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CEREAL IMPROVEMENT PROGRAM

Annual Report for 1986

ICARDA

CEREAL IMPROVEMENT PROGRAM

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The International Center for Agricultural
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Contents

INTRODUCTION AND PROGRAM HIGHLIGHTS

Projects carried out by Cereal Improvement Program (CP) staff during the 1985/86 season were diverse in nature and oriented towards assisting national programs to increase the productivity and yield stability of barley, durum wheat, and bread wheat, particularly in the rainfed areas.

The structure of the projects within the Program had a commodity focus. Multi-disciplinary research and training in agronomy, crop physiology, pathology, entomology, grain quality, germplasm development, all integrated in a strong team approach, was maintained. The Cereal Program received useful cooperation from the following programs in many of its activities: Genetic Resources, Farming Systems, Pasture, Forage, and Livestock, and Computer services in many of its activities. Research results are reported under seven project headings. Details of each subproject were reported in Research and Training Plans for 1985/86. In this year's Program Report greater coverage is given to research results on cereals agronomy/physiology, to barley improvement for dry areas, and to collaborative research with national programs in the region and specialized institutions in the developed countries for the primary reasons that: (1) this is the first major report on the reorganized agronomy/physiology work, (2) activities on barley improvement for dry areas were strengthend, and (3) new initiatives on collaborative research were started in 1986.

This document reports detailed research results from each project for the 1985/86 season AND should be viewed as an inventory of the Cereal Program's varied activities during 1985/86. Much of the report's content will be further refined and edited for publication as journal articles or special reports. A summary of significant achievements is presented below.

Highlights

- As a consequence of the Cereal Program's support over the years, several national cereal programs are changing from receiving to providing valuable germplasm, information and assistance to each other. For example, Cyprus is an important partner in identifying early maturing barley and durum wheat lines for areas with mild winters and low rainfall; Egypt is taking a leadership role in identifying barley and wheat lines resistant to aphids; Morocco is developing Hessian fly resistant cereal germplasm; and Tunisia recently supplied the barley variety Rihane to Algeria for on-farm demonstrations.

- Besides strengthening relations with individual countries, the Cereal Program is active in the development of small networks based on sub-regions. These networks allocate more leadership and responsibility to national programs and promote faster, closer collaboration among the regional research programs. Such a network is starting in North Africa comprising Algeria, Morocco, Tunisia and the Iberian Peninsula. A similar network is being developed for the Nile Valley countries of Egypt, Sudan, and Ethiopia, while the Yemen Arab Republic and the Peoples Democratic Republic of Yemen may join the network at a later stage. A network to cater to the needs of winter habit barley and wheat is being considered comprising parts of Pakistan, Afghanistan, Iran, Turkey, Morocco and Algeria. Countries of Western Asia growing spring habit barley and wheat are being encouraged to form a network as they face common production constraints.

- Interaction with Turkey was strengthened during 1985/86. Winter habit ICARDA barley and wheat germplasm has been planted in Ankara for evaluation for winter hardiness there and possible suitability for other high elevation areas. For the first time land and facilities were provided by the Central Anatolian Agricultural Research Institute. An International Conference co-sponsored by ICARDA and Turkey will be held in Ankara in July 1987 to promote a better understanding and appreciation of the agroclimatic conditions and production constraints of the high elevation areas, and to initiate a functional network. Interaction with Iraq, the Arab Republic of Yemen, Ethiopia, Portugal, Spain, France, Italy and Greece were strengthened during 1985/86.

- In the 1985/86 season, a pilot project for the verification and adoption of improved wheat production technology by farmers was started in Sudan and in cooperation with CIMMYT with financial support from the OPEC Fund. With financial and technical support from France, a project was started to increase production and strengthen research on cereal, food legume and forage crops in Algeria. Projects to strengthen research and production on barley and wheat in Ethiopia, Sudan and Egypt were developed for outside funding.

- Integrated efforts by national programs and ICARDA resulted in the release of new cereal varieties in several countries during 1985/86. Durum lines Sebou and Kourifla are under consideration for release in Syria. Kourifla a durum wheat line adapted to for dry areas and possessing improved gluten strength is also being considered for release in Jordan and Cyprus.

The following barley and wheat varieties have been released in partnership with national programs, ICARDA, and CIMMYT through 1985/86.

Crop	Country	Year of Release	Variety
Barley	Cyprus	-	Kantara (Roho)
	Tunisia	1985	Taj (WI 2198), Faiz (ER/Apam)
		1985/86	Rihane'S'
	Qatar	-	Gulf (Aut/Aths)
		1983	Harma
	Morocco	1984	Tamellalt (Orge 1703), Asni (Orge 1579)
	Lebanon	-	Tissa (Orge 1580)
		1985/86	Rihane'S'
	China	"	Gobernadora
	Mexico	"	Mona/Mzq//DL71
Durum wheat	Cyprus	1977	Aronas
		1982	Mesoaria (Anshinga'S' x Volunter)
		1984	Karpasia (Sham 1)
	Egypt	1978	Sohag (Stork 'S')
	Morocco	1984	Marzak (E12-BD11)
	Libya	1984	Marjawi (Eider), Baraka (AA'S'), Zorda (Glovz 469 AA), Fazan (D-25)
	**Portugal	1983	Celta (Sham 1)
	Syria	1984	Sham 1
	Algeria	1985/86	Sahl, Waha
	Lebanon	-	Sebou, Belikh
	Tunisia	-	21563-AA'S' x Fg'S'/DM x 69-133
Bread wheat	Iran	within last 10 years	Azadi
	Libya	1984	Zellaf, Sheba, Germa (CC-Inia/-Tob x ctn 136)
	Morocco	1984	Jouda (Kal x Bb), Merchouche
	Pakistan	1982	Zargoon (c-Inia/-Tob Cfn x Bb/7c)
	PDR Yemen	1982/83	Ahgaf (S311 x Norteno)
	Sudan	1982	Debeira (HD 2172)
	Syria	1982	Shan 2 (7C x Tob/Cno Kal)
		1985/86	Sham-4
	Tunisia	"	Sham-4

- During .1985/86 collaborative arrangements were made with specialized institutions such as the Plant Breeding Institute (PBI), Cambridge, Reading University, University of London supported by ODA, University of Tuscia, Viterbo, Italy and University of Perugia, Italy, supported by the government of Italy; Montana State University, Oregon State University, the USDA, and Kansas State University, supported by USAID; University of Cordoba, ETSIA, funded by Spain; and INRA, Montpellier, funded by France.

- Through developing collaborative projects with French and Japanese institutions, the Program plans to use the newer tools in plant breeding such as haploid breeding using H. bulbosum, embryo rescue in wide crosses. However, conventional breeding will continue as a mainstay.

- Cereal scientists were requested by Morocco, Tunisia, and the Arab Republic of Yemen to review their barley and wheat research and production activities, and to recommend priorities and research methods with the objective of developing more efficient and cost effective national programs.

- A request for assistance from Morocco was answered by posting a senior Cereal Scientist to assist in coordinating the national cereal program in Morocco. He will also serve as a regional Cereal Scientist for north Africa. On the other hand, after six years devoted to assisting in the establishment of a national barley improvement program, the cereal scientist assigned to the Tunisian program was withdrawn, as Tunisia's national capability is now well established.

- During 1986 efforts on evaluation, documentation and utilization of primitives and landraces of barley and durum wheat were strengthened with financial support from the government of Italy. Several collections, identified for tolerance to drought, cold, heat, salinity and diseases, were provided to breeders and pathologists.

- The training activities were geared to strengthen the capacities of the national programs through specialized short courses, degree training, individual training, and residential in-country training. Visits to ICARDA of senior national scientists for short and long term periods is helping promote interaction between ICARDA and national programs.

- During 1985/86 considerable progress was made in refining breeding strategies for barley, durum wheat and bread wheat improvement in the rainfed areas. Research results showed that genotypes selected under less than 250 mm of rainfall, as well as under moderate rainfall conditions, performed better under drought stress and in moderate rainfall areas than did barley or wheat selected under stress free environments.

- Results of the barley improvement project verified that selection for barley to be grown in dry environments should be made under those conditions. Different sets of morphological and physiological characters are required to maximize yield under stress conditions compared to those used under non-stressed conditions. The utilization of the variability in landraces has been shown to be useful in improving barley yield in harsher environments. Some barley genotypes with improved agronomy yielded over 2 t/ha in less than 250 mm rainfall areas, whereas farmers normally average 0.5 t/ha.

- The durum wheat improvement project provided national programs with germplasm developed to meet their specific needs. Through multilocation field tests genetic stocks possessing frost tolerance and earliness, drought and heat tolerance, septoria and common bunt resistance and high yields were identified. Several durum wheat entries gave larger grain yields as compared to national check varieties in on-farm trials conducted by national programs.

- The bread wheat improvement project has identified parent lines with desirable genes for yield, disease resistance, and nutritional and industrial quality. They were screened for frost, heat, drought tolerance, and earliness at several field locations in advanced yield trials. New sources of genetic variability were identified by the introduction and recycling of materials from national programs in West Asia and North Africa.

- In the high elevation cereal research project, 3 disease resistant, high yielding lines were identified at Tehran, Iran. Genes for high grain protein, disease resistance (yellow rust), and cold tolerance has been transferred into *T. durum* from *T. turgidum* var. *dicoccoides* through interspecific hybridization.

- Tests carried out in collaboration with the Grain Research Laboratory, Winnipeg, Canada, on semolinas and malts verified the ranking of durum wheat and barley genotypes made at ICARDA's cereal quality laboratory on the basis of simple tests (e.g. SDS sedimentation, kernel characteristics and saccharifying activity) used for early generation screening. As a result of ICARDA's cereal quality training, a network of cereal technologists is beginning to be formed in the region. Future plans include the exchange of reference samples and interlaboratory collaboration in testing.

- The Program distributed more genetic stocks and segregating populations to the more established national programs. Programs with less resources and manpower received only selected advanced lines. Emphasis was placed on developing germplasm to meet specific agroclimatic conditions, often through joint efforts of the national programs. Over 1400 sets of international barley, durum wheat, and bread wheat nurseries were dispatched to 115 national cooperators at their request. National programs were encouraged to use the ICARDA International Nursery System to test their most advanced lines throughout the region and beyond.

- Results of the program's physiology/agronomy studies have shown that deep sowing, close row spacing and early planting promote barley production. Factors associated with grain yield included slow leaf senescence, leaf rolling during early growth, greater number of heads/m^2, and early stage prostrate growth (barley). Other studies pointed out that different improvement strategies should be used for each cereal species.

- With the inclusion of covered smut and barley yellow dwarf virus (BYDV), the cereal pathology project is now screening eight major cereal diseases. BYDV screening was conducted at Tel Hadya using artificial inoculation with aphids infected with the PAV strain of BYDV. In addition lines from Mexico are being screened for BYDV at Tel Hadya, with selected lines from ICARDA being screened at Quebec. The development of germplasm pools for sources of resistance has been improved. Four such pools, for yellow rust, septoria tritici blotch, common bunt in wheat, and scald in barely are now available to breeders.

- Entomological research at Tel Hadya identified 1 barley line, 4 durum wheat lines, and 2 bread wheat lines with resistance to wheat stem sawfly. Only 1 barley line possessed moderate resistance to aphid infestation. Analyses of past research results revealed that currently measured plant variables do not explain variation observed in insect infestation.

Staff Changes

During 1985/86, Dr. Ahmed El-Ahmed, the barley breeder/pathologist left ICARDA following six years of excellent work in developing a Tunisian national barley program and cereal pathology component there. He has joined the University of Aleppo. Dr. D.K. Multize also left the program and joined the MIAC project of the USAID in Morocco as a cereal breeder. Dr. M.S. Mekni was transferred to Morocco to assist the Moroccan national cereal program. Dr. S.K. Yau was placed in charge of the International Nurseries project. Ir. J.A.G. van Leur joined ICARDA as a barley pathologist after serving the program for five years as an associate expert funded by the Dutch Government. Mr. M.A. Malik, a research associate, left ICARDA when triticale work was discontinued in 1986. Ms. Eva Weltzien completed her Ph.D. work and has joined the University of Iowa as a post-doctoral associate. Dr. A.B. Damania, formerly with IBPGR/FAO in Rome, Italy has joined the program as durum germplasm scientist. Dr. R.H. Miller formerly of USDA-ARS Rangeland Insect Laboratory, Bozeman, Montana, U.S.A has joined the program as cereal entomologist.

- J.P. Srivastava

1. Barley Improvement

Barley (Hordeum vulgare L.) is the world's fourth most important cereal crop after wheat, maize, and rice. Between 1982-84 the harvested area approached 79 million ha. with almost 17 million ha. grown in developing countries. Barley is grown over a wide range of environmental conditions and is mostly produced in areas where environmental stresses limit the production of other major cereals. Among the environmental stresses, drought is considered the most important, although it often occurs in combination with other environmental stresses such as low winter temperature, heat during the final period of grain filling, lack of macro- and micronutrients, the presence of toxic elements, and biotic stresses (diseases and insect pests).

In many barley growing areas in developing countries yield is severely limited by one or more abiotic and biotic stresses. However, even in areas where higher yield potential is possible, barley is considered to be a typical crop for marginal (economically or climatically) conditions. The benefits of a barley improvement project centered around abiotic and biotic stresses therefore transcend national boundaries.

The main objectives of the Barley Improvement Project are:

1. To develop and distribute to national programs suitable germplasm for the major barley agroecological zones. Target areas given priority are a) those where drought (with or without low winter temperatures) is the most important climatic stress limiting yield, b) high elevation areas, c) areas with moderate rainfall where a dry spell or a dry year can occur, and d) short season environments and subtropical areas where barley is grown above 1800 m with summer rainfall.

2. To continuously upgrade the level of resistance to diseases and insect pests.

3. To develop methodologies for improving selection efficiency for stress conditions.

4. To develop germplasm with suitable food or feed quality.

5. To provide training.

6. To strengthen national programs.

To meet these objectives the Barley Improvement Project has developed the following activities and methodologies:

a) two methods are used for barley breeding: the pedigree method for more favourable environments, and the bulk-pedigree method with multilocation testing for stress environments. Backcrossing is used to incorporate disease resistance and/or specific traits.

b) parents which show specific combining ability are being used in crosses designed for specific environments (targetted crosses).

c) most of the breeding material is evaluated in trials designed to continuously test and improve our methodologies and strategies, mainly in relation to breeding for stress environments.

d) an increasing use is being made of pure-line selection within adapted cultivars (landraces). The wild progenitor of cultivated barley, *H. spontaneum*, is used as a potential source of diversity for tolerance to high levels of drought stress.

e) most breeding material is tested for disease resistance using artificial and natural inoculation in many locations.

f) crop physiology studies are becoming increasingly important in our breeding strategy as they provide basic information on stress tolerance and in developing screening techniques to improve selection efficiency.

g) all lines in advanced stages of yield testing are also monitored for quality (including malting quality) characteristics.

h) improved germplasm is distributed and tested through the system of international nurseries in many locations as yield trials, observation nurseries, special purpose nurseries, and crossing blocks.

In carrying out these activities, involvement of national programs from developing and developed countries is maintained.

1.1. Breeding

Most of the breeding material was evaluated in the ICARDA's three experimental sites located in Aleppo province of northern Syria, i.e. Bouider (180 mm rainfall), Breda (208 mm rainfall), and Tel Hadya (316 mm rainfall). In addition, the lines promoted to the advanced yield trials were evaluated in Lebanon, Cyprus, and Tunisia. A number of segregating populations and promising lines were evaluated in many countries through the international nurseries system. The development of high yielding germplasm and lines for moderate rainfall areas continued to be successful as indicated by the release of varieties, lines selected by national programs and seed requests from many countries. In this Report we will highlight the results obtained from breeding for dry areas (about 200 mm rainfall), a component that was added to the projects two years ago.

In Aleppo province the 1985/86 cropping season was very different from the previous season. Winter temperatures were higher and rainfall distribution differed with a long, dry spell occurring between mid February and the end of March. Most of the breeding material has therefore been exposed during the last two cropping seasons to two of the major environmental stresses typical of many barley growing areas, i.e., low winter temperatures and drought between stem elongation and maturity. Data from the last two years were used to validate information generated in 1984/85 regarding the relationship between yield potential and drought resistance, and the efficiency of using an empirical approach (selection for grain yield) in barley improvement for dry areas.

Additional achievements to be discussed include:

- The relationship between yield and stability
- An analytical approach based on morphological characters
- The use of less conventional germplasm
- International nurseries.

1.1.1 Relationship between yield potential and drought resistance

The results of 1984/85 from the F_3 bulk families, and those obtained from the advanced yield trials, indicated that the lines or families selected for their yield under favourable conditions (Tel Hadya) did not perform well under stress conditions (Bouider).

This resulted in a strong negative correlation between grain yield at Bouider and the drought susceptibility index, and in a weakly positive (often nonsignificant) correlation between grain yield at Tel Hadya and the drought susceptibility index.

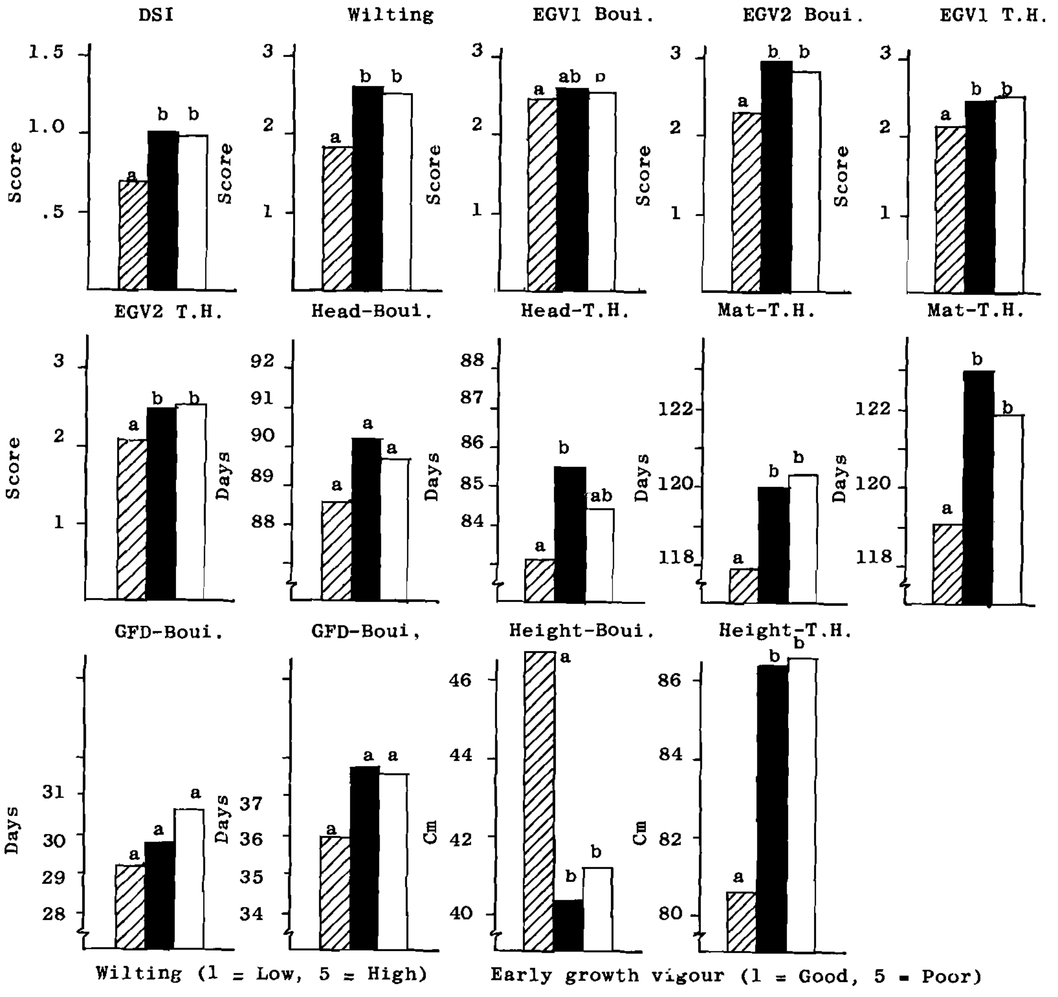
This indicates that selection for grain yield in a moderately favourable environment is not efficient in improving grain yield under stress conditions. It was not known to what extent the unusually low winter temperatures of 1985 affected results.

Similar results were obtained in 1985/86, with higher winter temperatures and a different rainfall distribution, for a large number of yield trials containing different types of genetic material, including improved germplasm, lines selected from landraces, and segregating populations. With few exceptions the correlation coefficients between grain yield at the two sites did not significantly differ from zero and even when significant they were always very low. Grain yield at Bouider was negatively correlated with drought susceptibility index, with 36 of the 41 correlation coefficients exceeding 0.8 On the contrary, grain yield at Tel Hadya was either independent from, or positively correlated with the drought susceptibility index.

The highest yielding families at Bouider, averaging 2699 kg/ha, yielded an average of 5186 kg/ha at Tel Hadya. This figure was not significantly different from the mean yield of the entire population (5072 kg/ha), and was slightly lower than that of the best local check (5380 kg/ha). By contrast the highest yielding families at Tel Hadya (5842 kg/ha) did not out-yield either local check when grown at Bouider, and yielded significantly ($P < 0.001$) less than the highest yielding families grown there. Only three of the 18 families selected at Tel Hadya were included in the top yielding families at Bouider.

The two groups of the highest yielding families at each location also differ in a number of morphological and/or phenological characters (Fig. 1). The families selected at Bouider had a significantly smaller drought susceptibility index and wilting score, and were in general more vigorous in the early stages of growth, earlier maturing, and taller than the families selected at Tel Hadya. Fig. 1 also shows an example of an adaptive morphological character. At Bouider the highest yielding families were significantly taller (46.7 cm) under stress than the families selected at Tel Hadya (40.3 cm). When families selected at Tel Hadya were grown at Tel Hadya, they were significantly taller (86.4 cm) than those families selected at Bouider (80.6 cm). Similar results were obtained in 1984/85 indicating that even for characters with high heritability, such as plant height, differences observed under favourable conditions are of little indication of the difference to be expected under stress conditions.

Figure 1. Agronomic and phenologic characters at Tel Hadya and Bouider of the 10% highest yielding F_4 bulks at Bouider (hatched) and Tel Hadya (black) compared with the population mean (white).



Some of the characters shown in Fig. 1, such as low wilting, tall plants, early heading and maturity, short duration of grain filling, and low drought susceptibility index, appear to be associated with higher grain yield under stress conditions but not with higher grain yield during favourable conditions (Table 1). This indicates that the plant architecture associated with high grain yield under stress conditions is different from the one which is associated with high grain yield under favourable conditions.

Table 1. Phenotypic correlation coefficients between different characters and grain yield in F_4 bulk families grown at Bouider and Tel Hadya.

	Grain Yield	
Character+	Bouider	Tel Hadya
Wilting	-0.403**	0.090
Days to heading	-0.287**	0.184*
Days to Maturity	-0.508**	0.105
Grain filling duration	-0.209**	-0.109
Plant Height	0.522**	0.003
Drought susceptibility	-0.957**	0.154
Early growth vigour-1	-0.215**	-0.207*
Early growth vigour-2	-0.254**	-0.324**

+ measured at the same location as grain yield with the exception of wilting
df = 151, * P<0.05, ** P<0.01.

A similar relationship between yield potential and yield under stress is shown by the grain yield of the best 18 (11.5%) advanced lines grown at four locations (Table 2). The highest yielding lines at Terbol (8411 kg/ha) and Tel Hadya (4762 kg/ha) yielded almost 600 kg/ha less at Bouider when compared with the highest yielding lines under stress conditions. Taking the location mean as a measure to categorize location as favourable or unfavourable, it is also evident that the highest yielding lines selected at progressively more favourable environments tend to have progressively higher values of drought susceptibility (Table 3).

Table 2. Mean grain yield (kg/ha) of the best 18 lines (11.5%) in the advanced yield trials grown at four locations in 1985/86.

Selection site	Testing site				Mean
	Bouider	Breda	Tel Hadya	Terbol	yield
Bouider	1831a	1797bc	4060c	7346b	3758b
Breda	1289c	2378a	3966c	7340b	3743b
Tel Hadya	1249c	1721c	4762a	7412b	3786b
Terbol	1256c	1759c	4110bc	8411a	3884b
Mean yield	1562b	2042b	4374b	8141a	4030a

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

Table 3. Drought susceptibility index of the highest yielding 18 lines (11.5%) in the barley advanced yield trials grown at four locations in 1985/86.

Location	Location mean	DSI
Bouider	1151	0.892a
Breda	1654	0.981b
Tel Hadya	4012	0.989b
Terbol	7296	1.012b

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

1.1.2. Efficiency of selection for grain yield in dry areas

Because of the emphasis given to the improvement of barley for stress conditions, and because grain yield can be improved in non-stress conditions, a first assessment of the efficiency of selection for stress conditions had high priority.

Yield under stress conditions is considered to be a poor selection criterion because of its low heritability.

In 1984/85 the pedigree method was replaced by a bulk-pedigree method in an attempt to increase the efficiency of selection for stress environments. With this method the segregating populations are grown for three generations (F_2-F_4 or F_3-F_5) in three environments using replicated yield trials in a lattice design. Selection is practised only between crosses. Single plant selection is applied, in F_4 or F_5, only within those crosses which consistently outyield a standard check during the bulk phase.

Among other advantages over the pedigree method, the bulk-pedigree method offers the possibility to measure the efficiency of selection when the segregating populations are evaluated as bulks.

The efficiency of direct selection for grain yield was measured in three ways:

a) by comparing the mean yield of the selected families with a standard check;

b) by considering the frequency of families outyielding a standard check in 1985/86 over the number of families selected in 1984/85;

c) by computing the narrow sense heritability either through regression analysis or as realized heritability from selection experiments.

Although selection in 1984/85 was mainly based on grain yield, a cycle of selection between lines derived from landraces was also conducted using plant height and kernel weight (per 1000) as selection criteria.

The results to be discussed in this section were obtained 1) from the evaluation of 148 F_4 bulk families selected in 1984/85 out of a total of 729 F_3 bulk families, 2) from a selection experiment where eight groups of five families each were evaluated at three locations, and 3) from one cycle of selection of pure lines within landraces.

In considering the results of this section it must be emphasized that the environmental conditions during selection were quite different in terms of winter temperature and rainfall distribution from those during testing. It was expected therefore that a number of genotypes and segregating populations selected in 1984/85 would not perform well in 1985/86.

1.1.3. Mean yield of selected families compared with a check

In 1984/85 the primary selection criteria were grain yield at Bouider and grain yield at Tel Hadya. Fifty eight families were selected mainly on the basis of the first criterion while 90 were selected mainly for grain yield at Tel Hadya. The selection at each site was made regardless of the selection at the other site.

In 1985 the mean yield of 58 families selected at Bouider was 1549 kg/ha (significantly higher than Arabi Aswad) and 4310 kg/ha at Tel Hadya (significantly higher than Arabi Aswad but not different from Arabi Abiad). In 1986 however, the average yield of the same 58 families was lower than both local checks at Bouider, and significantly higher than Arabi Aswad at Tel Hadya.

In 1985 the 90 families selected at Tel Hadya yielded significantly more than the best check at Tel Hadya (4898 vs. 4266 kg/ha) but significantly less at Bouider. Also the mean yield in 1986 of these families was lower than the best check at Tel Hadya (5147 vs. 5380 kg/ha) and lower than both checks at Bouider. The range in mean yields indicates that the lower mean yields of the two selected groups in 1986 must be attributed to a number of families which performed very poorly in 1986 despite their good performance the previous cropping season. This may be due to 1) large environmental effects on grain yield of some families in 1985, 2) the association of heterotic effects, and 3) the association of yield with cold resistance and not drought tolerance in some families. However, a number of families selected in 84/85 outyielded a common check also in 1985/86 and the frequency of these families was used as a measure of efficiency of selection.

1.1.4. Frequency of families outyielding a control

The efficiency of selection also was measured by the frequency of families selected in 1984/85 outyielding a common check in 1985/86.

As shown earlier, the average yield of the families selected in 1984/85 at Bouider and Tel Hadya was lower than the best local check in 1985/86. However 15 families (25.9%) at Bouider, and 29 families (32.2%) at Tel Hadya out-yielded the best local check both in 1985 and 1986 (Table 4).

Table 4. Grain yield (kg/ha) at Bouider and Tel Hadya of bulk families outyielding the best local check both in 1984/85 and in 1985/86.

Selection site or check	No. of families	Grain Yield (kg/ha) Bouider 1985	Bouider 1986	Tel Hadya 1985	Tel Hadya 1986
Bouider	15	1564**	2288**	4284	5083**
Tel Hadya	29	1079**	1711**	4915**	5669**
Arabi Aswad		1320	1907	3946	4424
Arabi Abiad		1302	2075	4266	5380

* Significantly higher or lower than the best check ($P<0.05$).
** Significantly higher or lower than the best check ($P<0.01$).

Response to selection appears to be highly specific to the selection site in both cases. The families out-yielding the best local check at Bouider during two cropping seasons yielded less (5083 kg/ha) than the best check at Tel Hadya (5380 kg/ha), and those outyielding the best local check at Tel Hadya yielded significantly less (1711 kg/ha, $P < 0.01$) than the best check at Bouider (2075 kg/ha). This further indicates that it is very difficult to combine high yield potential in non stress conditions with high yield in stress conditions.

One may now pose two questions:

1) Could the selection in 1984/85 have been done more efficiently?

2) What is the efficiency of selection at Tel Hadya for the Bouider-type of environment compared with direct selection at Bouider?

To answer the first question we compared, for a number of characters and using the 1984/85 data, the families which out-yielded the best check in both cropping seasons with those which did not maintain their superiority in the second cropping season.

At Bouider (Table 5) the 15 families selected in both cropping seasons did not differ in 1985 from those which were selected only in 1985 except for a higher level of cold tolerance and shorter stems. The two groups showed the same grain yield. By applying a higher selection pressure for cold tolerance it would have been possible to increase the efficiency of selection from 25.9% to 31.1% (Table 6). Similar results were obtained when the same comparison was done at Tel Hadya (Table 7) where the 29 families which performed well for two consecutive cropping seasons, differed significantly as regards days to heading. In comparison, 61 families performed well in 1984/85. Even in 1986 the two groups differed only for a few characters.

Table 5. Comparison of 15 bulk families outyielding Arabi Aswad at Bouider in both 1984/85 and 1985/86 with 43 bulk families outyielding A.Aswad only in 1984/85.

Character	Bouider		Tel Hadya	
	Two seasons (n = 15)	One season (n = 43)	Two seasons (n = 15)	One season (n = 43)
1985				
Vigour 1+	2.53	2.35	2.39	2.48
Vigour 2+	3.03	3.08	3.38	3.48
Cold+	1.99	2.30*	2.47	2.84**
Heading	148.0	147.7	128.4	128.4
Maturity	174.4	174.8	-	-
Height	47.0	52.2**	71.4	76.0*
Yield	1564	1543	4284	4319
DSI	0.86	0.86	-	-
1986				
Vigour 1+	2.56	2.91	2.75	2.63
Vigour 2+	2.70	3.13*	2.73	2.80
Wilting+	2.32	2.72*	-	-
Heading	90.3	91.7*	87.2	86.1
Maturity	118.3	121.5**	121.3	123.1
Filling	28.1	29.8*	34.2	37.0**
Height	42.3	39.6	80.4	89.2**
Yield	2288	1390***	5083	5046
DSI	0.82	1.08***	-	-

* P<0.05, ** P<0.01, ***P<0.001.
+ 1=good vigour, cold tolerance, low wilting; 5=poor vigour, cold susceptibility, high wilting

Table 6. Increased efficiency of selection at Bouider by selecting for both grain yield and cold tolerance

Selection criterion/a	N. of families selected in 1984/85	N. and frequency of families outyielding Arabi Aswad in both years
Grain yield	58	15 (25.9%)
Yield and cold	45	14 (31.1%)

Table 7. Comparison of 29 bulk families outyielding at Tel Hadya the best local check both in 1984/85 and in 1985/86 with 61 bulk families outyielding the best local check only in 1984/85.

Character	Tel Hadya		Bouider	
	Two seasons (n = 29)	One season (n = 61)	Two seasons (n = 29)	One season (n = 61)
1985				
Vigour 1	2.14	2.41	2.47	2.51
Vigour 2	3.20	3.24	3.22	3.35
Cold	2.70	2.75	2.37	2.44
Heading	129.1	127.3*	149.1	148.7
Height	76.2	77.7	44.8	45.8
Yield	4915	4890	1079	1128
DSI	1.06	1.05	-	-
1986				
Vigour 1	2.28	2.55	2.79	2.76
Vigour 2	2.34	2.67*	2.97	2.82*
Wilting	-	-	2.83	2.52*
Heading	86.6	85.4	91.0	90.1
Maturity	122.9	121.7	119.9	119.8
Filling	36.4	36.3	28.9	29.7
Height	86.9	85.8	39.8	41.4
Yield	5669	4899***	1711	1762
DSI	1.05	0.96**	-	-

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

A common feature of the comparisons shown in Tables 5 and 7 is that, with the exception of cold tolerance and plant height at Bouider and days to heading at Tel Hadya, most of the morphological and phenological characters routinely observed have no predictive value relative to grain yield. However these data confirm the relationship between grain yield and the drought susceptibility index, and suggest a possible association between cold and drought tolerance. Furthermore, they indicate the possible predictive role of the wilting score, with the limitation that without the use of facilities such as rain shelters wilting may not be always measurable.

The yield data of the 15 families selected at Bouider in both cropping seasons are given in Table 8. It must be emphasized that these families outyielded Arabi Aswad in both 1985 and 1986. An additional 16 families outyielded Arabi Aswad when averaged over two years, but this was associated with a great fluctuation among years. The selection criterion utilized should increase stability and yield at the same time. The maximum yield advantages were in the order of 31% over Arabi Abiad, of 37% over Arabi Aswad and 48% over Harmal, an improved check. The mean yield advantage was 14% over Arabi Abiad, 19% over Arabi Aswad, and 29% over Harmal.

A measure of the efficiency of selection at Tel Hadya for the Bouider-type of environment is given in Table 9. Out of the 90 families selected in 84/85 at Tel Hadya only eight (8.9%) outyielded Arabi Aswad at Bouider both in 1984/85 and in 1985/86. The efficiency of direct selection at Bouider (25.9%) was therefore almost 3 times higher than selection at Tel Hadya for environments like Bouider.

Response to selection in terms of frequency of families selected for two consecutive cropping seasons was also measured in the pure line selection scheme used to improve locally adapted cultivars.

Although the number of families selected in 1984/85 for grain yield was very small (14 white seeded and 20 black seeded) a high percent of them (42.9% and 80.0%, respectively) outyielded the best local check at Bouider in 1985/86 (Table 10). Yield advantages ranged from 5.5% to 81.0%. The frequency of lines maintaining their superiority over the local check decreased in Breda, and was only 8.8% at Tel Hadya, confirming that this activity is primarily targetted for dry environments and should not be expected to generate materials for favourable enviroments.

Table 8. Grain yield at Bouider in 1984/85 and in 1985/86 of 15 bulk families outyielding the best local check in both cropping season.

Cross	1985	1986	Mean Yield
Arabic white/WI 2291	1351	2824	2088
Esp/1808-4L//Alger/Ceres	1794	2624	2209
Apm/Ath//Gva/3/Arabic White/ 4/Api/CM67//Nacta	1442	2560	2001
Er/Apm//Lignee 131	1355	2514	1935
Er/Apm//Alger//Union	1521	2463	1992
Arr/Esp/Alger/Ceres 362-1-1/ 4/7028/3/69-82//Ds/Apm	1665	2329	1997
Agri 8/Imperial	1426	2242	1976
Esp/1808-4L//Emir	1715	2236	1976
O.P./Zephyr//Alger/Union, 385-2-2/3/Kantara	1332	2156	1744
Harmal 'S'//Alger/Ceres	1749	2156	1953
Kervana//Alger/Ceres,362-1-1/ 3/Arr/Esp//Alger/Ceres,362-1-1	1393	2152	1772
Rihane/Sawsan 'S'//Er/Apm	1343	2126	1734
Arabic White/Emir	1505	2081	1793
Soufara 'S'/3'RM 1508/Pro//WI 2269	1426	1935	1681
WI 2269/4/Comun//Apm/3/12410/Giza 134-2L	2162	1916	2039
Arabi Aswad	1320	1907	1614
Arabi Abiad	1302	2075	1689
Harmal	751	2243	1497

Table 9. Number and frequency of lines selected in 1984/85 at Bouider and Tel Hadya which outyielded A.Aswad at Bouider both in 1984/85 and 1985/86.

Sel. site or checks	No. Fam. selected 1984/85	No. lines sel.84/85, 1985/86	Select. effic. %	Grain yield (kg/ha) Bouider 1985	Bouider 1986	Tel Hadya 1985	Tel Hadya 1986
Bouider	58	15	25.9	1564	2288	4284	5083
Tel Hadya	90	8	8.9	1498	2315	4663	4998
Arabi Aswad				1320	1907	3946	4424
Arabi Abiad				1302	2075	4266	5380

Table 10. Results of selection for grain yield in barley landraces.

No. of lines selected in 1985 and seed color	Range of % of the best check in 1985
14 White seeded	107.4 - 144.6
20 black seeded	104.9 - 151.1

No. of lines outyielding the best local check in 1986: Bouider	Breda	Tel Hadya
6 (107.6-150.2)	3 (101.9-105.1)	3 (102.5-104.9)
16 (105.5-181.0)	11 (100.4-116.2)	0

From a methodological standpoint it was interesting to note that most of the lines outyielding the best local check in 1986 were selected from a 1985 trial where lines were evaluated in four row plots instead of two row plots (Table 11). This is especially significantly because of the widespread use of two rows plots in the preliminary evaluation of breeding material.

Table 11. Efficiency of selection for grain yield in relation to plot size during the testing stage.

Selection criterion	No. of lines	Plot size	No. and % lines outyielding the best local check in 1986	
			Bouider	Tel Hadya
Grain Yield	13	2 rows	5 (38.5%)	1 (7.7%)
Grain Yield	21	4 rows	17 (81.0%)	2 (9.5%)

1.1.5. Estimates of realized heritability

Estimates of realized heritability for grain yield and other agronomic characters were obtained from the results of a response to selection experiment and as coefficients of determination associated with the regression of the means of F_4 bulk families in 1986 onto the corresponding means of the F_3 families in 1985. This method should have avoided the scale effects associated with data comparisons in different years (Frey and Horner, 1957) provided that regression coefficients were positive.

The estimates of heritability for grain yield at Bouider were always nonsignificant (Table 12) regardless of the reference population used. At Tel Hadya a significant but very low estimate of heritability (about 7%) was found only when the entire population of F_4 families selected in 1984/85 was considered. Very low estimates of narrow sense heritability were also found for other characters scored at Bouider, with the only exception being days to maturity and early growth vigour scored 5 weeks after emergence. Characters with higher heritability at Tel Hadya were days to heading (about 60%), plant height (between 11 and 17%), and early growth vigour scored 5 weeks after emergence (between 6 and 9%). However, for a character such as plant height, data indicate that differences found in one enviroment are not necessarily expressed in a different environment Fig. 1.

Narrow sense heritability was also estimated as realized heritability from a selection experiment (Table 13). When selection was based on grain yield in only one location, response to selection and consequently realized heritabilities, were very low regardless of the selection site, eventhough selection at Breda appeared slightly more efficient than selection at either Bouider or Tel Hadya. Higher estimates of realized heritability were obtained in all the three sites when selection was based on the average grain yield across locations (Fig. 2).

These results were obtained using groups of 5 families selected for high and low grain yield at the three locations. Therefore the low values of heritability do not necessarily contradict the result of the previous section (indicating responses ranging between 25% and 32%) obtained with a much larger number of families.

Figure 2. Response to selection for high (▭) and low (▨) grain yield averaged across 3 locations.

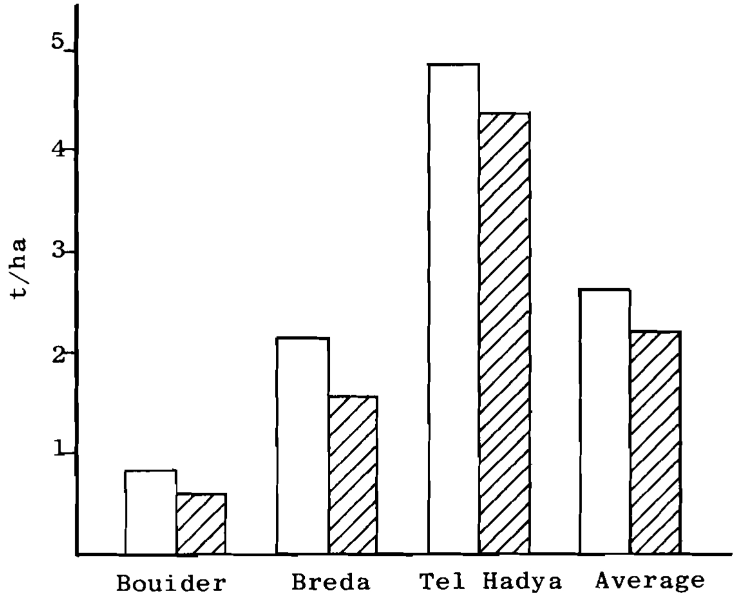


Table 12. Estimates of narrow sense heritability (%) as F_4/F_3 determination coefficients.

Character	All populations (n = 153)	Selected at Bouider (n = 58)	Selected at Tel Hadya (n = 90)
Grain yield			
Bouider	1.81	0.17	0.18
Tel Hadya	6.87**	5.24	1.93
Plant height			
Bouider	1.79	4.05	7.20*
Tel Hadya	12.06**	11.80**	17.29**
Days to heading			
Bouider	0.67	28.97**	0.00
Tel Hadya	61.69**	57.20**	61.40**
Days to maturity			
Bouider	13.10**	25.79**	16.21**
Early growth vigour			
Bouider	1.36	0.00	1.43
Tel Hadya	9.08**	9.65*	6.10*
DSI	1.12	0.18	0.00
Early growth vigour			
Bouider	21.98**	13.05**	
Tel Hadya		0.01	1.30

Table 13. Estimates of realized heritability for grain yield when selection and testing are done in the same or in different environments.

Selection site	Testing site			
	Bouider	Breda	Tel Hadya	Av. 3 Loc.
Bouider	10.52	<1	<1	62.92
Breda	91.10	1.99	31.60	24.61
Tel Hadya	*	<1	29.91	62.55
Av. 3 Loc.	17.58	69.04	26.63	38.31
Bouider	2.82	34.22	<1	<1
Breda	28.26	50.91	>1	58.81
Tel Hadya	<1	<1	<1	26.49
Av. 3 Loc.	46.60	86.82	44.37	56.93

*Selection differential was negative.

1.1.6. Relationship between yield and stability

Yield stability is a major objective of the barley project and is related to crop improvement in stress environments. The erratic and unpredictable nature of these environments results in large variations in yield. The reduction in the frequency of crop failures, or in the number of years of poor yield would amount to a significant improvement in dryland farming. The improvement of barley yield and stability in very dry areas would benefit large numbers of farmers and must be pursued even if the material developed for these areas does not have high yield potential in more favorable environments.

The joint regression analysis has been used extensively to measure yield stability, although its value depends on a linear response to environmental effects. Powell et al. (1985) recently showed that environmental sensitivity can be measured as the square root of the variance component over environments.

Although the amount of data available on the relationships between yield under stress conditions, yield under relatively favourable conditions, and stability are still limited, we tried to use the available data to predict the effects of our present selection strategy on yield stability. For this purpose we used the data collected on the bulk families considering the three locations used in 1985 and the two locations used in 1986 as five different environments.

Stability in these five environments, measured as the standard deviation of yield, was closely associated with the linear regression coefficient of family yield onto mean yield (Table 14). Regardless of the parameter used, higher grain yield at Bouider was usually associated with higher stability, while a higher grain yield at Tel Hadya was strongly associated with lower stability. Furthermore higher drought susceptibility (measured as DSI) was associated with lower stability.

It was shown previously that selection for grain yield under moderately favourable conditions reduces grain yield in stress conditions. The correlation coefficients shown in Table 14 lead one to expect that an additional consequence of selection conducted only in favourable environments is a decrease in stability. Table 15 shows that the bulk families selected at Bouider for grain yield in 1985, for grain yield in 1986, and for grain yield in both 1985 and 1986 always have a significantly (P < 0.001) higher stability than the families selected at Tel Hadya with the same criteria. The higher stability is obviously a consequence of lower responsivness to the more favourable environment of Tel Hadya. This is not neccessarily a limitation for at least two reasons:

Table 14. Correlation coefficients between two stability parameters, grain yield, and drought susceptibility index.

		Stability as stand. dev.	Linear regression coefficient
Grain Yield Bouider	1985	-0.400**	-0.371**
	1986	-0.123	-0.168*
Grain Yield Breda	1985	-0.147	-0.141
Grain Yield Tel Hadya	1985	0.722***	0.754***
	1986	0.663***	0.644***
Drought susc. index	1985	0.640***	0.642***
	1986	0.303**	0.340**

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

Table 15. Relationship between grain yield and stability in bulk families selected in stress (Bouider) and nonstress (Tel Hadya) environments.

Selection criterion		No. of families	Grain yield (kg/ha) Bouider 1985	1986	Tel Hadya 1985	1986	Stand dev.	Reg. coef.
Top 10% : Bouider		18	981	2699	4093	5186	1824a	0.93
Top 10% : Tel Hadya		18	1101	1833	4734	5842	2190b	1.16
Bouider	1985	58	1549	1622	4310	5055	1809a	0.95
Tel Hadya	1985	90	1112	1746	4898	5147	2022b	1.07
Bouider	85, 86	15	1564	2288	4284	5083	1695a	0.89
Tel Hadya	85, 86	29	1079	1711	4915	5669	2186b	1.17

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

1. the Tel Hadya-type of conditions (both in terms of rainfall, rainfall distribution, and soil fertility) are rare in very dry areas (about 200 mm rainfall).

2. it is conceivable, as a medium term approach, to modify the germplasm that will be developed with such a methodology to make it more responsive to favourable conditions.

1.1.7. Analytical approaches to improve grain yield in stress environments

As indicated earlier, one cycle of selection was conducted in 1984/85 for plant height and 1000 kernel weight using pure lines extracted from landraces. The objective was to test the extent to which it is possible to improve grain yield by selecting for two characters associated with drought tolerance.

As compared with direct selection for grain yield (Table 10), selection for plant height and for 1000 kernel weight was less efficient not only when evaluated in terms of frequency of selected families maintaining their superiority over the best check for two cropping seasons, but also in terms of yield advantage (Table 16). Selection for 1000 kernel weight appears to have potential in increasing grain yield in barley landraces in more favourable environments.

