from the analysis of 1984/85 and 1985/86 data (Ceccarelli, S., 1987 - Selection for specific environments or wide adaptability?). The difference is likely due to the lower maximum yield (2.6-3.1 t/ha) obtained in 1986/87, as compared with 1985/86 (4.0 t/ha at Tel Hadya, and 7.3 t/ha at Terbol).

As shown in Fig. 5 (from Ceccarelli, S., Wide adaptation: how wide?) at yield levels around 2.6-3.1 t/ha there is no difference between the best genotypes under severe stress and the best genotypes under moderately favourable conditions. Therefore it is

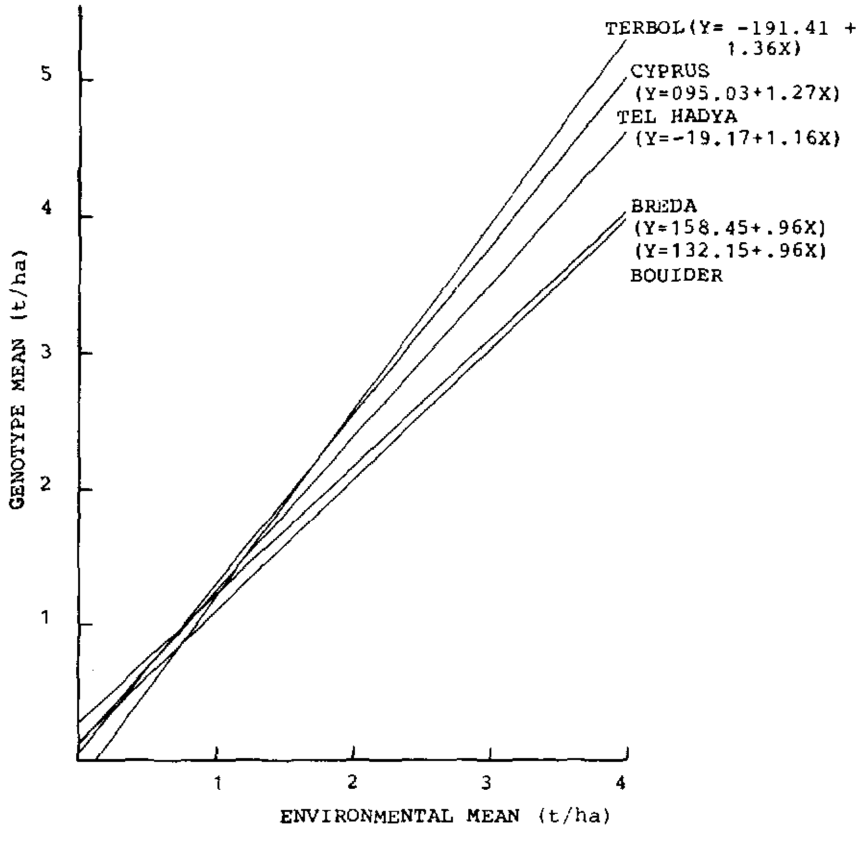

Fig. 4. Linear regression of the grain yield of the 10% top yielding lines at each of five locations on environmental means (averages of 260 lines).

not surprising that the selection at this yield level can identify genotypes which can maintain their superiority at a much lower yield level than the best genotypes selected at a much higher yield level.

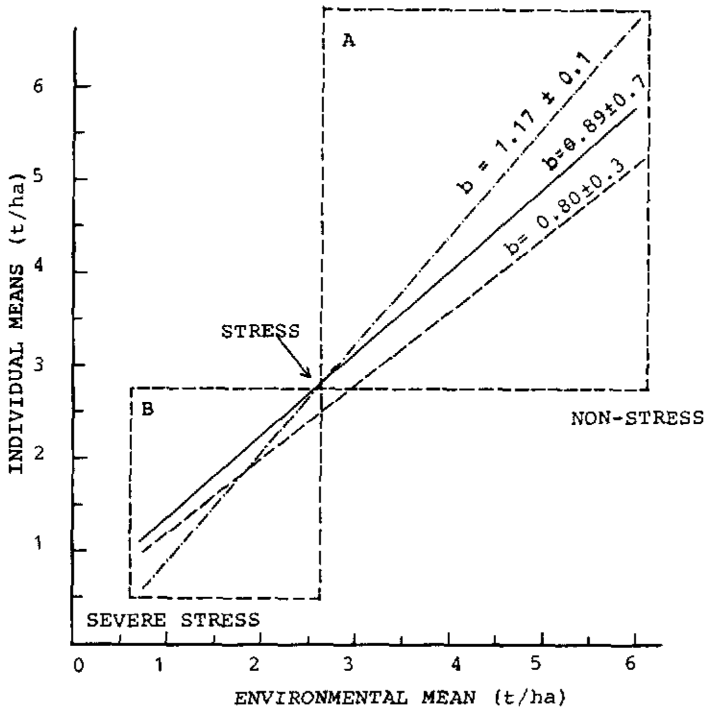

Fig. 5. Grain yield in kg/ha of F_4 bulks of barley from 5 contrasting environments. Regression lines refer to F_4 bulks selected in a 5-6 t/ha environment (—·—·—·), and in a 1.5-2.0 t/ha environments (———), and to a landrace (- - - -). (1985/86 data).

Two interesting aspects related to the data of Table 8 are the frequency of pure lines selected from landraces (thereafter referred to as landraces-lines) included in the top yielding 10% at each location, and the frequency of lines selected simultaneously at more locations. The pure lines derived from two cycles of selection within Syrian landraces were 76.7% and 60.0% of the top yielding lines at Bouider and Breda, respectively (Table 10). Relative to the total number of landraces-lines (74) among the 300 genotypes evaluated at 5 locations, the percent of top yielding lines was 31.1% and 24.3% at Bouider and Breda, respectively. The frequencies of landraces-lines were significantly (P<0.01) higher than expected on the basis of the frequency of landraces-lines among the total number of lines evaluated.

Table 10. Frequency of "improved" genotypes and of landraces-lines in the top yielding 10% of the 300 advanced barley lines evaluated at five locations.

LOCATION	IMPROVED GENOTYPES N	% Selected	% Improved Genotypes	LANDRACES-LINES N	% Selected	% Landraces	X^2 for Independence
Bouider	7	23.3	3.1	23	76.7	31.1	48.5***
Breda	12	40.0	5.3	18	60.0	24.3	22.4***
Tel Hadya	26	86.7	11.5	4	13.3	5.4	2.3 n.s.
Cyprus	26	86.7	11.5	4	13.3	5.4	2.3 n.s.
Terbol	24	80.0	10.6	6	20.0	8.1	0.4 n.s.

*** P<0.01; n.s. = not significant.

Table 11. Grain yield (kg/ha) of landraces-lines and of improved lines which were included in the top yielding 10% in the advanced barley yield trials evaluated at 5 locations.

Locations	Grain Yield Landraces	Improved	Difference	
Bouider	102.4	93.6	+ 8.8	n.s.
Breda	1034.6	954.2	+ 80.4	*
Tel Hadya	3464.7	3498.2	- 33.5	n.s.
Cyprus	4708.3	4583.5	+ 124.8	n.s.
Terbol	3635.1	5593.7	- 1958.6	***

*P<0.05;***P<0.01 based on t-test.

At the three locations with higher average yield (Tel Hadya, Cyprus and Terbol) the frequency of landraces-lines that were selected decreased while the frequency of improved lines increased. At these locations the relative frequencies of improved lines and of landraces-lines were not significantly different. This was expected because of the importance of an adapted genetic background in severe stress conditions. A number of landraces-lines were also included in the top yielding group at locations such as Tel Hadya, Cyprus and Terbol. Their grain yield at Tel Hadya and Cyprus was comparable with that of improved lines (Table 11), and was significantly (P<0.01) lower at Terbol where the yield potential of improved germplasm is above 5 t/ha. It appears therefore that pure lines selected within landraces have scope both as potential varieties for target environments where a high yield potential is not needed, and as parents.

Table 12. Number of lines and type of germplasm selected simultaneously at two or more locations.

Number Locations	Number Lines	Improved Germplasm	Landraces
2	21	13	8
3	6	4	2
4	2	0	2
0	0	0	0

A number of lines included in the top yielding 10% were selected simultaneously at 2 or more locations (Table 12). No lines were included in the top yielding group in 5 locations, two lines (both selected from landraces) were selected simultaneously at 4 locations (at Bouider, Breda, Tel Hadya, Cyprus the first, and at Bouider, Breda, Cyprus, Terbol, the second). Six lines (two from landraces and four improved) were selected at three locations, and 21 lines (8 from landraces and 13 improved) were selected simultaneously at 2 locations.

Table 13. Frequency of lines simultaneously selected in the top 10% at two locations.

	2 nd Location			
1st Location	Breda	Tel Hadya	Cyprus	Terbol
Bouider	23.8	4.8	4.8	4.8
Breda		0.0	9.5	9.5
Tel Hadya			14.3	14.3
Cyprus				14.3

The details of the 21 lines selected at 2 locations are shown in Table 13. Five (or almost one-fourth) of the 21 lines selected at 2 locations, were simultaneously selected at Bouider and Breda. All of these 5 lines were selected from landraces. The frequency of lines simultaneously selected at either Bouider or Breda and in other locations decreases to between 5% and 10%, and increases again to about 15% among the highest yielding locations (Tel Hadya, Cyprus, and Terbol). These results further suggest that a large portion of genotypes adapted to severe stress conditions would be discarded by conducting selection only under favourable or mildly stressed conditions. Furthermore they show that pure lines selected within landraces show some variability in their spectrum of adaptation.

Advanced Yield Trials at 3 Location

Analysis of the complete set (400 lines) of advanced yield trials grown at three locations in the Aleppo province (Table 14) confirmes information generated by initial, preliminary, and advanced yield trials evaluated at 5 locations.

Table 14. Grain yield (GY) and total biological yield (TBY), in kg/ha, of advanced barley lines selected on the basis of different selection criteria at 3 testing sites (Advanced Barley Yield Trials, 1987)*.

Selection Site		Bouider GY	Bouider TBY	Breda GY	Breda TBY	Tel Hadya GY
Bouider	GY	122.7 a	970.1 b	868.9 bc	1716.6 b	2790.4 b
	TBY	47.5 b	1120.7 a	698.2 d	1537.2 c	2702.0 cd
	GY+TBY	127.9 a	1097.4 a	977.8 a	1885.8 a	2861.8 b
Breda	GY	46.9 b	816.2 c	902.6 b	1829.0 a	2641.2 d
	TBY	40.8 b	818.9 c	834.1 c	1831.9 a	2664.4 cd
Tel Hadya	GY	41.9 b	914.1 b	669.1 d	1484.5 c	3587.6 a
best check		96.4	787.8	831.1	1682.9	3358.5
Population mean		32.3	812.9	671.1	1496.2	2657.9

* Means followed by different letters are significantly different ($P<0.05$) within testing site.

The most effective selection criterion for severe stress conditions seems to be a combination of grain yield and total biological yield. The lines selected at Bouider for grain yield and total biological yield had in fact:

a) the highest grain yield and total biological yield at Bouider and Breda.
b) the least reduction in grain yield at Tel Hadya compared with all other selection criteria applied at either Bouider or Breda.

The best lines at either Bouider or Breda always had a grain yield close to the grand mean at Tel Hadya. By contrast the highest yielding lines at Tel Hadya (3587.6 kg/ha), yielded almost 1 t/ha more than the population mean, but yielded only one-third of the highest yielding lines at Bouider (41.9 kg/ha vs. 122.7 kg/ha), although their total biological yield was only 18% less than the best lines at Bouider.

Conclusions

The evaluation of a large number of genotypes (2576) representing a wide germplasm diversity has indicated for the third consecutive season that the highest yielding barley lines under severe stress conditions have in general a limited yield potential under mildly stressed conditions. Similarly, only a small fraction of high yielding lines under non-limiting or mildly stressed conditions have an acceptable performance under severe stress conditions. This conclusion, confirmed over 13 environments (three locations in 84/85, five locations in 85/86 and five locations in 86/87), has implications on many aspects of the barley breeding project.

Response to Selection

The results presented previously confirmed that high yield potential and performance under severe stress conditions are probably the integrated expression of a large number of morphological and physiological traits. However those results do not indicate whether or not it is possible to select for grain yield under severe stress conditions, nor do they indicate the efficiency of selection. Both issues are of extreme importance in deciding future strategies and priorities.

In the following pages a line is classified as responding to selection when it outyields the check in the season following the selection. Efficiency of selection is measured as number of lines that outyield the check in year X over the number the lines that were selected in year X-1.

During the cropping season 1985/86 we made a first attempt to measure the efficiency of selection under severe stress conditions (Cereal Improvement Program, Annual Report for 1986, pg. 4). This was repeated in 1986/87 with a much wider array of germplasm including improved genotypes, bulk-pedigree selections, and landraces.

Improved Germplasm

During 1985/86 80 lines were selected from preliminary yield trials, 40 for their grain yield in Bouider (total rainfall in 1985/86 = 180 mm) and 40 for their grain yield in Tel Hadya (total rainfall in 1985/86 = 316 mm). The lines were evaluated during 1986/87 in four trials each with 20 lines of which 10 were selected from Bouider and 10 selected from Tel Hadya. The average grain yield of the two groups of lines at five locations in 1986/87 (Table 15) shows that in four of the five locations the 40 lines selected at Bouider significantly outyielded the 40 lines selected at Tel Hadya. No significant difference among the two groups was observed at Tel Hadya.

In considering the yield differences in Table 15 it should be kept in mind that these are the results of one cycle of selection for a character with low heritability, such as grain yield, in an environment where responses to selection are expected to be small.

Table 15. Grain yield (kg/ha) in 1986/87 of 40 barley lines selected in 1985/86 at a dry site (Bouider, 180 mm) and of 40 lines selected at a mildly stressed site (Tel Hadya, 316 mm).

Testing Site	SELECTION SITE		Difference
	Bouider	Tel Hadya	
Bouider	44.0	28.1	+ 15.9 ***
Breda	426.9	372.5	+ 54. 5 **
Tel Hadya	3136.2	3194.7	- 58.5 n.s.
Cyprus	2965.7	2763.0	+202.7 ***
Terbol	2909.2	2798.0	+111.2 ***

** P<0.01; *** P<0.001; n.s.= not significant

The results shown in Table 15 are not completely surprising when compared with Fig. 5. Those data showed that lines selected at low or very low yield levels should behave at least as well as lines selected at a high yielding level, even at sites with an average yield of about 2.5-3.0 t/ha. In fact the only location where the lines selected at Tel Hadya showed some (although not significant) superiority was also the only location where the average yield of all selected lines was slightly above 3 t/ha.

The two groups of lines differed significantly with regard to days to heading and days to maturity (Table 16). The lines selected in Bouider were from 4 to 7 days earlier in heading (depending on the location), 2 days earlier in maturity (at Tel Hadya), and had a slightly but significantly longer grain filling duration. Those lines were also slightly better for both cold tolerance and growth vigour but except for growth vigour at Tel Hadya the differences were not significant.

Table 16. Correlated responses to one cycle of selection for grain yield in contrasting sites.

Character	Site	Selection Site Bouider	Tel Hadya	Difference	
Cold tol.(1st score)	BO	2.39	2.55	-.16	n.s.
Cold tol.(2nd score)	BO	2.89	3.11	-.22	n.s.
Growth Vigour	BO	2.92	4.92	-.02	n.s.
Growth Vigour	TH	2.49	3.09	-.60	***
Agronomic score	BO	3.27	4.31	-1.04	***
Agronomic Score	CY	4.86	5.11	-0.25	***
Days to heading	BR	150.3	155.5	-5.2	***
Days to heading	TH	130.1	134.0	-3.9	***
Days to heading	CY	87.5	94.5	-7.0	***
Days to heading	TR	142.7	148.6	-5.9	***
Days to maturity	TH	169.7	171.9	-2.2	***
Grain filling dur	TH	39.7	37.9	+1.8	***

Three-Years Selection with the Bulk-Pedigree Method

Out of a total of 729 F_3 bulks 58 were selected at Bouider and 90 at Tel Hadya during 1984/85. The selection limit was the grain yield of A. Aswad at Bouider, and the grain yield of A. Abiad at Tel Hadya. These 148 F_5 bulks were evaluated during 1985/86 at Bouider and Breda (Cereal Improvement Program, Annual Report for 1986) where it was found that:

a) the frequency of bulks selected in 84/85 that responded to selection in 85/86 was 25.9% at Bouider and 32.2% at Tel Hadya.
b) that efficiency of selection at Bouider could have been increased from 25.9% to 31.1% by selecting for grain yield and cold tolerance simultaneously, and the efficiency of selection at Tel Hadya could have been increased to 40.0% by selecting for both grain yield and late heading.
c) that the efficiency of conducting the selection at Tel Hadya for a Bouider type of environment was 8.9%, about three times lower than the efficiency of direct selection.

During 1986/87 the 15 bulks outyielding A. Aswad at Bouider both in 1984/85 and in 1985/86, and the 29 bulks, outyielding A. Abiad at Tel Hadya both in 1984/85 and in 1985/86 were evaluated at Bouider, Breda and Tel Hadya with the same methodology and experimental designs described for the advanced yield trials.

Table 17. Three years of bulk selection under stress (Bouider) and under moderately favourable conditions (Tel Hadya).

Year	N. of bulks Selected	%	Grain Yield (kg/ha)			
			Bouider	A.Aswad	Tel Hadya	A.Abiad
			SELECTION SITE:BOUIDER			
1984/85	58	8.0	1549	1320	4310	4266
1985/86	15	25.9	2288	1907	5083	5380
1986/87	4	26.7	50	21	2713	2939
			SELECTION SITE:TEL HADYA			
1984/85	90	12.4	1112	1320	4898	4266
1985/86	29	32.2	1711	1907	5669	5380
1986/87	4	13.8	13	21	3492	2939

Only 4 of the 15 bulks outyielding A. Aswad at Bouider during 1984/85 and 1985/86, also outyielded the local cultivar at Bouider in 1986/87 (Table 17). The frequency of bulks responding to selection in 1986/87 relative to those selected in the previous year was 26.7%, similar to the frequency obtained in 1985/86 (25.9%). Of the total number of bulks which were evaluated in 1984/85 (729), only 0.55% outyielded the local cultivar at Bouider for three consecutive and contrasting cropping seasons. The same frequency was obtained with three cycles of selection under the more favourable conditions of Tel Hadya.

In 1985/86 eight of the 90 lines (8.9%) selected in 1984/85 for grain yield at Tel Hadya also outyielded A. Aswad at Bouider. However, in 1986/87 only one of these eight lines outyielded A. Aswad at Bouider (Table 18). Therefore for a Bouider-type of environment the efficiency of two cycles of selection at Bouider is more than six times higher than two cycles of selection at Tel Hadya.

Table 18. Efficiency of direct selection in stress conditions compared with indirect selection in moderately favorable conditions.

Selection Site	No. Bulks Selected in 1984/85	No. of Bulks outyielding A. Aswad in 1985/86 and in 1986/87	
		N	%
Tel Hadya	90	1	1.1
Bouider	58	4	6.9

The low frequency of successful bulks is not necessarily an indication of an inherent inefficiency of the selection method employed. The selection criterion used both at Bouider and Tel Hadya, namely stability of yield at a higher yield level than the local landraces, was severe. If the estimate of 0.55% is selection efficiency is a realistic one, there are basically three ways to increase the number of homozygous lines obtained:

a) increase the number of bulks in the initial population

b) increase the population size of selected bulks when reverting to the pedigree system.

c) increase the frequency of selected bulks by improving parents selection

In the future we plan to modify the bulk-pedigree method (Table 19) to obtain the following advantages:

1) at the end of the period of evaluation as bulks, pure lines extracted from selected bulks are already available,

2) the larger number of pure lines which can be extracted from the selected bulks,

3) the possibility of selecting for disease resistance starting in year 3 by using artificial inoculation on ear-to-row progenies.

The assessment of the relative efficiency of selection across different environments further confirms that barley improvement for dry areas and for moderate rainfall environments needs to be based on different methodologies and, to some extent, on different germplasm.

Pure Line Selection within Landraces

The objectives of pure line selection within landraces were to test the hypothesis that barley landraces are heterogenous populations for agronomically important characters, and to assess whether some of the genetic variability available within landraces can be promptly utilized in a breeding program for dry areas.

This activity started in 1984/85 with the evaluation of 400 pure lines extracted from both white-seeded and the black-seeded Syrian landraces. The evaluation was conducted at Breda (276.6 mm rainfall) in two row plots for 280 lines and in 4 row plots for 140 lines (20 lines were in common between one of the 2 rows trials and the 4 rows trial).

Table 19. Bulk-pedigree method of selection for dry areas.

Time	Material	Method of Evaluation	Locations	Selection Criterion
Year 1	F_2 bulks	two-rows plots solid planting	Bouider	Visual selection between F_2
		two-rows plots solid planting	Tel Hadya	Head selection and bulk seed for Year 2
Year 2	Bulks	2.5m, 6 rows plots (BIT)	Bouider, Breda Tel Hadya	Grain yield
	F_3 ear-to-row progenies	1 m, single row solid planting	Tel Hadya	Disease resistance -Select 30 heads/progeny -Bulk the seed of the resistant families within selected bulks for Year 3
Year 3	Bulks	2.5m, 6 rows plots solid planting (BPT)	Bouider, Breda, Tel Hadya	Grain yield
	F_4 ear-to-row progenies	1 m, single row solid planting	Tel Hadya	Disease resistance -Bulk the seed of all families for Year 4 -Keep 60 g of each selected family
Year 4	bulks	5m, 6 rows plots solid planting (BAT)	Bouider, Breda, Tel Hadya, Cyprus, Terbol	Grain yield
	F_5 single progenies	2.5 m 6 rows solid planting	Tel Hadya	Produce seed for BPT as pure lines in Year 5
Year 5	F_6	2.5m, 6 rows solid planting (BPT)	Bouider, Breda Tel Hadya	Yield testing of pure lines from selected bulks
Year 6	F_7	5 m, 6 rows solid planting	Bouider, Breda Tel Hadya, Cyprus, Terbol	Yield testing of pure lines

The selected lines were evaluated during 1985/86 at Bouider, Breda and Tel Hadya in 2.5 m long, 6 row plots and a second cycle of selection was conducted on the basis of grain yield. The 87 lines selected in the second cycle (24 from the grain-yield group, 44 from the plant height group, and 19 from the 1000 kernel weight group) were included in 1986/87 in the advanced yield trials. Because only the first 15 advanced yield trials were evaluated at 5 locations, 13 of the 87 lines were evaluated only at the three locations in Aleppo Province. The results of three-years selection within landraces (Table 20) indicate that 11 of the 34 lines initially selected for grain yield (45.8%), 9 of the 100 lines initially selected for plant height (9.0%), and 3 of the 39 lines initially selected for 1000 kernel weight (7.7%) outyielded A. Aswad at Bouider both in 1985/86 and in 1986/87.

Table 20. Three-years selection within two Syrian barley landraces.

Selection Criterion*	No. of lines selected in		No. & frequency** of lines among the best 10%				
	1984/85	1985/86	Bouider	Breda	Tel Hadya	Cyprus	Terbol
Grain yield	34	24	11(45.8%)	6(25.0%)	2(8.3%)	–	
Plant height	100	44	9(20.5%)	9	-2	(8.3%)	4(16.6%)
Kernel weight	39	19	3(15.8%)	3	2	–	–

*Only in 84/85. In the following two cycles the selection criterion was grain yield
**In the last cycle of selection.

Response to selection was slightly lower at Breda, and much lower at Tel Hadya, Cyprus and Terbol. While the response of landraces-lines to selection under severe stress conditions is not surprising, the magnitude of the response was unexpectedly high. Compared with results obtained using improved germplasm at Bouider (Table 17), the response to selection with landraces-lines was almost 3 times higher in the first cycle and almost 2 times higher in the third cycle. Relative to the initial population size (729 bulk and 420 landraces lines), the frequency of landraces-lines responding to selection was almost 5 times higher than the frequency of bulks responding to selection.

A large number of superior landraces-lines were collected from the same collection site, south of Damascus, near Sweida on the Haurani plateau (Table 21).

Table 21. Grain yield (kg/ha) of lines selected from landraces compared with four checks (two Syrian landraces, and two improved genotypes) in seven environments.

Material	1984/85	1985/86			1986/87		
	Breda	Bouider	Breda	Tel Hadya	Bouider*	Breda	Tel Hadya
Landraces-lines							
39/58	2233	1433	1822	5294	1142	1193	3733
39/10	2189	1183	1533	5356	1006	748	3480
39/60	2044	1778	1461	5033	882	763	2751
Checks							
A. Black	1622	1050	1533	4389	981	709	2939
A. White	1727	1183	1733	5106	836	764	2489
Harmal	1000	1333	1589	5011	788	831	2866
Rihane-03	956	1133	1700	5283	1204	671	3359

*Total biological yield.

Line 39/58 outyielded both local and improved cultivars (except Rihane-03 at Bouider in 1987 for total biological yield) in the seven environments in which it was tested. This line, which is white-seeded and resistant to powdery mildew and scald, will be evaluated in on-farm verification trials in Syria during the next cropping season with the name of Arta.

The Case of Tadmor

Tadmor is a black-seeded pure line derived from a single head collected at Taibe, about 90 Km north east of Palmyra, Syria. Its identification and performance can be considered as an example of successful empirical selection under very dry conditions.

Tadmor was first evaluated at Bouider in 1984/85 where it outyielded A. Aswad by about 49% (ICARDA, Annual Report 1985). It was then decided to test the line in the on farm verification trials for Zone C (<250 mm rainfall) in Syria. Figure 6 summarizes the results over 12 environments (five locations in 1985/86, and seven locations in 1986/87).

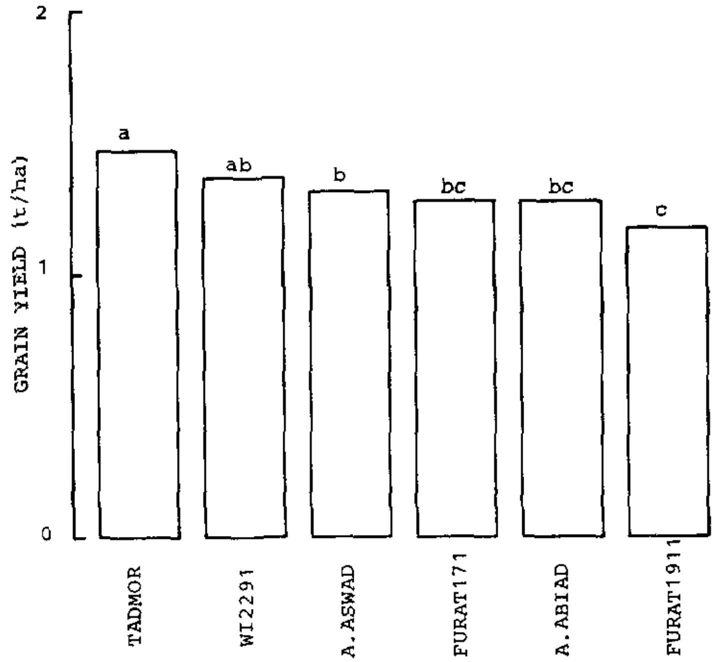

Fig. 6. Grain yield (t/ha) of 6 barley varieties evaluated for two years and in twelve locations (5 in 1985/86 and 7 in 1986/87).

Although selected on the basis of one year-one location data, Tadmor maintained its superiority over A. Aswad in all locations of the area where it was tested. The line is susceptible to powdery mildew, covered smut, and to lodging but it proves that progress can be made by selecting in stress environments.

International Nurseries

Four types of international nurseries are distributed each year to national program scientists. These are 1) Crossing Block,including a wide range of germplasm to be used as parental material in crossing programs, 2) Segregating Populations, designed to provide material for selection specifically for those national programs with limited facilities and manpower, 3) observation nurseries, which contain best finished or semi-finished lines from the ICARDA's breeding program and 4) Regional Yield Trials, where the best lines from the observation nurseries are evaluated in replicated yield trials.

During the last two years segregating populations, observation nurseries, and regional yield trials are divided into three sets targetted for low rainfall areas, moderate rainfall areas, and high elevation areas.

Table 22 summarizes the number of times the lines included in the observation nurseries were selected by cooperators.

Table 22. Frequency of lines in the barley observation nurseries 1985/86 selected by cooperators.

Type of Nursery	Total No. Entries	Frequency 5	4	3	2	1	0	Locations
Low Rainfall	90	3	9	23	30	22	3	12-13
Moderate Rainfall	90	3	3	8	20	31	25	6-11
High Elevation	90	0	0	6	20	36	28	7-10

In general most of the lines included in the Observation Nursery for Low Rainfall Areas were selected by one or more cooperators. Only three lines were never selected. The number of lines which were never selected increased in the Observation Nurseries for Moderate Rainfall Areas and for High Elevation Areas, indicating that more effort needs to be made in tailoring ICARDA germplasm for these two macro-environments.

The comparison of the frequencies of lines from the barley observation nurseries for both moderate and low rainfall areas, and from both 1984/85 and 1985/86 seasons (Fig. 7) showed clearly that progress has been made in developing lines suitable for national programs needs. The histogram in Fig. 7 shows the number of lines selected by cooperators in 1984/85 and 1985/86 season. In the histogram, and because of unequal numbers of lines and locations from one year to the other or from one type of the nursery to the other, the frequencies have been weighted by the number of lines and the number of locations where the nurseries were grown in that particular year. From 1984/85 to 1985/86 there has been a decrease in the number of lines which were not selected, and an increase in the number of lines selected simultaneously by 3, 4, and 5 cooperators.

In the case of the Regional Yield Trials, comparing yield data of ICARDA lines to those of the best national check is one method of assessing the success of barley lines which have reached the final stage in the breeding program.

A number of lines in Regional Yield Trials for both Low Rainfall Areas and Moderate Rainfall Areas significantly outyielded the national check. Table 23 shows only those lines which significantly outyielded the national check in a large number of countries, some of which have large barley growing areas (Turkey, Spain, China, Korea, Iran, Pakistan, Syria). Eventually, even in countries such as Ethiopia where ICARDA's germplasm has not shown good adaptation in the past some lines have shown modest but significant yield advantage over the national check (Table 24).

When the top 20% of the lines from each location were examined, Assala-04, Rihane 05, Faiz, Iris//Nopal 's', As46/Aths*2, a sister line of As46/Aths *2, from the moderate rainfall nursery, Rihane -03, M125-84/Attiki, Por/Nopal's', and Roho/Masurka from the low rainfall nursery, and Harrison/Nopal from the high elevation nursery seem to perform very well across different environments.

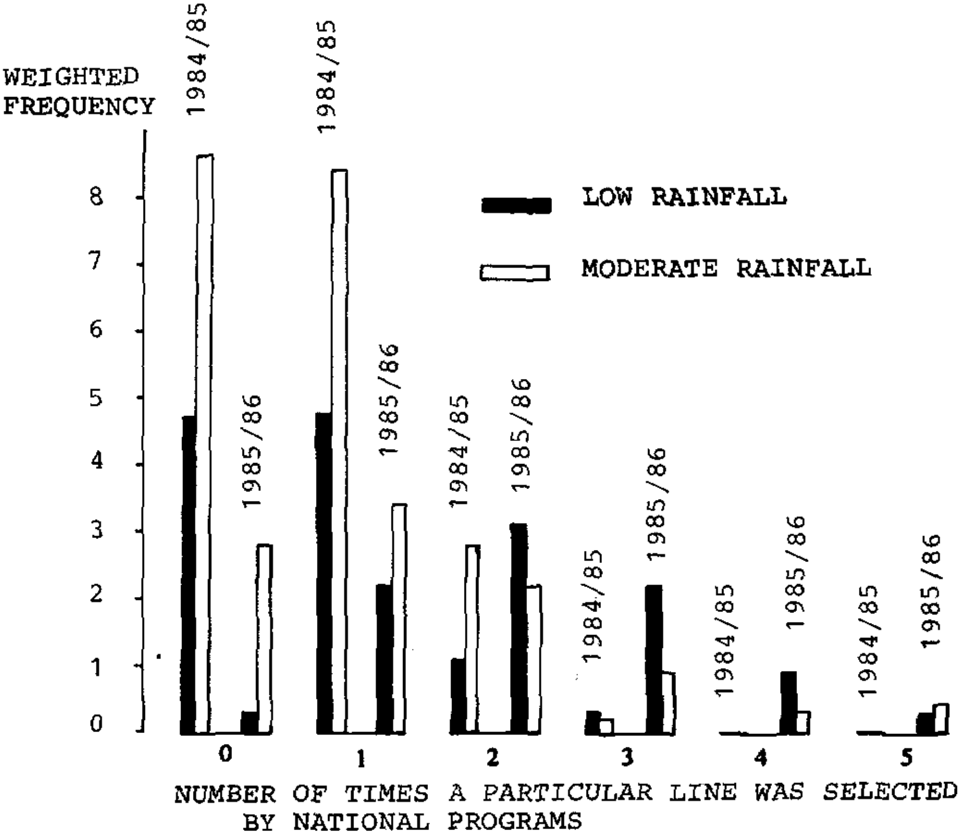

Fig. 7. Evaluation of the frequency of selected lines in the low and moderate rainfall observation nurseries from 1984/85 to 1985/86.

Table 23. Barley lines outyielding significantly ($P<0.05$) the national check in the Regional Yield Trials 1985/86.

Environments	Line	Countries
Low Rainfall	RIHANE-03	Pakistan, Jordan (2 Loc.),Turkey, Algeria, China, Iran, Peru.
	ROHO/MASURKA 4-1-3-1-0	Pakistan, Jordan, Syria, Algeria, Egypt, China, Peru.
	ROHO/MASURKA 4-5-0	Iran, Jordan, Syria, Algeria, Pakistan
	WI2291/WI2269	Jordan (2 Loc.), Saudi Arabia, Syria, Algeria
Moderate Rainfall	RIHANE-05	Turkey, Algeria, Tunisia, Portugal, Spain (2 Loc.), China, Pakistan
	RIHANE-01	Turkey, Algeria, Tunisia, Portugal, Spain (2 Loc.), China, Korea, Pakistan
	AS46/ATHS*2	Lebanon, Turkey, Algeria, Egypt, Spain, China, Pakistan
	FAIZ	Syria (2 Loc.), Turkey, Egypt, Spain (2 Loc.), Pakistan
High Elevation	HR/NOPAL	Syria, China, Korea, Pakistan

Table 24. Barley lines outyielding the national check in Ethiopia (Regional Yield Trials, 1985/86).

Line	Yield relative to National Check (= 100)
Giza 121/CI 06248/4/Apm/IB65// 11012-2/3/Api/CM67//Ds/Apro	115.7
Beecher	114.6
N-Acc4000-301-80	104.9
Matnan-01	104.2

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Mexico-Based Project

The development of improved barley germplasm in Mexico for the CIMMYT-ICARDA barley project is primarily oriented to the needs of national agricultural research systems (NARS) in Latin America. The major objective of the CIMMYT-ICARDA project is to interact with national programs in developing germplasm for high rainfall environments, with durable resistance to stripe rust, leaf rust, barley yellow dwarf virus (BYDV), and scald. In addition, the project is giving emphasis to early maturing germplasm that is well adapted to high rainfall areas not served by the Aleppo-based project.

During this past year, progress was made with the identification of advanced lines for NARSs, that are resistant to a combination of diseases and merit further large-scale testing. A short introduction to our activities in cooperation with NARSs and barley production needs of individual countries are presented.

Colombia. The country has two major barley producing areas:

1) Central Colombia, where leaf and stripe rusts are the main diseases and
2) The southern region, where additional resistance to a unique disease, called "dwarfing of Narino" is required. The germplasm sent from Mexico is screened by Colombian scientists from the national program (ICA).

Ecuador. Close cooperation with the National Research Center (INIAP) allows for the screening of a large number of segregating lines in the Santa Catalina Experiment Station, located near the capital. In the station there is a severe disease pressure (stripe and leaf rust, scald, and BYDV), and barley production is further limited by the presence of acidic soils.

During the winter of 1986-87, a group of advanced lines resistant to scald, leaf rust and stripe rust was yield-tested for the first time; the highest yielding lines will be promoted for national testing.

Peru. Testing of barley germplasm is done in cooperation with the National University, La Molina (UNA) and the National Research Organization (INIPA). Segregating populations sent to Peru for testing carry resistance to leaf rust and stripe rust coupled with high-yield potential and stiff straw.

Bolivia. The main testing site is located at the San Benito Experiment Station, located near Cochabamba. Here, in cooperation with barley researchers from IBTA (National Research Organization), a shuttle breeding project was implemented between Mexico and Bolivia that has resulted in the development of a number of advanced lines resistant to stripe rust, leaf rust, and scald. They were yield-tested in 1987.

A total of 75 advanced lines were yield-tested simultaneously under two different conditions in 1987, in northwestern Mexico at 39 m above sea level under irrigation and leaf rust, and in Bolivia, at 2200 m above sea level, under irrigation and stripe rust. Yield performance of the top yielders at both sites (Figure 8) will ensure better varieties for Bolivia. National yield trials in Bolivia will be conducted with the outstanding lines identified last year.

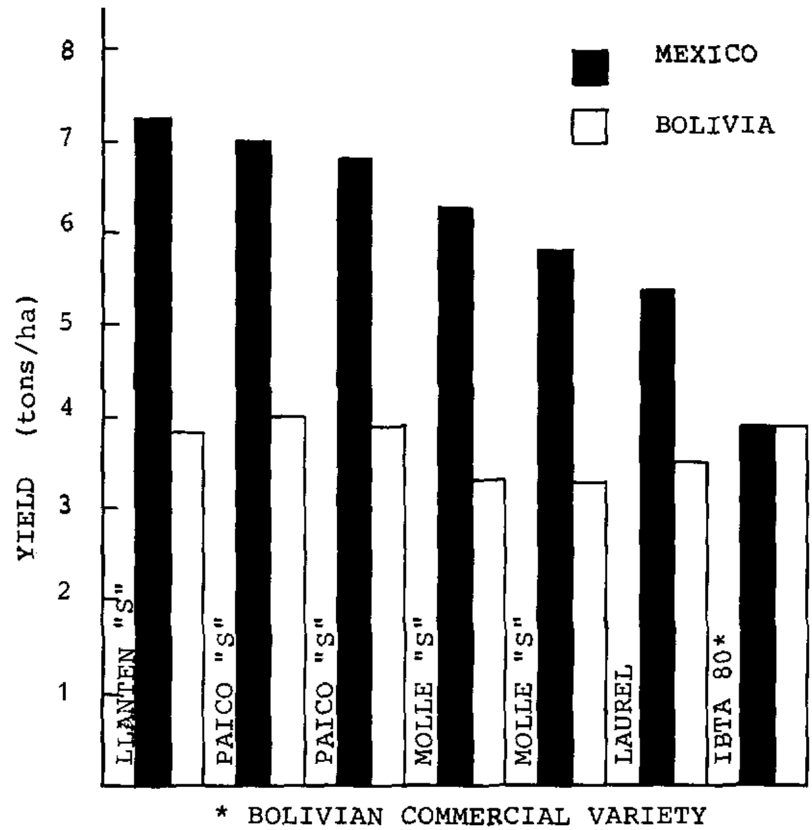


Fig. 8. Yield performance of barley lines in the Yaqui Valley, Mexico under heavy leaf rust and Cochabamba, Bolivia under heavy stripe rust in 1987.

Chile. Scald and stripe rust resistance and late maturity are characteristics required for barley production in southern Chile.

Scientists from the National Research Organization (INIA) sent 929 F3 lines developed in Temuco, Chile to Toluca, Mexico for scald screening. The 1967 scald-resistant plants selected in Toluca were planted in Obregon as F4 and 1159 lines were returned to Chile. The mechanism was set to shorten the number of years needed to develop Chilean varieties.

Mexico. In cooperation with INIFAP (National Research Organization) in northwestern Mexico, 20 t of foundation seed were harvested from the line Mona/Mzq/DL71. Mexican scientists have promoted this early maturity line, with a planting-to-maturity range of 90 to 100 days, for use by the Yaqui Valley farmers, who will grow the variety under irrigation to replace the fallow. It is expected that the economic return of an additional feed barley crop should be attractive to the farmers.

Yield Trial. A total of 175 advanced barley lines, resistant to scald and leaf and stem rust were evaluated under irrigation during the 1986-87 winter season in the CIANO Experimental Station. Each experiment consisted of 25 new lines and five checks. The checks include a Mexican cultivar (M9724B) and two Gloria/Copal Sister lines (Arupo and CACO"S"/3/API/CM67//1594). All checks were chosen for their high-yield in previous years.

None of new lines tested was superior to the highest yielding checks; however, there were some lines that equaled the yield levels of the highest yielding check. One hundred of the top yielding lines were selected to form the International Barley Observation Nursery (IBON) and were distributed internationally.

Yield comparisons during the last three years among the lines Gloria/Copal, Gloria/Come, Arupo, Trompillo, and Pistacho are presented in Table 25 and provide an indication of the year-to-year stability of these genotypes when tested under irrigation in the Yaqui Valley. Another measure of the stability is shown in a range of different environments, where these lines are compared with the local checks of national programs in the 8th International Barley Yield Trial (Figures 9 for six African countries, Figure 10 for five Asian countries, and Figure 11 for two southern European and five Middle East countries).

Table 25. Yield (t/ha) of five barley advanced lines at CIANO, Mexico during the last three years of testing under irrigation.

	Yield (t/ha)		
	1984-85	1985-86	1986-87
Gloria/Copal"S"	8.4	9.8	9.9
Arupo	8.1	8.9	9.5
Gloria/Come"S"	8.1	8.2	7.6
Pistacho	7.2	8.3	-
Trompillo	6.5	7.2	7.3

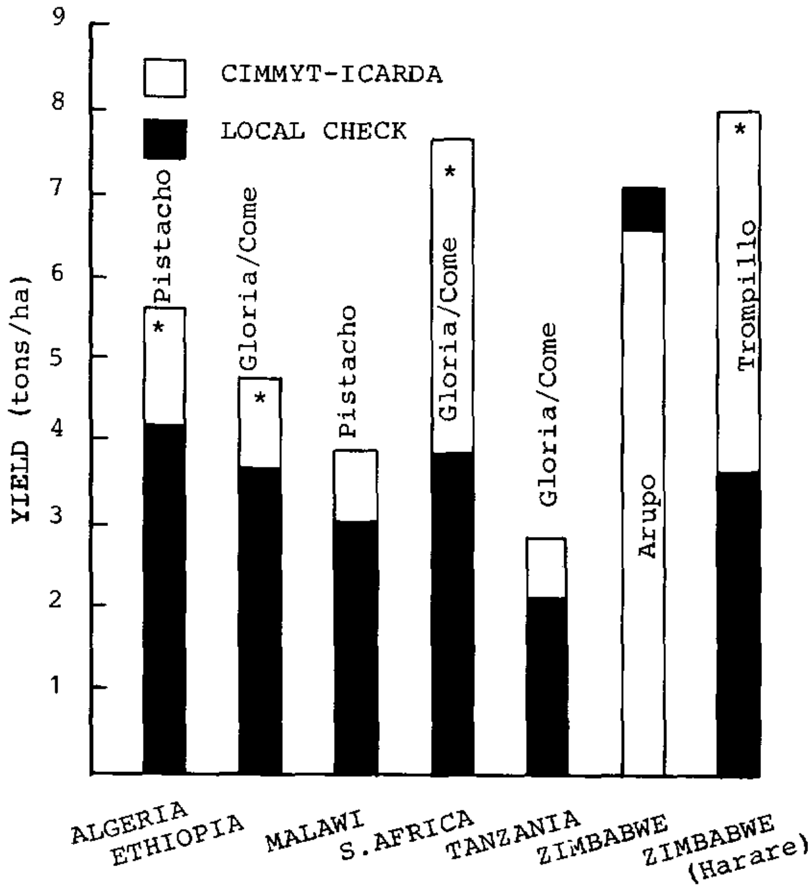


Fig. 9. Yield performance of the highest yielding CIMMYT-ICARDA barley line as compared with the local check in the 8th International Barley Yield Trial (BYT) for Africa.

Multiple disease resistance. Lines resistant to several diseases were distributed to NARSs for observation or preliminary yield testing. The disease reaction of several advanced lines to five diseases at six locations is presented in Table 26. Most lines include a number of sister lines (for example, Matico"S" has 18 sister lines) that will be evaluated for their yield potential.

The release of varieties with multiple disease resistance to farmers in the Andean Region will stabilize yields and will reduce the need for fungicide application. BYDV needs further evaluation not only in Mexico, but at South American sites, such as Pasto, Colombia and Quito, Ecuador where the disease appears in dry years. Preliminary information has shown that sister lines of Gloria/Come"S" and Gloria/Copal"S" were resistant to the virus under Californian conditions.

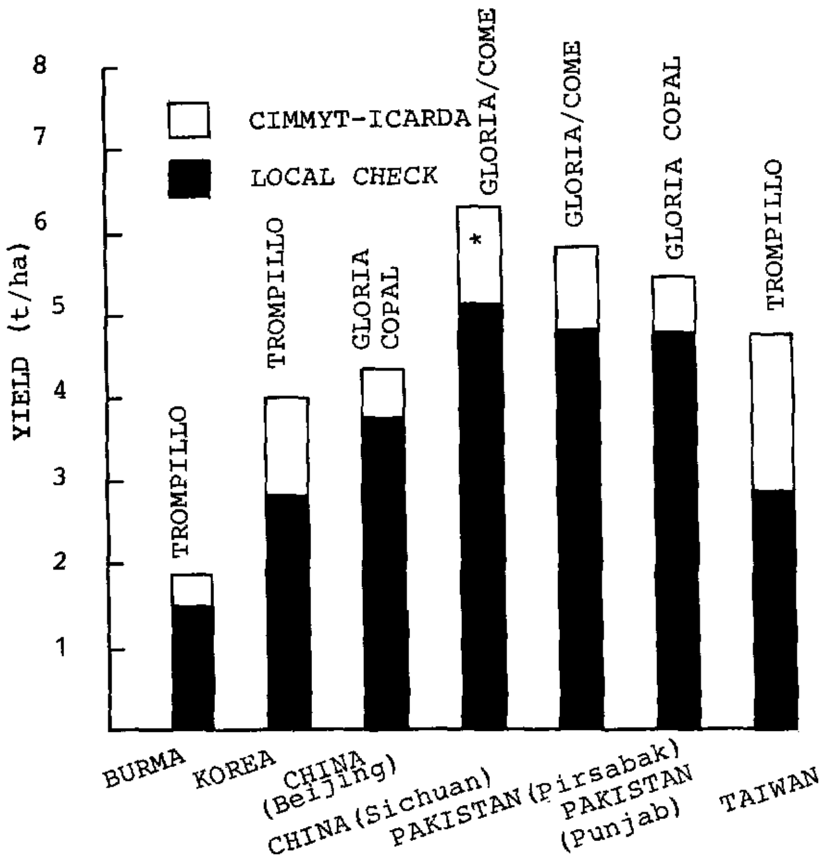


Fig. 10. Yield performance of the highest yielding CIMMYT-ICARDA Barley line as compared to Local Check in the 8th IBYT for Asia.