Table 16. Effect on grain yield of selection for plant height and 1000 kernel weight in barley landraces (selection site: Breda).

Sel. crit.	No.lines sel. 85	No.lines outyielding best local check 85/86		
		Bouider	Breda	Tel Hadya
Height	100	26(100.6-155.2)	21(100.7-116.6)	4(101.0-111.0)
1000 KW	39	13(102.5-137.6)	6(101.0-118.8)	11(100.2-115.1)

The results presented in Fig. 1 and in Tables 1 and 5 suggest that wilting may be a reliable indicator of yield under stress conditions. By comparing, both at Tel Hadya and Bouider, the top and bottom 10% of F_4 families for wilting scored at Bouider (Fig. 3) it was found that the families with a lower wilting score mature slightly earlier at Tel Hadya ($P < 0.05$), are taller at Bouider ($P < 0.001$), have a lower drought susceptibility index ($P < 0.001$), and higher yield ($P < 0.001$) than the families with a higher wilting score. The differences for plant height, DSI, and grain yield are expressed only at Bouider to confirm that the screening of genotypes under non-stress conditions does not necessarily reveal differences which may appear only under stress conditions. No differences were observed between the two groups for early growth vigour, cold tolerance (1985 data), and days to heading, although there was a weak association between low wilting and earliness.

1.1.8. Landraces

Some of the results obtained with selection for grain yield, plant height, and 1000 kernel weight within the two landraces grown in Syria have been already discussed in the previous sections.

During 1985/86 1479 pure lines, each derived from a single head and representing 45 collection sites in Syria and Jordan, were evaluated at Bouider and Tel Hadya in 13 trials using a 12 X 12 modified augmented design with two row plots. The lines at both sites were evaluated for growth vigour, plant height, days to heading, days to maturity and grain yield, and at Tel Hadya for powdery mildew resistance, and percent lodging.

The selection criteria used were powdery mildew resistance, earliness, early growth vigour, grain yield at Bouider, and grain yield at Tel Hadya. A total of 634 lines were selected for further testing in the initial yield trials during 1986/87. As two row plot data are not reliable, especially regarding grain yield, selection pressure was lowered by choosing all lines outyielding Tadmor at Bouider, and all lines outyielding Rihane-03 at Tel Hadya. The lines selected at Bouider were earlier in heading and maturity than those selected at Tel Hadya (Table 17). However, the lines selected at Bouider when grown at Tel Hadya yielded significantly ($P < 0.001$) less than those selected at Tel Hadya. The lines selected at Tel Hadya, with few exceptions, did not perform well at Bouider, corroborating similar evidence obtained with different types of germplasm.

Figure 3. Expected correlated responses to selection at Bouider and Tel Hadya for high (H) and low (L) wilting scored at Bouider (*$P< 0.05$;***$P< 0.001$).

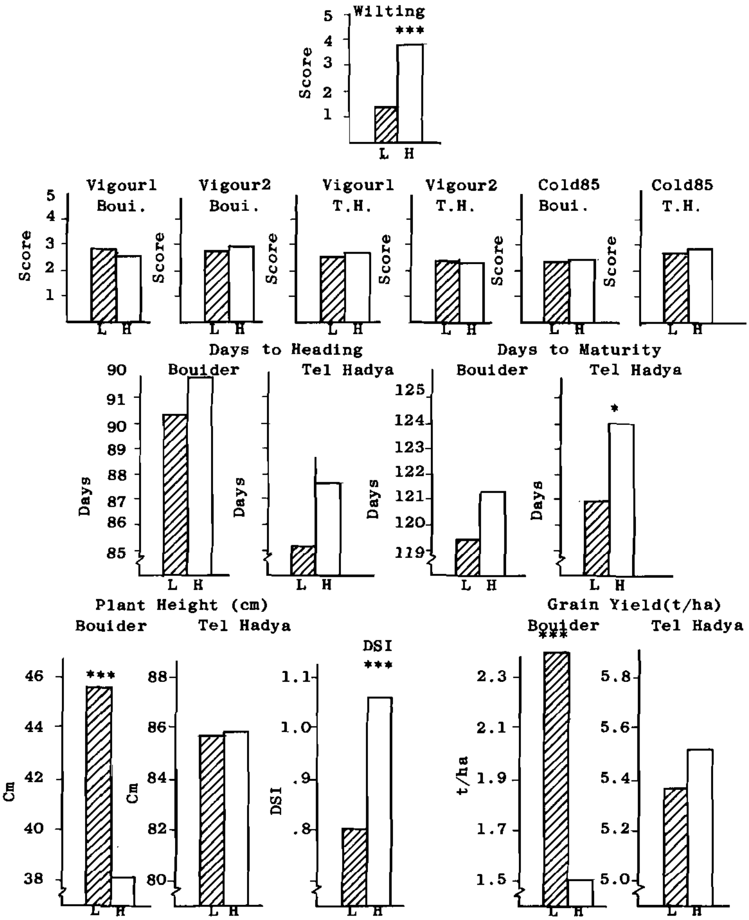


Table 17. Mean and range of pure lines from landraces selected at Bouider and Tel Hadya for grain yield (g/plot) in 1985/86.

Character	Bouider			Tel Hadya		
	Select. Bouider	Selected T. Hadya	Checks	Select. Bouider	Selected T. Hadya	Checks
Days to heading	88*** (80-99)	91 (84-102)	86-96	88*** (79-99)	90 (82-98)	83-95
Days to maturity	116*** (113-125)	120 (114-127)	115-125	123*** (119-134)	125*** (121-132)	122-128
Grain fill. period	28 (23-39)	29 (21-35)	28-32	35 (29-45)	35 (28-43)	34-40
Plant height	45 (30-75)	43 (30-65)	42-50	85 (70-100)	86 (65-105)	80-94
Lodging(1)				2.4* (1 - 5)	2.0 (1 - 3)	1-2.7
Powdery mildew(2)				5.4 (1-8)	5.3 (2-7)	0.5-6.6
Grain yield	376*** (165-870)	303 (90-520)	205-347	833*** (190-1250)	1153 (920-1385)	787-1029

(1) on a 1-5 scale, (2) on a 1-9 scale, *P<0.05, ***P<0.001 for the comparison between selections at Bouider and Tel Hadya in the same testing site.

The lines not yet evaluated (about 5000) have been rejuvinated at Tel Hadya, and will be evaluated at the rate of about 600 per year starting in 1986/87.

Pure-line selection within landraces, which started in 1983/84 with the agronomic evaluation at Breda of 78 pure lines, so far indicates that a large amount of readily available genetic diversity is available within landraces, and that this diversity can be utilized in the short term to improve barley yields in stress environments.

Using this strategy we identified a line, named Tadmor, which outyielded Arabi Aswad at Bouider by 49% in 1984/85 (Table 18). The line was promoted to the 1985/86 on-farm verification trials conducted in six locations in zone C and 9 locations in zone B. In zone C, the area for which the line was specifically selected, Tadmor ranked first and significantly outyielded (P < 0.05) Arabi Aswad. While the result is certainly not spectacular, it does show the potential of using landrace diversity for specific ecological niches. This is further corroborated by the identification of other lines such as 39/60, a white seeded line collected at Um-Zeitoun, near Sweida, which outyielded Tadmor by about 30% during 1985/86.

Table 18. Grain yield (kg/ha) of Tadmor, a pure line selected from a local cultivar of barley, in sites receiving less than 250 mm of annual rainfall.

Material	1984/85 Bouider	1985/86 Mean of 5 locations
Tadmor	2428a	1785a
Arabi Aswad	1633b	1580b

Values followed by different letters are significantly different (P < 0.05)

The work on locally adapted germplasm is at present limited to the two barley landraces grown in Syria. Therefore the benefits are likely to be limited to a small geographical area. Even so the purpose of this work is to develop and test work models with locally adapted cultivars which may be used by national programs with their own adapted germplasm.

1.1.9. Hordeum spontaneum

The work on Hordeum spontaneum is conducted to identify sources of resistance to severe drought stress. This research comprises an additional strategy for increasing yield stability in drought prone environments.

Four sets of material were evaluated at Bouider in 1985/86:

a) F_4 families H. vulgare x H. spontaneum selected in 1984/85
b) selected accessions od H. spontaneum
c) new accessions of H. spontaneum
d) natural crosses between H. vulgare and H. spontaneum collected in Cyprus by Dr. A. Hadjichristodoulou.

The F_4 families H. vulgare x H. spontaneum showed a large variability for growth habit, early growth vigour, earliness, and plant height.

Earliness and plant height were the most interesting attributes of some of these families grown in dry conditions in 1984/85. A number of these families have been already used in crosses with H. vulgare parents selected for kernel size. The other three sets of material were grown mainly to produce enough seed for a proper evaluation in the next cropping season.

Most of the work on H. spontaneum will be continued as part of the collaborative project on "Improvement of yield and yield stability of barley in stress environments" supported by the Italian Government expected to start at the end of 1986.

1.1.10. Observation Nurseries

As a result of the efforts of targetting germplasm for different environments, three types of barley observation nurseries were distributed to the national programs in the 1984/85 season: one for low rainfall areas (BON-LRA), one for moderate rainfall areas (BON-MRA), and one for high elevation areas (BON-CT). There were 100 genotypes in each nursery with a barley and a triticale check every twenty entries. Detailed information on the results are given in the "Annual Report for the Regional Barley Yield Trials and Observation Nurseries 1984-85". Table 19 contains names, pedigrees, and agronomic performances of the 5 highest yielding and/or the genotypes most frequently selected by national programs.

1.1.11. Regional Yield Trials

The most promising genotypes from observation nurseries are promoted to regional yield trials, which are orgainzed as a randomized block design with 24 genotypes (including an improved check, a long term check, and a national check). Plot consists of 6 rows 2.5 m long.

During the last few years a number of barley genotypes significantly outyielded the national check in a number of countries in the region. Examples of such genotypes in 1983/84 and in 1984/85 are given in Table 20. The countries where the germplasm distributed through the regional yield trials was more successful were Syria, Lebanon, Jordan, Morocco, Tunisia, Algeria, Ethiopia, and Pakistan. Some genotypes were identified in Lybia, Yemen A.R., Korea, and Portugal which significantly outyielded the national check.

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Table 19. Names, pedigrees, and performance of the 5 highest yielding lines and/or lines most frequently selected by national programs in the 3 barley observation nurseries, 1984-85.

Name or Cross/Pedigree	Yield	D.H	D.M	P.H
a) BON-LRA				
Roho/Masurka	3120	121	154	65
ICB77-0170-4AP-5AP-0AP				
WI 2197/Cam	3060	118	147	65
ICB77-0019-1AP-2AP-1AP-0AP				
T.H.Unk. 27	2650	126	154	75
Hja C4563/WI2291	2550	125	152	70
ICB78-0838-3AP-0AP				
CM/3/Api/CM67//Mona	2340	121	152	70
CMB77A-0125-2AP-2AP-1AP-0AP				
National Check	2130	114	145	64
No. of locations	10	20	14	19
b) BON-MRA				
Rihane-08	5670	133	149	80
Sel,12L-2AP-0AP				
Harbing/Avt//Aths	5570	136	151	90
CYB-0018-0882-3381-1AP-0AP				
As46/Aths*2	5450	132	149	85
Sel, 2L-1AP-3AP-1AP-0AP				
Aw Black/Aths	5270	131	148	80
CYB-0079-19A-6A-0A				
M25-84/Athiki	4860	131	150	65
CYB-0165-14A-2A-1A-0A				
Rihane (check)	5450	133	145	80
No. of locations	3	7	4	7
c) BON-CT				
Roho//Alger/Ceres, 362-1-1	5930	136	178	80
ICB77-0187-1AP-2AP-2AP-0AP				
Rihane-07	5800	125	162	75
Sel, 7L-4AP-0AP				
Kv/Prior	5680	131	167	75
ICB77-0372-1AP-0AP				
Api/CM67//Emir/Nacta/3/ MGH6355/4/Lignee 686	5560	128	161	70
ICB80-0669-0SH-5AP-0AP				
M64-76/Bon//Jo/York/3/M5/ Galt//As46/4/Hj34-80/Astrix	4970	128	163	80
CMSWB77A-0164-2AP-2AP-0AP				
National check	5610	125	161	70
No. of locations	4	13	7	11

Table 20. Names, pedigrees, and performance of lines which outyielded significantly the national check in regional yield trials in 1984/85 and 1985/86.

Name or cross/pedigree	1984/85 No. of countries	1984/85 % of check	1985/86 No. of countries	1985/86 % of check
Rihane-05				
Sel, 2L-1AP-4AP-0AP	5	81-31	6	99-17
Assala-04				
Sel,4L-3AP-0AP	3	112-63	4	89-25
Soufara-02				
Sel, 5AP - 0AP	5	58-36	4	107-26
CI 7117-9/Deir Alla 106	3	129-41	5	89-24
ICB77-3423-2AP-2AP-0AP				
Arr/Esp//Alger/Ceres, 362-1-1	4	83-65	4	120-22
LB-2L-9L-5AP-0AP				
WI 2197/Masurka	2	45-32	1	31

1.1.13. Mexico-based Barley Improvement Project

1.1.13.1. Introduction

The report covers joint CIMMYT/ICARDA barley project in Mexico from May 1985 to May 1986. During this period two additional generations of the breeding material have been produced.

Summer cycle (May-October) segregating barley populations were planted in three locations in the central plateau area of Mexico: El Batan (5 ha), Toluca (5 ha), and Lagunilla (1 ha). These were followed by winter cycle populations (November - May) in the northwestern part of Mexico near Ciudad Obregon, at Ciano's Experimental Station in the Yaqui Valley (15 ha).

Each location was in a different environment which allows for more efficient screening to important diseases. At CIMMYT headquarters at El Batan, leaf rust (Puccinia hordei) was artificially inoculated and satisfactory disease pressure obtained. In Toluca, a scald (Rynchosporium secalis) epidemic was obtained following artificial inoculation due to a favorable environment provided by frequent rains. In the Yaqui Valley, leaf and stem rust (Puccinia graminis) were favored by irrigation in desert-like conditions. In Lagunilla, the site where no artificial inoculations were made, net blotch (Helminthosporium teres), scald, and leaf rust naturally reached levels allowing for an efficient screening of the germplasm.

Field testing of advanced lines resistant to leaf rust and scald during the 1985-86 winter cycle confirmed their high yield potential (see Table 1).

Latin American activities increased and larger number of segregating lines were sent from Mexico to national programs in South American countries of the Andean Region for testing to major local diseases such as stripe rust (P. striiformis: sp. hordei), leaf rust, scald and barley yellow dwarf virus (BYDV).

In northwestern Mexico, two early maturing advanced lines with a planting-to-maturity range of 90 to 100 days, were grown in large demonstration trials, planted in early November, and harvested in February prior to recommended planting dates for cotton. The yields obtained during normal fallow periods have convinced Mexican scientists to release MONA/MZQ/DL71 to farmers, who will grow a barley as a catch up between soybeans and cotton.

An advanced line developed in collaboration with Chinese scientists who screened for scab resistance and barley yellow mosaic virus (BYMV), produced the line "Gobernadora". This line was tested in seven townships near Shanghai. The yield performance ranged from 7 to 60 percent higher than commercially grown cultivars and was superior at all locations.

1.1.13.2. Breeding for high yield potential and disease resistance for higher rainfall and irrigated conditions

The advanced lines tested in yield experiments were classified into three groups according to their maturity:

a) Early: lines with heading dates ranging between 44 and 63 days. The 50 lines tested were susceptible to leaf rust and scald.

b) Intermediate: lines with heading dates ranging between 67 to 85 days. All 275 lines tested were resistant to leaf rust and scald.

c) Late: lines with heading dates greater than 85 days. All 50 lines were resistant to leaf rust and scald.

Fifteen yield experiments were tested under irrigation during the winter cycle in the Yaqui Valley. Each experiment had 25 new lines and five checks, consisting of two commercial Mexican cultivars and three lines chosen for their previous high yields. The checks Centinela and Rumorosa are the most widely cultivated barley cultivars in Mexico.

Results reflect the high yield potential of the cross Gloria/Copal, which in 1984-85 also gave the highest yielding lines (Table 21). Only two different lines, CACO"/3/API/CM67//I594 and CIH'S'/LTE"S" matched yield potential of GLORIA/COPAL. The lines were resistant to leaf rust and scald in Mexico and were distributed in the International Barley Observation Nursery (IBON). Entries in the early trials were planted in ten row plots, with 10 centimeters between rows. This approach compensates for the low tillering capacity found of these barleys. No significant yield differences were observed when these new early lines were compared with the Swedish early variety MONA.

1.1.13.3. Incorporation of resistance to leaf rust

Leaf rust is considered a major constraint to barley production in South America. In Mexico leaf rust is present but is usually not as severe as in the Andean region.

The Mexican races of P. hordei were identified as races 7, 19 and 30 by the USDA Cooperative Rust Laboratory in Minnesota (USA) from samples collected at different Mexican site. During the winter cycle a new race infecting some previously resistant lines was collected. Virulence studies of this new isolate on seedlings in the greenhouse showed that the cultivar Aim, known to carry the Pa3 gene, was susceptible. The Pa3 gene was observed in Mexico and was also recognized as resistant to P. hordei in South America. No information on the virulence of leaf rust in the Andean region is available at this time.

Leaf rust resistance can be traced back to two sources: resistance coming from the Pa series and from minor genes reported having partial resistance, such as in the European varieties Vada, Georgie and Lofa Abed. The extreme scald susceptibility of the late heading advanced lines and cultivars, has considerably showed the incorporation of partial resistance to leaf rust, since most segregates are discarded.

Table 21. Highest yielding advanced barley lines at Ciano in 1985/86.

Early	Yield (tons/ha)
S"/4/EB489.6.3.2//Brea'S'/DL70/3/CEL/CI3909.2	6.7
Mona//MZ/D671	6.6
Mona (Check)	6.4
Mona/GWY//B1	6.1
B1/Guajillo/WI2274	6.1
Intermediate Maturity	
Gloria/Copal CMB81-295-30B-4Y-22M-1Y-1M-0Y	9.8
Gloria/Copal CMB81-295-30B-4Y-9M-1Y-2M-0Y	9.8
Caco'S'/3/Api/CM67//1594 CMB81-168-64-24-15M-1Y-3M-0Y	9.7
Gloria/Copal CMB81-295-30B-1Y-2M-2Y-1M-0Y	9.6
Gloria/Copal CMB81-295-30B-4Y-23M-1Y-2M-0Y	9.2
Gloria/Copal CMB81-295-30B-4Y-9M-3Y-2M-0Y	9.1
Cih'S'/Qlte"S' CMB82-1280-9B-4Y-1B-0Y	8.9
Gloria/Copal CMB81-295-30B-3Y-2M-2Y-2M-0Y	8.9
Gloria/Copal CMB81-295-30B-4Y-12M-1Y-2M-0Y	8.8
Gloria/Copal CMB81-295-30B-4Y-15M-2Y-3M-0Y	8.8
Bord rang/Jonguj//D /3/Gloria CMB82-2001-C-8B-1Y-1B-1B-1Y-0Y	8.3
Bord rang/Jongu//DC/3/Gloria CMB82-2001-C-8B-1Y-1B-2Y-0Y	8.1
Arupo	7.9
Pistacho	7.2
Centinela	6.7
Rumorosa	6.7

Yield of checks, average of 13 experiments except Rumorosa where the average is from seven experiments.

1.1.13.4. New sources of resistance to leaf rust

From a previous screening of 11,087 accessions from the world collection, only 285 entries were selected and planted in the Yaqui Valley during the winter of 1985-86. No change in their resistance was observed. The same number of entries were sent to Bolivia, Peru, Ecuador, and Colombia for screening against local isolates of leaf rust. In Bolivia and Colombia these entries were markedly susceptible to stripe rust (race 24) making any evaluation for leaf rust almost impossible. Only 17 accessions were identified as resistant to both stripe and leaf rust. These will be incorporated in our crossing program.

1.1.13.5. Incorporation of Leaf Rust Resistance in Early Barley

Early maturing barley may be grown in areas where land is fallowed between rotations, or may be used to escape frost or drought in areas with a short rainy season. Crosses addressed to correct the susceptibility to leaf and stem rust were made on a regular basis. Segregating populations were submitted to artificial inoculations of both diseases by growing the early barleys in areas surrounded by susceptible borders planted and inoculated earlier. The result was a severe infection of susceptible plants. The first resistant advanced lines will be yield tested next winter cycle in the Yaqui Valley.

1.1.13.6. Yield losses due to leaf rust

Yield losses on early barley plots treated and untreated with fungicide were compared during the winter cycle in the Yaqui Valley using three susceptible cultivars and one resistant cultivar. Lines were planted in small plots each with 10 five meter rows and replicated 8 times. Yield reduction of the three susceptible lines was 24, 25 and 28 percent which is equivalent to a grain loss of 908 to 1.422 kilograms per ha.

The severe outbreak of stem rust in the Yaqui Valley also allowed the classification of our parental material. Lines resistant to leaf and stem rust are listed in Table 22.

Table 22. Lines showing leaf and stem rust resistance at Ciano in 1985-86.

Line or variety	Diseases reading* Leaf Rust	Stem Rust
Aladin	0	TMS
Yriba	0	TMS
45-298.B	TR	5MS
53.85	TR	5MS
MoriII//Filsberk/Saxonia	TMR	5M
CR 270.2.3	TMR	5MS
St/Fld//C/3/C/4/Kby/5/Md/Atl//Arv/3/Br	TM	5M
Cal11	5MR	5MR
Sargent	5MR	10MR
Ase/3CM/4/Sut/5/Sb 401	5M	5MS
Daphne	5MS	5MS
DC Sel	10MR	TM
Brea'S'/3/447W/Emir//Nakta/4/SI'S'	10MR	TMS
Batina	10MR	5MS
18345 CO/Athos	10MR	5S
Mn.Rnb 293.80	10MR	5M
Mzq/Aths	10MR	5MS
Cyprus Ba	10MR	10MS
WI2231/Magnif 102	10MR	10M
CM67/Centeno//Cam	10MS	5M
Mary/Aths	10MS	10M
Beacon/Cel//Art/Aths	10MS	10M
Aramir/Vanja	15MR	TS

* Based on several scores throughout the season.

1.1.13.7. Incoporation of resistance to scald

Yield losses due to scald range from 33 percent to 43.1 in Mexico and Chile* respectively. The incorporation of genetic resistance by the program has produced resistant germplasm that is continuously distributed to national programs. Lines with increased leaf and stem resistance were frequently utilized in the crossing program. Since it was evident that a better level of resistance was obtained when two or more scald resistant parents were crossed, the recycling of this type of germplasm should be a constant practice in the breeding for scald resistance.

Scald screening was most efficient at Toluca, where Mexico, frequent rains provide optimum developmental conditions for the disease. This, in addition to our ability to create scald epidemic over large areas, has played a major role in producing resistant germplasm.

1.1.13.8 New sources of resistance to scald

A large number of new entries were screened in Mexico during the summer 1985 (Table 23). An outstanding group of resistant entries can be traced back to lines bred in California by Dr. R. Matchett (Northrup King). These lines have stiff straw and were of intermediate to late maturity.

1.1.13.9. Scald Virulence

The reaction of resistant parents to different races of scald presented in Mexico and Chile was determined by planting the crossing block in Temuco, Chile in 1985. From 82 parents with MR and R reactions to scald in Mexico, 22 entries were susceptible in Chile. A brief analysis of these susceptible parents may further split these lines into four groups:

1) Six Australian parents with resistance originating from crosses between: Tokak, Atlas 46 and Dampier.
2) Eight parents originating from Colombia or Ecuador.
3) Three parents from Ethiopia.
4) Parents of various origins including the differential cultivar Jet.

Most resistant parents maintained their resistance in both Chile and Mexico. A close cooperation with the Chilean program has thus evolved during the last three years. The breeder from Chile sends his F_3 populations for screening in Toluca. The resistant selections are advanced as F_4 in the winter cycle and returned to Chile as F_5.

1.1.13.10. Early barley

All segregating generations from this group were grown in Toluca for scald screening. In general, the early barley group was extremely susceptible to scald. Resistance is often associated with intermediate or late maturity. At present, only one genotype exists in the program that is resistant to scald and is early in maturity. In Mexico, earliness is favored by farmers of the central plateau, and therefore the development of resistant-early types has merit.

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* Investigation en Mejoramiento Genetico de la Cebada Maltera.

Table 23. Lines resistant to scald in Toluca in Summer 1985.

Cross	No.of lines	Disease score
ST/FLD//C/3/B/4/KB4/5/MD/ATL//ARV/3/BR	1	TR
ST/FLD//CM/3/BR.4.KBY/5/SMA1	1	R
4161/CI5831/4/ST/FLDP//CM/3/BR	4	R
ASE/3/CM/4//RO/5/SMA1	7	R-MR
13931/CM/BR/3/KBY/4/SMA1	5	R-TR
ASE/3CM/4/SUT/5/SMA1	1	R
4259/CI5831//SB401	7	R
2505/GUF//SMA1	2	TR-MR
CEN/2505//SMA1	1	TR
MD/2BR/3/CM72/4/2505/5/SMA1	6	R-TR
CEN/2505//SMA1	7	R-TR
4161/CI5831//SMA1	3	R
SMA/SB401	2	TR
ASE/3/CM/4/Seit/5/SB401	1	TR
4259/CI5831/UC F8042	3	R-TR

1.1.13.11. Formation of progenitors

The transfer of various scald resistant genes to a short improved genotype has been attempted by backcrossing. Since some of these genes are recessive, the BC1 was advanced to BC1 F_2 to identify resistant segregates. Original sources of scald resistance have poor agronomic plant type and a strong selection pressure against poor plant types had to be applied.

1.1.13.12. Stripe Rust

Since first reports in 1976 and related with the appearance of stripe rust *P. striiformis* f. sp. *hordei* (race 24), in Colombia, stripe rust has reached epidemic levels and has moved south to the Southern Cone. This has eliminated most of the barley landraces and commercial cultivars of the South America's Andean Region. The rapid response of the national barley programs in breeding for resistance to stripe rust has resulted in the release of resistant cultivars which, now dominate barley production. Because leaf rust races present in South America were able to infect most of the new varieties leaf rust has suddenly became a major threat. There is therefore an urgent need for germplasm with resistance to both leaf rust and stripe rust resistance. All segregating progeny were screened in South America since stripe rust race 24 is not present in Mexico. Last year segregating populations up to F_5 and F_6 were grown in Bolivia and Ecuador were resistant advanced lines from both countries and were identified for yield testing in the next cycle. Some advanced lines in Ecuador showed excellent resistance to stripe rust on the leaves, but had limited infection on the spike. Lines and cultivars used as parental material in these crosses are listed in Table 24.

1.1.13.13. Pyramiding major resistance genes

Most of the best advanced lines selected for stripe rust in Bolivia, Ecuador and Colombia were obtained by crossing two or more stripe rust resistant parents. Pyramiding genes appears to be a successful methodology for obtaining better levels of disease resistance. An F_5 line (Lignee 527/Kober//Teran) selected in Ecuador and derived from three stripe rust resistant parents of different origins was resistant to stripe rust, leaf rust and scald, and will be incorporated as a parent in our crossing program.

Table 24. Differential reaction of barley lines to spike and leaf infection caused by stripe rust (race 24).

Line	Disease reaction	
	Leaf	Spike (percent)
Tal	20S	5
CI 12513/Toska	30S	t
CI 14032	40S	5
DC Sel	40S	15
Ahor 353.70	60S	5
Boy/Moch//Boy/3/Mcu 3048.ID	60S	10
BDGC/GAS//CI 1382/Comp. CR 236	80S	10
K 8755	ts	10
LB Bolivia	ts	20
PI 14116.2D/CI 12272//CI 12225.23D	ts	20
Tintern	ts	20
Orge 1	tr	20
CI 12638	tr	40
Orge 4	tr	60
UNA 80	ts	t
Quibenras	ts	t

1.1.13.14. Net Blotch

Net blotch may in some years be the most important disease on barley in Mexico's central plateau. Net blotch also occurs in the Andean Region, but is not as important as stripe rust, leaf rust, scald, or BYDV. Net blotch resistance is being gradually incorporated by crossing resistant parents and field selecting at Lagunilla, where the disease occurs naturally each year. An advanced line, Gloria/Come CMB87 -294 - 4Y - 1H - 6Y -2M - 1Y - 0B, has resistance to leaf rust, scald, and net blotch in Mexico. This line also has stiff straw and high yield potential. A small seed increase was planted in the winter season in the Yaqui Valley for testing in the central plateau by the Agronomy Training Program.

1.1.13.15. Source of Resistance

New introductions of barley germplasm in Mexico are first tested in the greenhouse as seedlings (Table 25) and then screened in the field. Resistant lines are identified and provided to national programs. The resistant lines also are entered into our crossing program.

Table 25. Resistant lines to isolates of net blotch in seedling test.

Spring Barley	Winter Barley
SD-29/Por/3/Apm/Aths/Gva/4/Ore	80.5166
Estate	GK 59
CI 5791	Jogangbori
Robur/142//Astrix/Sutter 332.1	Belt 67/1448
Robur/142//Astrix/Sutter 332.3	Sich 415.80
Amapa"S"	Sich 140.80
Zua'S'	80.5004
Manker//Api/CM67	80.5009
Gloria/Come	
Gus/Kby//Sma 1	

* Scale 1-5.

1.1.13.16. Winter X Spring crosses

Crossing between two different barley gene pools, offers the opportunity for rare combinations of disease resistance that most probably evolved in different regions, i.e. BYDV resistance was reported in winter germplasm claimed to be different from the Yd2 gene, which has been widely used in spring types. Crossing between these two groups has also provided late segregates in Mexico corresponding with proper maturity for adaptation in southern Chile. During the winter cycle in the Yaqui Valley, most of segregating germplasm of this late maturity group was susceptible to stem rust and discarded. Stem rust is not a major disease in Latin America, but resistance should be incorporated immediately to cope with susceptibility of spring x winter crosses. Winter parental material could be classified as susceptible in comparison with spring germplasm that showed differential reaction and was largely resistant.

- H.E. Vivar

1.2. Pathology

1.2.1. Multilocation testing for disease resistance

Multilocation testing of breeding material for disease resistance is an important part of the disease screening activity in Aleppo based project. By testing material prior to its inclusion in the International Nurseries, the quality of these nurseries are improved and cooperators are furnished with more information about the entries.

Testing is done in 'hot spots' where high disease pressure naturally exists, or by means of artificial inoculation. The former method might be criticized as test locations are not necessarily representative of normal barley growing conditions and under high disease pressure small, important, differences may not be detected. However, the advantages of exposing the material to different virulences, and to different diseases in a wide variety of different environments, outweigh disadvantages. In addition, although certainly not a first objective, the disease screening nurseries provide a mechanism of distributing germplasm to the national programs.

During 1985-86 three different disease nurseries were distributed to a selected number of collaborators. These were:

1. Preliminary Disease Nursery consisting of 340 lines under preliminary yield testing during 1985-86 season.

2. Key Location Disease Nursery, consisting of 160 lines from the advanced yield trial, (KLDN) 100 lines repeated for the second year in the preliminary yield trial, and 10 lines selected for specific disease resistance.

3. Barley Scald Nursery, consisting of 100 lines previously tested in KLDN or International Nurseries and performing well for scald resistance.

The locations from which data have thus far been received are listed in Table 26. In Table 27, the number of lines showing resistance to a disease are given. Barley diseases rarely occur alone. Powdery mildew and leaf rust are found together in the mild winter areas of North Africa. Powdery mildew and scald occur together in most barley growing areas, while yellow rust and scald are found in the higher altitude areas of Iran. The number of lines showing a low infection level to one disease as well as to one of the above mentioned combinations is listed in Table 27.

Of three lines showing resistance to the combination of leaf rust, powdery mildew and scald, only one was also resistant to yellow rust. These lines are presented in Table 28.

Table 26. Returned data of Barley Key Location Disease Nursery 1985-86 (as per October 1st, 1986).

Location	Yellow rust	Leaf rust	Powdery mildew	Scald	Covered smut
Tel Hadya	*			*	
Syria, Lattakia			*	*	
Lebanon, Terbol	*		*		
Jordan, Deir Alla		*	*		*
Tunisia, Beja		*	*	*	
Portugal, Elvas				*	
Italy, Perugia		*	*	*	
Cyprus, Athalassa		*	*	*	*
Mexico, Obregon		*			

Table 27. Entries from BKL 86 showing a low average level of infection over all location tested. Total number of lines tested: 270.

Disease	Selected criterion	Selected for for one disease	Selected for two diseases
YR	< 10%*	30	
			4
SC	< 3**	59	
			28
PM	< 3**	157	
			73
LR	< 10%*	104	

* Percentage severity
** 0-9 disease scoring scale

Table 28. Lines in BKL 86 showing resistance to leaf rust, powdery mildew and scald.

Entry No.	Name/pedigree
42	CI 01021/4/CM 67/U.Sask.1800//Pro/Cm 67/3/DL 70 CMB 77A-1474-6AP-0SH-1AP-1AP-0AP
174*	WI 2197/CI 13520 ICB 77-0014-1AP-2AP-1AP-1AP-1AP-0AP
249	Roho//Alger/Ceres.362-1-1 ICB 77-0187-1AP-2AP-1AP-1AP-0AP

* Entry No. 174 also shows resistance to yellow rust

1.2.2. Covered Smut Testing

In recent years research in barley pathology has shifted towards diseases of special importance in marginal areas. Yields in these areas are low and farmers are in most cases not willing or do not have the means to sow certified seed, or seed with fungicidal seed dressings. This practice makes a seed borne disease like covered smut, which is obsolete in developed agricultural areas, prevalent throughout the Middle East, North Africa, and Ethiopia.

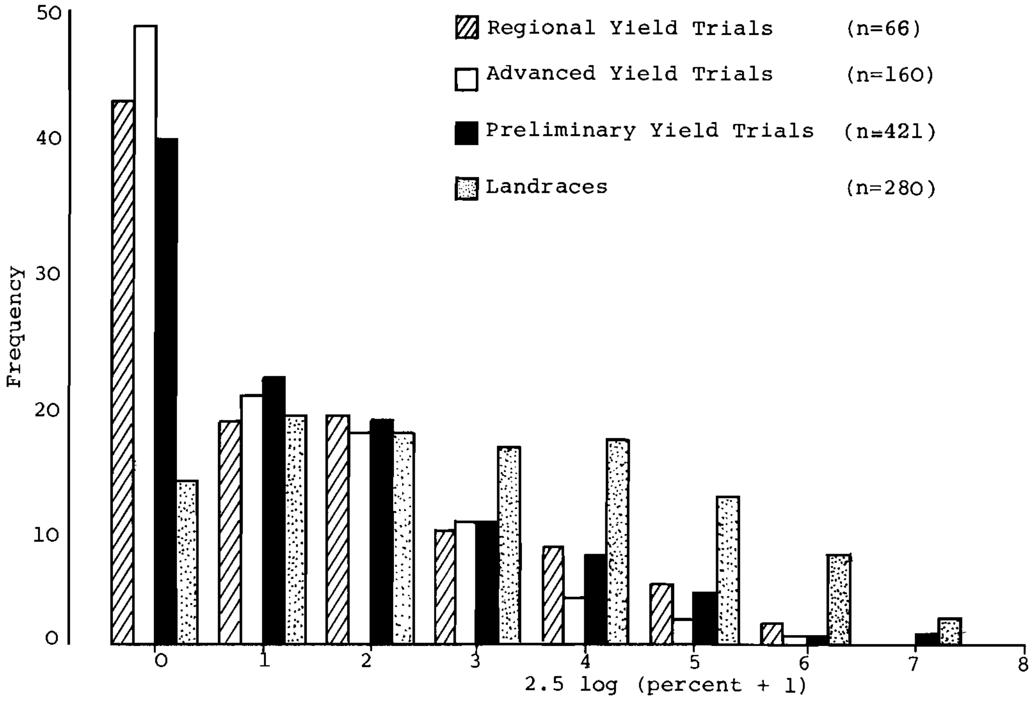
During the past season research on this disease has been considerably intensified. All material in preliminary and advanced yield testing, all entries in the International Yield Trials, and a set of 280 landraces have been screened after artificial inoculation. As results in the past were variable, special attention was given to the development of a repeatable inoculation procedure. Therefore inoculation was carried out by soaking the seed in a spore suspension. The procedure was carried out under vacuum to enable the spores to penetrate under the hull. Nurseries were planted in a randomized complete block design with two replicates and systematic checks. Every plot consisted of a single row of 1 meter. The number of infested heads and the total number of tillers were counted after maturity. To improve the homogeneity of the variances the percentages were transformed to a 0-9 scale according to the formula Y = 2.5 LOG (PERCENT + 1).

A comparison of the infestations within the different nurseries is given in Fig. 4. The higher susceptibility of local material as compared to material from the breeding program is obvious. This may indicate that newly identified parental material carries resistance to covered smut. Also it may well be that the growth habit of the advanced material, most of which heads far earlier than the local lines, enables them to escape the disease. However, no significant correlation between heading date and infestation was found within the advanced material nor within the set of local material.

For the coming year more detailed studies are planned to investigate the relationship between infestation and agronomic characters.

The fact that susceptible lines are found with high frequency within the Syrian landraces is important to the breeding program. Selection of resistant material should be relative easy and may have considerable impact on yield at the farmer's level.

Figure 4. Comparison of covered smut infestations within the different nurseries.



1.2.3. Testing local barleys for disease resistance

Within the Barley Project of the Cereal Improvement Program an increased effort in screening local barleys has resulted in the identification of a number of selections giving relatively large, stable yields in drought prone areas of northern Syria. From past observations it was felt that local cultivars were generally susceptible to diseases. This susceptibility showed when these landraces were cultivated under favourable (good water and nutrients) growing conditions. Therefore, a study was initiated to ivestigate the level and type of resistance of local barleys. Local barley populations probably exist in equilibrium with environmental stresses. These stresses can be abiotic such as drought or salinity, or biotic, such as diseases and insects. If a local population shows stress resistance this specific stress may have 'economic' importance within the collection area. A breeding program attempting to develop new, improved, germplasm for this, or similar, areas, will have to incorporate resistance to such stresses in the germplasm, and use of local cultivars possessing desirable traits could be used more effectively.

- J. van Leur, O. Mamluk

1.3. Agronomy and Physiology

The results presented in this section as well as in sections of other projects of this report dealing with cereal agronomy and physiology correspond to the first year of activity. The aim is to provide a physiology/agronomy input in an interdisciplinary effort to generate well adapted varieties for the areas of ICARDA's mandate. (For barley physiology/agronomy see also the durum wheat and bread wheat projects of this report).

1.3.1. The Effects of Sowing Depth and Coleoptile Length on Barley Establishment.

A common practice in planting barley in northern Syria is to make furrows about 30 cm apart and 15 to 20 cm in depth, broadcast the seed, and split the furrows to cover. In the planting process the seeds are distributed at various depths, ranging from 2 to at least 10 cm. Long coleoptiles should help the deep sown seeds emerge and threfore improve stand establishment. Variation in barley coleoptile length does exist (see Bread Wheat Cereal Physiology/Agronomy, this volume) and may be used in improvement programs.

A greenhouse experiment was conducted to test the hypothesis that long coleoptiles may improve stand establishment. The experiment was also designed to observe initial plant growth and the effects of drought in the early stages of plant development.

Three factors were studied in a split-split plot design with four replications. The main plots were assigned to four varieties which differed in coleoptile length. These were Wadi Hassa (5.68 cm, V1), Harmal (4.75 cm, V2), WI 2269 (3.65 cm, V3) and Tadmor (4.53 cm, V4). The sub-plots consisted of an irrigation treatment at two levels: wet, irrigated whenever tensiometers with the cup located in the center of the pot read 40 cb, and dry, irrigated at 80 cb. The sub-sub plots were allocated to sowing depths of 2.5, 5.0, 7.5 and 10 cm below the soil surface. Nineteen seeds were sown in each pot previously wetted to FC. The seeds were arranged in a circle with one seed in the middle.

The planting date (day 0) was February 9, 1986 and the plants were harvested on March 27, 1986, so the experiment spanned for 46 days. Two plants were left in each pot thereafter to score for heading date.

The variables measured in this experiment were number of coleoptiles emerged per pot (COSUR), coleoptile length (COLENG). These two variables were measured 14 days after planting, the time at which 9 equally spaced plants were left per pot. On day 23, the shoot water potential (PSI) and the abaxial leaf conductance (LC) were measured using a pressure chamber (Soil Moisture Equipment Co., Santa Barbara, California) and a MK-3 porometer (T Devices, England). Three consecutive readings were taken in all pots between 10 and 15 h. The average photosynthetically active radiation (PAR) during the measurements was 504 umol $m^{-2}s^{-1}$, one full replicate being measured at a time. At harvest, leaf number in the main shoot (LNO), tiller number per plant (TNO), subcrown internode length (SCIL), leaf length (LL), leaf width (LW), total number of leaves per plant (TLNO), stem green area (XSTM) and dry weight (DW) were recorded. Days to heading (DH) was scored through April.

The sanitary condition of the plants was good, powdery mildew being prevented by spraying once with Bayleton (0.5 g/l). The mean temperature during the experimental period was 18.8 ^{o}C.

Table 29 presents the number of coleoptiles which emerged for each variety and depth of sowing; V1 and V3 are the varieties with longest and shortest coleoptile respectively while V2 and V4 have coleoptiles with intermediate lengths.

Table 29. Number of coleoptiles emerged per pot.

Sowing depth (cm)	Variety V1	V2	V3	V4	Mean
2.5	16.7	16.4	15.9	14.5	15.9
5.0	14.6	11.5	9.5	13.6	12.3
7.5	7.8	5.6	4.9	4.2	5.6
10.0	5.2	4.1	1.6	2.0	3.2
Mean	11.1	9.4	8.0	8.6	

LSD 0.05 for depth at the same level of variety:2.9
LSD 0.05 for variety at the same level of depth:2.8

The analysis of variance (ANOVA) revealed significant ($P < 0.01$) effects of variety and sowing depth on the number of coleoptiles emerged per pot. All the varieties showed a significant decrease in the number of coleoptiles on the soil surface when planted at 7.5 cm depth or deeper, except for Harmal (V2) and WI 2269 (V3), intermediate and short coleoptile, respectively, which were already affected at the 5 cm sowing depth. Only 10 % of the coleoptiles emerged in V3 when planted at 10 cm depth, while the percentage of emergence for V1 (the longest coleoptile) from this depth was 31%. These results indicate that longer coleoptile varieties will stand a better chance for emergence when deep sown.

The coleoptile length of the varieties in the pots at the various planting depths is given in Table 30, along with the values obtained in a sand test (See Bread Wheat Cereal Physiology/Agronomy, this volume). The r^2 between the average coleoptile length for all depths and the germination chamber values was 0.97, indicating that the sand test is good for screening for the average coleoptile length of a genotype. As the sowing depth increased, however, the coleoptile length also increased reaching a maximum attained in V1 at the deepest sowing. In the other varieties it was reached at 7.5 cm depth. Analyses of the results (ANOVA) in Table 30 gave significant F values ($P < 0.01$) for variety and sowing depth.

Table 30. Coleoptile length of the varieties as affected by sowing depth.

Sowing depth	Variety				
(cm)	V1	V2	V3	V4	Mean
2.5	3.9	3.2	3.1	3.4	3.4
5.0	5.7	4.7	4.9	4.7	5.0
7.5	6.1	5.7	5.9	5.9	5.9
10.0	6.6	5.7	5.7	5.9	5.9
Mean	5.6	4.8	4.9	5.0	
Germination Chamber	5.7	4.8	3.7	4.5	

LSD 0.05 for depth at the same level of variety: 0.8 cm
LSD 0.05 for variety at the same level of depth: 0.8 cm

Sowing depth significantly affected ($P < 0.01$), the number of plants per pot, the averages being 17.3, 16.9, 16.8 and 14.2 with an LSD (0.05) of 0.72 for the 2.5, 5.0, 7.5 and 10.0 sowing depths respectively.

The difference between varieties in the effect of coleoptile length on the initial growth of the plants is worth exploring further.

Sowing depth and variety had an effect on most of the early growth variables as shown in Table 31. Deep sowing, beyond 7.5 cm reduced the leaf number in the main shoot (LNO), the tiller number (TNO), the total number of leaves per plant (TLNO) and the stem area (XSTEM) while there was a slight insignificant delay in heading date (DH). The main difference was observed in Tadmor (V4), with higher numbers of tillers and narrower leaves. Harmal (V2) had an increased stem area and higher total leaf number.

The difficulties in interpreting the effect of coleoptile length and sowing depth on early growth variables when working with non isogenic lines, are illustrated in Table 32 where the long coleoptile variety seems to be less affected in leaf number in the main stem, total leaf number and stem green area by the deep sowing eventhough tiller number was more affected.

Table 31. Effects of sowing depth and variety on early growth variables (see text for abreviations).

Sowing depth (cm)	Growth variable						
	LNO	TNO	LL (cm)	LW (cm)	TLNO	XSTM (cm^2)	DH (days)
2.5	6.1	3.6	13.6	0.54	15.3	27.5	58.7
5.0	5.9	3.7	18.2	0.54	14.1	24.2	59.8
7.5	5.7	3.1	14.9	0.59	13.6	27.8	59.9
10.0	5.0	2.5	14.2	0.55	10.4	18.5	61.4
LSD(0.05)	0.3	0.8	6.1	0.06	2.4	5.84	3.6
Variety							
V1	4.9	2.8	12.5	0.52	12.1	15.1	59.3
V2	6.5	2.3	19.4	0.63	12.6	32.7	60.2
V3	5.9	2.4	14.9	0.61	11.5	28.9	60.1
V4	5.2	5.4	14.3	0.47	17.2	21.3	-
LSD(0.05)	0.7	1.0	7.7	0.07	2.28	7.0	2.2

Table 32. Effects of sowing depth on early growth variables for two varieties differing in coleoptile length.

Sowing depth (cm)	Varieties							
	V1				V3			
	LNO	TNO	TLNO	XSTM	LNO	TNO	TLNO	XSTM
2.5	5.2	3.4	13.2	15.3	6.7	2.4	14.9	38.1
10.0	4.6	1.8	9.8	13.1	5.0	2.2	9.3	23.2
	(11.5)*	(47.0)	(25.7)	(14.3)	(25.3)	(8.3)	(37.5)	(39.1)
LSD(0.05)	0.6	1.5	4.8	11.7	0.6	1.5	4.8	11.7

* Values in parenthesis are % reduction of the variable at 10.0 compared to the 2.5 cm sowing depth.

1.3.2. Coleoptile Length and the Water Relations of the Plants.

Plants water status was assessed 23 days after planting at Zadoks stage 12-13, with a few plants starting tillering (Zadoks stage 21-22). The total water potential of the main shoot was determined and, at the same time the abaxial leaf conductance was measured in the last fully expanded leaf. Table 33 shows the values of water potential for variety and depth in the wet and dry treatments. The analysis of variance revealed significant effects ($P < 0.01$) for irrigation, sowing depth and the sowing depth X irrigation interaction. The second order interaction, variety X irrigation X sowing depth was also significant ($P < 0.05$).

The main effect of sowing depth appears to be of interest. The shallower the depth of sowing, the more negative the shoot water potential. This result came essentially from the dry treatment, as shown in Table 33 and depicted in Fig. 5, where the sowing depth x irrigation interaction can be easily seen.

Figure 5. Shoot water potential as related to sowing depth. LSD for depth is at the same level of irrigation. LSD for irrigation is at the same level of depth.

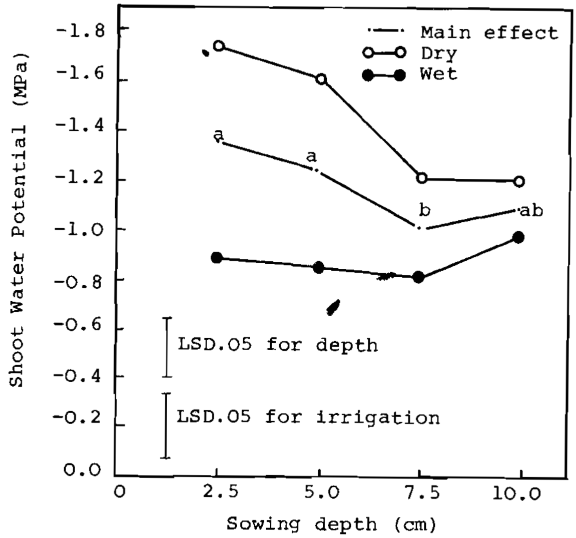


Figure 6. Abaxial leaf conductance in four barley genotypes as related to shoot water potential. Measurements taken in the last expanded leaf of plants grown in pots. Zadoks stage 1.2-1.3. Photosynthetically active radiation (PAR): 504 umol $m^{-2}s^{-1}$. Each point is the average of 12 readings.

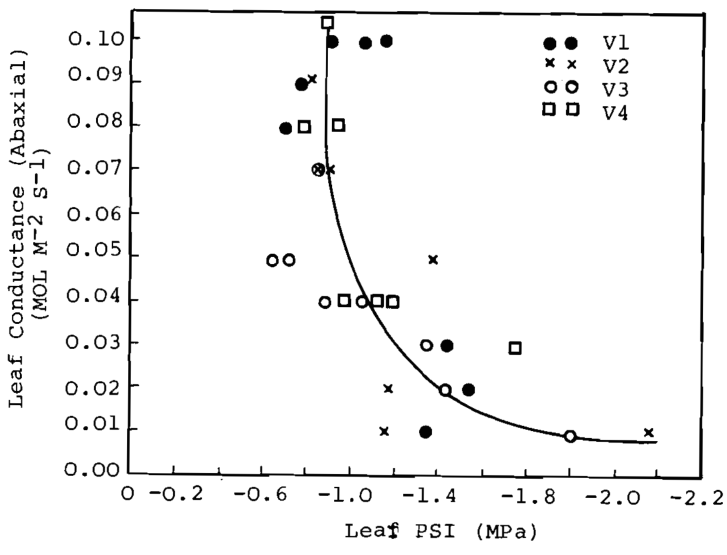


Table 33. Total water potential (MPa) of the main shoot at Zadoks stage 12-13.

Variety	Irrigation	Sowing depth (cm)				Mean
		2.5	5.0	7.5	10.0	
V1	Wet	-1.15	-0.70	-0.77	-1.07	-0.92
	Dry	-1.35	-1.52	-1.42	-0.90	-1.30
X	Irrigation	-1.25	-1.11	-1.10	-0.99	-1.11
V2	Wet	-0.82	-0.90	-0.85	-1.00	-0.89
	Dry	-2.27	-1.15	-1.38	-1.28	-1.62
X	Irrigation	-1.55	-1.03	-1.12	-1.14	-1.26
V3	Wet	-0.65	-0.88	-0.85	-0.72	-0.78
	Dry	-1.90	-1.42	-1.05	-1.35	-1.43
X	Irrigation	-1.28	-1.15	-0.95	-1.04	-1.11
V4	Wet	-0.92	-0.88	-0.78	-1.10	-0.92
	Dry	-1.42	-1.92	-0.97	-1.17	-1.38
X	Irrigation	-1.17	-1.40	-0.88	-1.14	-1.15
Mean	Wet	-0.89	-0.84	-0.81	-0.98	
	Dry	-1.74	-1.61	-1.21	-1.18	
X	Irrigation	-1.36	-1.23	-1.01	-1.08	
Mean for depth		-1.31	-1.22	-1.01	-1.07	

LSD (0.05) for depth = 0.17
LSD (0.05) for variety = 0.15
LSD (0.05) for irrigation at the same level of variety = 0.35
LSD (0.05) for depth at the same level of variety = 0.34
LSD (0.05) for variety at the same level of depth = 0.33
LSD (0.05) for depth at the same level of irrigation = 0.24
LSD (0.05) for irrigation at the same level of depth = 0.27

Leaf conductance (LC) is another variable closely related to water stress. Table 34 presents the results obtained at the same time the total water potential was measured. Significant effects ($P < 0.01$) were observed only for varieties and irrigation treatments, sowing depth being nonsignificant. Of note in Table 34 is that the variety with the longest coleoptile had the highest mean LC while that with the shortest coleoptile had the lowest mean LC. The landraces Wadi Hassa (V1) and Tadmor (V4) did not show differences in LC with respect to irrigation treatment when sown deep. From these data and the data on PSI, generalized relationship between shoot water potential and LC can be obtained. This relationship (Fig. 6), indicates that under the conditions of the experiment barley stomata close at about -1.4 MPa at early growth stages.

Table 34. Effect of variety and irrigation treatment on leaf conductance (mol $m^{-2}S^{-1}$) of the abaxial leaf surface. V1 = Wadi Hassa, V2 = Harmal, V3 = WI 2269, V4 = Tadmor.

Sowing depth (cm)	Irrigation	Varieties				
		V1	V2	V3	V4	Mean
2.5	Wet	0.10	0.09	0.05	0.08	0.08
	Dry	0.01	0.02	0.01	0.03	0.02
	X	0.06	0.06	0.03	0.06	0.05
5.0	Wet	0.08	0.07	0.04	0.12	0.08
	Dry	0.02	0.01	0.02	0.06	0.03
	X	0.05	0.04	0.03	0.09	0.06
7.5	Wet	0.09	0.07	0.07	0.08	0.08
	Dry	0.03	0.05	0.04	0.04	0.04
	X	0.06	0.06	0.06	0.07	0.06
10.0	Wet	0.10	0.04	0.05	0.04	0.06
	Dry	0.10	0.02	0.03	0.04	0.05
	X	0.10	0.03	0.04	0.04	0.06
Mean		0.06 a	0.05 b	0.04 c		0.06 a

LSD (0.05) Irrigations at the same level of depth = 0.03
LSD (0.05) Depth at the same level of irrigation = 0.03
LSD (0.05) Irrigation at the same level of variety= 0.04

The water relations of the plants were reassessed on day 38 after planting, three days after watering of all treatments, and after five irrigation cycles in the wet and 3 in the dry treatment had been completed. At this time the plants had tillered and stems were elongating, (Zadoks stages 31-33) with the exception of Tadmor, which was at the tillering stage (Zadoks 24-26) and seemed to require a higher degree of vernalization for stem extension. Only the treatments V1 and V3 at 2.5 and 10.0 cm depths, wet and dry, which were representive of the longest and shortest subcrown internode length (SCIL) were measured. The subcrown internode lengths were only affected by sowing depth (Table 35). The deeper the seed, the longer SCIL.

Table 35. Subcrown internode length (cm) as affected by variety and sowing depth.

Sowing depth (cm)	Varieties				
	V1	V2	V3	V4	Mean
2.5	1.0	0.6	0.6	0.9	0.8
5.0	3.1	3.8	2.7	2.0	2.9
7.5	4.4	3.3	3.8	3.7	3.8
10.0	5.3	4.6	5.4	5.3	5.2
Mean	3.5	3.0	3.1	3.0	

LSD (0.05) for variety : 0.9 cm.
LSD (0.05) for depth : 0.7 cm.
LSD (0.05) for depth at the same level of variety : 1.5 cm.
LSD (0.05) for variety at the same level of depth : 1.6 cm.

Neither variety, irrigation nor depth had an effect on PSI at this time. The only significant term ($P < 0.05$) of the analysis of variance was a variety X irrigation interaction is shown in Table 36.

Table 36. Water potential, PSI. Variety X irrigation interaction, three days after rewatering.

Irrigation	Variety V1	V3	Mean
Wet	-1.97	-2.22	-2.10
Dry	-2.29	-1.76	-2.03
Mean	-2.13	-1.99	

LSD(0.05) Varieties : 0.26
LSD(0.05) Irrigation: 0.38
LSD(0.05) Irrigation at the same level of variety:0.54
LSD(0.05) Varieties at the same level of irrigation:0.46

Inspecting the simple effects, the origin of the interaction in Table 36 was found in a very low PSI (-2.8 MPa) in the dry treatment of V1 at 2.5 cm depth, in comparison with -2.0 MPa for V3 at equal combination of the other factors. A similar situation occured with V3 but in the wet treatment. The same type of interaction (data not shown) was observed with leaf conductance. The physiological explanation may be related to a different root development under both contrasting cases.

1.3.3. Effect of Water Stress on the Early Growth Variables.

It was previously shown that the irrigation treatments had affected the water status of plants as assessed by their shoot water potential and leaf conductance. Irrigation had no significant effects on leaf number in the main shoot but did affect tillering and total leaf number ($P < 0.01$). There was also a significant interaction between irrigation and depth ($P < 0.05$) in the case of leaf number. Table 37 shows the main and simple effects of irrigation on these variables. The source of the interaction is seen to be in the deep planted seeds.

Table 37. Main and simple effect of irrigation on early growth variables.

Sowing depth (cm)	Irrigation	Mean of varieties LNO	TNO	TLNO
	Wet	6.2	4.1	16.8
2.5	Dry	6.0	3.1	13.8
	Wet	6.0	4.1	14.9
5.0	Dry	5.8	3.2	13.3
	Wet	6.0	3.9	16.6
7.5	Dry	5.4	2.2	10.4
	Wet	4.8	2.9	11.3
10.0	Dry	5.2	2.0	9.5
	Wet	5.7	3.7	14.9
Mean	Dry	5.8	2.7	11.8
LSD(0.05) Irrigation at the same level of depth		0.7	1.1	3.4
LSD (0.05) Irrigation		0.5	0.6	1.7

It may be concluded that long coleoptiles help in establishing the barley plants when sown deep. A sowing depth beyond 5 cm invariably depressed early growth irrespective of coleoptile length, which implies that sowing rates and/or plant spacing should be adjusted accordingly to avoid impairment of early canopy development when seeds are sown deep.

There is an indication that sowing depth affects the water relations of the crop in terms of water potential and leaf conductance which warrants a more detailed study.

1.3.4. Row Spacing, Sowing Date and Depth of Barley Genotypes under Low Rainfall Mediterranean Environments.

Barley is grown in North Africa and Southwest Asia in Mediterranean environments at altitudes below 1000 meters, where agricultural potential is determined by the incidence of sporadic and highly variable winter rainfall.

Spring barley varieties are grown in these environments. They are sown during autumn (October - December) with the onset of the first rains. They then grow during the winter months when low temperatures are the main limiting factor. Flowering occurs in early spring accompanied by the risk of late frosts. They are harvested in early summer when the grain filling period is limited by drought and high temperatures.

Where water limits crop performance the suggestion has been made to view yield as the product of three factors related by the equation,

$$Y = T * TE * HI$$

T is crop transpiration TE the transpiration efficiency or efficiency of dry matter production per unit water used by the plants and HI the harvest index, or how much yield is produced per unit total dry matter. The interaction between these factors is rare and therefore an increase of any one of them in a given environment should increase yield.

To maximize transpiration as a fraction of evapotranspiration (ET), practices should be adopted to promote a rapid, even development of leaf area by the crop. Early planting as well as decreased row spacing (Acevedo, 1985) are agronomic practices which when coupled to a proper fertilizer management (Cooper et al, 1983) could help in increasing ground cover and therefore the transpiration component of ET. The transpiration efficiency is very much affected by the vapor pressure deficit of the atmosphere, values being higher at reduced transpiration rate or in other words at low vapor pressure deficit. Growth during winter months uses less water than at other times of the year. Because of this and because of increased transpiration efficiency ground cover by the crop during winter months is desirable.

If crops are to be sown early, seedling drought may become important. A possible means to avoid seedling drought could be to deep sow seeds since the soil profile is dry at the start of the season and seeds will not germinate unless sufficient water has accumulated to reach them. Sowing should be performed prior to the first effective rainfalls to achieve this goal, and seedlings with long coleoptiles should be preferred to avoid difficulties in emergence and stand establishment.

With the above views in mind, an experiment was performed where three agronomic factors were tested. These were row spacing, sowing date, and sowing depth. These factors were studied in three barley varieties having similar phenology but differing in coleoptile length. The experiment was repeated at two sites differing in long term average annual rainfall. To test the hypothesis that long coleoptiles would help plant emergence a pot experiment in the greenhouse was performed (see 1.3.1).

The barley varieties differing in coleoptile length, namely Wadi Hassa (5.68 cm), Harmal (4.75 cm) and WI 2269 (3.65 cm), as determined in a germination chamber (see Bread wheat cereal physiology/agronomy, this volume) were planted at 10, 20 and 40 cm spacings, 3, 7 and 10 cm sowing depths and three planting dates (early, medium and late). The experimental design consisted of a single replication 3^4 factorial with nine blocks. The three factor interactions were partially confounded.

The experiment was repeated at Tel Hadya, ICARDA's main experiment station in northern Syria (36°N, 37°E, 392 m elevation with a long term average annual rainfall of 332 + 97 mm) and Breda (35° 55'N, 37° 10'E, 350 m elevation with a long term average annual rainfall of 278 + 102 mm).

Crop husbandry was that commonly followed by the Cereals Improvement Program at ICARDA. The sowing rate was adjusted to 250 plants per m^2. The plot size was 1.2 m width and 2.5 m long, and consisted of 12, 6 and 3 rows according to the row spacing treatment. One square meter per plot was harvested at the end of the season, eliminating the border rows and adjusting the length of harvest to complete the area.

Planting dates varied according to the sites. The planting and emergence dates for Tel Hadya and Breda are presented in Table 38. Due to the delay in the onset of rain at Tel Hadya early planting areas were irrigated with 4.5 cm of water on December 3/85.

Table 38. Planting and emergence date at Tel Hadya and Breda.

Planting treatment	Sowing date		Emergence date	
	Tel Hadya	Breda	Tel Hadya	Breda
Early	October 25	October 27	December 12	January 1
Medium	December 17	January 9	January 10	January 26
Late	January 17	January 27	February 2	February 10

The following variables were measured in these experiments: number of plants per m^2 (PNO) at Zadoks stage 11-12, subcrown internode length (SCIL) at Zadoks stage 22-23, tiller number per m^2 (TNO) at stem elongation, ground cover (GC) at late tillering, growth habit (GH) at the tillering stage, leaf rolling (Roll) at the tillering stage, predawn water potential (PSI) at heading, plant height (PLHT), peduncle length (PLNG), spike length (SPLNG) during grain filling, head number per m^2 (HNO), biological yield (BIOY, g/m^2), head weight (HWT, g/m^2), grain yield (GWT, g/m^2), straw weight (STWT, g/m^2), and harvest index (HI) at harvest. The last two values were calculated. Powdery mildew was prevented by spraying once with Bayleton (0.5 g/l).

The results of this experiment will be presented in terms of the main effects and two factor interactions on crop establishment, growth variables, and yield variables for each site. Total rainfall from germination to physiological maturity was 275 mm at Tel Hadya and 195 mm at Breda.

Crop establishment can be assessed in terms of plant number per unit surface, these values along with the ground cover attained at late tillering are presented in Table 39. Visual observations were used to assess ground cover using a 0-10 scale, where 0 indicates absence of plants and 10 corresponds to 100 % ground cover.

Coleoptile length (variety) had a highly significant effect ($P < 0.01$) on the number of plants per m^2 (PNO) at the driest site but did not have any effect at Tel Hadya. The longer the coleoptile of the genotypes the higher the number of emerged plants at the dry site. Early planting and deep sowing (7-10 cm) also significantly favored stand establishment at Breda. Sowing depth had no effect and early sowing decreased the number of plants per m^2 at Tel Hadya. Row spacing and planting date had a significant effect ($P < 0.01$) on ground cover at both sites, the best spacing being 20 cm at Tel Hadya and 10 cm at Breda to achieve a maximum ground cover. At both sites early planting favored ground cover. Deep (7-10 cm) sowing significantly ($P < 0.01$) increased ground cover at the driest site only. The results indicate that the crop establishment is favored by long coleoptile varieties, deep (7-10 cm) planted early in the season at the dry site and that the advantages tend to disappear in the higher rainfall site. They also show that close row spacing and early planting date will in general improve the ground cover by the crop and hence presumably increase the transpiration component of evapotranspiration. The planting depth x sowing date interaction was significant ($P < 0.01$) at Breda. Fig. 7a shows that deep sowing becomes critical when associated to early planting. Other significant interactions at the dry site were row spacing x planting date (P

< 0.05) and row spacing x sowing depth ($P < 0.05$) with regard to crop establishment (PNO). Decreased row spacing improved stand establishment when the crop was planted early in the season. In case of late planting the crop establishment was favored by increased row spacing (Fig. 7b) and deep sowing (data not shown).

Table 39. Effect of variety, row spacing, planting date and depth on crop establishment and ground cover.

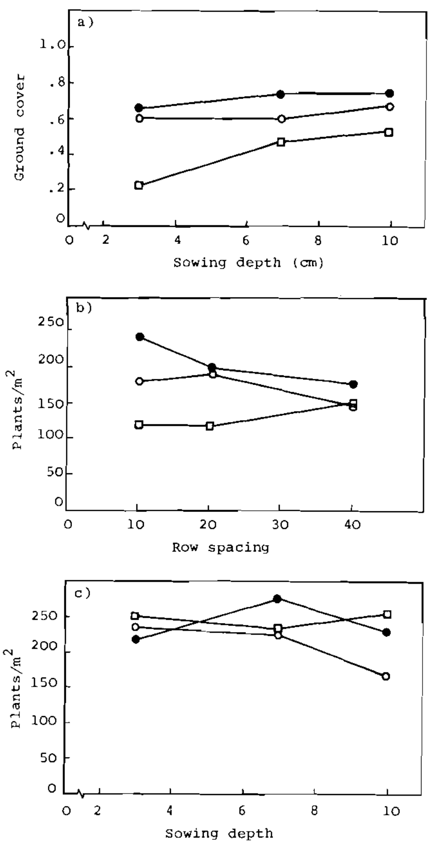
Factor	Tel Hadya		Breda	
	PNO (Pl/m^2)	GC	PNO (Pl/m^2)	GC
Variety				
W. Hassa (L)	247	7.0	202a**	6.0
Harmal (M)	229	6.7	154b	5.8
WI 2269 (S)	222	6.5	158b	5.6
Row spacing				
10 cm	234	7.4a**	182	7.1a**
20 cm	219	7.4a	172	5.9b
40 cm	244	5.5b	160	4.3c
Planting date				
Early	209b*	7.6a**	209a**	7.1a**
Medium	243a	7.4a	174b	6.2b
Late	245a	5.2b	130c	4.1c
Sowing depth				
3 cm	234	6.8	149b*	4.9b**
7 cm	245	6.9	178a	6.1a
10 cm	218	6.6	180a	6.4a

n = 27, * $P < 0.05$, ** $P < 0.01$

A significant interaction between planting date and sowing depth ($P < 0.05$) shows (Fig. 7c) that at Tel Hadya medium planting at relatively shallow depths (3-7 cm) produced a better crop establishment than early planting associated to deep sowing which reduced the plant number/m^2. From these data it may be inferred that different planting strategies may be needed to establish barley in relatively high rainfall areas (ca. 300 mm) as compared to low rainfall zones (ca. 200 mm).

The effects of the treatments on growth variables at Tel Hadya and Breda are given in Tables 40 and 41. Growth habit (GH) was scored on a 1-3 scale where 1 was erect and 3 prostrate. The score for plant vigor (VIG) was from 1 to 5, increasing according to a visual vigor observation. The length of the peduncle (PLNG) was measured from the penultimate node to the basal spike node, and plant height (PLHT) was measured from the soil surface to the top of the ears (awns excluded).

Figure 7. a) Effect of sowing depth on ground cover for early (● ●), medium (O O), and late (X X) planting at Breda. b) Effect of row spacing on plant number for early (● ●), medium (O O) and, late (X X) planting at Breda, c) Effect of sowing depth on crop establishment for early (● ●), medium (O O) and late planting (X X) at Tel Hadya.



Sowing depth did not have an effect on any of the growth variables measured at Tel Hadya. Deep sowing, however, increased plant vigor ($P < 0.05$) and plant height ($P < 0.01$) at Breda. Early planting significantly ($P < 0.01$) favored all the growth variables measured, both at Tel Hadya and Breda, the effect being more dramatic in the Breda experiment (Table 41) specially in the number of tillers per unit surface. Decreased row spacing significantly ($P < 0.01$) increased tillering and decreased plant vigor at both sites, plant height was decreased at Tel Hadya and increased at Breda and peduncle length was not affected at either site by row spacing. Other than the agronomic implication, the results of row spacing are relevant to the breeders' assessment of genotype behavior. Varietal effects were only observed in plant height and peduncle length, the latter being affected only by planting date at each site. This indicates that peduncle length is a relatively stable parameter and has probable usefulness as a screening tool.

Table 40. Effect of variety, row spacing, planting date and depth on growth variables at Tel Hadya.

Factor	Variable				
	TNO (Tillers/m^2)	GH	VIG	PLHT (cm)	PLNG (cm)
Variety					
W. Hassa (L)	745 a*	1.8 a**	3.5	66.6 c**	16.2 b**
Harmal (M)	661 b	1.5 b	3.6	79.2 a	18.6 a
WI 2269 (S)	658 c	1.4 b	3.4	78.2 b	18.2 a
Row spacing					
10 cm	805 a**	1.8 a**	3.1 c**	73.4 b*	16.9
20 cm	690 b	1.4 b	3.5 b	74.2 b	18.0
40 cm	588 c	1.4 b	3.8 a	76.4 a	18.2
Planting date					
Early	739 a**	1.3 c**	3.8 a**	82.2 a**	19.2 a**
Medium	710 a	1.4 b	3.8 a	75.8 b	17.7 b
Late	615 b	1.9 a	2.9 b	66.0 c	16.3 c
Sowing depth					
3 cm	700	1.5	3.6	74.2	17.1
7 cm	717	1.6	3.5	75.1	18.1
10 cm	646	1.6	3.4	74.7	17.8

n = 27, * $P < 0.05$, ** $P < 0.01$

Table 41. Effect of variety, row spacing, planting date and depth on growth variables at Breda.

Factor	Variable				
	TNO (Tillers/m^2)	GH	VIG (cm)	PLHT (cm)	PLNG
Variety					
W. Hassa (L)	535	1.0	2.6	37.8b*	8.6b**
Harmal (M)	494	1.0	2.5	44.2a	10.0a
WI 2269 (S)	480	1.0	2.6	43.1a	9.7a
Row spacing					
10 cm	638a**	1.0	2.3b**	43.8a*	9.4
20 cm	466b	1.0	2.3b	38.2b	9.2
40 cm	404c	1.0	3.0a	43.0a	9.8
Planting date					
Early	703a**	1.0	3.0a**	51.2a**	11.5a**
Medium	490b	1.0	2.6b	45.0b	9.0b
Late	315c	1.1	2.1c	28.9c	7.8c
Sowing depth					
3 cm	463	1.1	2.3c*	35.4b**	9.6
7 cm	525	1.0	2.6b	45.0a	9.2
10 cm	520	1.0	3.0a	44.8a	9.6

n = 27, * $P < 0.05$, ** $P < 0.01$

The beneficial effects of deep sowing on stand establishment and ground cover at the dry site (Table 39) are consistent with the response observed in plant vigor and height due to this factor (Table 41). Early planting shows up in the growth variables in general as a good practice for both sites.

A significant ($P < 0.01$) interaction was observed at Tel Hadya but not at Breda between planting date and variety on tiller number, in fact, while tillering decreased as planting date was delayed, Harmal presented its highest tiller number when planted in the medium planting date.

At Breda there was an interaction between row spacing and variety ($P < 0.05$) on peduncle length such that in Harmal the peduncle length decreased with the wider row spacing while in W. Hassa and WI 2269 it increased.

Before analyzing the yield variables let us examine some developmental parameters such as head number per square meter (HNO), and spike length (SPLNG). These are presented in Table 42.

Table 42. Effect of variety, row spacing, planting date and depth on development variables.

	Variable			
	Tel Hadya		Breda	
	HNO	SPLNG	HNO	SPLNG
Variety				
W. Hassa (L)	448.7c**	7.9a**	353.4a*	5.9a**
Harmal (M)	513.2b	7.1b	312.5b	5.5b
WI 2269 (S)	541.1a	7.1b	301.7b	5.3b
Row spacing				
10 cm	515.8	7.7a*	349.2a**	5.6
20 cm	479.7	7.3b	331.2b	5.5
40 cm	507.5	7.2b	287.1c	5.8
Planting date				
Early	493.8	8.0a**	387.5a**	5.7a*
Medium	522.9	7.1b	339.1b	5.4b
Late	486.2	7.0b	241.0b	5.7a
Sowing depth				
3 cm	502.4	7.3	277.1a**	5.7
7 cm	513.9	7.5	336.1b	5.4
10 cm	486.7	7.4	354.5c	5.7

n = 27, * $P < 0.05$, ** $P < 0.01$

Table 42 shows that head number per m^2 was only influenced ($P < 0.01$) by variety at Tel Hadya and the agronomic factors did not have a significant effect on this variable at this site. At Breda however, the effect of row spacing, planting date and sowing depth on HNO was highly significant ($P < 0.01$). Close spacing, early planting and deep sowing favored the number of heads per m^2. Wadi Hassa, had the highest number of heads per m^2 contrary to what was observed at the wetter site where it had the lowest value.

Spike length at Tel-Hadya was significantly longer ($P < 0.01$) in Wadi Hassa at 10 cm row spacing ($P < 0.05$) and early planting ($P < 0.01$) while at Breda, agronomically, there were early planting effects ($P < 0.05$). Wadi Hassa also had the longest spike ($P < 0.01$).

At Tel Hadya the interaction between row spacing and planting date was significant for head number ($P < 0.01$), such that increasing row spacing from 10 to 20 cm decreased HNO only at the early planting.

Table 43 shows the main effects of the treatments on the yield variables at Tel Hadya and Breda. The results indicate a consistant positive effect ($P < 0.01$) of early planting on all the yield variables considered except for HI which was favored by medium and late planting at Tel Hadya and was not affected at Breda. This is the result of a better performance of the crop through the season as judged by the effects of early planting on crop establishment and ground cover (Table 39), on the growth variables (Table 40 and 41) and on the development variables (Table 42). Deep sowing (7-10 cm) had a positive effect on grain yield at the dry site resulting from better crop establishment, increased ground cover (Table 39), and probably increased plant height under drought (Table 41) indicating better growth, even though the visual assessment of plant vigor was significantly lower ($P < 0.05$, Table 41). Close row spacing also improved grain yield under drought. A better ground cover was observed in this treatment (Table 39), as well as a tendency towards increased plant number (insignificant). Tiller number per unit surface and plant height were also favored (Table 41). At the wet site (Tel Hadya), even though the closest row spacing had the highest yield, the differences were not significant. The variety Wadi Hassa, a landrace with the longest coleoptile, had the best crop establishment, grain yield, and harvest index at the dry site although it had reduced plant height and peduncle length as compared with the other varieties (Table 41). Head number per m^2 and the spike length were significantly higher in Wadi Hassa than in the other two varieties. At the wet site two improved varieties, Harmal and WI 2269, outyielded Wadi Hassa ($P < 0.01$) both in straw weight and grain yield.

Since the main difference between the two experiments is related to rainfall, and sowing date and depth appear as important factors in the low rainfall site, it is of interest to analyze the effect of the treatments on subcrown internode length (SCIL), leaf rolling (ROLL), and total water potential close to anthesis (PSI) measured in the flag leaf-1. These results are presented in Table 44. Leaf rolling was scored from 1 to 3, according to an average number of turning of the leaves.

Table 43. Effect of variety, row spacing date and depth on yield variables.

Factor	Variable							
	Tel Hadya				Breda			
	BIOY	STWT (g/m^2)	GWT	HI	BIOY	STWT (g/m^2)	GWT	HI
Variety								
W. Hassa (L)	781.4b**	448.4b**	333.3b**	0.42	354.0	184.2	169.7a**	0.48a**
Harmal (M)	938.4a	533.0a	406.0a	0.43	358.8	202.2	160.8a	0.44b
WI 2269 (S)	953.1a	541.2a	409.6a	0.43	322.7	188.3	134.4b	0.42c
Row spacing								
10 cm	928.1	525.8	400.1	0.43	364.7	196.2	168.5a*	0.46
20 cm	858.8	491.6	367.1	0.42	359.9	206.9	157.0b	0.43
40 cm	886.1	505.0	381.7	0.43	310.9	171.6	139.3c	0.45
Planting date								
Early	970.3a**	561.0a**	407.6a**	0.42c*	466.6a**	252.9a**	213.7a**	0.46
Medium	935.4b	526.1b	409.4a	0.44a	355.7a	197.4b	158.3b	0.44
Late	767.3c	435.5c	331.9b	0.43b	213.2b	124.5c	92.9c	0.44
Sowing depth								
3 cm	870.5	493.6	374.8	0.43	305.7	171.2	138.6b*	0.45
7 cm	910.0	521.6	388.3	0.42	356.7	196.9	159.8a	0.45
10 cm	892.5	507.3	385.8	0.43	373.0	206.7	166.4a	0.44

n = 27, * $P < 0.05$, ** $P < 0.01$

The advantage of early planting was associated with higher predawn water potential close to anthesis and a decreased rolling of the leaves. Deep sowing induced a significantly longer subcrown internode ($P < 0.01$) but this parameter did not seem to have an effect on the water status of the plants at the time that the water status was measured as neither interaction was significant. In spite of a better water status at Tel Hadya, Wadi Hassa did not produce the highest yields at this site.

Table 44. Effect of variety, row spacing, planting date and depth on subcrown internode length and predawn total water potential prior to anthesis (flag leaf -1) at Tel Hadya and Breda.

	Variable					
	Tel Hadya			Breda		
Factor	SCIL (cm)	ROLL	PSI (MPa)	SCIL (cm)	ROLL	PSI (MPa)
Variety						
W. Hassa (L)	1.1	1.4b**	-0.68a*	1.2a*	1.5c**	-1.2
Harmal (M)	0.7	2.0a	-0.91b	0.8b	1.9a	-1.4
WI 2269 (S)	0.9	2.0a	-0.91b	0.7b	1.8b	-1.5
Row spacing						
10 cm	0.9	1.8	-0.78	0.9	1.9a**	-1.4
20 cm	0.8	1.8	-0.81	0.8	1.8b	-1.4
40 cm	1.1	1.7	-0.91	0.9	1.5c	-1.2
Plant date						
Early	0.8	1.4c**	-0.55a**	0.8	1.6c**	-0.9a**
Medium	1.0	1.7b	-0.64a	0.8	1.7b	-1.7c
Late	1.0	2.2a	-1.31b	1.2	1.9a	-1.4b
Sowing depth						
3 cm	0.6c*	1.8	-0.83	0.4c**	1.7	-1.3
7 cm	0.9b	1.8	-0.82	0.9b	1.8	-1.4
10 cm	1.3a	1.7	-0.84	1.4a	1.7	-1.4

n = 27, * $P < 0.05$, ** $P < 0.01$

Simple correlations between variables may further help to identify the key crop attributes to be pursued in barley production for the dry and wet areas where it is cropped. Table 45 gives the simple correlations of plant number and growth variables for Tel Hadya and Breda. It is of interest to observe that plant number per m^2 was highly correlated with ground cover at Breda while this correlation was very poor and non significant at Tel Hadya. A good crop establishment was critical at the dry site. Tillering was important for a good ground cover at both sites. Plant number at the dry site was strongly and positively related to plant height that may be the result of increased ground cover and reduced evaporation from the soil surface. Neutron probe data, presently being processed, should shed some light on this point. Peduncle length was also associated with ground cover at the dry site. At the wet site plant height and peduncle length were actually decreased by plant number. Based on these results, Table 46 presents the correlations between plant number/m^2, ground cover, tiller number/m^2, plant height and peduncle length with head number/m^2 and spike length. At the dry site the crop establishment and growth variables were highly correlated with head number per m^2, the correlation with spike length however was non-significant or even negative. At the wet site, only plant height was correlated with head number per m^2 while tiller number per m^2, and ground cover were correlated with spike length.

Table 45. Simple correlations between crop establishment and growth variables at Tel Hadya and Breda.

Growth variables	Tel Hadya		Breda	
	PNO	GC	PNO	GC
TNO	0.38	0.62	0.60	0.73
VIG	0.26	0.39	0.40	0.33
PLHT	-0.26	0.37	0.51	0.64
PLNG	-0.20	0.11	0.18	0.29
GC	0.03	-	0.66	-

Significant r at $P < 0.05 = 0.22$
$P < 0.01 = 0.28$

Table 46. Simple correlations between growth and development variables at Tel Hadya and Breda.

Growth variables	Development variables: Tel Hadya HNO	Tel Hadya SPLNG	Breda HNO	Breda SPLNG
PNO	0.15	-0.15	0.69	0.15
TNO	0.14	0.25	0.71	0.07
GC	0.11	0.32	0.74	-0.14
PLHT	0.28	-0.17	0.65	-0.02
PLNG	0.09	0.22	0.41	0.19

Significant r at $P < 0.05 = 0.22$
$P < 0.01 = 0.28$

Table 47. Head number per m^2, peduncle length and spike length as related to yield variables.

	Yield variables: BIOY g/m^2	STWT g/m^2	GWT g/m^2	HI
Tel Hadya				
HNO	0.80	0.73	0.82	0.35
SPLNG	0.08	0.11	0.02	-0.18
PLNG	0.30	0.32	0.27	-0.06
Breda				
HNO	0.93	0.88	0.91	0.14
SPLNG	0.06	0.00	0.11	0.17
PLNG	0.56	0.54	0.54	0.01

Significant r at $P < 0.05 = 0.22$
$P < 0.01 = 0.28$

The results of Table 46 confirm that the key issues for growing barley under low rainfall mediterranean climates are crop establishment and good preanthesis growth since head number is highly correlated with the growth and yield variables (Tables 46 and 47).

From this work it can be concluded that for a crop of barley under dry (ca. 200 mm rainfall) mediterranean environments, crop establishment can be improved by using deep sowing (7-10 cm) with long coleoptile high tillering varieties. The crop should be planted as early as possible in the growing season such that an early ground cover is reached. Reduced row spacing improved early ground cover, which in turn was related to head number and yield. At the relatively wet site (ca. 300 mm rainfall) crop establishment was favored by relatively shallow planting (3-7 cm) at wider (20 cm) row spacing.

Plant breeders should be concerned with plot management effects on selection at dry sites as well as pay attention to ground cover at mid tillering and head number per m^2 as selection criteria.

- E. Acevedo, I. Naji

1.4. Grain Quality

In 1985/86 a large number of barley lines were tested for protein, lysine content, 1000 kernel weight and proportion of plump kernels (PKC).

Barley grain quality was tested for malting potential at ICARDA and was verified by actual malting data provided by the grain Research Laboratory, Canadian Grain Commission Winnipeg, Canada (see Mekni et al, 1986. Rachis 5(1): 17-18 for commodity potential of malting barley). It was found that the test procedure adopted at ICARDA involving unsophisticated equipment before malting can effectively predict good malting quality. The saccharifying activity (diastatic power) determined at ICARDA was highly correlated to malt hot water extract (coarse, r^2 = 0.83). Saccharifying activity (SA) values determined on the original barley give an indication of the enzyme activity in the final malt and is a stable varietal characteristic which can indicate better malting quality.

Using this procedure the grain quality laboratory was able to identify lines exhibiting excellent malting qualities for brewing purposes. Some of these results are given in Table 48.

Among other things we also concentrated this year on kernel size as it is an important trait directly related to energy source for animal feed as well as malting quality. The kernel size was highly dependent on the test site. For example, kernel size was generally reduced at Bouider and Breda which are the dry sites. Despite the considerable genotype X environment interaction for this character we were able to conclusively identify barley lines with a high and stable 1000 kernel weight.

- P.C. Williams, F.J. El Haramein

Table 48. Barley genotypes with high yield and malting potential (Tel Hadya-Rf).

Pedigree	Yield (kg/ha)	PKC (% over 2.5 mm)	1000 KW(g)	Prot. (%)	D.P (unit)	Course Extract (%)
1)	4020	77.0	36.0	13.1	195	72.7
2)	3490	76.6	40.1	13.0	206	70.7
3)	3500	90.2	46.7	13.4	187	72.2

1) M64-76/Bon//Jo/York/3/M5/Galt//As 46/4/Hj34-80/Astrix
2) NK 1615
3) Weisel Burger/Ahor 1303-61

1.5. Entomological screening trials for barley

One hundred eighty four barley lines were screened for resistance to the wheat stem sawfly, Cephus pygmaeus, using caged populations of adult sawflies at Tel Hadya. Of these, 2 lines exhibited resistance (Table 49). In comparison, the local check (Arabi Abiad) ranged in infestation from 3.3% - 61.7% (mean = 25.8%). None of the resistant lines had an observed infestation rate greater than 0.6%.

Results of stepwise multiple regression of peduncle length, plant height, days to maturity, and days to heading onto % sawfly infestation show that only the variables days to maturity and days to heading contributed significantly to the regression. However these variable considered together, or separately, accounted for no more than 6% of the total variation observed in sawfly infestations. This indicates that more precise predictors of sawfly infestation must be identified to increase the efficiency of selecting insect resistant lines.

Of the 184 barley lines screened for resistance to naturally occurring aphid populations only variety

WI 2198/Emir
CMB 77A-0352-1AP-0AP

from seed source BON (86) 2 showed possible resistance. Aphid densities on this line ranged between 100 and 200 aphids/plant, suggesting that this line should be screened under controlled infestation levels.

- R.H. Miller

Table 49. Lines of barley exhibiting resistance to wheat stem sawfly using caged populations of adult insects at Tel Hadya 1985/86.

Variety	Seed source	Mean % infestation
FB 73-057	APCB (85) 14	0.0
MDATL/CM 5S-3W-B	BON (86) 41	0.6

2. Durum Wheat Improvement

Durum wheat (Triticum turgidum L. var. durum) is, after barley, the most important crop in the moderate rainfall areas of North Africa and West Asia.

Table 50. Moisture regime and crop area of durum wheat in West Asia and North Africa.

Moisture regime	Area (x1000ha)	% Area
1. Rarely stressed	252	2.95
2. Sometimes stressed	2455	28.80
3. Frequently stressed	2320	27.22
4. Normally under stress	3495	41.01

Around 9.0 millions hectares are annually devoted to durum wheat production in this region, which represents a major portion of the annual wheat crop in moderate to low rainfall areas. In general, durum wheat is grown under drier conditions than bread wheat. It is well known that the dry areas in this region are characterized by a large year-to-year climatic variability, particularly in precipitation, temperature, and damage due to diseases and insects. Most of the durum wheat is therefore grown in a risk-prone area and crop yield reduction and failures are not uncommon. Total area and moisture level for durum wheat grown in this region are given in Table 50.

2.1. Breeding

2.1.1. Introduction

The climatic data of some durum wheat growing areas in the mediterranean rainfed region are shown in Fig. 8, and 9.

Long term average data on precipitation and minimum and maximum temperatures indicate the severity of drought, cold and heat (see also program report 1984/85). In most places temperature starts rising from March onward. These increases in temperature coincide with increased moisture stress during the grain filling period. There are also interesting similarities between climatic data from Aleppo and the main durum wheat growing areas in the North African and West Asian region. During 1985/86 the Durum Wheat Project maintained its previous structure and overall objectives. However, the following areas of research were strengthened:

a) Identification of superior genetic stocks for specific traits through the use of stress gradients, particularly for tolerance to drought, heat, cold; for resistance to yellow and leaf rusts, Barley Yellow Dwarf Virus and Wheat Stem Sawfly.

b) Use of multilocation testing and selection of early segregating populations at different environments.

c) Evaluation of promising segregating populations and advanced lines for different traits in the major durum wheat growing countries.

d) Utilization of modified bulk to improve the efficiency of selection under rainfed conditions.

e) Evaluation and utilization of durum wheat landraces to upgrade the level of resistance to abiotic stresses, particularly drought and cold.

f) Cooperation with national programs of Morocco, Algeria, Tunisia, Jordan, Egypt, Cyprus, and Turkey.

Figure 8. Meteorological data for some key-sites in rainfed areas of the Middle East in comparison to Tel Hadya.

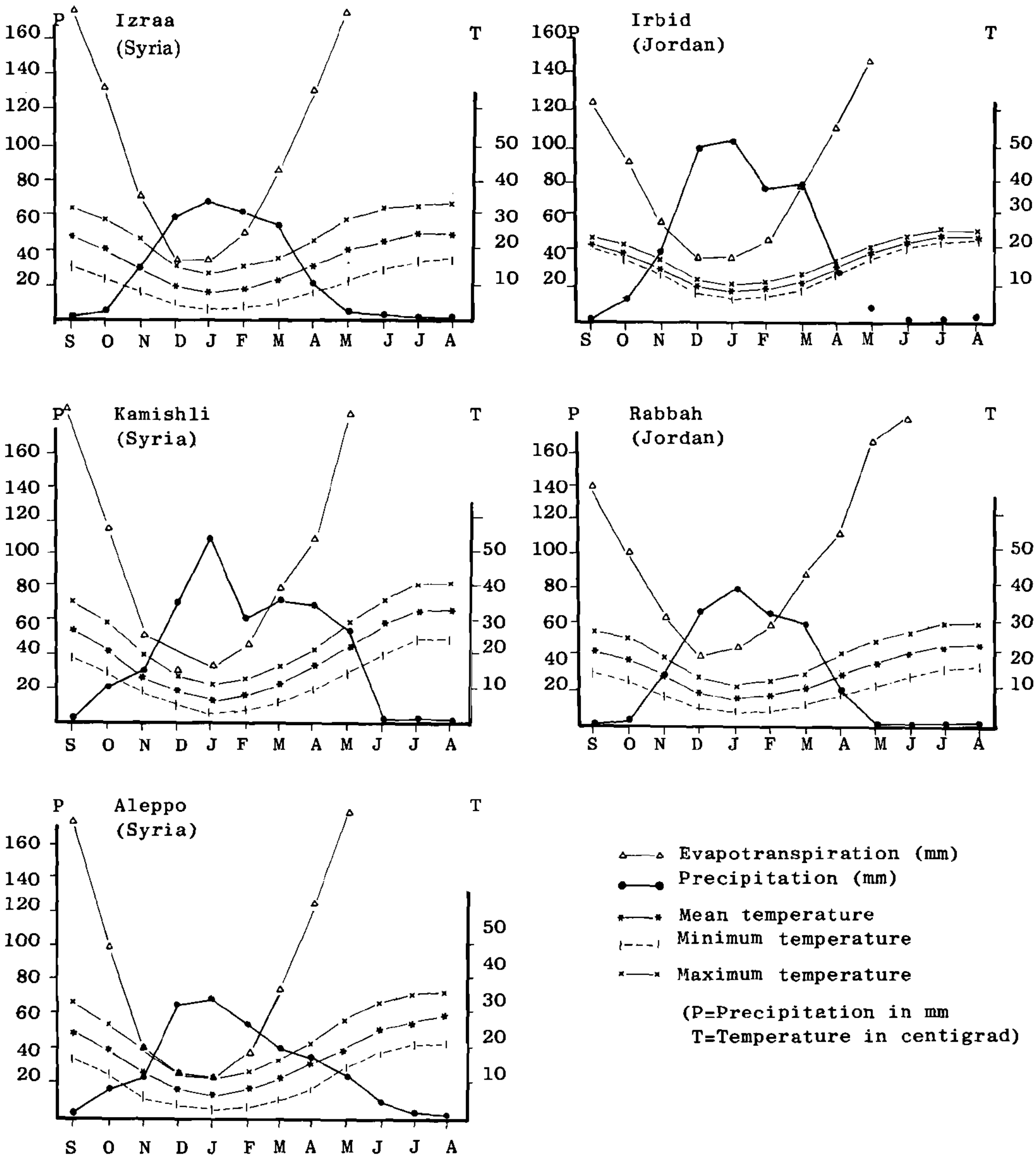
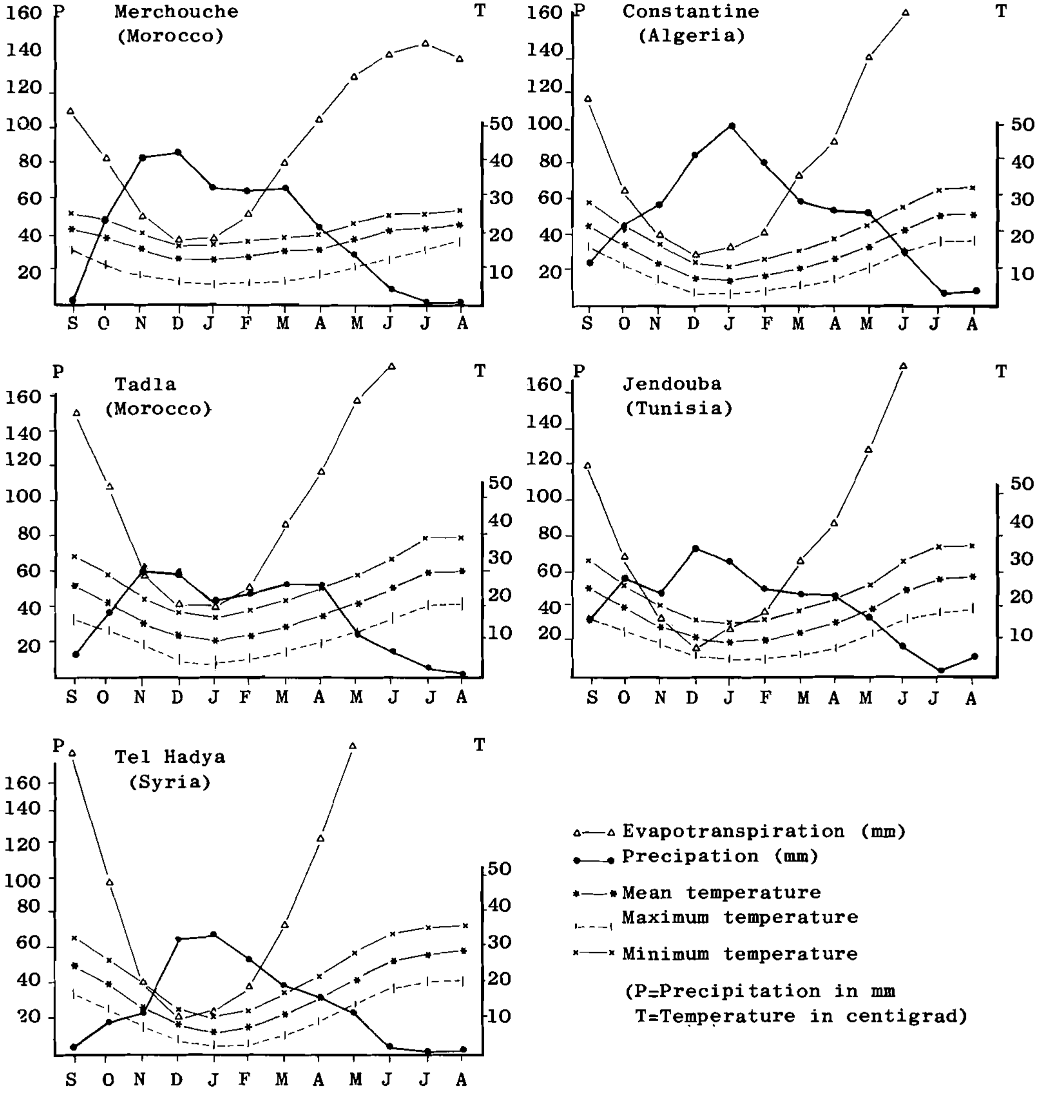


Figure 9. Meteorological data for some key-sites in rainfed areas of North Africa in comparison to Tel Hadya.