<u>Traits to Enhance Human Consumption</u>

As disease resistant advanced barley lines are available for countries in the Andean Region, breeding efforts toward the development of germplasm with suitable characteristics will enhance adoption of future barley varieties for human consumption. A food consumption survey indicated that barley contributes 20% of the total caloric intake of rural families in Puno (Peru) and was second only to potatoes (21%).

<u>Hull-less barley</u>. One trait that could prove to be important in increasing human consumption of barley is hullessness. Hulless barley could be incorporated into food products more easily, since grain pearling could then be eliminated. The main disadvantage of hulless barley is the low percentage of germination when the grain

Table 26. Reaction of advanced barley lines to five diseases in four Latin American countries*.

Genotype	Rust						Scald		Net Blotch
	Stripe			Leaf		Stem			
	B	C	E	E	M_1	M_1	E	M_2	M_3
GLORIA/COME"S"	R	R	R	R	R	R	R	R	S
GLORIA/COPAL"S"	R	R	R	R	R	R	R	R	S
VALERIANA			R	R	R	R	R	R	S
MOLLE"S"	R				R	R		S	
LAUREL"S"	R		R	R	R	R	R	R	S
MATICO"S"	R				R	R		R	R
LIGNEE 640/KOBER//TERAN			R	R	R	S	R	R	MS
RUDA"S"	R				R	R		R	
PAIGO"S"	R				R	R		S	S
LLANTEM"S"	R				R	R		S	S
ALISO	R				R	R		R	R

B= Bolivia, Cochabamba E=Ecuador, Quito M_2=Mexico, Toluca
C= Colombia, Tundama M_1= Mexico (CIANO) M_3= Lagunilla

is mechanically threshed; nevertheless, the embryo damage may be less when barley is threshed with the old and more simple walking animal system.

An increasing demand for hull-less barley from NARSs such as in Nepal, Bhutan, Bangladesh, and those in the Andean region, has resulted in a small breeding effort to produce hulless lines with disease resistance and large grain size. Two hundred seeds from each plant with large and hulless grain selected in F2 populations during the 1986-87 winter cycle were planted in the greenhouse in a Single Seed Descent Method. The F3 generation was harvested in a 68-day growing cycle and immediately planted again as F4s in pots in the greenhouse. The F5 seed will be shared with the Bolivian National Program for stripe rust screening, while in the Yaqui Valley the same F5 will be screened for both leaf and stem rust. In addition, a small nursery of hulless types that do not necessarily have large grains has been assembled.

Early maturity varieties. Earliness is seen by many barley workers in the Andean Region as a mechanism to escape frost and late drought. The early maturing barley germplasm presently available needs to be improved by:

1. Incorporating stripe rust resistance into lines already resistant to leaf and stem rust and,
2. Increasing plant height. Currently, the early genotypes are too short for cultivation under rainfed conditions, making them unable to compete with weeds and more difficult the hand harvesting.

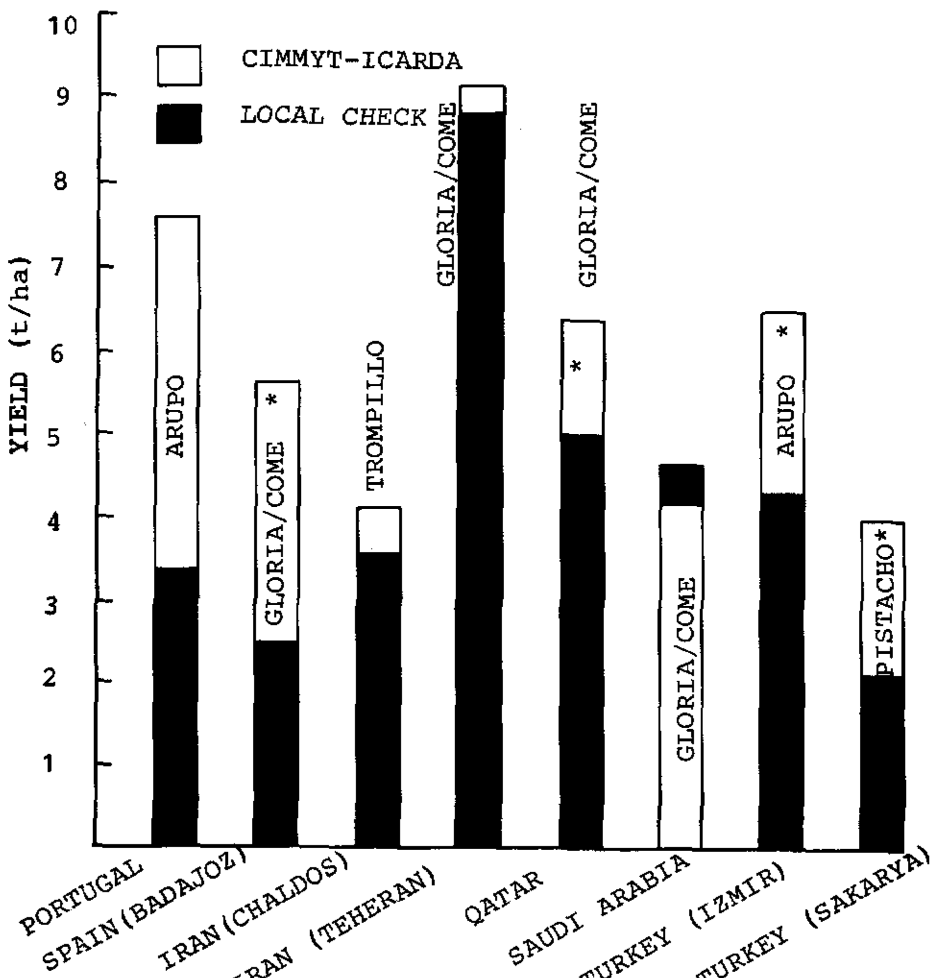


Fig. 11. Yield performance of the highest yielding CIMMYT-ICARDA Barley line as compared to National Check in the 8th IBYT for Southern Europe and Middle East.

One hundred and twenty-seven sister lines of Marco"S" were grown as F6s in the summer of 1987 in Toluca for scald resistance evaluation and El Batan, for leaf rust and stem rust reaction. Marco lines are the first group of early maturity lines with a height range of 90 to 115 cm, that have combined resistance to scald, leaf and stem rust. During the 1987-88 winter seed of several Marco lines will be sent to South America for stripe rust screening. Marco"S" lines are expected to carry resistance to stripe rust, since two of its three parents are stripe rust-resistant.

General Conclusions

Most of the results discussed in the previous sections are related to the efforts of raising barley yield in stress environments. This does not mean that the efforts being done to raise barley yields in other macroenvironments (moderate rainfall, high elevation, subtropical) are less important or deserve less attention. At this particular stage of development of the barley project, there was a need to assess whether the activities initiated three years ago in the area of barley improvement for dry areas were generating some promising results. While barley improvement for relatively more favourable environments is not a controversial topic, many doubts still exist on whether progress with selection is at all possible in a harsh environment.

In this context the emerging evidence of three years work is that it possible to raise yield in stress environments provided we accept the need for a methodology and a germplasm which are different from those which have been and are effective in more favourable conditions.

The work for the moderate and high rainfall areas has been very successful so far, and needs to be continued in close cooperation with the national programs, which will gradually assume increasing responsibilities. The germplasm developed for these macroenvironments has a greater chance of being rapidly adopted and of showing its impact. Similarly the work being done by the Mexico-based project covers environments which are difficult to serve from the Aleppo-based project. In some of the countries where the Mexico-developed germplasm has proved its superiority, the potential clients are among the poorest farmers in the world.

The activities for the high elevation areas in a continental-mediterannean climate will be described under the High Elevation Project.

H. Vivar

2.2. Durum Wheat Breeding

Introduction

Winter cereals contribute a large proportion to the total food production of West Asia and North Africa. Durum wheat (Triticum turgidum L. var. durum) is, after barley, the most important crop in the low rainfall areas of the ICARDA region. The area and average grain yield for durum wheat in North Africa and West Asia region based on moisture stress are presented in Table 27.

Table 27. Area and average grain yield (t/ha) of durum wheat for varying moisture stress in North Africa and West Asia.

Moisture regime	Area (x1000) ha	%	Grain yield (t/ha)
1. Usually under some stress	3500	41	0.63
2. Frequently stressed	2400	27	0.98
3. Sometimes stressed	2500	29	1.23
4. Rarely stressed	500	3	2.12

Around 9.0 million hectares are annually devoted to durum wheat with Turkey, Morocco, Algeria, Syria, and Tunisia accounting for 85% of this area. In several countries, durum wheat occupies the largest portion of land devoted to cereals. Durum wheat is grown on about 70% of the total wheat growing area in Morocco, Algeria, Tunisia, Syria and Jordan. Durum wheat is generally grown under drier and more stressful conditions than bread wheat. Of the total annual area devoted to durum wheat in the developing countries, 80% is in West Asia and North Africa. In the Maghreb and Middle East regions, nearly all (97%) durum wheat is grown without irrigation.

Durum wheat plays an important role in the diet of the people in the Maghreb and Middle East region, particularly in the rural areas. Traditional products made from grain of durum wheat include burghul, frekeh, couscous and other pasta products. Wheat consumption is very high, ranging from 150 to 200 Kg per person per year. When durum wheat production is low, imported bread wheat is often substituted for durum wheat in the diet as durum wheat is priced higher (20%) than bread wheat in international markets.

Agro-ecological Zones for Durum Wheat in the North Africa and Asia Region

Facultative or spring durum wheat is grown in three main geographical regions, namely North Africa, West Asia and the Nile Valley.

Long-term precipitation, average evapotranspiration rates, minimum temperatures, and frequency and extent of diseases and insect pests in the main durum wheat growing areas in the North Africa and West Asia region have resulted in the identification of four major agro-ecological zones to which germplasm are targetted. They are:

1. Low rainfall (<350 mm) with low winter temperature. This zone covers approximately 40% (3.50 million ha) of the total area planted to durum wheat in North Africa and West Asia. The major production constraints are drought, cold and terminal drought/heat stress during the grain filling period. Site and yearly variation within this zone are very large, and crop reductions and failures due to climatic fluctuations occur often. Stem sawflies and suni bugs perennially cause damage while yellow rust and common bunt are major diseases frequently occurring in relatively wetter seasons. This exemplified environment is represented by the continental areas of Morocco, Algeria, Syria, Turkey, Iraq and Iran.

2. Low rainfall (<350 mm) with mild winter. This zone covers approximately 25 % or 2.5 million hectares, mainly in the coastal areas of Morocco, Algeria, Tunisia, Syria and Libya. In addition to the above-mentioned environmental stresses, diseases and insects contribute towards reducing grain yield and quality. In particular, Hessian fly, sawfly and sunni bugs are perennial pests, dryland root rot occurs in dry seasons, and leaf rust and septoria leaf blotch are common in wetter seasons.

3. Moderate rainfall (350-500 mm) with low winter temperature. This zone covers 1.5 million hectares, or 17% of the total durum wheat area of the region. It includes such areas as the northeastern sections of Morocco, Algeria and Syria and the southeastern part of Turkey. Yellow rust, septoria leaf blotch and leaf rust are important diseases in this area, while wheat stem sawflies and sunni bugs are serious insect pests.

4. Moderate rainfall (350-500 mm) with mild winter. About one million hectares are cropped in this zone which is mainly found in North Africa, Ethiopia and in southern and coastal Turkey. In addition to climatic fluctuations, diseases and insects are major constraints. Almost all diseases and insects are present in this zone and can drastically affect grain yields, particularly in more favorable seasons. Irrigation occurs in a small area confined to Egypt, and parts of Turkey, Syria and Morocco and Saudi Arabia.

During 1986/87 the Durum wheat project maintained its structure and overall objectives. However while strengthening work on developing resistances to multiple abiotic and biotic stress, particular emphasis was placed on drought, heat, yellow rust, wheat stem sawfly and common bunt for the low or moderate rainfall areas with cold winters. Resistance to drought, heat, leaf rust, stem rust and septoria leaf blotch were emphasized for areas with low or moderate rainfall and mild winters.

Germplasm Development and Testing

Traditionally durum wheat is grown in harsher environments and because less research has been conducted in the past, grain yields are in general lower than those of bread wheat. Therefore, the joint ICARDA/CIMMYT durum wheat project has focused on improving yield stability and grain quality of this crop in rainfed areas.

To meet the needs of the various agro-ecological zones in the durum wheat growing countries of North Africa and West Asia, the project has adopted the following strategy:

1) Optimum utilization of testing sites through the use of a gradient selection technique (ICARDA, Annual Report, 1986) to encompass the important stresses occurring in the major agroecological zones of the region. This technique, is also now used by several national programs in the region for stress tolerance testing, for example in Morocco for drought and heat and in Egypt for heat.
2) Use of a selection procedure that subjects early segregating generation to different biotic and abiotic stresses occurring in the major agroecological zones. A modified bulk method is more extensively used where selections are bulked in the early segregating generations and individual plant selection starts in advanced generations. The results indicate that if selection is to be effective, it is should be carried out in the environment for which the crop is ultimately intended. In particular, selection for dryland areas should be done in dry environments.
3) A simple and very useful method was developed to describe the relative performance and consistency of a cultivar when compared with other cultivars over a set of environments. In this method, ranks are given to all entries at each environment and the mean rank (R) and standard deviation of ranks across environments (SDR) are computed for each entry. A relatively more desirable cultivar is one having smaller values for both R and SDR.
4) A multilocational testing program has been established to provide data for assessing the consistency of relative cultivar performance, and for identifying cultivars combining desirable attributes such as resistnace to various diseases, tolerance to drought, cold, heat, salt, etc. The multilocation testing also enhanced the cooperation with national programs through exchange of both improved germplasm and breeding strategies for stressful environments. More and more national programs are including

their material in the international nurseries to be tested at the regional level in North Africa and West Asia.

5) Adapted landraces, wheat relatives (e.g. Triticum dicoccoides) are frequently used in the hybridization program to transfer desirable traits and broaden the genetic base of spring facultative durum wheat for different stresses. Our results on the use of durum landraces and wheat relatives in the hybridization program show that substantial progress can be achieved in developing improved cultivars for dry areas. Omrabi and Sebou are examples which illustrate the useful exploitation of desirable genes from landraces and wheat relatives.
6) This breeding strategy has helped in the gradual improvement of durum wheat germplasm for the important stresses prevailing in the different agro-ecological zones of the North African and West Asian region.

For the drier zones, genetic stocks have been developed with single or multiple stress tolerance. The number of durum wheat lines possessing stable and high yields is steadily increasing as reflected by an increased number of lines out-yielding the national and regional checks in the regional yield trials. Outstanding lines have been identified by cooperators in national yield trials and field verification trials. Some of these lines are released, such as Korifla in Syria, where it is named Sham 3, and Belikh in Lebanon. Korifla is the first durum wheat variety to be released for dry areas in the region. It was tested for several years under dry conditions (<350 mm) in Syria, and has significantly out-yielded Haurani, a cultivar with high levels of drought and cold tolerance.

Evaluation and Selection of Segregating Populations

Because of inconsistency and unpredictability in climatic conditions in the dry areas of the Mediterranean region, and large G x E interactions, a multilocation testing with a double gradient of rainfall and temperature is practiced encompassing the important stresses prevailing in the four dryland agro-ecological zones of the region.

Eight environments in four sites are heavily used, particularly during the early phases of selection. The sites are:

Tel Hadya: 35°00 north latitude, 36°55 east longitude, 342 mm annual rainfall

Breda: 35°55 north latitude, 37°10 east longitude, 278mm average annual rainfall

Lattakia: 35°30 north latitude, 35°47 east longitude 784mm annual rainfall

Terbol: $33^{o}52$ north latitude, $36^{o}00$ east longitude. 550mm annual *rainfall.*

In Tel Hadya durum wheat is grown under 3 environments: a) Early planting (mid October) with supplemental irrigation (450mm including rainfall) to simulate a crop cycle with long duration and favorable growing conditions, b) Normal date of planting (mid-November) with durum wheat nurseries grown under rainfed conditions, and c) late planting date (late March-early April) to simulate a short growing season. Early planting date subjects plants to cold damage during tillering and stem elongation, to frost during anthesis and fertilization, and to attacks by yellow rust and septoria leaf blotch. Late planting exposes the plants to terminal heat and drought stress during the flowering and grain filling stage, and to infestation by aphids, Hessian fly and leaf rust.

Breda, a dry area, allows the testing for pre and post anthesis moisture stress and for resistance to wheat stem sawfly. Lattakia is a high rainfall site with coastal climatic conditions, and is used to test for resistance to diseases under natural and artificial infection by; normal planting date for septoria leaf blotch; and late planting date for leaf rust, stem rust and BYDV resistance screening.

An environmentally favorable site at Terbol, Lebanon is used to determine yield potential during the normal winter season, and is used during summer for additional screening and heat tolerance testing.

All segregating populations are subjected to stresses in these test environments with the objective of identifying the populations that do particularly well in certain environments but are not sensitive to the stresses of other environments. Populations selected under these conditions are advanced for further selection at the regional level in collaboration with national institutions. Selected populations are directed towards different target environments, depending on the biotic and abiotic stress tolerance of each population and the occurrence of a given stress in a given target environment. Table 28 shows the percentage of populations selected in different test environments. Table 29 shows that selection for performance across environments was higher in the crosses yield x stability, yield x adapted landraces/dicoccoides and yield x drought tolerance, and with parental lines previously identified as possessing disease and insect resistance. These results confirm findings from 1985/86.

Although the pedigree selection method is used in advanced generations and occasionally in crosses designated for specific problems in moderate rainfall areas, a modified bulk method is more extensively used. In this technique selections are bulked in the the early generations and individual plant selection starts in advanced generations. This method provides the advantage of testing more crosses at a relatively larger number of sites/environments. Bulked segregating populations are also tested in cooperation with national programs in several environments in the region.

Table 28. Percentage of selected populations in durum wheat segregating populations subjected to environmental conditions, 1986/87.

Constraints Environment	YR+Cold+Frost (EP-TH)	Septoria TR. (LT-NP)	LR+SR BYDV (LT-LP)	Drought Sawfly (Breda)	Heat SR+LR (SN-TR) (SN-TH)	Rainfed Sites (NP-TH)	Across Environments
F2	39	43	84	51	43	67	19
F3	31	61	78	68	39	73	14
F4	49	41	79	60	43	69	22
F5	77	27	88	57	46	78	31
F6	80	50	83	51	33	81	46
F7	66	61	80	29	43	78	63
Average	57	47	82	53	41	74	33

TH-EP = Tel Hadya/early planting
LT-LP = Lattakia/normal planting,
BYDV = Barley yellow dwarf virus,
TH-SN = Tel Hadya/summer nursery,

LT-NP = Lattakia/normal planting
LR = Leaf rust, SR = Stem rust,
TR-SN = Terbol/summer nursery,
TH-NP = Tel Hadya/Normal planting

Table 29. Percentage of F2-populations selected at different sites from targetted crosses.

Objective of Cross	Test Environments						Across Envi-ronments
	EP-TH	LT-NP	LT-NP	Breda	Terbol	TH-RF	
High Yield Landraces/DIC	29	71	76	76	14	29	14
Drought 5	8	33	83	93	24	71	14
Stability	33	19	100	78	57	89	17
Cold /Earliness	80	100	80	40	8	78	8
Heat	9	13	100	43	51	59	7
Diseases	61	32	65	64	27	23	12
Insects	61	36	57	55	41	19	13
Quality	35	35	48	81	38	67	9
	39.5	42.2	76.1	66.1	32.5	54.5	11.9

Yield Trials

Lines from promising F5, F6, or F7 generations were tested in replicated trials at three locations and in observation nurseries for diseases, insects, and kernel quality in 10 locations. Based on these evaluations the more promising lines were promoted to advanced yield trials where they are evaluated as observation nurseries in North Africa and West Asia for one or more years under 5 contrasting environmental conditions and in 30 locations. They are extensively subjected to screening for disease and insect resistance, and for high nutritional and industrial kernel quality. High grain yield combined with stability is required of any variety recommended for commercial production under Mediterranean rainfed conditions. This is mainly due to the recurrent alternation between moderate and less-favorable growing seasons in the region, and the occurrence of stress conditions in the moderate rainfall environments in some years. Table 30 also shows the mean yields of the environments and the genotypic coefficients of variability indicating that the genotypic coefficient of variability in a low rainfall is not lower than GCV in a moderate rainfall site.

Table 30. Yields means, ranges and genoytpic coefficients of variablity of Advanced trials (moderate and low rainfall) in different environments, 1986/87

Environment	Grain Yield (KG/HA)					
	ADYT-Moderate rainfall			ADYT-Low Rainfall		
	Mean	Range	GCV*	Mean	Range	GCV
Drought (Breda)	1127	821-1405	13.0	1095	784-1494	14.7
Heat (TH-LP)	888	91-1519	36.8	869	112-1548	31.1
Rainfed (TH-LP)	3774	2757-4727	10.2	3648	2871-4510	9.4
Cold/Frost (TH-EP)	3632	125-6713	41.3	3356	227-7150	46.7
Favorable (Terbol)	7860	4003-10749	17.5	8188	5574-10851	12.3

GCV = Genotypic coefficient of variability

Adaptation to Stressed Environments and Responsiveness to Moderate Rainfall Conditions

The ability of a variety to perform well under suboptimal conditions and at the same time to be responsive to improved environmental conditions is a key factor in the acceptance of new durum wheat cultivars by farmers. Variety yield in a given environment is dependent on its inherent genetic yield potential and its resistance to biotic and abiotic stresses. This season's data corroborate also last years' results and demonstrate the ability of selected lines to perform well under stressed and moderately favorable conditions (Table 31). It corroborates the concept that improving stress *tolerance also increases yield* stability (Fig. 12) for such variable conditions ranging from stressed to moderately stressed conditions.

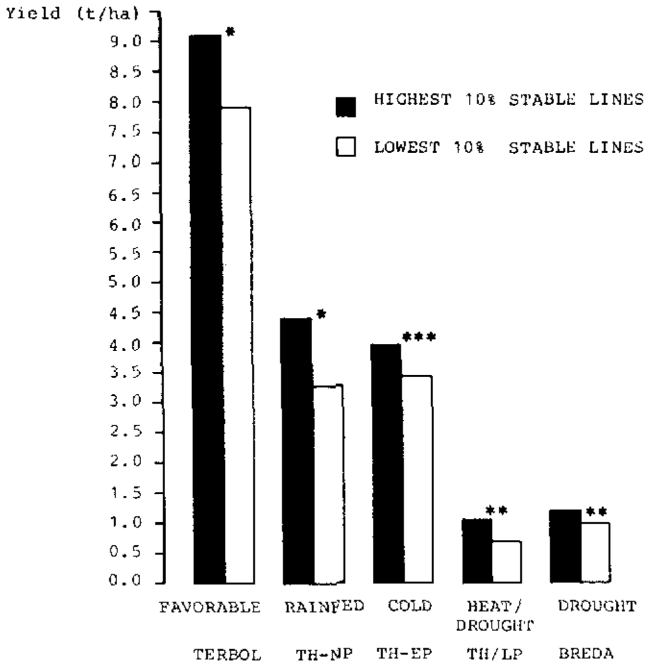


Fig. 12. Performance of the highest 10% and the lowest 10% stable lines in different environments.

Table 31. Some high yielding durum wheat entries under moderate rainfall and dry conditions and their stability parameters, ADYT.

NO.	ENTRY/CROSS	Grain Yield (kg/ha)		Stability (NPM)	
		Rainfed	Breda	AR	SDR
216	Brachowa	4380	1407	13.8	14.6
308	Haurani/Cando	3901	1308	16.0	12.1
205	Omrabi-Shawb	3988	1431	18.6	26.5
206	Zeroud-5	3961	1123	20.2	16.9
	Haurani	2956	1066	76.6	10.9
	Sham 1	3349	957	36.2	35.1
	Stork	3197	919	73.0	19.3
	LSD	416	321		
	CV	5.24	8.44		

NPM: Nonparametric method, R=Average rank, SDR=standard deviation of ranks across environments

Drought Tolerance

Results in durum wheat shows that yielding ability and drought tolerance can be combined successfully to increase yield under dry conditions. Drought tolerance can be further improved without reducing the yielding ability of a genotype (Nachit and Ketata 1986). Table 32 shows the grain yield of the 10% highest (HYL) and lowest yielding (LYL) lines in the advanced durum yield trials of 1986/87 season at Breda (dry site) with some agronomic attributes.

Data in Table 32 show the differences between the highest and lowest yielding genotypes under dry conditions (Breda) are highly significant. Some traits such as heading date, fertile tillering, plant vigor, peduncle length, and spike fertility show significant differences. The association between heading date with grain yield at Breda, clearly indicates the importance of earliness under dry conditions.

Table 32. Average performance of the 10% highest and lowest yielding entries sorted according to their yields at Breda. Also shown are some agronomic traits.

Line/Group	GY	HD	LT	TLL	PL	SF	PH	PV
HYL 10%	1381	131	32.5	7.6	4.3	4.0	61	6.5
LYL 10%	855	136	33.1	4.1	3.3	3.0	56	4.1
Diff.	526***	-5***	-6 n.s	3.5***	1.0***	1.0***	5 n.s	1.4*

*** P < 0.001, ** P < 0.01, * P < 0.05, ns P > 0.05, GY = Grain yield (kg/ha), HD = days to heading, LT = Leaf temperature, TLL = Tillering score, PH = Plant height, PL = Peduncle length, SF = Spike fertility, PV = Plant vigor.

Results on the importance of peduncle length to drought tolerance corroborate previous results (Nachit and Jarrah, 1986), and shows that peduncle length is also an important predictor of performance under dry conditions.

Grain yield was analysed under both the stressed and favorable environments. Data (Table 33) show that grain yield under stress environments was highly and negatively associated with days to heading, positively correlated to the number of heads per square meter, plant height and peduncle length, followed by early plant vigor. Under favorable environmental conditions grain yield was positively associated with days to maturity and to heading.

Table 33. Correlations of grain yield in the stress *environment (Breda) and in the high performance* environment (irrigated).

Grain Yield	Environment	
	Breda (stress)	Tel Hadya (irrigated)
Grain Yield to:		
1) Early plant vigor	+.2188 *	-.3175 **
2) Date to head	-.4878 ***	+.6538 ***
3) Plant height	+.3683 ***	-.1395 ns
4) Heads m^{-2}	+.5097 ***	+.1489 ns
5) Days to mature	-.2570 *	+.701 ***
6) Days to peduncle length	+.5097 ***	+.1489 ns
7) Number of grains over heads	+.3301 ***	-.0701 ns

*** P<0.001, ***<0.01, *P<0.05, ns P>0.05

The relationship of grain yield to days to heading shows the importance of earliness in durum wheat. Early genotypes were also able to maintain a high number of grains per head and heads per m^2. Regression analyses of the combined effects of number of heads per m^2, and days to heading on grain yield in the stress environment indicated that these two factors accounted for 60% of the observed variation in grain yield in the dry environment. The relationship of grain yield and number of heads per unit area show that genotypes having a high number of heads and a medium to high number of grains per head were the highest yielders under dry conditions.

Terminal Stress Tolerance

Durum wheat in the dry lands of the mediterranean region is affected by high temperature, water deficit and increased evapotranspiration at the grain filling stage. High temperatures also occur earlier and can affect tillering capacity, primordia and *terminal spikelet development. Identification of germplasm with* terminal stress tolerance and development of efficient screening techniques for terminal stress receive high priority in the durum wheat project. Under late planting conditions (drought and heat) at Tel Hadya the maximum yield achieved was 1548 kg/ha while the yield trial average was 888 kg/ha. Genetic variation for different traits under terminal stress conditions as measured through the genotypic coefficient of variability of both trials (low and moderate rainfall) were high for several traits (Table 34). Table 35 shows some of the highest yielding lines under terminal stress conditions. Crosses with Haurani, such as Omrabi 6 and Haucan perform very well under these conditions.

Table 34. Genetic variation under terminal stress conditions.

	Minimum	Maximum	Mean	GCV(%)
Grain yield (kg/ha)	91.0	1519.0	888.0	37.0
Peduncle length	0.3	7.0	3.5	43.1
Tillering	1.4	6.0	3.6	29.1
Floret/spiket	1.0	4.0	3.1	24.6
Spikelet/spike	1.0	5.0	3.8	22.8
Leaf green duration	1.0	9.0	4.4	47.5
Days to head	50.0	10.0	58.4	21.5
Leaf temperature	27.0	32.3	30.2	3.9
Plant vigor	3.0	9.0	6.8	17.3
Plant height	26.3	59.6	43.5	15.0
Thousand kernel weight	25.9	461.0	34.3	12.1

GCV = Genotypic Coefficient of variation

Table 35. Durum wheat lines significantly outyielding the checks under terminal stress conditions, Tel Hadya, ADYT-MR,1986/87.

No.	Entry/Cross	grain yield (kg/ha)
320	Sapi//Rabi/Ibis	1519
213	Mrb 6	1416
216	Brachowa	1391
3 8	Haucan	1310
214	Gdovz 471/Br//Pg.	1291
215	D-2/Gd	1274
319	Gd75/3/Stk//Ch 67/Jo	1269
	Checks	
	Sham 1	765
	Stork	658
	Haurani	550
	LSD (.05)	469
	CV (%)	15.1

Cold and Frost

Early planting was used as a technique to screen durum wheat germplasm for tolerance to cold and frost at critical stages of plant development. This technique proved useful in ensuring the plant exposure to cold stress and increasing the efficiency of selection. The maximum yield achieved under these conditions was 7150 kg/ha and the lowest was 134 kg/ha, when the nursery mean was 3356 and the genotypic variability 46.7%.

The primary gene pool for cold tolerance in durum wheat includes local germplasm from the Middle East and Maghreb regions and selections from the program. Table 36 shows some of the cold tolerant lines along with their agronomic traits.

Table 36. Durum wheat lines significantly outyielding checks under cold and frost conditions, ADYT-LR,TH, 1986/87.

NO.	Entry/Cross	GY	CT	FD	TS	HD
310	Lahn	7150	8	1	7	168
410	Gd/Win	6330	8	1	7	164
316	D-2/Gd	6142	7	1	7	176
303	Cp/Gdvz 156//Kobak 2916/3/Sincape	5933	9	1	6	165
306	Sapi//Rabi/Ibis	5783	8	1	8	175
115	D-2/Sham 1	5564	9	1	7	164
417	Korifla/Tell 76	5381	8	1	8	171
Checks						
	Haurani	2325	9	1	6	168
	Sham 1	1025	4	82	4	155
	Stork	133	1	91	4	137
	LSD	719	2.1	7.9	2.0	8.8
	CV	14.9	7.3	3.2	10.1	1.4

GY = Grain yield (kg/ha),
CT = Cold tolerance, (1 = susceptible, 9 = resistant),
FD = Frost damage(1 = susceptible, 9 = resistant),
TS = Tiller score,
HD = Days to heading

International Nurseries

Segregating populations, genetic stocks, observation nurseries and yield trials of durum wheat are targetted to two major agroecological zones; one with moderate rainfall and a mild or cool winter and another with low rainfall and a mild or cold winter.

More emphasis is now placed on the development of special genetic stocks and targetted segregating material, while standard breeding is more and more transferred to national programs.

Genetic Stocks

Adequate useful genetic variability is a prerequisite for a successful breeding program. Systematic selection of parental material to be utilized for increasing variability in durum wheat is undertaken with national programs and in interaction with the various subdisciplinary research projects. Physio-morphological studies help to identify genotypes with superior drought associated traits. Plant pathologists assist with disease inoculation and screening methodology for yellow rust, leaf rust, stem rust, septoria tritici, and common bunt. Virologists screen for BYDV. Entomologists provide resistance screening, for wheat stem sawfly and aphids. Cereal chemists assess durum quality parameters.

Parental material identified for different desirable traits and distributed to national programs is shown in Table 37. In the hybridization program special emphasis is placed on rainfed areas with mild as well as cold winters and to associated biotic and abiotic stresses.

About one third of the crosses made in 1986/87 season involved crosses with landraces, Triticum dicoccoides and wild relatives to broaden the genetic base of durum wheat for different stresses. Our results through the use of durum wheat landraces and dicoccoides in the hybridization program show that substantial progress can be achieved in developing stress tolerant and high nutritional quality genotypes.

Table 37. Number of durum wheat lines (genetic stocks) identified with desirable characteristics, and distributed to national programs.

Characteristics	Total Number of Lines	Lines Distributed to National Programs
Tolerance to Environmental Stresses		
Drought	10	8
Heat	10	9
Cold	10	7
Short Crop Duration	6	6
High Yield and Stability	16	9
Disease resistance		
Yellow rust	21	9
Leaf rust	5	3
Stem rust	12	9
Powdery mildew	2	2
Septoria leaf blotch	10	6
Common bunt	5	5
BYDV	7	3
Lines combining multiple disease resistance	21	15
Insect Resistance		
Wheat stem sawfly	2	2
Grain Quality		
Multiple quality traits	13	4
High sedimentation value	6	2

Observation Nurseries

Data for 1985/86 have been analyzed and compiled in a final report already sent to durum wheat scientists in the national programs of the region. The report contained results of the durum wheat observation nursery-low rainfall (DON-LR) which were received from 30 sites in North Africa, West Asia , the Nile Valley, and Mediterranean Europe. While from thirty three sites results were included for the moderate rainfall (DON-MR) nursery.

Table 38 shows some selected entries from DON-MR 1985/86 along with agronomic characteristics, disease and grain quality data. Remarkable improvement of disease resistance, particularly to leaf and stem rusts, has been made in comparison to the germplasm in the observation nurseries of previous years.

For the areas where frost occurs during spring, damaging durum wheat primordia and reducing spike fertility, genotypes have been developed that can escape frost damage. The strategy followed was to develop late heading genotypes that can escape frost damage during heading and anthesis, but mature early enough to escape drought and heat stresses. Table 39 shows some of these lines with a number-of-days-to-heading similar to the late cultivar Haurani, but a number-of-days-to-mature similar to Sham 1, an early variety. From DON-MR and DON-LR, 73 lines were selected for leaf rust resistance, 59 for yellow rust, 51 for stem rust, 40 for septoria leaf blotch and 81 for powdery mildew.

Table 38. Yield, agronomic characteristics, and diseases of the highest yielding and most frequently entries selected in the DON-MR, 1985/86.

Cross/Name	GY	DH	DM	PH	A C I YR	LR	SR	ST	1000 KW	TW	C.C	P.C.
113 Gd/Boy	4992	117	158	99	1	14	11	5	34	84	7.0	12.5
75 Mrb 16	4617	116	156	91	14	6	28-	5	39	82	7	12.7
105 D-2/Sham 1	4600	128	159	91	0	4	7	3	40	80	5	13.7
55 Shwa/Stk//Bit	4252	116	163	79	0	1	17	5	37	82	5	13.0
111 Guil/Shwa//Ren	4245	124	160	77	0	0	19	5	34	80	5	12.2
106 Qfn/Memo/3/Oyca //Rurr/Fg	4239	122	160	91	0	2	17	5	39	81	5	12.2
Stork(Reg. Check)	3467	115	156	88	27	10	45	6	40	81	5	12.2
Sham 1(Imp. check)	4104	115	155	82	0	9	27	7	36	82	5.5	12.3
No. of locations	14	27	14	22	4	7	4	6	4	4	4	4

GY = Grain Yield, DH = Days to Heading, DM = Days to Maturity, YR = Yellow Rust, LR = Leaf Rust, SR = Stem Rust, ST = Septoria Tritici, 1000 KW = Thousand Kernel Weight, TW = Test Weight, Prot. = Protein Content, DON-MRA = Durum Observation Nursery - Moderate Rainfall

Table 39. Durum wheat lines with the highest average grain and most frequently selected, late heading and early maturity, DON-LR 1985/86.

Cross/Entry	GY	HD	DM	PH
63 Mrb 13	3425	121	156	80
41 Belikh	3526	121	157	82
22 La Dulce	3589	121	157	81
70 Ruff//Jo/Cr/3/F9.3	3852	121	157	75
65 Zeroud 4	3674	119	156	72
Haurani	2975	122	162	91
Sham 1	2836	117	155	75
No. of Locations	18	25	17	20

GY = Grain Yield, DH = Days to Heading,
DM = Days to maturity, PH = Plant Height

Regional Yield Trials

The most promising lines from the observation nurseries were included in the regional durum wheat yield trials. These trials were also targetted to two major environments, those with moderate rainfall (RDYT-LR) and those with low rainfall (RDYT-LR). Yield data for 1985/86 were received from 32 locations for RDYT-LR and 39 locations for RDYT-MR. The lines Daki, Quadalete, Kabir 2 and Omrabi 15 for two consecutive years have shown outstanding performance across all locations in North Africa and West Asia (Table 40). In the RDYT-LR, Belikh and Lahn have performed well in most sites in North Africa and West Asia for two consecutive years. However, some of the newly-developed entries have a performance similar to that of Belikh and Lahn (Table 45).

During the last 10 years the number of durum wheat genotypes outyielding the local check have increased. In the 1980/81 season 15% only of the test entries in RDYT across all sites were outyielding the national check. In 1985/86 this value has increased to 65%. Durum wheat varieties released by national program are shown in Table 1.

Table 40. Performance of the high and stable yielding entries in the RDYT-MR, for two years (1984/85 and 1985/96).

No.	Entry	Grain Yield (kg/ha)	Stability Parameters AR 1984/85	AR 1985/86	SDR 1984/95	SDR 1986
4	Gd/Bit = Dades	4324	-	7.7	-	6.06
15	Daki	4303	7.8	8.9	5.5	6.42
18	Quadalete	4266	10.0	9.3	7.5	7.22
11	Kabir 2	4091	9.7	9.5	7.1	6.33
OM	Omrabi 15	4057	11.5	10.4	5.7	6.15
	Stork	3683	14.7	16.5	7.6	7.38
	Sham 1	4000	11.7	10.6	5.7	7.38
	Trial Mean	4005				
	LSD	293				
	CV	16.0				
	No. of sites	39	30	39	30	39

AR = Average Rank, SDR = Standard Deviation of Ranks

Table 41. Performance of the high and stable yielding entries in the RDYT-LR, 1985/86.

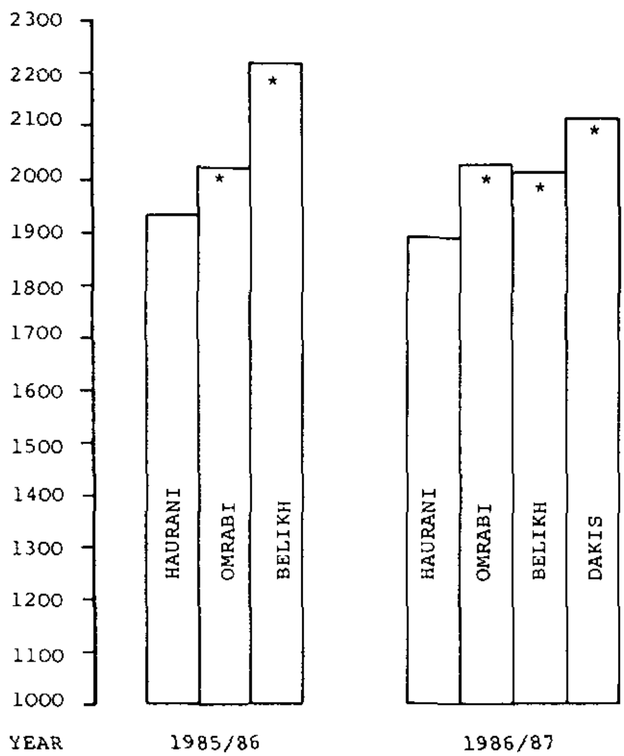
Entry No.	Entry	Grain yield	Stability Parameters AR	SDR
3	Cr/Albe	3607	9.70	6.20
4	Gdovz 512/Cit/Ruff/Fg	3538	9.20	5.42
7	Acu	3633	9.60	6.48
2	Belikh	3521	10.3	5.48
21	Lahn	3500	10.3	5.53
	Haurani	2389	19.1	6.7
	Sham 1	3490	11.9	7.0
	Trial Mean	3327		
	LSD (0.05)	193		
	CV	16.4		
	No. of sites	31		

AR = Average rank, SDR = Standard deviation of ranks

Field Verification Trials

Two varieties were released in the 1986/87 season by the national programs of Syria and Lebanon. In Syria, the cultivar Korifla is released under the name Sham 3 for dry areas receiving 350 mm or less, while the Lebanese national program released Belikh 2 under the same name for moderate to high rainfall. Korifla is also under large scale testing in Morocco, Turkey, Jordan and Cyprus. Belikh is also performing very well in Algeria and Syria and *is tested under farmers' conditions. Fig. 13 shows the* performance of Belikh, Omrabi 9 and Daki in comparison to the local check Haurani in the dry zone (B,350mm).

M. Nachit



NO. OF SITES	6	6
LSD (5%)	139	107
CV (%)	8.2	11.2

Fig. 13. Mean grain yield (kg/ha) of Omrabi,Belikh and Daki in comparison to Haurani at farmers fields (Zone B) in Syria (1986 and 1987).

Genetic Studies

Three crosses in the F2 and F3 generations along with corresponding parents and pairwise mixtures were included in replicated experiments to investigate the possible advantage of heterogeneous and heterozygous populations as compared to pure stands. The parents were:

P1 = Omrabi
P2 = Ato's'//Ibis/Fg's',
P3 = Waha's'/3/Rabi's'/31810//Pg's', and
P4 = Ibis/Fg's'//Cando.

The crosses investigated were P1/P3, P1/P4 and P2/P3. Mixtures were made in the proportions (0.25: 0.75), (0.5: 0.5) and (0.75: 0.25) for each parental combination. The experimental material was grown at Tel Hadya both under rainfed conditions (350 mm of rainfall) and supplemental irrigation (an additional 40 mm in mid May), The results showed no heterotic effect nor an advantage of mixtures over midparental or F2 and F3 mean yields. Average yields were 4.06 t/ha and 3.74 t/ha for the irrigated and rainfed trials, respectively.

In another experiment, a number of durum wheat crosses are used to compare the efficiencies of the bulk and pedigree methods of selection under different environmental conditions. One hundred crosses involving landraces and high yielding cultivars were grown during 1985/86 in the F2 generation under two different sowing conditions: space planting (20 kg/ha) and solid seeded (100 kg/ha). The whole trial was duplicated in two separate fields with different cropping histories. Five checks were included in both the space-planted and the solid-seeded sets. Visual selection was made throughout the 1985/86 season based on disease reaction, plant height and agronomic type. Forty crosses were selected for further testing. These were bulk harvested from the solid-seeded set and individual plant selection was made in the space-planted set. The number of selected plants varied from 0 to 8 per cross ($x = 4.5$, $s = 1.9$) with a total of 168 plants selected for further testing. All entries in the solid-seeded set were bulk harvested. Yield was determined subsequently.

During 1986/87, the 40 crosses from the solid-seeded set were grown as F3 bulks in replicated experiments under rainfed and irrigated conditions (40mm of supplemental irrigation). The 168 families selected were also grown as F3 bulks under space planting. Selection was also made during 1986/87 on the basis of disease reaction, maturity, tillering (for the solid-seed set), plant height and other plant characteristics. Results show that most F3 families performed differently under rainfed and irrigated conditions with a few showing good performance in both environments. All 40 F3 families were bulk-harvested for further testing in the coming season. Individual plant selection was made among the space-planted F3 families and a total of 746 F3 plants belonging to 37 crosses were retained for further selection in the F4 generation.

H. Ketata

2.2.1. Durum Wheat Germplasm Evaluation and Development

The cooperative project between ICARDA and Italian institutions, has the following objectives: (a) to evaluate durum wheat landraces at ICARDA utilizing a multilocation approach, (b) to document, utilize and disseminate information and germplasm of these genetic resources for the use of breeders and other scientists and (c) to identify and test selected germplasm in co-operation with national programs in other countries for wider testing and application. The agronomical, physiological as well as grain quality characters, a total of twenty-nine observations, not only take into consideration the present requirements of the breeders but are also aimed at providing useful data for future breeding goals. The project also provides training opportunities for national program personnel. A short course was conducted on Germplasm Evaluation: Cereal Landraces and Wild Relatives (May 1987) in which eleven scientists from several countries of the region participated.

The project has identified a number of lines possessing resistance to major abiotic and biotic stresses prevalent in the region as well as good food processing qualities, including tolerance to drought and resistance to some diseases. These lines have been made available to ICARDA breeders and other scientists for further testing and subsequent inclusion in their crossing blocks and data are included in Genetic Resources Program data base.

In 1986-87, the second season for the project, 2644 lines from the germplasm collection were planted at Tel Hadya (>350 mm rainfall) and Breda (<275 mm rainfall). One hundred accessions selected for salt tolerance from 1985-86 season were planted at Hegla.

The results of screening for tolerance to yellow rust, carried out in a special nursery, were as follows: 220 (or 9%) lines were classified as resistant, 500 (20.7%) as moderately resistant, 624 (25.8%) as moderately susceptible and 1075 (44.4%) as susceptible.

To screen germplasm against common bunt the percentages of infected spikes was used to measure resistance. Accessions with at least 15 spikes available for observation were considered for scoring. The results were as follows: 144 (or 8.4%) were classified as resistant, 71 (4.1%) as moderately resistant, 214 (12.5%) as moderately susceptible and 1284 (74.9%) as susceptible (Fig. 14).