2.1.2. Germplasm Development and Testing

To meet the needs of the dryland durum wheat production in the region, the durum wheat project has adopted a breeding strategy aimed at developing germplasm that is less sensitive to drought, cold, and heat, and is able to cope with environmental fluctuations of rainfed conditions, while maintaining responsiveness to improved crop growing environment. The breeding strategy consists of:

a) Testing at stress-specific sites, representing prevalent biotic and abiotic constraints in the region.

b) Combination of desirable traits

c) Selection and evaluation of segregating and advanced material in different environments. The environments are chosen to cover a wide range of rainfall, temperatures, and biotic and abiotic constraints.

The breeding strategy mentioned above is carried out in close collaboration with national scientists and advanced research institutions. Selection is based on data gathered from the region. Data are processed, compiled, and utilized in an approach targetted to meet the demands of the various agroclimatic conditions prevalent in North Africa and West Asia.

2.1.3. Identification of Genetic Stocks for Hybridization

The numbers of parental material identified for different desirable traits and distributed to national programs are shown in Table 51.

The hybridization program in the durum wheat project is targetted to cope with various agroclimatic conditions. Special emphasis is placed on rainfed areas with mild as well as cool winters. Table 52 shows the durum wheat crosses made during the 1985/86 season. Almost half of the crosses involved landraces, *Triticum dicoccoides*, and winter durum wheats as one of the parents to broaden the genetic base of durum wheat for different stresses.

Table 51. Number of durum wheat lines identified with desirable characteristics, and distributed to national programs.

Characteristics	Total number of lines	Lines distributed to national programs
Tolerance to envrionmental stresses		
Drought	16	8
Heat	7	2
Cold	16	8
Salt	1	1
Short crop duration	16	9
High yield and stability	20	16
Disease resistance:		
Yellow rust	12	12
Leaf rust	4	3
Stem rust	22	17
3 rusts	18	9
Septoria leaf blotch	14	3
Common bunt	4	2
Insect resistance		
Wheat stem sawfly	6	3
Aphids	4	2
Grain quality		
Protein content	9	5
1000 kernel weight	12	8
Vitreousness	7	6
Sedimentation value	11	3
Multiple quality traits	14	8

Table 52. Durum wheat crosses made in 1985/86 season.

Objective of cross	No.	% of total
Tolerance to stresses		25.4
Drought	75	
Heat	66	
Salt	44	
Cold	63	
Multiple stresses	291	
Environmental fluctuations	30	
Resistance to diseases		19.7
Yellow rust	70	
Leaf rust	77	
Stem rust	93	
Septoria leaf blotch	66	
Common bunt	80	
Barley yellow dwarf virus	55	
Resistance to insects		4.4
Wheat stem sawfly	55	
Aphids	44	
Grain quality		3.2
Protein content	44	
Vitreousness	5	
Hectoliter weight	22	
Broadening of genetic base		47.4
- Landraces:		
simple crosses	316	
3-way crosses	337	
- Triticum dicoccoides:		
simple crosses	68	
3-way crosses	172	
Interspecific crosses	47	

2.1.4. Evaluation and Selection of Segregating Populations

There is a general agreement among plant breeders dealing with dryland conditions that the genotype-environment interaction may reduce progress in improving yield under rainfed conditions due to site-by-site and year-by-year variability. Genetic progress from early generation selection at a single site can be negated at other sites and during other seasons by genotype-environment interaction. A lack of similarity between yearly conditions or between sites implies that selections taken in any one year may confer limited or no advantage in the long term under "normal" conditions. A multilocation testing program was developed to cope with these environmental conditions, it covered a wide range of abiotic and biotic constraints representing various stresses in North Africa and West Asia.

Segregating populations were planted at Breda, Tel Hadya, Lattakia and Terbol under the following conditions:

a) Breda rainfed: 218 mm rain, 30 kg N and 30 kg P_2O_5/ha, with heavy attacks of stem sawfly

b) Tel Hadya rainfed: 318 mm rain, 60 kg N and 60 kg P_2O_5/ha

c) Tel Hadya late planting (15 February) under supplementary irrigation: 450 mm total precipitation

d) Tel Hadya high input conditions : early planting (15 October) with supplementary irrigation: 450 mm, 120 kg N and 60 kg P_2O_5/ha, with high incidence of yellow rust

e) Lattakia: under favorable rainfall (740 mm) to screen for disease resistance, particularly septoria tritici

f) Terbol: summer and winter planting to screen for heat, stem rust, and leaf rust.

Early segregating populations are thus exposed to a gradient of moisture stress with different incidences of diseases and insects. Moisture ranged from 218 mm at Breda to 740 mm at Lattakia during 1985/86. The populations that were selected under these conditions were advanced for further selection at the regional level in collaboration with national institutions. Selections were directed towards different target areas with the overall objective being to develop a simple and feasible breeding methodology, in collaboration with national programs, for identifying germplasm stable over a wide range of environmental fluctuations. Table 53 shows the percentage of crosses selected in different environments. The highest across-sites selection was made from crosses with landraces for high and stable yield, followed by crosses for earliness, drought tolerance, and disease resistance.

Table 53. Percent of F_2-populations selected at different sites from targetted crosses.

Objective of cross	TH (RF)	Breda	TH (LP)	LTK	Sites combined
Drought tolerance	30	21	11	55	10
Heat tolerance	15	7	24	44	5
Cold tolerance	19	6	11	32	5
Stability	11	14	18	18	9
Earliness	12	13	16	15	11
Landraces	13	16	13	60	13
Multiple disease resistance	28	14	4	28	4
Septoria tritici	28	16	10	40	11
Common bunt	42	15	15	50	9
Tan spot	10	1	10	20	1
Insect resistance	10	10	10	20	7
Average selection	22	12	13	35	8

These results confirm earlier findings showing that desirable selections for rainfed conditions came from crosses of high yielding lines with adapted landraces and parental lines previously identified as possessing drought tolerance as well as earliness and disease resistance under rainfed conditions.

Selected F_3, F_4 and F_5 lines were again evaluated in several agroenvironmental conditions in Cyprus, Jordan, Morocco, Tunisia, Egypt, and other sites. The best homogeneous lines were promoted to replicated yield trials.

2.1.5. Genetic Studies

Fifty F_4 lines from each of two durum wheat crosses (Gezira 17/Belikh and Cando/Ben Bechir) were grown in a replicated experiment under two environments (rainfed vs. irrigated) at Tel Hadya during the 1985-86 season.

Narrow-sense heritability (h^2) for various traits was estimated using: (1) regression of F_4 lines in 1985-86 over respective F_3 lines in 1984-85, and (2) realized selection response using a selection intensity of 0.15. For both crosses, the two methods were consistent in showing low h^2 values for grain yield (-0.12 to 0.01) and high h^2 values for heading date (0.77 to 0.93). In addition, these two traits were correlated in both environments. These results indicate that, for the improvement of durum wheat yield under conditions similar to those of the experiment, selection in early generations may be more efficient if based on highly heritable traits such as heading date rather than yield itself.

In another study, three durum wheat cultivars (C_1 = Har, C_2 = Bit, and C_3 = Win) along with F_3 bulks and 1:1 blends of the parents in all possible pairwise combinations were grown in a replicated experiment at 2 sites in Tel Hadya (Site 1: having been in fallow during 1984-85 and site 2: having a grain legume as previous crop) and one site in Breda during the 1985-86 season. The objective of the experiment was to study the performance of the blends in comparison with the bulks and the parents under competitive (seed rate = 100 kg/ha) and less-competitive (seed rate = 20 kg/ha) growing conditions. Grain yield differences among entries were significant only in Site 1. The blends do not appear to possess a yield advantage over the F_3 bulks nor the average parental performance. The F_3 bulk families generally outyielded the mixtures as well as the "midparents". There was a striking difference in heading and maturity between the two seed rates, plots with the higher seed rate being 5-7 days earlier than plots with the lower seed rate.

2.1.6. Advanced Yield Trials

2.1.6.1. Yield performance and stability

Entries showing promise in the F_5, F_6 or F_7 generations (frequently selected in several environments of countries growing durum wheat and combining high yielding ability and other desirable traits) are tested in preliminary replicated yield trials at three locations and in observation nurseries for diseases, insects, and quality testing in 10 locations. Based on these evaluations the more promising lines are 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 (Table 54) and in 20 other locations. They are also extensively subjected to screening for disease and high insect resistance and for high nutritional and industrial grain quality.

Table 54. Mean yields of ADYT in different environments in 1985/86.

Site	Rainfall (mm)	Mean yield grain (kg/ha)
Breda	218	1224
T. Hadya		
- Late planting	450	3385
- Rainfed	318	2966
- Suppl. irrigation and early planting	450	3927
Terbol	550	7012

High grain yield and stability are required traits in any variety recommended for cultivation under Mediterranean rainfed conditions. Stability in performance plays a decisive role in the acceptance of new cultivars by farmers. Farmers will not grow a new cultivar if it gives very low yields or fails in "poor" years.

Table 55 shows the highest yielding and most consistent entries screened under five different environments, along with their mean grain yield and stability parameters. We used two different techniques for stability analysis. These were a regression method proposed by Yates and Cochran (1938) and elaborated by Eberhart and Russel (1966), and a nonparametric method (Nachit and Ketata 1986) developed for estimating yield stability. In this method, a given genotype is described by the mean and standard deviation of ranks across environments. Using ranks of genotypes presents several advantages. In particular, stability estimates are distribution-free and not affected by outliers; in addition, the nonparametric method is easy to use and allows simultaneous selection for yield and stability.

Table 55. Some high yielding durum wheat entries under rainfed conditions and their stability measurement with 2 methods.

No.Entry/Cross	Grain yield (rainfed)	Stability[1)] NPM R	NPM SDR	RM X	RM b	RM R^2
121: Dera	3033	6.2	5.6	4380	1.12	0.97
110: Daki	2558	7.6	4.9	4196	0.98	0.94
122: Trob/4/Fg/Can .0261/3/Qfn// Ruff/Fg	3037	7.8	4.9	4135	0.95	0.97
102: Omrabi-L	2865	8.2	6.4	3972	1.09	0.97
118: Omrabi-11	2704	9.4	6.1	3897	1.07	0.98
109: Sajur	2604	9.6	4.4	4022	1.07	0.98
103: Lahn	2575	9.8	5.3	3954	1.08	0.97
114: Ain Arous	2512	10.0	5.6	3875	0.98	0.98
Stork	2650	20.2	5.3	2827	0.97	0.86
Sham 1	2679	14.8	6.2	3470	0.82	0.99
Haurani	2433	22.0	4.1	2984	0.90	0.95
Trial mean	2595			3781		
LSD	763			477		
CV	11			10		

1) NPM: nonparametric method, R = mean rank over 5 environments, SDR = standard deviation of ranks across environments;

RM : regression method (Eberhart & Russel), X = mean performance over 5 environments, b = regression coefficient, R^2 = coefficient of determination;

The lines included in Table 55 were also selected in Tunisia, Morocco, Jordan, Cyprus, and Lebanon.

2.1.6.2. Yield Performance and Moisture Stress

Table 56 shows the grain yield of the 5% highest and lowest yielding durum wheat lines in the advanced durum wheat yield trials at Breda (dry site). Also shown is their stability rank and some agronomic traits.

The lines in the highest yielding group were also the most stable. These results corroborate last year's findings and demonstrate that breeding for drought tolerance is associated with increased yield stability under rainfed conditions.

Plant vigour , fertile tillering capacity, plant height and peduncle length, were found to be strongly associated with grain yield under dry conditions.

Table 56. Average performance of the 5% highest and lowest yielding lines sorted according to their yields at Breda. Also shown are their stability values.

Line group	GY	R	SDR	PV	PH	FTC	PL
HYL 5%	1697	7.6	5.7	5.4	62	5.9	3.9
LYL 5%	697	17.9	7.1	4.4	56	3.6	1.6
Difference	1000***	10.3***	1.4*	1**	6*	2.3***	2.3**

GY = grain yield (kg/ha) under Breda conditions, R = mean rank over 5 environments, SD = standard deviation of rank, PV = early plant vigor (1 = poor, 9 = profuse), PH = plant height (cm), FTC = fertile tillering capacity (1 = poor, 9 = profuse), PL = peduncle length (1 = short, 5 = very long), HYL = highest yielding lines, LYL = lowest yielding lines.

2.1.7. Yield related traits

2.1.7.1. Earliness

The relationship between grain yield and time to heading were estimated for different environments (Table 57). In all environments, a highly negative and linear correlation was found between grain yield and time to heading.

Table 57. Coefficients of correlation of grain yield and time to heading of 288 entries grown in 4 environments.

Environment	Coefficient of correlation
Late planting (Tel Hadya)	-0.250***
Breda	-0.162***
Rainfed (Tel Hadya)	-0.131**
Irrigated (Tel Hadya)	-0.111*

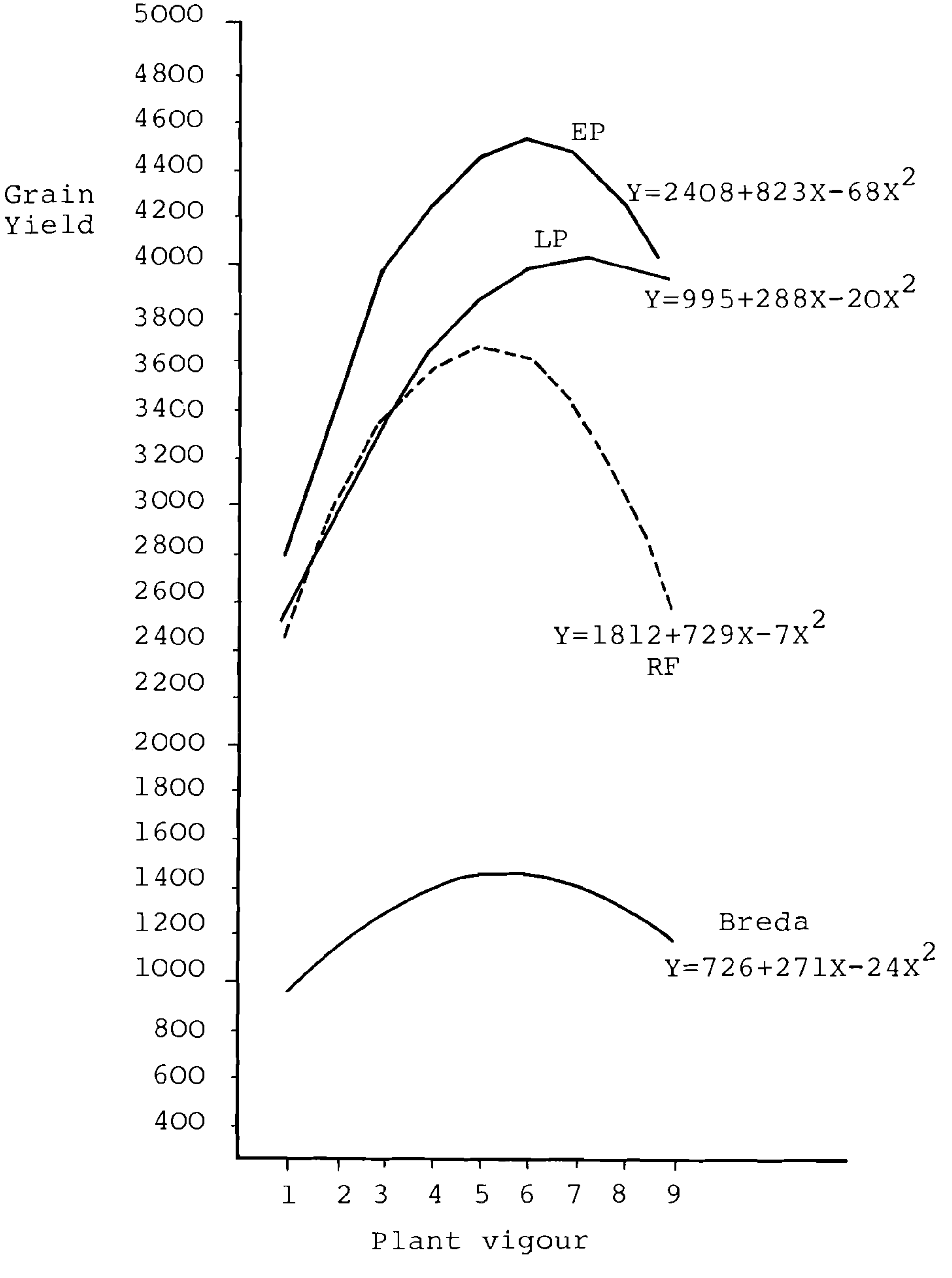
* P<0.05, ** P<0.01, *** P<0.001

Of note is that correlations were higher in stressfull environments than under irrigation.

2.3.2. Early vigor

Although a positive correlation was found between grain yield and early vigor, there may be an optimum vigor beyond which, an excess of vegetation will not be beneficial (Fig. 10). This differs from 1984/85 results where a position linear relationship between yield and plant vigor was found. This difference may be due to the severe winter conditions of 1984/85.

Figure 10. Relationship between grain yield and early plant vigor.



2.1.7.2. Fertile tillering

A linear relationship was found between grain yield and the number of fertile tillers/m^2 in 4 environments (Table 58). The highest correlations between grain yield and tillering were found in the stressed conditions of Breda and late planting at Tel Hadya.

Table 58. Coefficient of correlation between grain yield and number of fertile tillers.

Environment	Coefficient of correlation
Breda	0.658***
Tel Hadya (Late planting)	0.603***
" (Rainfed)	0.529***
" (Irrigated)	0.468***

N = 288, *** P<0.001

2.1.7.3. Plant height and peduncle length

Plant height and peduncle length are important plant traits under moisture stressed conditions. Table 59 shows that the association between the grain yield and plant height is positive in dry environments but negative in wetter conditions. This was not the case for the correlation with peduncle length (Table 59). The positive association of peduncle length with grain yield under different moisture levels shows that long peduncle may be a useful indicator of yield capacity in dry environments as well as for favorable conditions.

Table 59. Association of grain yield with plant height and peduncle length in different environments.

Environment	Coefficient of correlation	
	height	peduncle length
Breda (218 mm)	0.368***	0.397***
Tel Hadya: rainfed (318 mm)	0.205***	0.283***
" : Late planting (450 mm)	-0.161**	0.186**
" : Irrigated (450 mm)	-0.188**	0.061ns

N = 288, ** P<0.05, *** P<0.001, ns = not significant

2.1.7.4. Yield performance and heat and terminal drought

Under late planting conditions at Tel Hadya the maximum yield achieved was 4433 kg/ha, when the average yield of the ADYT trial was 3385 kg/ha. Table 60 shows that grain yield under terminal stress conditions was strongly related to the number of fertile tillers/m^2, and earliness.

Table 60. Correlation coefficients between grain yield and some agronomic traits, under terminal stress conditions. Tel Hadya (late planting), 1985/86.

Traits	Coefficients of correlation
No. of days to heading	-0.23**
Plant height	-0.127
Fertile tillering	0.706***
Spike fertility	0.427***

N = 210, * P<0.05, *** P<0.001

Several durum wheat lines outyielded Sham 1, the highest yielding check under late planting in 1985/86 (Table 61).

Table 61. Durum wheat lines significantly outyielding the checks under terminal stress conditions at Tel Hadya in 1985/86.

Line or cross	Grain yield	% of Sham 1
121 Dera	4433	168
122 Trob/4/Fg/Can.0261/3/Qfn//Ruff//Fg	4075	154
103 Lahn	3950	149
102 Omrabi	3708	140
123 Pin/Gre//Trob	3525	133
Stork (Regional check)	2317	88
Sham (Improved check)	2642	100
Haurani (Local check)	2033	77
Trial mean	3385	118
LSD (0.05)	774	
CV	12	

2.1.8. International Testing

Nurseries and trials for the Mediterranean region are targetted to two major environmental zones: one with moderate rainfall and a mild winter and one with low rainfall and a relatively cool winter.

2.1.8.1. Observation Nurseries

The Durum Wheat Observation Nurseries (DON) are the channel through which promising advanced lines developed at Aleppo are provided to national programs for preliminary screening. Data for 1984/85 have been analyzed and compiled in a final report available to national programs.

Results of the Durum Observation Nursery-Moderate rainfall (DON-MR) and the Durum Observation Nursery-Low rainfall (DON-LR) were obtained from 25 sites in North Africa, West Asia, the Nile Valley, and Mediterranean Europe.

Table 62. Yield, agronomic, diseases and quality data of the highest yielding and most frequently selected entries in the DON-MR, 1984/85.

Name	GY	DH	DM	PH	ACI YR	ACI LR	ACI SR	ST	Quality Prot.	Quality Vitr.	Quality TKW
Shwa/Ptl = Syrica	5135	120	171	84	10	8	41	5	14	98	14
Cr/4/Jo/5/Nabel jamal/6/Gs/Cr// Shwa	5048	120	169	86	1	26	34	5	13	94	38
Scar/GdoVZ 579//Stk	5046	128	176	90	0	12	34	6	15	99	38
Omrabi-4	5042	122	172	94	1	7	38	5	15	100	36
Ato/Ptl	4880	122	172	83	1	34	38	6	14	98	83
Stork (Regional Check)	3714	117	168	82	1	36	33	6	13	98	34
Number of locations	14	18	10	16	1	5	3	3	3	3	5

GY = Grain yield, DH = Days to heading, DM = Days to maturity, PH = Plant height, YR = Yellow rust, LR = Leaf rust, SR = Stem rust, ACI = Average coefficient infection, ST = Septoria tritici, Prot. = Protein, Vitr. = Vitreousness, TKW = Thousand-kernel weight, DON-MR = Durum Obervation Nursery-Moderate Rainfall.

Selected entries from 1984/85 DON-MR and DON-LR are reported in Tables 62 and 63. The overall range for grain yield in DON - MR between 3533 and 5135 kg/ha with a grand mean of 4284 kg/ha. The mean number of days to heading ranged between 116 and 131 with a grand mean of 122 days. However, large variation occurred from one site to another (Table 62).

Similar data for DON-LR are shown in Table 63. Thirty five lines were selected for their resistance to leaf rust, and 40 lines for resistance to stem rust. Most of the durum wheat lines originating from the Aleppo-based program have good resistance to yellow rust: For Septoria leaf blotch, 29 resistant lines were selected, and 14 lines were selected for powdery mildew.

Table 63. Yield, agronomic and diseases data of the top-yielding entries in the DON-LR, 1984/85.

Entry no.	Name	GY	DH	DM	PH	ACI YR	ACI LR	ACI SR
126	Bit//Erp/Ruso	4652	122	171	81	0	32	3
33	Omrabi 4	4583	121	169	86	0	50	12
67	21563/Jo//D.Dwarf 15/Cr	4457	124	171	84	0	50	6
30	Omrabi-SH	4415	121	170	84	4	32	12
83	Belikh	4372	124	172	85	4	24	30
Sham 1 (regional check)		3367	122	167	76	0	52	50
Nursery mean		3645	123	170	80	4	21	26
Max		4652	131	177	90	30	65	99
Min		2810	118	166	72	0	0	0
No. of locations		13	17	11	15	2	2	2

GY = Grain yield, DH = Days to heading, DM = Days to maturity, PH = Plant height, YR = Yellow rust, LR = Leaf rust, SR = Stem rust, ACI = Average coefficient infection, DON-LR = Durum Observation Nursery-Low Rainfall.

2.1.8.2. Yield Trials

The Regional Durum Wheat Yield Trials are also targetted to two major environments, those with moderate rainfall (RDYT-MR) and those with low rainfall (RDYT-LR). Each trial includes best performing lines from the corresponding observation nurseries. The 1984/85 RDYT trials each consisted of 19 test durum wheat lines, and one regional, one improved, and one national check in addition to one bread wheat and one triticale. Yield data were received from 27 locations for RDYT-LR and 29 for RDYT-MR.

Table 64. Performance of the highest and most stable yielding entries in the RDYT-LR, 1984/85. n = 24

Entry no.	Name	Grain yield (kg/ha)	Stability parameters R	SDR
20	Daki	3293	7.8	5.6
19	Bige	3178	8.9	5.5
5	Lahn	3148	10.1	6.0
14	Kabir 2	3108	9.7	7.1
2	Omrabi	3012	11.5	5.7
11	Karasu	3012	11.0	5.7
Stork		2779	14.7	7.6
Sham 1		2925	11.7	5.7
Trial mean		2968		
LSD (0.05)		213		
CV		17.2		
No. of Locations		27		

R = Average rank, SDR= Standard deviation of ranks

Table 65. Performance of the highest and most stable yielding entries in RDYT-MR, 1984/85.

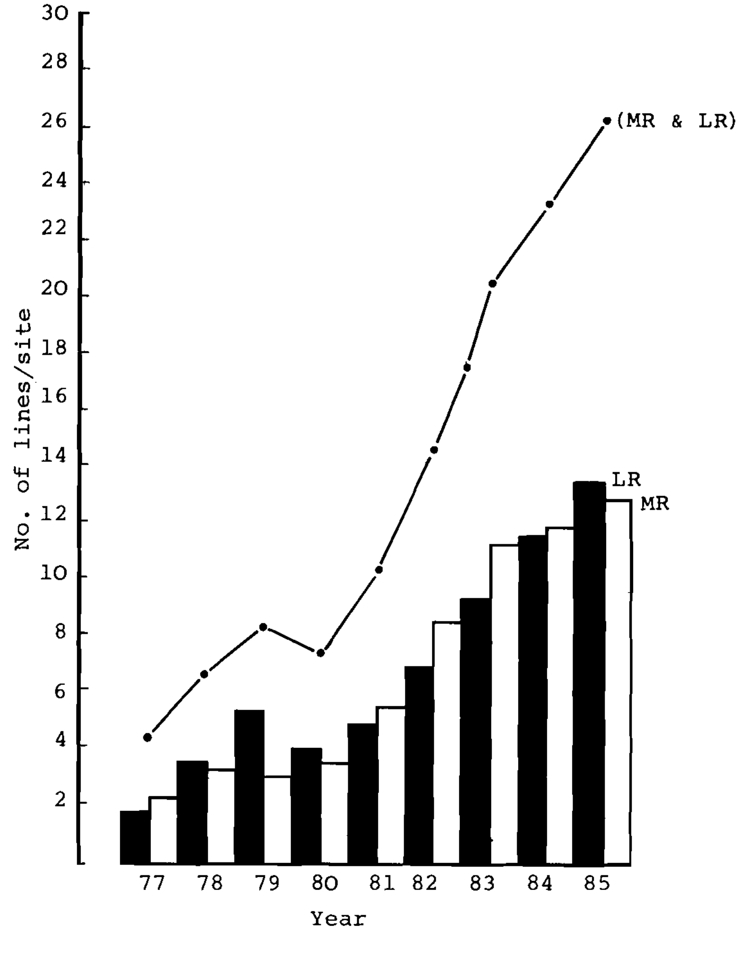
Entry No.	Name	Grain yield (kg/ha)	Stability parameters R	SDR
17	Belikh 2	4028	8.0	5.3
18	Heidar	3872	8.7	6.1
21	Quadalete	3819	10.0	7.5
11	Thica	3807	10.1	6.5
9	Zeroud	3705	11.4	5.2
8	Omrabi	3609	12.5	5.7
Stork		3465	14.8	7.9
Sham 1		3526	13.2	6.9
Trial mean		3640		
LSD (0.05)		217		
CV		15.4		
No. of locations		29		

R = Average rank, SDR= Standard deviation of ranks

In the RDYT-LR (Table 64), Daki showed outstanding performance across all sites in North Africa and West Asia, while Bige was more adapted to the Maghreb environments. In contrast, Lahn and Kabir 2 were more adapted to the Middle East region. In the RDYT-MR (Table 65), Belikh 2 and Thica performed well in most of the sites in North Africa and West Asia.

Figure 11 shows the progress achieved in developing durum wheat germplasm adapted to Mediterranean rainfed conditions. It also clearly illustrates that multiloction testing in collaboration with national programs, in addition to selection at stress specific sites is efficient for the development of superior genotypes in dry land conditions.

Figure 11. Number of durum wheat lines outyielding the national check in ICARDA's region RDYT-MR and RDYT-LR, 1977 through 1985.

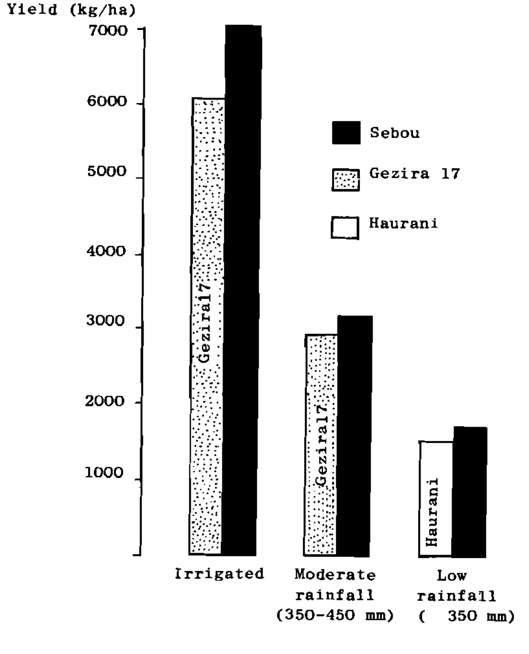


2.1.8.3. On-Farm Trials

The on-farm trials, started in Syria and Jordan during the past eight years, have been extended to other countries in the ICARDA region. During 1985/86 seed for on-farm trials was requested and supplied to Syria (Sebou, Korifla, Omrabi, Siliana, Belikh, Lahn and Hazar), Jordan (Korifla, Po, Sebou), Lebanon (Sebou and Belikh), Morocco (Korifla, Sebou, Belikh and Omrabi), Algeria (Sham 1, Sahl, Sebou and Omrabi), Turkey (Kabir, Korifla and Omrabi) and Saudi Arabia (Sham 1). In Syria the on-farm trials are jointly conducted by the Ministry of Agriculture and Agrarian Reform and ICARDA.

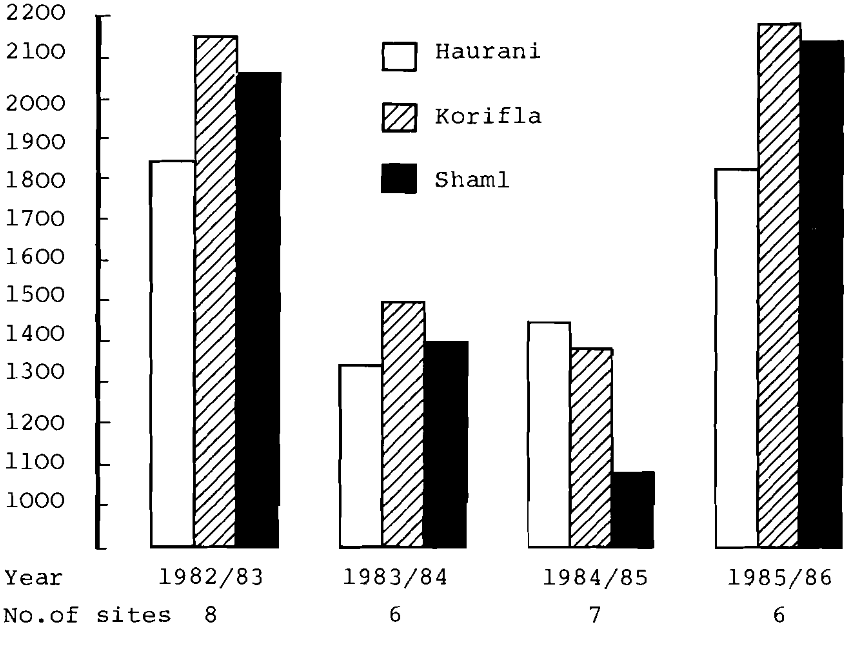
The performance of "Sebou", demonstrates the useful exploitation of desirable genes from Triticum polonicum. This durum wheat line is in fact derived from a cross involving 'Crane', a durum wheat line adapted to high input conditions, and a strain of T. polonicum, which is a wheat adapted to arid conditions (Nachit and Ketata 1986). Figure 12 shows the performance of "Sebou" over 3 years at on-farm trials in comparison to the local checks 'Haurani' in the dry areas and Gezira 17 in the higher-rainfall or irrigated areas of Syria.

Figure 12. Mean grain yield (kg/ha) of Sebou in comparison to Gezira 17 and Haurani at on farm trials in Syria (1983-1985).



The results show that 'Sebou' combines high yield potential with good yield consistency across various agroclimatic environments in Syria. This variety has also shown good adaptation both in Jordan and in Algeria. Other varieties such as Korifla, Omrabi and Belikh 2 are also performing well under low rainfall areas (See Fig. 13).

Figure 13. Mean grain yield (kg/ha) of Korifla in comparison to Haurani and Sham 1 at on farm trials (Zone B) in Syria (1983-1986).



In Jordan, Sebou, Korifla, Sham 1, Po, Oronte and Sajur are undergoing on farm testing, with Korifla and Po giving the best performance.

In Lebanon, Sham 1 and Belikh 2 are the most promising durum wheat varieties. In Turkey, the Agricultural Research Institute, Adana, is conducting large scale demonstrations with Sham 1. Also Sebou, Omrabi, Korifla and Kabir are tested in National Turkish Regional Yield Trials. In Cyprus and Morocco, Korifla is under consideration for release, while Algeria has released Sham 1 and Sahl.

– M. Nachit, H. Ketata

2.2. Pathology

2.2.1. Screening for resistance to yellow rust (*Puccinia striiformis*), leaf rust (*P. recondita*), septoria tritici blotch (*Mycosphaerella graminicola*), and common bunt (*Tilletia foetida* and *T. caries*).

The annual screening is done at the principal station, Tel Hadya, and some off-sites in Syria. However, some germplasm is sent to other locations and the disease data returned are included for the general evaluation. The annual screening aims at (1) testing the performance of germplasm developed for its resistance to yellow rust, leaf rust, septoria tritici blotch and common bunt and (2) identification of new sources of resistance to these diseases for subsequent retesting in special purpose disease nurseries.

2.2.1.1. Yellow rust

The durum germplasm tested for yellow rust consisted of 1671 lines from Aleppo Crossing Block (APCB), Regional Crossing Block (DCB), Preliminary Disease Nursery (PDN), Key Location Disease Nursery (KLDN), Durum Observation Nursery, Moderate (DON-LR), Durum Yellow Rust Nursery (DYR), and Observation Nursery-Tunisia (DOT) screened at 1,1,3,4,3,2,3, and 1 site, respectively (Table 66). Out of the tested lines, 518 showed resistance to the disease. However, after considering their resistance to other major diseases, only 86 were selected for the DYR87. The highest percentage resistant lines were found in the APCB (68%) followed by DYR (61%) and DCB (51%).

2.2.1.2. Leaf rust

Screening for resistance to leaf rust was successful this season for the first time using plastic houses and the PDN and KLDN germplasm. However, leaf rust data from other sites where these nurseries were planted have also been included in the analyses. Out of 675 lines tested, 7 and 13 lines, from PDN and KLDN respectively, were resistant. These lines were selected for inclusion in the new Leaf Rust Nursery 1986-87.

Table 66. Durum wheat germplasm screened for resistance to yellow rust (YR), leaf rust (LR), septoria tritici blotch (ST) and common bunt (CB) in the season 1985-86.

Germplasm	No. Entries tested	No. entries resistant YR*	LR*	ST+	CBx
Aleppo Crossing Block	214	145	-	100	13
APCB 86		(68)	-	(47)	(6)
Regional Crossing Block	163	83	-	-	-
DCB 86		(51)			
Preliminary Disease Nursery	375	127	7	86	11
PDN 86		(36)	(2)	(24)	(3)
Key Location Disease Nursery	300	53	13	33	9
KLDN 86		(20)	(6)	(12)	(3)
Observation Nursery-Moderate Rainfall	113	16	-	57	-
DON-MR 86		(15)	-	(53)	-
Observation Nursery-Low Rainfall	96	12	-	27	-
DON-LR 86		(13)	-	(30)	-
Yellow Rust Nursery	100	55	-	-	-
DYR 86		(61)	-	-	-
Septoria Nursery	52	-	-	30	-
DST 86		-	-	(64)	-
Repeat Testing Bunt	100	-	-	-	23
DRTB 86		-	-	-	(24)
Land Races 86	41	-	-	-	21
		-	-	-	(51)
Observation Nursery-Tunisia	310	27	-	-	-
DOT 85		(9)	-	0	-
Total entries	tested	1671	675	1460	1030
	resistant	518	20	333	77
	selected	86	20	32	25

( ) = % resistant lines; checks excluded

* Average severity 0-5% in the screening sites: Tel Hadya/Syria; Terbol/lebanon; Elvas/Portugal; Izmir/Turkey.

\+ Average score 0-5 in the screening sites: Lattakia and Al Ghab/Syria; Elvas/Portugal; Beja/Tunisia; not exceeding 7 in Al Ghab

x 0-15 % infected heads.

2.2.1.3. Septoria tritici blotch

The germplasm tested for septoria blotch consisted of 1460 lines from APCB, PDN, KLDN, DON-MR, DON-LR, Durum Septoria nursery (DST) and DOT screened at 1,4,4,3,2,4 and 1 site respectively. Of these 333 were resistant to the disease, but only 32 were selected for retesting in the DST-87. The highest percentage of resistant lines were found in the DST (64%) followed by 53% in the DON-MR and 47% in the APCB.

2.2.1.4. Common bunt

Preliminary and advanced screening for resistance to common bunt is carried out in the isolation area of the Center. After evaluation of the lines, special care is taken not leave bunted heads in the field. This is done by pooling all plants in both nurseries and burning them in one heap.

The preliminary screening for common bunt was done in Common Bunt Nursery I, where this season's inoculum consisted of 15 Syrian isolates collected from durum and bread wheat lines. The inoculum was bulked and adjusted to maintain 1:1 ratio of the pathogens T. foetida and T. caries. The germplasm tested consisted of 1030 lines from APCB, PDN, KLDN, Repeat testing bunt (DRTB), and 41 land races. Of this germplasm, 77 were resistant of which 25 were selected. The highest percentage of resistant lines (51%) was found in the land races, followed by 24% of the lines from DRTB. These were resistant last season (1984/85) and were retested this season.

An advanced screening for resistance to common bunt is done in the Common Bunt II Nursery, where 10 different isolates from the region were used (2 Syria, 3 Turkey, and one each from Lebanon, Tunisia, Iran, Pakistan and Morocco). Out of 11 durum lines tested in this nursery, 7 had on average 0-10% infected heads (Table 67, entry No. 16-22). These were included in a selection of wheat lines available for the use by national programs (Table 67).

In the past three seasons this selected collection/selection has undergone severe screening and therefore only lines ranging from resistant to moderately resistant (< 10% infected heads) were included in either a) two successive screenings towards a collection of Syrian isolates or b) one screening towards different isolates from the region. Lines in this collection have also reasonable yellow rust resistance and acceptable agronomic traits, some also yield well.

Table 67. Durum wheat lines resistant-moderately resistant (R-MR)* to common bunt, *Tilletia foetida* and *T. caries* (season 1983/84-1985/86)

Entry name or cross	% average infected heads Isolates (Syria) 84	85	86	Isolates (Region) 84+	85+	86x	Source	
1. Stork	-	-	-	2	-	-	BUII84	33
2. Senator Cappelli	-	3	3	-	0	-	BUII85	11
3. Cr/Jo//Cr/3/Gd	5	-	-	-	4	-		2
4. Gd/Bit	-	-	-	-	3	-		3
5. Fa/Cando	5	-	-	-	1	-		5
6. W-2057	5	-	-	-	1	-		7
7. Gdovz 469/Plc//Jo	5	-	-	-	4	-		8
8. Cit/Gdovz 579	5	-	-	-	1	-		10
9. Snipe/F9-3	-	3	9	-	-	-	DRTB86	6
10. Jo/Cr/5/Gll/4/Br180/LK//Gz220/3/21563/AA	-	3	3	-	-	-		14
11. CDK	-	0	8	-	-	-		49
12. Vlnv	-	0	8	-	-	-		51
13. Cpt Mut	-	4	9	-	-	-		67
14. MG5927CV Montferrier	-	0	5	-	-	-		71
15. 61-130/414/AA//3/AA	-	0	4	-	-	-		82
16. Swan//Dack/Rabi	-	0	-	-	-	5	BUII86	17
17. Swan//Dack/Rabi	-	0	-	-	-	5		18
18. Daki	-	-	-	-	-	8		20
19. Syrica	-	-	-	-	5	9		21
20. Tigris	-	-	-	-	-	6		23
21. Oronte	-	0	3	-	-	2		25
22. Barika	-	-	-	-	-	9		26

* R - MR = 0 - 10 % infected heads

\+ 8 isolates (3 Syria, 2 Turkey, and one each Lebanon, Tunisia, Iran)

x 10 isolates (2 Syria, 3 Turkey and one each Lebanon, Tunisia, Iran, Pakistan, Morocco)

2.2.2. Multilocation testing for disease resistance

Multilocation testing aims at screening advanced breeding material and special purpose lines for resistance to prevailing diseases and their pathotypes in 'hot-spots' in and outside of the region. In many of these locations, inoculation is applied to create artificial epiphytotics.

Useful information on the Key Location Disease Nursery (KLDN 86) were obtained from 12 locations within the region. Table 68 summarizes the results obtained on the three rusts, powdery mildew and septoria tritici blotch. Results of common bunt testing, though done in one site, were included in the table to search for combined resistance to the major diseases among the lines.

Out of the 270 lines tested 112, 24, 32, 35, 13 and 9 lines were resistant to yellow rust, leaf rust, stem rust, powdery mildew, septoria botch and common bunt respectively. Four lines showed combined resistance to leaf rust and stem rust (Entry Nos. 68, 107, 135, 288). There were 2 entries with combined resistance to powdery mildew and septoria blotch (Entry Nos. 2, 282) and 10 entries with combined resistance to yellow rust and septoria blotch (Entry Nos. 46, 75, 145, 166, 215, 226, 246, 247, 252, 282), those with combined resistance to yellow rust and common bunt were six (Entry Nos. 27, 36, 132, 202, 222, 283). Three lines only showed combined resistance to yellow rust, septoria blotch and common bunt. These were:

- Stk/Gll//T.dic.V.Ver/3/A63037/Sentry   DKL 86 132
  ICD 79-1347-2AP-1AP-3AP-1AP-0AP

- Scaup/Sapi   202
  ICD 79-0403-20AP-2AP-1AP-0AP

- Qfn/Memo/3/Oyca//Ruff/Fg   222
  CD 35213-A-1Y-1M-1Y-0M

In addition to their resistance to the above three diseases, these lines were moderately resistant to leaf rust and stem rust, but showed moderate susceptibility to powdery mildew.

- O. Mamluk, J. van Leur

Table 68. Number* of durum wheat lines resistant+ to yellow rust, leaf rust, stem rust, powdery mildew, septoria tritici blotch and common bunt in the different locations (KLDN-86).

Disease	No.of. Loc.	Location codes(x)	No. Lines Resistant				
Yellow rust	4	SYR 01; LEB 01; TUR 01; POR 01	112				
Leaf rust	7	SYR 03; TUR 01; JOR 03; EGY 01,04; POR 01; ITA 01	24	4			
Stem rust	4	TUR 01; JOR 03; EGY 04; POR 01	32		10	6	3
Powdery mildew	2	JOR 03; TUN 01	35	2			
Septoria leaf blotch	5	SYR 51,53; TUN 01; POR 01, 02	13				
Common bunt	1	SYR 01	9				

* Number of lines tested = 270

\+ Selection criteria : a) rusts = 0-10 % average severity, not exceeding 10 % at T. Hadya for yellow rust and for leaf rust and at Izmir for stem rust, b) powdery mildew and septoria = 0-5 on 0-9 scale, not exceeding 5 at Al Ghab for septoria and at Deir Alla for powdery mildew, c) common bunt = 0-15% infected heads.

(x) Syria = SYR 01,03 screening sites T. Hadya; 51 Lattakia; 53 Al Ghab
Lebanon = LEB 01 Terbol
Turkey = TUR 01 Izmir
Portugal= POR 01,02 screening sites Elvas
Jordan = JOR 03 Deir Alla
Egypt = EGY 01 Gemeiza, 04 Sids
Tunisia = TUN 01 Beja

2.3. Agronomy and Physiology

2.3.1. Wheat and Barley Genotype Characterization.

Physical or abiotic stresses have great importance for the growth of cereal crops in North Africa and Southwest Asia. In the rainfed areas within ICARDA's mandate, drought, heat and cold predominant. Drought may be present alone or in combination with each of the thermal stresses, or a given thermal stress may prevail at various stages of crop development. Furthermore, the stress pattern may differ in each of the various climatic zones (ICARDA, Annual Report 1984, 1985).