Identification of Lines for Specific Traits

At Hegla (rainfall <150 mm, saline/drought affected site) 100 lines selected from trials during 1985-86 for salt tolerance were replanted in three replicates using a lattice design. Accessions selected on the basis of cold tolerance, earliness and overall agronomic score, 70 from 1984-85 and 210 from 1985-86 were also planted at Breda and Tel Hadya in a simple lattice design with three checks. The following characters were recorded: early vigour, days to heading, plant height, days to maturity, plant colour, frost damage, leaf senescence, fertile tillers/m^2, peduncle length, straw yield, number of seeds per spike, plant color, harvest index, total biological yield and grain yield in tons/ha.

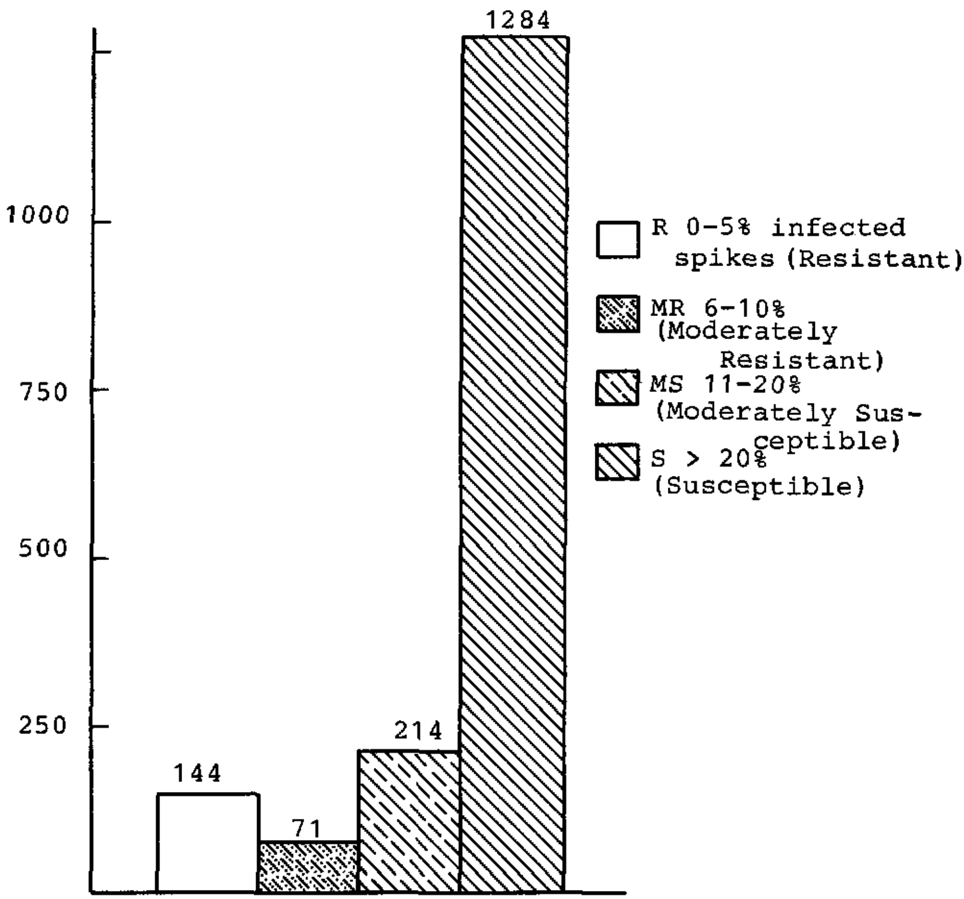


Fig. 14. Evaluation of durum wheat germplasm for resistance to common bunt in 1986/87. (Tilletia foetida and T. caries; inoculum ratio of the two pathogens 0.6:1; in vitro spore germination 99%; contamination with about 0.8 x 10^5 spores/seed)

At Hegla data was recorded on emergence, early vigour, days to heading, plant height, grain yield, total biological yield, harvest index, 1000-kernel weight and agronomic score. This season there were only 80 mm of rain and considering salinity and very high temperature conditions it was not surprizing that only four accessions survived to maturity at Hegla. These were: IC 6279, IC 6582 (origin unknown at present but probably collected from low rainfall areas), IC 7674 and IC 7719 (originally collected from 1800m and 2550 m alt., long-term average annual rainfall 318 mm., in Afghanistan by Dr. W.V. Harlan and Dr. Koelz during June - September 1939). IC 7719 has a local name of "Surklak-i-bahari" in the passport data file. In addition lines Candealfen from Argentina and Boohai from Ethiopia performed well at Hegla for the third year. These accessions were also multiplied at Tel Hadya so that more seed is available for further experiments and distribution to national programs and interested scientists.

Based on the past three years of work durum germplasm with the following traits has been identified:

a) Drought tolerance
b) Frost tolerance during vegetative phase
c) Salinity tolerance
d) Short duration
e) High protein content
f) Good industrial quality
g) Disease resistance
h) Solid stem

Germplasm with these specific traits is available on request along with complete evaluation data and information on sites from where they were originally collected.

To increase access to this germplasm ICARDA together with the University of Tuscia convened a small group of scientists to review the work done by the project, to discuss constraints to evaluation, documentation and utilization of germplasm, and to study the feasibility of developing a work-plan for undertaking evaluation of selected germplasm in different countries at diverse locations.

Evaluation Network for Selected Durum Germplasm

A Durum Germplasm Evaluation Consultation Meeting sponsored by ICARDA and the University of Tuscia was held at Viterbo, Italy on 27-29 July, 1987. It was strongly recommended that germplasm selected at ICARDA should be further developed so that it could be recommended to breeders for use in their germplasm enhancement programs.

It was decided to develop a network of co-operators to evaluate selected germplasm in their respective countries. The pooled information will be provided to interested scientists. The network is already operating with the following countries participating in the first year (1987-88): Ethiopia, Kenya, India, Pakistan, Turkey, Tunisia and Italy. Two hundred accessions selected for specific traits, as well as one regional check (Sham 1) and a local check have been included in these experiments. The research group at the University of Tuscia, Viterbo will study the electrophoretic banding patterns of storage proteins (gliadins) to see if any correlation exists between specific traits such as drought tolerance, or resistance to specific diseases, and presence of identifiable gliadin subunits. The group will meet again next year to review work accomplished, make plans for the 1988-89 season and expand the network to other interested countries, as many requests to join and contribute to the network have been received from major durum wheat growing areas of the world.

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

The research group in Italy headed by Professor E. Porceddu has completed electrophoretic analysis of 3536 accessions from Ethiopia. The banding patterns were compared with one of the standard Italian durum wheat cultivars "Karel" which is known for its good pasta cooking qualities distinguishable by the presence of band with relative mobility (Rm) 45 in its electrophoretic profile. Several accessions from Ethiopia had variability for components in the slow moving omega region of the profiles. Others had variability of bands in the gamma region. However, the bands Rm 42 (associated with poor pasta cooking qualities) and Rm 45 (good pasta cooking qualities) were absent or present together in the same accession. The significance of this finding is that the two quality types can be easily differentiated and utilized.

Primitive Forms and Wild Relatives under Evaluation

During 1986-87 a number of primitive forms of cultivated wheats and wild forms, such as T. dicoccoides and boeoticum, were evaluated together with the durum germplasm. Considerable genetic variability for agronomic traits e.g. growth habit, early vigour, drought tolerance, tillering capacity, disease resistance, crop duration, lodging and grain quality was observed. For example, 18 accessions of T. dicoccum, 2 of T. carthlicum (syn. T. persicum) and one T. sphaerococcum were found resistant to yellow rust. In addition, 13 accessions of T. dicoccum, 2 of T. polonicum and one each of T. ispahanicum Heslot and spelta were resistant to common bunt. However, none of these forms performed well under low rainfall conditions at Breda. A list of these accessions is given in Table 42, in order of their ploidy level.

Table 42. Primitive and wild forms under evaluation in 1986-1987.

Botanical species	Common name	Ploidy level	No.seeds/ spikelet
T. boeoticum	Wild einkorn	2 X	1
T. urartu	Armenian wheat	2 X	1
T. monococcum	Einkorn	2 X	1
T. timopheevi	---	4 X	2
T. dicoccoides	Wild emmer	4 X	2
T. dicoccum	Emmer	4 X	2
T. turanicum	Khurasan wheat	4 X	2-3
T. turgidum	Rivet wheat	4 X	3-6
T. polonicum	Polish wheat	4 X	2-4
T. ispahanicum	---	4 X	1-2
T. persicum	Persian wheat	4 X	3
T. carthlicum	Carthlicum wheat	4 X	3
T. spelta	Spelt wheat	6 X	2-3
T. compactum	Club wheat	6 X	2-4
T. macha	Macha wheat	6 X	2-4
T. sphaerococcum	Shot wheat	6 X	4

Because of the increasing usage of primitive and wild forms in breeding programs to enhance wheat productivity and yield stability in the dry areas the above collection is a valuable addition to ICARDA's genetic resources holdings.

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

2.3. Bread Wheat Breeding

Bread wheat ranks first in production among cereal crops in West Asia and North Africa. During 1986 this region produced 55.5 million tonnes of wheat (Fig. 15). Approximately 82% was bread wheat while the rest was durum. Bread wheat is the principal food source for the majority of the population, which on average consumes more than 145 kg per capita per year, the highest in the world. Wheat imports have increased during the years, and in 1985 this region imported 23.1 million tonnes to meet demands (Fig. 16).

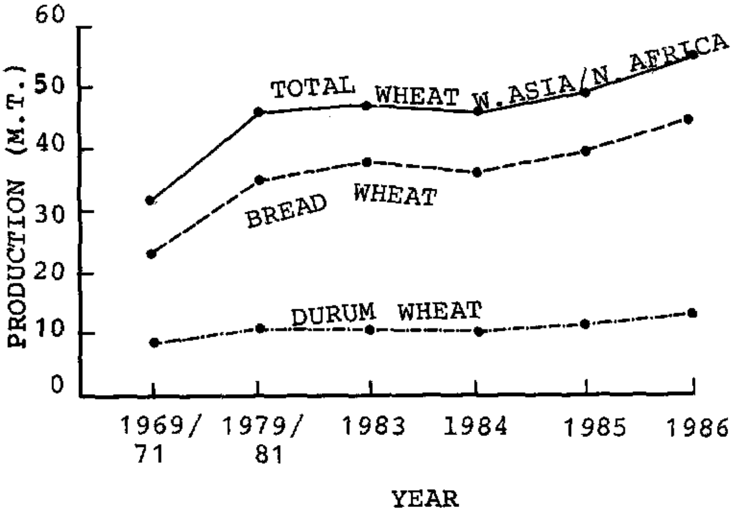


Fig. 15. Production (million tonnes) of bread and durum wheat in West Asia and North Africa. Source: FAO monthly bulletin of statistics 1985 and 1986.

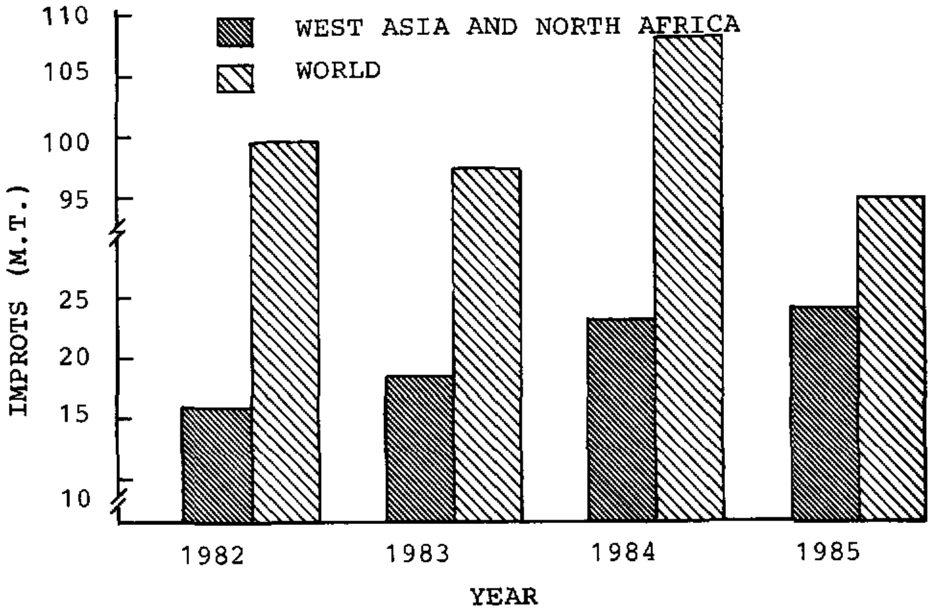


Fig. 16. Wheat imports in West Asia and North Africa and in the world. *Source: FAO monthly Bulletin of statistics*, 1985-1986.

The environments where wheat is grown in West Asia and North Africa are characterized as highly variable and unpredictable in terms of rainfall, temperature, and soils as well as disease and insect pests. In this region bread wheat is grown and harvested were temperatures fluctuate significantly. Typically, however, wheat is sown in the fall, where its early growth and development occur during the coolest months and grain ripening occurs during the warmest months. Extreme cold and heat are common abiotic stress factors during the crop season, and frequently a complex interaction between them and moisture deficits develops.

Research results confirm that the region's semi-arid rainfed sites (rainfall less than 500 mm), where most of bread wheat is grown, are more dissimilar and variable in terms of moisture availability and temperature than sites with adequate moisture supply (rainfall more than 500 mm or irrigated, Table 43). The semi-arid low temperature rainfed sites are characterized by a longer maturity duration, shorter plant height, and possibly lower grain yield when compared to the mild winters adequate moisture sites. The greater standard deviation for the four agronomic characters tested in the semi-arid rainfed sites is a reflection of the greater variability in moisture availability and temperature among the semi-arid rainfed vs. adequate moisture sites. Variability in plant height and grain yield is greatly affected by rainfall and temperature variability, and variability in maturity duration is greatly affected by fluctuation in winter temperature.

Table 43. Summary statistics for four plant response variables in semi-arid and adequate moisture sites* of West Asia and North Africa.

	Semi-Arid Rainfed low temperature sites		Adequate Moisture mild winters sites		All sites	
Variable	Mean	STD.DEV	Mean	STD.DEV	Mean	STD.DEV
Grain yield (kg/ha)	3693	2108	4256	1655	3916	1944
Days to heading	127	32	89	16	112	27
Days to maturity	168	28	133	18	154	25
Plant height (cm)	83	18	96	13	89	16
Simple size	32		21		53	

* Based on trial means from RWYT 1983-84 and 1984-85.
Adapted from : Ortiz Ferrara and Mulitze, 1986.

Faced with such large variation in climate and weather in the semi-arid rainfed sites of the region, the bread wheat program places special emphasis on developing cultivars suitable to these marginal environments. The list of research priorities within the program are visualized in Table 44. The low rainfall environments of the region receive highest priority.

Table 44. List of research priorities for bread wheat improvement.

Research Activity	Production Zone	
Priority	MRT	LRT
Breeding		
Yield	***	****
Yield stability	***	****
Stresses		
Drought	***	****
Cold	**	****
Heat	***	**
Salinity	**	*
Methodology		
Selection methods	***	***
Multilocation testing	****	****
Strategies	***	***
Pathology		
Foliar diseases	***	*
Seed borne diseases	***	****
Entomology		
Insect pests	***	***
Agronomy	**	*
Physiology	*	***
Quality		
Bread making	***	***
Nutritional	***	***

MRT = Moderate rainfall with moderate temperature
LRT = Low rainfall with low temperature
* Low; ** Medium; *** High; **** Very High

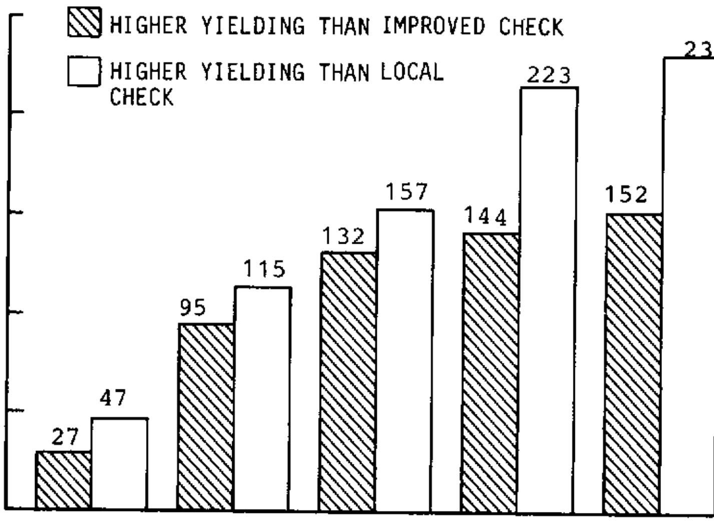
The bread wheat project is a joint ICARDA/CIMMYT breeding effort. High yield and yield stability over years, important characteristics needed in the rainfed environments of the region, are derived through application of four basic strategies:

- Continuous evaluation of potential parents
- Targetted crosses
- Multilocation selection and testing
- Targetted distribution of improved germplasm to national programs in the region.

These strategies reflect the program's interest in improving crop production under major macro crop conditions. Of course, within this breeding context, the program emphasizes environment-specific breeding activities. The orientation of these special efforts, however, is always towards overcoming one or more limiting environmental factors by incorporating into adapted germplasm the specific genetic traits needed to improve performance in certain locations, i.e. cold and heat tolerance, disease and insect pest resistance, etc.

A variety to be recommended for stress areas must be able to give relatively better yields under low input conditions, but must possess the genetic potential for higher yields should environmental conditions such as moisture, temperature or fertilizer availability improve. The breeding strategy of the program involves growing and testing genetic material simultaneously under stressed and moderately favorable conditions.

The stressed conditions include: low rainfall (200 to 300 mm), low fertility (40 kg of N and 40 kg of P205), and exposure of the germplasm to low or high temperatures during critical stages of plant development. The favorable conditions include: supplementary irrigation to simulate approximately 700 mm rainfall, high fertility (100 kg of N and 60 kg of P205). This provides information on yield potential, disease development and earliness to maturity. In between these two, several intermediate sites, representing different levels of stresses, are used. Fig. 17 shows five contrasting environments in which bread wheat germplasm is tested. Segregating populations of crosses involving spring x spring and spring x winter parents are selected on the bases of disease resistance, tillering ability, spike length, and fertility. Shrivelled grains from selected plants are discarded. Lines from advanced generations (F5 to F8) with outstanding agronomic performance are further evaluated in preliminary and advanced yield trials over these contrasting environments. The cumulative number of lines statistically ($P < 0.05$) superior to the local and improved checks over the years has been higher in the moderate stress than in the severely stressed environments, indicating that it is easier to develop improved germplasm for stress-free environments than for stressed environments.



ENVIRONMENT:	BREDA	TH-LP -SIR	TH-NP -RF	TH-EP -SIR	TERBOL
MOISTURE RANGE (mm):	208/283	250/300	316/358	400/450	500/700
TEMP. RANGE (°C):	3/28	15/40	6/32	-8/24	5/30
$\bar{X}$ YIELD RANGE (kg/ha):	866/ 1355	1536/ 2419	2578/ 3013	3350/ 3926	4300/ 5515

Fig. 17. Number of lines selected under five contrasting environments. Advanced yield trials 1984-85 to 1986-87.

Screening for Disease Resistance

Disease resistance plays an important role in the adaptation of the germplasm. In breeding for this characteristic, the program emphasizes multilocation testing of early segregating material which is done with a modified bulk (MB) method of selection in the F2 generation. Plants are individually selected in each of the most desirable F2 crosses, then bulked within each cross. The resulting F3 bulk families are evaluated for disease resistance and overall agronomic performance in five "hot spots" in the region. Undesirable families/plants are then discarded early in the segregating phase. Further information on disease resistance is collected as soon as selected lines are bulked for preliminary yield testing. Table 45 shows the current level of resistance to stem rust and yellow rust in the bread wheat segregating populations, F2 to F8, grown at two locations over two years.

Table 45. Percentage of resistant or susceptible bread wheat families to stem rust in Terbol summer 1986 and to yellow rust in Tel Hadya, 1986-1987.

Generation	Terbol Summer 86			Tel Hadya EP-SIR 86/87		
	SM	%R	%S	SM	%R	%S
F2	B	24	76	B	37	63
F3	MB	29	71	MB	39	61
F4	MB	62	38	MB	68	32
F5	MB	70	30	MB	79	21
F6	MB	86	14	MB	87	13
F7	P	30	70	MB	85	15
F8	P	29	71	P	48	52

R = Resistant; S = Susceptible; SM= Selection Method; B = Bulk; MB = Modified x Bulk; P = Pedigree; EP = Early Planting; SIR = Supplementary Irrigation.

Through the use of the modified bulk method of selection described earlier, and by exercising strong selection pressure for disease resistance in early segregating generations, the level of stem and yellow rust resistance has been upgraded.

Temperature Stress Screening

Cold and heat tolerance are essential characteristics of wheats grown in certain areas of West Asia and North Africa. In selecting and testing for these characteristics, the program uses a methodology which involves manipulation of planting dates. The hub of this screening program is Tel Hadya, Syria, where planting of cold and heat tolerance nurseries are advanced or delayed to allow low or high temperatures hit the germplasm during critical stages of development.

Figure 18 presents the long-term (1980 to 1985) weather conditions for the wheat crop season at Tel Hadya, Syria. Traditionally, wheat is planted in this area during November and harvested in late May. To screen for cold tolerance, the germplasm is planted early (first week of October) with only one irrigation

Table 46. Correlation coefficients between grain yield and six agronomic characters under cold stress conditions. Tel Hadya 1985 and 1986.

Agronomic Characters	Correlation Coefficients	
	1984/85	1985/86
Seedling vigor	0.64***	0.41**
Tillering ability	0.32 **	0.12 NS
Spike fertility	0.66***	0.32 **
1000 kernel weight	0.24 **	0.36 **
Days to heading	0.59***	0.14 NS
Days to maturity	0.34 **	0.23 **

* P < 005; ** P < 0.01; *** P < 0.001

for germination. This exposes the germplasm to cold temperature at the seedling, tillering, booting and flowering periods. Correlation coefficients between grain yield and six agronomic characters evaluated under cold stress conditions indicate that seedling vigor, spike fertility, 1000-kernel weight, and possibly tillering ability, are useful selection criteria for cold tolerance (Table 46). Although a positive correlation (P < 0.05) between grain yield and maturity was found, caution is taken in considering this trait as a selection criteria due to the negative effect of cold in early maturing genotypes.

The screening for heat stress tolerance is done at two stages: 1) terminal heat stress (THS), where the planting date of germplasm is delayed until middle of March, (Fig. 18 and 19.) This exposes the germplasm to high temperatures during the reproductive phase. 2) Early heat stress (EHS), where planting is done in the summer and the germplasm is exposed to heat stress during the vegetative and part of the reproductive periods (Fig. 20).

In both screening stages, supplementary irrigation and optimum fertilization is used to minimize the effect of drought or soil fertility. Correlation coefficients between yield and seven agronomic characters tested under THS and EHS conditions indicate that maturity time, number of fertile tillers, spike fertility and possibly seedling vigor, are useful selection traits for heat tolerance (Table 47).

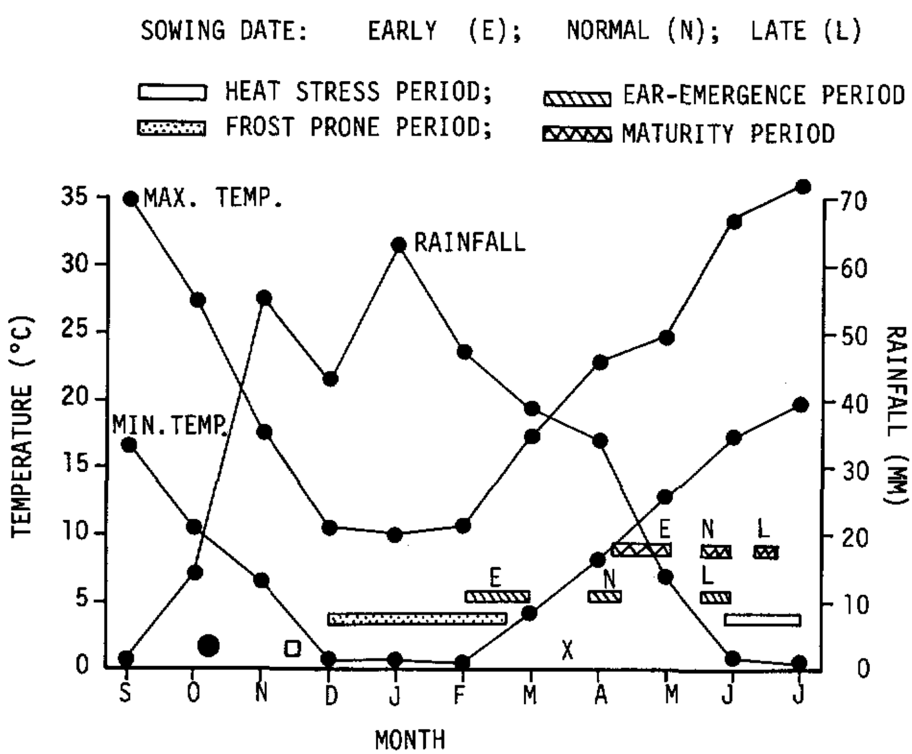


Fig. 18. Weather conditions for the wheat-crop season, Tel Hadya, Syria, 1980 to 1985.

Table 47. Correlation coefficients between grain yield and seven agronomic characters under terminal (THS) and early heat stress (EHS) conditions. Tel Hadya 1985 and 1986.

	Correlation Coefficients		
Agronomic character	THS - 1985	THS - 1986	EHS - 1986
Days to emergence	0.03 NS	0.08 NS	- 0.27 **
Seedling Vigor	0.12 NS	0.24 **	0.34 **
Days to Heading	- 0.28 **	- 0.32 **	- 0.61 ***
Days to Maturity	- 0.25 **	- 0.23 **	0.72 ***
No. of Fertile Tillers	0.62 ***	0.36 **	0.37 **
Spike Fertility	0.43 **	0.32 **	0.65 ***
Plant Height	- 0.13 NS	- 0.282 **	0.14 NS

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

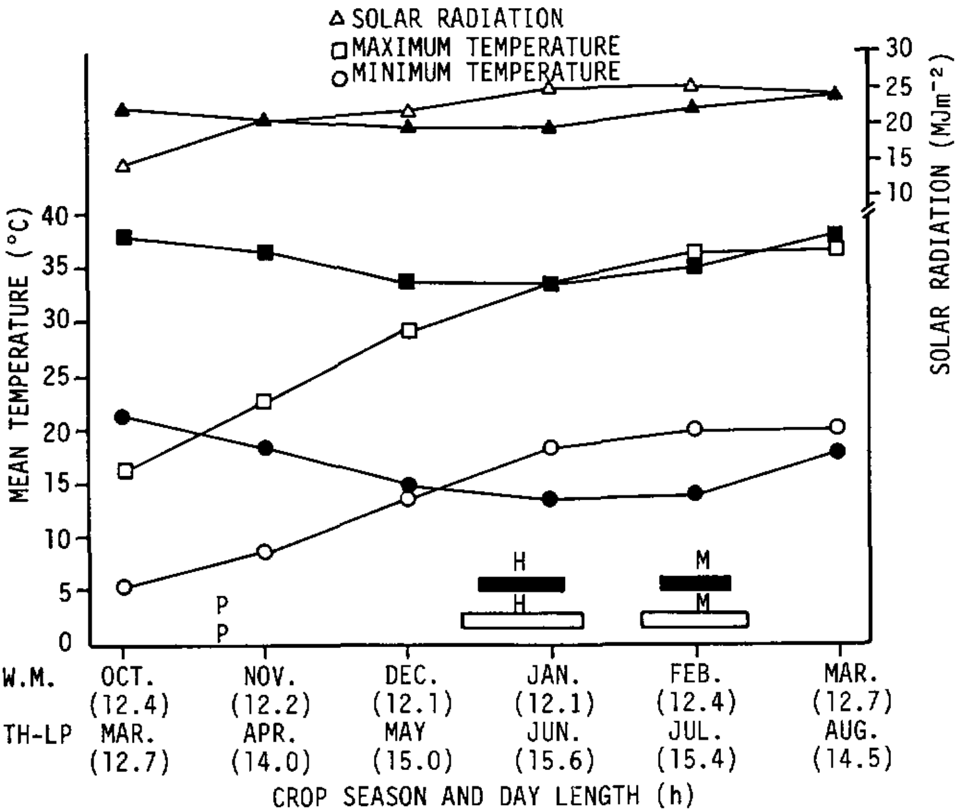


Fig. 19. Long term, 1974 to 1984, mean monthly solar radiation, maximum and minimum temperature, and day length of the wheat growing seasons in wad Medani, Sudan (WM, solid symbols), and Tel Hadya-late planting (TH-LP, open symbols.)

Days to emergence is an important criteria when selecting for early heat stress tolerance but not for terminal stress. Preliminary research data indicates that longer leaf retention, curling of the leaves and 1000-kernel weight may also be useful selection traits for heat tolerance. For purposes of comparison, Figures 19 and 20 present the long term maximum and minimum temperatures, solar radiation and day length duration during the wheat growing season of Wad Medani, Sudan. The same environmental variables for the THS and EHS screening stages at Tel Hadya are also shown. Using three years average data for days to heading and days to maturity from yield trials of Wad Medani and of Tel Hadya,

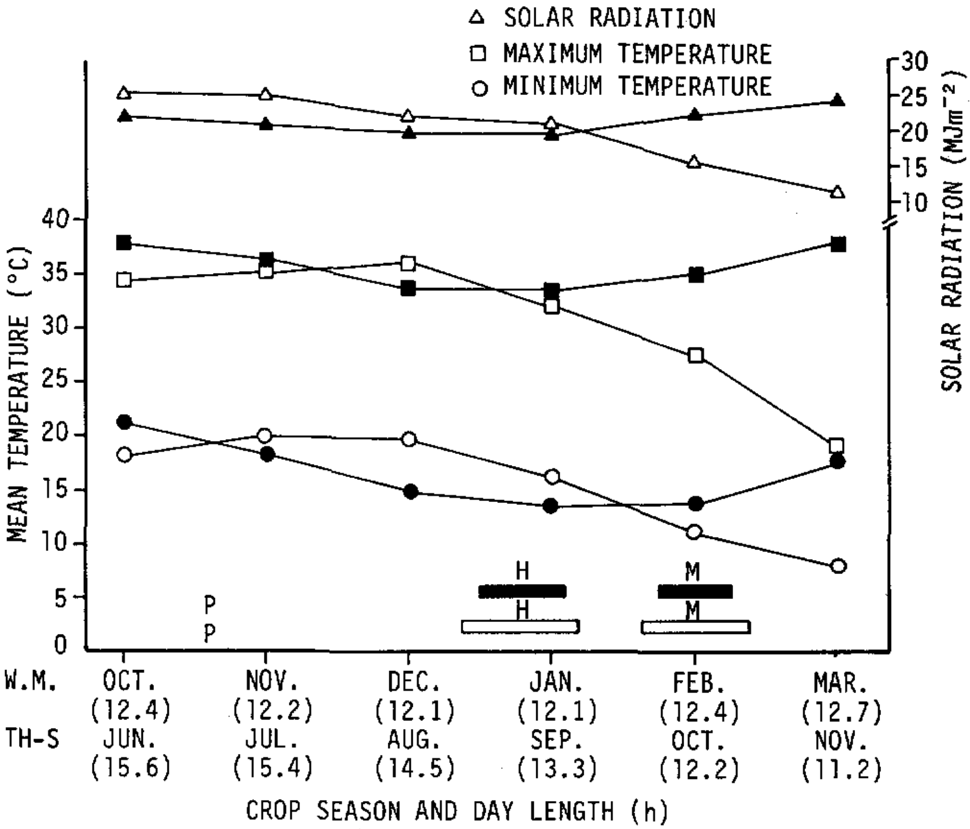


Fig. 20. Long term, 1974 to 1984, mean monthly solar radiation, maximum and minimum temperature, and day length for the wheat growing seasons in Wad Medani, Sudan (WM, solid symbols), and Tel Hayda-summer (THS, open symbols).

the crop duration in both cycles are similar. Ranges in days to heading and maturity for both THS and EHS at Tel Hadya are longer than in Wad Medani, indicating the presence of large amounts of genetic variability for these agonomic characters. Using these techniques a number of lines combining THS and EHS have been identified and distributed to the moderate-rainfall associated with moderate to high temperature environments of the region (Table 48).

International Testing

Nurseries and trials distributed to West Asia and North Africa are targetted at two major environmental zones: one with moderate

Table 48. Bread wheat lines with combined tolerance to terminal heat stress (THS) and early heat stress (EHS); 1985 and 1986 yield trials.

Cross and Pedigree	THS 1985 Yield (kg/ha)	THS 1985 %Of Check	THS 1986 Yield (kg/ha)	THS 1986 %Of Check	EHS 1986 Yield (kg/ha)	EHS 1986 %Of check
P106.19/SN64/Klre/Cno.. L484-1L-2AP-0AP-2AP-1AP-0AP	2472*	136	2533	101	188**	158
K6290.9/4/Cno/KT58N/Tob/Cno. L051-2S-4S-2AP-1AP-6AP-OAP	2400*	132	1766	110	1560*	131
Cno's'/pj//G11/3/Pci's' CM 35044-OAP-7AP-2AP-1AP-OAP	2194	121	2600	104	1668*	140
Vee's' CM33027-F-12M-1Y-1M-1Y-1M	2055	132	2844*	117	1760	117
Bch's' (B)/7C CM45186-2AP-OAP-2AP-1AP-OAP	2005	129	2788*	115	1628	108
Za75/6/Tgfn's'/5/Cfn/4/4777.. CM45 739-1AP-OAP-2AP-1AP-OAP	1905*	127	2338	93	1908*	161

* Significant at $P < 0.05$

rainfall and a mild winter and one with low rainfall and a relatively cool winter. Increasingly, genetic stocks, crossing blocks, early segregating populations and special trait nurseries are provided to national programs as compared to semi-finished lines for yield testing. The Bread Wheat Observation Nurseries (WON) are provided to national programs for preliminary screening. This network is formed with the goals of: 1) providing promising lines for potential release as commercial varieties in those countries, and 2) collecting information on the adaptation of those lines in the region.

Results were obtained from 31 sites in West Asia, North Africa, the Nile Valley, and Mediterranean Europe. Selected entries from the 1985/86 WON-MRA and WON-LRA are reported in Tables 49 and 54. The overall range for grain yield in WON-MRA was between 4814 and 2844 kg/ha with a grand mean of 3737 kg/ha. As expected, lower yields were obtained in the WON-LRA ranging from 3465 to 2221 kg/ha with a grand mean of 2923 kg/ha. Results from both types of nurseries indicate that there is a large number of lines with substantially better yields, grain quality, and more acceptable disease resistance than the national check varieties.

Table 49. Yield, agronomy, diseases and quality data of the highest yielding and most frequently selected entries in the WON-MRA 1985-86.

					ACI				QUALITY	
Cross and pedigree	GY	DH	DM	PH	YR	LR	SR	ST	PROT.	TKW.
PVN 'S'/CLI CM 52139-2AP-2AP-1AP-4AP-1AP-OAP	4814	117	152	92	9.2	14	4.6	3.8	13	40
Bb//Kal//Tjb 791-12765 SWM 555500-02H-2P-1S-0S	4413	140	175	70	0.8	0.2	29	1.6	14	32
Veery 'S' CM33027-F-12M-1Y-12M-1Y-2M-OY	4397	114	149	82	0.1	2.0	0.0	7.4	14	36
Tsi/Vee's' CM64335-3AP-2AP-2AP-OAP	4268	114	151	78	2.8	0.0	4.0	3.8	13	36
Buc'S'/Pvn 'S' CM 8732-3AP-3AP-3AP-2AP-1AP-OAP	4162	127	161	86	14	2.0	8.0	3.4	13	35
National Check	3664	115	151	83	64	66	6.0	6.6	12	29
No. of Locations	22	31	23	26	5	5	2	5	2	5

Table 50. Yield, Agronomic, diseases and quality data of the highest yielding and most frequently selected entries in the WON-LRA 1985-86.

					ACI				QUALITY	
Cross and pedigree	GY	DH	DM	PH	YR	LR	SR	ST	PROT.	TKW.
C182.24/C168.3/3/Cno*/7C//CC/Tob SWM 6828-6AP-6AP-1AP-2AP-OAP	3465	129	162	76	4	7	1	4	12.2	37
Kvz/HD 2009 SWM 2894-1M-2Y-OM-OMm	3328	116	151	79	8	2	0	5	13.1	42
Vee 'S'/Tsi CM 58943-1AP-1AP-OAP	3315	115	149	78	32	24	2	5	13.9	32
C182.24/C168.3/3/Cno*2/7C//CC/Tob SWM 6828-6AP-2AP-2AP-3AP-OAP	3290	129	164	74	10	9	1	2	13.2	37
Jup 's'/4/Lr64*2/Sn64//CC/3/Ska L764-4L-1AP-OAP-1AP-1AP-OAP	3250	117	152	71	2	0	0	4	13.9	39
National Check	2822	114	151	72	85	18	2	7	11.3	29
No. of Locations	26	30	23	28	3	4	2	4	2	5

The Regional Wheat Yield Trial includes the best performing lines from both observation nurseries. The 1985/86 RWYT consisted of 20 test bread wheat lines, and one regional, one improved in addition to one durum and one national check. Yield data were received form 41 locations. Table 51 shows the progress made in developing germplasm adapted to Mediterranean rainfed conditions. These six lines have substantially higher yields and yield stability than both the regional and improved checks.

The bread wheat project encourages some of the national programs to assume greater responsibility for variety development through conventional breeding. The emphasis will be on developing genetic stocks with stress tolerance factors, developing more efficient breeding and selection methods and in developing technologies which will improve and sustain productivity from more stressed areas.

Table 51. Grain yield and stability of the best performing entries in the RWYT 1985-86 grown in 41 locations in West Asia and North Africa.

Name	Mean Yield (kg/ha)	Reg. Coef.	Res. M.S.	Corr.
Veery 's'	4589	1.185	574500	0.935
Kal//Bb/Kal/3/Au//YU50E/...	4461	1.145	267600	0.966
Kvz/Cgn	*4400*	*1.023*	*353300*	*0.9945*
Wa 476/3/391//S6D-81-14-53...	4371	1.132	256700	0.967
Kvz/Cgn	4363	1.018	221300	0.964
Jup 's'/7/Pch/6/Kt 54A/..	4258	1.0056	219800	0.967
Regional Check	3967	1.113	534400	0.932
Improved Check	3996	1.088	599800	0.921

Farmers Field Verification Trials

On-farm verification trials started in Syria eight years ago. These are jointly conducted by the Ministry of Agriculture and Agrarian *Reform* and ICARDA. *These activities have been extended to* other countries in West Asia and North Africa including Algeria, Morocco, Sudan, Lebanon, Turkey, and Yemen A.R.

Figure 21 and 22 show the performance of the promising bread wheat lines in the on-farm trials of Syria. Four years data of these trials show that Seri 82 and Nesser's' have a yield advantage of 9% and 16% respectively over the local check Mexipak 65 under low rainfall conditions (250-300 mm).

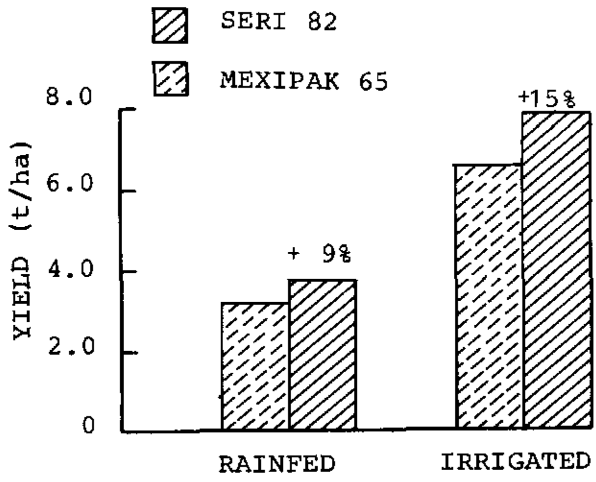


Fig. 21. Performance of Seri 82, promising bread wheat cultivar, under rainfed and irrigated conditions in Syria. * Four years average, 1983-84 to 1986-87.

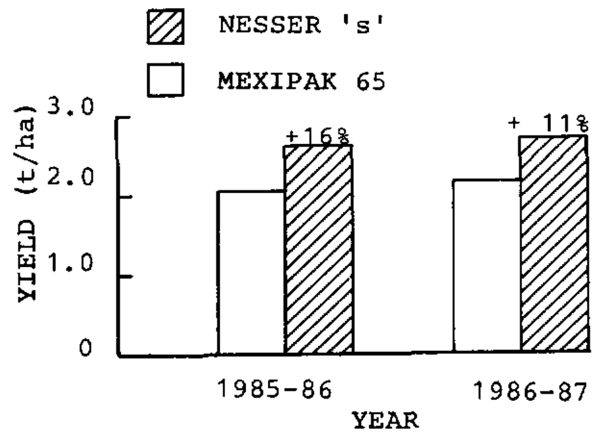


Fig. 22. Performance of Nesser's', promising bread wheat line, under low-rainfall (250-300 mm) conditions in Syria. Farmers' field verification trials 1985-86 and 1986-87.

Farmers' field verification trials carried out in Algeria during 1986/87 were encouraging (Table 52). Promising lines such as GV//Ald'S' and Sham 4 show a yield advantage of 25% and 24% over the local variety M. Demias. These two lines are under extensive testing and multiplication for possible release as commercial varieties.

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Table 52. Performance of promising bread wheat germplasm in farmers' field verification trials of Algeria, 1986-87.

Variety	Locations *					%Over Check
	Ouaddah	Haboul	Zidene	Tayebi	X	
GV/ALd 's'	27.03	21.42	14.79	22.39	21.41	125
Sham 4	23.14	26.11	14.19	21.28	21.18	124
Neelkant 's'	19.45	21.90	12.39	23.49	19.43	114
ACSAD 59	26.12	19.47	12.39	-	19.32	113
Tessalah 75	23.57	22.36	13.48	15.55	18.74	109
Sham 2	21.21	16.55	11.03	25.24	18.50	108
M. Demias (check)	27.00	-	13.71	10.64	17.11	100
Zargoon	17.90	7.36	11.89	12.19	12.33	72

* Plot size of 1 Ha in each location
** Yield in Qx/ha.

2.4. Breeding for High Elevation Areas

Introduction

Wheat and barley rank top in importance and in area devoted to cultivated crops in the high elevation areas with a continental Mediterranean climate. Resource-poor farmers of these areas practice a cereal-pasture-livestock farming system. In spite of the pivotal role of cereals in high elevation areas, their production per unit area in most parts is approximately one half ton per hectare. This low production per unit area can be ascribed to several factors:

1. Biotic

Use of unimproved, low yielding, disease susceptible wheat and barley varieties and poor crop husbandry. Major diseases are: Yellow rust (P. striiformis), Tilletia caries and T. foetida (common bunt), H. tritici-repentis (tan spot), Erysiphe graminis f.sp. tritici (powdery mildew) and barley yellow dwarf virus (BYDV).

2. Abiotic

a. Highly variable agro-climatic environments.
b. Severe cold during the early phases of plant development.
c. Moisture stress: Though it can occur at anytime during the plant life cycle, the most serious one is at the grain filling period as the rains cease around end of April (heading time for cereals) and the crop has to mature on residual soil moisture.
d. Heat: In most parts of high altitude areas the short spring is followed by hot dry summers and strong gusty winds causing increased evapotranspiration. Therefore the crop suffers from moisture stress and high temperatures.

3. Weak Research Infrastructure

Most of the developing countries have given research priority to areas of low risk and under high input: output ratio. As a consequence the high altitude areas with harsh and highly variable agroclimatic conditions have received low or no research input, except in Turkey. Lately the national programs are giving more attention and importance to such areas to increase agricultural productivity and alleviate economic disparity.

In view of the importance of cereals in the overall farming systems of high elevation areas, the Cereal Program desires to improve wheat and barley productivity through;

a. Germplasm improvement
b. Strengthening of national programs
c. International cooperation

Germplasm Improvement

To overcome the problem of high agroclimatic variability a breeding strategy (Annual Report 1986) based on multilocation testing and selection in close association with the national programs of Algeria, Morocco, Turkey, Iran, Iraq, Afganistan and Pakistan has been developed.

To develop a network of wheat and barley research in countries with major high altitude areas the following ecological zones have been identified:

Zone	Main station	Additional station
(i) Zone-1: Central Anatolian Plateau of Turkey	Ankara (Turkey)	Konya (Turkey) Sarghaya (Syria)
(ii) Zone-2: Eastern Turkey & Western Iran;	Tabriz (Iran)	Erzuram (Turkey) Hamadan (Iran)
(iii) Zone-3: Central & Eastern Iran, Afghanistan & Western parts of Pakistan	Quetta (Pakistan)	Darul Amman (Afghanistan) Karaj (Iran)
(iv) Zone-5: Himalayan & Sub mountain areas;	Khumultar (Nepal)	Almora (India) Gilgit (Pakistan)
(v) Zone-4: Atlas mountains of Morocco & Algeria	Annaceur (Morocco)	Setif (Algeria)
(vi) Zone-6 (North China)		Tibet (China)

Close cooperation with the main research station of the national programs in the first four zones (1-4) has been developed. A major part of the germplasm improvement work is carried out at these sites. In the coming years these major stations will be further strengthened and extended to other areas through substations.

Evaluation of Introduced Germplasm

Close cooperation is maintained with winter wheat improvement programs around the world for germplasm exchange. This germplasm evaluation and exchange is helpful to identify lines/cultivars for direct or indirect use in breeding. Seven kinds of nurseries listed in Table 53 were evaluated at Aleppo. Selections were carried out on the basis of agronomic performance, plant height, days to maturity, disease resistance, and yield. Out of a total number of 1728 accessions only 118 lines/cultivars (6.8%) were found to carry one or more desirable agronomic traits. These entries will be further evaluated and used in the breeding programs. The material suitable for high elevation areas of the ICARDA region should possess cold tolerance and a long vegetative phase but a short reproductive phase to avoid terminal moisture stress and heat. The selected introductions will be used to broaden the genetic base for disease resistance and high yield.