Breeding for cereal improvement under dry conditions is therefore very challenging. When plant responses to environmental (physical) stresses are included in the improvement process, additional factors must be considered. These are:

a) there seems to be no single plant trait confering stress resistance in the form of avoidance or tolerance, but there are responses to a suite of traits,

b) some traits that confer a better performance to a plant under stress are constitutive (always present) while others are adaptive, such that they will be expressed only under a given set of environmental stimuli,

c) plant performance is the result of a combination of constitutive and adaptive traits,

d) the response depends on the stress history of the plant since acclimation (short term responses) may also be present,

e) if adaptive traits are important to plant response under stress, a target environment for the breeder's selection is needed,

A set of Mediterranean environments along a rainfall gradient (ca. 500 mm to ca. 200 mm) were selected in northern Syria. A wide range of genotypes were fully characterized to identify specific parameters or attributes representing significant traits conferring survival and productivity for each stage of the life cycle. Since water stress is of major concern in the region, a group of plant and crop attributes were derived based on the conceptual model of Passioura (1977) and Fischer and Turner (1978). The model (see also 1.3.4, this volume) suggests that yield under water stress may be viewed as the product of transpiration (T), transpiration efficiency (TE) and a partitioning term (F) which in the case of grain yield is the harvest index of the crop. Based on this model, an hypothesis was formulated to build a crop ideotype fitting Mediterranean environments.

The main features of the environments under consideration may be summarized as follows: a) low and variable winter rainfall associated to low temperature; b) high probability of early and terminal drought stress; c) low temperature during canopy development with the danger of frost; d) high temperature during grain filling; and e) water availability determined by current rainfall, particularly in low rainfall areas.

The attributes that maximize T, TE and F under these environments must be evaluated to allow plant breeders to confidently select for attributes other than yield conferring stress resistance.

The objective of the current work is to evaluate a wide range of barley, durum wheat, and bread wheat genotypes. Between species and within species comparisons are being made. Only part of the information obtained in 1985/86 will be presented since much it is still being analysed.

Seventy two barley, 22 durum wheat, and 22 bread wheat genotypes were grown at Jinderess, Tel Hadya, Breda and Bouider in northern Syria. The sites covered a steep, long term rainfall gradient (Table 69). Lines chosen represented contrasting characters of early vigor, growth at low temperature, height under stress, flowering date, grain filling period, varieties with high yield potential, varieties with good yield stability, pure lines isolated from landraces (in the case of barley), and lines thought to be stress tolerant. Lines with contrasting characters were selected by ICARDA cereal breeders.

Two experiments were performed at each site with the barley lines and the wheat genotypes. In both cases a completely randomized block design with three replicates was used. Plots were 2.4 m wide (12 rows, 20 cm apart) and 5 m long. Sowing rate was adjusted to 250 plants/m^2 for each genotype by correcting for germination and kernel weight of the seed.

Table 69. Average annual rainfall at four sites in Northern Syria (after Dennet *et al*. 1984).

Station	Years	Annual rainfall (mm) Mean	SD
Jinderess	1960-81	479	138
Aleppo*	1956-81	332	97
Breda	1957-81	278	102
Khanasser*	1957-81	214	71

* Aleppo is indicative of the Tel Hadya site. Khanasser represents the Bouider site. Long term rainfall records were not available at these two sites.

At Jinderess and Tel Hadya, the two wetter sites, the soil was fertilized with a preplanting dose of 40 Kg of nitrogen/ha in the form of ammonium sulphate (21 % N) and 60 Kg of P_2O_5/ha in the form of triple superphosphate. An additional 40 Kg of nitrogen/ha, were broadcast at mid tillering. At Breda and Bouider, the drier sites the split application of nitrogen was reduced to 20 Kg/ha at each application while preplanting phosphorous was kept at 60 Kg P_2O_5/ha. All preplanting fertilizations were incorporated into the soil with the last harrowing. Perforan was used as a preemergence herbicide at a rate of 2.5 l/ha at all sites. Weed control was complemented with Brominal plus applied at a rate of 1.5 l/ha in 400 liters of water at the 5 leaf stage.

At each site, an additional 14 plots 10.5 m in length and 4.8 m wide (24 rows, 20 cm apart) were sown with barley, durum wheat, and bread wheat. Barley genotypes included - Rihane-03, Cytris, Tadmor, Beecher, Arabic Aswad, Alger/Ceres, Arabi Abiad and Swanneck. Durum wheat genotypes were Haurani and Sham 1; and bread wheat genotypes were Mexipak and Sham 2. A fallow plot was also included. Two 2-m long neutron probe access tubes were installed in each of the plots at Jinderess and Tel Hadya while one tube per plot was installed at the driest sites. In the plot containing Arabi Abiad at each site, a set of gypsum blocks were installed at various depths. The neutron probe readings were taken at 15 cm intervals every 10 days along with the gypsum block readings. This allowed a soil water characterization at each site both in terms of soil water content and tension.

Daily climatic records for rainfall, radiation, class A pan evaporation, screen and soil temperature at 3 depths, relative humidity, and windspeed were provided for each site by ICARDA's Farming System Program.

Observations were periodically taken on development at each site, but more intensively at Tel Hadya and Bouider (relatively wet and dry site), Zadoks stages and apex development were obtained by dissection (Kirby, 1984). Dry matter, leaf length, width and stem area, peduncle length and ear length were measured to determine growth. Water relations measurements included predawn water potential in the shoot or last expanded leaf using a pressure chamber, samples for solute potential at full turgor and stomatal conductance. Net photosynthesis and related parameters measured were leaf temperature, and leaf conductance, internal CO_2 was calculated. Biological yield (roots excluded), grain yield, number of spikes per unit surface, and 1000 kernel weight were determined at harvest. Other crop and plant observations were scored in the field five times during the growing season.

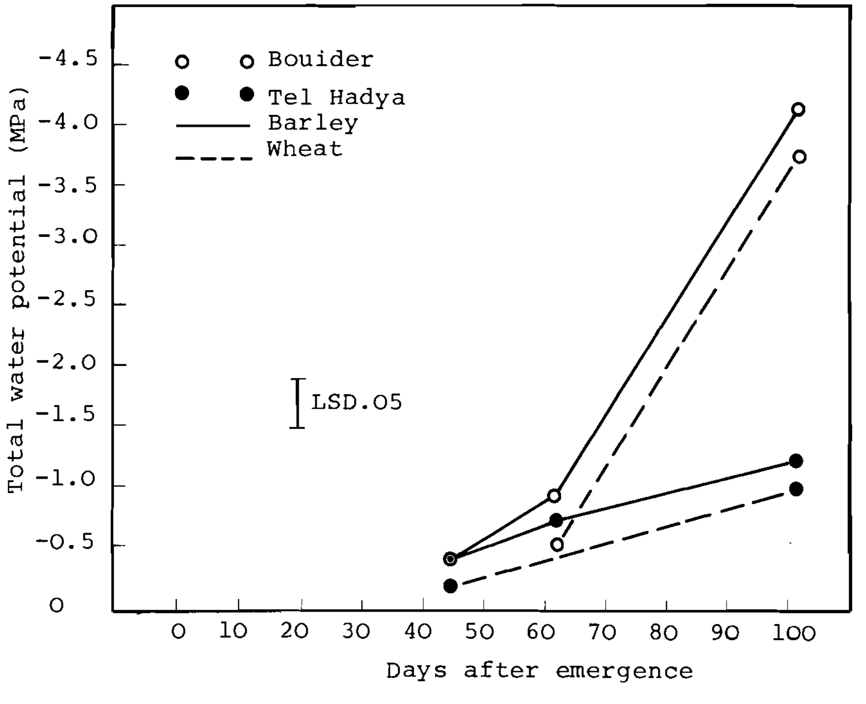
2.3.1.2. Climatic Conditions

Climatic conditions during the study were typical of Mediterranean climate. In general the opportunity for grain filling decreased as rainfall decreased due to terminal drought and heat stress. Concurrently the risk for a false start or seedling water stress increased. There was also a 6 week drought period during late February and March particularly severe at Breda and Bouider.

2.3.1.3. Water Relations

Figure 14 shows generalized curves of predawn leaf water potential through the growing season at Tel Hadya and Bouider. These curves indicate the contrasting severity of water stress experienced by the genotypes at the two sites.

Figure 14. Predawn water potential during the growing season for barley and wheat. Measurements were taken in the last fully expanded leaf at Bouider and Tel Hadya. The LSD is for site comparison of the pooled populations.



The working hypothesis postulated that a relatively high resistance to liquid water flow would be desirable for plants growing under drought. Passioura (1977) has advocated this trait, and it is been tested as a breeding objective (Richards and Passioura 1981 a,b, Richards 1985) for cereals experiencing terminal drought stress. The cereal physiology nurseries assembled in 1985/86 provided an opportunity to test this trait under natural conditions. Fig. 15 shows the shoot water potential (PSI) of wheat, improved barleys and barley landraces measured at midday at the Tel Hadya site 38 days after emergence. The day was overcast following rain, the photosynthetically active radiation (PAR) being around 400 umol m^{-2} s^{-1} during the measurements. The plants were at the 2 to 3 leaf stage (Zadoks stages 12-13). Nodal root growth had not yet started nor was incipient. The plants were therefore growing on their seminal root systems. Wheat had a significantly higher PSI than the improved barleys, which in turn had a significantly ($P < 0.001$) higher value than the barley landraces. Figure 16 shows that the shoot water potential of the barleys during the morning period was significantly lower than in wheat at the same site even after nodal root development had been initiated (55 days after emergence).

Figure 15. Midday shoot water potential in wheat (W), 4 genotypes, improved barleys (IB), 8 genotypes and barley landraces (LB), 4 genotypes. Tel Hadya, 38 days after emergence. Zadoks 12-13.

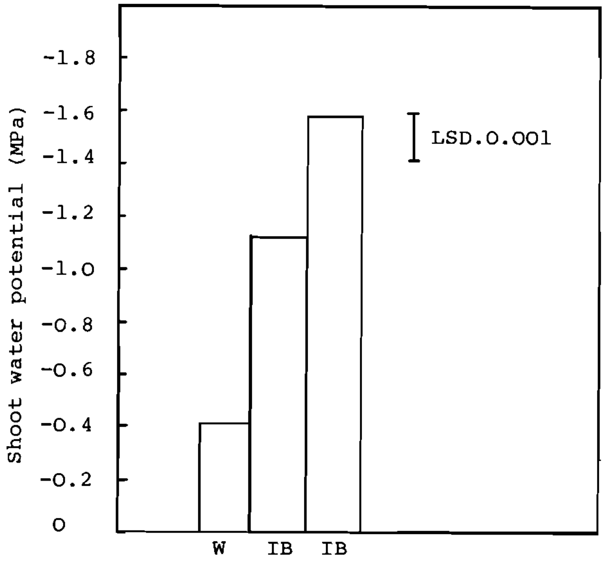
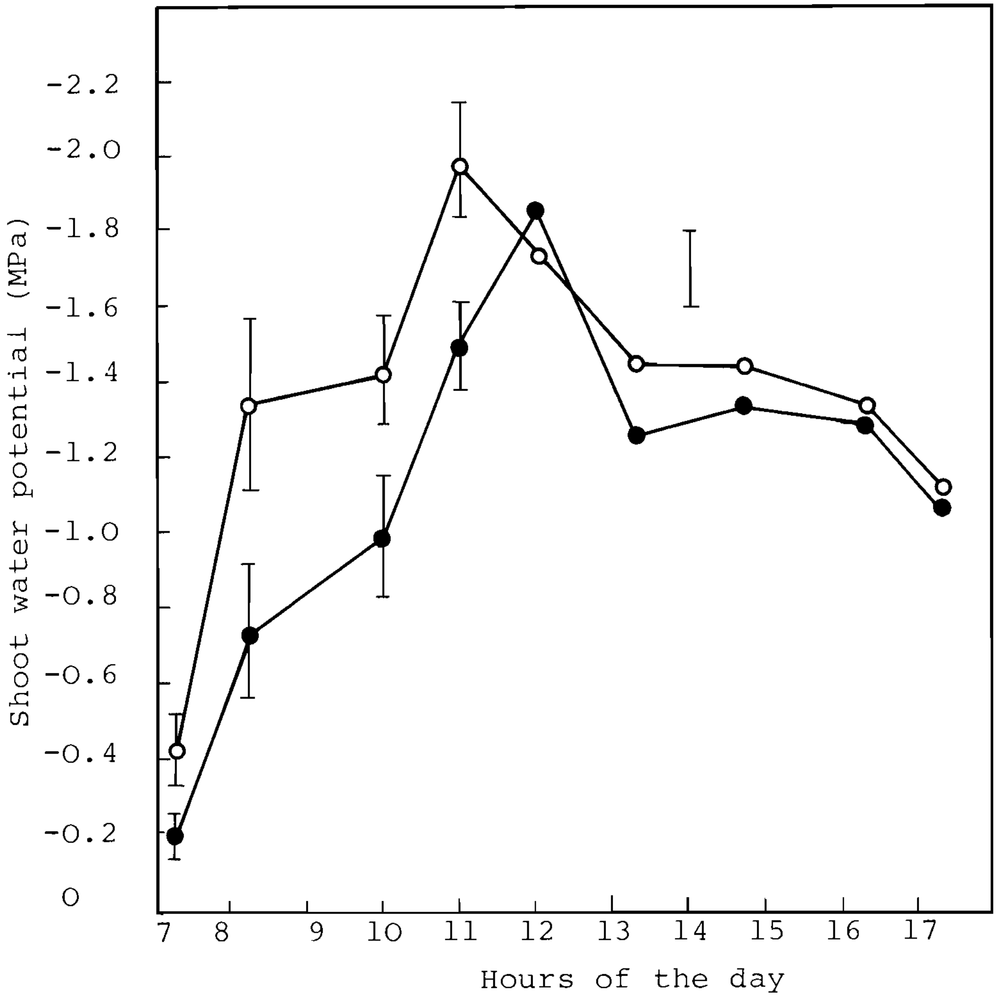


Figure 16. Daily course of shoot water potential. Wheat (● ●), 4 genotypes, and barley (O O), 8 genotypes. Tel Hadya, 55 days after emergence. The bars indicate twice the standard error of the means.



Shoot water potential alone, even when measured with the soil at field capacity, does not prove that there are differences in resistance to liquid water flow between or within species as the water status of a plant results from water uptake and transpiration. Measurements were therefore taken of leaf conductance. Stomatal conductance of barley was significantly lower at both Tel Hadya and Bouider at the tillering stage (Zadoks 22-25). These results clearly indicate that for the genotypes tested barley has a conservative strategy in terms of water use as compared to wheat and that there is increased resistance to liquid water flow in the plants in the order

wheat < improved barleys < landraces barleys.

In terms of rainfall, this trend is consistant with the areas, where these species and/or genotypes are grown in northern Syria. In fact, landrace barleys are grown in the very low rainfall areas, (ca. 200 mm) while wheat and improved barleys are grown in areas of 300 mm and above.

There is great variability in, predawn water potential and stomatal conductance as exemplified in the barley physiology nursery. Detailed analyses on the cause(s) for this variability and its implications for productivity and stability of production are underway.

It has been suggested during the last decade, that the ability of the tissues to retain water is an important attribute of plants grown under stress. This is usually achieved by osmoregulation. Morgan advocated osmoregulation as a selection criterion for drought tolerance in wheat. In the working hypothesis, stomatal adjustment associated with osmoregulation was postulated. Leaf moisture release curves in predawn samples taken around anthesis were determined for selected wheat and all the barley genotypes.

Fig. 17 shows that there was a tendency for barley landraces to retain more water in the leaf tissue at a given water potential as compared to improved barleys and wheat. Release curves in the barley nursery were more intensively studied. Large differences were found between genotypes. In some genotypes this character was constitutive (the same curve observed at Tel Hadya and Bouider (Fig. 18), with no extra osmotic adjustment under drought. Others (Fig. 19) presented an adaptive trait and adjusted at the dry site (Bouider)osmotically up to about 1MPa at full turgor (RWC = 1.0). Still other genotypes increased their apoplastic tissue under drought (Fig. 20). This increase may be due to decreased mesophyll cell size and increased A^{mes}/A, associated with decreased mesophyll resistance to photosynthesis (Nobel, 1980, 1983). The trend in internal CO_2 concentration (Figure 21) seems to indicate this.

The internal CO_2 concentration is strongly and negatively correlated with net photosynthesis (see 3.3.1 this volume). Other variables that affect photosynthesis also play a role.

The shift within a given barley genotype of the leaf moisture release curve (Fig. 18) to the right under stress had a significantly ($P < 0.05$) negative correlation with grain and biological yield ($r = 0.26$) at the dry site (Bouider). The change in position of the curve was quantified as the PSI value (negative) at which the RWC dropped to 75 %, which is roughly the value of zero turgor pressure (Fig. 18, 19 and 20) for barley. The implications of the type of leaf moisture release curve in terms of stability of performance of a variety under drought are yet to be assessed.

Figure 17. Average moisture release curves. Wheat (□ □), 4 genotypes; improved barleys (O O), 5 genotypes; and barley landraces (● ●), 3 genotypes. Bouider, flag leaf-2, March 18, 1986.

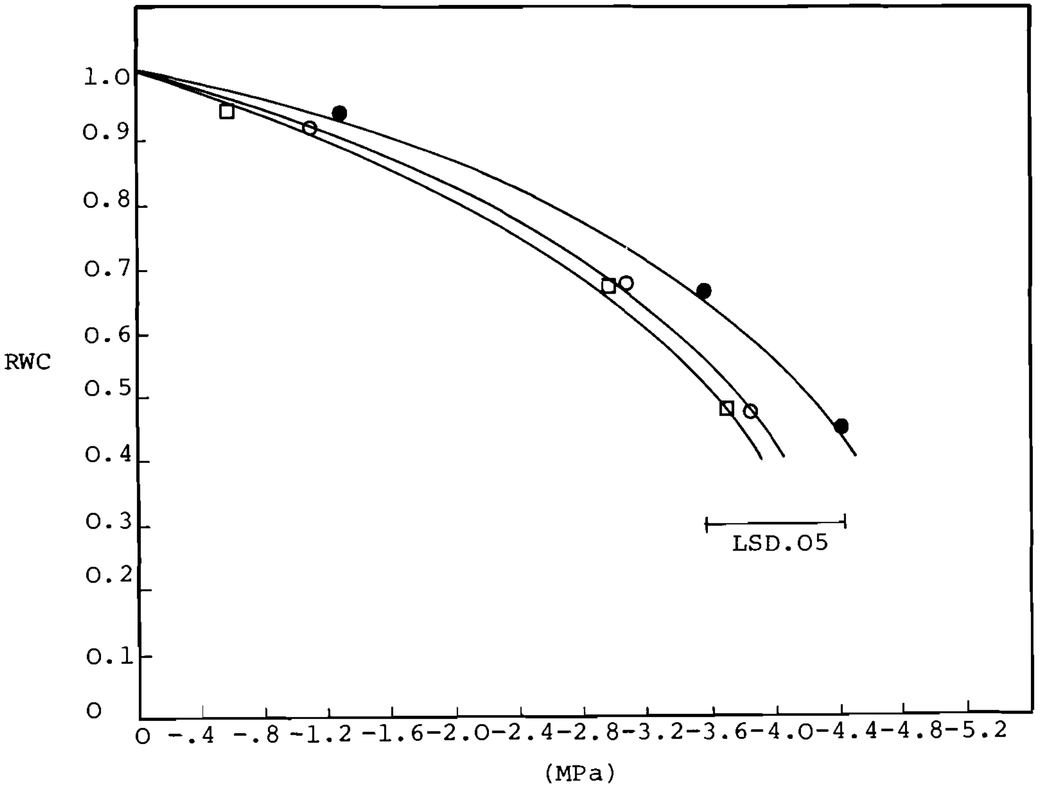


Figure 18. Leaf moisture release curves of contrasting barley genotypes. Flag leaf-2, S BON 38 (⊙ ⊙) and ER/APM (● ●). The data points of each curve are from Tel Hadya and Bouider, 72-75 days after emergence.

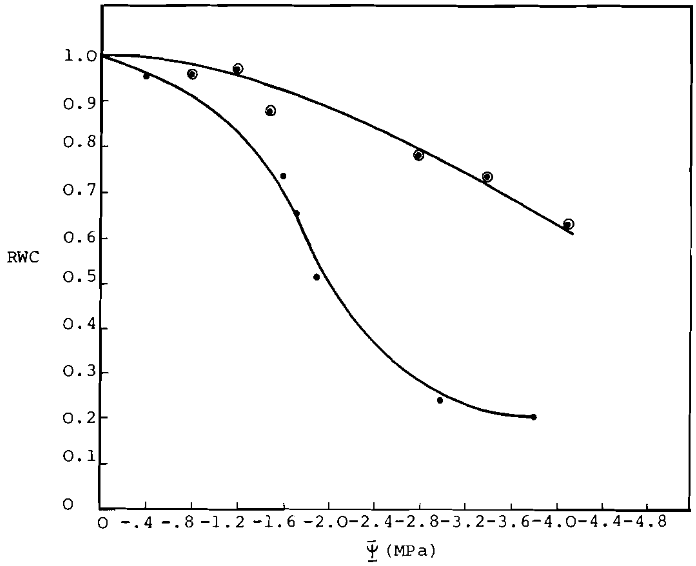


Figure 19. Osmotic adjustment in a barley landrace (ELB 40). Flag leaf-2. Predawn sampling, 72 days after emergence at Bouider (● ●) and Tel Hadya (O O).

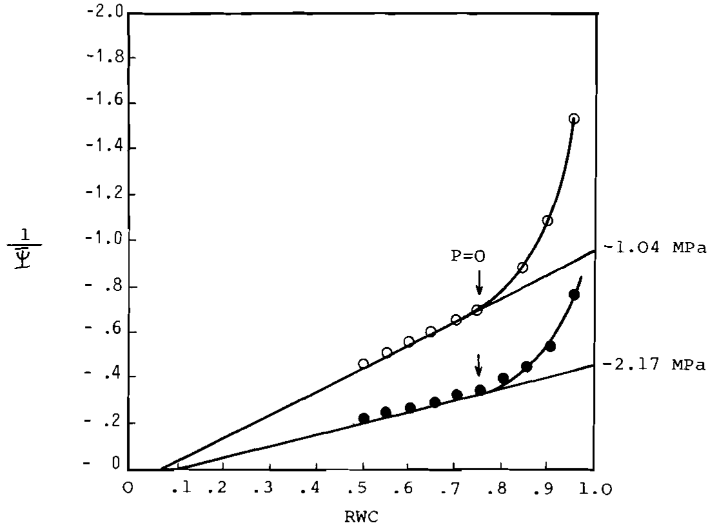


Figure 20. Barley landrace (Tadmor). Osmotic adjustment and increase in a poplastic tissue under drought. Flag leaf-2. Pre dawn sampling, 72 days after emergence at Bouider (O O) and Tel Ḥadya (● ●).

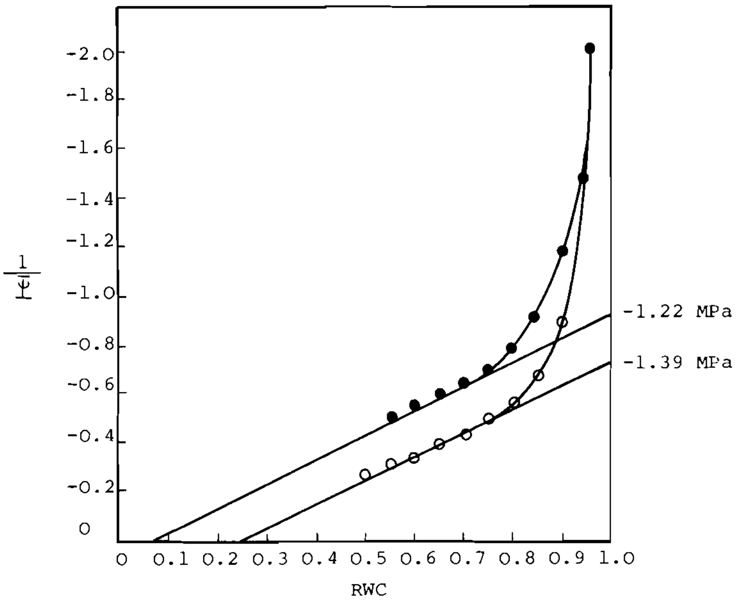
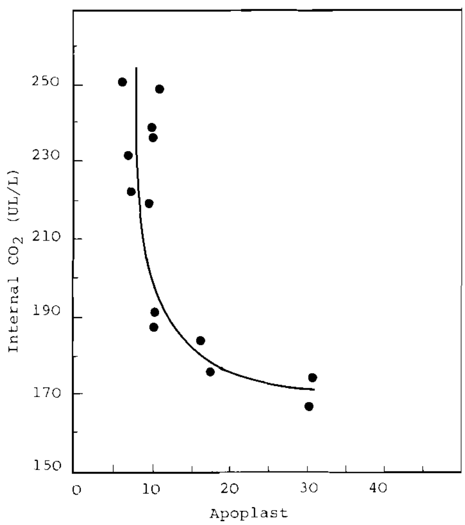


Figure 21. Sub-stomatal CO_2 concentration of barley genotypes differing in apoplastic leaf tissue.



2.3.4. Net Photosynthesis

presumably as a result of a less conservative strategy of water use in wheat, wheat leaf conductance dropped drastically by anthesis as compared to barley and is probably the limiting step in photosynthesis under drought. On the contrary, barley seemed to be limited by the carboxylation mechanism, as evidenced by an increased internal CO_2 concentration under drought, as compared to wheat. If substantiated, this finding would be important since it would imply different strategies in these two species for improving transpiration efficiency under drought. Osmotic and stomatal adjustment might be important in wheat (Morgan 1983), while finding lines with higher carboxylation rates would be the goal in both species. Variability in net photosynthesis exists within these species.

2.3.5. Plant (Crop) Attributes and Yield

Tables 70 and 71 show some crop and plant attributes including their mean and range as well as simple correlations with yield at Bouider and Tel Hadya. A highly significant correlation was found both at Bouider and Tel Hadya between early ground cover and biological (BIOY) as well as with grain yield (GY). Note, however the weak correlation of ground cover at anthesis with GY at Bouider. This might indicate an optimum ground cover at the dry site for maximum grain yield as postulated by Fischer (1981). Wilting symptoms were highly negatively correlated with yield at the dry site (no wilting was observed at Tel Hadya). Leaf rolling (assessed as the number of turns of the leaves) early in the season was positively correlated with yield at the dry site only. The genotypes showing this trait at this time were not experiencing drought stress and hence it may be a constitutive trait. The same trait at anthesis, however, was negatively correlated with yield at the dry site and had a higher mean for the population. At this stage water stress was probably inducing rolling.

In the working hypothesis it was also postulated that slow leaf senescence would be a desirable trait. This was shown to be the case both for Tel Hadya and Bouider (Tables 70 and 71). Peduncle length and plant height had a highly significant correlation with yield at both sites. Days to heading was negatively correlated at both sites but days to maturity was strongly negatively correlated with yield only at the dry site.

Table 70. Barley physiology nursery 85/86. Bouider (174 - 195 mm). Correlation between plant and crop attributes and yield (72 genotypes).

Crop Attribute	Score	Mean (range)	Standard error	Correlation coefficient Bioy	GY
Ground cover (10-40 days)	(0-10)	1.9 (0.2-5.5)	0.04	0.38**	-0.21**
G.C. Anthesis	(0-10)	7.7 (4.0- 10)	0.09	0.34**	-0.16*
Wilting Anthesis	(1R-5S)	2.5 (1- 5)	0.07	-0.33**	-0.32**
Leaf rolling (20 days)	(1L-5H)	1.1 (0-2.0)	0.02	0.31**	0.20**
Leaf rolling Anthesis	(1L-5H)	2.1 (1.5- 3)	0.03	-0.11	-0.03
Senescence (Grain filling)	(1L-5H)	2.6 (1 - 5)	0.07	-0.32**	-0.29**
Peduncle length	(Measured)	7.2 (2.7-15.9)	0.16	0.28**	0.40**
Plant height	(Measured)	40.7 (24.0-78.1)	0.60	0.43**	0.29**
Days to heading	(50 %)	88 (80 - 115)	0.29	-0.26**	-0.23**
Days to maturity	(50 %)	115 (106-126)	0.32	-0.20**	-0.23**

N = 211; * $P < 0.05$; ** $P < 0.01$
R = resistant; S = susceptible; L = low; H = high

Table 71. Barley physiology nursery 85/86. Tel Hadya (261 - 290 mm). Correlation between crop attributes and yield (72 genotypes).

Crop Attribute	Score	Mean (range)	Standard error	Correlation coefficient Bioy	GY
Ground cover (30 days)	(0-10)	1.6 (0.3-5.5)	0.07	0.39**	0.31**
G.C. Anthesis	(0-10)	7.0 (1.5-9.5)	0.10	0.41**	0.31**
Wilting Anthesis	(1R-5S)	1.0 (1.0-1.0)	0.00	-	-
Leaf rolling (30 days)	(1L-5H)	1.6 (0.5-5.0)	0.03	0.04	0.11
Leaf rolling Anthesis	(1L-5H)	2.4 (1.5-3.6)	0.03	0.08	0.05
Senescence (Grain filling)	(1L-5H)	1.1 (1.0-2.5)	0.02	-0.24**	-0.15*
Peduncle length	(Measured)	16.4 (5.3-28.9)	0.28	0.24**	0.34**
Plant height	(Measured)	78.7 (57.0-110.0)	0.62	0.27**	0.20**
Days to heading	(50 %)	92 (85 - 105)	0.25	-0.20**	-0.35**
Days to maturity	(50 %)	120 (114-133)	0.25	0.03	-0.14*

N = 211; * P < 0.05; ** P < 0.01
R = resistant; S = susceptible; L = low; H = high

If, as shown, early ground cover is a desirable crop attribute, then growth habit of the plant may play an important role. Ground cover between 30 and 50 days (tillering stage) was highly and positively associated to a prostrate habit. Plants became erect after shoot extension (70 days), and this was associated with ground cover and highly correlated ($r = 0.38$, $P < 0.01$) with grain yield.

During the mild winter of the 85/86 season frost damage consistently affected the ground cover at Tel Hadya and hence may have affected yield. Frost resistance must therefore be included as a necessary trait for cereal crops grown in these Mediterranean environments.

Stepwise multiple regression analysis of grain yield and crop physiology attributes at the dry site indicated the relative importance of the following: head number/m^2 > peduncle length > growth habit at anthesis > senescence during grain filling > predawn PSI at anthesis (flag leaf -1). At Tel Hadya, the order of importance of variables were: ground cover > duration of grain filling (positively correlated with grain yield) > plant height. Light plant color was significantly ($P < 0.01$) correlated with yield at the dry site.

2.3.6. Preliminary Conclusions

1. Barley as compared to wheat seems to have a conservative strategy in terms of water use. This strategy is shown by an increased resistance to water flow within the plant and a decreased leaf conductance to water vapor.

2. Within barley genotypes there seems to be variation in resistance to water flow, the implications of which must be studied in terms of their contribution to "responsiveness" and "stability" in production.

3. The limiting step of wheat photosynthesis under water stress seems to be decreased stomatal conductance. This probably occurs due to a less restricted strategy in water use. On the contrary, in barley the limiting step seems to be at the carboxylation level. This may imply different plant improvement strategies of the transpiration efficiency in these species.

4. The relative importance of osmotic adjustement to genotype "responsiveness" and "stability" needs to be assessed. Both adaptive and constitutive genotypes regarding this trait were observed. In barley, those genotypes having a constitutive trait seem to behave better under drought.

5. Light color of the canopy seems to be an advantage for barley grown under drought (ca. 200 mm) while dark color favors the genotypes behavior at wetter sites (ca. 300 mm).

6. An early ground cover is strongly and positively associated with biological yield at the dry and wet sites. Grain yield is clearly associated with ground cover only at the wet site, indicating that probably an optimum ground cover and/or a more conservative water use strategy may be needed for the dry site.

7. Early leaf senescence during grain filling is particularly detrimental at the dry sites, both in terms of total biological yield and grain yield.

8. At the dry and wet sites the number of spikes per m^2 seems to predict biological yield and grain yield well. The same occurs with plant height and peduncle length.

9. Leaf rolling during early growth (10 - 30 D) was significantly correlated with biological and grain yield, at this stage being probably a constitutive character.

10. In barley, a postrate habit through stem elongation is highly desirable on the grounds of increasing ground cover. Thereafter, an erect habit with relatively vertical leaves is highly correlated with biological and grain yield.

11. Sufficient variability within barley genotypes exists in the above mentioned attributes to explore them as selection tools. Firm conclusions on this point, however, cannot be achieved with one season of studies.

- E. Acevedo, I. Naji

2.4. Grain Quality

The most important parameters of quality in durum wheat are gluten strength, protein content, vitreousness and size of kernel and content of yellow pigment.

At the cereals quality laboratory gluten strength is determined by the SDS sedimentation test and Brabender farinograph for advanced durum wheat lines.

A study of the SDS sedimentation of RDYT yield trials which were planted in different environments found that the gluten strength of durum wheat is stable and, the ranking of durum genotypes does not vary greatly with the environment.

Most of the lines from the advanced durum wheat yield trial have good gluten strength (Table 72). A sediment volume of at least 40 ml is preferred for both flat bread baking, pasta and burghul preparation.

Table 72. Frequency distribution of lines for SDS sedimentation, ADYT 1985/86.

Management	Less than 20	20-29	30-39	40-49
ADYT-Rf	34	77	103	25

During the 1985/86 season a study was conducted to examine whether high quality durum genotypes could be used for plant bread baking as well as for making pasta/couscous. It was found that the selection of durum wheat genotypes on the basis of dough strength as related to the baking quality of two-layer flat bread, is also satisfactory for identifying high pasta quality (Table 73). The SDS sedimentation test was also highly correlated to both dough strength and gluten strength as assessed by farinograph stability. The use of the combined procedure of SDS sedimentation test, farinograph and two-layers bread baking, allows the identification of durum wheat lines with high gluten strength that is suitable for baking quality and spaghetti-making.

A method also was developed to estimate the color of durum wheat flour by a color gradient board for the rapid visual evaluation of durum wheat flour. The yellow pigment values thus obtained using the color gradient are highly correlated to actual yellow pigment content, as determined by water-satuarated n-butanol extraction and spectrophotometer analysis (r = 0.88). This method allows screening of large number of samples. A total of 3865 lines were screened for yellow pigment content during 1986 using the color gradient board.

- P. Williams, A. Sayegh

Table 73. Relationship between durum strength and spaghetti quality.

Spaghetti C.Q. (Arbitrary unit)	SDS (ml)	FDT (min)	FMT (B.unit)
44.5	49	3.0	50
37.5	42	3.2	60
26.4	39	2.8	68
28.4	33	2.1	91
24.9	27	2.0	110
21.6	17	1.8	131

Spaghetti C.Q. = Spaghetti cooking quality; SDS = sedimentation; FDT = Farinograph development time; FMT = Farinograph mixing tolerance.

2.5. Entomological Screening Trials for Durum Wheat

Emphasis in entomology in 1985/86 was given to screening 114 durum wheat lines for resistance to wheat stem sawfly, Cephus pygmaeus, and aphids at Tel Hadya. All wheat stem sawfly screenings were conducted under cages using artificial infestations of adult insects. Naturally occurring populations of aphids were allowed to infest lines previously screened for sawflies, and were rated on a 0-5 scale according to the density of aphids on each line.

Four lines were found to exhibit resistance to wheat stem sawfly (Table 74). In all cases % infestation was less than 1.7%. In comparison, the local check Hammari ranged in infestation from 8.3% to 55.0% (mean = 32.0).

Table 74. Lines of durum wheat exhibiting resistance to wheat stem sawfly under artificial infestation at Tel Hadya.

Variety	Seed source	Mean % infestation
Marrocos 46 3617 PI 191621	DSSN 83 36	0.6
VALRICARDO	IDYN 85 14	0.0
Rabi/3/Gll//LDS/RL 3601/4/Fg/5/Cn/Plc ICD 80-0692-9AP-1AP-3AP-3AP	ADYT 86 910	0.6
D-2/Waha ICD 79-0282-10AP-3AP/-2AP-1AP.-0SH	ADYT 86 1111	0.6

No resistance to aphids was observed in any of the durum lines tested. In each case densities of over 200 aphids/plant were observed.

Stepwise multiple regression of peduncle length, days to maturity, and days to heading onto % sawfly infestation were all significant. About 25% of the observed variation in sawfly infestation rates was explained by these 3 variables when considered together. Better predictors of sawfly infestation associated with the host-insect interaction must be identified.

- R.H. Miller

2.6.1. Evaluation and Documentation of Durum Wheat Germplasm

This is a cooperative project between ICARDA and Italian institutions: University of Tuscia, Viterbo; Germplasm Institute, Bari and ENEA, Rome, with the following objectives:

(a) to evaluate durum wheat germplasm in several contrasting environments, (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 to confirm results. The agronomical, physiological as well as grain quality characters which number about twenty-five, not only take into consideration the present requirements of the breeders but are also aimed at providing useful data for future breeding goals.

In 1985-86, approximately 5000 (nearly 25% of the total) lines from the germplasm collection were planted at Tel Hadya (relatively moderate rainfall site >350 mm), Breda (low rainfall site <275 mm) and at Hegla (very low rainfall <150 mm, saline/drought affected site). This year more emphasis was placed on two aspects of evaluation: a) inclusion of some important agronomic characters previously excluded, as well as observation on major stresses and diseases in the region, and b) adoption of an experimental design which could deal adequately with the variability within the soil in experimental fields without the use of replicates.

In addition single 30 cm rows of the same 5000 lines were planted at Lattakia (high temperature/rainfall site) for screening against Septoria (leaf blotch) infection, and at Tel Hadya for yellow rust and common bunt screening.

Observations on infection of yellow rust in the Tel Hadya pathology nursery was recorded. Many lines with low infection were noted in March. During April the field was irrigated to see if a second attack of yellow rust could be induced. It was noted that some plants which were heavily infected during the first observation were only slightly or moderately infected after about 30 days when the second observation was recorded. These observations are given in Fig. 22.

In the main experiment at Tel Hadya, some accessions were heavily infected with yellow rust under natural conditions and were noted. The same accessions were among those also affected in the artificial inoculation in the pathology nursery, re-confirming the susceptibility of certain accessions to yellow rust in a moist, relatively moderate rainfall environment. In contrast only half a dozen accessions were moderately affected with this disease at Breda and almost none at Hegla.

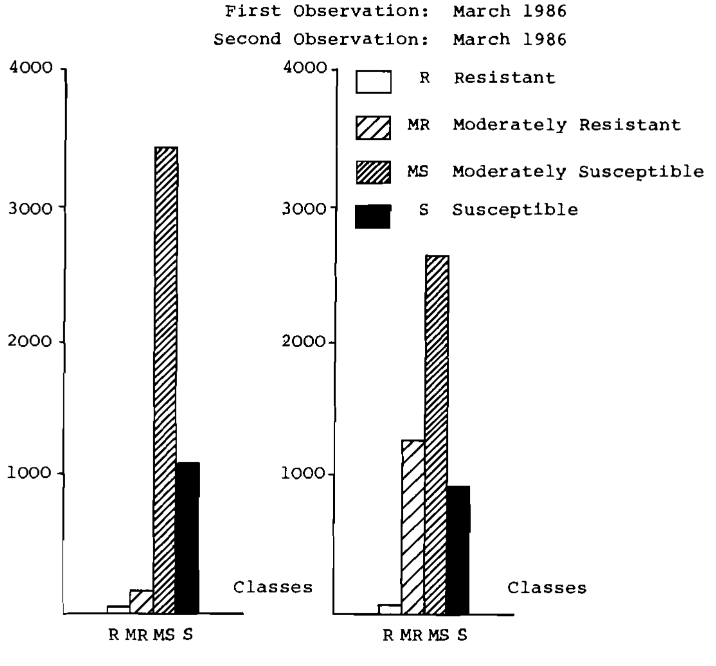
The results of observations at Lattakia on the incidence of infection on plants due to Septoria inoculations were as follows: 18.1% were rated as highly resistant, 40.2% were resistant, 25.7% were moderately resistant and 16% were highly susceptible to the disease.

The germplasm was also evaluated at INRA, Tunisia. The results of the Septoria screening trials performed in Tunisia are given in Table 75.

Table 75. Results of the screening for Septoria (leaf blotch) in Tunisia (two different methods of scoring were used).

Classification	No. of accessions	Percentage
A. Accessions from ICARDA's collection		
Resistant	700	24.1
Intermediate	1056	36.3
Susceptible	1152	39.6
B. Accessions received from Bari, Italy		
Resistant	571	25.0
Moderately resistant	485	21.7
" susceptible	723	33.0
Susceptible	455	20.3

Figure 22. Evaluation of durum wheat germplasm for yellow rust resistance 1985/86.



For the screening of germplasm against common bunt the number of infected spikes were counted and percentages obtained to arrive at the degree of infection present. Because this disease, even in its mildest form, can significantly reduce the value of the farmer's crop a very strict formula was used to classify the accessions which were recorded as not affected by the inoculation. Hence only 10.5% were classified as not infected, 3.9% as moderately infected, 9.0% as moderately susceptible and 76.6% as highly susceptible.

The area around Breda, the dry site, is mostly given to rainfed agriculture of barley due to a harsh environment which makes cultivation of wheats an uncertain proposition in most years. However, the site is ideal for testing wheat lines for performance where there is little rainfall and poor soil fertility. Out of the 5000 accessions planted in 1985 and harvested next year, the overall performance of 90 lines was better than the local well-adapted check "Haurani" and 536 lines did as well as the check as per an agronomic score based on earliness, plant vigour and yield potential, that is, a total of 626 lines (or 12.5%).

The 5000 accessions were planted in two replicates at Hegla. About 1105 lines in the second replicate were found to be superior to the check "Haurani". However, due to the extreme variability for soil salinity in the field, there were parts in both replicates where all plants had failed to survive. Therefore, the results of the two replicates were combined to identify 322 lines which were able to bear seeds in both replicates. Most of these will be replanted at Hegla during 1986-87 in at least three replicates to identify the best 100 truely salt tolerant lines. Attempts will also be made to improve soil uniformity at Hegla in order to minimise experimental errors as a result of wide fluctuations in the ECe levels.

Heading was recorded at Hegla on only a few samples. The majority did not head or produce seeds. Most died due to salinity, drought and very high temperatures. However, total biological yield was recorded on all accesions. Those plants which had spikes were threshed and seeds obtained. Most of the seeds were shrivelled and small. The results are still being analysed. The same germplasm is also being evaluated using electrophoretic techniques at the University of Tuscia at Viterbo, Italy. The results of these analyses will be made available to interested scientists when they become available.

In addition to the above experiments thirty-five selected lines from the Durum Observation Nurseries (DONs) were planted at Tel Hadya. Seventy-six selected germplasm lines from last season's evaluation and 104 lines with suitable checks being tested for yield potential were planted at Tel Hadya and Breda.

The data is being analysed and results will be published shortly.

2.6.2. Selected germplasm from 1984-85

For the selected germplasm from last season the following characters were considered: emergence, seedling vigour, plant height, days to heading, days to maturity, and yield. At Breda an additional character of agronomic score was recorded. The accessions which performed equally well or better than the check for the above characters at Tel Hadya and Breda have been identified and were made available to ICARDA breeders for further evaluation and possible use in crosses.

An analysis showed significant variability for yield at both locations. However, the variability was greater at Tel Hadya than at Breda. Interesting correlations were also found at both locations. At Tel Hadya days to heading and days to maturity were negatively correlated with yield, i.e. the late types had poor yield. On the other hand days to maturity was negatively correlated with lodging, indicating that late types were also resistant to lodging. It is possible that the lines which matured early were subjected to high winds and rains prevalent in April which could have contributed to the lodging.

At Breda many accessions did not head and others produced heads too late, as much as 150 days after germination. On the other hand the lines with a higher number of days to maturity had a longer grain filling period and are therefore yield positive. This result may indicate that in a dry area like Breda a higher grain filling period is beneficial as far as yield is concerned. This is in marked contrast to the situation at Tel Hadya where higher days to maturity results in lower yields. The data and results of evaluation and characterization will be produced as a catalogue.

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3. Bread wheat Improvement

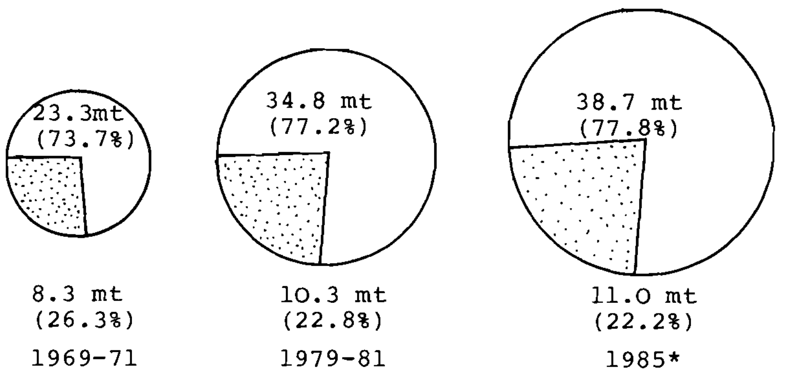
3.1. Breeding

3.1.1. Introduction

Bread wheat is the most important cereal crop grown in West Asia and North Africa. During 1985, these countries produced 49.7 million metric tons (m.m.t) of wheat (Fig. 23). Of this, approximately 77.8 percent was bread wheat. The environments where wheat is grown West Asia and North Africa are very variable in terms of rainfall, temperature, soils, disease, and insect pest. Crop management also varies greatly. More than 85% of bread wheat that is grown in the region is rainfed. It has been estimated that about 50% of this area receives less than 400 mm rain annually.

In West Asia and North Africa where wheat is grown the seasonal variation in temperature is large. Typically wheat is sown in the fall, where its early growth and development occurs during the coolest months, but temperatures rise rapidly as the grain ripens. Extreme cold, and heat are common stresses and are often combined with drought. Diseases and insect pests are also important constraints that limit wheat production in the region.

Figure 23. Production (million tonnes) of bread wheat (clear portion) and durum wheat (shaded portion) in the ICARDA region for the periods 1969-71, 1979-81, and 1985.



*Estimate, FAO Monthly Bulletin of Statistics, Vol.8, December, 1985

The objectives of the ICARDA/CIMMYT joint Bread Wheat Improvement Project are the development and identification of germplasm possessing following attributes:

1. Increased and stable yield under varied amounts and distributions of rainfall.

2. Tolerance to drought, cold, heat, and salt.

3. Resistance to diseases including the three rusts, septoria, common bunt, etc.

4. Resistance to insect pests such as sawfly, Hessian fly, suni bug, and aphids.

5. Acceptable nutritional and industrial grain quality.

6. The development of improved agronomic practices in conjunction with national programs in the region.

7. Training

3.1.2. Breeding for high yield and stability

Bread wheat is usually grown in West Asia and North Africa at precipitation levels ranging from 250 mm to 650 mm. During 1986 the bread wheat program selected and identified breeding material for this wide range of precipitation. This was done through the use of three contrasting locations, two in Syria and one in Lebanon, representing a range between 208 to 600 mm average rainfall (Table 76). The yield level of 240 advanced bread wheat lines was significantly increased over two years in the three locations. The percent change in yield was greater in the moderate rainfall environment (Tel Hadya, 316-373 mm), and least in the driest site (Breda 208-277 mm). It is interesting to note that during the first year of testing, 1984-85, at least 25 days of $-10^{o}C$ were registered in these locations, while the 1985-86 season was characterized as being extremely dry and with mild temperature. The yield levels were consistently higher in 1985-86 indicating that temperature stress may be more important than moisture stress when breeding for rainfed environments.