Table 53. Evaluation of International Nurseries and Germplasm.

Nursery	Total No.	No. Selected
2nd Int. Winter Wheat Screening Nursery	130	12
19th Int. Winter Wheat Performance Nursery	30	8
14th Int. Winter X Spring Wheat Screening Nursery	102	14
Russian Winter Wheat Observation Nursery	69	5
Turkish Durum Wheat Observation Nursery	415	23
Turkish Winter Wheat Observation Nursery	781	27
Turkish Wheat Lines	221	29
Total	1748	118(6.8%)

Basis of selection: AS, Pl.H, DM, diseases and yield.

Crossing Program

Crosses involving Winter x Winter and Winter x Spring types of bread and durum wheat were carried out. Details on the number of crosses for each character in bread wheat and durum wheat are given in Table 54. Crosses involving <u>T. monococcum</u>, <u>T. urartu</u>, <u>Ae. crossa</u>, <u>T. zhukovskyi</u> and <u>T. polinicum</u> were performed. A few top crosses with bread wheat were also made. These interspecific crosses were made for transferring specific traits such as yellow rust resistance, cold tolerance, drought tolerance and high protein content.

Table 54. Number of crosses for various characters in *T. aestivum*, *T. durum* and other *Triticum* species during 1986-87.

Character	Number of crosses		
	Bread wheat	Durum wheat	Interspecific
High yield	60	53	41
Yellow rust	102	85	81
Common bunt	55	25	-
Tan spot	48	35	-
Septoria	30	20	-
Local landraces	65	53	48
Earliness	52	61	-
Cold	23	33	65
Drought	19	15	46
Quality	10	15	33
Total	464	395	314

Segregating Populations and Preliminary Screening Nurseries

Selections carried out of F_2-F_6 segregating populations (Table 55) numbered 1752, 1177 and 1380, respectively, for bread wheat, durum wheat and interspecific crosses. Very little selection pressure was exerted on segregating populations originating from interspecific crosses. Most of the populations were bulk harvested for having better genetic balance and homozygosity. In the coming season selections based on the phenotypic expression of desirable traits and cytological examinations of populations with higher degrees of homozygosity will be carried out. Selections carried out on targetted F_2 populations at high altitude sites are given in Table 56.

From the preliminary screening nurseries for bread wheat and durum wheat, 352 and 118 lines out of 900 and 300, respectively were selected on the basis of yield, disease resistance and grain quality (Table 55). Some of these selected lines have been included in the observation nurseries and yield trials.

Table 55. Selections out of segregating populations and preliminary screening nurseries during 1986-87.

Species Generation	Bread wheat Total	Bread wheat Selected	Durum wheat Total	Durum wheat Selected	Interspecific Crosses Total	Interspecific Crosses Selection
F_2	840	495	400	276	325	300
F_3	945	625	472	318	200	180
F_4	630	400	580	360	290	290
F_5	280	150	340	200	382	382
F_6	113	75	30	23	228	228
Total	2808	1745	1822	1177	1425	1380
PSN	900	352	300	118	-	-

PSN = Preliminary Screening Nursery

Observation Nurseries

150 lines/cultivars each of bread wheat and durum wheat were supplied to cooperators in high altitude sites of Pakistan, Iran, Turkey, Algeria, Morocco and Syria. The selection frequency out of bread and wheat observation nurseries at each site is given in Table 56. The selection frequency at high altitude sites for bread wheat ranged from 12% at Setif-Algeria to 26% at Quetta-Pakistan. However in durum wheat it ranged from 8% at Ankara to 25 % at Quetta-Pakistan. The frequency of selection at Ankara results from a low level of cold tolerance as many lines were completely killed by cold.

The Breda, Syria site was used to test tolerance to moisture stress and earliness. Eleven bread wheat and 15 durum wheat lines were selected on the basis of earliness and agronomic score.

It was obvious that our durum wheat and barley material did not possess adequate cold tolerance to suit Central Anatolian environments. Therefore the selected lines which survived the cold kill at Hayamana will be used in the crossing program to generate cold tolerant material. Furthermore, 24% of the lines out of interspecific crosses involving T. durum X T. dicoccoides were selected. T. dicoccoides seems to be a good source for cold tolerant gene(s).

Testing and Selection at Ankara-Turkey:

Collaboration was initiated with the Turkish national program at Ankara to accelerate the winter cereal germplasm development for the cold high altitude environments. The field Crops Research Center, Ankara extended full cooperation and assistance in screening wheat and barley germplasm. Besides supplying regular nurseries of winter and facultative types of wheat and barley to the Turkish national program, materials ranging from F_2 segregating populations to semi-finished lines (Preliminary Screening Nurseries PWSN) were planted in a block of 5 ha at Haymana Research Station (Table 57).

Forty one percent of the bread wheat lines out of were selected, against 16% in durum wheat. An overall 29% lines/populations were selected at Haymana. The bread wheat selections material were based on agronomic score, cold tolerance, disease tolerance, etc. but in the case of durum wheat and barley all those lines which survived cold were retained and no other selection pressure was exerted.

Table 56. Selection frequency (%) of F_2 Segregating Populations and Observation Nurseries at high altitude sites, 1986-1987.

Site	Total	Pakistan	Iran	Turkey	Algeria	Morocco	Syria	
Nursery		Quetta	Tehran	Ankara	Setif	Oulemes	Sargaya	Breda
F_2 BW-HA	150	35	63	20	-	-	34	-
F_2 DW-HA	150	27	34	14	16	-	33	-
BWON - HAA	150	26	17	15	12	21	16	11
DWON - HAA	150	25	-	8	16	23	14	15

BW = Bread wheat, DW = Durum wheat, ON = Observation Nursery, & HAA

Table 57. Selection frequency at Ankara-Turkey out of various screening nurseries.

Name of Nursery	Total No.	No. Selected	Yield (kg/ha)	
			Range	Mean
PWSN - HA*	840	342 (41%)	1743-4134	3547
PDSN - HA	310	49 (16%)	1676-4399	3632
Interspecific-HA	140	33 (24%)		
DWCB-HA	190	34 (18%)		
BWCB-HA	232	85 (37%)		
BSN -HA	240	57 (24%)		
F_2BW-HA	740		212 (29%)	
F_2DW-HA		365		75 (21%)
Total	3057		887 (29%)	

PWSN-HA = Preliminary Bread Wheat Screening Nursery
PDSN-HA = " Durum " " "
DWCB-HA = Durum Wheat Crossing Block
BSN -HA = Barley Screening Nursery
F_2 BW-HA = F_2 Seg. Pop. of Bread Wheat
F_2 DW-HA = " " " " Durum Wheat
HA = High Altitude Areas.

Barley Screening Nurseries

With barley the second most important cultivated crop after wheat in the high altitude areas, research to develop suitable germplasm has been stepped up in collaboration with the barley project of ICARDA's Cereal Program and national programs.

Three different kinds of nurseries, the Barley Observation Nursery (BON-HAA), Barley Yield Trial (BYT-HAA) and Barley F_2 Populations-HAA for High Altitude Areas, were supplied to the cooperators at key locations for testing and selections. The percentage of lines selected out of BON-HAA was 36%, 16%, 24%, 9%, 12%, and 12 at Sariab, Kan Mehterzai, Tehran, Tabriz, Ankara and Sargaya, respectively (Table 58). Out of the Barley Yield Trial 21% and 25 % lines were selected at Sariab and Tehran under supplementary irrigation. At Kan Mehterzai all the entries were killed by cold.

Only 18% of F_2 segregating populations were selected at Sariab-Quetta, Pakistan. The low selection frequency in different barley nurseries was primarily due to the low level of cold tolerance. However in new material such as Preliminary Barley Screening nursery, 20% and 32% lines were selected at Ankara and Sargaya, respectively, indicating better cold tolerance in the new material.

A barley line, Alger/Ceres 362-1-1, has been performing excellently in Tabriz-Iran for the last two years. Fifty kilograms seed was supplied to Iran for on-farm trials and possible release to the farmers.

Table 58. Barley lines selected (%) at different locations in the high altitude areas.

Name of Nursery	Total No.	Percent selected at: Quetta Sariab	Quetta KM	Tehran	Tabriz	Ankara	Sargaya
BON-HA	143	36	16	24	9	12	12
BYT-HA	24	21	0	25	-	-	-
F_2 Barley-HA	90	18	-	-	-	-	-
Pre. Barley Screen. Nur.	270	-	-	-	-	20	32

HAA = High Altitude Areas.

Barley Observation Nursery (BON-HA) - High Altitude Areas

This nursery contained 143 entries and was tested at all high altitude sites in West Asia and North Africa. Yield data of 10 best lines at Sariab-Quetta, which were also selected at other sites are given in Table 59. Yields ranged from 2133-2666 kg/ha as compared to the best check variety, V3229 (2200 kg/ha). Entry numbers 52, 59, 60, 62, 63 and 79 were selected at four or more sites. The variety Ager has wide adaptability and a high combining ability as its derivatives were selected at other sites. Similarly the variety Sonja also performed well at Tabriz-Iran during the last two years.

Table 59. Barley lines selected from BON-HAA at more than two sites.

Entry No.	Variety/Line	Yield (kg/ha)	Selected at
52	Miraj-1	2466	H,T,K,S,L
59	Roho/Masurka	2399	H,T,K,S
60	Alger/Union	2666	H,T,K,S
62	Kenya Res./Belle	2266	H,T,S,L
63	Ager	2133	H,T,S,L
72	Cg/Cm//APM/3/---/5/Ager	2133	H,K,S
79	Kitchin/Mullers Heydla	2533	H,K,S,L
107	Chyton	2666	T,K,S
111	Sonja	2299	H,T,S
137	CWB 117-77-9-7	2599	T,K,S
V3229-Check		2200	S

H: Hayman-Turkey; T = Tehran-Iran, K = Kan Mehterzai-Pakistan, and S = Sariab-Pakistan, L = Leonessa-Italy.

This nursery was also planted at Leonessa-Italy, a high altitude cold site for screening against cold. Entries 52, 62, 63, and 79 also showed high level of cold tolerance at Leonessa.

Cold Tolerance Studies

Cold causes considerable damage to winter cereals at various plant development phases in high altitude areas. Among winter types of wheat and barley, a number of lines and cultivars are winter hardy but phenologically do not fit well with the growing period at high altitudes. In major parts of the high altitudes, long, severe winters are followed by short springs and hot, dry summers. The fluctuations in the temperature are enormous. Crops such as wheat and barley have to pass through severe and variable cold during their vegetative phase and then complete their reproductive phase quickly to avoid terminal moisture stress as the rains are usually finished by the end of April, which coincides with the reproductive phase. The suitable cultivars, therefore, must possess cold tolerance and earliness in maturity as well as other positive characters.

Three different approaches have been followed to develop cold/frost tolerant germplasm to fit the highly variable agro-climatic conditions of the high altitude areas. These are:

1. Field screening at suitable sites, such as Sargaya, Syria; Quetta, Pakistan; and Ankara, Turkey in the high altitudes. Parental material and early generations of segregating populations developed through hybridization of winter x spring types involving locally adapted landraces and improved winter wheats from other places are planted for testing and selection.

2. Tolerance testing for crown freezing: Plants grown 40-45 days in trays are removed and shaken free of loose soil; all plant parts more than 2.5 cm above and 1.2 cm below the crown are removed, and the crowns are washed, placed in plastic freezer bags, and moved to a freezing chamber where they are subjected to 2 hours at $0^{o}C$, 3 hours at $-5^{o}C$, 18 hours at $-10^{o}C$ or $-12^{o}C$ or $-13^{o}C$, 3 hours at $-5^{o}C$, 3 hours at $0^{o}C$ and 19 h at $4^{o}C$. For a freezing test without a hardening, the samples are placed directly in the freezer at the screening temperature without any prior thermal treatment. Afterwards they are replanted in sand in a greenhouse and observed for survival and performance at various times.

3. Monitoring and recording of attributes in primordia development and growth that are associated with cold and drought tolerance: stages are recorded according to the classes described by Inamura et al. 1955. [J, Kamto-Tozan Agric. Exp. Sta. 8:75-91]. Data on growth habit, plant height, development stage and length of primordia, culm length, days to heading and maturity are recorded.

Crown Freezing Testing

Crown freezing tests on selected barley and wheat were conducted in co-operation with Dr. Victor Shevstov, a barley breeder from Krasnodar Research USSR who was a visiting scientist in the program.

A. Barley

Six barley varieties (Table 60) were tested for tolerance to crown freezing at -10°C, -12°C, and -13°C. Harmal 2 was highly susceptible and was completely killed at -10°C. The variety Radical was the most tolerant, with a mean survival of 97.4% for all three temperatures. At -10°C, the varieties Miraj and Cyclone had more than 50% survival. At -12°C their survival dropped to 23.8% and 37.5%, respectively and only Radical (92.3%) and Cyclone (28.5%) survived freezing at -13°C. Arabic Aswad, a widely cultivated landrace in the drier areas of Syria, was sensitive to temperatures below -10°C. Its drought tolerance makes it a good candidate for improvement with transfers of genes from Radical.

B. Wheat

Of the 45 cultivated landraces and improved wheats tested, Bezostaya was the most cold tolerant (Table 61). ICW H81-1610 and ICW H81-1781 had better cold tolerance at -10°C than did cultivated varieties like Local White (Pakistan), Sabalan, Sardari (Iran), and Bolal (Turkey). When these cultivated varieties were exposed to -10°C without prior hardening, none could survive.

At -5°C, all varieties survived, so this temperature is probably too mild to screen for cold tolerance. For efficient screening, -10° to -15°C appears to be appropriate.

Table 60. Frost resistance of six varieties as measured by survival after freezing of crown.

	Plant survival (%) after freezing at			
	-10°C	-12°C	-13°C	Mean
Harmal 2	0.0	0.0	0.0	0.0
Arabic Aswad	26.6	4.3	0.0	10.3
Radical	100.0	100.0	92.3	97.4
Ager	44.8	13.8	0.0	19.5
Miraj	62.8	23.8	0.0	28.7
Cyclone	70.4	37.5	28.5	45.4
LSD (0.05)	10.2	10.6	14.6	

Frost Tolerance in Cultivated Landraces and Improved Wheat Varieties

Genetic differences in cold tolerance were observed in barley and wheat irrespective of their growth habit -- a finding in agreement with others. As the cold tolerant genes can be transferred from winter types to spring types, improved cultivars like Radical and Cyclone will be valuable parental material in ICARDA's breeding program.

Screening breeding material under field conditions appears to be feasible, as the cold-tolerant selected varieties, ICW H81-1610 and ICW H81-1781, performed well in follow-up tests. Similarly, other work has observed good agreement between field data and laboratory tests (crown freezing) on 30 varieties under controlled conditions with temperatures down to -8°C for 16 h. In fact, field screening and crown freezing tests have been widely used to screen for cold tolerance.

Primordia Development and Growth Attributes in Relation to Cold Tolerance

The two groups of wheat have been subdivided into five categories (1 = spring type to 5 = winter type) by the degree of prostrate character at seedling/tillering stage and vernalization. This is a slight modification of Gotoh's (1979, Bull. Tohoku Nat. Agric. Exp. Sta, 59: 1-69) method. The data on growth habit indicated that Bezostaya and Avalon were the only varieties/lines possessing a strong winter habit *(Table 66)*.

Table 61. Scoring for frost tolerance in eight cultivated landraces and improved wheat varieties.

Variety	*Scoring after 10 and 25 days of freezing at:* -10°C		-10°C, no hardening		-5°C	
	10	25	10	25	10	25
Local White	1.3	1.0	1.0	1.0	4.3	1.9
Sabalan	2.6	1.0	1.0	1.0	4.4	4.2
Sardari	3.4	1.2	1.0	1.0	4.0	3.8
Bolal	1.2	1.0	1.6	1.0	3.3	2.9
CA-8055	3.6	2.3	1.5	1.0	4.9	5.0
Bezostaya	5.0	4.0	1.0	1.0	4.5	4.6
ICW H 81-1610	3.4	1.5	1.0	1.0	4.5	4.3
ICW H 81-1781	3.5	1.4	1.0	1.0	4.7	3.3

At 90 days after planting, no major differences were observed in plant height or culm length and only minor differences were found for primordia length (Table 62). Local White was in stage VI of primordium development, whereas Sabalan, Sardari, Bolal, ICW H81-1610, and ICW H81-1781 were in the same stage (V) as Bezostaya and Avalon. According to Inamura et al. (1955) wheat and barley varieties during their growth to stage VII are not prone to cold. As none of the cultivars from cold, high altitudes nor the two promising lines exceeded primordia development, stage V suggests that during severe cold in the early stages development is similar to that of Bezostaya, the most cold-tolerant cultivar. Their slow primordia development in both stages indicates that they can avoid frost damage.

Table 62. Growth habit, culm length, and primordia development in landraces and improved wheat varieties, 90 days after planting (6 Feb 1986).

	Growth habit	Plant height (cm)	Primordia development		Culm length (mm)
			Stage	Length (mm)	
Local White	3.0	14	VI	1.5	5
Sabalan	3.5	19	V	0.3	5
Sardari	3.0	21	V	0.3	5
Bolal	4.0	19	V	0.5	5
Vratza	4.0	27	V	0.6	4
CA-8055	3.0	22	V	0.3	5
Avalon	5	21	V	0.4	3
Bezostaya	5	17	V	0.5	5
ICW H 81-1610	4	25	V	0.5	5
ICW H 81-1781	4	16	V	0.3	5

At 115 days after planting and at maturity differences were relatively pronounced. The varieties from Pakistan (Local White), Iran (Sabalan, Sardari) and Turkey (Bolal) as well as the newly bred lines ICWH 81-1610 and ICWH 81-1781 grew rapidly compared with Vratza, Avalon, and Bezostaya (Table 63). The local landraces and the promising lines for high altitudes reached stage X whereas other improved cold-tolerant winter types were still in stages VIII - IX. Local White, Sabalan, Sardari, ICWH 81-1610, and ICWH 81-1781 had primordia of 6.4 - 9.5 mm, more than two or three times that of Bolal (2.3 mm), Vratza (1.5 mm), CA 8055 (2.8 mm), Avalon (1.9 mm), and Bezostaya (1.8 mm).

Local White and CA 8055 headed earliest (164 days), and Avalon took the longest (190 days). All the varieties from the high altitudes and the newly developed lines matured earlier than Avalon and Bezostaya. The most suitable variety among those tested seemed to be CA-8055, which developed slowly during cold and rapidly later.

Table 63. Growth performance of landraces and improved wheat varieties at 115 days after planting and at maturity.

Variety	PH (cm) at: I	PH (cm) at: II	Primordia Stage	Primordia Length (mm)	Culm Length at Maturity (mm)	DH	DM
Local White	54	121	X	9.5	125	164	198
Sabalan	55	118	X	9.0	121	174	206
Sardari	52	117	X	6.5	118	182	210
Bolal	53	120	IX m	2.3	44	175	208
Vratza	40	104	VIII	1.5	8	180	215
CA-9055	45	100	IX e	2.8	55	164	208
Avalon	48	80	VIII	1.9	10	190	245
Bezostaya	37	95	VIII	1.8	21	176	216
ICW H-1610	51	115	X	6.4	121	177	208
ICW H-1781	52	127	X	7.5	50	175	208

PH = Plant Height; I = 115 Days after Planting; II = at Maturity
DH = Days to Heading; DM = Days to maturity.

Frost tolerance was positively correlated with primordia development stages (Table 64), as were growth habit up to 90 days after planting (r = 0.491) and culm length. However, frost damage was found to be negatively correlated (r = -0.467) with culm length.

Table 64. Relationship between primordia development stage and other characters.

	Frost	Days to Maturity	Growth Habit	Culm Length
Primordia development				
90 days	0.816**	-0.231	0.491*	0.870**
115 days	0.658**	-0.063	0.276	0.658**
Frost damage	-	-	0.383	-0.467*

Other workers have a observed positive relationship between ear primordia length, low temperature, and cold damage.

An inverse correlation (r = -0.467) between culm length and frost damage was found.

These findings indicate that varieties can be bred to have a long vegetative phase with slow primordia development during winter and followed by rapid development in warmer weather. Breeders should be able to develop cultivars with short grain filling periods and good yields, an achievement that has to date been regarded as impossible.

The strategy to develop cold and drought tolerant germplasm able to escape or resist heat at grain filling period using the distant hybridization involving winter X spring type crosses with local landraces and improved varieties seems to be successful.

Earlier studies have indicated that the duration of grain filling is positively correlated with yield. However, cultivar CA 8055 and breeding lines ICW H81-1610 and ICW H81-1781 are ideal from the viewpoint of primordia initiation and development, and they produce high yields after a short ripening period. Breeding and directed selection can be used to combine high yield and late initiation of primordium along with short grain filling.

Based on the above studies, a breeding strategy to develop suitable germplasm which will fit high altitude environments has been charted out in Fig. 23.

This study was conducted in co-operation with Dr. T. Hoshino from TARC, Japan, who was a visiting scientist in the program.

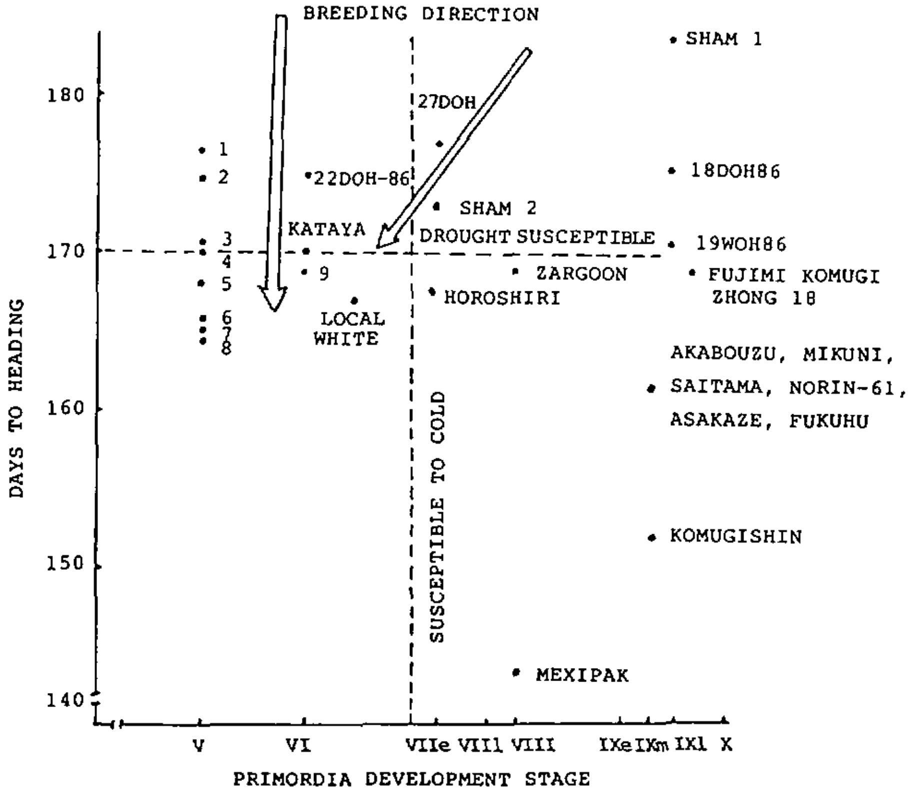
Regional Yield Trials - High Altitude

Barley Yield Trial - Karaj, 1985/86

This trial was comprised of 24 entries with one longterm check, an improved check and a national check variety. The results of the five top yielding lines along with the check varieties are given in Table 65. None of the entries out-yielded national check (8924 kg/ha). However two entries, nos. 15 and 20 with yields of 8783 and 7787 kg/ha, respectively were statistically at par with the national check. All the rest of varieties/lines gave a significantly lower yield. The experiment was conducted under irrigation.

Table 65. Performance of top yielding lines out of regional barley yield trial - cold tolerance, at Karaj-Iran. 1985-1986.

Entry No.	Variety/Line	Rank	Yield (kg/ha)
24	National Check	1	8924
15	Harrison/Nopal	2	8783
20	LTH/3/Nopal//Pro/11012-2	3	7787
21	CQ/CM//APM/3/Egypt 20...../5/Ager	4	7662
22	Jerusalem a barbes lisses/Bonnus	5	7624
12	Beecher - Check	6	7541
18	Alger/Union-Check	23	5183
CV			12.45
LSD (5%)			1172.81



*1. AVALON 17
2. GEZIRA 17
3. HOURANI, ABVD-1,DAWS,
4. BEZOSTAYA, GRANA,
5. NS2699,BOLAL,TRAKIA,VRATZA,OGOSTA,
6. AZADI,SARDARI,SABALAN,
7. ICWH81-1610 & 1781,
8. PAIYU PAO,CA8055,
9. WCBH76,WCBH195,WCBH213,DONGXIC AKASABISHIROZU, CHIKOKU,

Fig. 23. Breeding for cold tolerance, early heading varieties from a primordia initiation viewpoint.

Barley Yield Trial - Quetta, 1986/87

The trial was conducted under supplementary irrigation but there was severe cold damage. Four entries, nos. 2, 6, 22 and 17 gave significantly higher yields of 588, 536, 511, and 499 kg/ha as compared to 291 kg/ha of national check variety V3329 (Table 66). The best lines were similar to the national check variety in other agronomic characteristics. This very low yield level was due to highly variable weather conditions, especially rainfall distribution and prolonged cold (-15°C) which caused severe damage.

Table 66. Top yielding lines out of Regional Barley Yield Trial-High Altitude at Quetta-Pakistan, 1986-87.

Entry No.	Variety/Line	Rank	Yield (kg/ha)	Pl.H (cm)	Days to maturity
2	M64-76/BON/JO ..	1	588	74	157
6	Lignee 131	2	536	74	159
22	APM/HC 1905//Robur	3	511	62	159
17	Jeru. A Barbes/BON	4	499	68	162
23	OP/ZY//Gem	5	437	65	158
18	Alger/Union	17	324	82	159
24	National Check-V3329	23	291	76	159
	LSD 5%	167.39			

Bread Wheat Yield Trials, Tehran and Quetta, 1985/86

This trial was conducted under supplementary irrigation. Of 24 entries 14 outyielded the national check variety Azadi. Data from the top yielding five lines/varieties, along with the national improved check variety and longterm winter wheat check variety Bezostaya are presented in Table 67. Variety Kataya A-1 was also among the five top yielding lines at Quetta-Pakistan and Diyarbakir-Turkey. Variety Zargoon, which ranked number 3 with yield of 7100 kg/ha as compared to local improved check variety Azadi (5649 kg) at Karaj, is commercially cultivated in the high altitude areas of Pakistan. The fourth and fifth ranking entries, numbers 2 and 6, gave yields of 6941 and 6875 kg/ha, respectively. They were also among the five top yielding entries at Quetta-Pakistan with yields of 7466 kg and 7022 kg/ha, respectively (Table 68). The increase in yield over the national check ranged from 21% to 27% at Karaj. The preferred plant height was over 100 cm. Except for the top yielding entry no. 19 (WWP 4258) all of the top yielding entries had plant height of one meter or more. Their time to maturity was similar to that of the national check except variety WWP 4258, which was late. Though line WWP 4258 has shorter plant height and late maturity, it possessed higher thousand kernel weight (45 gm) and protein (14.0%).

At Quetta 10 entries outyielded the national improved check Zargoon. The first 5 lines given in Table 68 gave significantly larger yields as compared to Zargoon. Though these lines/varieties gave very high yields, they did not differ significantly in other agronomic traits such as plant height and days to maturity. All the entries had higher 1000 KW as compared to Zargoon.

Three entries, ICWHA 81-1610-1, ICWHA81-1781, and Kataya A-1 were among the top five ranking lines at Quetta and Karaj. Similarly, Zargoon also ranked No.3 at Karaj. There was some variation in the expression of plant height at these two sites. However the selection and high performance of similar genotypes at Karaj-Iran and Quetta-Pakistan indicate agro-climatic similarities between these two places.

Table 67. Performance of top yielding lines out of regional bread wheat yield trial at Karaj-Iran, 1985/86.

Entry No.	Variety/Line	Rank at: Quetta	Karaj	Yield (kg/ha)	% Incr.	Pl.H (cm)	DM	TKW (gm)	Prot. (%)
19	WWP 4258	20	1	7216	127	90	181	45	14.0
16	Kataya A-1	5	2	7124	126	110	173	41	12.3
15	Zargoon	10	3	7100	125	105	175	35	13.6
6	ICW-HA 81-1610-1	3	4	6941	122	100	175	36	11.8
2	ICW-HA 81-1781	4	5	6875	121	120	179	35	12.6
12	Bezostaya I-Check	11	17	5525	97	110	176	43	13.3
24	Azadi - Check	-	15	5649	100	115	177	39	13.5
LSD (5%)				1148.81		12.7		2.8	

Table 68. Performance of top yielding lines out of Regional Bread Wheat Yield Trial at Sariab-Quetta, 1985-86.

Entry No.	Variety/Line	Rank at : Quetta	Karaj	Yield (kg/ha)	YR	Pl.H (cm)	DM	TKW (gm)	Prot. (%)
4	ICW-HA 81-1341	1	10	8222	R	95	232	40	12.6
20	WWP 4394	2	8	8088	R	100	220	31	14.0
6	ICW-HA 81-1610-1	3	4	7466	R	80	235	35	12.6
2	ICW-HA 81-1781	4	5	7022	R	102	230	39	13.6
16	Kataya A-1	5	2	6888	R	88	220	41	12.3
12	Bez - Check	11	17	6144	R	84	231	43	12.5
24	Zargoon - Check	10	3	6155	R	86	229	29	14.5
CV				18.36			11.25		8.34
LSD (%)				1536.32			13.42		10.15

YR = Yellow Rust

Durum Wheat Yield Trial-Quetta, 1985/86

This nursery had 24 entries. However the national check was the improved bread wheat variety Zargoon because durum wheat is not commercially grown in the high altitude areas of Baluchistan-Pakistan. Due to the lack of a good widely grown winter type durum cultivar an improved cultivar, (Sham 1) with wider adaptibility was also used as a check.

Twenty one lines/varieties exceeded in yield the national bread wheat check CV. Zargoon and 17 entries were better than Sham 1. Data on yield and other agronomic characters of the significantly higher yielding six lines/varieties are given in Table 69. The yields of the top six lines ranged from 4533 kg to 5555 kg/ha as compared to the yields of 3377 kg/ha, and 2733 kg/ha, respectively for cultivars Sham 1 and Zargoon. No big differences in plant height and days to maturity were observed. However all the durum lines had very high 1000 KW. The protein content (%) of top ranking lines except entry No. 2 (ICD 77-0185) was also higher than Sham 1 and Zargoon.

Table 69. *Performance of top yielding lines out of regional durum* wheat yield at Sariab - Quetta, 1985-86.

Entry No.	Variety/Line	Rank	Yield (kg/ha)	Pl.H (cm)	DM	TKW (gm)	Prot. (%)
1	Chap/21563//INRAT 69	1	5555	82	230	44	14.8
7	Gdovz 394/3/21563 AA'S'/Fg'S'	2	5511	75	225	45	16.9
15	Sert Bugday	3	4777	80	220	41	13.5
2	ICD 77-0185	4	4666	97	223	45	12.2
19	Yuma/Kohak 4638//Scar'S'	5	4599	84	223	41	14.8
22	Bit'S'/Gdovz 394	6	4533	90	221	41	15.4
23	Sham 1	18	3377	81	223	40	13.2
24	Zargoon - Check (BW)	22	2733	85	222	31	13.0
	CV		22.84				
	LSD (5%)		1212.60				

New Research Areas:

Haploid Breeding:

Research on haploid breeding of wheat and barley has been intiated during 1987 by:

a) Pollen culture: This is in collaboration with the University of Paris-Sud.
b) Haploid production by bulbosum technique: A H. bulbosum nursery of 206 accessions (10 diploid; 2n = 2x = 14, and 196 tetraploid; 2n = 4X = 28).

A permanent H. bulbosum garden has been established at Tel Hadya Syria. The chromosomal determination of these accessions has been partly completed (Table 69) and the genetic variability in their agronomic performance is being studied. The preliminary studies show a great variation in growth habit, plant height, plant vigour, head size, brittleness of rachis, etc. In addition to agronomic traits their crossability with wheat and barley will be studied to identify genotypes with high crossability.

Wide Crosses:

Two types of collaborative projects have been developed:

I. Wheat and barley hybridization (Tritordeum). This work is in collaboration with Univ. of Cordoba, Spain.
II. Winter barley improvement: Collaboration with Oregon State Univ. USA.

M. Tahir

3. Research Components

3.1. Physiology and Agronomy

Introduction

This project addresses the abiotic environmental problems relating to cereal improvement for the harsher environments of cereal production in North Africa and South West Asia. The major physical stresses are intermittent and terminal drought, low winter temperatures in the highlands and occasional winter frosts in mediterranean environments as well as high temperatures and drought during grain filling. In lowland subtropical areas, the major physical stress is high temperature throughout the growing season.

The project's goal is to equip cereal breeders with physiological data for the selection of parents and progenies under physically stressed environments. We examine also agronomic practices which may improve varietal performance under stress and which may assist plot management by breeders. As well as increase production by farmers.

In this report emphasis has been given to genotype characterization in terms of morphological traits, evaluated according to their relation to yield. Gas exchange patterns in relation to stress has been discussed, inasmuch as they provide insight into selection tools for stable biomass production in harsh environments. Comparative stress physiology between cereal species to within species phenotypic differences has been examined, and finally results concerning agronomic tools for improving variety performance under stress have been provided. Drought is central to the discussion since it is by far the major stress of concern.

The materials and methods used were described in detail in the 1986 Cereals Improvement Program Report. Briefly, physiology nurseries for barley, durum wheat and bread wheat were assembled in the 1985/86 season. The genotypes were chosen to represent a wide range of morphological and phenological characteristics as well as the breeders own assessments of drought resistance. The nurseries were grown in replicated trials at three sites in northern Syria for two consecutive years. An RCB design with large plots (10 M^2) and 3 replicates has been used. The main difference across sites is rainfall, ranging from ca. 350 mm to ca. 200 mm over the long term for the sites of Tel-Hadya, Breda and Bouider, which cover the rainfall range. The barley physiology nursery is also being studied at the Plant Breeding Institute (PBI) in Cambridge, UK. There, two treatments are being imposed, optimum water supply, and growth on stored soil moisture (approximately 85 mm for the growing season). The dry treatment is maintained by using rain-out shelters.

Visual morphological traits, plant development, leaf tissue water relations, gas exchange, soil water content and environmental variables, through a class A meteorological station at each experimental site were measured throughout the season. This report presents a brief summary of the agronomy results. Details are discussed elsewhere (Barley management for low rainfall Mediterranean areas. Submitted to Rachis).

4.1.1. Gas Exchange of Barley and Wheat Genotypes under Drought

Background

Net Photosynthesis - We define net photosynthesis (NP) as the amount of CO_2 taken up by leaves from the atmosphere measured in a gas exchange chamber. It includes the assimilation of external CO_2 and that released in respiratory processes, i.e. respiration and photorespiration. Changes in NP reflect changes in stomatal conductance and mesophyll capacity for incorporating CO_2.

Figure 24 shows three hypothetical leaves with different photosynthetic capacities. The solid NP-Ci curve represents an average leaf, the lower dotted line a leaf with decreased photosynthetic capacity and the upper dotted line, a leaf with high photosynthetic capacity. This type of curve is usually referred to as the demand function. Superimposed on the three demand functions, two supply functions are drawn in Fig. 24, labelled g_1 and g_2. Their slope corresponds to stomatal conductance. The supply function represents the flux of CO_2 from the exterior to the interior of the leaf according to the following equation:

$$NP = gco_2 \ (Ca - Ci) \qquad (1)$$

where gco_2 is the leaf conductance to CO_2, Ca the CO_2 concentration outside the leaf and Ci the CO_2 concentration in the intercellular air spaces of the leaf.

The photosynthetically active radiation (PAR) affects NP. Light saturation was obtained at about 1000 umol quanta m^{-2} s^{-1} for recently fully expanded leaves. The average light compensation point (PAR intercept) was 50 umol quanta m^{-2} s^{-1} and the average dark respiration (NP intercept) 1.8 umol CO_2 m^{-2} s^{-1}. All measurements reported are at saturating PAR.

Transpiration. The second major component of gas exchange is transpiration (T) or water vapor flux from the inside to the outside of the leaf. It is defined by a similar diffusion equation as the supply function but now in terms of water vapor pressure:

$$T = gwv\ (e_i - e_a)/P \qquad (2)$$

where gwv is the conductance to water vapor, e_i is the intercellular vapor pressure, and e_a the atmospheric vapor pressure and P the atmospheric pressure. Both NP and T are also affected by the boundary layer conductance. Transpiration is essentially determined by the stomatal conductance and the water vapor pressure deficit of the atmosphere with respect to the saturation water vapor pressure at the leaf temperature.

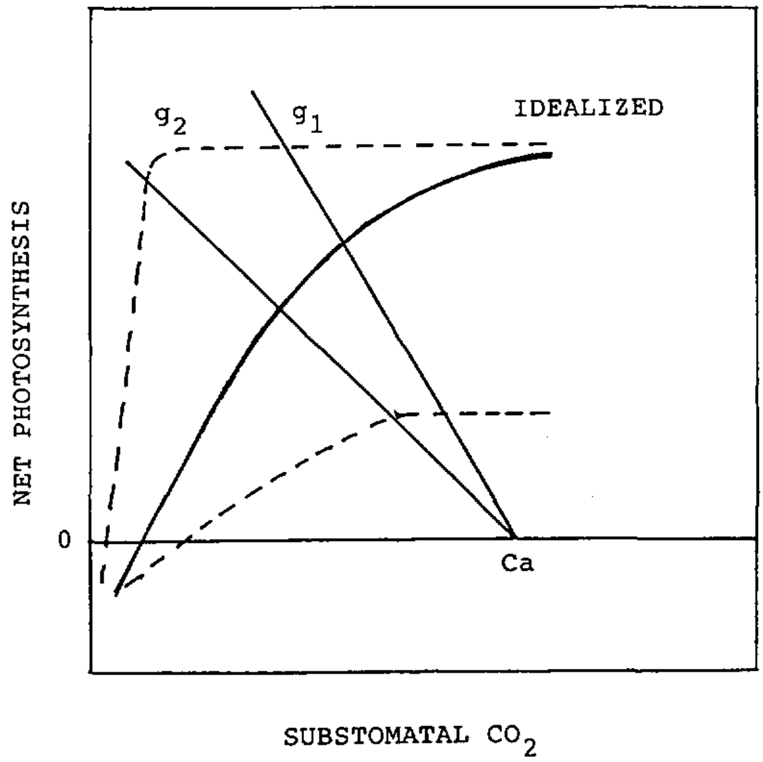


Fig. 24. Photosynthetic Response to Intercellular CO_2, (Ci) at a given ambient CO_2 (Ca) and two stomatal conductances, g_1 greater than g_2, for different photosynthetic capacity.

Transpiration efficiency (TE) may be defined as the ratio of NP to T. Species across environments and genotypes within any given environment may differ in TE according to their ability to keep functional demand and supply functions. The optimum supply function would be the one that would allow enough CO_2 diffusion according to photosynthetic capacity and keep transpirational losses to a minimum. In Fig. 24, g_2 would be optimum for the low and high photosynthetic capacity leaves while g_1 would be optimum for the medium photosynthetic capacity leaf. An option for increased production under drought would be to select plants with greater TE, i.e. greater NP and smaller T under stress.

General Pattern of NP, Ci and gco_2 Changes with Environmental Stress

Before analyzing differences between and within cereal species in TE and related variables it is worthwhile to establish the general trends observed in gas exchange components in the field, as plants are grown from relatively high rainfall environments to low rainfall. A pattern has been observed in 40 wheat and 72 barley genotypes during the 1985/86 and 1986/87 seasons. We choose for simplicity eight barley genotypes and present data obtained in the 1985/86 season. The data were collected between ear emergence and anthesis. Gas exchange was measured with a portable IRGA (ADC, The Analytical Development Company, England) equipped with an air supply unit and a Parkinson leaf chamber. The measurements were standarized to the central part of the penultimate leaf (flag leaf-1). The genotypes were grown at four sites in Northern Syria: Jindiress, Tel Hadya, Bread and Bouider. These sites received 340, 276, 195 and 180 mm of rainfall respectively during the growing season. Table 70 summarizes the gas exchange data. There was a 96% decrease in NP within the rainfall range with an increase in Ci at both extremes of the range. Genotype values (means of four readings) at the various sites are plotted in Fig. 25. As CO_2 conductance decreased from 0.4 to 0.1 mol m^{-2} S^{-1} NP decreased by 50 % and Ci by 25 %. At gco_2 below 0.1 mol m^{-2} S^{-1} there was a sharp decrease in NP from about 10 umol CO_2 m^{-2} S^{-1} to values approaching zero. This was associated with an increase in Ci from about 160 umol mol^{-1} CO_2 to values close to ambient within a narrow range of gco_2. NP and Ci were positively correlated (r^2 = 0.73 n = 15) for gco_2 above 0.1 and negatively correlated (r^2 = 0.52 n = 17) for gco_2 below this value.

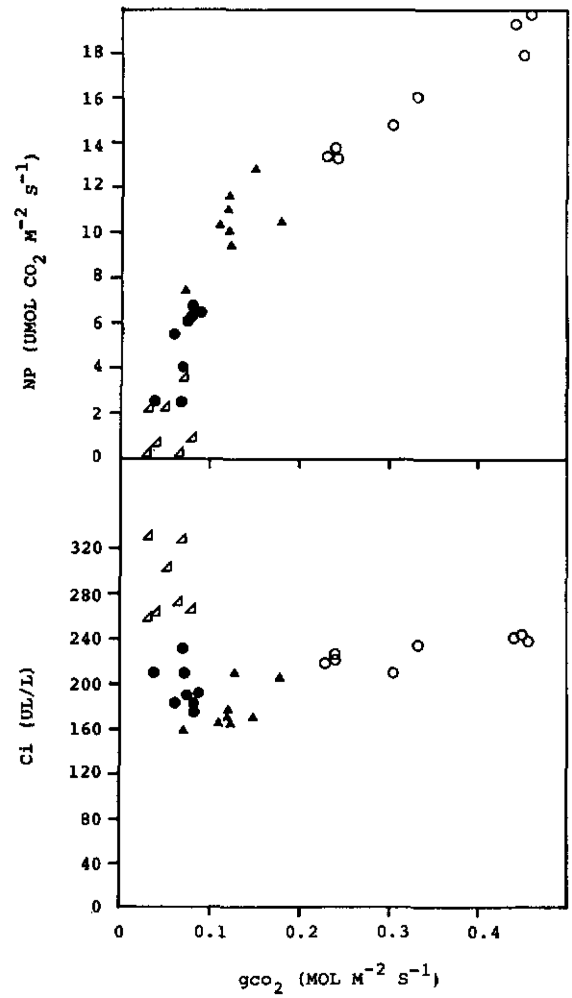


Fig. 25. Gas exchange data for eight barley genotypes grown at Jindiress (open circles), Tel Hadya (solid triangles) Breda (solid circles) and Bouider (open triangles). Data obtained between ear emergence and anthesis.

The increase in NP with Ci for gco_2 above 0.1 was mainly related to stomata opening. For gco_2 below 0.1 there was a decrease in photosynthetic efficiency, schematically depicted in Fig. 26 and shown by significant decrease in the slope of the demand function. Photosynthetic capacity and stomata conductance decreased with increased stress.

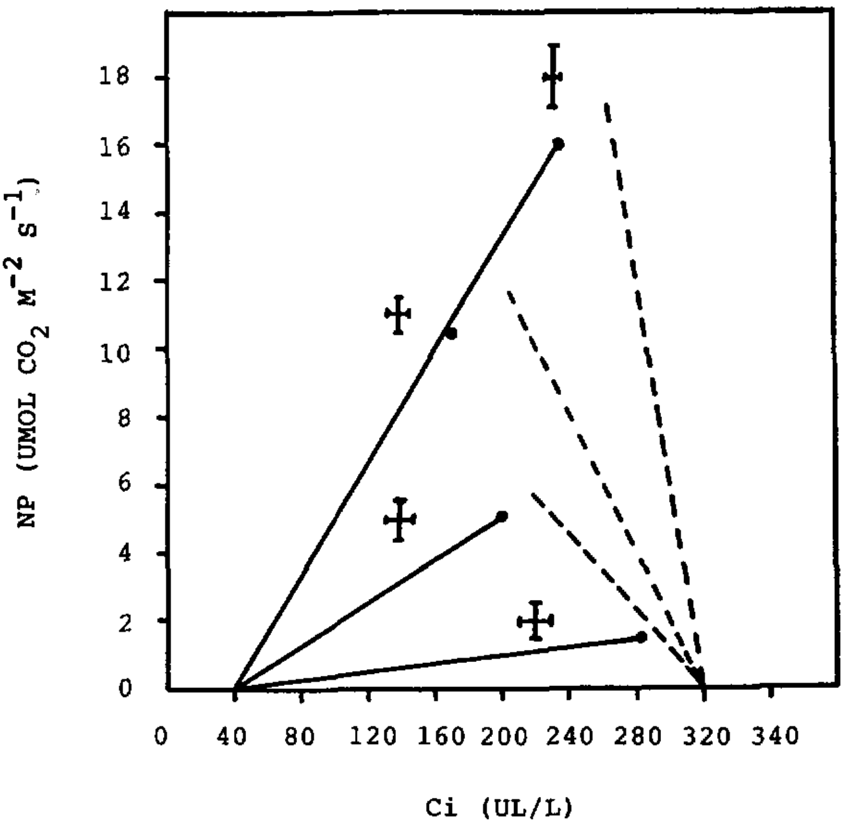


Fig. 26. Estimated supply and demand functions for eight barley genotypes grown at four sites of decreasing rainfall in Northern Syria. Bars indicate twice the standard error of the mean.

NP was highly and positively correlated with gco_2 (r^2 = 0.93) above 0.1 mol m^{-2} S^{-1}, the correlation below this point was also positive but weaker (r^2 = 0.39). Furthermore, most of the increase in Ci at the relatively wet sites can be attributed to increase stomatal conductance (r^2 = 0.84), while at the driest sites the relation between these two variables was negative and weak (r^2 = 0.15), i.e. the increase in Ci was not related to stomatal conductance.

Instantaneous transpiration efficiency was calculated from the ratio of NP to T and normalized by VPD as in Constable and Rawson (Aust. J. Plant physiol. 7:89-100, 1980). TE and T were strongly negatively related for gco_2 above 0.1 mol m^{-2} S^{-1} (r^2 = 0.76) while

Table 70. NP, Ci, gco_2 and leaf temperature. Barley genotypes $\bar{X} \pm$ (S.E.).

Parameter	Rainfall (MM)			
	340	276	195	185
NP (UMOL M^{-2} S^{-1})	16.07 (0.94)	10.41 (0.60)	5.12 (0.63)	1.45 (0.49)
Ci (UMOL MOL^{-1})	232.6 (3.4)	178.4 (5.0)	199.2 (6.8)	282.2 (9.4)
gco_2 (MOL M^{-2} S^{-1})	0.338 (0.035)	0.126 (0.011)	0.070 (0.005)	0.053 (0.007)
T (^oC)	25.4 (0.4)	26.9 (0.3)	30.2 (0.3)	34.7 (0.2)

this relation was positive and weak for gco_2 below this value. A maximum was observed in a TE vs NP curve (Fig. 27). Below about 6 umol CO_2 m^{-2} S^{-1} NP, the decrease in NP was higher than the decrease in normalized T thereby decreasing the normalized TE substantially. Above about 12 umol CO_2 m^{-2} S^{-1} NP the normalized TE ratio decreased again but due to a proportionally higher increase in T than in NP.

Figure 27 strongly resembles normalized TE vs photon irradiance curves obtained in our work (for others, see per example. Aust. J. Plant physiol. 13:475-489, 1986), suggesting that the light reactions and electron transport may be impaired at high stress levels. In the way expressed here, TE is inversely proportional to the intercelluair CO_2 concentration, Ci or to Ci/Ca. Furthermore, the relation is linear and it remains linear over a wide range of environmental conditions at various stress levels in plants of various ages. The relation, however, was found to be different between species as shown in Table 71.

Table 71. Linear regression parameters of normalized TE on Ci/Ca (independent variable) for wheat and barley.

Species	Regression Parameters			
	n	Intercept (CL)	Slope (CL)	R^2
Wheat	142	12.03 (11.22 to 12.85)	-11.24 (-12.40 to -10.08)	0.72
Barley	190	15.58 (15.05 to 16.10)	-15.80 (-16.69 to -14.90)	0.86

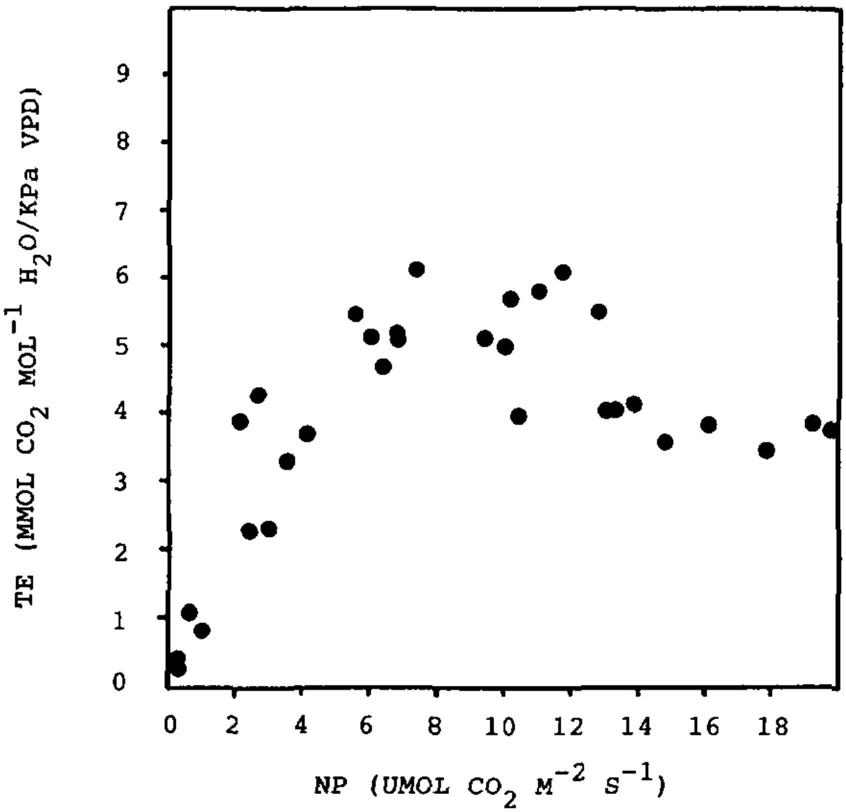


Fig. 27. Transpiration efficiency normalized by VPD for eight barley genotypes grown across a rainfall gardient.

The equations in Table 71 indicate that the maximum normalized TE is 29.5 % higher in barley than in wheat. TE decreases with increasing Ci/Ca, doing so faster in barley. At a Ci/Ca of 0.7, an average value for C_3 plants, barley would still have an advantage of TE over wheat (4.58 vs 4.16 or 10 % higher). The equations also indicate that by choosing genotypes with a given low value of Ci/Ca a relatively better progress in improving TE could be made in barley as compared to wheat. Furthermore selection for this trait should be made under stress, when NP and Ci are negatively related (Fig. 25). By selecting for relatively low Ci under stress we could probably select at the same time for higher NP and TE in these environments.

From Table 71 it can be seen that intercept and slope are equal for each equation. This is to be expected from theory.

Comparison Between Species

Data on leaf conductance obtained during the 1985/86 season indicated that under non-limiting water conditions barley would present a decreased leaf conductance as compared to wheat. This finding was corroborated in the 1986/87 season. Figure 28 presents the daily course of NP and gco_2 measurements taken in the fifth last expanded leaf of wheat and barley. The crops were not experiencing stress at the time of the measurements.

Each point in the figure is the average of seven barley genotypes, and four wheat genotypes. There was a significant ($P<0.01$) difference in stomatal conductance through the day. It was about 30% higher in wheat. The Ci was similar for the two species, implying a higher photosynthetic rate for wheat shown at saturating PAR in the NP curve. The transpiration efficiency on a daily basis significantly higher ($P<0.05$) in barley as compared to wheat.

As water stress set in, however, there was a marked decrease in NP and gco_2 which was greater in wheat than in barley. Between stem extension and heading NP decreased by 50.0 % in barley as compared to 77.9 % in wheat at the Breda site. The decrease was in parallel to a decrease in stomatal conductance of 55% and 77% respectively. Measurements taken between ear emergence and flowering in the penultimate leaf (flag leaf-1) at Tel Hadya and Bouider in the 1985/86 season and at Tel Hadya and Breda in the 1986/87 season are presented in Table 72 and further illustrate this point. The figures are the average for 72 barley and 40 wheat genotypes except for wheat at Breda where the average represents 31 genotypes since nine of these had their stomata completely closed at the time of measurement resulting in an upwardly biased average NP. An increased Ci at the dry sites can be clearly observed. *Furthermore, the gco_2 drop was greater in wheat than in barley at* the dry sites.

Table 72. Gas exchange parameters for wheat (n = 40) and barley (n = 72) genotypes at Tel Hadya (relative wet site) and Bouider or Breda (relative dry sites) in northern Syria. All measurements taken between ear emergence and anthesis (flag leaf-1). The TE values are normalized by vpd. Average of two seasons. Units as in Table 70.

Enviornments	Parameters				
	NP	gco_2	Ci/Ca	TE	Leaf T
Wetter Site					
Barley	12.8±0.26	0.18±0.05	0.06±0.006	5.6±0.12	26.9±0.25
Wheat	16.5±0.37	0.29±0.04	0.64±0.005	4.3±0.60	24.9±0.16
Drier Sites					
Barley	9.1±0.40	0.13±0.007	0.68±0.009	4.8±0.16	27.0±0.31
Wheat	2.6±0.22	0.04±0.002	0.73±0.020	4.0±0.30	33.0±0.22

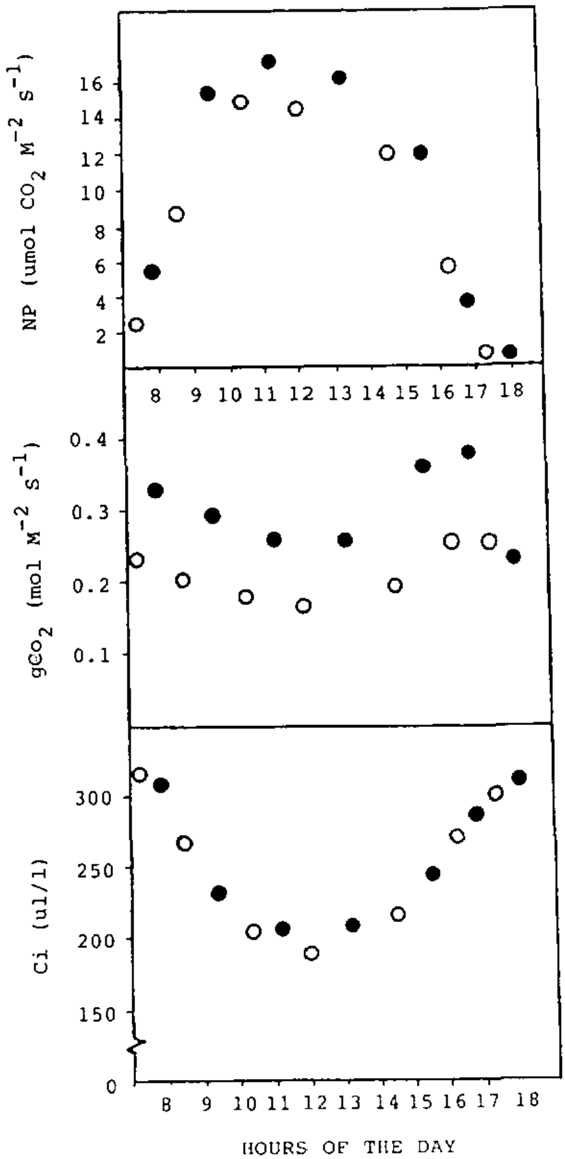


Fig. 28. Diurnal course of gas exchange on a cloudless day. Measurements taken in the fifth last expanded leaf wheat (closed circles) and barley (open circles). Tel Hadya. Stem elongation.

Hordeum spontaneum. The previous discussion shows that barley as compared to wheat uses less water per unit leaf area at the early stages of growth. The pattern changed as stress set in, such that as development proceeded from stem extension through anthesis and grain filling, barley kept its stomata more open than wheat. This was associated with higher photosynthetic rates in barley.

H. spontaneum is a wild progenitor of barley and is know to have a higher stress resistance than barley. Gas exchange observations where made at anthesis in twelve Hordeum spontaneum accessions at a relatively wet site (Tel Hadya). Comparisons between barley and H. spontaneum were also made at Bouider which had an extermely dry season. Table 73 shows the H spontaneum data in Tel Hadya. These are compared with the barley data for Tel Hadya in the 1986/87 season. Measurements were taken in similar leaves at similar stage of development in the two species. The H. spontaneum accessions had widely open stomata, higher NP and lower predawn leaf water potential at this stage of development as compared to barley.

Table 73. Gas exchange parameters of H. spontaneum accessions (n = 12). Tel Hadya. Units as in Table 70.

Variable	H. spontaneum $\bar{X} \pm$ S.E.	H. spontaneum/ Barley
NP	16.90 ± 0.80	1.49
gco_2	0.40 ± 0.03	3.57
Ci/Ca	0.70 ± 0.01	1.27
TE	4.35 ± 0.09	0.63
Leaf temeprature	25.50 ± 0.36	0.85
Predwan Ψ	0.89 ± 0.25	1.35

At the dry site some photosynthetic activity was found in H. spontaneum early in the morning, between 0700 and 0800 hrs. The average NP was 2.7 ± 0.4 (n = 8) umol CO_2 m^{-2} S^{-1} and gco_2 was 0.060 + 0.003 mol m^{-2} S^{-1}. At the same time the stomata of the local barley variety Arabic Black were closed. The predawn water potentials were -2.63 and -2.45 MPa respectively. By midday the stomatal conductance of H. spontaneum decreased to 0.025 mol m^{-2} S^{-1} at a leaf water potential of -4.6 MPa while the leaf water potential of Arabic Black was -3.5 MPa and the stomatal conductance was zero. Net photosynthesis was negative in the H. spontaneum entries at this time of the day.

The results obtained among species, barley, wheat, and _H. spontaneum_ confirm and expand preliminary conclusions drawn from results of the 1985/86 season. These may be summarized as follows:

a) At the leaf level, during the early stages of growth, in the absence of severe stress, the stomatal conductance of barley is significantly lower than wheat.
b) Even though the PAR saturated photosynthesis at normal ambient CO_2 (P max) is higher in wheat at this stage, the transpiration efficiency normalized by VPD on a daily basis is lower than in barley.
c) As stress increases there is a proportionally higher crop in stomatal conductance in wheat as compared to barley and in the last species as compared to _H. spontaneum_. Under low rainfall environments this leads to decreased NP associated with increased Ci.
d) There are indications that the more drought resistant species have lower leaf water potentials at earlier stages of development.

Within Species

One of the major challenges in cereal improvement for the harsh environments of the ICARDA region is to select and breed genotypes which are more efficient in the use of limited resources. In terms of water use this means an improved transpiration efficiency.

From the relation of TE and Ci (Table 71) and NP vs Ci under drought (Fig. 25) we reasoned that the selection had to be done under drought to be efficient. Figure 29 is revealing in this respect. the same set of 40 wheat genotypes were grown at Tel Hadya (276 mm rainfall during the growing period) and at Bouider (185 mm rainfall). Instantaneous NP was obtained in the penultimate leaf (flag leaf-1) between ear emergence and anthesis. The values are expressed on a leaf conductance basis and plotted against Ci. Similar patterns were obtained for 72 barley genotypes.

A much wider Ci range was observed at the drier site. the genotypes spread accordingly and there was a strong negative relation between NP per unit leaf conductance (which has the same ranking as normalized TE) and Ci. At the wetter site, however, as might have been expected, the Ci range was narrower and hence differences between genotypes were more difficult to detect.

The implicit weakness in the previous analysis is that it is based on point measurements of the genotypes. Furthermore, an independent assessment of TE is needed. We elaborate on these points below. It is clear, however, that in selecting genotypes for TE, a dry site should be preferred. Those genotypes with relatively low Ci and high NP under stress should be selected. The ability to maintain open stomata under drought is also of upmost importance.

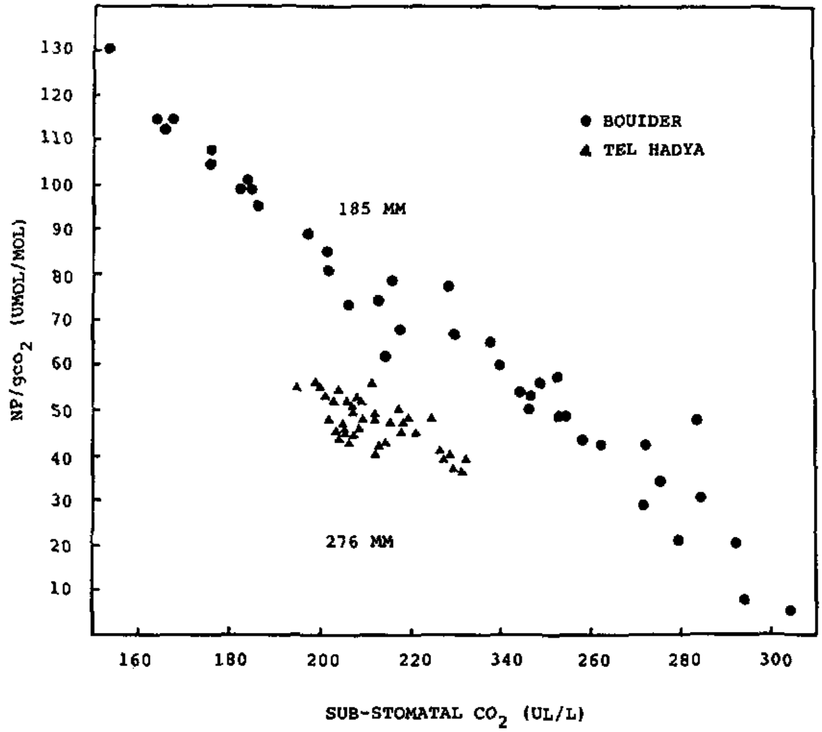


Fig 29. The relation between net photosynthesis per unit leaf conductance and Ci. Data obtained at a relatively wet site (Tel Hadya) and at a dry site (Bouider) in 40 wheat genotypes.

The Short Versus the Long Term Problem

We have discussed gas exchange, its general pattern, the differences observed between species and genotypes and the way that the variables should move in order to improve the transpiration efficiency for plants grown in harsh environments. Even though we gained some insight into the system, the problem is still far from clear. The environmental noise is extremely high since we are dealing with intermittent stresses. Water or temperature may be limiting at unpredictable times. Within a given stress site the Ci - gco_2 relation (Fig. 25) may shift from one position to another. Under the conditions of intermittent stresses a time integrated TE is therefore needed. Attempts to identify integrated TE differences between species, and between genotypes faced the unresolved problem of accurately measuring transpired water.

Farquhar and Richards (Aust. J. Plant physiol. 11:539-552. 1984) explicitly proposed the use of carbon - isotope n (c-13) analysis as a tool for investigating differences in TE and for selecting genotypes in a breeding programme for improved dry matter yield under drought. Later, Condon et al. (Crop Science, Vol. 27, September-October 1987. In press) expanded the use of this technique to screen wheat genotypes for yield under non-stress environments.

Ten high and ten low yielding two row barley entries from the 1985/86 season were selected for C-13 discrimination analysis (D). The criterion for selection was grain yield at Bouider (the driest site). The analysis was done in grain samples of the same entries grown at Bouider, Breda and Tel Hadya. Table 74 presents the results. The mean D was similar at Breda and Bouider but significantly lower at Tel Hadya. Regressions of D on grain yield and biological yield (g/m^2) across environments gave positive relations [G.Y = -1162.6 + 90.86 ($D \times 10^3$); n = 60; R^2 = 0.74 and BIOY = -2250.6 + 184.59 ($D \times 10^3$); n = 60; R^2 = 0.70]. As the environmental stress decreased, D, i.e. the average Ci/Ca over the season, increased. Within sites the C-13 discrimination differed between yielding groups at the dry sites only, such that for the higher grain yielding varieties at Bouider, D was significantly higher at Bouider and Breda. The discrimination was equal for the two groups at Tel Hadya. A positive relation between yield and D has recently been shown to exist between wheat genotypes presumably grown without stress (263 mm rainfall, 3.8 T/ha, n = 25; Condon et al. in press). The Tel Hadya barley genotypes analysed for C-13 were grouped in two sets differing ($P<.05$) in grain yield. D among the groups, however, did not differ. From gas exchange data (Figure 29) it would be expected that a wider range of Ci would be shown under drought.

Table 74. Average C-13 discrimination for the 10 top and 10 bottom grain yielding two-row barley lines at Bouider. Values are also given for the same lines grown at Breda and Tel Hadya.

	Bouider	Breda	Tel Hadya
Top 10	14.93 a	14.55 a	16.31
Bottom 10	14.41 b	14.00 b	16.26
Mean $\pm$ S.E.	14.66$\pm$0.12	14.27$\pm$0.18	16.29$\pm$0.12
Straw D[1]	16.98	16.53	18.87
Mean Ci/Ca	0.56	0.54	0.64
TE Index	6.73	7.05	5.47

1 Grain D plus 15.82 %.

Within sites correlation coefficients between yield and D are presented in Table 75. The C-13 discrimination, as measured in the grain, was highly positively correlated to grain yield ($P<0.01$) at the dry sites (Bouider and Breda). The correlation with total above ground biomass (BIOY) was significant ($P<0.05$) at Bread only.

Table 75. Correlation coefficient between C-13 discrimination and yield (n = 21).

	Sites		
	Tel Hadya	Breda	Bouider
Grain Yield	0.086	0.839**	0.732**
BIOY	0.167	0.583*	0.294

* P<0.05, ** P<0.01

Positive correlations between D and yield at the dry sites indicate that the most significant contribution of carbon to the grain was made at times when photosynthetic tissues were assimilating in the region where NP and Ci are positively related (Fig. 25). In this region, stomatal conductance to CO_2 is the most limiting factor to NP.

In the dry environments of Breda and Bouider, the barley genotypes are apparently maximizing their long term TE (Table 74) since their C-13 discrimination is lower than in the wetter site, i.e. they have a lower Ci/Ca and hence a higher TE. Within a dry environment, however, the genotypes with a higher D, i.e. a higher Ci/Ca over time, produce more. This implies that the ability to keep a functional supply of atmospheric carbon under stress becomes critical to the plant. According to theory the C-13 fractionations associated with "dark" respiration in the light and photorespiration are probably small (Aust. J. Plant physiol. 9:121-137. 1982). By conservation considerations and by the drastically decreased photosynthetic efficiency at the dry sites one would not expect a significant effect on D of the increased Ci/Ca (coming from respiration and photorespiration), observed at very low stomatal conductances (say, below 0.08 mol m^{-2} S^{-1}, Figure 25). The increased D of the genotypes grown under stress must come from increased Ci/Ca due to wider stomata opening.

The penalty associated to an increased stomatal conductance is a decreased TE for a given NP rate, other factors being equal (Fig. 27), unless there is a severe uncoupling of the leaf with the atmosphere of the crop (unlikely for the windy conditions of the areas).

The C-13 discrimination technique probably separates those genotypes which are able to keep functional supply and demand functions in spite of the stress. It also indicates that there is a trade off between transpiration efficiency and yield in a stressed environment. One way to assure that selections are being made for genotypes having high TE is to select in the right environment.

The positive correlations between yield and D at the dry sites, considering the high degree of stress that the genotypes experienced during grain filling, indicate that an important fraction of the carbon in the grain may come from assimilates stored earlier in the season. The ears may have been also an important source of photosynthetic products. The Ci/Ca needs weighting for photosynthetic rate. Most probably a major part of the seasonal photosynthesis took place during the early to mid stages of growth, when photosynthetic efficiency was not so drastically checked, as shown in Fig. 26.

The rankings for D were highly correlated ($r = 0.76$; $P<0.01$) between the genotypes grown at the two dry sites. The correlations were close to zero between the rankings at the drier site and the wet site, i.e. there was a strong genotype x environment interaction in D. Table 76 presents the genotypes having a deviation of 2 S.E. from the mean D at the three sites.

Table 76. Two row barley genotypes deviating two standard errors from the C-13 discrimination mean at each site. (Sample = 20).

Deviation From the Mean	Tel Hadya	Breda	Bouider
+ 2 S.E.	WI 2291/WI 2269	ELB 11	WI 2291/WI 2269
	ELB 75	Roho	Roho
	Roho/Masurka	ELB 40	ELB 40
	Tadmor	ELB 75	ELB 75
	SBON 89	ELB 80	ELB 80
			Roho/Masurka
- 2 S.E.	SBON 96	SBON 89	Atem
	ELB 11	Atem	Alger/Unio
	Roho	Alger/Union	Swan-neck
	ELB 40	Swan-neck	Lignee 131
	ELB 51	Lignee 131	Cytris
	ER/APM	Cytris	
	Cytris		

The high D genotypes of Table 76 for the Breda and Bouider sites are those that, in the long term average of the growing season, maintain better demand and supply functions for NP while at the same time having a high TE as compared to the wetter site. The low D genotypes may have a high TE but are unable to maintain an adequate supply of carbon under drought.

The genotypes at Tel Hadya may have a consitutive high TE (low TE at the drier site), as ELB 11, Roho and ELB 40, a very fast stomata closure as in Cytris, or stomata which adjust to the environment as in ELB 75 and Roho/Masurka and WI 2291/WI 2269.

Conclusions

We draw the following conclusions.

a) Under the severely stressed environments conditions arise whereby carboxylation efficiency, in barley and wheat, may be drastically impaired this occurs at CO_2 leaf conductances below 0.1 mol m^{-2} s^{-1}. This is reflected in gas exchange by a simultaneous increase in Ci and decease in the NP. The Ci must essentially come from respiratory processes. Around 40% of NP reduction observed in a rainfall gradient occurred at gco_2 below 0.1 mol m^{-2} s^{-1}.

b) The ability to keep stomata open under stress with functional supply and demand functions for carbon is higher in *H. spontaneum* as compared to barley and in barley as compared to wheat.

c) There is a strong positive correlation between C-13 discrimination of barley and yield across environments. At the highly stressed sites the discrimination is lower suggesting a higher transpiration efficiency. Within a dry environment those genotypes which have a higher C-13 discrimination produce more. This suggests the need to look at transpiration efficiency in conjunction with the ability of the genotypes to maintain functional supply and demand functions for carbon.

d) Selections for yield under stress assure that the selected genotypes do have a high adaptive or constitutive TE.

E. Acevedo

4.1.2. Genotype Characterization

The main purpose of this work is to identify easily measurable visual characters that correlate with yield. As mentioned we use three Mediterranean environments, Tel-Hadya, Breda and Bouider in northern Syria for barley, durum wheat and bread wheat. In the analysis we proceed from yield to the identification of those traits which correlate with it. Table 77 presents the biological and grain yield obtained in the nurseries at the three sites in northern Syria during two seasons. In the 1986/87 season there was a crop failure at Bouider, therefore the grain yield is not presented. Table 78 shows the rainfall use efficiency (biological yield/ha/mm of rainfall) in the growing seasons. As seasonal rainfall decreased there was a more than proportional decrease in yield, i.e. a decrease in rainfall use efficiency. Wheat had a comparative yield advantage at the relatively wet site which changed in favor of barley at the two drier sites. For the two crops there were strong positive linear relations ($P < 0.05$) between biological yield (BIOY) and seasonal rainfall ($R^2 = 0.75$ for barley and $R^2 = 0.87$ for wheat). These are shown in Fig. 30. The lines cross at a BIOY of 5.5 T/ha, corresponding to an environment of 290 mm of rainfall. The generally held view that barley would do better than wheat in environments below 300 mm rainfall is supported by these data.

Table 77. Biological and grain yield of the cereal physiology nurseries at three sites during two seasons (T/ha). Barley (B), durum wheat (DW) and bread wheat (BW).

Site	B		DW		BW		BARLEY / WHEAT (BIOY)
	BIOY	GY	BIOY	GY	BIOY	GY	
Tel Hadya							
1985/86	7.91	3.33	8.46	3.58	7.58	3.10	
1986/87	5.73	2.33	6.64	2.59	6.71	2.60	
Mean	6.82	2.84	7.55	3.09	7.15	2.85	0.92
Breda							
1985/86	3.39	1.22	2.91	0.85	3.35	0.99	
1986/87	3.34	1.41	2.62	0.77	d2.64	0.83	
Mean	3.37	1.32	2.77	0.81	3.00	0.91	1.17
Bouider							
1985/86	3.80	1.25	2.75	0.50	3.03	0.69	
1986/87	0.78	-	0.42	-	0.37	-	
Mean	2.29	-	1.59	-	1.69	1.40	

Table 78. Rainfall use efficiency at three sites of decreasing rainfall in northern Syria. Barley and wheat. Average of two seasons.

Site	Rainfall (mm)	Rainfall use efficiency (kg BIOY/ha/mm)		
		Barley	Wheat	Mean
Tel Hadya	330	20.7	22.3	21.5
Breda	232	14.5	12.4	13.5
Bouider	190	12.0	8.6	10.3

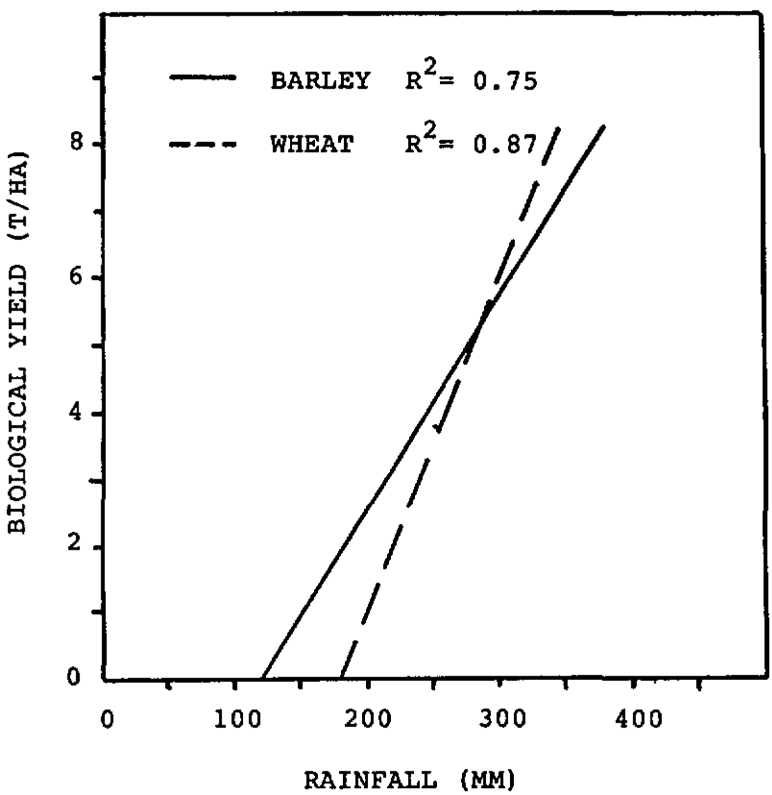


Fig. 30. Cereal production under drought. Each regression derived from six environments. Slopes differ at P<0.05.

Within barleys, the landraces as a group (14 out of 72) outyielded the improved varieties by 11 % in biological yield and 28% in grain yield at Breda. At Tel Hadya the yield was 3% and 1% lower respectively (average for two years). Figure 31 shows, for the barley nursery, a relation between a stability parameter, the linear regression slope of entry yield vs. an environmental index (mean of all varieties at the Y environment minus the grand mean) and mean yield across environments.

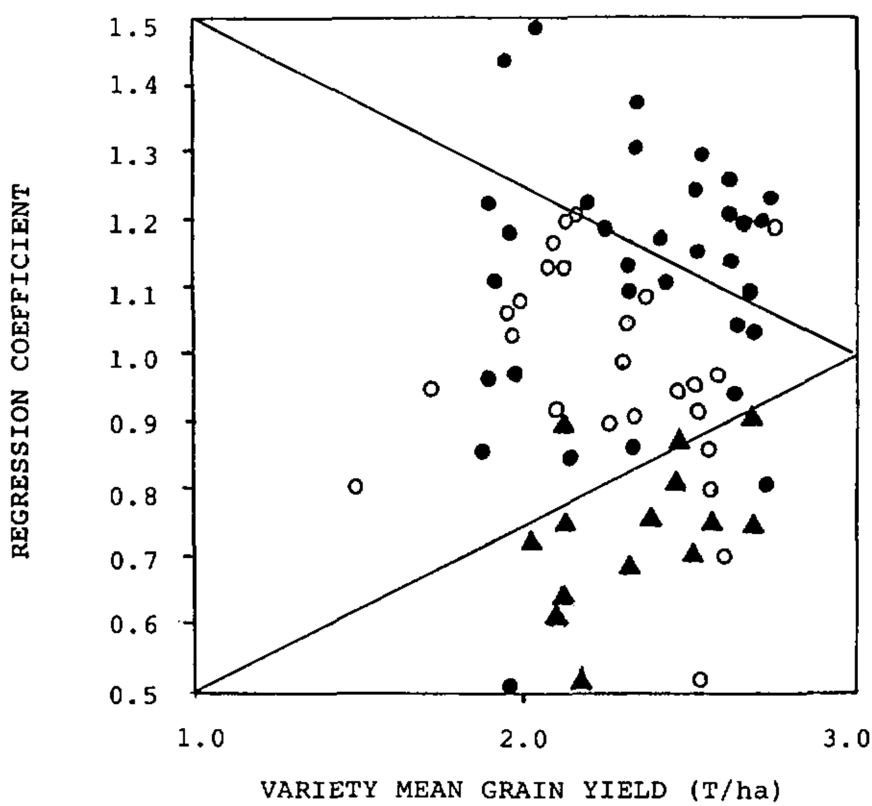


Fig. 31. Regression coefficient of genotype yield on environmental index over seven environments VS variety mean grain yield across environments. Six row barleys (closed circles), two row landraces (closed triangles) and two row improved barelys (open circles).

In general the six row barleys appear with a lower stability (slope above one) than the two row barleys. The landraces of the nursery seem to have the highest stability (slope lower than 1.0) but at the same time they span across the whole yield range. It should be noted that the landraces included in the nursery are two row lines derived from material collected in Syria and hence are well adapted to the experimental environments.

A similar graph (Fig. 32) is presented for bread and durum wheat. Five environments (sites and year) are included, Tel Hadya and Breda 1985/86 and 1986/87, and Bouider 1985/86. The mean grain yield is dominated by stressed environments. The stability is lower in the durum wheat nursery as compared to bread wheat. This result is of interest since durum wheat is generally grown in lower rainfall areas than bread wheat where a higher intra and interseasonal variability in rainfall occurs.

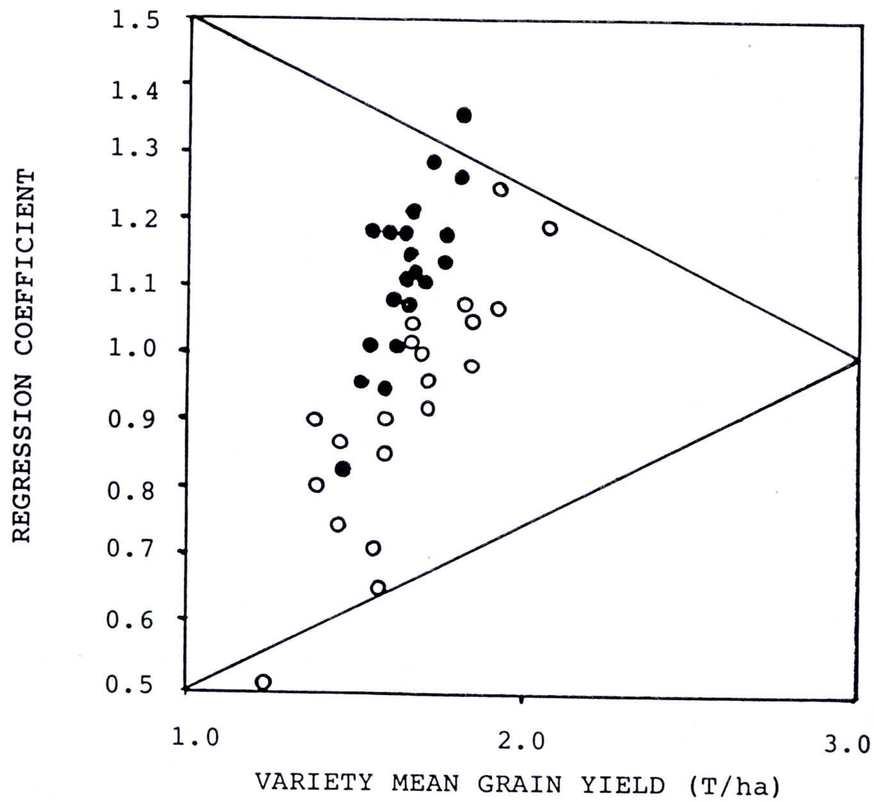


Fig. 32. Regression of coefficient of genotypes yield on environmental index, over five environments, versus variety mean grain yield across environments. Bread wheat (open symbols) and durum wheat (closed symbols).

Trait Correlation

Several visual and/or simply measured variables were studied for correlation with biological yield and grain yield. Table 79 presents phenotypic characters in barley found to be correlated with grain yield at the drier sites (Breda and Bouider, 1985/86; Breda 1986/87) and at the wetter site (Tel Hadya, 1985/86 and 1986/87). The entries are divided into two row and six row types since they present some distinct morphophysiological traits. Common characters of interest correlated to yield for the two types of barleys across environments are spikes per unit area, grain number per unit area, early flowering and frost resistance. A short crop duration is advantageous at the dry sites and a good ground cover, mid season vigour and long grain filling period at the wet site. Growth variables, such as ground cover, mid season vigour, plant height and peduncle length bear a close relation to yield in six row barleys, particularly under drought. An increased grain number per ear also favors grain yield in these barleys.

Other than the common character identified for all barleys, early growth vigour (seedling vigour) correlated with grain yield in the two row types. Work is in progress and selection experiments are being started to assess unequivocally these traits.

The actual value of the selected variables averaged over five environments is given in Table 80. The higher number of spikes per unit area in the two row barleys is compensated by a higher number of grains per spike in the six row types, such that the grain number per unit area is equal in both types. Early growth is superior in the two row barleys. The Syrian landraces had a higher grain mass and harvest index, a slightly earlier heading, shorter grain filling period and crop duration. The number of spikes per unit area were significantly higher even though this did not show in an increased grain or biological yield due to compensatory effects of grain number per ear and in straw weight (neither significant). Of note was a reduced plant height and higher tiller number in the landraces.

Ranking of Genotypes

The top five and lowest five two row barley genotypes using grain yield as a criterion for ranking are presented in Table 81. The results are from two seasons at Breda and Tel Hadya and one season at Bouider. The underlined entries in Table 81 are those that would have been selected using the C-13 discrimination technique. With C-13 analysis of one year, 77% of the entries would have been selected or discarded. On the contrary, had this screening technique been used in a wetter environment as Tel Hadya only one entry would have been selected, Roho/Masurka, yet many of them would have been wrongly assessed.

Table 79. Morphophysiological traits correlated with grain yield at dry (Breda-Bouider) and wet (Tel Hadya) sites in northern Syria, consistent correlations in two year observations. Barley.

Variable	Site			
	Breda-Bouider		Tel Hadya	
	2 row	6 row	2 row	6 row
Harvest index	++	+++	+++	+++
Grain mass	+++	+++	+++	0
Straw weight	0	+++	++	0
Spikes/m^2	+++	++	+++	+
Grain No/ear	0	+	0	+
Grain no/m^2	+++	+++	+++	++
Early flowering	+++	++	+++	++
Grain filling	0	0	++	+
Crop duration	---	--	0	0
Seedling vigour	+	0	++	0
Ground cover	0	++	++	++
Plant height	0	+	0	0
Frost resistant	++	+++	++	+++
Long peduncles	0	+++	0	+++
Mid season vigour	0	+	++	++
Early leaf rolling	0	++	++	++

0 Insignificant or not consistent across years
\+ Positive ($P < 0.05$); ++ ($P < 0.01$); +++ ($P < 0.001$)
\- Negative ($P < 0.05$); -- ($P < 0.01$); --- ($P < 0.001$)

Table 80. Selected morphophysiological traits correlated with grain yield. Mean of five environments (S.E.).

Variable	2 Row	6 Row
Grain yield (T/ha)	1.98 (0.35)	1.83 (0.38)
Biological yield (T/ha)	5.01 (0.80)	4.65 (0.78)
Harvest index	0.39 (0.03)	0.39 (0.03)
Straw yield (T/ha)	3.03 (0.27)	2.99 (0.25)
Spikes/m^2	348 (38)	223 (23)
Grains/spike	13.6 (1.2)	21.4 (2.3)
Grains/m^2	4839 (482)	4820 (664)
DH	88.7 (1.8)	90.7 (2.2)
GFP (days)	34 (1.4)	38 (1.4)
Seedling vigour	1.2 (0.2)	0.8 (0.1)
Ground cover	3.6 (0.3)	3.1 (0.4)
Plant height	53.7 (3.4)	58.2 (4.1)
Peduncle length	10.7 (1.0)	11.4 (1.7)
Midseason vigor	2.6 (0.3)	2.2 (0.3)
Crop duration	122.6(2.3)	129.0(1.7)

Table 81. Grain yield. Top and bottom five genotypes at Breda and Tel Hadya, performance over two seasons. For Bouider the genotypes for the 1985/86 season are given.

	Tel Hadya	Breda	Bouider
Top Ranking	[S BON 86]	WI 2291/WI 2269	WI 2291/WI 2269
	Roho/Masurka	Roho*	SBON 96
	[ER/APM*]	ELB 75	ELB 11
	Harmal*	ELB 51	Roho
	J.B./CI 10836	ELB 80*	ELB 40
	ELB 51	Harmal	
	[ELB 11]	SBON 96	
	WI 2198	ELB 11	
Bottom Ranking	ELB 22	SBON 89*	ELB 22
	ELB 37	Swan neck	Kervana/Masurka
	Alger/Union*	Atem*	Swan neck
	ELB 24*	Cytris	Lignee 131
	Kervana/Masurka*	Alger/Union*	Cytris
	BON 27	Kervana/Masurka	
	Lignee 131	BON 27	
	[SBON 89]		

[ ] Wrongly selected or discarded using C-13 discrimination
--- Selected or discarded using C-13 discrimination
* Consistent across two seasons

From the interim morphophysiological trait analysis of barley it may be tentatively concluded that the following traits should be pursued:

A. Six and two row barleys across environments:
- High harvest index.
- Large grains.
- High number of spikes per ear.
- High grain number per unit area.
- Early flowering.
- Resistance to frost.

A.1. Six and two row barleys under severe stress:
- Those in A plus
- Short crop duration
- Light plant color

A.2. Six and two row barleys under mild stress:
Those in A plus
Long grain filling period
Resistance to lodging
Good mid season vigour
Good mid season ground cover

B. Two row barleys under severe stress:Those in A and A.1 plus
Good seedling vigour

B.1. Two row barleys under mild stress:
Those in A and A.2 plus
High straw weight
Good seedling vigour

C. Six row barleys under severe stress: Those in A and A.1 plus
High straw weight
High grain number per ear
Good mid season ground cover
Tall plants
Long peduncles
Good mid season vigour

C.1. Six row barleys under mild stress:
Those in A and A.2 plus
High grain number per ear
Long peduncles.

A similar trait analysis (Table 82) was done for wheat. Of note was a high positive correlation between straw yield and grain yield indicating that plant growth is one of the important limiting factors to grain yield across sites. The characters correlated with grain yield did not differ much between durum and bread wheat. They do differ between the drier and wetter sites. Taller plants with short duration, relatively long peduncles, of a light color and horizontal leaf posture in the early stages seem to favor wheat grain production under severe stress. Peduncle length was found to be consistently associated to grain yield in durum wheat only. The grain number per ear was a major determinant of yield under stress while the spike number per unit area was important in all environments. The mean grain mass, although positively correlated with grain yield was not significant.

The average grain yield of the two species was equal. Bread wheat had a significantly higher number of spikes per unit area with a similar grain number per ear such that the grain number per unit area was higher. The mean grain mass was significantly lower in bread wheat. Durum wheat had longer peduncles and was slightly taller than bread wheat, it also had a tendency for a longer crop duration (3 days for the population), was more erect in the earlier stages and slightly lighter in color.

Table 82. Morphophysiological traits correlated with grain yield at a drier (Breda) and wetter (Tel Hadya) sites in northern Syria. Consistent correlations over two years of observation.

Variatale	Site			
	Breda		Tel Hadya	
	Durum	Bread	Durum	Bread
Harvest index	+++	+++	+	+++
Straw yield	++	0	++	+++
Spikes/m^2	++	+	+++	+
Grain No./ear	++	++	0	+
Grain No/m^2	+++	+++	+++	+++
Days to heading	--	0	-	0
Crop duration	-	-	0	--
Grain filling period	0	0	0	0
Plant height	+	+	0	0
Peduncle length	++	0	0	0
Leaf posture (-Hor.)	-	-	-	-
Light color	++	+	0	0
Prostrate habit (early stages)	+	+	0	0

0 Insignificant or not consistent across years.
+ Positive ($P < 0.05$); ++ ($P < 0.01$); +++ ($p < 0.001$)
- Negative ($P < 0.05$); -- ($P < 0.01$); --- ($P < 0.001$)

Tables 83 and 84 give the five top and five bottom entries (out of 20 in each species) in terms of grain yield in two seasons at Tel Hadya (relatively wet site) and Breda (dry site). No data is yet available on C-13 discrimination for wheat. The entries underlined are those that would have been selected or discarded if a high net photosynthesis per unit leaf conductance and low Ci for the genotypes under severe stress (Bouider) had been used as a selection criterion (Fig. 29).

A 75% agreement is observed for durum wheat, with 15% of the genotypes wrongly assessed. The agreement for bread wheat (Table 84) is poor, 52%, with 28% of the genotypes wrongly assessed. The results are encouraging, however, in light of the discussion presented in the gas exchange section of this report.

Table 83. Grain yield. Top and bottom genotypes at Tel Hadya and Breda. Durum wheat.

	Tel Hadya	Breda
Top ranking	* Karasu	* Sham I
	Belikh 2	* Sebou
	Ceyhan	Belikh 2
	Kabir 1	Kabir 1
Bottom ranking	Oronte	Siliana
	[Haurani]	GR/BOY
	Sajur	* Sajur
	GR/BOY	

[ ] Wrongly selected or discarded using measurements of net photosynthesis. per unit leaf conductance. (NP/gco_2).
– Selected or discarded using NP/gco_2.
* Consistent yield across two seasons.

Table 84. Grain yield. Top five and bottom five genotypes at Tel Hadya and Breda. Bread wheat.

	Tel Hadya	Breda
Top ranking	* FLK'S'/Hork'S'	* HD 2206/Hork
	* Sunbird	Sonalika
	* [Neel Kant'S']	Ures 81
	[Sham II]	FLK'S'/Hork'S'
	[Seri 82]	Kataya A-1
Bottom ranking	* Inia//Napo/Cal	* 9D-27-262
	* [Florence-Aurora]	[Florence-Aurora]
	Veery	Veery
	Vulture'S'	[Mexipak]
	Sakha 8	Vulture'S'
		Sham II

[ ] Wrongly selected or discarded using measurements of NP/gco_2
– Selected or discarded using NP/gco_2
* consistent yield across two seasons

We note that the data presented here are currently under analysis, to finding a combination or combinations of easily measurable morphophysiological characters which will help in making selections. The simple correlation analysis presented does not provide a definitive answer to the problem, yet it does provide an interim assessment of the traits.