Table 77 shows seven advanced Bread wheat lines that combine high yield and yield stability under two contrasting moisture regimes. The highest yield achieved under low rainfall conditions was 1877 kg/ha while the highest yield achieved in the well-watered environment was 7222 kg/ha. All seven lines were significantly higher yielding than the local and improved checks.

Table 76. Trends in yield levels of 240 advanced bread wheat lines over two years and three locations.

	Yield (kg/ha)											
	Highest yielding line			X of best 10 lines			X of all lines			Local check X yield		
Year	B	TH	T	B	TH	T	B	TH	T	B	TH	T
84/85	1711	3544	6094	1428	3290	5819	1088	2577	5197	1225	2754	5284
85/86	1905	4725	7266	1698	4488	6543	1355	3736	5515	1353	3196	5828
%Change	11	33	20	19	36	13	25	45	6	10	16	10

B = Breda, Syria; TH = Tel Hadya, Syria; T = Terbol, Lebanon.
Precipitation(mm): 84-85 : B = 277; TH = 373; T = 600, 85-86: B = 208; TH = 316; T = 600

Table 77. Bread wheat lines in the AWYT that significantly (P<0.05) out-yielded Mexipak 65 under limited moisture conditions (208 mm) and Sham 2 under high input management, 1985/86.

	Breda, Syria (rainf.)			Terbol, Lebanon (irr.)		
Cross and pedigree	Yield (kg/ha)	LSD (5%)	% of Mexipak 65	Yield (kg/ha)	LSD (5%)	% of Sham 2
Kvz/Cgn SE1066-9S-1S-6S-0S-6K-0K	1877	302	169	5777	619	108
Ald'S'/Ska CM51979-2AP-1AP-1AP-2AP-1AP-0AP	1744	303	157	5850	620	109
Desc/Fcr//Pima/3/Pvn'S'/ Ald'S' CM57857-K-6Y-1Y-3M-3Y-1M-3Y-0M	1686	251	140	6355	616	121
Snb'S'/Pima CM59034-3AP-1AP-2AP-1AP-0AP	1633	365	118	7222	501	127
Tsi/Vee'S' CM64335-3AP-3AP-1AP-0AP	1630	287	104	5505	724	103
SD648.511/SD648.5/5/8156// Chr//Sn64//Kbre/3/Bb/4/Zb2 CM32670-6S-1AP-1AP-2AP-0AP	1497	251	125	6833	616	130
Tob//HD832/Bb/3/Mon'S' CM56718-5Y-2Y-3M-3Y-1M-0Y	1483	252	123	6311	617	120

3.1.3. Multilocation selection and testing for abiotic stresses

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

These five regional environments, their average yearly precipitation and the average grain yield of 210 advanced Bread wheat lines are shown in Table 78. Breda and Terbol represent the extremes in environmental conditions in terms of moisture availability and soil fertility, while the three simulated environments at Tel Hadya aid in screening germplasm under different moisture and temperature regimes. Using this strategy, several lines significantly higher yielding than the local and improved checks have been identified by the project (Table 78). In this regard, more lines have been identified in the less stressed environments than in the more stressed ones, indicating the level of difficulty when breeding for marginal environments.

Table 79 presents five bread wheat lines that, under 208 mm rainfall, performed better than local and improved checks. These were Mexipak 65 and Sham 2, respectively. One line yielded 2066 kg/ha and all five lines were statistically higher yielding than both checks.

Our efforts continued in 1986 to select and identify genetic material with tolerance to both, terminal heat stress and heat stress at early stage of plant development. Figure 24 shows the program's common strategy in breeding for this characteristic. By shifting planting dates of segregating populations and advanced lines at Tel Hadya, germplasm is exposed to low or high temperatures during critical stages of plant development. Furthermore, by using shuttle breeding between Wad Medani, Sudan and Tel Hadya, Syria, it has been possible to make progress in identifying germplasm tolerant to heat stress. Figures 25 and 26 describe longterm (1978-1985) environmental data in Wad Medani, Sudan and Tel-Hadya, Syria. These two figures confirm that by exposing breeding material to terminal heat stress (Fig. 25) and heat stress at early stages of plant development (Fig. 26) at Tel Hadya, and by subsequent exchange of germplasm between Wad Medani and Tel Hadya, breeding progress can be obtained.

Table 78. Number of lines that were significantly higher yielding than the local check, Mexipak 65, and the improved check, Sham 2, in the advanced wheat yield trials*, 1984-85 and 1985-86, respectively.

Regional environment	Year	Average yield (kg/ha)	Seasonal Rainfall (mm)	No. of lines higher yielding (P<0.05) than Mexipak	or Sham 2
Breda	84/85	1200	283	11	3
NP-RF	(85/86)	1355	208	22	5
Tel Hadya	84/85	1672	300	20	9
LP-SIR	(85/86)	1536	250	50	24
Tel Hadya	84/85	2578	342	21	6
NP-RF	(85/86)	3736	316	118	15
Tel Hadya	84/85	3350	450	15	15
EP-SIR	(85/86)	3926	400	84	26
Terbol	84/85	5198	600	20	21
NP-IRR	(85/86)	5515	600	12	16

NP = Normal planting; LP = Late planting; EP = Early planting
RF = Rainfed; SIR = Supplementary irrigation; IR = Irrigation
* = 210 Entries different in each year.

Figure 24. Weather conditions for the wheat-crop season, Tel Hadya, Syria, 1980 to 1985. Sowing date: Early (E), Normal (N), X Late (L).

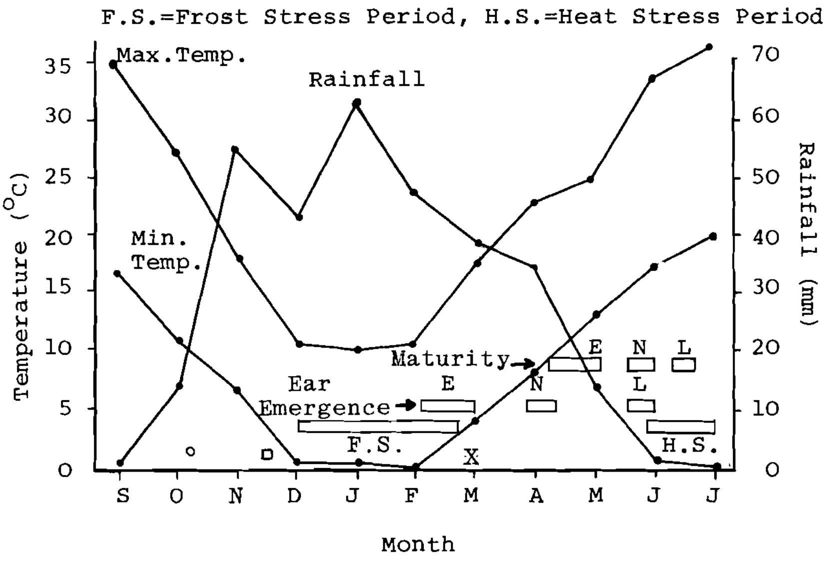


Table 79. Bread wheat lines with higher yield ($P<0.05$) than Mexipak 65 (local check) under drought conditions (208 mm) in PWYT 1985/86, Breda, Syria.

Cross and pedigree	Yield (kg/ha)	L.S.D (o.o5)	Mexipak %	Sham 2 %	CV %
Cli/Maya 74 CM49544-2AP-1AP-1AP-2AP-1AP-2AP-0AP	2066	433	127	137	13.32
Cno/7C//Cc/Tob/3/Cno'S'/ No.66/4/Cal/Kal/5/Cno'S'/ No.66//Cc/Inia ICW79-0852-3AP-5AP-3AP-3AP-0AP	1833	244	127	141	9.12
Veery 1/Prl'S' CM69572-1AP-1AP-1AP-0AP	1641	321	142	130	11.88
Bow'S'/Crow'S' CM69599-2AP-2AP-2AP-0AP	1625	538	135	111	20.79
Kvz/Bjy'S' SWM11027-2AP-2AP-2AP-1AP-0AP	1550	404	136	119	15.81

Figure 25. Average long-term (1978-1985) environmental data between Wad Medani, Sudan and Tel-Hadya, Syria. Crop phenology drawn using two years data from each location.

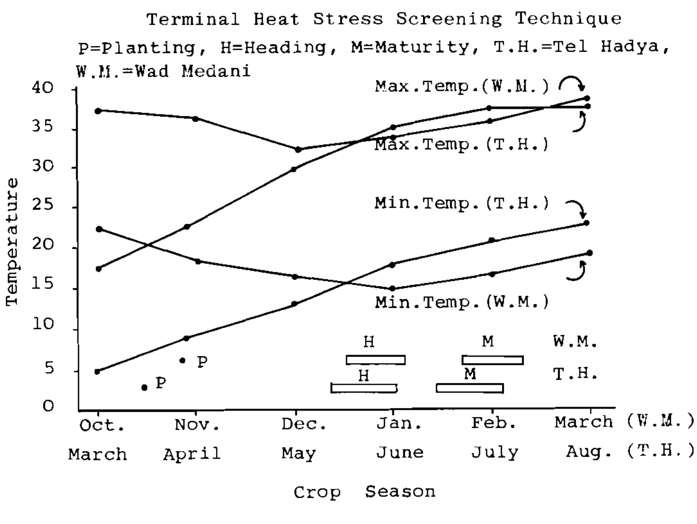


Figure 26. Average long term (1978-1985) environmental data between Wad Medani, Sudan and Tel Hadya, Syria. Crop phenology from 2 years data from each location.

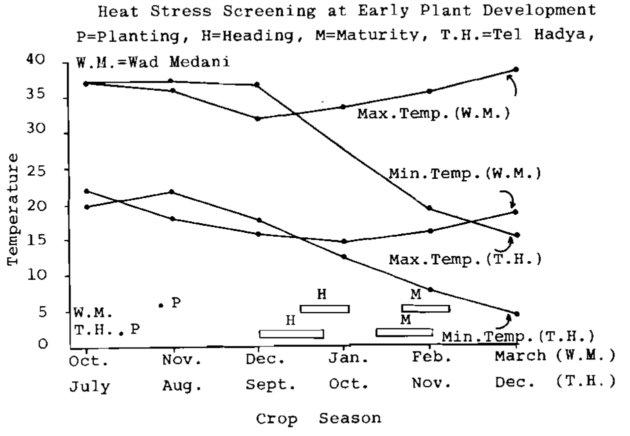


Table 80 presents the top performing lines developed using this strategy. These five lines combine earlier maturity, heat stress tolerance and significant ($P < 0.05$) higher yield than the improved check under the conditions described before.

Table 80. Advanced bread wheat lines combining grain yield, heat tolerance and earliness at Tel Hadya, 1985/86.

Cross and pedigree	Yield (kg/ha)	LSD (5%)	% Ahgaf	HTS L/C	DH L/C	DM L/C
Bb/7C*2//Y50E/Kal*3 CM29014-7S-2AP-1AP-4AP-0AP	3122	437	122	1.0/2.0	69/72	104/109
Flk'S'/Hork CM39816-1S-1AP-0AP	3105	408	116	1.6/2.0	69/71	107/108
Yr/Sprw'S' L825-4AP-4AP-1AP-2AP-1AP-0AP	2977	438	116	1.6/2.0	70/72	106/109
Tuc'S'/3/Tob//Cno/NO.66 CM32462-3AP-1AP-0AP-1AP-0AP	2850	426	117	2.0/2.3	71/72	107/109
Bch'S' (B)/7C CM45186-2AP-0AP-2AP-1AP-1AP-0AP	2788	322	115	1.6/2.3	69/72	104/109

HTS = Heat tolerance score (1 = Best 5 = worst)
L = Line, C = Check, DH = Days to heading, DM = Days to maturity

3.1.4. Performance of new germplasm in co-operating countries

During 1986 the project continued distributing improved bread wheat germplasm to national programs in West Asia and North Africa with the goal of: 1) providing promising lines for potential release as commercial varieties in those countries, and 2) collecting information on the adaptation of those lines in the region. Results from the Wheat Observation Nursery 1984-85 (Table 81) indicate that there is a large number of lines with substantially better yield, earlier maturity, and more acceptable disease resistance than both the long term check and the national check. Although this nursery is an unreplicated trial, the information on qualitative characters such as disease resistance and maturity over locations reflects the value of these entries in those locations.

Table 81. Number of bread wheat lines with superior grain yield, earlier maturity, and acceptable disease resistance in comparison to the long term check Mexipak 65 and the national check in WON 1984/85. Data are given for 125 entries.

	Number of superior entries						
				ACI			
	Yield	DH	DM	YR	LR	SR	ST
Long term check (frequency)	69	58	61	103.0	109.0	79.0	73.0
National check (frequency)	8	16	22	96.0	85.0	25.0	81.0
Long term check Yield (kg/ha)	2969	104	143	25.8	50.6	13.6	5.7
National check Yield (kg/ha)	3405	99	139	20.3	16.3	2.8	6.0
No. of locations	19	28	24	6.0	6.0	5.0	4.0

DH = Days to heading, DM = Days to maturity, ACI = Average coefficient of infection, YR = Yellow rust, LR = Leaf rust, SR = Stem rust, ST = *Septoria tritici*.

Table 82 shows the five best performing lines in this nursery. These lines have higher yield, improved disease resistance, and better agronomic type than the regional check. They were also selected on eight or more occasions by national cooperators in the region based on visual evaluation of agronomic type and disease resistance.

Results of eight years of Regional Wheat Yield Trial data (1978 to 1985), indicate that the adaptation of bread wheat germplasm in the region has increased over the years (Fig. 27). Although the number of test locations of this trial remained constant over the years, the number of lines selected by national programs in the region based on their statistical superiority over the national check variety has increased. This is a modest but significant achievement considering that the national check at each location is usually a well adapted, widely grown commercial variety. It is also interesting to note that the yield gap between the top bread wheat line and the national check has widened to approximately one ton/ha during the last two years.

Figure 27. Number of bread wheat lines significantly (P<0.05) outyielding the national checks at 21 countries in West Asia and North Africa, 1977-1985.

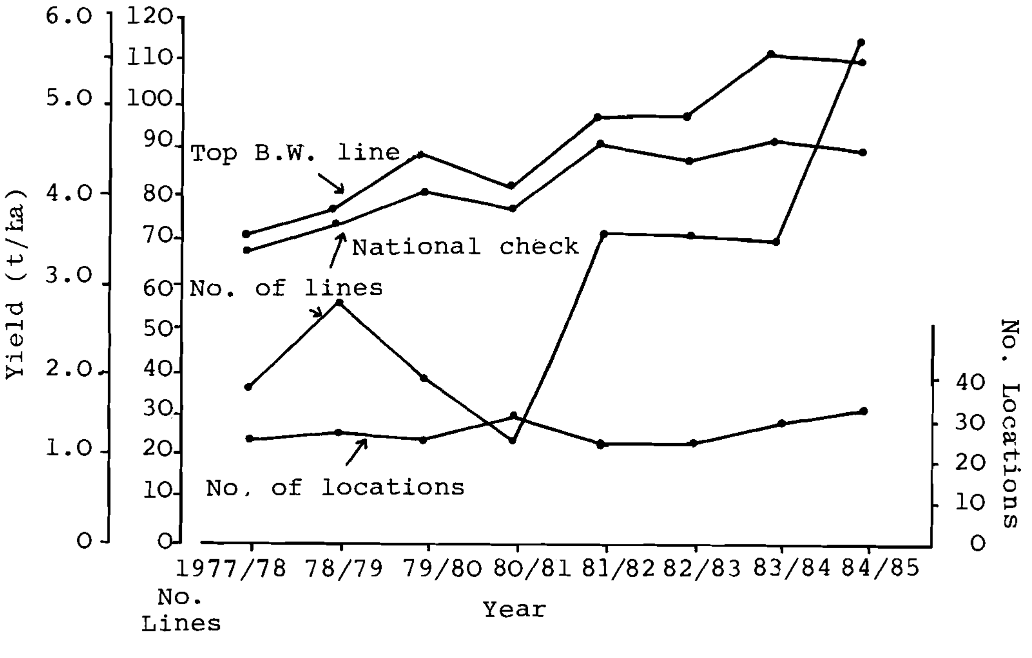


Table 82. Bread wheat lines that combine high grain yield, disease resistance and agronomic type with good adaptation in the region from the bread wheat observation nursery at 19 locations 1984/85.

Cross and pedigree	Yield (kg/ha)	Sum sel	DH	DM	PH (cm)	ACI YR	ACI LR	ACI SR	ACI ST
Sannine/Ald 'S' L 932-0L-11AP-0AP-2K-0AP	3430	10	109	146	84	0.53	0.50	2.04	3.75
Trm/K 253.18 CM46127-1AP-0AP-2AP-1AP-1AP-0AP	3819	10	101	142	87	11.53	15.33	28.20	5.75
Kvz/Cgn SE1066-9S-3S-4S-0S-4K-0AP	3253	9	103	146	85	14.00	5.67	1.60	6.50
Trm//Kal/Bb CM49744-1AP-4AP-1AP-6AP-0AP	3474	9	99	140	81	3.70	15.50	7.24	6.25
Cal//Bb/Cno/3/7C/4/ Kt54/N10B L901-0L-1AP-1AP-0AP	3315	8	104	144	84	5.50	16.83	11.60	6.00
Mexipak 65 (Regional check)	2969	5	104	143	87	55.50	57.33	19.64	6.75

Sum sel = Number of locations where the entry was selected as promising, based on visual evaluation of agronomic type and disease resistance.

DH = Days to heading, DM = Days to maturity, PH = Plant height, ACI = Average coefficient of infection, YR = Yellow rust, LR = Leaf rust, SR = Stem rust, ST = Septoria tritici.

Table 83 presents the most promising lines in four different sub-regions of West Asia and North Africa. Two of these lines, W3918 A/Jup and Neelkant'S' were among the five best lines in all 32 locations across all 4 sub regions and they are now considered for release as commercial varieties by several national programs in the region.

Table 83. Performance of promising bread wheat lines in four different sub-regions of West Asia and North Africa, RWYT 1984/85.

Subregion and entry name	Yield (kg/ha)	Rank	% Over national check
Middle east (13 locations)			
W 3918 A/Jup	3775	1	113
CMH 72-428/Mrc//Flr'S'	3566	2	107
Neelkant'S'	3455	3	104
National Check	3332	6	100
Arabian Peninsula (8 locations)			
W 3918 A/Jup	5020	1	129
Sunbird'S'	4917	2	126
Bb/7C*2//Y50E/Kal*3	4801	3	123
National Check	3889	21	100
Nile Valley (6 locations)			
T. Aest/Mo//Nac	5056	1	116
HD 2206/Hork'S'	4830	2	111
GV/Ald'S'	4382	3	101
National Check	4350	6	100
Maghreb (5 locations)			
Neelkant'S'	3636	1	123
W 3918 A/Jup	3449	2	116
GV/Ald'S'	3379	3	114
National Check	2963	16	100

3.1.5. Farmers field verification trials

The bread wheat project places special emphasis in developing germplasm with adaptation to the low rainfall environments of the region. Results from these efforts indicate the possibility of making breeding progress in these marginal areas as regards moisture stress. Table 84 presents data from Farmers Field Verification Yield Trials grown in the low rainfall zones of Syria (250-350 mm). The cultivar W 3918 A/Jup ranked first over seven locations and significantly outyielded the local check (Mexipak 65) in that area. This line is considered for release as a commercial variety for the low rainfall areas of Syria. Syria released this year a new wheat variety Sham 4 (Flk'S'-Hork'S') for commercial cultivation. Sham 4 was released after three years of testing in Farmers' Field Verification Trials in which it consistently showed significantly higher yield than the local and improved checks.

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Table 84. Performance of bread wheat lines in the low rainfall areas of Syria (250-350 mm) in farmers field verification trials, 1985/86.

Cultivar	Suran Y	Suran R	Rasafeh Y	Rasafeh R	T.Hadya Y	T.Hadya R	El Safeh Y	El Safeh R	Ghzial Y	Ghzial R	El Jamel Y	El Jamel R	Bosra Y	Bosra R	Mean yield (kg/ha)	R
Mexipak 65	2.1	3	2.1	2	2.1	5	1.9	3	1.9	4	1.9	2	0.4	4	1815	4
ACSAD 59	2.0	4	1.9	4	2.3	3	1.8	4	2.2	1	1.8	3	0.5	2	1820	3
Veery'S'	2.2	2	1.9	3	2.2	4	2.0	2	2.1	2	1.8	4	0.4	3	1833	2
Bohouth 4	2.0	5	1.9	5	2.4	2	1.5	5	1.7	5	1.6	5	0.4	5	1663	5
W 3918 A/Jup	2.6	1	2.4	1	3.0	1	2.1	1	2.0	3	2.1	1	0.6	1	2120	1
Mean	2.2		2.0		2.4		1.9		2.0		1.8		0.5			
LSD(0.05) (kg/ha)	333		164		399		248		220		208		114			
CV (%)	8.0		4.1		8.8		6.9		5.8		6.0		12.4			

Y = Yield (tons/ha), R = Rank

3.2. Pathology

3.2.1. Screening for resistance to yellow rust (*Puccinia striiformis*), leaf rust (*P. recondita*), septoria tritici blotch (*Mycosphaerella graminicola*), and common bunt (*Tilletia foetida* and *T. caries*).

This screening is done annually at, Tel Hadya, and some off-sites in Syria. However, some of the germplasm is sent to other locations and the disease data returned are included in the evaluation. This screening aims at (1) testing the performance of germplasm developed for its resistance to yellow rust, leaf rust, septoria tritici blotch and common bunt, and (2) identification of new sources of resistance to these diseases for retesting in the special purpose disease nurseries.

3.2.1.1. Yellow rust

The bread wheat germplasm tested for yellow rust consisted of a total of 1660 lines from Aleppo Crossing Block (APCB), Regional Crossing Blocks (WCB), Preliminary Disease Nursery (PDN), Key Location Disease Nursery (KLDN), Observation Nursery Moderate Rainfall (WON-MR), and Low Rainfall (WON-LR), Regional Yield Trial (RWYT), Yellow Rust Nursery (WYR) and Observation Nursery-Tunisia (WOT) screened at 1,1,3,3,2,1,2,3, and 1 site, respectively (Table 85). Out of these, 510 showed resistance to the disease. However, only 50 lines were selected for enclusion in the WYR of the coming season 86-87. The highest percentage resistant lines (56%) was found in the WYR followed by 55% in WON-LR and by 45% in RWYT.

3.2.1.2. Leaf rust

For the first time screening for resistance to leaf rust in the plastic houses at T. Hadya was sucessful on PDN and KLDN germplasm. However, data on this disease from other sites where these germplasms were planted are included in the analyses. Out of 650 lines tested, 175 showed resistance and were selected for inclusion in the newly initiated Leaf Rust Nursery 1986-87.

Table 85. Bread wheat germplasm screened for resistance to yellow rust (YR), leaf rust (LR), septoria tritici blotch (ST) and common bunt (CB), 1985/86 season.

Germplasm	No.Entries tested	No. entries resistant YR[1)]	LR[1)]	ST[2)]	CB[3)]
Aleppo Crossing Block	200	81	-	10	55
APCB 86		(40)	-	(5)	(28)
Regional Crossing Block	160	63	-	7	21
WCB 86		(39)	-	(4)	(13)
Preliminary Disease Nursery	400	139	107	108	26
PDN 86		(36)	(28)	(28)	(7)
Key Location Disease Nursery	250	77	68	74	10
KLDN 86		(34)	(30)	(33)	(4)
Observation Nursery-Moderate Rainfall	113	40	-	42	-
WON-MR 86		(37)	-	(39)	-
Observation Nursery-Low Rainfall	91	47	-	5	-
WON-LR 86		(55)	-	(6)	-
Regional Yield Trial	24	10	-	1	-
RWYT 86		(45)	-	(5)	-
Yellow Rust Nursery	75	38	-	-	-
WYR 86		(56)	-	-	-
Septoria Nursery	150	-	-	94	-
WST 86		-	-	(70)	-
Repeat Testing Bunt	200	-	-	-	44
WRTB 86		-	-	-	(23)
Observation Nursery-Tunisia	347	15	-	26	-
WOT 85		(4)	-	(8)	-
Total entries	tested	1660	650	1735	1210
	resistant	510	175	367	156
	selected	50	175	56	78

( ) = % resistant lines, checks excluded; 1) Average severity 0-5% in the screening sites: T. Hadya,Lattakia/Syria, Terbol/lebanon, Elvas/Portugal; 2) Average score 0-5 in the screening sites: Lattakia and Al ghab/Syria, Elvas/Portugal, Beja/Tunisia, not exceeding 7 in Al Ghab; 3) 0-15 % infected heads.

3.2.1.3. Septoria tritici blotch

The germplasm tested for septoria blotch consisted of 1735 lines from WAC, RCB, PDN, KLDN, WON-MR, WON-LR, RYT, WST and WOT screened at 1,1,3,5,3,1,1,4, and 1 site, respectively. Out of these 367 showed resistance to the disease and 56 were selected for inclusion in the WST 1986-87. The highest percentage of resistant lines (70%) was found in WST-germplasm, followed by 39 % in WON-MR.

3.2.1.4. Common bunt

Preliminary screening for resistance to common bunt is done in the Common Bunt Nursery I, where the inoculum for this season constituted of 15 syrian isolates collected from durum and bread wheat lines. The inoculum was bulked and adjusted to have the pathogens T. foetida and T. caries present in a 1:1 ratio. The germplasm tested totaled 1210 lines from WAC, RCB, PDN, KLDN and WRTB. Of these lines, 156 showed resistance to the disease, and 78 lines were selected. The highest percentage of resistant lines (28%) was found in the WAC-germplasm, followed by 23% in the WRTB.

Advanced screening for resistance to common bunt is done in the Common Bunt Nursery II with 10 different isolates from the region used (2 Syria, 3 Turkey, and one each from Lebanon, Tunisia, Iran, Pakistan and Morocco)*. Out of the 15 bread wheat lines tested only two lines had an average infection of 0-10% for all isolates used (Table 86, entry no. 22, 23). These two lines were included in a selection of wheat lines resistant to common bunt and are available for the use of the national programs.

This selection/collection (Table 86) has been critically screened the past three seasons (1983/84-1985/86). In this selection only resistant to moderately resistant lines (< 10% infected heads) were included after being screened at least twice with a bulk of Syrian pathogen isolates, or once with different regional isolates. Lines in this selection also have reasonable resistance to yellow rust, possess acceptable agronomic traits, and are also good yielders. Khyber 79 has shown resistance to common bunt during three years of testing in Pakistan.

Another selection of 50 bread wheat lines resistant to common bunt and yellow rust is also available from the project (see 4.2 Pathology).

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*) For precautions taken see page 103

Table 86. Bread wheat lines resistant-moderately resistant (R-MR)* to common bunt, Tilletia foetida and T. caries (1983/84, 1985/86 season)

Name or cross	% average infected heads						Source	
	Isolates(Syria)			Isolates(Region)				
	84	85	86	84+	85+	x		
1. Kirac 66	-	-	-	1	-	-	BUII84	11
2. Fn/Tb//K58/N/3/My54	-	-	-	5	-	-	BUII85	12
3. Kal-B10	1	-	-	-	6	-		15
4. Idem	5	-	-	-	5	-		16
5. Bb(son64-An64*Nad/ JarLR64A-TZPP AnE3/Jar17	0	-	-	-	2	-		17
6. Sx/Cardinal	1	-	-	-	1	-		19
7. C182.24/C168.3/3/ Cno*2/7c/Cc/Tob	-	1	5	-	-	-	WRTB86	6
8. F//68.44/Nzt/3/Cuc'S'	-	4	6	-	-	-		19
9. F//68.44/Nzt/3/Cuc'S'	-	0	8	-	-	-		22
10. F//68.44/Nzt/3/Cuc'S'	-	4	8	-	-	-		23
11. Buc'S'/Bjy'S'	-	0	5	-	-	-		38
12. Lira'S'	-	0	8	-	-	-		42
13. Bb/Pato (B)//Coc	-	5	3	-	-	-		99
14. Lira'S'	-	1	6	-	-	-		152
15. Ald'S'Pima77/3/ CMH24A.630/Bui'S'// CMH74.630	-	0	0	-	-	-		154
16. Bezostaya	-	0	4	-	-	-		158
17. Au/Tob66/5/K338/Edch// Kovdiat 17/Rtv/3/ Wc/4/Ccu	-	4	10	-	-	-		164
18. F3.71/Nkt'S'	-	0	5	-	-	-		174
19. F3.71/Nkt'S'	-	5	7	-	-	-		175
20. Shi44/4/Pcw'S'	-	0	8	-	-	-		182
21. Sap/Pato (R)//Bjy'S'	-	0	9	-	-	-		197
22. T1/3/Fn/Th//Nar 59*2/ 4/Bo/'S'	-	0	-	-	-	10	BUII86	3
23. Khyber 79	-	-	-	-	-	9		15

* R - MR = 0 - 10 % infected heads, + = 8 isolates (3 Syria, 2 Turkey, one each Lebanon, Tunisia, Iran), x = 10 isolates (2 Syria, 3 Turkey, one each Lebanon, Tunisia, Iran, Pakistan, Morocco)

Table 87. Number* of bread wheat lines resistant+ to yellow rust, leaf rust, stem rust, powdery mildew, septoria blotch and common bunt in the different locations (KLDN-86).

Disease	No.of Loc.	Location codesx	No. Lines Resistant				
Yellow rust	3	SYR 01; LEB 01; POR 01	103				
Leaf rust	4	SYR 03, 51; TUR 01; MEX 01	68	41			
Stem rust	2	EGY 04; MEX 01	109		26	5	1
Powdery mildew	2	JOR 03; TUN 01	117	31			
Septoria blotch	5	SYR 51,53; TUN 01; POR 01, 02	44				
Common bunt	1	SYR 01	10				

* Number of lines tested = 225

\+ Selection criteria: a) rusts = 0-10 % average severity, not exceeding 10 % at T. Hadya for yellow rust and for leaf rust and at Izmir for stem rust; b) powdery mildew and septoria = 0-5 on 0-9 scale, not exceeding 5 at Al Ghab for septoria and at Deir all for powdery mildew; c) common bunt = 0-15% infected heads.

x Syria = SYR 01,03 screening sites T. Hadya, 51 Lattakia, 53 Al Ghab; Lebanon = LEB 01 Terbol; Turkey = TUR 01 Izmir; Portugal = POR 01,02 screening sites Elvas; Jordan = JOR 03 Deir Alla; Egypt = EGP 04 Sides; Tunisia = TUN 01 Beja. Mexico = MEX 01 Obregon

3.2.2. Multilocation testing for disease resistance

Multilocation testing aims at screening advanced breeding material and special purpose lines for their resistance to prevailing diseases and their pathotypes in 'hot-spots' in and of outside the region. In many of these locations, inoculation is applied to create artificial epiphytotics.

Useful information on the Key Location Disease Nursery (KLDN 86) has been obtained from 12 locations. Table 87 summarizes results obtained on the three rusts, powdery mildew, and septoria blotch. Results on common bunt testing, though done in one location, were included to search for combined resistance to the major diseases among the lines tested.

Out of the 225 lines tested 103, 68, 109, 117, 44, and 10 lines showed resistance to the diseases yellow rust, leaf rust, stem rust, powdery mildew, septoria blotch and common bunt, respectively. The large number of lines given for leaf rust, stem rust and powdery mildew is a result of inadequate development of the three diseases in the locations tested.

Combined resistance to leaf rust and stem rust was found in 41 lines, to powdery mildew and septoria blotch in 31 lines, to yellow rust and septoria blotch in 26 lines, and to yellow rust and common bunt in 5 lines (Entry Nos. 66, 112, 157, 161, 234). Only one line, was resistant to yellow rust, septoria blotch and common bunt (Entry No. 161). This line was:

Rmn F3-71/Torim	WKL 86
SWM 765704-11P-2H-3P-0P	161

This line possesses also excellent resistance to leaf rust, stem rust, and powdery mildew.

- O. Mamluk, J. van Leur

3.3. Agronomy and Physiology

3.3.1. Monitoring the Effect of Selection on Net Photosynthesis and Related Variables

The strategy followed by cereal breeders at ICARDA is to assess the performance of a wide range of entries in different environments, ultimately selecting for yield. A study was conducted to determine how a fundamental physiological process such as photosynthesis was affected by the breeders' selection.

Two late planted (LP) advanced bread wheat yield trials (AWYT) of the 1985/86 season were used in the experiment. Late planting is commonly used at ICARDA to expose cereal crops to high temperatures and drought during flowering and grain filling. The trials were planted at Tel Hadya, ICARDA's main experiment station (36°N, 37°E, 392m elevation) in northern Syria. One of these trials (trial A, 24 entries) was in the first year of selection under LP, while the other (trial B, 24 entries) was in the second cycle of selection under these conditions. Trial B included lines that yielded significantly higher ($P < 0.05$) than the best check under LP in the 1984/85 season. Both trials had different entries with a common check.

Rainfall and climatic conditions during the growing period are described in Table 88.

Table 88. Weekly averages of climatic variables during late planting for bread wheat, Tel Hadya.

Week	Max.T(^{o}C)	Min.T(^{o}C)	Rainfall (mm)	Radiation MJ/m^2/day
Mar 10-16	20.1	5.7	4.8	17.69
Mar 17-23	18.2	4.5	9.0	16.26
Mar 24-30	21.9	6.1	10.2	18.60
Mar 31-Apr 6	22.4	9.2	13.0	19.79
Apr 7-13	25.1	9.3	7.6	22.16
Apr 14-20	25.2	7.9	2.0	21.02
Apr 21-27	27.3	7.7	0.0	24.86
Apr 28-Apr 4	28.0	11.0	0.0	24.49
May 5-11	26.3	9.8	3.3	24.61
May 12-18	22.0	7.1	16.3	18.62
May 19-25	28.2	13.1	8.8	23.90
May 26-Jun 1	31.5	14.0	0.0	27.90

Photosynthetic measurements were made on May 27 and 28 in the flag leaf of each of the 48 bread wheat entries using a portable infrared gas analyser equipped with a broad leaf Parkinson leaf chamber, an air supply unit, and a data processor (ADC). The genotypes were at the late milk to early dough stage of development (Zadoks stages 77 to 83), except 8 entries in experiment A which, having vernalization requirements, were between tillering and pseudostem erection (Zadoks stages 29 to 31). In the last cases, photosynthetic measurements were taken in the last expanded leaf.

Four measurements per plot were taken between 10:30 and 12 h. local time on two consecutive clear days. The average photosynthetically active radiation (PAR) was 1574 and 1516 umol $m^{-2}s^{-1}$ for the determinations in experiments A and B respectively, with a range of 1317 to 1738 umol $m^{-2}S^{-1}$.

Table 89 gives average values for PAR, cuvette air temperature, relative humidity and external CO_2 concentration for the two days. These values are the average for the 24 entries measured in each experiment. The table shows that the means for PAR did not differ significantly ($P < 0.05$). Cuvette temperature and relative humidity however were different, especially the last one. Reference CO_2 (Ref CO_2) had a difference of only 3 ul/l between fields, which while significant is so small to not have physiological implications. The correlation coefficient between NP and Ref CO_2 being negative and low (-0.15) for all the measurements taken in the two fields.

Table 89. Photosynthetically active radiation, cuvette air temperature and relative humidity, and CO_2 concentration of air entering the cuvette (Parkinson Leaf Chamber).

Experiment	Variable			
	PAR umol m^{2}S	Ref.CO_2 ul l	RH %	Cuvette temperature °C
A	1574	300	12.7	36.1
B	1516	297	26.4	35.2
LSD (0.05)	81	2	2.3	0.5

A. ABWYT in its first year of selection for Heat Tolerance.
B. ABWYT in its second year of selection.

In terms of environmental variables, it is worth noting, that the crop was begun with an almost fully wet soil profile (250 mm available water per meter of soil). Adding to this the 40 mm of emergence irrigation water plus the 75 mm rainfall during crop growth prior to the measurements, it is unlikely that the entries suffered substantial water stress. It follows then that the experiments under analysis were mainly affected by heat stress (Table 88).

Table 90 compares experiments A and B in terms of main effects for physiological variables. These are leaf temperature (Leaf T), net photosynthesis (NP), transpiration rate (Transp), leaf conductance (LC), leaf internal CO_2 (Int. CO_2), and transpiration efficiency (TE), a variable derived as the ratio of NP over transpiration. The population undergoing the second cycle of selection (Experiment B) under late planting, in this case predominantly heat stress, 34.8 ^{o}C mean leaf temperature, had significantly higher net photosynthesis and leaf conductance but a significantly lower leaf internal CO_2 concentration. These values, compared with the population of experiment A indicate that the entries of experiment B are better suited to higher temperatures during grain filling. In fact, the derived mean transpiration efficiency, even though is low in both experiments, is almost doubled in experiment B, due mainly to increased NP. In spite of a lower leaf conductance in population A, which tends to decrease transpiration rate, the feedback effect of increased leaf temperature and therefore saturation vapour pressure inside the leaf as well as lower cuvette RH, partially compensated for the effect of LC on transpiration rate. One should note that the mean leaf temperature of population A is only 0.1 ^{o}C higher than the cuvette temperature, while in population B the mean leaf temperature is 0.4 ^{o}C lower than the cuvette temperature (Tables 89 and 90). Since the transpiration rate is function of both the vapor pressure gradient between the inside and outside of the leaf and the leaf conductance, the net result is to minimize differences in transpiration rate between experiments. The higher mean leaf temperature in experiment A is most probably due to reduced mean stomatal conductance.

It is worth showing the general relations between the variables presented in Table 90. The correlation coefficients for the data obtained in this experiment are shown in Table 91. First note that LC is strongly and positively correlated with NP and transpiration. Both CO_2 and water vapor use the stomatal path to move to and from the inside of the leaf. Secondly, a strong negative correlation exists between NP and the CO_2 concentration inside the leaf. A high internal CO_2 in this case implies that the carboxylation process in photosynthesis is impaired, probably and CO_2 accumulates in the intercellular spaces of the photorespiration probably increased, mesophyll tissue of the leaf. The accumulation may be due to a decrease in photochemical energy (i.e. disturbance in the light reaction of photosynthesis), to a decrease in chloroplast biochemical activity, or both. A high internal CO_2 was negatively correlation with LC. This in turn tends to decrease transpiration but to a lesser extent, due to increase in leaf temperature, than a decreased leaf conductance *per se* would induce (lower transpiration). It would therefore be desirable to look for genotypes which maintain a "reasonable" LC with low internal CO_2 under normal ambient CO_2 concentrations in the presence of the physical stress under study, in this case from heat. From the limited data obtained it seems that the visual selection of the breeder is indirectly moving in this direction.

Table 90. Mean values of net photosynthesis and related variables in A, advanced bread wheat yield trial in its first cycle of selection for heat tolerance and B, advanced wheat yield trial in its second cycle of selection.

Experiment	Variable					
	Leaf T ^{o}C	NP umol CO_2 / m^2s	Transp. mmol H_2O / m^2s	LC mol / m^2s	Int.CO_2 ul / l	TE mmol CO_2 / mol H_2O*
A	36.2	2.57	5.5	0.118	242.6	0.47 (2.46)
B	34.8	6.00	6.6	0.174	205.6	0.91 (3.81)
B - A	-1.4	3.43	1.1	0.056	-37.0	0.44
LSD (0.05)	0.6	1.28	0.7	0.022	14.1	

* The saturation dificit for experiment A was 5.2459 KPa and for experiment B 4.1902 KPa. The values in parenthesis are the product of the saturation deficit times TE.

Table 91. Correlation matrix for NP and related variables. Total of 192 measurements on forty seven bread wheat genotypes between 10.30 and 12.00 hrs, local time, on two consecutive clear days.

	Leaf T	NP	Transp	LC
NP	-0.53			
Transp	-0.38	0.52		
LC	-0.65	0.74	0.78	
Int. CO_2	0.41	-0.83	-0.30	-0.45

In Table 92, data is presented which substantiates the above point. The "best" and "worst" entries, using NP as a criterion for ranking, are presented along the associated variables. After two cycles of selections (Experiment B), the differences between the parameters of the "best" and "worst" entries has decreased substantially, i.e. the range of variation has narrowed, the internal CO_2 has markedly decreased and LC is moving towards intermediate values. No significant differences in leaf conductance, transpiration and leaf temperature were found for the selected (Experiment B) genotypes.

The data presented are for the grain filling period, or terminal heat stress. Even though similar physiological principles may apply at other stages of development, it is not clear if visual observations, especially during spike development, would parallel the physiological facts.

Table 92. Best and worst entries in terms of NP along with associated variables. Experiments A and B as described in Table 88.

Experiment	Leaf T ^{o}C	NP $\frac{umolCO_2}{m^2s}$	Transp. $\frac{mmolH_2O}{m^2s}$	LC $\frac{mol}{m^2s}$	Int.CO_2 $\frac{ul}{l}$	TE $\frac{mmolCO_2}{molH_2O}$
A	33.9	8.38	6.7	0.228	210.7	1.2
	38.0	-1.42	4.1	0.068	304.6	-20.0
LSD 0.05	1.1	3.46	2.4	0.05	32.3	
B	35.2	8.87	7.2	0.188	180.0	1.2
	35.6	2.64	6.0	0.144	237.6	0.4
LSD 0.05	1.0	2.80	1.8	0.074	19.3	

3.3.2. Variation in Coleoptile Length of Barley, Durum Wheat and Bread Wheat Genotypes

For early sown cereals in rainfed mediterranean environments when the soil profile is dry at the start of the season, the suggestion has been made that plants are at risk of germination and subsequent death if a rainfall event occurs followed by a drought period. In theory, this risk can be minimized by deep sowing. Deep sowing, however, can adversely affect crop establishment if the coleoptile is not long enough to ensure that the first leaf emerges.

Coleoptile length has been shown to be a highly heritable trait in cereal plants, hence a group of barley, bread and durum wheat genotypes were screened for this character. The results of this work are presented here.

The barley (72), bread wheat (20) and durum wheat (20) entries of the 1985/86 cereal physiology nurseries of ICARDA were used for the experiment. A wooden, dark germination chamber, 2 m high, 2 m wide and 1 m deep was built with four horizontal compartments. The interior walls of the chamber were covered with cloth. The cloth was periodically moistened to keep a high internal relative humidity and to dampen temperature oscilations. The mean temperature inside the chamber was 19.5 ^{o}C for the 28 days of the experiment. The mean absolute maximum being 24.2 ^{o}C and the mean absolute minimum 14.8 ^{o}C. The mean relative humidity was 70.6 throughout the experiment, oscilating between 82.6 and 58.6.

Eighteen seeds of each genotype were sown in rows, germ up, at 3 cm depth in 10 cm height metal trays containing moist coarse sand. The genotypes were randomly distributed within each tray and replicated in each compartment of the germination chamber. A complete randomized block design with four replicates was used. The coleoptile length was recorded to the nearest milimeter when the coleoptiles of the seedlings had been ruptured by the first leaf. Readings were made between 7 and 8 days after planting.

Table 93 presents the statistics for the three populations examined. The durum wheat had significantly longer coleoptiles than the barley and bread wheat studied. The three species, however, exhibited similar ranges between the longest and shortest coleoptile, 26 mm in barley, 26 mm in durum wheat and 30 mm in bread wheat, with significant ($P < 0.05$) within species differences. Table 94 presents the 5% longest and shortest coleoptile entries for each species.

Table 93. Coleoptile length for populations of barley, durum wheat and bread wheat genotypes.

	Mean (cm)	Range (cm)	CV	LSD(0.05)
Barley	4.55	3.42-6.04	6.79	0.43
Durum wheat	6.18	4.82-7.47	6.09	0.53
Bread wheat	4.60	3.71-6.28	7.28	0.47
LSD (0.05)	0.22			

Table 94. Entries with coleoptiles longer and shorter (5% probability level) than the population mean.

Entry No.	Line/Pedigree	Coleoptile length (cm)
Barley		
Short coleoptile		
37	Gerbel	3.42
55	S. BON 79	3.56
15	WI 2269	3.65
33	Deir Alla 106//MZA/DL 17	3.80
17	TH. UNK 48	3.91
57	S. BON 29[1]	3.93
44	BET 121	3.93
Long coleoptile		
34	Jerusalem Barbelisse/CI 10836	5.17
64	S BON 96[2]	5.17
70	ELB 75	5.52
58	ELB 11	5.62
40	Roho	5.68
22	Wadi Hassa	5.68
71	ELB 18	6.04
Durum wheat		
Short coleoptile		
3	Oronte	4.82
11	Quadalete	5.16
6	Gr/Boy	5.37
Long coleoptile		
1	Om Rabi	7.08
2	Kabir 1	7.45
18	Awali 1	7.47
Bread wheat		
Short coleoptile		
9	Golan	3.71
17	Veery	4.01
Long coleoptile		
3	Sonalika	5.57
8	Florence Aurore	5.68

1 WI2291/4/11012-2/70.22425/3/APM/IB65//A16 ICB78-0635-2AP-0AP

2 Pallidum 10342//CR115/PO3/3/Boh tim9/4/D5/Apro/5/WI2291ICB78 0058-9AP-4AP-0AP

In Table 94 the 5% longest and shortest coleoptile entries are presented for each species. This material could be included for further studies or used in crosses to increase or decrease the coleoptile length of a given variety.

The values presented should be considered as relative, since the coleoptile length expression is dependent on soil temperature as well as sowing depth.

- E. Acevedo, I. Naji

3.4. Grain quality

The bread wheat project continued efforts during 1986 to identify germplasm with improved nutritional and industrial quality, i.e., % protein, gluten strength, hardness, and kernel size.

There is a need in the ICARDA region for lines that maintain their quality under the varied moisture conditions prevalent in West Asia and North Africa. The bread wheat project has identified some lines that are stable under rainfed and irrigated conditions (Table 95).

Additional studies on the factors affecting the experimental baking of two-layered flat bread was completed and presented in an International meeting this year. The factors studied were: yeast, salt, sugar content, water absorption, fermentation time, and temperature of water and fermentation. For these studies, three types of flour were used: weak, medium, and strong.

The most striking effects were apparent with the changes in the amounts of yeast and salt, in terms of ingredients. Regarding thfe baking procedure, the most important factor was the temperature, of the water used in mixing, and the temperature of the fermentation.