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4.1.3. Barley Management for Dry Areas

Results of the 1985/86 season indicated that winter grown spring type barleys may increase their production in low to medium rainfall (200-300 mm) Mediterranean environments if they are planted early in the growing season (15 October - 15 November). An additional advantage was obtained by decreasing the row spacing to 10 cm between rows. The experiments were repeated in the 1986/87 season and the results were confirmed. During the last season an additional experiment was conducted where a commercial seed drill (IS) sowing at a distance of 10 cm between rows was compared to the farmers' practices (FP) and to a single pass planter (SPP), both of which use a row distance of 45 cm. Plantings were done early and late in the season and under dry and wet soil. Table 85 shows that the dry and early planted treatment had a better crop establishment. The narrow spacing increased early ground cover significantly (Fig. 33) probably improving water use efficiency. Grain yield was increased by early planting and narrow spacing (Table 86).

Table 85. Crop establishment as affected by soil water content at sowing and date of planting.

Date of planting	Number of Plant/m^2		
	Dry	Wet	Mean
Early	224.9	189.8	207.3
Late	163.4	158.5	161.0
Mean	194.2	174.1	

LSD [0.05] for planting date at the same level of soil water : 44.5.

LSD [0.05] for soil water at the same level of planting date : 33.9.

LSD [0.05] for soil water : 13.0.
LSD [0.05] for planting date : 31.5.

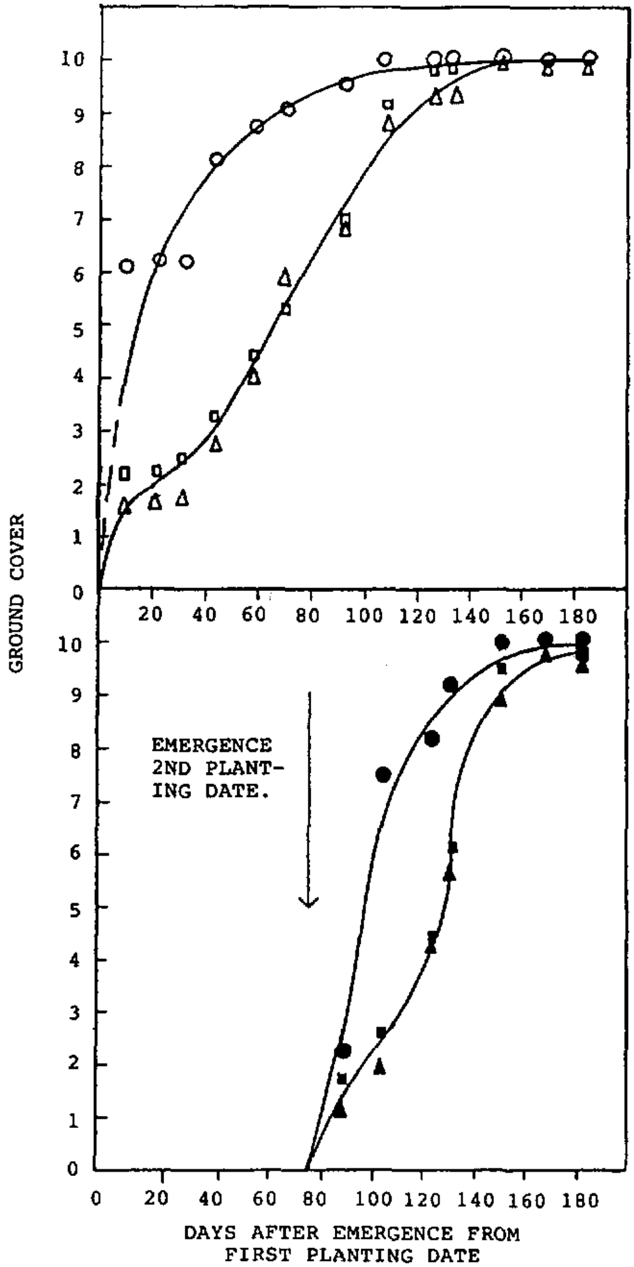

Fig. 33. Ground cover with various sowing methods at two planting dates; early (open symbols) and late (closed symbols). IS (*circles*), *FP* (*squares*) *and SPP* (*triangles*).

Table 86. Grain yield (T/ha) as affected by sowing method, soil water at sowing and sowing date.

Sowing date	Soil water	Sowing method FP	SPP	IS	Mean
October	Wet	3.748	3.636	4.398	3.927 a
	Dry	3.423	3.776	4.180	3.793 a
	Mean	3.586	3.706	4.289	3.860
January	Wet	2.511	2.441	3.000	2.650 a
	Dry	1.285	1.548	1.816	1.549 b
	Mean	1.898	1.994	2.407	2.100
Mean for sowing method (LSD [0.05]=218)		2.748	2.850	3.348	

Mean for soil water : Dry: 2.671; Wet: 3.289 (LSD [0.05]= 257)

LSD [0.05] for sowing date : 302
for sowing date at the same level of soil water: 428
for sowing method at the same level of soil water: 309

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3.2. Pathology

Introduction

Rainfed cereal production encounters numerous biotic and abiotic stresses, interacting (with) and aggravating with each other. Furthermore this type of farming is often characterised by a relatively low input, which means that pest control strategies proven effective in more advanced sytems cannot be implemented. The use of resistant cultivars and appropriate cultural practices are therefore the most effective and economic control measures for most cereal diseases. The Cereal Pathology Project strives to up-grade the level of resistance in newly developed germplasm. This is pursued by assessing resistance in breeding material through field screenings consisting of local screenings backed up by multilocation testing. The later is done on more advanced material with specific disease resistance. Another tool to up-grade resistance level in breeding material is the development of germplasm pools as sources of resistance to different diseases. These are used as parental material in crossing programs. Improving national program facilities and capabilities in reducing crop losses is an integral part of cereal pathology activities.

Wheat Diseases

Major wheat diseases in the region are yellow rust (Puccinia striiformis), leaf rust (P. recondita), stem rust (P. graminis), septoria tritici blotch (Mycosphaerell graminicola) and common bunt (Tilletia foetida & T. caries).

Screening for Disease Resistance at the Base Program

Screening for yellow rust and common bunt was done in the field at the principal station, Tel Hadya, while plastic houses were used for leaf rust. Screening for septoria was done at the sub-station El-Ziereh near Lattakia.

For yellow rust artificial inoculations were applied four times during the period Jan 14 - Apr 20 and for leaf rust four times in the period Mar 11 - Apr 20. In both cases spores were used which were collected during the previous season at Tel Hadya. During the period Feb 2 - Apr 13 five inoculations were carried out in the septoria screening nurseries at El Ziereh. Conidia of this pathogen were grown in a liquid sugar-yeast medium and originated from strains isolated from 14 durum wheat and 15 bread wheat leaf samples collected in 1985 and 1986 at different locations in Syria. Prior to spraying, the inoculum ratio was adjusted to an equal amount of conidia originating from durum and from bread wheat strains.

Inoculation for common bunt was carried out by contaminating the seed to be tested with chlamydospores at about 0.8 x 10^5 spores/seed. The inoculum originated from 5 bunt samples collected in 1986 from durum wheat and bread wheat in different locations in Syria. The inoculum was adjusted to a ratio 0.6:1 between the two pathogens, T. foetida and T. caries. The spore germination, checked on water agar, was 99%.

Table 87 summarizes the results of the local screening of the different durum wheat nurseries. Of the 1015 entries screened for yellow rust, 406 were resistant and 3 were selected. The highest percentage of resistant entries was found in DOH-HAA, APCB and DCB with 79.6, 76.5 and 71.8% respectively. For leaf rust 22 entries of the 50 tested were resistant and 12 were selected for retesting in the Leaf Rust Nursery 1988. For septoria, 84 entries out of 403 were resistant and 7 were selected. The highest percentage (67.6%) of resistant entries was found in the Durum Germplasm selection. For common bunt, 200 entries out of the 1015 tested were resistant and 4 were selected. Excluding the 176 resistant entries of the T. dicoccoides species, there actually remain only 34 lines resistant to common bunt. Evaluation of T. dicoccoides is difficult because of its brittle rachis and the apparantly high resistance of this species should be reconfirmed.

The results of bread wheat screening are summarized in Table 88. For yellow rust, 691 entries showed resistance and 35 were selected. The highest percentage (78.9%) of resistant entries was found in the Observation Nursery-HAA. Out of the 73 entries tested for leaf rust, 63 were resistant and 27 were selected. Screening for septoria resulted in 8 resistant entries out of the 180 tested and 4 were selected. Out of the 1120 entries tested for common bunt, 167 were resistant and 32 selected. The highest percentage (30.3%) of resistant entries was found in the Repeat Testing Bunt Nursery, consisting of material selected from the screening during the previous season.

Fifteen bread wheat lines and eleven durum wheat lines, in previous years selected for their resistance to local bunt strains, were tested in a special nursery against foreign isolates (Common Bunt Nursery II). Apart from 2 isolates from Syria, 3 originate from Turkey, and one each from Lebanon, Tunisia, Iran, Pakistan and Morocco (Table 89). Each isolate had a different ratio of the two pathogens species. Inoculum density was 0.8 x 10^5 spores/seed and germination ranged between 88 and 100%. Two bread wheat entries were resistant based on the average percentage of infected heads for all ten isolates. In the durum germplasm, 10 out of the 11 entries tested were resistant. Stork, Senatore Cappelli, Haurani and Kabir-1 still maintain good resistance after several years testing. In both, bread wheat and durum wheat, some of the entries show a high susceptibility to one specific isolate, but remain on the average within the limit of the selection criteria for all isolates.

Table 87. Local screening of durum wheat germplasm for resistance to yellow rust (YR), leaf rust (LR), septoria tritici blotch (ST) and common bunt (CB); 1986/87 season.

Germplasm	No Entries Tested	No. Entries Resistant*			
		YR	LR	ST	CB
Aleppo Crossing Block APCB 87	166	127 (76.5)	-	15 (9.0)	0
Regional Crossing Block DCB 87	124	89 (71.8)	-	-	2 (1.6)
Leaf Rust Nursery DLR 87	50	-	22 (48.9)	-	-
Repeat Testing Bunt DRTB 87	42	16 (41.1)			0
Land Races 87	32	0	-	-	1 (3.1)
H. Land Races 87	72	1 (1.4)	-	-	0
T. dicoccoides 87	200	41 (20.5)	-	43 (21.5)	17 (88.0)
Crossing Block DCB-HAA 87	192	18 (9.4)	-	-	12 (6.2)
Observation Nursery DON-HAA 87	150	113 (79.6)	-	-	2 (1.4)
Durum Germplasm DUR-GMP 87	37	1 (2.7)	-	26 (67.6)	7 (18.9)
Total Entries	Tested	1015	50	403	1015
	Resistant	406	22	84	200
	Selected	3	12	7	4

( ) = % *resistant lines; checks excluded*

* Resistant: 0-5 % severity for YR and LR, 0-6 score, on 0-9 scale, for ST, 0-15% infected heads for CB

Table 88. Local screening of bread wheat germplasm for resistance to yellow rust (YR), leaf rust (LR), septoria tritici blotch (ST) and common bunt (CB); 1986/87 season.

Germplasm	No Entries Tested	No. Entries Resistant*			
		YR	LR	ST	CB
Aleppo Crossing Block APCB 87	180	113 (62.8)	-	8 (4.4)	16 (8.9)
Regional Crossing Block WCB 87	169	90 (53.2)	-	-	23 (13.6)
Observation Nursery WON-MR 87	102	61 (62.9)	-	-	2 (2.1)
Observation Nursery WON-LR 87	104	61 (61.6)	-	-	2 (2.0)
Leaf Rust Nursery WLR 87	73	-	63 (96.9)	-	-
Repart Testing Bunt WRTB 87	183	103 (6.1)	-	-	50 (30.3)
Crossing Block WCB-HAA 87	232	151 (65.1)	-	-	57 (24.6)
Observation Nursery WON-HAA 87	150	112 (78.9)	-	-	17 (12.0)
Total Entries	Tested	1120	73	180	1120
	Resistant	691	63	8	167
	Selected	35	27	4	32

(   ) = % resistant lines; checks excluded

* Resistant: 0-5% severity for YR and LR 0-6 score, on 0-9 scale, for ST, 0-15 % infected heads for CB

Table 95. Bread wheat lines resistant-moderately resistant (R-MR)* to common bunt, _Tilletia foetida_ & _T. caries_, and to yellow rust, _Puccinia striiformis_ (WBYG 1984-87).

Entry	Name	Common bunt		Yellow rust			Yield and other agron.charcter.					Source
		1984	1986	1985	1986	1987	t/ha**	DHE	GH	PLH	Remarks	WBYG 87
1.	H82-1252-4	0.0	10.8	0.0	15MR	15MR	2.6	128	S	75		4
2.	H82-1271-1	0.0	0.0	0.0	10MR	15R	2.6	127	S	85		5
3.	H82-1357-4	0.0	1.2	0.0	10MR	15MR	2.7	129	S	70		6
4.	R82-1907	0.0	0.0	-	10MR	15MR	2.7	127	S	75		7
5.	R82-3307	0.0	2.2	-	15MR	15M	2.4	125	S	90		9
6.	M82-3366	0.0	0.0	0.0	15MR	15MR	3.1	132	S	85		12
7.	M82-3644	0.0	5.0	-	15MR	10MR	2.7	125	S	60		19
8.	M82-3648	0.0	1.4	-	10MR	15MR	2.0	124	S	70		21
9.	M79-4527	0.0	0.0	-	5MR	15M	1.7	136	F	75	L	31
10.	R82-3832	0.0	0.0	0.0	15MR	10MR	2.1	143	W	65	L	43
11.	M79-4545	0.0	0.0	0.0	15MR	10MR	2.0	135	W	75	L	45

* R-MR = 0-10% infected heads for common bunt; R-MR = 0-15% severity for yellow rust.
** Yield of checks: Zargoon 4.9 t/ha, Bezostaya 3.8 t/ha, Sham 2 3.9 t/ha.

Table 90. Durum wheat germplasm tested in multilocations for resistance to yellow rust, leaf rust, stem rust, powdery mildew, septoria tritici blotch, and common bunt (1986-87season).

Germplasm/Disease	No. Locations	No. Entries				
		Tested	Resistant*			Selected
Preliminary Disease Nursery		360				
Yellow rust	2		107			24
Leaf rust	2		37			34
Powdery mildew	1		98			-
Septoria blotch	3		52			12
Key Location Disease Nursery		250				
Yellow rust	4		101			56
Leaf rust	6		12			5
Stem rust	3		52	1	11	-
Powdery mildew	1		25			-
Septoria blotch	4		35	6		17
Common bunt	1		0			-
Septoria Nursery		70				
Septoria	3		18			10
Powdery mildew	1		18			8
Yellow rust	1		34			
Yellow Rust Nursery		100				
Yellow rust	4		54			11
Leaf rust	1		17			
Septoria blotch	2		60			

* Resistant = 0-5 % average severity for rusts
= 0-5 average score, on 0-9 scale, for powdery mildew and septoria
= 0-15 % infected heads for common bunt

Table 91. **Bread wheat germplasm tested in multilocations for resistance to yellow rust, leaf rust, stem rust, powdery mildew, septoria tritici blotch and common bunt (1986–87 season).**

Germplasm/Disease	No Locations	No. Entries Resistant*		
		Tested	Resistant*	Selected
Preliminary Disease Nursery	550			
Yellow rust	3		213	30
Leaf rust	2		286	3
Powdery mildew	1		268	-
Septoria blotch	3		3	3
Key Location Disease Nursery	250			
Yellow rust	2		111	21
Leaf rust	2		76	19
Powdery mildew	1		142	-
Septoria blotch	5		3	1
Common bunt	1		4	3
Septoria Nursery		70		
Septoria blotch	3		14	4
Powdery mildew	1		18	
Yellow rust	1		45	
Yellow Rust Nursery		100		
Yellow rust	4		65	19
Leaf rust	1		56	
Septoria blotch	2		10	

* Resistant = 0–5 % average severity for rusts
= 0–5 average score, on 0–9 scale, for powdery mildew and septoria
= 0–15% infected heads for common bunt

International Testing

The durum and bread wheat material tested in several locations included the Preliminary Disease Nursery, the Key Location Disease Nursery, the Septoria Nursery and the Yellow Rust Nursery for each commodity. These nurseries were tested in 'hot-spots' for the diseases yellow rust, leaf rust, stem rust, Septoria and powdery mildew. Hot-spots are sites with favourable environmental conditions or where the disease development is enhanced by artificial inoculation using indigenous pathotypes from the respective site or country. Useful information was obtained so far (Oct 1987) on multilocation testing of the durum germplasm (Table 90) from Syria, Lebanon, Egypt, Tunisia, Morocco, Portugal and Yugoslavia. Table 90 shows the number of resistant durum wheat entries from the different nurseries for diseases on which data were received. One entry showed combined resistance to leaf rust and stem rust, entries showed combined resistance to powdery mildew and septoria, and 11 entries showed combined resistance to yellow rust and septoria. For the sake of brevity the names of the entries and detailed list of resistant lines are not provided, however this information will be made available on request. Table 91 contains similar information for the bread wheat nurseries tested. Useful information was obtained on multilocation testing from Syria, Lebanon, Tunisia, Morocco, Portugal and Yugoslavia. Three entries showed combined resistance to powdery mildew and sepotria, one entry to yellow rust and septoria, and three entries to yellow rust and common bunt.

Development of Germplasm Pools for Sources of Resistance

Resistant germplasm selected through local screening and multilocation testing are included in germplasm pools for retesting and/or further processing as sources of resistance to yellow rust, leaf rust, septoria and common bunt. The development of the germplasm pool for yellow rust resulted in several durum wheat lines that maintained good resistance to the disease over the last four seasons. Table 92 includes 26 lines tested in Syria, Lebanon and Portugal. Some of these lines were also tested in the seedling stage at IPO/Wageningen towards ten different yellow rust isolates/races originating in the region.

In developing the bread wheat germplasm pool for yellow rust resistance, 26 bread wheat lines maintained their resistance to yellow rust over the years (Table 93). Eighteen of these lines were tested at IPO in the seedling stage against 14 isolates/races from the region and in the adult stage against 8 isolates/races from The Netherlands.

Over the seasons 1983/84-1985/86, a collection of bread wheat lines, originating from diverse sources, has twice been screened for common bunt and three times for yellow rust (Table 94). Of the original collection of 1304 lines, 11 have been selected over the years for their combined resistance to both diseases (Table 95). Seeds of three germplasm pools are available from the Program.

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Table 92. The performance of selected durum wheat lines to yellow rust, <u>Puccinia striiformis</u> (Germplasm Pool, DYR 1984-1987)

Ent.	Name or Cross	1987			1986			1985	1984			Seed source
		SYR	LEB	POR	SYR	LEB	POR	IPO	SYR	LEB	POR	
									S*			DYR-87
1	Pen'S'	5R	1R	10MR	0	1R	0	R-10	0	-	-	1
2	Gr'S'/S.Cp//St464/3/Cr'S' 4/Gta'S'	5R	1R	0	1	0	1MS	R-10	1MS	-	0	2
3	Rabi'S'/31810//Snipe'S'/3/ Balcarceno Inta	1R	1R	10MR	1	0	0	R-10	0	-	0	3
4	BD 2014/Rabi'S'	1R	5R	1R	1	0	1MS	R-9	2MS	-	0	4
5	Fg'S'/Ati'S'	10MR	5MR	1R	5	1R	0	-	10MR	5MS	0	5
6	Snipe'S'/Magh'S'	5R	1R	5R	5	1R	0	-	0	0	1R	6
7	Ovi/Cp//Cando	1R	1MR	0	1	1R	0	-	0	5MR	0	7
8	Ruff'S'//Jo'S'/Cr'S'/3/F9.3	5R	1R	5R	5	0	0	-	1R	1MR	0	8
9	Gta'S'/Stk'S'//Snipe'S'	1R	1R	1R	5	0	0	-	-	0	0	9
10	Can 2101/Magh'S'//Stk'S'/ /3/Wlls/65150	10MR	5MR	-	5	5MR	0	-	1MS	1MR	1R	11
11	D.dwarf S15/Cr'S'/3/Plc 'S'/Gv//Jo/RD119	10MR	1R	0	5	5MR	0	-	1R	0	0	12
12	Ato'S'//S15/Cr'S'	5R	1R	0	5	1R	0	-	0	1R	0	13
13	Ato'S'/Gta'S'	5MR	1R	1R	5	0	0	-	0	1MR	0	14
14	AA'S'/Br'S'//V1658/Cr'S'/ 3/Shwa'S'/4/Swan'S'	10MR	10MS	1R	5	3MR	1MS	-	1MS	1MS	0	15
15	Frigate'S'	1R	1R	0	1	0	0	-	10MS	1MS	0	16
16	Phibirol.82	5MR	1R	0	5	1R	0	-	1R	0	10MR	17
17	Plc'S'/Ruff'S'//Gta'S'/ D6715/3/Shwa'S'	5R	5MP	0	1	3MR	0	-	0	1MR	0	18
18	Cit'S'/GdoVZ579	10MR	5MR	0	5	1MR	0	-	1R	5MS	0	19
19	Stil'S'/Bit'S'	5MR	1MR	0	1	1R	5MR	-	5MR	5MS	1MS	21
20	Trob'S'	10MR	5MR	1R	5	1R	0	-	10MR	5MS	0	22
21	D.dwarf S15//Cr'S'/Stk'S'	5MR	1MS	20R	5	1R	0	-	5MS	5MR	0	23
22	GgoVZ385/Gs'S'/4/D.dwarfS15 //T.dic.V.Vern/G11'S'/3/Plc'S'	5R	1R	0	5	1R	0	-	-	-	-	24
23	Lds Mut/Teal'S'	1R	1R	0	1	1R	0	-	-	-	-	25
24	Shwa'S'/Ptl'S'	1R	1R	0	1	1R	0	-	-	-	-	26
25	WAHA 5MR	1R	0	1	0	1MS	R-10	-	-	-	27	
26	Gr'S'/Boy'S'	1R	5MR	-	5	5MR	0	R-9	-	-	-	28

* Seedling test at IPO using ten different isolates; figures indicate number of isolates to which the entry was resistant.

Table 93. The performance of selected bread wheat lines to yellow rust, <u>Puccinia striiformis</u> (Germplasm Pool, WYR 1984-1987).

Ent.	Name or Cross	1987			1986			1985			1984			Seed source
		SYR	LEB	POR	SYR	LEB	POR	I	P	O	SYR	LEB	POR	
							S*		A**					WYR-87
1	Jbrr4/3/Inia'S'/Soty/Czho	0	5R	0	5	0	1R	R-14		R-5	1R	0	0	1
2	KVZ/Cgn	1MR	1R	0	5	0	1R	R-11		R-8	1R	0	0	2
3	Sannine/Ald'S'	5MR	5MR	0	5	5R	1R	R-11		R-5	1R	0	0	3
4	Chr/4/Inia'S'/7C/Cno'S'/ G11/3/Pci'S'//Bb/Inia	0	1R	5MR	1	0	0	R-11		R-5	5MR	20MS	0	4
5	Bow's	0	5MR	0	5	1R	1R	R-11		R-7	0	1MS	0	11
6.	Ald'S'/Huac'S'	0	1R	0	5	1R	1R	**SYR**		**ECU**	1R	-	-	5
								0		10M				
7.	Yr/Sprw'S'	0	5MR	0	5	5MR	1R	0		10S	10MR	-	-	6
8.	GV/D6301//Ald'S'	0	5MR	0	1	5R	1R	1R		1R	1R	-	-	7
9.	Sannine/Ald'S'	5MR	5R	0	1	5MR	0	0		1R	1R	-	-	8
10.	F63.70/Aldan'S'	0	5R	0	5	0	1R	0		10S	0	-	-	9
11.	Maya'S'//Nd/P101/3/Pam'S'	0	1R	0	1	1R	1R	0		0	20MS	-	-	12
12.	Kvz/HD2009	1MS	5R	0	1	5MR	1R	0		0	0	-	-	13
13.	Gv/4/D6301/Nai//WRM/3/ Cno 3/Chr	0	1R	0	1	0	1R	**I**	**P**	**O**		-	-	18
								R-11		R-8	0	1MR	0	
14.	Skb8/4/Rr68/WW15/3/Bj'S' On 2//Bon	0	5MR	0	5	5MR	1R	R-14		R-8	5R	40MS	0	19
														WYR-86
15.	Tuc'S'/4/Tob/Cc/Pato/3/ HD832/Bb	-	-	-	5	10MR	10MR	R-1		R-8	5MR	5MS	10MS	1
16.	Bch'S'//Y50/Kal	-	-	-	5	1R	30MR	R-2		R-8	5R	10MS	0	3
17.	Maya 74'S'Nr. Resel	-	-	-	10	10MR	1R	R-7		R-7	5MS	5MS	0	4
18.	Seri 82	-	-	-	15	10MS	25M	R-11		R-7	5MS	0	0	8
19.	Vee'S'	-	-	-	15	5MS	10MR	R-12		R-7	5MS	5MS	0	9
20.	Bow'S'	-	-	-	1	0	1R	R-12		R-6	1R	0	0	11
21.	II58-57/4/Maya 74'S'/Cgn/ 3/Cc/Inia//Cal	-	-	-	1	0	1R	R-11		R-4	0	20MS	0	12
22.	MN 72131/Pvn'S'	-	-	-	1	0	20MR	R-9		R-3	1R	0	0	13
23.	Chr/4/Inia'S'/7C//Cno'S'/ G11/3/Pci'S'//Bb/Inia	-	-	-	5	5R	1R	R-11		R-5	5MR	20MS	0	14
24.	Jup'S'/4/LR64 2/Sn64// Cc/3/Ska	-	-	-	10	10MR	20M	R-11		R-4	5MR	10MS	0	15
25.	Kvz/Cgn	-	-	-	20	20MS	10MR	R-10		R-5	5MS	5MS	0	17
26.	Ures 81	-	-	-	10	5R	5R	R-12		R-7	1R	0	0	18

* Seedling test at IPO using 14 different isolates, figures indicate number o isolates to which the entry was resistant.

** Adult, field test at IPO using 8 different isolates.

Table 94. The development of germplasm pool for sources of resistance to common bunt (CB), *Tilletia foetida* and *T. caries*, as well as of combined resistance to common bunt and yellow rust (YR), *Puccinia striiformis* (1983/84-1986/87).

	Screening		Characterization/	No. of	No. Entries R-MR*		
Season	CB	YR	selection/yield	Entries tested	CB	YR	CB & YR
1983/84	+	-	-	1304	707	-	-
1984/85	-	+	+	707/690	690	280	280
1985/86	+	+	+	280	233	50	50
1986/87	-	+	+	50	233	11	11

*) R-MR = 0-10% infected heads for CB; 0-15% severity for YR.

Table 89. Bread and durum wheat lines resistant (<15% infected heads) to isolates of common bunt (_Tilletia feotida_ and _T. caries_) from the ICARDA region (CB II-87).

Isolate number	01	11	02	03	12	4/58	05	06	07	08	Aver
Isolate origin	SY	SY	TR	TR	TR	LE	TU	IR	PA	MO	Inf.
T. foetida: T. caries	0.6:1	1.4:1	4:1	15:1	6:1	21:1	47:1	1:0	1:0	40:1	
Entry Name of cross											
BREAD WHEAT											
1. Ald's'/Pima77/3/CMH24A.630/B	13.5	12.5	17.5	14.9	16.4	36.8	16.0	14.1	3.3	1.6	14.7
2. Shi4414/Pew's'	22.0	18.8	27.5	2.7	0.5	4.1	53.1	0.0	1.8	0.3	13.1
DURUM WHEAT											
3. Snipe's'F.9-3	6.0	3.6	3.2	2.3	0.0	0.9	1.3	0.3	0.0	18.8	3.6
4. Jo's'/Cr's'/5/Gll's'/4/Br180	23.3	5.5	6.2	3.1	0.5	5.1	6.3	1.5	1.3	20.4	7.3
5. CDK	13.0	12.8	8.1	2.0	9.8	9.1	6.7	3.9	0.0	50.0	11.5
6. Vlnv	13.2	20.1	12.0	9.8	2.4	3.4	5.8	5.6	0.4	24.6	9.7
7. Cpt Mut	15.8	12.1	6.4	4.3	10.1	3.4	9.3	0.7	0.0	16.5	7.9
8. MG 5927 CV Montferrier	14.7	6.9	2.8	9.6	0.0	4.2	3.3	1.5	1.4	9.5	5.4
9. Stork	30.2	9.4	12.5	18.5	2.8	8.6	4.9	1.1	0.0	13.3	10.1
10. Senatore Cappelli	12.1	5.8	2.8	3.4	0.0	2.1	1.0	1.7	0.0	5.7	3.5
11. Haurani	29.1	4.3	2.5	5.7	1.0	2.6	1.4	0.0	0.4	15.5	6.3
12. Kabir 1	33.7	21.3	12.9	15.5	2.7	2.5	9.9	7.1	6.4	19.6	13.2

- Isolates: 01,11 SY from Syria; 02, 03, 12 TR from Turkey; 4/58 LE from Lebanon; 05 TU from Tunisia; 06 IR from Iran; 07 PA from Pakistan; 08 MO from Morocco.

Barley Diseases

Screening for Disease Resistance at Base Program

Covered Smut

The 1986-87 season was the second year that covered smut testing of advanced material was carried out. Techniques used are described in 1986 Program Annual Report. Infestation levels during the 1986-87 season were slightly lower than those of the previous year. Out of the 226 entries in the 1986-87 Advanced Yield Trial, 149 entries were tested in the Preliminary Yield Trial of the 1985-86 season. Infested tillers averaged 1.3% during this season, compared to 1.9% the year before. A set of 280 head selections from Syrian landraces was as well tested during both seasons, 1.7% infested tillers versus 4.4%. There was a good correlation between the results of both years, 0.40 for the Yield Trials and 0.33 for the land races.

The influence of the environment on the expression of covered smut was evident in another experiment. One inoculated set of the KLDN was tested by collaborators from ACSAD at Izraa, a location in the south of Syria with a warmer climate than Tel-Hadya. The average percentage of infested tillers was 7.8% in this location compared to 1.3% in Tel-Hadya. Again there was a good correlation between both locations (r=0.54).

Scald

Scald of barley, caused by Rhynchosporium secalis is a important disease in all barley growing areas. The pathogen oversummers on stubble or is introduced by infested grain. It is highly variable in its virulence and numerous examples of the breakdown of cultivars with a previously high level of resistance have been reported in the literature. For new material we aim at levels of partial resistance, sufficient to control the disease to acceptable levels, without increasing unnecessarily a selection pressure on the pathogen population. As the spread of the scald pathogen is localized and a large variability in infestation levels was encountered in the past, special attention was given to the design of the screening nurseries and the method of note taking in order to assess the level of resistance correctly.

A total of 1700 entries in 6 different nurseries were tested this year in two locations for scald resistance. All nurseries were tested in a randomized complete block design with two replicates and systematic checks. Plots consisted of 0.3 m rows, sowed with 1.5 g of seed. Spreader rows, consisting of a mixture of highly susceptible cultivars were planted next to each entry to ensure a high disease pressure and to avoid interplot interference. Inoculum was prepared by mixing spores of local Syrian strains grown on Lima bean agar. Inoculations were carried out repeatedly, starting in

January, while plants were at Zadoks Growth Stage (ZGS) 14-23. In previous years notes on scald infestation were taken using the standard 0-9 disease scoring scale, based on the spread of the disease through the vertical plant structure. Although this is an easy and fast system to use, it is not suitable for disease nurseries with a high, continuous disease pressure. Instead of this the Percentage of Infested Leaf Area (PILA) was estimated for every plot. For readings taken after plants had passed the heading stage (ZGS 51), the PILA was recorded separately for the top two leaves and for the lower part of the plant. Percentages were transformed to a 0-9 scale by using the formula $y=4.5*\log(x+1)$, and by taking the mean of the readings of the top two leaves and the rest of the plant. Through this logarithmic transformation more weight is given to the lower levels of infestation, which are the most interesting for breeding purposes. In Table 96 the results of the readings taken in early April (ZGS 55-65) are presented. The improvement of disease resistance from Preliminary Yield Trials through International Nurseries is clear. As the results from Tel Hadya are highly correlated with those from Lattakia, only the location in Tel Hadya will be used for scald screening during the 1987-88 season.

Table 96. Comparison of scald infestation between nurseries in two locations. Given are the number of entries (N), the average infestation (X) and the percentage (%) of entries with a score of 3 or less (= 3.5 percent leaf area infested), using the logarithmic transformation of the percentage infested leaf area.

Nursery; type of material	N	Tel Hadya X	Tel Hadya %	Lattakia X	Lattakia %	Mean X	Mean X
BPD87; Preliminary yield trials	525	5.9	13	5.7	14	5.8	12
BKL87; Advanced yield trials	226	4.4	24	5.8	17	5.1	17
BID87; International nurseries	450	4.2	33				
BAL87; Selected landraces	90	4.4	27	5.1	16	4.7	19
BSC87; Selected for scald res.	80	2.6	74	1.7	86	2.2	80
BMS87; Head progenies from MSP's	180	2.5	73	1.8	83	2.2	81

Screening in Controlled Environments

Barley Leaf Stripe

Barley leaf stripe is a seed borne disease with a life cycle stretching over two seasons. Although the splashing of raindrops is necessary for the dissemination of spores, and high humidity is needed to allow infection of the the seed, it is present in all barley growing regions, including drier areas. Breeding programs have encountered difficulties with this disease in the past as newly developed material sometimes appears to be highly susceptible. Natural infection, often satisfactory to select against susceptible material in the case of leaf diseases, is unreliable for this highly environmentally dependent pathogen. Futhermore, allowing this disease in breeding plots is dangerous since it has the potential to develop explosively and adequate fungicides to clean up seed stocks are not available.

During the past season a start was made to screen parental material using artificial seed inoculation. Existing techniques were modified to develop a fast and reliable methodology for testing a large number of genotypes. Inoculation was done by allowing the seed to germinate in close contact with active mycelium at a low temperature, thereby enhancing the chance of the pathogen to infect during the short period while the plant is susceptible. Factors such as the number of replications of the fungal culture on artificial media, the age of the mycelium, the incubation period, temperature during incubation or post-incubation and nitrogen content of the soil were found to influence the expression of the disease. Although plants were grown in growth chambers under standarised environmental conditions, high variability in results was noticed. Table 97 shows the most susceptible and the most resistant lines of a group of 63 cultivars tested twice with the same mono-spore isolate under the same experimental conditions. The infestation level in the second test was far higher, 21 lines showed 100% infestation in the second experiment and none in the first. There was, however, a good correlation between both tests.

Table 97. Highly resistant and susceptible lines for barley leaf stripe out of 63 entries from the Regional Crossing Block 1986-87.

Cross Pedigree	Percentage infested plants 1st test	 2nd test	 mean
Resistant entries			
Esp/1808-4L//W.W.Cillo ICB79-0413-1AP-3AP-0AP	0	30	15.0
Alger/Union	15	23	19.0
Legia F2	13	30	21.5
Susceptible entries			
Arr/Esp//Alger/Ceres,362-1-1 LB 3L-9L-2AP-0AP	63	100	81.5
Pitayo/Cam//Avt/RM1508/3/PmB ICB78-0012-1AP-2AP-1AP-1AP-0AP	78	100	89.0
Roho/Delisa ICB77-0166-2AP-3AP-1AP-1AP-0AP	90	94	92.0

The relationship between the seedling tests and the performance under farming conditions has not yet been studied, but has been demonstrated by other researchers. Two lines that have shown to be susceptible in the field, ER/Apm and Atlas 46, were among the worst infested in both seedling tests.

Scald

Seedling tests for scald resistance to Rhynchosporium secalis are frequently reported, both for screening germplasm and for the analysis of virulence. Most researchers inoculate plants by an overdos of spores, while after the incubation period the plants are scored using a qualitative scale based on the severity of the scald symptoms. This method can give misleading results as the expression of the symptoms depends on many factors during incubation and post-incubation (latent) period.

It has been reported that if seedlings are inoculated with a range of spore concentrations, a relationship can be demonstrated between the seedling test and the actual level of resistance under field conditions. We have tried to develop a method, based on the same principle, which is simple and will enable us to test a large number of genotypes or fungal strains in as short a period as possible.

Sixteen different varieties chosen for their difference in scald infestation during field testing and differing in gorwth habit, were used for this test. A localized inoculation was carried out by placing a drop of inoculum in the funnel of the just emerged first leaf. Four different spore concentration were used: 10^6, 10^5, 10^4, and 10^3 spores/ml. After 2 weeks the individual plants were scored to be either infested or non-infested. Thirty two pots per variety, each with five plants, were used with eight replications for every concentration.

For the analysis the number of infested plants summed over the four concentrations per replication was used. Table 98 compares results of the seedling test with the field test. The seedling test seems capable of allowing a better differentiation than the field testing in nurseries with a high level of disease pressure. This method will enable us to confirm levels of resistance of promising material using foreign or highly virulent strains, under controlled conditions.

International testing

As part of a special project funded by USAID, a network of programs in the region (Morocco, Algeria, Tunisia, Egypt, Turkey and Syria) has been established, which is collaborating in research on different aspects of barley pathology. Apart from these, co-operators within and outside of the region are growing the nurseries in hot-spots with severe development of one or more diseases. Through this multi-location testing, material is exposed to a wide range of virulences of a number of leaf diseases across a wide range of environmental conditions.

Table 98. Testing for resistance to scald in growth chamber compared to testing in field.

Variety	growth-chamber*	field**
Arar	1 a	0.0 a
Alger/Ceres	9 a	0.0 a
Atlas 46	9 a	.7 ab
DA 106/Celaya	15 a	2.1 bc
Tadmor	42 b	4.6 de
Rihane-01	44 b	2.8 cd
Rihane-03	45 b	4.5 de
SLB 56-79	45 b	2.4 bc
Awn.Bl./Ath.	47 bc	5.5 e
SLB 39-60	52 bc	5.8 ef
Deir alla 106	61 c	5.8 ef
SLB 63-15	62 c	-
Faiz	80 d	6.1 efg
WI2291	83 d	5.8 ef
SLB 37-74	89 d	7.5 fg
SLB 6-35	94 d	7.8 g

* Percentage infested plants of 20 plants per dilution series, 8 replicates.
** 0-9 scale (9 = 100% infested), 2 replicates.
Letters indicate grouping by LSD test (p=5%).

The most important of the disease nurseries is the Barley Key Location Disease Nursery, which is assembled yearly to test breeding material before it is introduced in the observation nurseries or international yield trials. As of October 1987 data were received from 16 locations on a total of 6 diseases. The most frequently reported diseases were powdery mildew (8 locations) and scald (6 locations). Correlation between the different locations for powdery mildew readings was lower than those for scald. This difference may be explained by a larger variability in virulence for the first pathogen, or by a lower selection pressure for resistance in the past. In each location the 25% most resistant entries for powdery mildew were selected. Three lines were found to be among the most resistant in each of the 8 locations (Table 99). The higher correlation among the scald readings permitted a higher selection level. Three out of the 226 entries tested were in the best 10% of each of the 6 locations (Table 100).

Table 99. Entries from Advanced Yield Trials 1986-87 selected for powdery mildew resistance.

No. BAT87	Cross/ Pedigree
1017	Cr.264-8-4/Nopal'S' ICB79-0420-10AP-1AP-2AP-1AP-0AP
909	Roho/Masurka ICB78-0169-4AP-2AP-1AP-2AP-1AP-0AP
1108	Pld10342//Cr115/Por/3/Bahtim 9/4/Ds/Apro/5/WI2291 ICB78-0058-7AP-1AP-2AP-6AP-0AP

Table 100. Entries from Advanced Yield Trials 1986-87 selected for scald resistance

No. BAT87	Cross/ Pedigree
210	WI2197/Arabische ICB77-0042-4AP-0SH-1AP-2AP-2AP-0AP
301	Impala/Julia//Api ICB78-1085-2AP-2AP-1AP-2AP-0AP
316	Giza 121/CI06248/4/Apm/IB65//11012-2/3/Api/CM67//Ds/Apro CMB78A-0044-3AP-6AP-3AP-5AP-0AP

Barley Yellow Dwarf Virus Research

Results on screening for resistance to BYDV in wheat and barley are presented in the Annual Report of the Genetic Resources Program 1987.

J. van Leur

3.3. Entomology

Introduction

In accordance with ICARDA's CGIAR mandate, entomology in the Cereals Program seeks to 1) develop the research capabilities of national program scientists in countries within the ICARDA region, 2) pursue research beyond the present capabilities of the national programs, and 3) train technicians and scientists in current entomological theory and techniques. This is being accomplished through the development of subregional networks consisting of several countries sharing common insect pest problems (Table 101).

Table 101. Subregional networks envisioned or in place for the major insect pests of West Asia and North Africa.

Pest Species	Subregional Network	
Wheat Stem Sawfly		
Cephus pygmaeus L.	*Syria	Morocco
Cephus libenensis Andre	Turkey	Algeria
Cephus tabidus F.	Lebanon	Tunisia
Sunn Pest		
Eurygaster integriceps Put.	Iran	
Aelia rostrata Boh.	Iraq	
	Syria	
	* Turkey	
Hessian Fly		
Mayetiola destructor Say	Algeria	Libya
	* Morocco	Tunisia
Aphids		
Rhopalosiphum padi L.	* Egypt	
Rhopalosiphum maidis Fitch.	Sudan	
Schizaphis graminum Rond.	Ethiopia	
Microsiphon avenae F.		

1) Subregional network functioning
2) Subregional network envisioned
* Country with potential for network leadership.

The insects identified for work by ICARDA are currently serious economic pests in the countries identified. In developing subregional networks for entomology, ICARDA hopes to act as a catalyst between the participating countries, allowing them to share expertise and facilities already in place in their respective national programs. ICARDA also acts as a buffer between the participating countries and advanced institutions in more developed countries by sifting through new technologies and suggesting and implementing collaboration with those institutions best suited to the region's unique needs. This section will deal with those insect problems researched in 1986/87 at the Tel Hadya research farm in northern Syria, (sawflies) in the Bekaa Valley of Lebanon (Hessian fly), and in the Nile Valley of Egypt and Sudan (aphids).

Wheat Stem Sawfly

ICARDA's wheat stem sawfly (C. pygmaeus) screening program was significantly increased in 1986/87 to allow the screening of about 360 lines each of barley, durum wheat and bread wheat under cages. Fifty seeds of each line of each commodity were planted in an RCB design with 2 replications, with those lines in a single cage constituting a block. Germination and development were monitored for each line. Laboratory reared females C. pygmaeus were introduced into the cages at a density of 1 female/m^2 in April at the time sawflies were present naturally in the field. Males were also introduced into the cages as they emerged in the laboratory. Following harvest 60 stems were collected from each line and scored for the presence of sawfly larvae. A percentage infestation was then computed. Yield and 1000 KW were also computed for each line from harvested seed. An index of stem solidness was computed for each variety by subtracting the width of the inner stem cavity from the outside diameter, dividing by the outside diameter, and then multiplying by 100. Stem solidness measurements were taken midway between the rachis and uppermost node. An identical screening experiment, with the exception that all lines were located on the open in a sawfly "hot spot," was planted in a farmer's field about 20 km south of Tel Hadya. Results were pooled with those obtained under cages at Tel Hadya to give an average sawfly infestation rate for each line and to the checks. In selected lines for rescreening during 1987/88, the mean infestation rates of all lines was compared to the mean infestation rate of each individual line. Usually the cutoff point for selecting promising lines was X -1.5 st. dev., although this varied somewhat.

An additional experiment was designed to test the effects of plant spacing on stem solidness of durum lines previously shown to be resistant (D-2/Waha ICD 79-0282-9AP-4AP-0AP BON-LR(86)25) and susceptible (Haurani) to C. pygmaeus. Each of the two lines were machine planted at 2 seed spacings, 40 cm by 40 cm or 10 cm by 3 cm. In additional to the variables previously mentioned, stem solidness was measured at the midpoint of the uppermost 4 internodes. Care was taken that these plots were kept free of weeds.

Table 102 contains a listing of the best lines of barley durum wheat and bread wheat tested in 1986/87, while Table 103 lists the grand means of variables measured for these lines as well as the worst lines of each species. Durum wheat was the most sawfly resistant species, followed in turn by bread wheat and then barley. A regression of variables possibly related to sawfly resistance (Table 104) revealed that stem solidness in bread wheat was significantly and negatively correlated with percent sawfly infestation. There was positive correlation of yield and percent infestation in both durum wheat and bread wheat, suggesting that current higher yielding varieties lack good sawfly resistance. The relationship between stem solidness and yield was not clear, although other workers have demonstrated a negative correlation.

A number of results with important implications were derived from the seed spacing study. First, the level of stem solidness varies with vertical position on the stem. Second, the degree of stem solidness may be altered by changing the distance between plants. This also suggests that sawfly resistance in durum wheat may not be due solely to stem solidness, as was also suggested by data in Table 104. Rather, other characteristics such as constitutive chemicals or unique morphology may play a role.

The effects of plant spacing on plant height and on development (Zadoks scale) are shown in Figs. 34 and 35 respectively. Plant height did not differ in the two spacing regimes, but did differ according to variety. The susceptible line was taller than the resistant line, a difference that first became noticeable at Julian Date (JD) 53. However plant spacing did appear to affect development. Close spaced plants began to develop faster than wide spaced plants apart from JD 111 when April's warmer spring temperatures promoted plant growth. This increase in development roughly coincided with the midpoint of the period when C. pygmaeus was observed in the field. From sawfly collection data it appears that the emergence of C. pygmaeus at Tel Hadya is normally distributed over the sawfly emergence "window." This would allow the maximum number of sawflies to be present when durum wheat and bread wheat are beginning to head. Field observations of sawfly infestations in barley consistently higher than those in wheat may be due to a low level of resistance in barley, a high sawfly population during the period when barley is heading, or both.

Perhaps the most important implication of these results, and, it must be remembered that this is based on only a single year's data in unreplicated trials, is that altering plant spacing in a farmer's field may alter crop susceptibility to sawflies. Similarly, the results of sawfly screening trials may be suspect if care is not taken to insure uniform plant density among lines.

Further emphasis will be placed on examining the effects of different agronomic practices such as row spacing, planting depth, and planting date on the expression of sawfly resistance as well as locating new sources of resistance. The project's ultimate goal is to provide farmers with a complete pest management package that includes resistant varieties and proper agronomic techniques to increase farmer income by minimizing crop losses and pest control expenditures.

Table 102. Promising barley, durum wheat, and bread wheat lines screened for *C. pygmaeus* resistance in 1986/87.

Name	Seed	Sawfly Nos.	%INF
BARLEY			
IB73-075	BAB85	14	0.83
35-52	BIT687	36	5.83
Pld10342//Cr.115/Por/3/Bahtim 9/4/ Ds/Apro/5/WI2291	BAT87	1109	6.66
Roho//Alger/Ceres, 362-1-1	BAT87	512	6.66
46-23	BIT687	72	6.66
Roho//Ci 08887/Ci 05761	BAT87	908	7.50
Mzq/M59-247//MT/Ds/3/Ben/4/Bahtim10	BAT87	107	7.50
46-93	BIT687	128	7.91
WI2197/Arabische	BAT87	210	7.91
A. Aswad	BIT687	7	8.33
DURUM			
Chen	DAT87	310	0.00
Po	DAT87	802	0.00
Amstl	DAT87	1014	0.00
Amst	DCB87	26	0.00
Ruff//Jo/Cr/3/Gediz	DCB87	34	0.00
Blk2	DCB87	103	0.00
Pin/Gr//Trob	DCB87	42	0.41
Lahn	DCB87	60	0.41
Fa/Cando	DCB87	77	0.41
D. Dwarf S-15/Cr/3/Plc/CII//Jo/RD119	DCB87	84	0.41
Fa/Cando	DCB87	86	0.41
Gediz/Bit	DCB87	97	0.41
BREAD WHEAT			
Fta/W71//Imuris	WCB87	71	0.83
Fta/W71//Imuris	WCB87	72	2.91
BOL'S'/PVN'S'	WOM87	42	2.91
Tow'S'/Pew'S'	WOL87	32	3.33
Bage/Hork//Aldan	WOL87	56	3.33
Ttr'S'/Jun'S'	WOM87	11	3.33
Yr/Sprw'S'	WCB87	61	3.33
G11/Ti/3/Kvz//Kal/Bb/4/Kal/3/Cno/ Chr//On	WCB87	33	3.75
Gv/Ald'S'	WCB87	12	3.75
Tzpp/Sn64A/Napo/3/Mn72131	WRT87	17	3.75

Table 103. Grand means of the best and worst lines of barley, durum wheat, and bread wheat screened for resistance to *C. pygmaeus* in 1986/87.

	N	Germination	Stem Solidness	Yield kg/ha	% Infestation
Barley					
Good	45	75.69	13.46	2340	7.0
Bad	139	79.17	15.25	2841	44.3
Durum					
Good	263	68.70	26.10	3261	2.6
Bad	122	71.77	27.02	3479	13.1
Bread wheat					
Good	140	67.80	27.19*	2433	5.4
Bad	112	68.29	19.94*	2327	22.7

Table 104. Regressions from selected lines of variables possibly related to wheat stem sawfly resistance.

	n	r	p	Equation
Barley				
INF VS SS	105	-0.034	0.322	
INF VS YLD	105	0.065	0.189	
SS VS YLD	105	0.074	0.159	
Durum				
INF VS SS	302	0.016	0.381	
INF VS YLD	302	0.143	0.003	Y = 1.531+.001X
SS VS YLD	302	0.128	0.006	Y = 22.441+.001X
Bread wheat				
INF VS SS	240	-0.215	0.001	Y = 17.518-.179X
INF VS YLD	240	0.124	0.026	Y = 9.518+.002X
SS VS YLD	240	0.035	0.293	

[1] Regression equation not computed where P > 0.05.

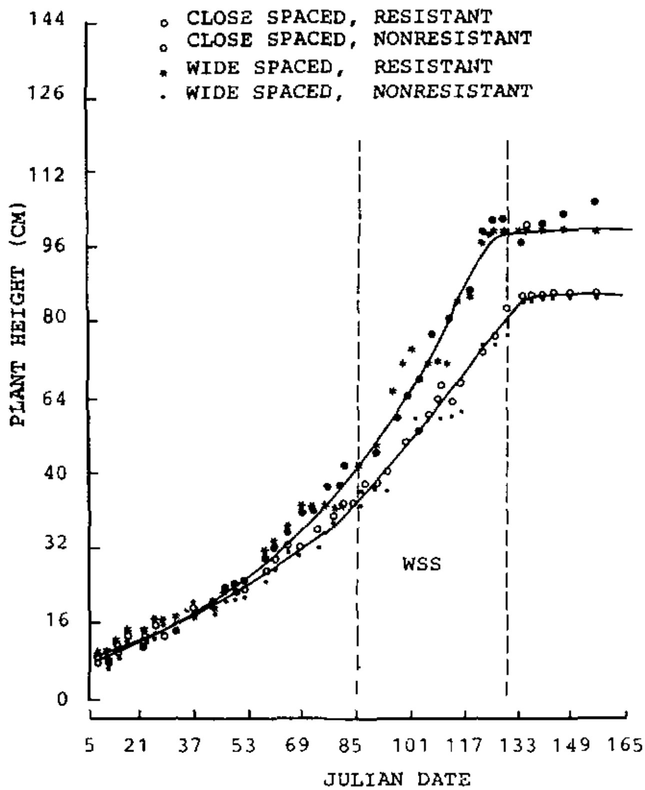

Fig. 34. Plant height of resistant and nonresistant durum wheat varieties planted at different spacing intervals.

Hessian Fly

Two Hessian fly nurseries, obtained from the Uniform Hessian Fly Nursery (USDA - Kansas State University, USA) were planted at Tel Hadya in 1986/87. High populations in the area allowed the additional scoring of these lines for sawfly resistance. All were susceptible to sawflies. The earlier Hessian fly nursery was also planted at ICARDA's Terbol Station in the Beka'a Valley of Lebanon and subjected to naturally ocurring Hessian fly populations. Only the variety "Caldwell" possessing the H6 gene was observed to be resistant as determined by the presence of dead first instars on the plants. Of note is that SD 8036, the bread wheat variety being developed as a "stop gap" solution to Morocco's chronic Hessian fly problems, was highly susceptible to sawflies. In light of the severe sawfly infestations experienced in 1986/87 in Morocco, developing varieties resistant to both Hessian fly and sawflies would appear a desirable goal.

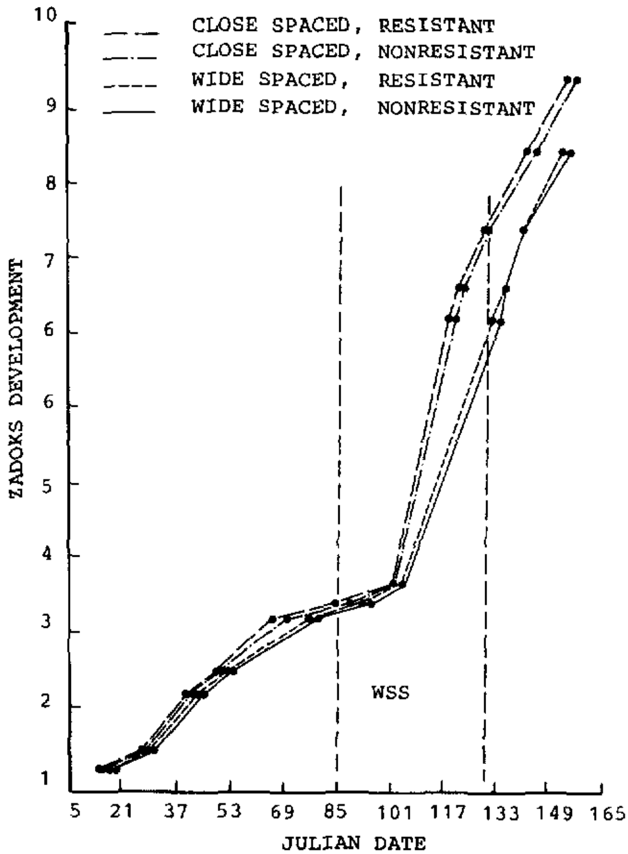

Fig. 35. Plant development (Zadoks scale) of resistant and nonresistant durum wheat varieties planted at different spacing intervals.

Aphids

Nurseries assembled at ICARDA were screened against Schizaphis graminum and Rhopalosiphum padi in laboratory trials in Egypt and in field trials in Egypt and Sudan. While no lines showed adequate resistance to R. padi, Egyptian scientists identified S. graminum resistance in crosses they made between local commercial varieties (Giza 157, Sakha 61, Sakha 69) and lines from the USA (Bushland/Amigo 101 and 105). They concluded that resistance was conferred by two recessive genes. Future work will concentrate on adding resistance to otherwise suitable varieties by screening commercial varieties, exotic germplasm, and primitive forms and landraces.

R.H. Miller

3.4. Cereal Quality

Introduction

ICARDA's cereal quality laboratory has focused its attention on both the functionality and nutritional aspects of the three cereals. Barley genotypes have been screened for lysine content for several years.

Cereal-based foods provide more than half of the total protein and energy requirements of people in the Middle East and North Africa. Although there is a negative relationship between lysine content of the protein and protein content, as the protein content increases the total amount of lysine also increases, so that a high protein cereal also contributes more significantly to lysine requirements. The use of T. dicoccoides can increase protein content of durum wheat dramatically. Advanced ICARDA durum/dicoccoides germplasm has been screened for industrial potential.

In bread and durum wheats quality means end product utilization potential. Cereals used as food undergo both primary (milling, raw burghul preparation, etc.) and secondary (baking, cooking etc.) processing before being consumed. Chemical and physicochemical characteristics of cereal grains are used to predict their quality. This is used in the screening of early generation genotypes to identify lines which should be rejected because of one or more persistent poor quality characteristics. In advanced generations where more seed is available comprehensive testing for the quality of lines which have been advanced is verified. The tests employed for screening and evaluation of cereals at ICARDA are summarized in ICARDA Technical Manual No. 14 (1986). In addition to the procedures described in the manual, advanced lines of durum wheat and barley have been processed into spaghetti and micro-malting, respectively, by arrangement with the Grain Research Laboratory, Winnipeg, Canada.

During 1986-87 over 60,000 tests were carried out in the cereal quality laboratory. These are summarized in Table 105.

1. Screening of advanced barley lines for quality

The main objective of the barley quality testing program is to ensure that barley genotypes which are advanced on the basis of yield potential also conform to quality specifications for nutrition and industrial use. Since over 90% of the barley is used as feed, all lines are also screened for lysine content simultaneously with protein by near-infrared spectroscopy. The first step in screening barley genotypes for quality is kernel weight, which is highly correlated with the plump kernel count (PKC). The second test is the PKC itself (plump kernel cont). Genotypes which contain over 40% kernels above 2.8 mm in width, and over 75% kernels over 2.5 mm in width are selected for diastatic potential (DP) testing (Mekni et al, Rachis 1986).

Table 105. Tests carried out at ICARDA Cereal Quality Laboratory, 1986-87.

Project	TKW[a]	VKC	PSI	WMFT	SDS	YP	FM	FAR	KSD	DP	LYS	PROT	Total	% DISTR.
Barley	3274	-	-	-	-	-	-	-	644	144	2554	2554	9170	15.2
Bread wheat	864	-	864	308	-	-	-	-	-	-	864	2900	4.8	
Durum wheat	3511	3511	179	-	1486	3511	91	91	-	-	-	3511	15891	26.4
Durum Germplasm	6224	5000	-	-	-	5000d	-	-	-	-	-	5000	21224	35.3
High elevation	2043	-	2043	244	758	758	-	-	-	-	-	2043	7889	13.1
Other projects	-	120	-	-	-	-	-	-	-	-	-	589	709	1.2
CQN[b]	405	126	117	117	126	126	274	274	102	-	108	405	2180	3.6
FFVT[c]	-	-	-	-	-	-	100	100	-	-	-	-	200	0.3
Total	16321	8757	3203	669	2370	9395	465	465	746	144	2662	14966	60163	99.9

a) TKW = Thousand kernel weight, VKC = vitreous kernel count, PSI = particle size index, WINFT = wheat meal fermentation time test, SDS = Sodium dodecyl sulphate sedimentation, YP = Yellow pigment, FM = Flour milling, FAR = Farinograph, KSD = kernel size distribution, DP = diastatic potential

b) Cereal Quality Nursery

c) Farmers' Field Verification Trials

d) Colour tests carried out by visual evaluation of external seed coat only

Although there is a negative correlation between kernel size and diastatic potential (Mekni et al, loc. cit.) some genotypes possess both characteristics. Screening of the 1985-86 advanced barley yield trials resulted in the identification of five such lines (Table 106). Of these, accession no. 821 has been reported as having good yield potential and disease resistance when grown in Ethiopia, where there is a particular interest in growing malting barley, which is used mainly for food and feed, with some being used for malting. There is an increasing interest in malting quality in national programs, some of whom have requested that ICARDA's quality screening for barley include identification of genotypes with good malting potential.

Table 106. Advanced Barley Genotypes with good Malting Potential

Acc. No.	Pedigree	PKC[a]	TKW	DP
622	BA1.16/AP://DEIR ALLA 106 L083-2AP-2AP-1AP-2AP-1AP-1AP-OAP	95.5	41.5	179
714	3309/Attiki//XV2240-OSK/3/Api/... ICB 79-01L3-OSH-5AP-2AP-1AP-OAP	91.0	39.7	165
718	Giza 121/Por ICB 77-0214-2AP-3AP-2AP-1AP-2AP-OAP	82.1	38.2	159
815	Impala/Julia//Api ICB 78-1085-1AP-2AP-3AP-2AP-OAP	91.1	41.7	156
821	Pitayo/Cam//Aut/RM 1508/3/PIROLINE ICB 78-0010-11AP-2AP-4AP-2AP-OAP	97.2	47.2	158

2. Studies on kernel size in barley landraces

The selection of genotypes with superior kernel characteristics from the barley landraces Arabi Abiad and Arabi Aswad has been reported earlier (Ceccarelli and Yau, Cereal Program Annual Report 1986). The study was extended to verify that kernel shape characteristics of high kernel weight genotypes also possessed desirable plump kernel characteristics. The results verified that many high kernel weight lines were of satisfactory plumpness, as distinct from kernels which were simply long and narrow (Table 107).

Table 107. PLC of some high kernel weight Arabi Abiad Selections.

Acc. No.	> 2.8mm	2.5-2.8mm	2.2-2.5mm	< 2.2mm	TKW
3-120	53.6%	37.9	6.0	2.4	56.3 g
4-73	54.0	39.8	5.3	0.8	56.6
4-85	61.8	27.9	6.1	3.9	57.3
4-90	43.4	41.7	10.9	3.9	58.2
4-136	61.1	30.0	7.1	1.7	55.9
5-74	49.7	38.6	8.7	2.9	56.4

3. Stability of kernel size and protein content in barley

Kernel size and protein content are important attributes of barley while both are inherently involved in malting quality. Protein content is particularly important in feed and food barley. Some poultry feed manufacturers prefer low protein so that they can use protein concentrates or amino acids to provide an optimum protein balance. Kernel size and protein content are both important attributes of barley. Both are inherently involved in malting quality. Stability of a characteristic is best assessed by determining broad sense heritability using an analysis of variance technique, but an indication of the stability of a characteristic can be gained by growing a number of genotypes at any two locations and computing the coefficient of correlation between the two data sets. High coefficients of correlation indicate that the environmental effect on protein content is low.

The preliminary barley trials grown at Tel Hadya and Breda during 1986-87 contained about 600 genotypes. The coefficients of correlation for individual series of 25 genotypes for kernel weight ranged from less than 0.6 to over 0.9 with an overall correlation coefficient of 0.91. On the other hand the respective correlation coefficients for protein content in the same data sets varied by ± 0.5 with an overall coefficient of -0.05. The significance of these findings, which corroborate many similar reports, is that barley genotypes with high (or low) kernel weights are likley to retain their respective size under a variety of growing conditions, whereas the protein content is governed mainly by the environment.

4. Barley as human food

A short survey of barley consumption in Tunisia revealed that the chief types of barley foods include soups made from *frek, or coarsely ground* barley, malthoude, a type of cous-cous made from coarse semolina (also called malthoude) and barley breads, made from fine semolina. A wide range of foods are prepared from the fine semolina. The three types of barley raw material are manufactured in barley semolina mills, in which decortication is a preliminary step. The quality parameters sought for by the semolina millers include hard kernels, high protein, blue aleurone, and a small ventral "crease". The first three parameters are diametrically opposed to the parameters necessary to malting quality, so that high yielding lines which are not suitable for growing in barley food-consuming areas such as Tunisia *and Ethiopia may be acceptable for malting.*

Bread Wheat Research

1. Stability of quality parameters

Using the simple between-location correlation evaluation refered to in the barley quality section, mean correlation coefficients for wheat hardness (particle size index) and wheatmeal fermentation time test (WMFT) were 0.79 and 0.57, respectively. The breakdown in strength (predicted by the WMFT test under certain growing conditions referred to *in the 1986* Annual Report of the Cereal Program was again observed in the Advanced Yield Trials (Table 108). Observations were confirmed by data obtained using WMFT and farinograph tests on bread wheat lines grown in several countries in the Cereal Quality Nursery. Variations in WMFT were mirrored in variations in farinograph data in protein content. Variations were not commensurate. On the basis of high values for WMFT, protein and kernel weight, and optimum values for kernel hardness (PSI) combined with stability in WMFT, two genotypes were of above average quality. Both were superior to Mexipak. The characteristics of these lines are given in Table 109.

Table 108. Changes in WMFT under different growing conditions.

Acc. No.	THRF		THEP		BR	
	WMFT	Protein	WMFT	Protein	WMFT	Protein
303	193	12.5	61	13.8	159	13.4
324	173	13.2	93	13.6	64	15.8
519	97	12.8	262	14.1	203	16.4
1003	86	15.6	73	13.9	242	13.0

THRF = Tel Hadya Rainfed;
THEP = Tel Hadya Early Planting; BR = Breda

Table 109. Quality Characteristics of improved wheats.

Pedigree	PSI	WMFT	PROT	KW
	Acc. No. 809			
	PSI	WMFT	PROT	KW
THFR	49	197	12.5	39.1
THEP	48	220	12.8	41.7
Breda	46	177	16.4	27.8
	Acc. No. 920			
	PSI	WMFT	PROT	KW
	53	201	13.2	27.9
	52	172	12.5	28.1
	55	223	13.2	20.7
	Mexipak			
	PSI	WMFT	PROT	KW
	48	47	12.4	26.0
	47	44	13.4	25.2
	45	53	15.7	23.6

THRF = Tel Hadya Rainfed;
THEP = Tel Hadya Early Planting

2. Prediction of strength in wheat by near-infrared reflectance (NIR) spectroscopy

A study was conducted during 1986-87 to predict strength in medium-hard wheats by means of NIR spectroscopy using a Pacific Scientific Model 6250 Research Composition Analyzer. To minimize the effects of protein content per se and particle size, medium-hard wheats exhibiting a range of protein of less than three percent were selected. Correlation coefficients of nearly 0.9 were obtained for the prediction of farinograph characteristics, while correlations of 0.75-0.80 were obtained for prediction of wheat meal fermentation time (WMFT) and sodium dodecyl sulphate (SDS) sedimentation volumes. Since the WMFT and SDS tests are themselves only capable of correlation coefficients of 0.7-0.8 with farinograph characteristics, the NIR technique may prove superior in predicting the functional properties of bread wheat for breeding programs (Table 110).

Table 110. Efficiency of prediction of bread wheat strength parameters by NIR.

Parameter	SEP[a]	CV.	r.
FAR. ST.	2.6	27.1	0.86
FAR. MT.	7.1	12.4	0.88
WMFT	31	29.2	0.80
SDS	5.6	9.8	0.75
Protein	0.23	1.7	0.99

SEP = Standard error of performance = standard deviation of differences between NIR and reference analyses; CV = coefficient of variability; r = coefficient of correlation between NIR and reference data; FAR. ST. = farinograph stability; FAR.; MT. = farinograph mixing tolerance; WMFT = Wheat meal fermentation time; SDS = Sodium dodecyl sulphate sediment volume.

Durum Wheat Quality Research

1. Variance in durum wheat quality parameters due to growing conditions

The main characteristics used to categorize early generation durum wheat cultivars include protein content thousand kernel weight (TKW), vitreous kernel percentage (VKC), yellow pigment content (YP), sodium dodecyl sulphate sedimentation volume (SDS) and the SDS index (SDSI, obtained by dividing the SDS volume by the protein content). SDSI gives an indication of the "efficiency" of the protein in terms of hydration capacity per unit of protein and is particularly useful when working with nurseries where the average protein content varies widely due to growing conditions. The influence of growing conditions on the above quality parameters was evaluated in the Regional Durum Yield Trials which are grown under early, midseason and late season planting conditions, and under low fertility at Tel Hadya, and higher moisture stress at Breda (Table 111).

Table 111. Influence of growing conditions on durum wheat quality parameters.

	Protein		TKW		YP		SDS		SDSI	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
THEP	15.6	6.7	40.52	13.6	6.08	13.7	33.58	17.7	2.16	20.3
THRF	14.51	9.3	37.21	4.2	6.04	15.2	45.09	14.4	3.11	13.3
THLP	16.39	3.1	33.32	8.6	5.70	15.7	43.52	13.7	2.65	13.5
THDQN	9.71	13.3	36.31	11.8	5.09	14.1	23.22	23.6	2.40	20.9
Breda	14.77	5.4	29.30	9.6	5.41	10.2	34.73	20.1	2.35	20.1

Kernel size and yellow pigment content progressively decreased from early to late planting. SDS volume and SDS index increased significantly from early and midseason planting. Both decreased with late planting, despite a significant increase in protein content. This indicates that high temperature during the maturation phase possibly affected protein hydration capacity under late season planting. Low fertility significantly reduced protein content, yellow pigment, SDS volume and SDS index relative to the rainfed trial, but did not change the mean kernel weight. Moisture stress at Breda resulted in reductions in kernel weight, pigment, and SDS volumes relative to the rainfed trial, and caused a slight increase in protein content.

On the basis of overall performance for five quality parameters at early and midseason planting the genotypes described in Table 112 typify the advanced material.

Table 112. Quality characteristics of advance durum genotypes.

Acc. No.	Protein	KW[a]	SDS	SDSI	YP
520	15.8	35.2	47	3.0	6
1005	15.8	36.2	43	2.7	5.5
1019	14.5	44.1	43	3.0	6.3
1021	15.6	46.0	43	2.7	5.8

KW = 1000 Kernel weight;
SDS = Sodium dodecyl sulphate sedimentation volume;
SDSI = SDS index;
YP = yellow pigment (PPM).

In studying the overall quality pattern of the advanced material for the past three seasons a progressive increase has been observed in mean yellow pigment content (16%) SDS volume (41%) and SDS index (33%) reflecting the results of selection for these characteristics.

2. Influence of fertility level on evaluation of quality characteristics of durum wheat

During the past three years advanced durum genotypes have been planted in a special low fertility trial to learn how genotypes react to the low fertility with respect to vitreous kernel percentage and other characteristics. The vitreous kernel percentage (VKC) of durum wheat is important to the milling of semolina for cous-cous and pasta production. Low vitreous kernel percentages result in higher yields of unwanted flour in semolina milling. An earlier study (Rachis Vol 3, No.2, 1984) indicated that the VKC of durum cultivars varied widely at low fertility, but that some lines retain a high VKC even at low fertility. At the higher fertility conditions under which advanced material is usually grown in breeding centers it is impossible to evaluate VKC since all genotypes have well above 90% VKC. The low fertility nursery has demonstrated that selection on the basis of high VKC has led to a gradual improvement in the proportion of genotypes with a high VKC. Genotypes with VKC of over 90% have increased from 4.6% in 1985-86 to 22% in 1986-87 despite no change in mean protein content (Table 113).

Table 113. Distribution changes of durum genotypes with high VKC.

VKC %	0-20%	20-40%	40-60%	60-80%	80-100%	Mean Protein
1985 - 86	18.2	27.1	25.0	18.4	11.3	9.75
1986 - 87	1.7	13.6	17.0	23.3	44.5	9.71

Low fertility trials also provided a better understanding of the relationships between parameters such as the SD sediment volume, SDS index VKC and protein content (Table 114).

Table 114. Relationships (r^2) between protein content and other quality parameters under normal and low fertility conditions.

Date	Fertility	Protein (VKC)	Protein (SDS)	Protein (SDSI)	SDS:VKC
1984-85	LF[c]	0.69	0.33	0.09	0.38
	NF	0.05	0.02	0.11	0.03
1985-96	LF	0.03	0.25	0.06	0.05
	NF	0.01	0.002	0.02	0.02
1986-87	LF	0.62	0.31	0.66	0.45
	NF	0.17	0.31	0.05	0.04

r^2 = coeff. of determination; VKC = vitreous kernel count; SDS = sodium dodecyl; sulfate sediment volume; SDSI = SDS index; LF = Low fertility; NF = normal fertility.

Earlier studies (Cereal Foods World Vol. 31; 589, Abstract No. 83 1986) established the value of SDS test for the perdiction of end-product utilization potential in durum wheat. The present three-year study enabled the determination of the stability of the SDS and SDSI values at different planting times and fertility conditions over three seasons (Table 115).

Table 115. Stability of SDS and SDSI values in durum wheat genotypes.

	NPNF:NPLF SDS	NPNF:NPLF SDSI	EPNF:NPLF SDS	EPNF:NPLF SDSI
1984-85	0.66	0.84	0.55	0.68
1985-86	0.56	0.66	0.65	0.81
1986-87	0.41	0.58	0.88	0.33

a) all values refer to r^2 (coefficient of determination)
b) NPNF = Normal planting time of normal fertility;
LF = Low fertility; EP = Early planting

High Elevation Cereals

High elevation cereals quality research is devoted mainly to durum and bread wheats. Nearly 8000 tests were carried out during 1986-87. Of particular interest was the use of T. dicoccoides to improve disease resistance and protein content.

1. The use of near-infrared (NIR) analysis to distinguish between genotypes with durum or bread wheat characteristics

Introduction of T. dicoccoides to bread wheats can lead to the segregation of genotypes carrying either bread wheat or durum wheat hardness. Using NIR to determine kernel hardness some genotypes have been characterized as soft wheats, while others are of the extra hard durum type, indicating extensive modification of the classical durum-type hardness by dicoccoides genes. Table 116 illustrates a wide range of hardness in different genotypes.

Table 116. Texture (hardness) variation in *T. dicoccoides/T. durum* genotypes.

Acc. No.	PSI	Category
ICI-5-12	30	Very hard
ICI-5-216 [a]	40	Hard
ICI-5-41	50	Medium hard
ICI-6-54	60	Fairly soft
ICI-6-65	65	Soft

a) Retained durum kernel characteristics.

2. Influence of increased protein content induced by *T. dicoccoides* on quality parameters of *T. dicoccoides/T. durum* genotypes

Sodium dodecyl sulphate (SDS) volumes may reflect increased protein content and/or strength. The degree to which a high SDS volume is indicative of increased strength can be estimated by dividing the volume by the protein content to give a SDS index, which is the volume of SDS sediment contributed by one percent of protein. A SDS index of above 3.5 is regarded as very good in durum wheat while an index of 2.5 or lower is weak. In the case of bread wheat an index of 6 and over indicates superior strength. The WMFT result (reported in minutes) can be similarly indexed. A WMFT index of above 15 indicates a "strong wheat, "whereas an index of 5 or less indicates" weak" gluten.

Table 117 indicates some lines selected from *T. dicoccoides/T. durum* crosses with high SDS volumes or WMFT times, but low indices. These results are being verified by natural milling, physical dough-testing and baking tests of *T. dicoccoides/T. durum* genotypes with high and low SDS and WMFT indices. It is well-recognized that increasing protein content does not necessarily result in increasing gluten strength and functional properties in bread wheats or durum wheats. Use of *T. dicoccoides* lines which themselves possess superior gluten strength may result in recombinations with increased gluten strength.

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

Table 117. T. durum/ T. dicoccoides lines with low apparent strength but high protein content.

Acc. No.	Protein	KW	SDSI[a]	WMFTI
A. Durum Types				
ICI-5-44	18.1	43.3	1.22	-
ICI-5-74	18.6	42.7	1.08	-
ICI-5-345	17.4	40.6	0.98	-
ICI-5-24[b]	17.4	38.5	3.28	-
B. Bread Wheat Types				
ICI-5-173	18.7	30.1	-	2.46
ICI-5-297	17.0	33.6	-	2.36
ICI-6-25	19.0	34.9	-	1.53
ICI-6-180[b]	14.2	27.0	-	15.8

a) SDSI = Sodium dodecyl sulphate index :
WMFTI = Wheatmeal fermentation time index.
b) "Good" comparisons.

4. International Cooperation

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 Cereal Program's breeding strategies for more stable and increased production in stress environments and significant increases in moderately favorable environments. Close partnership with national research program activities within the region has promoted more joint research among countries and the sharing of research results. It also encourages leading research institutions around the world to focus resources on the complex problems of dryland cereal farming. Some accomplishments emerging from this partnership are highlighted below.

Afghanistan

During the season consultations took place between ICARDA, FAO, and UNDP officials concerning the Program's involvement in the project entitled: "Research in Cereal and Pulses Improvement in Afghanistan". If approved, FAO will be the executing agency in collaboration with ICARDA and on behalf of UNDP. The project is still in the preparation phase, and it is planned that exchange of germplasm and training will be inceasingly emphasized. The Program has been providing the germplasm and some training opportunities for the last several years.

Algeria

The 1986/87 crop season was the first year for the formal collaborative project between the Institut Technique des Grandes Cultures (ITGC) Algiers, ICARDA and LECSA/INRA France to improve research, production and transfer of technology for winter cereals in the Wilaya of Sidi Bel Abbes. The project aims to develop improved varieties and production technologies, to test and verify results on farmers' fields and demonstrate research findings to farmers in the various agro-ecological zones of the Wilaya while evaluating the impact of this technology. This includes identifying, by means of socio-economic surveys, production constraints and methods to alleviate them. Also included is the upgrading and acceleration of seed production systems for identified varieties. Training activities seek to develop manpower needs for Algeria.

The first coordination meeting for this project was held at ITGC, Algiers, September 21-23 during which results of the 1986/87 crop season were discussed and 1987/88 plans developed. Training requirements, visits, workshops, seminars. etc. for the coming season were also finalized.

At Sidi Bel Abbes, the total rainfall during 1986/87 crop season was 105 mm lower than the annual average of 285 mm. Rain distribution was also poor as 40% fell during February and very little occurred during March, April and May. 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, and earliness.

Off-station results indicate the effect of improved variety and soil and crop management technology on production. In testing and verifying research station results on farmers' fields, four trials were conducted in Zones I, II, and III in randomized blocks of 12 m^2/plot with two replicates for each of the three species. Nine durum varieties, five bread wheats and nine barleys were yield tested. Results show that all durum varieties tested were superior to the local check Oued Zenati. The varieties Belikh, Kourifla, Sebou and Sham I yielded on average twice as much as the local check. Similarly, majority of the bread wheats, evaluated outyielded the local check Mahon Demias, Sham 4 being the highest yielding line. Sham 4 seed is currently being multiplied. The best yielding barley varieties were early maturing Harmal, and WI 2291.

Demonstration plots incorporating improved varieties and production technology were conducted in unreplicated 1 ha plots in zones I, II and IV of the Wilaya. In Zone I, Waha yielded 1.2 t/ha compared to 0.4 t/ha for the local durum Oued Zenati. In Zone II, the bread wheat Fliker"S"/Horck yielded 1.1 t/ha while the crop of the local variety Mahon Demias was a complete failure. In Zone IV the variety Rihane-03 yielded 1.5 t/ha compared to 0.8 tons/ha of the local variety Saida 183.

From this year's results, it is obvious that improved variety and production technology can play a major role in increasing farmers' income from dryland farming systems in Algeria.

China

Cooperation with China continued during the season and a formal agreement was signed. A barley variety was released in China from the germplasm provided by the CIMMYT/ICARDA barley project based in Mexico. It is planned to increase the cooperation on barley improvement with China. A delegation from the Cereal Program will visit China in the Spring of 1988 to assess cereal growing needs and discuss the direction of future collaborative efforts.

Cyprus

The collaborative project to identify early maturing drought tolerant barley and durum lines continued with the Agricultural Research Institute (ARI). 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.

Earlier work on dual-purpose barley, agronomic studies, and selection techniques and methodology development for yield stability under rainfed conditions were summarized. 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 development of barley for very low rainfall grazing lands will continue.

Egypt

During 1986/87 the Program strengthened its collaborative effort with Egypt on screening for aphid resistance in the laboratory and field and for heat resistance in the field. Egyptian scientists screened over 5000 lines each for resistance to greenbug and the oat bird cherry aphid, finding greenbug resistance in wheat lines derived from US-developed Bushland/Amigo varieties. 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, initiating new projects on salt tolerance, and developing external funding for projects dealing with wheat and barley production in Egypt. In May ICARDA signed a Memorandum of Understanding with the Ministry of Agriculture and Land Reclamation to assist in implementing a 5 year USAID funded research and training project containing a cereals component emphasizing crop improvement, integrated pest management, socio-economic assessments, training, and on-farm trials. However, specific projects are still to be finalized. Several Egyptian scientists visited ICARDA and ICARDA scientists visited the Egyptian Cereal Program for program discussions.

Ethiopia

Ethiopia has the largest barley area in subsaharan Africa. The crop is grown on almost a million hectares in the highlands, with an average yield of about 1 t/ha and it is the second most important crop. During 1985/86 ICARDA trained scientists on breeding methods and use of landraces, and ICARDA scientists visited Ethiopia to give seminars and to provide assistance in developing breeding strategies.

The Program supplied barley, durum and bread wheat germplasm with drought tolerance and disease resistance for evaluation and use by the national program. Ethiopian scientists were trained in an in-country workshop in cereal pathology and barley breeding. Outside funding is sought in cooperation with Ethiopian scientists for strengthening research and production of barley. The foundation was laid to increase collaboration with Ethiopian scientists in a number of areas, including participation in the subregional network for aphid resistance screening with Egypt and Sudan.

India

An agreement between the Indian Council of Agricultural Research and ICARDA was signed during the season and germplasm exchange and visits of scientists increased.

Iran

Cooperative work with Iran continued. Cereal Program scientists visited Iran and several Iranian scientists visited Aleppo. Several junior scientists were trained in different disciplines. A new memorandum of understanding was signed with a detailed workplan for the period 1987/1990. Existing cooperation with the Seed and Plant Improvement Institute was expanded to include the Plant Pests and Disease Research Institute among others. The high altitude cereal research network in Iran was strengthened during the season.

Jordan

Jordanian scientists planted several international nurseries at dryland locations, and disease nurseries for net blotch, powdery mildew and leaf rust. Program pathologists will help take disease notes on germplasm lines in the Jordan Valley. ICARDA offered technical training for the National Center for Agricultural and Technology Transfer (NCARTT) in this year's specialized course. The Program supported Graduate Research work at University of Jordan, Amman.

Several scientists visited the Program during the season and a project entitled 'The Production of Barley as Forage in the 200-250 mm Rainfall Zone of the Jordan Highlands' was developed and proposed by Jordanian and ICARDA scientists for funding by USAID through the NCARTT. The Program assisted the Jordanian Highland Agricultural Development Project (HADP) and the National Center for Agricultural and Technology through research training, consultancies, germplasm and conferences. Collaborative research with Jordan University of Science and Technology (JUST) in dry areas continued and four research papers were jointly published.

Latin American Countries

Co-operation on barley research and production was achieved through the Mexico-based barley program, (CIMMYT/ICARDA).A number of yellow rust resistant lines with adaptation to the Andean region and increased yields were made available to the national programs. Short maturity and high yielding barley varieties have performed well in Mexico.

Lebanon

The Program continued to use Terbol Station as a higher-rainfall site and summer nursery. Yield trials, observation nurseries, segregating populations, crossing blocks, and disease screening nurseries for barley, durum wheat, and bread wheat were planted. Results from the station complemented those from Tel Hadya. The Program provided assistance and support to ARI, Tel Amara, in varietal improvement and seed production. In spite of difficulties in Lebanon, there is close cooperation between ICARDA, the Lebanese national program, the American University of Beirut, and the University of St. Joseph, Zahle.

The production of winter cereals only covers a very low percentage of home demands. One very important and relatively cheap crop production input is the high-quality seed. The Cereal Seed Production Project aims at (1) identifying superior varieties of cereals for release in Lebanon, and (2) producing breeder and basic seed of improved and commercial varieties of bread wheat, durum wheat and barley. During the first year of the project the durum wheat variety Belikh was identified and released by the Agricultural Research Institute. The project produced 9 tons of basic seed of Belikh, which is ready for distribution. In addition several tons of seed of commercial varieties were produced. One improved barley variety, Rihane 03 was identified as promising, which will be tested in the 1987-88 season on large scale in farmers' fields.

Morocco

The partnership between INRA-Morocco and ICARDA dates back to the fall of 1979 when the cereals program established a broad framework for its involvement in cereals improvement in Morocco with Dr. Faraj, Director of INRA and his cereal workers. Two reviews of the Cereal Improvement Program of Morocco were carried out, the first in 1982 and the second in 1986. Their recommendations have been published and were adopted by the Moroccan national program.

In September 1986 ICARDA posted a cereal scientist in Morocco. The major research objectives and priority tasks of the ICARDA-Morocco cooperative efforts are as follows:

1. Help INRA-Morocco with the planning and direction of research on wheat and barley, insure the continuation of research in progress while Moroccan scientists gain academic degrees.

2. Facilitate the transfer of research findings to farmers and develop a comprehensive scheme for the rapid testing of these findings as they evolve from the research programs.

3. Serve as a catalyst in bringing together national workers from the various agricultural research, training and extension institutes and coordinate their activities across areas of research.

4. Upgrade the research capabilities of the national program, and improve its access to research findings by worldwide research and its exploitation of the acquired information.

Rainfall received in the growing season 1986-1987 was the lowest of the past decade. However, this year of drought highlighted the outstanding quality of the germplasm supplied by ICARDA for stress conditions. At the dry sites of Jemaat-Shaim and Sidi Laidi, lines of ICARDA supplied germplasm were the only entries that managed to complete their life cycle and produce seed.

The first national Moroccan annual cereal program planning meeting was organized in October 1986. It involved cereal plant breeders, pathologists, agronomists, seed scientists and extension agronomists from INRA-Morocc, IAV-HII, DPV, ICARDA, MIAC, CIMMYT, as well several national research, extension and seed multiplication directorates. During the meeting data of the previous season was reviewed, workplans were developed for 1986-87 season and complementary research activities were outlined and agreed for implementation between the researchers. Four junior scientists were also trained at Aleppo and several Moroccan scientists visited ICARDA and participated in international conferences. Several ICARDA scientists participated in research activities during the season and in cooperation with national program scientists, several promising lines were identified: Barley varieties Harmal and Faiz were registered in the national varietal catalog. Barley varieties Harmal, Faiz and Rihane and durum wheat Korifla and bread wheat FLK/Hork: (Sham 4) were included in on-farm verification trials for low and moderate rainfall zones.

Other activities included a joint ICARDA/NARC(Japan)/INRA collecting trip in northern and northeastern Morocco for cereal germplasm and trips by ICARDA scientists to assess the impact of diseases and insect pests. Several junior scientists were trained at ICARDA. There was considerable exchange of visits, consultancies and discussions between ICARDA/CIMMYT and national program scientists.

Pakistan

Germplasm, consultancies, etc. were provided as in previous years. Technical backstopping was provided to the Quetta project. Detailed results on performance of cereal germplasm is provided in AZRI-Quetta Project report and in the high elevation cereals project.

Sudan

The OPEC fund provided financial support for the Pilot project on Verification and Adoption of Improved Production Practices (for wheat). The project strengthened the capabilities of the national research programs to verify research results under actual farming conditions through a system of on-farm trials with the full participation of farmers, extension and production personnel. On-farm trials and demonstrations in the major wheat producing areas in the Sudan were extended to new areas. Essential features of the project were described in the Cereal Improvement Program Report 1986.

The research program consists of:

1. Details on activities and accomplishments of the project are published as a separate report and can be obtained from the Cereals Program.

2. Large scale on-farm demonstration trials were carried out in Gezira Scheme, New Halfa Scheme as well as in the Northern region. In all the areas improved production packages resulted in significantly higher yields and economic analysis indicated that the effect of the packages on farmers' income was positive at all sites.

3. Researcher managed trials were conducted to determine the effect of irrigation methods on crop establishment and wheat yields, response of wheat to N, P, fertilizers and on-farm yield verification of new cultivars. Land preparation, sowing methods, seed rate and aphid control were also studied.

Dr. Musa B. Taha and Mr. Abdalla I. Mohamed spent 3 months as visiting scientists in the Cereal Improvement Program. Dr. Taha worked with Dr. Acevedo on wheat responses to heat and drought stress. He acquainted himself with methodology and equipment used in these studies. The skills he acquired will greatly help him in the development and execution of his future research programs. Mr. Abdalla I. Mohamed worked with Dr. Ferrara in the bread wheat breeding program, particularly in developing germplasm to heat stressed environments.

The second National Coordination Meeting for wheat research in the Sudan was held 20-22 July, 1987 at Wad Medani, Sudan to review the work done during 1986-87 season and to develop a workplan for 1987-88 cropping season. Twenty three research papers were presented and discussed over five sessions in two days.

The meeting was attended by research workers from ARC, Gezira University, Khartoum University, Regional and International Organizations which have agricultural activities in Sudan (USAID, Global 2000, ICARDA, CIMMYT), Ministry of Agriculture, Field and Extension staff from irrigated schemes, farmers from the Gezira scheme and the farmers' union.

Syria

The cooperative cereals (wheat and barley) on-farm trials, jointly conducted by the Syrian Ministry of Agriculture and Agrarian Reform (through ARC-Douma) and ICARDA's Cereal Improvement Program were carried out according to the work-plan jointly developed at the beginning of the season. These trials test a number of cereal lines proved to be promising in the research stations, in large plots in farmers' fields. The varieties tested come from the Syrian National Program and ICARDA. A report on the findings is available from the Program. In 1986/87, 33 wheat and barley variety verification trials were planted. Trial sites were selected to represent the major agricultural zones where cereal crops are grown. Bread and durum wheat were tested under irrigation, in Zone A (> 350 mm annual rainfall) and in zone B (250-350 mm annual rainfall). Barley was tested in Zones B and C (250 mm annual rainfall). Through this collaboration a number of varieties were released by the Syrian Variety Release Committee. Korifla, a durum wheat released as Sham 3 in 1987 for its superior yield, disease resistance and grain quality is the first variety released for Zone B. Douma 3966 was released as Bohouth 5 and the line Daki is doing well and ranked first in Zone A and B. The bread wheat variety, Bohouth 4 was released as Bohouth 4. The bread wheat line Seri 82 has done well for the third consecutive year for irrigated conditions. Grain quality characteristics and disease resistance were also better than Mexipak. The barley variety Furat 1113 was released as Furat 1 for Zone B. In Zone B the Barley lines Rihane 03 ranked first in grain yield followed distantly by the local check, Arabi Abiad. The line Furat 654 gave good yields. The lines WI 2291 and Tadmor performed better than the local check, Arabi Aswad in Zone C and showed more stability than other varieties.

Yield Trials, Segregating Populations, Crossing Blocks, and disease nurseries of wheat and barley from ICARDA were planted at a number of research stations in Syria. Joint planning, visits, and discussions were arranged by the ministry and ICARDA scientists and useful selections and crosses were made from these materials. Also several Syrian researchers participated in cereal residential and short term specialized courses. A barley scientist spent six months at ICARDA as a visiting scientist in the barley improvement project.

Tunisia

The Tunisia/ICARDA Cereal Project is a collaborative project between ICARDA and various institutes including the Institut National de la Recherche Agronomique de Tunisie (INRAT), and the Institut Agronomique de Tunisie (INAT) with participation of DAP of the Office des Cereales.

Total cereal production was estimated at 1.9 million t of which 1.07 million were durum wheat, 0.29 million were bread wheat and 0.54 million were barley. The national average yield this season was 21.9% higher for durum wheat than in the 1984/85 crop and 15.2% higher for barley. Average yield for the northern zone exceeded 2.0 t/ha. This is 15.9% above the 1984/85 average and is an all-time record.

The main highlight of this year was registration of three varieties for release: a durum wheat (Razzak), a bread wheat (Byrsa) and a barley (Rihane). Razzak yielded 10.0 tons/ha under large scale multiplication. The variety gives 6% yield advantage over the widely grown variety Karim, and has better lodging resistance, higher kernel weight and produces better seed even under stress. The release of this line indicates the competence level of the national program. Razzak was derived from a cross made in Tunisia and selected all the way by the national program. The bread wheat Byrsa, has good resistance to yellow rust and septoria leaf blotch which are the two major diseases of importance in Tunisia. It is also resistant to lodging which renders it suitable for the higher yield conditions. Over three years and at five stations, Byrsa outyielded Tanit by 112.6%. The barley variety Rihane continued to be superior to most genotypes across all locations. Rihane yielded 5.0 t/ha over five trials in dry areas compared to 4.2 and 4.4 tons/ha for Taj and Roho the newly released varieties. Rihane is also preferred by farmers as it is six rowed.

The on-farm verification/demonstration trials conducted by the DAP of Office des Cereales aimed at verifying results obtained from research stations in farmers' fields. Trials were conducted in eleven sites for variety performance, nitrogen response, seed rate and weed control. The superiority of the proposed varieties for release was confirmed on farmers' fields and results showed that on average 0.7 to 0.8 t/ha can be gained from weed control.

Pathology research including the evaluation breeding material of the three crops to prevalent diseases, a regional virulence survey to scald and net blotch diseases of barley, the screening of the durum world collection to septoria leaf blotch at seedling stage and a disease survey conducted for the first time across the entire country.