The baking conditions used at ICARDA, which represent an "average" procedure of that used in the region, were shown to be optimum for the weaker bread wheat flour, and for the bread wheat/durum wheat flour blends commonly used. On the other hand the work on water absorption confirmed the importance of using the correct amount of water for individual flours.

Other research aspects of the bread wheat breeding program have indicated that under some local growing conditions, not necessarily those leading to the highest protein contents, some wheats display strong-to-very strong gluten characteristics. On the other hand the same genotypes showed weak to very weak gluten characteristics under conditions where protein fell to 11% or less. This excessive variability in strength does not appear to have been observed anywhere else. Several of the most recently advanced lines displayed these features, and it is likely that future bread wheat lines produced both by ICARDA and the National Programs of the region will result in a progressive increase in the overall gluten strength of bread wheat as shown in Table 96.

- P. Williams, F.J. El Haramein

Table 95. Bread wheat lines with stable quality performance under rainfed (350 mm) and supplementary irrigation (600 mm) moisture regimes at Tel Hadya, 1985-86.

Cross/Pedigree	PSI		WMFT		Protein		1000 KW	
	RF	SIR	RF	SIR	RF	SIR	RF	SIR
Ttr'S'/Jun'S' CM 59123-1AP-2AP-1AP-0AP	44	-	147	171	12.0	10.0	34.6	34.2
Vee'S'/Snb'S' CM 61981-4Y-1M-6Y-3M-0Y	41	-	183	190	12.8	10.4	37.4	39.0
Bow'S'/Tsi CM 64691-14Y-1M-3Y-1M-0Y	42	-	185	135	12.4	10.5	33.3	32.3
Mexipak 65(local check)	37	-	49	42	11.6	11.8	32.7	24.4
Sham 2 (improved check)	36	-	189	133	12.9	12.6	30.5	23.9

RF = Rainfed, SIR = Supplementary Irrigation

Table 96. Promising bread wheat lines combining good grain quality and high yield (kg/ha) under rainfed conditions (316 mm) at Tel Hadya, Syria, 1985-86.

Cross/pedigree	PSI (%)	WMFT (MIN)	Prot. (%)	1000 KW(%)	Yield (kg/ha)	Yield Mexipak
Ttr'S'/Jun'S' CM59123-1AP-2AP-1AP-0AP	44	147	12.0	34.6	3875	3191
Tzpp*2Ane//Inia/3/Cno/ Jar//Kvz/4/Mn72252 CM59483-2AP-2AP-1AP-1AP-0AP	49	182	12.3	36.4	4025	3241
Tl/3/Fn/Th//Nar 59*2/ 4/Bol'S' CM56569-1AP-1AP-5AP-2AP-0AP	49	100	12.2	43.2	4216	3033
Condor/Mus CM30458-6M-2Y-2M-0Y	43	189	12.9	36.1	3908	2975
Desc/Fcr//Pima/3/Pvn'S'/ Ald'S' CM57857-K-6Y-1Y-3M-3Y-1M-3Y-0M	43	161	12.1	35.4	4333	3208
Vee'S'/Snb'S' CM61981-4Y-1M-6Y-3M-0Y	41	183	12.8	37.4	4191	3208
Bow'S'/Tsi CM64691-14Y-1M-3Y-1M-0Y	42	185	12.4	33.3	4358	3100
Mexipak 65 (local check)	37	49	11.6	32.7		

3.5. Entomology screening trials for bread wheat

Eighty-eight bread wheat lines were screened for resistance to the wheat stem sawfly, Cephus pygmaeus, using caged infestations of adult insects. Of these, one line exhibited resistance (Table 97). In comparison, the local check, Golan, ranged in % infestation from 8.3% - 38.3% (mean = 16.2%).

Table 97. Bread wheat line exhibiting resistance to wheat stem sawfly under caged infestations at Tel Hadya.

Variety	Seed source	Mean % infestation
Rmn F12-71/Jup's' CWM 765784-01H-1H-1S-0S	WOL (86) 89	0.6

No bread wheat lines were found to exhibit resistance to naturally occurring aphid populations at Tel Hadya. All lines examined were infested with more than 200 aphids/plant.

Results of stepwise multiple regression of peduncle length, days to maturity plant height and days to heading onto % sawfly infestation reveal only the variables plant height and days to heading contributed significantly to the regression, but only explained 11% of the variation observation in % infestation. As previously stated for durum wheat and barley, more precise predictors of sawfly infestation need to be identified to increase the efficiency of selecting resistant lines.

- R.H. Miller

4. High Elevation Cereal Research Project

The high elevation areas with continental Mediterranean climate account for a major part of the total land area of West Asia and North Africa. In these environments either winter or facultative type of wheat and barley cultivars are grown by farmers. In the majority of the areas, production per unit area is very small due to a very harsh and highly variable climate (ICARDA's Annual Reports, 1984-85) and to lack of suitable technology.

To improve the productivity of winter cereals the broad objectives of the project are:

1. Germplasm improvement:

   a) Develop better barley and wheat varieties with phenology adapted to specific areas of the high elevations in the region.

   b) Transfer desirable gene(s) from other wild *Hordeum* and *Triticum* species through interspecific intergeneric/hybridization to cultivated types.

   c) Gradually shift breeding efforts to develop genetic stocks with genes to counter major problems of the areas, for use by national breeding programs.

   d) Initiate work on haploid breeding and its transfer to national programs.

2. Assist national programs to identify problems and develop research programs.

3. Develop trained manpower at the national level.

4. Develop cooperative network for germplasm development and its testing among high elevation research sites of the region.

4.1. Breeding

4.1.1. Evaluation of Germplasm

Seventy nine bread and durum wheat cultivars (China 20, England 14, Turkey 20, U.S.A. - Utah 25) were evaluated for various agronomic traits such as yield, cold tolerance, yellow rust resistance and earliness in maturity. Twenty-nine lines out of this material with one or more desirable characteristics were retained and used in the crossing program to improve the germplasm. The International Winter Wheat Performance Nursery (IWWPN) from Nebraska and the International Winter x Spring Wheat Screening Nursery (IWSWSN) from Oregon-USA were evaluated. Fifteen and 42 entries out of 30 and 180 lines/cultivars of IWWPN and IWSWSN, respectively, were selected for further testing and use in germplasm improvement work.

4.1.2. Crossing Program

One hundred sixty eight F_1 winter durum wheat and 600 F_1 bread wheat crosses were made to generate improved winter cereal germplasm suitable for the stresses of high elevation areas. An attempt was made in these crosses to transfer drought, cold, disease tolerance, and high yield into locally adapted material.

Desirable gene(s) were found in other *Triticum* species (*T. monococcum*, *T. dicoccoides* etc.) and *Aegilops* to broaden the genetic base against those stresses. To transfer the desirable genes for characteristics such as drought and cold tolerance, disease resistance, and high protein, 240 and 147 crosses (single, top and back) with *dicoccoides* and *aegilops* were made with *T. durum* and *T. aestivum*, respectively.

4.1.3. Segregating Populations

A total of 3682 durum wheat and 5688 bread wheat segregating populations (F_1 to F_6) were evaluated at Tel Hadya against yellow rust. Only those F_1s which showed severe necrosis or chlorosis, hybrid clamping (grassy clamp) and severe disease (in case of back, double, or top crosses) were discarded. The F_2 populations of durum and bread wheat were also planted at the high altitude sites in Morocco, Turkey, Iran, and Pakistan. Populations performing well at one or more sites were retained with the exception of those which were highly susceptible to diseases and did not give resistant segregants.

F_3-F_6 populations were subjected to heavy yellow rust epidemic at Tel Hadya and susceptible populations were discarded. Populations with spring type growth habit and plant height less than 100 cm were also discarded as plant height under rainfed environments at high altitudes gets further depressed. Weather conditions near maturity were such that severe grain shattering occurred in shattering-susceptible lines/populations. All lines showing more than 50% shattering were discarded.

The number of F_2 segregating populations selected out of 100 durum and 150 bread wheat for bulking or single plant selection at high altitude sites in the region are given in Table 98. Only those populations which did not perform well at any of the outreach sites or contracted severe diseases infestation were discarded.

Table 98. Number of F_2 populations selected at high altitude locations in the region, 1985/86.

Populations	Syria	Iran		Turkey		Morocco
	T. Hadya	Tehran	Tabriz	Ankara	Eskesher	Annoceur
F_2 Durum wheat	140*	-	8	32	10	10
F_2 Bread wheat	507**	55	14	33	14	26

* and ** out of 153 and 750, respectively.

4.1.4. Observation Nurseries

Three observation nurseries, i.e., one winter type of durum wheat (100 entries), one bread wheat (200 entries), and one of barley were supplied to national programs for planting at high altitude sites. The lines selected at each location from the durum and bread wheat nurseries are given in Table 99. Fifteen percent of the entries included were from national programs. Since the national programs of some countries having high altitude areas are not yet well developed the advanced material from similar sites of other countries may be of direct or indirect use to them.

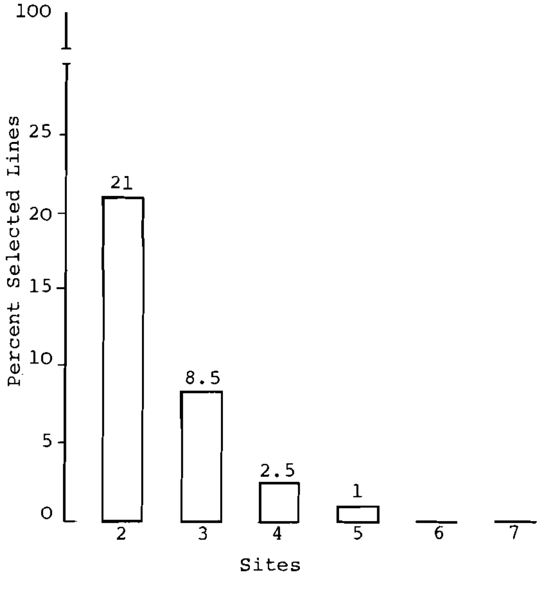
Table 99. Number of lines selected out of winter cereal observation nurseries at high altitude sites and at Tel Hadya during 1985/86.

	Syria		Turkey		Iran		pakistan	Morocco
Nursery	T.H	Sarghaya	Ankara	Eskesher	Tehran	Tabriz	Quetta	Annaceur
WON-HA	130	39	38	28	63	14	40	14
DON-HA	75	24	10	15	-	11	-	6

Total entries in WON and DON were 200 and 100, respectively.

An experiment was carried out to determine the adaptablity of wheat germplasm at seven high altitude sites in the region having very different agro-climatic features (Cereal Program Report 1985). Twenty one % of the lines were selected at two sites whereas the selection frequency of commonly selected lines dropped to 8.5, 2.5 and 1.0 percent at 3, 4 and 5 sites (Fig. 28). None of the lines was selected at all sites. The low frequency of commonly selected lines at more than one or two sites indicates a need to target material for specific adaptiblity. With further analysis of agroclimatic data it will be possible to make groupings of these sites.

Figure 28. Multi-site selected lines (%).



4.1.5. Broadening of Genetic Base through interspecific hybridization

4.1.5.1. Evaluation of *T. dicoccoides* and *T. monococcum*

Five hundred eighty one lines of *T. dococcoides* and 239 lines of *T. monococcum* collected from Turkey, Syria and Jordan were evaluated for 32 characters. The lines selected on the basis of disease resistance are listed in Table 100. The detailed results of these evaluations will be presented elsewhere following another year's evaluation. These studies indicate that considerable genetic variation for a number of agronomically important traits exists in *T. turgidum* var. *dicoccoides*. Desirable gene(s) for disease, cold and drought can be found in germplasm originating from the areas or regions facing such problems.

Table 100. Evaluation of *Triticum dicoccoides* and *T. monococcum* for disease resistance.

Species	YR	LR	BYDV	YR + LR + BYD
T. dicoccoides	111	437	245	33
T. monococcum	175	239	181	162

YR = yellow rust, LR = leaf rust, and BYDV = barley yellow dwarf in durum wheat.

4.1.5.2. Utilization of Dicoccoides for the Improvement of Durum Wheat

The results of 64 F_4 derived lines from var. *durum* x var. *dicoccoides* are summarized in Table 101. In *majority* of the crosses improvement in grain color resulted over the check varieties. The average agronomic score of three cross combinations i.e. Rubio Canadeal/SY 20017, Rubio Candeal/SY 20021//Ente/Stk, and BD 272/SY 20021 was equal to check variety Sham 1, the remainder of the crosses were lower than both the checks. The 64 derivatives were tolerant to frost as compared to check varieties. The *dicoccoides* lines employed in these crosses originated from very cold areas and therefore possess gene(s) for cold tolerance. It seems that the cold tolerance character has been transferred from *dicoccoides* into these F_4 derived lines.

Out of 13 cross combinations 10 showed significantly higher mean values for seed protein content. Only one cross combination, Quetta 2/SY 20258, had a lower mean value for protein content. However even in this cross, from four selected lines, two had significantly higher % protein than the check varieties. It appears that the high protein character of dicoccoides has been transferred into these lines. The cross combinations in which dicoccoides were used as the female parent had in general, higher mean values for % protein content. The lowest ranges of 12.4 to 18.2, and 12.4 to 17.0 were found in the crosses Rubio Candeal/SY 20021//Ento/Stk and Quetta2/Sy20258, respectively. The relatively lower range in protein content in the former cross may be due to a top cross with another durum line resulting the loss of some of the high protein gene(s). However, these data clearly indicate that the seed protein of cultivated durum wheat can be improved by transferring high protein gene(s) from its wild relative, emmer wheat (dicoccoides).

The average 1000 kernel weight (g) was significantly lower in all the combinations as compared to Haurani Check cultivar. However, the ranges of 1000 kernel weight indicate that there were a number of lines within these crosses having as high a 1000 kernel weights as the Haurani cultivar. The average 1000 kernel weights of 4 crosses, i.e. Rubio Candeal/SY 20021//Ent/Stk, B272/SY 20021, BD272/SY 30027 and Quetta 2/SY 20258 were 41, 44, 42 and 42(g), respectively as compared to 43 grams of the newly released cultivar Sham 1. The majority of the lines derived from crosses where dicoccoides were used as female parents had lower thousand kernel weights and higher protein content. These two characters are generally negatively correlated. These data, however, indicate that seed protein can be improved without sacrificing seed weight.

The average grain yield for different cross combinations indicate that 7 out of 13 were equal to the Haurani cultivar in their yielding ability whereas the rest gave significantly lower yields. The occurrance of a high percentage of lines with yielding ability equal to check cultivars but possessing significantly higher seed protein content indicates that these characters can be improved. Furthermore, it is also evident that certain cross combinations give better results. It is therefore desirable to use genotypes with diverse genetic background.

Table 101. Average values of agronomic traits for T. durum X T. dicoccoides derived F_4 lines.

Variety	Grain colour (1)	Agron. score (2)	Frost tol. (3)	Protein (%)		1000 KW (gm)		Yield (ton/ha)	
				Average	Range	Average	Range	Average	Range
Rubio Candeal/SY20017= ICI81-19IC	A	2.5	1.0	17.7	16.5-19.6	40	39-46	2.1	1.0-3.3
Rubio Candeal/SY20021//Stk =ICI81-20	A	2.6	1.5	15.5	12.4-18.2	41	32-54	3.4	1.3-5.1
BD272/SY20021=ICI81-31	A	2.8	1.0	15.5		44		4.2	
BD272/SY20017=ICI81-35	AA	1.2	1.0	18.7	16.6-20.2	42	37-49	2.4	1.6-3.4
BD272/SY20101=ICI81-38	AA	0.6	1.0	19.7		40		1.9	
BD1658/SY20189=ICI81-42	AA	1.0	1.0	19.8	18.5-21.1	37	32-47	1.9	1.4-2.4
Quetta 2/SY20258=ICI81-50	AA	1.9	1.0	15.0	12.4-17.0	42	40-45	4.1	1.6-5.3
SY20101/I-1-10-585=ICI81-32-1	AA	2.0	1.0	17.7		35		3.0	
SY20101/I-1-10-297=ICI81-33	AA	2.0	2.0	19.8	19.7-19.8	31	30-31	2.64	2.6-2.7
SY20101/I-10-305=ICI-81-34	AA	1.8	1.0	19.4	18.0-20.3	38	35-40	1.7	1.3-2.0
SY20101/E-1-10-305=ICI-81-70	AA	1.7	1.0	17.1		29		4.0	
SY20017/Reno de Granada= ICI81-71	A	1.0	1.0	17.2	16.1-17.4	29	28-30	1.8	0.8-3.32
SY20017/617(F_6)=ICI81-68	AA	1.0	1.0	20.2	20.0-20.5 32	32		2.3	1.6-2.9
Sham 1 - Check	A	2.5	3.5	15.7		43		2.93	
Haurani - Check	A	3.5	2.5	13.6		48		3.9	

1) A = Amber, AA = Deep Amber
2) Agronomy score (1 = Poor, 5 = Best)
3) Frost tolerance = (damage < 10%), (5 = damage > 90%)
L.S.D. (0.05) for protein, 1000 KW and yield was 0.6, 2.4 and 1.6, respectively

Table 102. Agronomic traits of F_4 derived lines out of _T_. _durum_ X _T_. _dicoccoides_ crosses.

Cross	Grain colour (%)	Agro. score (2)	Frost tol. (3)	1000 KW (gms)	Protein (%) (ton/h)	Average yield
Rubio Candeal/SY20017 = ICI 81-19-1	A	2.5	1	45	16.5	3.45
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-1	A	3.0	1	38	17.4	2.45
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-2	AA	2.5	2	34	18.2	3.25
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-3	AA	3.0	2	35	18.0	3.35
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-4	A	2.5	2	42	17.0	3.95
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-5	A	2.5	2	36	16.1	4.69
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-6	A	2.5	2	39	17.3	5.05
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-7	AA	3.0	2	42	17.7	5.21
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-8	A	3.0	1	38	16.4	3.61
Rubio Candeal/SY20021//Ente/Stk = ICI 81-20-9	AA	2.0	1	48	15.3	4.45
Rubio Candeal/SY20021//Ente/Stk = ICI 81-22-3	A	2.0	1	46	15.2	4.15
Rubio Candeal/SY20021//Ente/Stk = ICI 81-22-5	A	3.0	1	48	13.0	4.97
Rubio Candeal/SY20021//Ente/Stk = ICI 81-22-9	A	2.0	1	44	15.1	5.01
Rubio Candeal/SY20021//Ente/Stk = ICI 81-22-15	A	3.0	1	47	15.7	2.89
Rubio Candeal/SY20021//Ente/Stk = ICI 81-22-18	A	2.5	1	54	15.4	3.09
BD 272/SY20021 = ICI 81-35-1	A	3.0	1	45	15.0	4.11
BD 272/SY20017 = ICI 81-37-3	A	1.0	1	41	20.2	2.67*
BD 272/SY20017 = ICI 81-37-5	AA	1.5	1	44	20.1	3.27*
BD 272/SY20101 = ICI 81-38-1	AA	1.0	1	45	19.4	2.71
BD 1658/SY20189 = ICI 81-42-2	AA	1.0	1	47	17.6	2.32
Quetta 1/SY20258 = ICI 81-50-1	AA	2.0	2	42	16.0	5.23
Quetta 1/SY20258 = ICI 81-50-2	A	3.0	1	40	15.0	5.43
Sham 1 - Check	A	4.0	3.5	42	15.7	2.93
Haurani - Check	A	3.0	2.5	47	15.6	3.85
CV				1.8%	1.4%	16.8%
L.S.D. (0.05) level				2.4	0.6	1.63

* Shriveled grain, (1) A = Amber, AA = Deep Amber, (2) (Agronomic score (1 = Poor, 5 = Best) scale, (3) Frost tolerance (1 = damage < 10%, 5 = damage > 90%)

The agronomic traits of twenty two yellow rust resistant F_4s lines of durum x dicoccoides crosses are presented in Table 102. In majority of these lines agronomic traits such as grain colour and frost tolerance as well as yellow rust resistance were improved over the check varieties. Some lines gave larger yields eventhough they were not signifincantly different from the check. More than 50% of these lines had significantly higher protein content.

Lines derived from crosses where T. dicoccoides was the female parent were lower yielding than the check. The best lines involve Rubio Candeal, BD 272 (durum wheat) SY 20017, and SY 20021 in their parentage. This indicates that certain genotypes among durum and dicoccoides are better combiners than others.

4.1.6. Transfer of High Grain Protein into Durum Wheat

Ten F_4 lines derived from durum x dicoccoides crosses having significantly higher % protein than the durum check cultivars and with acceptable seed weight are listed in Table 103. With the exception of the lines BD 272/SY 20101, SY 20017/617(F_6) and SY 20101/1-1-10-297, all lines had significantly lower yield than the Haurani cultivar. Though their yield level is low, these lines possessed a number of desirable agronomic traits including good level protein, cold tolerance, and disease tolerance eventhough their yield level was low. These lines have the high protein level characteristic of dicoccoides with significantly improved seed weight over their dicoccoides parents (Cereal Program Annual Report 1985).

In addition to the above, following observations were made:

a) in simple durum x dicoccoides crosses wild characters, such as brittleness of rachis, glume hairiness of rachis, loose crown, and low seed set fertility persist in the subsequent generations. For rapid progress top crosses should be made with durum wheat.

b) generally the crosses in which dicoccoides is used as the female parent do not give good segregants. It is therefore suggested that wheat may be employed as female parent.

Table 103. Selected high protein lines out of *T. durum* X *T. dicoccoides* derived F_4 lines.

Cross	Grain colour (1)	Agro. score (2)	Frost tol. (3)	1000 KW (gms)	Protein (%)	Average yield (ton/h)
Rubio Candeal/SY20017 = ICI 81-19-15	A	2.5	1	44	19.6	1.96*
SY 20101/I-10-305 = ICI 81-39-3	AA	1.5	1	40	20.5	1.20*
SY 20101/I-10-305 = ICI 81-34-3	AA	1.0	1	41	20.3	1.55
SY 20101/I-10-305 = ICI 81-34-4	AA	2.5	1	39	18.5	1.71
BD 272/SY 20017 = ICI 81-37-1	AA	1.0	1	50	18.6	1.55
BD 272/SY 20101 = ICI 81-38-1	AA	1.0	1	45	19.4	2.71
BD 1658/SY 20189 = ICI 81-42-9	AA	1.0	1	32	20.3	1.76
SY 20017/617 (F_6) = ICI 81-68-2	AA	1.0	1	32	20.5	2.82
BD 1658/SY 20189 = ICI 81-42-1	AA	1.0	1	36	20.4	1.92
SY 20101/I.1-10-297 = ICI 81-33-1	AA	2.0	2	32	19.8	2.59
Sham 1 - Check	A	4.0	3.0	42	15.7	2.93
Haurani - Check	A	3.0	2.5	47	15.6	3.83
L.S.D. (0.05)				2.4	0.6	1.63

* Slightly shrivelled grain, (1) A = Amber, AA = deep amber, (2) Agronomy score (1 = Poor, 5 = Best), (3) Frost tolerance (1 = damage < 10%, 5 = danage > 90%).

c) many dicoccoides lines carry ne genes. In crosses with durum wheat one may frequently observe severe necrotic plants.

d) grass clamping is also frequently observed. It is therefore suggested to use wider genetic bases of both durum as well as dicoccoides in breeding for rapid progress.

4.1.7. Primordia development studies in wheat cultivars

Wheat encounters frost damage from January through March. It is under drought and heat stress from April onwards. There may be two ways to minimize the effect of stresses at different plant development phases to obtain high yield in this region. This could be achieved by a long ripening period brought about by early heading for effective utilization of the limited soil moisture, or by rapid ripening within short grain filling period after heading once the plant has passed through long vegetative growth. Selection of breeding materials at ICARDA has been accomplished using the later strategy, as wheat suffers seriously from early and late frost damage in the ICARDA region. In Japan the former approach has been successfully adopted to develop early maturity lines with longer grain filling period, based on slow primordia development during early plant growth which allows escape from damaging frost.

In 1985/86 we analyzed the growth performance of wheat from primordia initiation viewpoint and also used it as a screening technique.

Seventeen cultivars and five breeding lines with different growth performances were planted at the Tel Hadya Station of ICARDA on November 5, 1985. After planting, the experiment was irrigated to induce germination. Data on plant length (cm), tiller number (no./plant), stage of primordia development*, primordia length (mm) and culm length (mm), were measured on February 6 and March 2, 1986 (93 and 117 days, respectively after germination).

Wheat did not encounter severe frost damage during the relatively mild winter of 1986, while many cultivars suffered cold damage during the harsh winter of 1985. Therefore, the frost damage value in each cultivar used here corresponds to data recorded in 1984/85. Data on other growth parameters were also taken from the 1984/85 crop season.

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*(Ref. Inamura, H., K. Suzuki and S. Nanaka, 1955. On the standard of successive stages of barley and wheat spike development. J. Kanto-Tozan Agric. Exp. Sta. 8: 75-91).

Large differences for various traits among wheat cultivars were observed at 93 days and 117 days after planting, as shown in Tables 104 and 105. Primordia initiation at 93 days after planting was at stage V in Haurani and in another 10 cultivars which were free from frost damage. Primordia initiation occurred in stage IX in Sham 1 and in another 3 cultivars susceptible to frost damage. All characters except tiller number at 117 days after planting were greater than with the values measured at 93 days. Culm elongation occured rapidly in all cultivars except Ogasta, Vratza, Pai yu Pao, and Bezostaya. Cultivars at stage V after 93 days of planting proceeded to stage VII_e (Pai yu Pao, Gezira-17) and IX_m (Bolal). The primordia of Ogasta was still at stage V after 117 days as it was at 93 days after planting.

The relationship between primordia developmental stage for all cultivars in 1985/86 and their growth performance in 1984/85 was analyzed (Table 106). Frost damage was highly correlated with primordia developmental stage at 93 days (r = 0.866) and at 117 days after planting (r = 0.647). The correlation of days to heading and primordia developmental stage was not significant at both dates (r = -0.247 at 93 days as shown in Fig. 29, and r = -0.063 at 117 days after planting). Growth habit was significantly correlated with primordia developmental stages at 93 days after planting (r = 0.511) but not at 117 days after planting (r = 0.284). No significant correlation between growth habit and frost damage (r = 0.383) as well as heading date and frost damage (r-0.048) was observed. Frost damage was more highly correlated with primordia developmental stage at 93 days than at 117 days after planting. In the interrelationship study between primordia developmental, stage primordia length and culm length, a highly significant correlation (r = 0.900) at 93 days and (r = 0.643 - 0.776) at 117 days after planting were observed.

Table 104. Growth performance of wheat cultivars 93 days after planting (6 Feb. 1986).

	Plant length (cm)	Tiller No. plant	Leaves/ plant	Primordia dev. stage*	Primordia length (mm)	Culm length (mm)
Sham 1	38	4.7	6.8	IX e (9.1)	2.1	15
Sham 2	36	5.0	7.2	IX e (9.1)	1.7	17
Haurani	29	7.3	7.1	V (5)	0.3	4
Gezira 17	30	6.7	7.3	V (5)	0.8	5
Kataya A-1	27	6.6	7.9	VI (6)	0.8	5
Ogosta	28	11.3	7.3	V (5)	0.4	4
Trakia	21	11.7	7.9	V (5)	0.6	2
Vratza	27	6.7	7.6	V (5)	0.6	4
Mexipak 65	34	3.0	6.0	VIII (8)	1.4	10
Zarghoon	36	5.3	7.3	VIII (8)	2.4	12
Pai yu Pao	19	9.5	7.6	V (5)	0.4	4
CA-8055	22	9.2	8.0	V (5)	0.4	3
Bolal	27	7.0	7.1	V (5)	0.5	5
NS-2699	21	10.7	7.8	V (5)	0.4	3
Bezostaya	17	4.3	6.9	V (5)	0.2	3
Fujimikomugi	39	5.0	7.3	IX m (9.4)	3.0	20
Avalon	21	10.3	7.9	V (5)	0.4	3
32 WOH86	30	6.3	7.8	VIII (8)	1.3	7
19 WOH86	31	6.0	7.6	IX e (9.1)	1.8	18
18 DOH86	48	8.3	6.6	IX e (9.1)	2.1	22
22 DOH86	41	7.7	6.6	VI (6)	1.3	8
27 DOH86	39	7.7	7.4	VII e (7.2)	1.3	10

( ) Figures in parenthesis are the numerical expressions of primordia development stage.

Table 105. Growth performance of main wheat cultivars 117 days after planting (2 March 1986).

	Plant length (cm)	Tiller No. plant	Primordia dev. stage	Primordia length (mm)	Culm length (mm)
Sham 1	64.0	6.0	>X (11.0)	12.0	180
Sham 2	58.7	4.7	IXI (9.7)	5.0	119
Haurani	65.0	8.3	IX e (9.1)	2.7	96
Gezira-17	39.3	4.3	VII e (7.2)	2.8	18
Kataya A-1	48.7	6.0	IX m (9.4)	4.2	48
Ogosta	31.7	13.0	V (5.0)	0.8	5
Trakia	39.3	6.7	IX e (9.1)	2.6	14
Vratza	40.3	14.3	VIII (9.0)	1.5	8
Mexipak	66.3	5.3	IXI (9.7)	5.9	170
Zargoon	54.3	7.3	X (10.0)	5.7	131
Pai yu Pao	45.0	9.3	VII e (7.1)	1.2	12
CA - 8055	44.7	10.0	IX e (9.1)	2.8	45
Bolal	53.0	10.0	IX m (9.4)	2.3	44
NS - 2699	48.0	9.7	VIII (8.0)	2.0	17
Bezostaya	36.7	7.3	VIII (8.0)	1.8	10
Fujimikomugi	69.3	6.3	>X (11.0)	1.5	189
Avalon	48.0	9.0	VIII (8.0)	1.9	21
32 WOH86	47.0	8.0	IXl (9.7)	4.1	63
19 WOH86	56.0	7.0	IXl (9.7)	4.6	129
18 DOH86	61.0	7.0	>X (11.0)	6.9	127
22 DOH86	62.7	9.3	IXl (9.7)	3.2	46
27 DOH86	58.7	10.3	IX m (9.4)	3.3	80

Large differences among wheat cultivars were observed in growth performance in 1984/85 as shown in Table 107. Cultivars CA 8055, Bolal and Bezostaya were resistant to frost damage whereas Sham 1, Mexipak 65, Zargoon, Fujimikomugi, and three breeding lines were susceptible to frost damage. Sham 2 was the earliest cultivar and Gezira 17 was the latest. Yield increase rate (yield/ripening duration) ranged from a maximum value of 174 g/day in Zargoon to a minimum value of 53 g/day in Pai yu Pao.

As a convenient and simple index of growth and type in wheat growth habit (prostrate and erect) and winter type, spring type have been used. These two characters were not always correlated with primordium development and no significant relation was observed between growth habit and frost damage. However, a highly-significant relationship was observed between primordia developmental stage and frost damage. Only the frost damage was taken into consideration while screening the breeding material in breeding new lines for cold tolerance at ICARDA. The most effective way to select breeding lines able to escape frost damage will be to study primordia initiation and development. The two groups, winter and spring types of wheat, have been classified into seven categories (I - VII) depending on the cold duration required to allow heading.

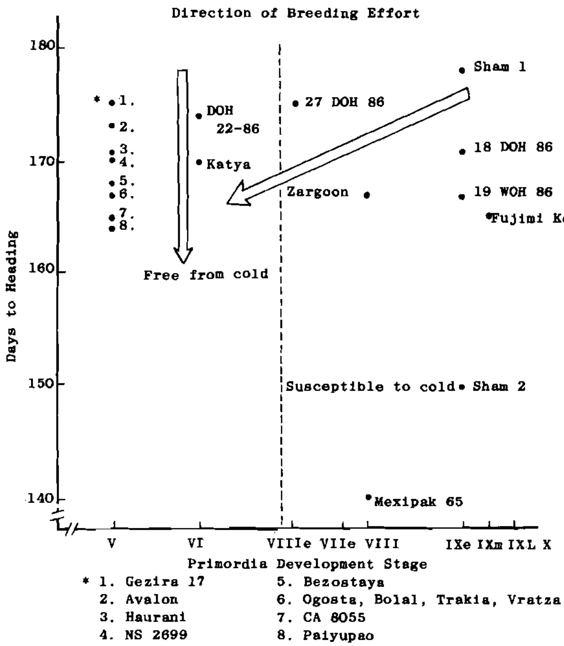
The significant relationship between primordia developmental stage and days to heading was observed because earliness in heading is influenced by factors such as cold requirement, earliness in narrow sense, response to temperature and photoperiod. It has been estimated that earlier initiation of primordia corresponds to earliness in heading time. However, the cultivar with late primordia initiation and early heading perform best while cultivars with early primordia initiation and late heading are the worst in escaping frost damage (Fig. 29). Out of cultivars used in this study, Pai yu Pao and CA-8055 are of the ideal type from the primordia initiation and development aspect, though these two cultivars did not yield as high as others (which may have been depressed by yellow rust). In general, reducing the grain filling period is extremely difficult as the ripening period is associated with low wheat yield. Zarghoon and Sham 2 have high yielding ability with short ripening duration. It can be concluded that through breeding efforts and directed selection it is possible to combine high yield and late primordium initiation character with short grain filling period.

Table 106. Growth performance of wheat cultivars during 1984/85.

Cultivar	Growth habit	Frost damage	Days to heading	Days to maturity	Ripening duration (days)	Yield ton/ha	Yield increase rate (g/cm)
Sham 1	3	5	175	219	44	3.40	100
Sham 2	3	3	150	180	30	4.07	136
Haurani	3	2	171	210	39	4.50	115
Gezira	3	2	175	215	40		
Kataya A-1	2	2	170	205	35	5.47	156
Ogosta	2	2	167	203	36	5.13	143
Trakia	1	2	167	207	40	4.73	118
Vratza	2	2	167	206	39	5.33	137
Mexipak 65	3	5	140	180	40	3.67	92
Zargoon	2	5	167	200	33	5.73	174
Pai yu Pao	1	2	164	208	44	2.33	53
CA-8055	1	1	165	208	43	3.87	90
Bolal	2	1	167	209	42	3.53	84
NS - 2699	2	2	170	208	38	2.67	70
Bezostaya	1	1	163	212	44	6.07	138
Fujimikomugi	3	5	165	198	33		
Avalon	1	2	173	218	45		
32 WOH86	2	4	167	211	44	4.80	109
19 WOH86	2	4	167	204	37	5.13	139
18 DOH86	2	5	171	210	39	2.93	75
22 DOH86	1	5	174	211	37	2.60	70
27 DOH86	2	5	175	211	36	3.20	89

Growth habit (1 = Prostrate, 2 = Semi prostrate, 3 = Erect)
Frost damage (1 = Resistant, 3 = Medium, 5 = Susceptible)

Figure 29. Direction of breeding effort for early heading with escaping the cold damage from the viewpoint of primordia initiation.



4.1.8. Regional Yield Trials

4.1.8.1. Wheat Yield Trial 1984-85, Tehran, Iran

The wheat yield trial in Tehran, Iran contained the 24 best lines/cultivars of bread wheat tested in previous years for yielding ability and disease resistance at high altitude sites. The average yield and other agronomic characteristics of the top five lines are presented in Table 107, along with those of the long term check variety Bezostaya 1 and the best improved national check variety Azadi. These 5 lines/cultivars significantly outyielded the check variety Bezostaya. Yield increase was not significantly large when compared to improved national check. However three lines gave an increase of up to 5 %in yield. Lines which were statistically at par with the variety Azadi in yield had better disease resistance and matured earlier. Variety Zargoon is an improved cultivar from Quetta, Pakistan which also performed well at Tehran. This variety was also the best looking line in Tehran during 1985/86 crop season. Fifty kg seed of variety Zaragoon has been sent to Iran for extensive national testing.

Table 107. Performance of the highest yielding lines in the Regional Bread Wheat Yield Trial at high altitude, 1984/85 at Tehran, Iran.

Variety/line	Yields (kg/ha)	Days to maturity	Plant height (cm)	Yellow rust	Protein (%)
NS15-89A	5085	167	80	R	14.7
Ogosta	5255	169	70	R	12.3
Kataya A-1	4555	168	105	R	12.6
HAW 81-1513	4855	164	90	R	15.1
Zargoon	5105	165	85	R	12.6
Bezostaya-Check	2655	169	65	MR	14.0
Azadi-Check	5030	171	90	MS	
LSD (0.05)	1520				

4.1.9. Bread Wheat Yield Trial, Diyarbakir, Turkey, 1985/86

Out of 24 entries 11 outyielded the improved check cultivar Malabadi. Yield and other characteristics of the top yielding lines along with two check varieties are presented in Table 108. The increase in yield over the best check variety ranged from 14-27 %. One line, RNN F12-71/SKA, gave significantly larger yield (5221 kg/ha) as compared to the check variety Malabadi (4110 kg/ha). Variety Kataya A-1, which ranked number two in this experiment was also identified as large yielding cultivar at Tehran, Iran and Quetta, Pakistan. All the top yielding lines had originated from winter x spring type crosses. The three top yielding lines are facultative in their growth habit. Furthermore the top yielding lines were significantly late in heading time as compared to the check cultivar, but no difference in time to maturity was observed. This type of genetically controlled phenology is associated with slow primordia development during early plant growth and aids in escaping forst damage. It seems that genotypes of facultative growth habit combined with short reproductive phase are also successful in this region.

Table 109. Performance of top yielding lines out of regional bread wheat yield trial, 1985/86, at Diyarbakir, Turkey.

Variety/line	D.H	D.M	P.H	Yield	% of checks 1	2	G.H
RMN F12-71/SKA	115	156	112	5221	128	127	F
Kataya A-1	115	156	107	4930	121	119	F
HAW 81-1863	115	155	122	4874	119	118	F
SHI 4414/PEW'S'	110	152	107	4791	117	116	S
HAW 81-1931	119	161	97	4721	116	114	S
Bezostaya-Check 1	119	162	105	4069	100	98	W
Malabadi-Check 2	113	155	92	4110	101	100	
LSD (0.05)	0.66	1.2	7.82	990.0	-	-	

F = Facultative, S = Spring type, W = Winter growth habit

4.1.10. Durum Wheat Yield Trial, Diyarbakir, 1985/86

This trial consisted of 24 cold tolerant varieties/lines of facultative and spring type durum wheat. Thirteen entries out yielded the local improved check variety Diyarbakir-81. The data of the five top yielding lines at Diyarbakir along with improved local check variety and Sham 1, are given in Table 109. Yield increase ranged from 115 to 136% over the best check cultivar. However only one line, S0179/S0179//Durum 6/3/Gta's'/21563/AA'S', gave significantly larger yield. The top yielding lines did not differ significantly in their maturity time and plant height than the check cultivar, with the exceptions of Snipe'S'//Amarelejo/Haynaldia, which was significantly taller in plant height than the check cultivar. Taller plant height is a desirable character under dry high altitude environments as it is depressed during dry years. Two top yielding entries at Diyarbakir, S0179/S0179//Durum 6/3/Gta'S'//21563/AA'S', and Ovi/CP//Fg'S', were also the largest yielders at Tel Hadya. Both these entries are of facultative type and resistant to yellow rust. These two entries have also been selected at other high altitude sites indicating their stability in yield and in the expression of other characteristics.

Table 109. Performance of top yielding lines out of regional bread wheat yield trial, 1985/86, at Diyarbakir, Turkey.

Variety/line	D.H	D.M	P.H	Yield	% of checks 1	2	G.H
Sol79/Sol79//Durum6/AA	114	158	85	5249	137	136	SP
Ovi/Cp//Fg'S'	115	160	97	4638	121	121	SP
Snipe'S'//Mamrelejo/ Haynal	118	161	115	4472	117	116	E
Zf/Lds//Kohak 2916...	116	160	90	4471	112	116	E
Sol79/Sol29//Dur.6/3/Ptl	114	159	87	4444	116	115	E
Sham 1 - Check	113	153	87	3819	100	99	E
Diyarbakir 81-local check	116	159	92	3833	100	1000	
LSD (0.05)	1.47	2.5	12.9	1281.12			

F = Facultative, S = Spring type, W = Winter growth habit

4.1.11. Regional Yield Trial

Two yield trials, one each of bread and durum wheat lines, selected at high altitude sites in the region out of observation nurseries were conducted at Tel Hadya and high altitude sites in the region to determine the yield potential and resistance to yellow rust. Results from other sites are yet to arrive at the time of reporting.

- M. Tahir

4.2. Pathology

4.2.1. Screening for resistance to yellow rust (*Puccinia striiformis*) and common bunt (*Tilletia foetida* & *caries*).

The annual screening for resistance to yellow rust and common bunt is done at T. Hadya, Syria. The germplasm developed for high elevation and screened for both diseases consisted of 629 lines from WCH, WOH, DCH and DOH (Table 110). Of the tested lines 265 showed resistance to yellow rust with the highest percentage of resistant lines (55% and 47%) ocurring in the WCH and WOH germplasm. Resistance to common bunt was found in 247 lines with the highest percentage of resistant lines (51% and 44%) coming from the WCH and WOH germplasm.

Table 110. Number of durum and bread wheat lines resistant (1) to yellow rust and common bunt in the different high elevation germplasm.

Germplasm	Tested	Resistant				Combined resistance
		Yellow rust		Common bunt		
		Ab.	%	Abs.	%	YR + CB
WCH 86	225	123	55	114	51	86
WOH 86	200	94	47	83	44	36
DCH 86	104	25	24	31	30	15
DOH 86	100	23	23	19	10	6
Total	629	265	42	247	39	143

(1) Selection criteria: 0- 5 % severity for yellow rust, 0-15 % infected heads for common bunt.

Combined resistance to yellow rust and common bunt occurred in. 86, 36, 15, and 6 lines in WCH, WOH, DCH and DOH, respectively. A total of 143 of these lines, were selected for possible inclusion and retesting in the special purpose disease nurseries of 1986-87.

4.2.2. Development of germplasm pool for sources of resistance to common bunt (*Tilletia foetida* and *T. caries*) and yellow rust (*Puccinia striiformis*)

Work on the development of germplasm pool for sources of resistance started in the 1983-84 season on 1304 lines received from USDA/Oregon State University. (See pages 142-143, Program Report 1984/85, Cereal Improvement Program).

In the 1983-84 season this collection was screened for resistance to common bunt with 707 lines showing resistance (Table 111). In the 1984/85 season, 707 lines (actually 690 germinated) were agronomically characterized and screened for resistance to yellow rust. Lines showing combined resistance to common bunt and yellow rust, 280, were planted in 1985-86 season and again screened for both diseases. Screenings over the last three seasons revealed 50 lines with resistance to both diseases. Two hundred thirty three entries still maintain their resistance to common bunt alone. In the original Oregon-USA screening, 31 entries were resistant to highly virulent races of bunt and 19 were resistant to one or more USA races of common bunt.

Some of these lines have undesirable agronomic characteristics under Aleppo-Syria conditions such as lodging, lateness of maturity, and height. This collection will be planted in yield trial in the 1986/87 season. Seed is available in reasonable quantities (25-30 gr) for use by national programs.

– O. Mamluk, J. van Leur

Table 111. 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_ (1983/84-1985/86).

Season	Screening CB	Screening YR	Characterization and selection	No.of Entries tested	No.Entries R-MR[1)] CB	YR	CB & YR
1983/84	+	-	-	1304	707	-	-
1984/85	-	+	+	707/690	690	280	280
1985/86	+	+	+	280	233	50	50[2)]

1) R-MR = 0-10 % infected head for CB; Average susceptible check 37.8% in 1985/86, Average resistant check 0.8%. R-MR = 0-15% severity for YR.
2) Growth habit: 23 spring, 12 facultative, 15 winter type.

4.3. Grain Quality

Three nurseries, i.e. Bread wheat Observation Nursery (200 entries), durum wheat observation nursery (100 entries) and tetraploid derivatives from durum/dicoccoides crosses (200 entries) were evaluated for grain protein and thousand kernel weight.

The protein content in bread wheat observation nursery ranged from 11 to 15 %, where as in case of durum wheat and durum/dicoccoides derivatives the protein ranged from 12-16% and 12 to 20 %, respectively (Fig. 30 and 31). The mean protein content for bread, durum wheat and durum/dicoccoides derivatives was 13.0, 14.1 and 15.2 % respectively, whereas the protein content of the check varieties Bezostaya, Haurani, and Sham 1 was 12.5, 14.0, and 13.2 %, respectively. These data clearly indicate that the protein content of the new germplasm has been considerably improved.

The great range of 12-20 % protein content in the durum/dicoccoides derivatives having other good agronomic characteristics are valuable for direct or indirect exploitation.

Thousand kernel weight for the above mentioned material was also determined. The 1000 kernel weight ranged from 25-51, 30-60, and 28-63 gms in bread, durum wheat and durum/dicoccoides derivatives, respectively (Fig. 31). The mean 1000 KW of bread wheat was 37.5 gm, of durum wheat was 45.3 gms, and of durum/dicoccoides was 40.4 gms. The mean 1000 KW for the check varieties Bezostaya, Haurani, and Sham 1 were 35, 41 and 40 gms, respectively. Almost 50 % of the durum/dicoccoides derivatives had better protein and 1000 kernel weight than the durum check varieties.

- M. Tahir, P. Williams

Figure 30. Protein content in the high altitude wheat material.

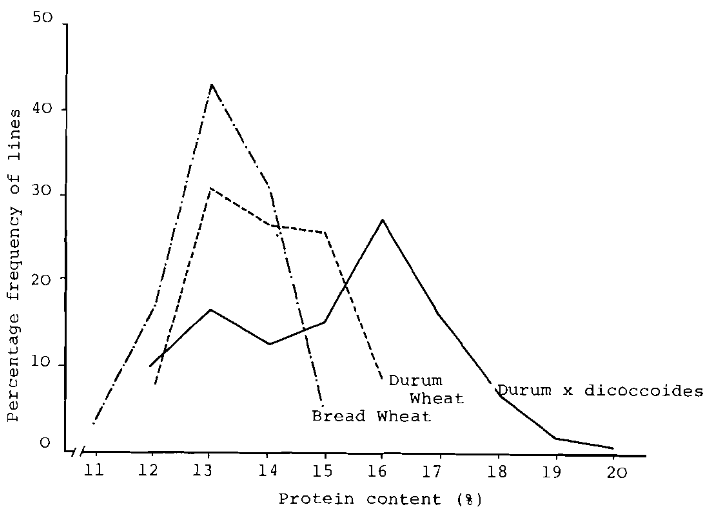
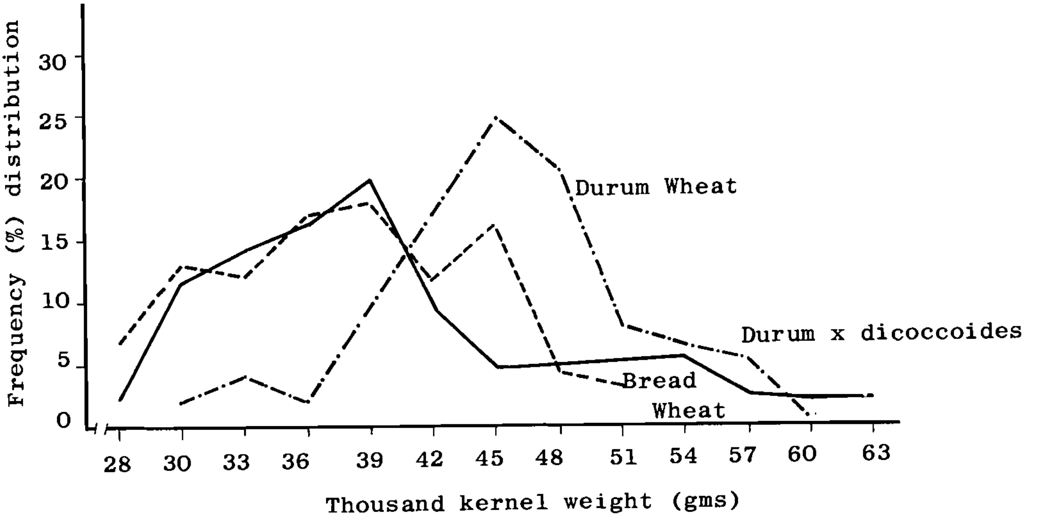


Figure 31. 1000 Kernel weight (gms) of the advanced wheat germplasm.