The survey of virulences included scald and net blotch samples collected from Algeria, Cyprus, Egypt, Morocco, Saudi Arabia, Syria, Tunisia and Turkey. The disease survey, although based on only a single year, showed that the most predominant barley diseases were net blotch, powdery mildew, covered smut and scald. The major wheat diseases were flag smut, septoria leaf blotch and leaf rust. A report on this survey was submitted to the FAO Plant Protection Bulletin for publication.

Support to various MSc. thesis research in INAT is also continuing on the following areas: minor gene resistance to net blotch, yield loss estimates to net blotch, scald and septoria, the genetic and environmental factors influencing yellow berry on durum wheat, the evaluation of crosses between local and high yielding varieties, and the use of tissue culture in durum breeding. This last item includes screening for regeneration ability among local and high yielding varieties and the study of the inheritance for initiation and regeneration ability.

For more details please refer to the Report of the Fifth Tunisia/ICARDA Coordination Meeting, September 1987.

Turkey

A symposium entitled "Problems and Prospects of Winter Cereals and Food Legumes Production in High Altitude Areas of West and Southeast Asia and North Africa" was held in July in Ankara. Its recommendations are available in the Program. In conjunction with this meeting, the 3rd annual coordination meeting between Turkish and ICARDA scientists was held to discuss research plans for 1987/88. A barley pathology travelling workshop visited western and north central Turkey in early May. Pathologists from North Africa, Egypt, and West Asia observed disease conditions in the field and discussed interregional collaboration. Seven Turkish researchers were trained in different disciplines. Turkey provided 5 ha of land in Ankara for screening ICARDA high elevation cereal germplasm and provided to ICARDA its cold tolerant germplasm.

Arab Republic of Yemen

Cooperation with the Agricultural Research Authority (ARA) of YAR was strengthened in 1987. In addition to the regular nurseries of wheat and barley, specific nurseries selected under stress conditions were provided to ARA. ICARDA offered short term consultancies in order to assist multilocation on-farm verification/demonstration trials in wheat and barley in Yemen's different agroclimatic zones. At the end of the 1987 season, two bread wheat lines were identified that could replace the variety Magrib 1 which has become susceptible to stem rust. The lines, Aziz (Seri 82) and Muhtar (Veery 7) are the best in on-farm trials in terms of biological yield and disease resistance and were released. ICARDA also offered training opportunities to ARA researchers and support staff in different cereal improvement desciplines.

Cooperation with Institutions Outside the Region

1. Evaluating Durum Wheat Germplasm for Drought Tolerance.

Collaboration between Cereal Improvement Program, ICARDA, and Agriculture Canada, Swift-Current, Canada

Based on 1984 single-replicate screening for excised-leaf water loss rate, 50 highest and 50 lowest lines without regard for any other traits were chosen. The lines were also grown in the 1985-86 season at three ICARDA sites in Syria (Tel Hadya, Breda, and Bouider). The purpose of the study was to assess the relationship between leaf water loss rate and yield under varying environmental conditions. Rate of leaf water use loss of the high and low loss groups was significantly different in 1985 and 1986, although means comparison tests revealed an overlap of the two groups. In the poorest sites, the low leaf water loss group out-yielded the high loss group, significantly. Relatively yield advantage of the low loss genotypes over the high loss group was clear, especially for low yielding sites where drought is the major limiting factor. Twenty crosses between genotypes from the ICARDA material and a high yield local durum line (DT369) were made in 1986. These parental lines were of interest for their high yield potential under dry growing conditions and for high and low rates of leaf water loss. Progeny from these crosses will be evaluated for physiological traits such as excised-leaf water loss and for yield in the 1988 growing season (F_4 generation). — J.M. Clarke, (Wheat physiology; Program Leader), S. Jana, University of Saskatchewan, J.P. Srivastava, M. Nachit, and B.H. Somaroo, ICARDA.

2. Screening Advanced ICARDA Wheat and Barley Lines for Barley Yellow Dwarf Virus (BYDV) Resistance.

Collaboration between ICARDA and Agriculture Canada, Saint-Foy, Canada. Funded by Agriculture Canada/IDRC

The project screens ICARDA's advanced wheat and barley germplasm for barley yellow dwarf virus (BYDV) resistance. Annually sets of Key Location Disease Nursery (KLDN) are sent to Quebec, Canada for screening for resistance to BYDV and results are made available to the cereal pathologists and breeders (see project report for details). — A. Comeau, Agriculture Canada, Canada, and K. Makkouk, ICARDA.

Cooperative Research between ICARDA, Laval University, Canada and Agriculture Canada

A collaborative project (Phase III) between ICARDA and Laval University/Agriculture Canada and supported by IDRC was initiated in 1987 with the main objective to support research on BYDV in North Africa (Tunisia and Morocco). A survey for BYDV incidence was carried out in both Tunisia and Morocco. Screening of cereal cultivars for BYDV resistance in these countries using artificial inoculation with aphids will start in 1988. During the summer of 1987, trainees from Tunisia, Mr. Rida Shgari, and a trainee from Morocco, Mr. Kacem El-Kacemi, spent six week at ICARDA virology lab to learn more about serological detection of BYDV. K. Makkouk, ICARDA.

3. Collection, Evaluation and Conservation of Barley and Durum Wheat and Their Wild Relatives

Collaboration between Cereal *Improvement Program*, ICARDA, and the University of Saskatchewan, Canada.

Germplasm is being evaluated for a variety of characters at ICARDA, the University of Saskatchewan, Canada and Jordan Universitsy of Science and Technology. -- S. Jana, University of Saskatchewan, Canada, A. Jaradat, JUST University, Jordan, and J.P. Srivastava, Cereal Improvement Program, ICARDA.

4. Grain Quality and Local Product Evaluation of Barley and Durum Wheat

Collaboration between, ICARDA, and Canadian Grain Commision, Winnipeg, Canada.

Collaborative work continues on evaluating barley, durum wheat and bread wheat for cereal grain quality and local food processing. (For details see the grain quality section of the report). Consultancy for Dr. P.C. Williams is financed by CIDA. -- P. Williams, Canadian Grain Commision, Canada, and J.P. Srivastava, Cereal Improvement Program, ICARDA.

5. Use of Haploid Breeding Technique in Cereal Improvement Using Anther Culture.

Collaborative project between Cereal Program and 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 in barley and wheat and test their suitability (using anther culture) as 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. -- E. Picard, University of Paris South, France. M. Tahir, J.P. Srivastava, Cereal Improvement Program, ICARDA.

6. Decline in Cereal Yield in Continuous Cropping System

Collaboration between ICARDA, and University of Bonn, Federal Republic of Germany. Funded by GTZ

This project is designed to study probable causes of the reduction in yield when cereals are grown continuously. Traditionally, most cereals are grown in rotation with fallow, but in recent years farming practices have intensified and many farmers have discarded the fallow in favour of continuous cereal production. The result has been a decline in cereal yields.

The project includes study of the incidence and significance of cereal root diseases in northern Syria, and their control by crop rotation, especially the inclusion of a legume pasture or forage phase. The project is conducted in collaboration with the University of Bonn. S. Krause, University of Bonn, Federal Republic of Germany, H. Harris, P. Cocks and O.F. Mamluk, ICARDA.

7. Yield Physiology of Durum Wheat

Collaboration between Cereal Improvement Program, ICARDA, and 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 photoperiodic insensitivity, to determine the linkage between photoperiodic insensitivity and thermosensitivity (vernalization requirement), to understand plant reaction during different developmental stages on changing photoperiodism, to study the inheritance of photoperiodic insensitivity, and to compare phototrials with field trials. Preliminary results show that genotypes differ in their sensitivity to photoperiod. Some genotypes were insensitive until the double ridge stage, but then required sensitivity. Others were insensitive during the whole development phase. P. Ruckenbauer, University of Hohenheim, Federal Republic of Germany, and M. Nachit, ICARDA/CIMMYT.

8. Improving Yield and Yield Stability of Barley in Stress Environments

Collaboration between the Cereal Improvement Program, ICARDA, and University of Perugia, Italy and Experimental Institute for Cereal Research, Ministry of Agriculture, Catania, Italy. Funded by Government of Italy.

The objectives of the 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 the performance of pure lines compared with mixtures of pure lines over a variety of different environments, 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 for seedling root characteristics, and to utilize H. spontaneum in crosses with lines selected from landraces as well as improved cultivars. The project has access to the facilities of Centro Appenninico "C. Jueei" (University of Perugia) Terminillo to screen for cold tolerance and disease resistance and to the facilities of Catania for mild winter and dry conditions. P. Rudi, and A. Grillo, Univ. Perugia, Dr. G. Boggini, Ministry of Agriculture, Catania, Dr. S. Grando and Dr. S. Ceccarelli, ICARDA.

9. Evaluation and Documentation of Durum Wheat Germplasm

Collaboration between Cereal Improvement Program, Genetic Resources Program, ICARDA, and University of Tuscia, Viterbo, Germplasm Institute, Bari and ENEA, Rome, Italy.

The project was initiated in 1985/86. The major objectives were to evaluate durum wheat germplasm at ICARDA utilizing a multilocation approach, to document, utilize and disseminate information and germplasm of these genetic resources for the use of breeders and other scientists, and to identify and test selected germplasm in cooperation with national programs in other countries to confirm results.

The 29 agronomic, morphological, physiological, electrophoretical as well as grain quality characters not only take into consideration the present requirements of the breeders but are also aimed at providing useful data for future plant development goals.

The project has already evaluated "in depth" about 13,200 accessions from the ICARDA world collection of durum wheat and has now reached a stage where a number of landraces have been identified that possess positive attributes for economically important characteristics including good food processing qualities, and tolerance to low rainfall conditions and certain diseases. These lines have been made available to breeders and other scientists for further testing and subsequent inclusion in their crossing blocks. A network of co-operators for the evaluation of trait-specific selected germplasms in their respective countries at different eco-geographical zones has been finalized. The network is already operating in seven countries of the region. The pooled information received from the evaluators will be provided to interested scientists. The project also provides opportunities for national program trainees in wheat germplasm evaluation. -- J.P. Srivastava, B.H. Somaroo, A.B. Damania, ICARDA and E. Porceddu, Institute of Agricultural Biology, Univ. of Tuscia, Vitero, Italy.

10. Eco-Physiological Studies on Improvement of High-Yielding Wheat Varieties

Collaboration between Tropical Agricultural Research Centre, TARC, Japan and ICARDA.

The Project was started in 1985 by Dr. T. Hoshino and the haploid breeding of wheat using H. bulbosum undertaken by Mr. N. Ishikawa is reported in the High Elevation Cereal Research Section in this report. A memorandum of understanding for the implementation of the cooperative research project (1986/1990) between ICARDA and TARC was signed.

The project aims to improve high-yielding wheat varieties based on eco-physiological studies in the rainfed drylands so as to target the response of wheat varieties to environmental stresses.

Within the framework of the project, two series of experiments are scheduled to be carried out during 1986-1990 as follows:

1. Eco-physiological studies on improvement of high-yielding wheat varieties: The growth performance of leading wheat cultivars including promising breeding lines will be evaluated, mainly from the viewpoint of primordia development in order to breed new cultivars with early maturity to avoid frost damage.

2. Haploid breeding of wheat using H. bulbosum: The ability to cross wheat cultivars and different ecotypes of H. bulbosum will be evaluated in order to genetically fix promising lines of wheat at early generations by haploid breeding.

M. Inagaki, N. Kawada, TARC, M. Tahir, J.P. Srivastava, Cereal Improvement Program, ICARDA.

11. Screening for Resistance to Yellow Rust, Septoria, Scald, and Powdery Mildew

Collaboration between Cereal Improvement Program, ICARDA, and ENMP, Elvas, Portugal. Funded by Government of Portugal.

Collaboration in cereal pathology with ENMP in Elvas continued to be of great value as ENMP provided excellent data on yellow rust, leaf rust scald, and septoria tritici blotch. Results of the the virulences of leaf rust samples from the region were furnished which is very important for the region. M.J. Concalves spent two weeks in ICARDA and ICARDA scientists visited BNMP, Elvas. -- E. Barradas, M.J. Concalves, ENMP, Portugal, and O.F. Mamluk, J.v. Leur, Cereal Improvement Program, ICARDA.

12. Barley Stress Physiology

Collaboration between Cereal Improvement Program, ICARDA, and University of Cordoba, and INIA, Spain. Funded by Government of Spain.

The Cereal Improvement Program and Spain are collaborating in cereal physiology focused on cereal breeding. Emphasis is being given investigating crop physiological attributes and plant traits of potential usefulness of barley breeding for low rainfall Mediterranean areas. Results are included in the Cereals Physiology/Agronomy report of this season. Spain provides financial support to two students. An International Symposium on Improving Winter Cereals under Temperature and Salinity was jointly organized at Cordoba, Spain, 26-29 Oct. 1987. -- E. Fereres, ITSIA, University of Cordoba, A. Royo, Servicio Investigacion Agraria D.G.A. Zaragoza, Spain, and E. Acevedo, Cereal Improvement Program, ICARDA.

13. Genotype Characterization in Barley

Collaboration between Cereal Improvement Program, ICARDA, and the Plant Breeding Institute, Cambridge, U.K. Funded by ODA.

Results of the first year of this project were presented at the International Symposium on Improving Winter Cereals under Temperature and Salinity Stresses. Cordoba 26-29 October 1987.

Analysis of C-13 descrimination of barley grains of selected entries of the Barley Physiology Nursery through this project revealed a close relation between C-13 analysis and yield under drought. The technique is being further evaluated for screening purposes. -- R.B. Austin, PBI, Cambridge, U.K. and E. Acevedo, Cereal Improvement Program, ICARDA.

14. Development of a Metabolic Index of Drought Stress in Barley and Durum Wheat

Collaboration between Cereal Improvement Program, ICARDA and University College London, U.K. Funded by ODA.

This project was terminated during the 1986/87 season. The final report is available in the Program. -- G.R. Stewart, J. Pearson, University College London, U.K. and E. Acevedo, I. Naji, Cereal Improvement Program, ICARDA.

15. Barley and Wheat Variety Root Study

Collaboration between ICARDA and University of Reading, U.K. Funded by ODA.

The results of this project are being analysed and will be reported as soon as available. -- P. Gregory, S. Brown, University of Reading, U.K. and H. Harris, E. Acevedo, S. Ceccarelli, ICARDA.

16. Photothermal Responses of Barley

Collaboration between Cereal Improvement Program, ICARDA and University of Reading, U.K. Funded by ODA.

Ten contrasting genotypes in terms of photothermal responses are being grown in controlled cabinets to investigate their flowering responses to daylength and temperature.

The photoperiod limits to long-day responses, photoperiod-insensitive phases, effects of low temperature and short-day vernalization, as well as the rate of development as a function of temperature and photoperiod and its modification by low-temperature vernalization have been reported.

The results suggest that there is a linear relation between photoperiod and the reciprocal of the time taken to flower (awn emergence) between the critical photoperiod and the ceiling photoperiod.

All genotypes were initially insensitive to long days. This was followed by an inductive phase depended on photoperiod. Finally, there was a photoperiod-insensitive, post-inductive phase, which probably began about two weeks before awn emergence.

The low-temperature seed-vernalization considerably hastened awn emergence in Arabi Abiad and in Ager. In Arabi Abiad low-temperature vernalization could be partially replaced by treating young plants with short days (8 or 10 h). Both low temperature and short-day vernalization advanced flowering by advancing ear initiation (reducing the duration of the preinductive phase). whereas long days stimulated the rate of development following ear initiation. — E.H. Roberts, R.J. Summerfield, J.P. Cooper, University of Reading, U.K. and E. Acevedo, S. Ceccarelli, Cereal Improvement Program, ICARDA.

17. Research and Training on Barley Diseases and Associated Breeding Methodologies

Collaboration between Cereal Improvement Program, ICARDA, and Montana State University (MSU), USA. Funded by Science and Technology Bureau, USAID, USA.

The project studies the major barley diseases in developing countries, particularly in the ICARDA region. The overriding objective is to incorporate disease resistance into adapted, high yielding barley cultivars through national, university, and international research program cooperation. Major and minor gene resistance sources will be collected and studied. An equally important objective is to upgrade the national research capabilities of developing countries through long-and short-term training, graduate degree (MSc) training, and through seminars and workshops in pathology and plant breeding methodologies. Selected laboratories in some countries are being encouraged to assume a leadership role for specific diseases in their own and neighbouring countries.

This year a barley pathology travelling workshop from the regional countries was held in Turkey in May. In addition, a survey of mycorrhizae to determine their beneficial effects in drought prone areas was initiated. A barley workshop for Sub-Saharan Africa was held in Ethiopia in October of 1987. — D. Sands, W. Grey, M. Biarko, Montana State University (MSU), USA and O.F. Mamluk, J.v. Leur, Cereal Improvement Program, ICARDA.

18. Collaborative Interdisciplinary Research and Training Program to Enhance Germplasm of Selected Cereal 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 LDCs. The project maintains a strong relevant graduate training program at OSU. — W. Krosted, P. Hayes, Oregon State University and J.P. Srivastava, M. Tahir, Cereal Improvement Program, ICARDA.

19. ICARDA-CIMMYT Joint Projects on Wheat and Barley Improvement

Collaboration between Cereal Improvement Program, ICARDA, and Wheat Program, CIMMYT, Mexico.

Provisions of the agreement between two centers provide for the following: ICARDA receives the services of a bread wheat breeder and a durum wheat breeder, seconded from CIMMYT, together with the sum of US$ 180,000 to cover part of their operating costs. A similar arrangement has been made with CIMMYT for barley, whereby ICARDA stations a barley breeder in Mexico and provides US$ 100,000 towards the operating expenses of the CIMMYT-based barley program. A separate agreement has been signed to permit a CIMMYT breeder to work on triticale in North Africa (Morocco) with ICARDA providing backstopping. J.P. Srivastava, ICARDA and B. Curtis CIMMYT.

Conferences and Meetings

Workshop on Plant Parasitic Nematodes in Cereal and Legumes Crops in Temperate Semi-Arid Regions, Larnaca, Cyprus, March 1-5, 1987.

The Conference recommended that ICARDA must be able to respond to present and future nematological problems that have, or could, arise as agriculture intensifies and new cropping systems are introduced. The need for information and advice expressed by nematologists in the region could be satisfied by an effective ICARDA nematological system giving guidance and support to national research.

Barley Diseases Travelling Workshop, Turkey, May 10-15, 1987.

A travelling workshop was organized jointly by the Turkish National Program and ICARDA to enable pathologists and breeders to discuss barley diseases and appropriate control measures. Eleven researchers from different institutions in Turkey and nine from other national programs, ICARDA and Montana State University participated in the Workshop. The group visited the research stations of Izmir, Eskishehir and Haymana and a large seed production farm at Altinova. The workshop was considered to be very useful both by the Turkish participants, for whom it was the first opportunity to share their research results with other national program's representatives, and by the non-Turkish participants. Discussion centered around ways to improve the contacts between national programs and those between national programs and ICARDA.

International Symposium on Problems and Prospects of Winter Cereals and Food Legumes Production in High Elevation Areas of West Asia and North Africa, Ankara, Turkey, July 6-10, 1987.

The Symposium was jointly sponsored by the Ministry for Agriculture, Forestry and Rural Affairs, Ankara, Turkey and the objectives of this Symposium were: to characterize the agro-ecological conditions of the high altitude regions; to identify the major physical, biological and socio-economic constraints to production; to review the present status of research and research infra-structure related to high elevation areas; to suggest a set of recommendations for researchers and policy makers for the future development of these areas; and to develop an action plan and functional network at national and international level. The Conference was very well attended by representatives of the national programs, international centers and other institutions. Recommendations of this Conference are available and proceedings of the Symposium will be published.

Durum Germplasm Evaluation Consultation Meeting, Viterbo, Italy, July 27-29, 1987.

In order that the breeders in national programs have immediate access to evaluated trait-specific germplasm and to improve utilization of available information, ICARDA together with the University of Tuscia, Viterbo, Italy convened a meeting of a small group of scientists. The objectives of this meeting were: a) to review the work done by the project on Evaluation and Documentation of Durum Wheat Germplasm at ICARDA and Viterbo, b) to discuss constraints to evaluation, documentation and utilization of germplasm, and c) to study the feasibility of developing a workplan for undertaking evaluation of selected germplasm in a network comprising different countries with diverse locations. Scientists from Ethiopia, India, Kenya, Pakistan, Tunisia, Turkey and Italy were invited to the meeting. The summary, recommendations and minutes of the meeting are available from the Program.

International Symposium on Improving Winter Cereals under Temperature and Salinity Stresses, Cordoba, Spain, October 26-29, 1987

This Symposium was jointly organized by Spain and ICARDA and was held in Cordoba, Spain during October 26-29, 1987. The objective of the seminar was to encourage a dialogue between agroclimatologists, agronomists, plant breeders and physiologists in an effort to promote understanding between disciplines so that research results available could be effectively utilized to increase the yield and yield stability in stress prone areas. The meeting was very well attended by leading international scientists from all the Continents. Proceedings of the Symposium are being published.

The following Annual Coordination Meetings were organized with the National Programs to review the 1986/87 collaborative research activities and to plan for the 1987/88 workplan

- 3rd Annual Coordination Meeting held on July 10, 1987 between the Ministry of Agriculture, Forestry and Rural Affairs, Turkey and ICARDA.

- Cereal Annual Coordination Meeting in Sudan, July 22-23, 1987.

- Cereal Program Coordination Meeting in Tunis, September 17-19, 1987.

- Cereal Project Coordination Meeting in Algeria, September 21-23, 1987.

- Cereal Program Coordination Meeting in Morocco, October 22-23, 1987.

- 6th Annual Coordination Meeting in Aleppo between SMAAR and ICARDA, October 3-6, 1987.

Visits

During 1986/87 season around 135 scientists visited the Program from 39 countries. Program 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 of the Program scientists visited research centres in the advanced institutions.

Information Exchange

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 System

The international nurseries system has three objectives:

1. To distribute improved barley and wheat germplasm to the 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 1986/87 great effort was spent on achieving the second objective as more national programs have increased their competence in wheat and barley breeding. It was the first season that cooperators were invited to nominate their best lines for testing in the system. In the observation nurseries distributed in 1987 there were 27 entries nominated by national scientists.

Types, Numbers and Distribution of Nurseries

With the subdivision of the Regional Bread Wheat Yield Trial into two nurseries, tailoring germplasm for the three major environmental zones in the ICARDA region, namely low rainfall areas, moderate rainfall areas (both in the lowland), and high altitude areas, was completed in 1987. The types and names of the nurseries distributed in 1987/ are given in Table 118.

In addition to the yield trials, observation nurseries, segregating populations and crossing blocks (sent over the last nine seasons), a new type of nursery called the trait specific nursery was initiated for the 86/87 season in response to the gradual improvement in the ability of the national programs. The first nursery of this type was the Heat Tolerance Observation Nursery created in 1986.

In 1987, 1440 sets of international nurseries were assembled and distributed from Aleppo to 120 cooperators in 49 countries. 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 67% 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%, 28% and 32% of the overall total, respectively. Detailed information on distribution of nurseries for 86/87 can be found in the booklet "International Cereal Nurseries 1986/87 List of Cooperators and Distribution of Nurseries" which is available from the Cereals Program.

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Table 118. ICARDA's Cereal International Nurseries distributed in 1987.

Nursery	Barley	Durum Wheat	Bread Wheat
Crossing Block	*	*	*
Segregating Populations			
- LRA	*	-	-
- MRA	*	-	-
- HAA	*	*	*
- Lowland	-	*	*
Observation Nursery			
- LRA	*	*	*
- MRA	*	*	*
- HAA	*	*	*
Yield Trial			
- low rainfall areas (LRA)[1]	*	*	*
- Moderate rainfall area (MRA)[1]	*	*	*
- High altitude areas (HAA)	*	*	*
Heat Tolerance Observation Nursery[2]	*	*	*
Key Location Disease Screening Nursery	*	*	*
Specific Trait Nurseries	*	*	*

1 LRA & MRA are for the lowland.
2 3 crops included into the same nursery.

Figure 36 shows that the demand of international nurseries by national programs continued to increase over the years. There was an increase in the number of sets of nurseries distributed to national scientists in 1986. This was due to the poor growing conditions in 83/84 and 84/85 which decreased seed production and prevented the Cereals Program from meeting all seed requests from the national scientists. However, 85/86 was a favourable cropping season. In 1986 six nurseries for high altitude areas were included in the system and the Heat Tolerance Observation Nursery was created.

In addition to regular nurseries, key location disease screening nurseries, and aphid tolerance screening nurseries, specific trait lines were provided to scientists on specific requests. In general there is an increase in efforts to provide specific need germplasm and genetic stocks to the national programs as well as targetted segregating populations, and a decrease in the finished or semi-finished lines.

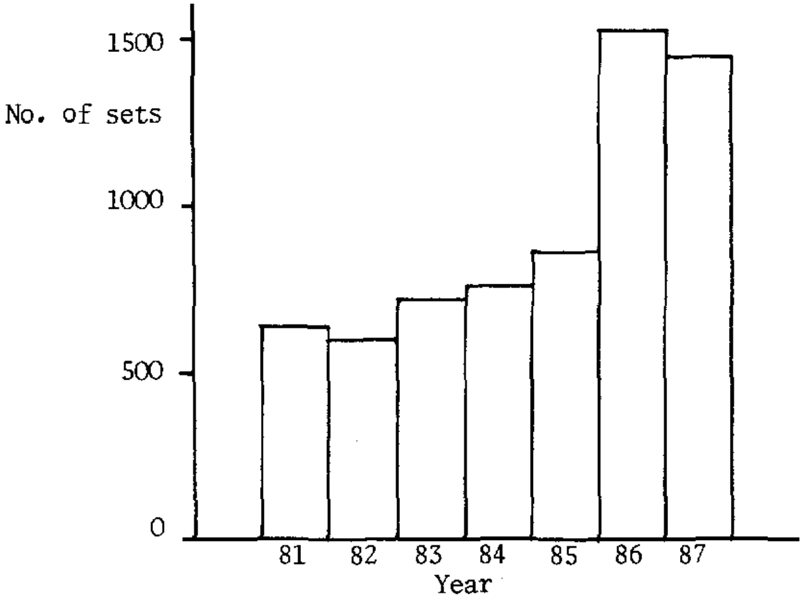


Figure 36. Number of sets of international cereal nurseries distributed to national programs from Aleppo since 1981.

Data Collection, Analysis and Report

The proportion of field books returned from cooperators continued to rise and reached a record level for the 85/86 nurseries: 59% for observation nurseries and 67% for yield trials. This was achieved as more effort was exerted in encouraging cooperators to return their data and as a result of improvements in reporting data over the last three seasons.

In 1986 a decision was taken to stop the production of the preliminary nursery report but to produce the annual report earlier. This decision was made as it was found impossible to deliver a resonable amount of data to cooperators in the few months between harvesting and the next planting. A new service was initiated instead. Upon receipt of the yield trials field books from cooperators, data were immediately analyzed and results in the form of computer print-outs were returned to allow cooperators make a more critical decision on the germplasm as soon as possible.

The annual nurseries reports for the 1985/86 barley, durum wheat and bread wheat international nurseries were distributed to cooperators in July 1987. The annual reports were more detailed and informative, but still retained the best features of the previous reports. New analysis and information that had been incorporated into the 1985/86 reports were:

1) Similarity of the trial sites and entries obtained by the cluster analysis.
2) Stability of the genotypes provided by the regresssion technique.
3) The mean relative yield and standard deviation of each entry in each geographical region or cluster of locations.

Classification of Trial Sites

It is desirable that useful information can be extracted from previous results of the international nurseries to guide ICARDA's breeders target their germplasm more precisely in the future. The first major attempt to achieve this objective was initiated in 1986/87 and a statistical approach using the multivariate cluster analysis was chosen. Cluster analysis is an empirical technique for grouping objects into clusters, so that objects within the same cluster are relatively homogeneous and objects between clusters are relatively heterogeneous. The objective of this study is to delineate trials sites into a reasonable number of clusters based on the differential yield responses of the entries across sites. If the composition of the clusters are stable, breeders may consider developing specific germplasm for each cluster.

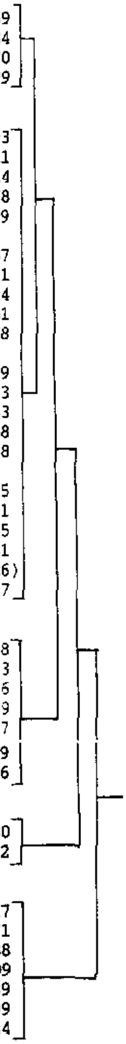
The BMDP 1M hierarchical and agglomerative program employing the options of correlation as a distance measure and average linkage as clustering strategy was used on grain yield data of the 23 genotypes (the national check excluded) in each yield trial. So far, data of the 1985/86 yield trials have been analyzed. Results were given in the annual reports for ICARDA's cereal international nurseries for 1985/86, which are available from the Cereals Program.

For demonstration, results of the Regional Bread Wheat Yield Trial which has been studied in more detail, will be briefly presented here. Table 119 gives the names of the 40 trial sites and of the countries, their latitudes, elevation, rainfall, amount and number of irrigation, and mean trial yield. Five clusters of trials were formed. Cluster I and II were the most similar, and cluster V was the most distinct from the first four clusters. Trial mean yield per se and proximity between locations were not the underlying factors causing the clusters to form. Upon closer examination, it could be seen that the first two clusters included sites with full irrigation, high rainfall or stored water, while the last three clusters included trials with low to moderate rainfall or supplementary irrigation. Sites in cluster II were all below 32-33 ^{o}N or near the coast. Contrarily, clusters III, IV and V contained sites above 32 ^{o}N, except 3 high altitude sites. Thus besides moisture supply, temperature was also a determinant of the clusters.

S.K. Yau

Table 119. Grouping of 40 trials in the 85/86 Regional Bread Wheat Yield Trials by cluster analysis.

Country	Location	Lat.	Elev. (m)	Rain (mm)		Irrigation (no)	Irrigation (mm)	Yield (kg/ha)
Group I:								
Afghanistan	Darul Aman (Kabul)	34.27 N	1825	294		6	*	2859
Iran	Karaj	35.50 N	1300	350		5	500	7634
Lebanon	Ta'anayel (Zahle)	33.48 N	880	501		0	0	6270
Saudi Arabia	Hail	27.31 N	>500	na		*	*	3809
Group II:								
Afghanistan	Shesham Bagh Stn (Jalalabad)	34.25 N	552	na	N	6	*	7093
Saudi Arabia	Riyadh	24.41 N	>500	na	H	*	*	4711
Pakistan	Bhawalapur	29.25 N	170	6	L	3	250	3124
Egypt	Sakha	31.07 N	20	59	N	*	*	5178
Turkey	Izmir	38.35 N	20	na		0	0	4399
Pakistan	Islamabad	33.39 N	683	494		0	0	3657
Pakistan	Chakwal	32.56 N	>500	153		0	0	5011
Egypt	Sids	29.04 N	30	40		6	500	4614
Greece	Thessaloniki	40.38 N	10	353		1	25	4851
Saudi Arabia	Dirab (Riyadh)	24.25 N	635	na	N	*	*	5768
Saudi Arabia	Kharj	24.10 N	430	na		*	*	3569
Jordan	Deir Allah	32.12 N	-224	236	N	6	*	4693
Turkey	Sakarya	40.44 N	33	459	N	0	0	4753
Saudi Arabia	Onaizah Stn (Al Gassim)	26.04 N	724	na		16	*	6658
France	Le Rheu	48.04 N	40	250	N	0	0	5748
Turkey	Samsun	41.18 N	10	700	N	0	0	3015
Egypt	Gemmeiza	30.43 N	20	na	L	6	500	5561
Pakistan	Faisalabad	31.30 N	213	41	L	1	100	3585
Pakistan	Tandojam (Sind)	25.00 N	19	na	L	6	*	5161
(Mexico	Ciudad Obregon (Sonora)	27.20 N	38	23	N	2	200	3126)
Sudan	Gezira Stn (Wad Medani)	14.24 N	408	na		8	*	1317
Group III:								
Algeria	Setif	36.90 N	1000	313	L	0	0	1528
Yemen, A.R.	Taiz	13.42 N	1350	183	L	7	*	3733
Ethiopia	Ambo	8.58 N	2225	na		0	0	2976
Portugal	Alentejo Stn (Elvas)	38.54 N	208	330	L	0	0	2849
Spain	Badajoz (Finca la Orden)	38.49 N	200	248	L	0	0	2287
Syria	Tel Hadya, rainfed	36.05 N	282	322	N	0	0	4429
Syria	Tel Hadya, early planting	36.05 N	282	326	N	2	100	2966
Group IV:								
Jordan	Maru	32.33 N	618	330		0	0	2030
Turkey	Diyarbakir	37.55 N	600	434		0	0	6762
Group V:								
Cyprus	Athalassa Stn (Nicosia)	35.08 N	150	198	L	0	0	2117
Lebanon	Terbol Stn (Beka'a Valley)	33.52 N	890	396		1	50	6671
Spain	El Encin Stn (Madrid)	40.29 N	600	294	N	0	0	3938
Iraq	Hamman Al-Alile Stn (Mosul)	36.91 N	320	252	L	0	0	1109
Syria	Breda	35.55 N	350	218	L	0	0	1289
Lebanon	Tel Amara (Beka'a Valley)	33.55 N	950	395		0	0	3499
Pakistan	Sariab (Quetta)	30.15 N	1675	na	L	3	*	2344



na - not available
* - irrigation applied but amount and no. of application not known
N - normal; H - high; L - low

6. Cereal Training

Lack of trained personnel is still a major constraint to research progress in many countries of the ICARDA region. The Cereal Improvement Program devotes therefore an important part of its efforts to training. The objective is to help national agricultural research institutions improve the skills of junior and senior researchers working on barley and rainfed wheat. These researchers will ultimately assume greater responsibilites in germplasm development and training and will contribute to the progress of cereal production in their countries.

In addition, there is great diversity among countries for the type and number of trained staff needed in cereal research. The Cereal Improvement Program is adapting its training to the evolving needs of the various national programs (Table 120).

In the 1986-87 season, ICARDA cereal scientists trained over 150 national program participants in specialized short courses, individual non-degree or graduate research training, in-country and residential courses. In addition, scientists from the region visited the program for various periods.

A. Short Courses

Four specialized intensive courses were offered in 1986-87 in response to requests from national programs. These courses were much appreciated by the participants for their short duration, topic specificity and the diversity of scientists involved.

Barley Improvement

This was the first specialized course on barley improvement offered at ICARDA headquarters, Tel Hadya, Syria. Five barley researchers one each from Algeria, Egypt, Ethiopia, Morocco and Syria, participated in the course from 1 - 12 March 1987. The course focused on breeding techniques and methodologies, agronomic principles and cultural practices, and control of diseases and insect pests. In addition, classroom lectures, laboratory sessions were offered and field visits were made to barley selection sites at Breda and Bouider. The small number of trainees enabled them to participate in all parts of the course, and to discuss barley research problems in their countries with ICARDA scientists.

Cereal Landraces and Wild Relatives

Eleven participants from Algeria, Ethiopia, India, Iran, Jordan, Morocco, Pakistan, Syria and Tunisia attended a two-week training course on cereal landraces and wild relatives from 10 - 21 May 1987 at ICARDA, Tel Hadya, Syria. The course focused on the evaluation and utilization of cereal landraces and wild relatives for the genetic improvement of cultivated barley and wheat species. Course topics were: principles and methods of characterization and evaluation, electrophoretic techniques, data compilation and management, advantages and limitations in the use of landraces and wild relatives for the genetic improvement of cultivated barley and wheat species. In addition to attending classroom lectures, the participants observed cereal germplasm at several testing sites in Tel Hadya, Hegla, Breda and Bouider and collected wild cereal species within Aleppo province.

Table 120. Number of participants in various cereal training courses.

Year	Type of Training				
	Residential	Short	In-Country	Individual	
				Non-degree	degree
1979	19	25	-	3	-
1980	16	-	-	-	-
1981	12	16	-	3	-
1982	10	35	24	2	-
1983	18	-	-	3	-
1984	8	36	20	7	2
1985	15	49	47	8	4
1986	18	15	44	14	4
1987	12	29	88	17	8

Cereal Disease Methodology

Six participants one each from Algeria, Ethiopia, Greece, Jordan, Morocco and Syria attended a 2-week intensive training course on cereal disease methodology from 1 - 15 April 1987 at ICARDA, Tel Hadya, Syria. The major objective of the course was to improve the knowledge of the trainees in cereal pathology with a particular emphasis on the use of laboratory and field techniques. The course covered the following topics: techniques of collection, isolation and preservation of disease inoculum, procedures of inoculation, disease identification and scoring, and disease data analysis. Disease screening nurseries at Tel Hadya were visited for demonstration and actual screening and a one-day visit was made to a disease prone testing site in Lattakia.

Statistical Data Analysis

A Two-week intensive course on statistical data analysis was conducted at ICARDA, Tel Hadya, 1 - 14 February 1987. Seven participants from the Cereal and Food Legume Programs in Algeria and Syria attended the course. The topics included: CR and RCB designs, split-plot, latin square, and augmented design lattice design, combined analysis of a series of experiments, stability, and cluster analysis.

B. Individual Non-degree Training

Individual non-degree training was offered to researchers and technicians from national programs to update them on specific research techniques or methodologies. In response to increased demands from national programs for this type of training, seventeen participants from 10 countries were trained for a period of 1 week to 2 months on various research topics (Table 121).

Table 121. Specialized non-degree individual training at the Cereal Improvement Program, ICARDA 1987.

Subject	Duration	Country
Breeding techniques	4 weeks	Sudan
Wide crosses and cytogenetics	3 weeks	Turkey
Durum wheat breeding	3 weeks	Jordan
Barley breeding	1 month	India
Barley diseases	2 weeks	Tunisia
Cereal diseases	2 weeks	Iran
Germplasm evaluation	1 week	India
Cereal grain quality	2 weeks	Syria
Cereal grain quality	2 weeks	Morocco
Cereal entomology	6 weeks	Sudan
Cereal entomology	4 weeks	Syria
Cereal physiology	1 month	Turkey
Cereal physiology	2 weeks	Syria
Cereal physiology	2 months	Netherlands
Cereal breeding	1 week	Lebanon
Techniques in cereal improvement	1 month	Syria
Farm machinery	2 weeks	Yemen AR

C. Graduate Research Training

ICARDA scientists, in collaboration with university professors, provide supervision for M.Sc and Ph.D candidates. Frequently the student does all or part of his research work at ICARDA.

Graduate students supported by the program are indicated in Table 122. Four other students (three from Syria and one from the Netherlands) have been accepted to start their research work at ICARDA during the 1987-88 season. In addition, 12 B.Sc. students from Aleppo University received practical training on barley and wheat diseases and 6 students were trained on agronomic scoring and selection in wheat as part of their graduation projects.

D. In-country Courses

Algeria

An in-country training course was conducted in 3 phases at ITGC research station Sidi Bel Abbas, Algeria. The general theme of the course was "Cereal and Food Legume Improvement." Part I (25-29 OCT. 1986) focused on farm machinery, soil preparation, field plot techniques, sowing, seed production, and on-farm testing and demonstration. Thirty seven trainees participated in the course, including research technicians and farm managers. Instructors were four scientists from ITGC and four from ICARDA.

Part II (21-25 March 1987) dealt with growth and development of cereal and legume crops, diseases and insects, and weed control. Practical and field activities covered about half of the schedule. Field visits were made to demonstrate important crop growth problems and discuss related topics. The limited number of trainees (18) as compared to Part I made the practical sessions more useful to the participants. Seven scientists from ITGC and five from ICARDA delivered the course.

Part III (27 June - 1 July 1987) was designed for the technical staff involved in the implementation of cereal and food legume on-farm trials conducted by ITGC. The course focused on statistical analysis of data and interpretation of results. Crop losses during harvest were also discussed. The participants included ten trainees from ITGC and two instructors from ICARDA.

Ethiopia

Twenty three cereal researchers from 6 research centers in Ethiopia participated in an in-country training course on "barley improvement" which was jointly organized by the Institute of Agricultural Research (IAR), Ethiopia, and ICARDA. The course took place 9-14 October 1987 at Holetta Research Center, Ethiopia. Six scientists from IAR and three from ICARDA delivered lectures on genetics, breeding, diseases and insect pests, agronomy and cultural practices, on-farm trials, field plot techniques, and data analysis and interpretation. In addition, one full day was spent in the research and on-farm fields to demonstrate to the trainees the different aspects of barley improvement discussed in the lectures. The course was highly rated by Ethiopian trainees and scientists.

E. Residential Course

Twelve trainees from 7 countries (Table 123) attended the residential training course at Tel Hadya Syria from 1 March through 18 June 1987. Three participants from Syria were financially supported by AOAD.

As in the previous season, the trainees attended lectures and participated in practical lab and field sessions. Practical activities covered about 75% of the schedule. Classroom presentations centered around the following topics as they relate to the improvement of barley, durum wheat and bread wheat: genetics, breeding, agronomy, physiology, pathology, entomology, on-farm trials, cereals for high elevations, genetic resources, seed production, seed health, farm machinery and soil preparation, weed control, field plot techniques and statistical data analysis.

The trainees visited and observed on-farm verification trials at Hama, Idlib and El Ghab and participated in note taking in off-station research sites at Breda and Bouider.

Although all trainees participated in all theoretical and practical exercises, each trainee was assigned a small project (Table 123) in which he had to make observations, take appropriate data and write a final report.

Table 122. Graduate students supported by the Cereal Improvement Program 1986-87.

Name	Country	Degree	Research area
Moncef Ben Salem	Tunisia	Ph.D	Wheat physiology
Deghaies Mahmoud	Tunisia	Ph.D	Wheat breeding
Jamal Abu El-Enein	Jordan	M.Sc	Wheat genetics
Adel Deif Alla	Sudan	M.Sc	Cereal physiology
Mohamed Sir El Khatem	Sudan	M.Sc	Cereal physiology
Pedro P. Marco	Spain	ph.D	Cereal physiology
Helena A. Gomez Mcpherson	Spain	Ph.D	Cereal physiology
Hani Ghoshe	Jordan	M.Sc	Wheat genetics

F. Visiting Scientists

Several research scientists from different countries visited the Cereal Improvement Program at ICARDA to get acquainted with the program's research activities and discuss research issues and topics of interest with ICARDA scientists. In particular, six scientists from the region visited the program and worked with ICARDA scientists in barley breeding, physiology, wheat breeding, or pathology (Table 124). These scientists established or strengthened personal working relationships with their respective colleagues at ICARDA.

Table 123. List of participants in the Cereal Residential Training Course, ICARDA, 1987.

Trainee's name	Country	Project
Yin Jin Lai	China	Barley physiology/agronomy
Assad Ahmed Hamada	Egypt	Bread wheat Improvement
S. El Sayed M. El-Fawal	Egypt	Barley breeding
Saadani Ahmed	Morocco	Durum wheat improvement
Mohamed Oumimoun	Morocco	Cereal physiology
Abdel Azim Ali El Amin	Sudan	Bread wheat improvement
Hasan Ekiz	Turkey	Breeding cereals for high elevation areas
Khalid Haje Bakhder	Yemen	Cereal physiology/agronomy
Riad Soubhi Hammoud	Syria	Durum wheat breeding
Ahmed Bahij Sawas	Syria	Durum wheat breeding
Mehialddin Ahmed Jobba	Syria	Durum wheat breeding
Ahed Abdel Kader Zebiedah	Syria	Bread wheat improvemnet

Table 124. Regional visiting scientists to the Cereal Improvement Program, ICARDA, 1987.

Scientist's name	Country	Duration	Research area
Ismail Abdel Moneim	Egypt	4 months	Barley breeding
Maria Julia Goncalves	Portugal	2 weeks	Cereal pathology
Baha El Din Jamal	Syria	4 months	Barley breeding
Musa Babeker Taha	Sudan	3 months	Cereal physiology
Abd Alla Ibrahim	Sudan	3 months	Bread wheat breeding
Fekadu Alemayehu	Ethiopia	2 months	Barley breeding

H. Ketata

7. Publications

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8. Staff List of Cereal Improvement Program

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Dr. Edmundo Acevedo	Agronomist/Physiologist
Dr. Salvatore Ceccarelli	Barley Breeder
Dr. Guillermo O. Ferrara	Bread Wheat Breeder (CIMMYT/ICARDA)
Dr. Habib Ketata	Senior Training Scientist
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 (ICARDA/CIMMYT)
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Dr. Stefania Grando*	Research Scientist (Barley)
Mr. Issam Naji	Agronomist
Dr. Sui K. Yau	International Nursery Scientist
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Mr. Abdel Jawad El Sabouni	Training Assistant
Mr. Michael Michael	Research Assistant
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Mr. Pierre Asbati	Research Assistant
Mr. Fuad Jabi El-Haramein	Research Assistant
Mr. Mazen Jarrah	Research Assistant
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Mr. Mohamed Mushref	Research Assistant
Mr. Munzer El Naimi	Research Assistant
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Mr. Riad Sakkal	Research Assistant
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Mr. Mufid Ajami	Research Technician
Mr. Ziad Alamdar	Research Technician
Mr. Haitham Altunji	Research Technician
Mr. Joseph Aziz	Research Technician (Terbol)
Ms. Talin Halwadjian	Research Technician
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. Ghanoum	Research Technician
Mr. Riad Lutfi	Research Technician
Mr. Abdel Rahman Touma	Research Technician
Mr. Zuhair Younis	Research Technician
Mr. Salem Farrouh	Research Technician
Ms. Gisele Dadour	Assistant Research Technician
Mr. Abdullah Steif	Assistant Research Technician
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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 Jassem	Farm Labourer
Mr. Michael Abu Nakad	General Worker (Terbol)
Mr. Hassan El Khatib	General Worker (Terbol)
Mr. Mohamed Charrab	Driver (Morocco)

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Dr. Ismail Abdel Moneim	Barley Breeder Egypt
Mr. Fekadu Alemayehu	Barley Breeder Ethiopia
Mrs. Maria Julia Concalves	Agronomist Portugal
Dr. Musa Babeker Taha	Agronomist Sudan
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Mr. Angelo Grottanelli	Durum Wheat	(Viterbo)
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* Joined in 1987
** Left in 1987

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