5. International Cooperation

5.1. Cooperation with National Programs

One of the objectives of the Cereal Improvement Program is to assist national barley and wheat scientists with the technology and information to improve cereal production in their countries, while enhancing their skills and abilities. Besides 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 programs breeding strategy for more stable and increased production in stress environments and significant increases in 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 key accomplishments emerging from this partnership and joint work are highlighted below.

5.1.1. Algeria

An agreement was signed between Algeria and ICARDA for cooperation. Algeria released two durum wheat varieties from the international nurseries sent there. These are Waha and Sahl and both varieties have performed well in Algeria. In 1986, Algeria purchased 500 tons of Waha from the Syrian Seed Production Organization. ICARDA supplied nucleus seed of these and a number of other barley and wheat lines for on-farm trials.

A project aimed at increasing cereal, food legume and forage production was during 1986 between IDGC (Algeria), INRA (France) and ICARDA. Activities of on-farm demonstration, on-farm verification, back-up research, and training are being implemented at the four agroecological zones of the Willaya of Sidi Bel-Abbes area. The socio-economic survey of the introduced technology is being carried out and the development of an efficient system of seed production and multiplication is being considered. The program provides consultancies, germplasm, literature and training. During 1986/87 season, the project will be supported by France. Additional support is being sought for the project.

5.1.2. Cyprus

The collaborative project to identify early maturing drought tolerant barley and durum lines continued with the Agricultural Research Institute (ARI). The project has been mutually beneficial in providing ICARDA with sources of earliness in good genetic background and providing Cyprus with high yielding lines which have been released as varieties.

Recently program activities were reviewed and it was agreed to summarize earlier work on dual-purpose barley, agronomic studies, and selection techniques and methodology development for yield stability under rainfed conditions. Several papers have come from this project and will be summarized in the coming year. For the 1986/87 season work on dryland root-rot disease and evaluation of targetted germplasm for rainfed areas with mild winters will be emphasized. Cyprus will play a greater role in providing such germplasm for the use of other countries with similar agroclimatic conditions. Work on development of barley for very low rainfall grazing lands will continue.

5.1.3. Egypt

During 1985/86 season, the program maintained its collaboration with Egypt on screening for aphid resistance and heat tolerance nurseries in the field and greenhouses. A number of lines have been short listed and more concentrated studies will be conducted in 1986/87 season.

During the year several meetings were held with Egyptian scientists and a project proposal for strengthening research and production on wheat in Egypt was developed. Financial support for the special project is sought.

5.1.4. 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. During 1985/86 ICARDA trained two young 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 increased co-operation has resulted in the identification of barley lines outyielding the national checks in the regional yield trials.

The program also supplied durum and bread wheat germplasm with drought tolerance and disease resistance for evaluation and use by the national program. Ethiopian scientists were trained at Aleppo in cereal pathology work. In coopration with Ethiopia scientists a special project proposal for strengthening research and production of barley and wheat in Ethiopia was developed under the Nile Valley Cereal project and outside funding is sought.

5.1.5. Iran

Under the collaborative project agreement between Iran and ICARDA two Iranian scientists were trained in the Cereal Program's residential course with special emphasis on cereal improvement in the cold and dryland areas. Four sets of targetted wheat and barley germplasm, comprising genotypes of targetted genetic make up was supplied. Iranian scientists have selected a number of good lines for local adaptive tests. About 35 Iranian scientists visited Cereal Program and ICARDA to aquaint themselves with our research activities and methodologies.

A team of four ICARDA scientists visited several agricultural research institutions and research programs in Western Iran to review the work being done in Iran. The team has recommended to Iranian authorities possible areas of agricultural improvement and co-operative work with ICARDA. A detailed work program to develop suitable production technology for dryland areas of western Iran, including germplasm exchange and training was prepared for possible implementation by Iranian colleagues by the team.

5.1.6. Iraq

An agreement was signed between ICARDA and the Government of the Republic of Iraq for co-operative research activities in the Republic of Iraq. During the season exchange of scientists, germplasm and literature was made. Iraqi trainees attended Cereal Program training. In the coming season these activities will be strengthened.

5.1.7. Jordan

The Winter Cereal Project continued during 1985/86 season with the support of USAID funds and involved the Ministry of Agriculture, the University of Jordan, and ICARDA. The project has demonstrated improved production in rainfed areas by the use of improved barley and wheat varieties and beneficial cultural practices. Both varietal as well as agronomic field verification trials were conducted by Jordanian scientists. Varieties Kourifla, Sebou, Sham 1 and Heider performed very well and larger quantities of seed were provided.

The Jordanian scientists planted several international nurseries at dryland locations and disease nurseries for net blotch, powdery mildew and leaf rust. This collaboration will be expanded in the coming season to evaluate a larger number of germplasm lines in the Jordan valley. The program pathologists will help in taking disease notes. ICARDA will offer technical training for staff from NCARTT in this year's specialized course.

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' has been developed and proposed by Jordanian and ICARDA scientists for funding by USAID through the National Center for Agricultural and Technology Transfer (NCARTT). The program will continue to assist the Jordanian Highland Agricultural Development Project (HADP) and the National Center for Agricultural and Technology Transfer (NCARTT), and expand the co-operative relationship through research training, consultancies, germplasm and conferences.

5.1.8. Lebanon

The program continued to use Terbol Station as a higher-rainfall site. 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. The most promising wheat and barley lines were multiplied and provided to Lebanese scientists and to farmers in the Bekaa Valley. In spite of difficulties in Lebanon, there is close co-operation between ICARDA, the Lebanese national program, the American University of Beirut, and the University of St. Joseph, Zahle.

During 1986 the entire summer nursery work was shifted to Terbol. About 6 ha was planted under summer nurseries. In the future Terbol will be increasingly used as the summer nursery site for the program.

For 1986/87 season a special project of cereal seed production was developed and it is being implemented jointly by Agricultural Research Institute, Tel Amara and ICARDA. The project will allow multiplication and availability of improved wheat and barley varieties in Lebanon.

5.1.9. Morocco

Favorable weather conditions during the 1985/86 crop season, coupled with Ministry of Agriculture efforts to encourage timely tillage and planting operations as well the use of newer cultivars, allowed Morocco to harvest a record crop which covered 90 percent of its cereals needs. Agriculturalists in Morocco now realize that self sufficiency can be easily reached provided:

1) A greater effort is made to enable farmers in mountainous areas to improve their production. Mountainous produced below average yields compared to other cereal growing regions.

2) Better protection against diseases is obtained by growing of disease resistant cultivars.

The major problems in barley in northern Morocco, were lodging and diseases, while wheats were plagued by Septoria and to a lesser extent, tan spot and the rusts. The breeding program will intensify its research efforts in these weak areas.

A course was designed to train cereal research workers to carry out on-farm trials,to verify research results obtained in on-station trials, and to demonstrate their usefulness to farmers.

Seed of three six-rowed and two two-rowed barley cultivars developed at ICARDA and found promising by the Moroccan National Program, was requested by INRA Morocco. These five cultivars were multiplied at Merchouch research station near Rabat. Further large scale testing and seed multiplication will be carried out during 1986/87 season. Seed of promising wheat and barley lines was dispatched to the national programs as trials, observation nurseries, crossing blocks, and segregating populations nurseries. Research results for these nurseries are being summarized by the national program with the support of ICARDA resident scientists.

In September 1986 ICARDA posted a cereal scientists in Morocco. The major research objectives and priority tasks of the ICARDA-Morocco cooperative efforts are as follows:

1) Coordination with national research and educational institutions working in Morocco. In its efforts to co-ordinate research work among national scientists and expatriate scientists in Morocco, as well as among scientist working in complementary disciplines and fields

of research, ICARDA and INRA organized the first cereal research workers workshop.

2) Barley research objectives are: a) to improve drought tolerance for areas of low spring rainfall in the northern and southern areas. b) to develop lines adapted to poor soils and marginal areas in mountainous areas. c) to improve net blotch and scald resistance for moderate rainfall areas. d) to develop research methodologies for fast development of fixed lines. e) to screen germplasm in major barley growing areas with the objective of rapidly replacing older cultivars and local land varieties showing poor performance over the past five seasons.

3. Research plans for durum wheat and bread wheat are similar to those for barley with a stronger emphasis on disease resistance and quality. For all three crops, national program scientists agree that improved and targetted research, combined with simpler breeding methodologies adapted to existing manpower and technical capabilities, will lead to a more rapid identification of superior germplasm.

5.1.10. Pakistan

Collaboration in wheat and barley research has been developing steadily with the agricultural research institutes of Pakistan. To expand the collaborative research in cereal pathology with the Crop Diseases Research Institute (CDRI) of Pakistan Agricultural Research Council, a project on virulence analysis of yellow rust has been suggested. ICARDA provided mist irrigation equipment to create epiphytotics under field conditions. Germplasm exchange, consultancies, etc. were provided as in previous years.

In the Baluchistan province of Pakistan, under supplimentary irrigation a number of high yielding bread wheat lines, such as T. aestivum (Rom)//Tob'S'/8156/3/Tx69A460-1/4/Emu'S', WWP4394, Chambord/5133//Mt/3/KKC/4/Lfn//ND/2*P101/5/Rom//CC/Inia with yields of 8.2, 8.0 and 7.5 tons/ha respectively as compared to 6.2 tons of local improved check variety Zargoon, were identified.

In durum wheat 20 entries out of 24 outyielded the national check variety. A number of selected lines of bread and durum wheat have been included in the provincial variety testing program.

To expand and accelerate the work on barley and wheat improvement for the rainfed areas of Baluchistan the program of work for the 1986/87, crop season was developed jointly at Quetta. Six to eight sets of wheat and barley observation nurseries will be planted at suitable sites to select good varieties. Bulk quantity seeds of selected wheat and barley varieties were supplied for extensive and large scale testing.

5.1.11. Sudan

The OPEC fund provided financial support for the Pilot project of verification and Adoption of Improved production. 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. For the first time Sudanese scientists were able to conduct on-farm trials in the major wheat producing areas in the Sudan. The project area stretched from Selaim (near Dongola) in the Northern Region near the the Egyptian borders to Gezira in the Central Region and to New Halfa in the Eastern Region near the Ethiopian border.

The research program consists of:

a) Farmers's managed trials: The number of farmers involved in this trial was 27 and 15 in the Gezira and New Halfa projects respectively. There was a marked difference between the wheat, crops grown, with the improved package and those grown with farmers' methods.

b) Researcher's managed trial: A trial comprised of factors at two levels (improved and farmers level) was executed at three locations to quantify the main effects and interactions of improved production practices. Wheat yields were increased by 60 to 80% when the crop was given 9 instead of five irrigations. The additional of phosphorus fertilizer in the Gezira increased yield by 25%.

c) On-farm verification variety trial: Twelve varieties including two checks, four introduced, and four locally made crosses were tested in 12 locations; six in the Central Region, three in the Eastern Region and three in the Northern Regions. Results showed that a number of varieties were yielded better than the checks.

d) Back-up research:

1. Crop improvement: Support from this project was confined to a series of yield trials at Wad Medani and New Halfa to secure the flow of new improved cultivars to the on-farm verification yield trials and hence new cultivars to the farmers. From the yield data a number of cultivars will be promoted and included in the Verification Yield Trial next season.

2. Pest management: Three trials were executed which included: chemical screening for aphid control, biological control of aphids and screening wheat germplasm for tolerance to aphid damage. The results indicated that a number of chemicals were identified as being superior to the standard. The screening of a number of wheat entries against natural infestations of aphids showed that earliness is an important character that enables some wheat lines to escape heavy aphid infestation.

3. Water management: A trial was conducted to the effect of irrigation interval at different stages of crop growth on wheat yield. Data showed that a irrigation interval of 10 days during early reproduction phase in increased wheat yields.

e) Socio-economic surveys: The surveys were carried out in the main wheat production areas in the Sudan. A sample of 108 farmers was taken from Gezira, 30 from New Halfa and 60 from the Northern Region. The sample size was adequate to draw statistically significant conclusions, and is now being analysed. Results will be included in the final report.

f) Seed multiplications (pre-release): A general plan for variety maintenance and seed multiplication was initiated this season. Seed increase for promising cultivars in the advanced yield trials was carried out so that they can be included in the on-farm verification yield trial in the coming season.

g) Field days: Five successful field-days were organized in the project area which were attended by more than 500 farmers plus extension and production personnel. The farmers using the improved package explained to other farmers what they did to attain such good crop performance. The research scientists also explained the objectives of the project and the importance of adherence to recommended production practices to attain high economic yields.

Several ICARDA and CIMMYT scientists visited during the cropping season. Two senior scientists (a plant breeder and an agronomist) visited ICARDA for three months.

The project also helped in the literature review of wheat research in the Sudan by hiring an experienced retired national scientist for a period of 6 weeks. The review will be published as an important document which will be of great help to national scientist and others in the region.

The first National Coordination Meeting held in Wad Medani, Sudan, Aug. 3-5, 1986 was organized to review the work done during 1985/86 season and to develop the workplan for the 1986/87 season. The project also invited one farmer from each region who had produced highest yield in the fields. Each of them was given an award during the workshop and an opportunity to express their views concerning the new varieties, agronomic practices in improving wheat production in Sudan. The details of the workplan including training are available in the program.

During the season a proposal for strengthening research and production on wheat in Sudan was developed under the Nile Valley Cereal project. Outside funding for this special project is sought.

5.1.12. Syria

Through collaboration Syria has identified a number of varieties for possible release and commercial cultivation. Bread wheat variety, FLK'S'-Hork has been released as Sham 4 in 1986 for its superior yield, disease resistance and grain quality. Two durum wheat varieties, Kourifla and Sebou, have been found to do better than existing varieties for the last 3 years and are under consideration for release. The collaborative barley and wheat on-farm trials were carried out according to the workplan jointly developed in September. 1985. A detailed report on the cooperative trials is available from the program. Part of the work was done by the Syrian National Program scientist. This trend will be encouraged.

About 2 tons of Sham 4 was given to the Seed Bureau to be planted in farmer's fields next year. In Zone B, the barley lines Rihane'03 ranked first in grain yield followed distantly by the local check, Arabi Abiad. The lines Furat 654 and Furat 1113 both gave good yields. The Tadmor line performed better than the local check, Arabi Aswad in Zone C and showed more stability than any other variety.

Advanced 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. Training, from short intensive courses on specific topics to informal instruction, was an important feature of the collaborative program.

Cooperation with ARC-Douma in cereal pathology activities continued as planned. Results from monitoring status of cereal diseases in Syria for the third consecutive year were obtained and will be published later. Results of the 1985/86 cooperative projects were jointly reviewed by national program scientists and ICARDA staff in October 1986. Details of results and the 1986/87 workplan are available as separate reports from the Cereals Program.

5.1.13. Tunisia

Contrary to the very favorable climatic conditions that prevailed last year (1984/85) and which resulted in a record cereal crop of 2 million tons, the 1985/86 growing season was characterized by a severe drought that affected nearly all the cereal growing regions of the country and resulted in a poor crop. Production this season was only 0.6 million tons and was one of the poorest in the last few years. This is almost one third of last year's crop and half the average crop for the last 10 years. This season was also full of lessons learned on the farm as well as at the research level. Agronomic practices are much more important in dry years. The rotation system, nitrogen fertilization, weed control, etc. were the most limiting factors for production this year. The yield of wheat after wheat or after a forage crop or even after a food legume crop was inferior to the yield of wheat after fallow. Nitrogen fertilizer when applied late (March or April) had a negative effect on yield. Barley was the most drought tolerant species, followed by triticale, bread wheat and durum wheat. This will affect the decision of species distribution in the various zones of Tunisia. Salambo and Ariana 66 bread wheat varieties, Ben Bechir in durum and the new barley variety Rihane were the most tolerant to drought among these species.

From the research point of view the season was favorable for the efficient screening for drought tolerance. Some durum, bread wheat, barley and triticale lines filled the grain well even under 100-150 mm of effective rain. These lines were identified and will be further tested under low rainfall conditions. Scientists discussed breeding strategies for dry areas, type of crosses, selection procedure, etc. and the approach adopted by ICARDA for the last 3 years. ICARDA was requested to provide the Tunisian national program, beside the regular germplasm, with material selected under arid conditions.

Dr. Ahmed El-Ahmed left Tunisia after 6 years with INRAT, during which he participated in restarting a good barely program and initiated cereal pathology work. The national cereal staff assumes that these activities will be sustained and even strengthened if possible.

In durum wheat, the variety Ben Bechir was more drought tolerant and yielded better than Karim and the other varieties tested in the research station or in farmers fields. Few other lines also seem promising in this respect. The bread wheat varieties Bobwhite No. 1 and Sunbird'S' did not outyield Tanit significantly, but both have disease resistance, and will therefore be more suitable to irrigated or high rainfall zones. Some advanced lines were better in yield, disease resistance and grain size than Tanit. In barley, Rihane'S' continued to be a high yielder and five Rihane selections were as good yielder as the three released varieties Taj, Roho and Faiz. A farmer in the area of Lorbous, El-Kef, harvested 4.2 tons/ha from the variety Rihane'S', 2L-1AP-3AP-0AP. The total of about 5,000 hectares were grown during the 1985/86 crop season to the three released varieties Taj, Roho, and Faiz. There will therefore be enough seeds for distribution.

The grain quality analysis for 1985/86 growing season showed a significant decrease in specific weight and thousand kernel weight. Compared to 1st year results, the total protein content increased for durum wheat, bread wheat and barley. Yellowberry was very low in all locations and the variations in the parameters analysed were less significant in barley compared to the other crops. In general the specific weight and the thousand kernel weight were highest at Beja and lowest at Kef while the protein content was highest in Koudiat, Mateur, Krib and Kef and lowest in Beja.

The highlight of this season was the decision to release the following 3 new varieties (one of each durum, bread wheat and barley):

a) 21563-AA'S'xFg'S'/Dm69-331. D76-296-1b-1b-3b. This durum variety derived from a Tunisian cross is adapted to the favorable zones of the country and probably supplementary irrigation. The variety has excellent tillering capacity and good grain.

b) Snb'S'. CM 34630-D-3M-3Y-1M-1Y-0M. This bread wheat variety is equivalent in yield to Tanit and at times yields better and it has an attractive agronomic type with stiff straw.

c) Rihane'S'. Sel.2L-1AP-3AP-0AP. This barley variety gave excellent results in yield tests on stations as well as in the on-farm trials conducted by 'Office des Cereales' and in some farmer's fields. On a request from Algeria, 0.6 ton of seeds (0.2 breeder seed, and 0.4 ordinary) was provided for seed increase and experimental purposes.

As regards pathology, the dry conditions that prevailed in Tunisia during the 1985/86 crop season reduced the development of some foliar diseases such as yellow rust of wheat and net blotch of barley inspite of the artificial inoculation conducted several times. However, other diseases developed at Beja and Ariana sites either under natural infection conditions. e.g. powdery mildew and leaf rust on barley, or when artificially inoculated, like scald and stripe diseases on barley and septoria and common bunt on wheat. At Kef, no disease developed on the nurseries grown.

The barley nurseries were severely infected by scald and powdery mildew at Beja and Ariana and by leaf rust at Beja. Therefore, the number of entries which showed multiple disease resistance/tolerance was relatively low. Two isolates of *Rhynchosporium secalis* (Beja and Mateur) were used for inoculation. These were very virulent, resulting in a reliable screening for scald. For wheat a mixture of four isolates of *Septoria tritici* was used in field inoculation. The analysis of virulence showed that three isolates were more virulent on durum and one was more virulent on bread wheat.

The lines included in POT-B and POT-D were inoculated using a mixture of two new isolates (B and C) of *T. caries* collected from Tunisia. Out of these 28 and 39 lines respectively were free of infection and only 7 bread wheats and 6 durums were also free of septoria. In the second year bunt nursery, five bread wheat lines were resistant to the mixture of the two isolates used. A set comprising six commercial durum and bread wheat cultivars as well as promising bread wheat lines was inoculated separately by each of the two common bunt isolates. The results indicated that all tested lines were affected by both isolates. However, Ben Bechir and Mahmoudi (durum wheats) were less susceptible cultivars to isolate C. Both isolates were virulent equally on Karim and Maghrebi, durum wheats. Isolate C was more virulent on the bread wheat cultivars Tanit, Dougga, Bow=1 and Snb'S'.

In collaboration with ICARDA the following activities were carried out during 1985/86 growing season. ICARDA partially financed research carried out by students pursuing their M.Sc. graduate programs.

From master students are expected to complete by this fall. Their thesis topics are:

1. Variability of net blotch in Tunisia and inheritance of resistance to *P. teres* in some barley varieties.

2. Minor gene resistance to net blotch in some barley cultivars and the changes in resistance to net blotch in eight minor gene recurrent selection populations.

3. Virulence pattern of scald in Tunisia and Syria and the inheritance of resistance in some barley varieties.

4. Yield loss assessment in barley to *R. secalis* and *P. teres* and in wheat to *S. tritici*.

In addition, two senior thesis research programs were undertaken. These were:

1. Effect of three temperature profiles on *P. teres* expression on some barley cultivars.

2. Evaluation of the durum world collection to *S tritici* and some agronomic characters.

In addition, a special disease nursery for scald resistance assembled by ICARDA's cereal program was evaluated at the seedling stage to three isolates of *R. secalis*, one from Tunisia and two from Ethiopia. The results showed that the isolates used are different in their virulence and that few cultivars are resistant to this pathogen.

The same nursery was evaluated for net blotch reaction with three isolates from Tunisia varying in their degree of virulence at three temperature/light profiles to simulate fall, winter and spring conditions. The objective of this work was to detect minor genes for resistance to this pathogen since this type of resistance is believed to be more durable and could circumvent frequent pathogen mutations. The results showed that out of 100 varieties tested 15 interacted with temperature. Their reaction changed from susceptibility to complete resistance.

Five thousand entries from the durum world collection supplied by ICARDA were evaluated as to *S. tritici* reaction at the seedling stage and for some agronomic characters at the adult stage at Mornag station. Agronomic evaluation included data on stand, growth type, plant habit, tillering capacity, awn type, height and agronomic score. The best agronomical and those that showed good tolerance to drought will be grown next season for further evaluation in addition to 5000 new lines from the same collection. These will be grown at Mornag and Sidi Rabea and will also be screened for Septoria tritici.

The cereal group of Tunisia and ICARDA met on Sept. 1st, 1986 to review the 1985/86 research results and achievements and a 1986/87 workplan was developed which is available in the program.

5.1.14. Turkey

The workplan developed during 1985/86 season between Turkey and Cereal Program was fully implemented. A coordination meeting was held 28 and 29th July, 1986 to review and to develop 1986/87 workplan between the Ministry of Agriculture, Forestry and Rural Affairs (MAFRA), Turkey and the International Center for Agricultural Research in the Dry Areas (ICARDA). The detailed report is available in the program.

In Southeastern Anatolian region the 1985/86 season was characterized by mild winters and good rainfall, and except for black point (Helminthosporium sativum alternaria) on durum wheat there was no appreciable presence of diseases. All the nurseries (barley, durum wheat and bread wheat nurseries) looked good and several lines were selected. However, these lines should be tested for cold tolerance and the germplasm should have some winter hardiness. The spring germplasm would be suitable for areas close to the Syrian border and therefore it was agreed that spring materials would be tested at Haran and Gaziantep.

Demonstrations/regional trials were conducted including the varieties, Om-Rabi, Kourifila, Sebou, FLK'S'-Hork"S", Bloudan and Sham 1 and Sham 2. Shan 2 performed very well in large scale demonstrations. Mr. Ali Aydin requested one ton seeds of Sham 2 and 500 kg of Sham 1 for the second year of on-farm demonstrations. At Ceylanpinar state farm Om-Rabi was first (5.2 t/ha). Sebou and Kourifla also performed very well. The seed of Kourifla was excellent. FLK'S'-Hork'S' also performed well. These varieties will be included in the regional trials/demonstrations for the second year. Sham 2 is being used as an improved check variety.

In the Cukurova region Director of Agriculture Research Institute, Adana, had conducted large scale field demonstrations at the institute to compare performance of new varieties with farmers' varieties. Performance of Sham 1 was found to be excellent and Sham 2, FLK'S'-Hork'S', Sebou, Om-Rabi, Kourifla also performed well. Dr. Necati Celik selected a few early maturing, disease resistant and high yielding varieties of barley and wheat at Aleppo during his visit and will test them at Adana. In general, barley is not an important crop in the Aegean region and ICARDA barleys were too tall and lodged in Izmir. Also there was high incidence of leaf rust disease. It was agreed to reduce the number of barley nurseries at Izmir. In the future, Izmir station will be used primarily for disease screening.

At the Agricultural Research Institute, Eskishehir, a number of spring and winter habit, barley, durum wheat and bread wheat nurseries were planted at the research station. However, the season had a mild winter and weeds were a major problem. Although some lines have been selected, they need to be retested for winter hardiness. The station would like to receive material specially developed for high altitude areas. More training in pathology and agronomy was requested. The Turkish national program made a special request for germplasm coming from durum wheat x T. dicoccoides and H. vulgare x H. spontaneum as well as other wide crosses and winter habit material with good grain yield, large kernels and high protein content. Winter hardiness and grain quality are important considerations in Turkey.

It was emphasized that more attention has to be paid to improving barley production for harsher environments. It was suggested that Ankara, Eskishehir and Diyarbakir could be the main research stations for barley improvement. Diyarbakir would work on winter as well as spring barley.

The in-country course conducted at Diyarbakir on breeding methods for moisture limiting environments was attended by 20 young scientific staff and 13 senior staff from Turkey and 6 cereal scientists from ICARDA. The interaction and discussions on breeding strategies was beneficial to the national program.

Turkish scientists visited ICARDA during 1985/86. Dr. Ayhan Atli, Head of Grain Quality Laboratory came to ICARDA as a visiting scientist and worked in the grain quality laboratory. Dr. Engin Kinaci, Pathologist, Central Anatolian Regional Agricultural Research Institute, participated in barley disease and associated breeding methodlogy meeting at ICARDA. A number of Turkish senior scientists participated in ICARDA's Cereal Program Planning Meeting and visited during crop sowing season. Similarly, several ICARDA cereal scientists visited Turkish research stations during the season. A workplan for the 1986/87 collaborative research project has been developed and is available in the program.

5.2. Cooperative Projects with Institutions Outside the Region

5.2.1. Screening Advanced ICARDA Wheat and Barley for barley Yellow Dwarf Virus (BYDV) Resistance (BYDV)

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, some sets of Key Location Disease Nursery (KLDN) is sent to Quebec, Canada for screening for resistance to BYDV and the results are made available to the Cereal Improvement Program. In 1985/86 some F1 crosses were sent that were developed for BYDV resist for evaluation. -- A.Comeau, Agriculture Canada, Canada, and K.Makkouk, ICARDA.

5.2.2. 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.

The germplasm is being evaluated for a variety of characters at ICARDA and University of Saskatchewan. In 1985/86 Dr. Jaradat from Jordan University of Science and Technology, Irbid, Jordan Also became a cooperator. Research results have been presented in 3 papers. — S.Jana, University of Saskatchewan, Canada, A.Jaradat, JUST University, Jordan, and J.P.Srivastava, Cereal Improvement Prorgam, ICARDA.

5.2.3. Evaluating Durum Wheat Germplasm for Drought Tolerance

Collaboration between Cereal Improvement Program, ICARDA, and Agriculture Canada, Swift-Current, Canada.

Over 4000 durum wheat lines received through ICARDA were grown at Swift Current in 1984. Observation were made on morphological characters such as growth habit, leaf size, glaucounsness, height, and heading date. In addition, lines were screened for water loss under rainfed conditions. Excised leaf water retention capability was determined during the vegetative phase and water loss of the lines ranged from slower than the slowest local check (Hercules). The 4000 durum lines were characterized and a conouterized catalog prepared.

Six hundred and forty of these lines were chosen for study in replicated trials in 1985. The lines were selected on the basis of fast and slow water loss within the morphological categories of leaf rolling, glaucousness, maturity, leaf size, and general agronomic score. -- J.M.Clarke, S.Jana, T.N.McGaig, T.F.Townly-Smith, Agriculture Canada, Canada, and J.P.Srivastava, M.Nachit, Cereal Improvement Program, ICARDA.

5.2.4. Grain Quality and Local Product Evaluation of Barley and Durum Wheat

Collaboration between Cereal Improvement Program, 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. During the 1985/86 season five papers were published on topics, malting barley, two-layered flat bread, durum evaluation, and flour color.

A new method was developed to determine yellow pigment in durum wheat flour without using chemicals or water.

Current work is focussed on using infra-red instruments for wheat strength and straw quality. Consultancy for Dr.P.C.Williams is financed by CIDA. -- P.Williams, Canadian Grain Commision, Canada, and J.P.Srivastava, Cereal Improvement Program, ICARDA.

5.2.5. Decline in Cereal Yield in Continuous Cropping System

Collaboration between ICARDA, and Univesity of Bonn, Federal Republic of Germany. Funded by GTZ.

This joint collaborative project started in 1984/85 through a Ph.D. student. The project studies the probable causes of yield reduction when cereals are continuously grown. The incidence and significance of cereal root diseases in northen Syria and their control by crop rotation, especially through the inclusion of a legume pasture phase are being investigated. -- S.Krause, University of Bonn, Federal Republic of Germany, and H.Harris, P.Cocks, O.F.Mamluk, ICARDA.

5.2.6. 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 and determing linkage between photoperiodic insentivity and thermosensitivity (vernaliztation requirement), understand plant reaction during different development stages on changing photoperiodism, to study the inheritance of photoperiodic insensitivity, to compare phototrials with field trials. The preliminary results of last year indicate that of out of 40 varieties originating from various durum growing areas, 13 were found to have photoperiodic insensitivity. During 1986/87 work is designed to clarify the relationship between photoperiodism insentivity and thermosensitivity. -- P.Ruckenbauer, University of Hohenheim, Federal Republic of Germany, and M.Nachit, CIMMYT/ICARDA.

5.2.7. Improving Yield and Yield Stability of Barley in Stress Enivornments

Collaboration between The Cereal Improvement Program, ICARDA, and Italian Institutions, 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 over a variety of different environments the performance of pure lines compared with mixtures of pure lines 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, to utilize _H. spontaneum_ in crosses with lines selected from landraces as well as improved cultivars.

The project has become opperative and the Cereal Improvement Program is identifying the cooperating Italian Institutions and a work-plan for 1986/87 season has been developed. -- Italian Scientists (to be named) and S.Ceccarelli, Cereal Improvement Program, ICARDA.

5.2.8. Evaluation and Documentation of Durum Wheat Germplasm

Collaboration between Cereal Improvement Program, Genetic Resources Program, ICARDA, and University of Tuscia, Viterbo, Insitute of Germplasm, ENEA, Itaty. Funded by Government of Italy.

The project was initiated in 1985/86 and the major objective of this project is to evaluate diverse durum germplasm to identify desirable traits that can be used in crop improvement. The project has evaluated about 10569 accessions of durum wheat collection, for drought susceptibility, resistance to Septoria leaf blotch, yellow rust, common bunt, and salt tolerance as well as some important agronomical characters. The project evaluated this germplasm at different ecological sites in Syria and in other countries such as Tunisia. The evaluation data which is currently being documented, will be disseminated to intereseted scientists. Multiplied seed material will be entered into the Genetic Resources Program at ICARDA and the Germplasm Institute, Bari, Italy for long-term storage. The project also provides opportunities for national program trainees in germplasm evaluation and utilization. One such trainee from the Plant Genetic Resources Center in Ethiopia has already benefited from this. -- J.P.Srivastava, B.Somaroo, A.B.Damania, ICARDA, and E.Porceddu, University of Tuscia, Italy.

5.2.9. 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. ENMP provided excellent data on yellow rust, leaf rust scald, and septoria tritici blotch. Also, results on the virulences of leaf rust samples from the region were furnished to the program, this form of collaboration will be maintained. Cereal pathologist from ENMP was invited to visit ICARDA this season. -- E.Barradas, M.J.Concalves, ENMP, Portugal, and O.F.Mamluk, J.v.Leur, Cereal Improvement Program, ICARDA.

5.2.10. 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 to cereal breeding. Emphasis is being given to investigate crop physiological attributes and plant traits of potential usefulness of barley breeding for low rainfall mediterranean areas. The work started this season and is being financed by Spain through two graduate students. -- E.Fereres, ETSIA, University of Cordoba, A.Royo, Servicio Investigacion Agraria D.G.A. Zaragoza, Spain, and E.Acevedo, Cereal Improvement Program, ICARDA.

5.2.11. Genotype Characterization in Barley

Collaboration between Cereal Improvement Program, ICARDA, and The Plant Breeding Institute, Cambridge, U.K. Funded by ODA.

The aim of this project is to characterize barley genotypes in terms of constitutive and adaptive traits for improved performance in dry Meditarranean climates. This project is complementary to the barley genotype characterization being performed at the Cereal Improvement Program in northen Syria. At PBI, Cambridge, the barley genotypes characterization nursery is being studied under wet and dry conditions using rain shelters.

Results are not available as yet, being the first year of the project. -- R.B.Austin, PBI, Cambridge, U.K. and E.Acevedo, Cereal Improvement Program, ICARDA.

5.2.12. 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.

The project was started in 1984 and is entering its third year. It aims at the development of screening technologies for resistance to drought in barley and durum wheat. Physiological and biological responses to drought are studied, primarily under field conditions at ICARDA and under controlled environment at Department of Botany and Micro-biology, University College London.

The major emphasis of this project has been to develop a metabolic index of stress that characterizes plant stress history and the ability to tolerate drought stress. Multi-location field trials have been used and a line source sprinkler experiment was installed in a low rainfall (about 200mm) areas. Water stress developed under field conditions has been shown to induce large alternations in the metabolism of barley plants. These metabolic changes include: increases in total plant nitrogen, free nitrate ions, soluble nitrogen, proline, phenylalanine, leucine, isoleucine, valine, glycine betaine and the activity of leucine amino peptidase; and decreases in aspartic acid, glutamic acid and sugars. Many of these changes appear correlated with the ability of plants to resist water loss during drought. Thus the greater the increase in proline the more rapidly a variety loses water. Proline accumulation in grain seems to correlate with yield reduction under water stress and may be a diagnostic character for assessing the contribution of water stress in yield reduction.

Varietal differences in metabolic response are usually quantitative and unidirectional. However changes in polyamine levels can be positive or negative depending on the variety. Thus in varieties which resist water loss under drought, putrescine levels increase while they decline in those which lose water. - G.R.Stewart, J.Pearson, University College London, U.K. and E.Acevedo, I.Naji, Cereal Improvement Program, ICARDA.

5.2.13. Photothermal Responses of Barley

Collaboration between Cereal Improvement Program, ICARDA and University of Reading, U.K. Funded by ODA.

Barley crops are cultivated in a wider range of environments than any other of the major cereal. Crop durations and seed yields vary widely, from less than 90 to about 270 days and from less than 100 to about 10.000 kg/ha^{-1}. In seeking not only larger but also more stable yields from traditionally productive crops in temperate regions, plant breeders recognize the importance of timely ear emergence as a prelude to optimum maturity date in relation to local climatic constraints.

A trio of large experiments on a wide range of genotypes each carefully selected on the basis of contrasting phenology in various ICARDA field trials was carried out. The experiments were designed in close collaboration with colleagues at ICARDA and with common objective: to establish the photo-thermal response surface for flowering in quantitative and predictive terms as a prelude to (a) the development of simple, rapid and reliable screening techniques for durations to heading in different agroclimates and (b) the genetical analysis of relative responsiveness to v,t, and p.

The data generated from these three experiments are approaching the latter stages of analysis and formal presentation, and so it is premature to summarise our final conclusions here. But, what is already clear is that vernalization, photoperoid and temperature can have dramatic effects on time to heading, the relative effect of these factors depends on the genotype tested. Mean duirnal temperature (E) regulates development rather than day or night temperature _per re_. The traditional approach, which analyses photo-thermal responses in barley in terms of days to heading (_f_), is in appropriate. Rather an analysis based on rates of development towards heading (i.e. 1/_f_) is far more informative, for the following reasons:

a. rates of development expressed in this way are linear functions of mean tempetature and of photoperiod;

b. many reemingly complex interations are removed sa that the separate effects of photogenoid, vernalization and post-vernalization mean temperature can be identified, quantified and therefore, if necessary, genetically analysed;

c. removal of interactions is also a prelude to the formulation of a simple quantitative model with a minimal number of parameters each with identifiable biological meaning. -- E.H.Roberts, R.J.Summerfield, J.P.Cooper, University of Reading, U.K. and E.Acevedo, S.Ceccarelli, Cereal Improvement Program, ICARDA.

5.2.14. Barley and Wheat Variety Root Study

Collaboration between ICARDA and University of Reading, U.K. Funded by ODA.

During the 1985-86 growing season an experiment was carried out to examine the relation between

a) root to root-plus-shoot weight ratio, total root length, root lenght to wight ratio and the rate of plant growth to the begining of stem extension.

b) root growth and water uptake from stem extension to maturity.

Thirteen barley and two wheat varieties were sown at four sites (Jinderess, Tel Hadya, Breda and Bouider) and root and shoot measurements made at tillering. Shoot weights and green areas were determined at intervals throughout the season at Tel Hadya, Breda and Bouider. In six of the barley varieties at Tel Hadya and Breda, root measurements were made at anthesis and maturity. Soil water contents were determined in the six barley varieties at Tel Hadya (gravimetrically, during grainfilling) and at Breda and Bouider (neutron moisture meter probe, throughout the season). In a parallel experiment in a glasshouse at Reading, the thirteen barley varieties were grown in a phosphate-poor nutrient solution up to the onset of tillering.

There was significant varietal variation in shoot weight and root length at all sites at tillering and in the glasshouse, but the performance of many of the varieties was not consistent across sites. The ranking of the varieties in terms of shoot weight and root length at the four field sites were not very consistent between sites. However, the shoot weights from the glasshouse experiment corresponded well to the field measurements. The root length results were more variable than the shoot weight results. Results for 1985/86 are not yet fully analysed.

Root characteristics of H. spontanaeum, the wild progenitor of cultivated barley, has the ability to survive in the arid areas of the Mediterranean region and may have useful characters for the breeding of more productive barley varieties. Measurements of root length, weight and distribution were made on cultivated barley/H. spontanaeum crosses and on four pure H. spontanaeum lines with different shoot characteristics. Arabi Abiad was included as a reference. Sampling was done at the beginning of stem extention.

The pure H. spontanaeum lines had approximately the same total root lengths as Arabi Abiad but shoot weights were between 30% and 60% less. Of the crosses, total root length varied from 70% to 180% of Arabi Abiad and shoot weights from 50% to 110% of Arabi Abiad. One H. spontanaeum line (244776) had particularly long roots between 45 and 75 cm depth. — P.Gregory, S.Brown, University of Reading, U.K. and H.Harris, E.Acevedo, S.Ceccarelli, ICARDA.

5.2.15. 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 addresses the need to study the major barley disease in developing countries, particularly in the ICARDA region. The overriding objective is to create a model integrated approach to the incorporation of 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 seminars and workshops in pathology and plant breeding methodologies.

A coordination meeting was held December 3-5, 1985 in Aleppo. Ten barley researchers (Cyprus, Egypt, Iran, Jordan, Libya, Morocco, Syria, Tunisia, Turkey), three from MSU and barley breeders and pathologist from ICARDA reviewed the disease problems of the region and measures for solving them. Four researchers from the national programs were identified asprinciple collaborators to conduct research on specific pathogens. They are from: ARC-Giza, Cairo, Egypt (to work on powdery mildew); ENE-Meknes, Morocco (to work on barley stripe); INAT-Tunis, Tunisia (to work on scald and net blotch); CARARI-Ankara, Turkey (to work on barley stripe and scald).

A training course on barley diseases and breeding methodologies was held on March 16 - April 5, 1986. The course was attended by 12 trainees from (Algeria, Cyprus, Egypt, Ethiopia, Iran, Jordan, Libya, Morocco, Syria, Tunisia, Turkey. The course instructors were from MSU and 11 were from ICARDA. The principal collaborators met in Tunis, November 3-4, 1986, to discuss constrants on the development of national centers. Three national centers identifical received field equipment, laboratories supplies, and research supplies. The MSU staff provided consultancy, training and literature to the national programs. -- E.L.Sharp, D.Sands, Montana State Univesity (MSU), USA. and O.F.Mamluk, J.v.Leur, Cereal Improvement Program, ICARDA.

5.3. 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 station a barley breeder in Mexico and provides US$ 100,000 towards the operating expenses of the CIMMYT-based barley program

5.4. Conferences and Meetings

5.4.1. International Wheat Conference, Rabat, Morocco, May 2-5, 1986

An International Wheat Conference was organized in Rabat, Kingdom of Morocco, May 2-5, 1986 where ICARDA was a co-sponsor with USAID, Washington D.C., University of Nebraska, USDA-ARS Lincoln, CIMMYT and MIAC, University of Missouri - USA. It was a highly successful conference where wheat researchers from Africa, Asia, Europe, North America and Australia participated. Several ICARDA/CIMMYT scientists presented papers.

5.4.2. Workshop on Breeding Strategies for Rainfed Areas, Syria, 23-27 March 1986

This 3 day workshop was organized at Aleppo headquarters. Participants from Syria and others from the region as well as one barley breeder from Chile and Ecuador participated. There were 3 days of lively discussions on methodologies for improving yield and stability of production for winter cereals in low rainfall areas. This was followed by field visits.

5.4.3. Travelling Workshop on Wheat Breeding Strategies ICARDA/INRA, France 16-19 June, 1986

French, ICARDA, and CIMMYT cereal scientists visited major wheat and barley research stations in France. The visit was organized by Dr. Max Rives and as a result two collaborative projects are being developed with France.

5.4.4. North Africa Cereal Travelling Workshop, Tunisia, 28-30 April 1986

The North Africa Travelling Workshop was conducted in Tunisia during April 28-30, 1986. There were 3 participants from Algeria, 4 from Morocco, 3 from Portugal, 5 from Spain in addition to CIMMYT and ICARDA scientists. Dr. J. Vieira Da Silva from the University of Paris, joined the group in the field visits. Participants visited INRAT research stations at Beja and El Kef as well as the seed production organizations (COSEM) and on-farm verification/demonstration plots of Office des Cereales as well as INAT. The participants considered the workshop very beneficial as they discussed cereal improvement strategies for rainfed areas and note taking methods. It provided an excellent opportunity for improving regional cooperation.

5.4.5. Nile Valley Cereal Project Meeting, Cairo, 23-24 February, 1986

Cereal scientists from Egypt, Ethiopia, Sudan, CIMMYT and ICARDA met to review the cereal research work and factors limiting improved research and production in these countries. A document was produced which is available in the program.

5.4.6. Cereal Coordination Meeting in Khartoum, Sudan 3-5 August, 1986

A National Cereal Coordination Meeting was organized by Sudan with the assistance of OPEC Fund and ICARDA. It was attended by cereal scientists and administrators as well as extension workers and farmers. The 1985/86 research results were reviewed and recommendations were made for 1986/87 workplan.

5.4.7. Presented Papers

During the season program scientists presented papers at the following conferences and meetings:

1. Plant Water Stress Workshop, University of California, Conference Center, Lake Arrowhead California, April 28 - May 1, 1986.

2. Cereal Breeding Strategies for Moisture Limiting Environments, Diyarbakir, Turkey, 24-28 February, 1986.

3. International Wheat Conference, 2-5 May, 1986.

4. Eucarpia Meeting on Biometrics, Birmingham, U.K., July 27 - Aug. 1, 1986.

5. Crop Improvement and Management in Dryland Areas, Instituto Agronomico Mediterraneo de Zaragoza, Spain, Dec. 3, 1985.

6. Wheat Breeding Strategies, ICARDA/INRA, France 16-19 June, 1986.

7. IBPGR Workshop, Montpellier, France 8-12 Sept., 1986.

8. EEC meeting on Drought Resistance in Plants: Genetic Physiological aspects: Oct. 20-23, 1986, Amalfi, Italy.

9. Program scientists were requested to review the national cereal programs of Morocco and Tunisia and Yemen Arab Republic.

10. IFPRI Seminar on Yield Fluctuations in Crops, Fedalfing, Germany 12-14, Nov. 1986.

11. 5th IBGS - International Barely Genetics Symposium, Okayama, Japan 6-11 Oct. 1986.

12. 71st Annual Meeting of the AACC, Canadian Grain Commission, Toronto Canada, Sept. 28 - Oct. 3, 1986.

5.4.8. Visitors to the Program

During 1985/86 about 109 scientists visited the program. Nineteen of these spent 1-6 months at Tel Hadya and came from Canada, Ethiopia, Iran, Italy, Spain, Sudan, Syria, U.K., U.S.A., and U.S.S.R. Visits of shorter duration were made by scientists from Algeria, Canada, Chile, Cyprus, Egypt, Ethiopia, Ecuador, France, Germany, India, Iraq, Iran, Italy, Jordan, Lebanon, Libya, Mexico, Morocco, Pakistan, Sudan, Syria, Spain, Thailand, Tunisia, Turkey, U.K., U.S.A., Yemen Arab Republic and Yugoslavia.

5.4.9. Visits to National Programs by Program Scientists

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.

5.4.10. 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

6. International Nurseries System

The major objective of the international nurseries system is to provide improved barley and wheat germplasm to the national breeding programs and to provide a channel to the national programs to evaluate their best lines across national boundaries through the region or world. The second objective is to collect, analyze, summarize and report the results of the international nurseries for the use of all the scientists of the national programs. This latter component is essential for the identification of superior genotypes by both ICARDA and national scientists in the yield trials and observation nurseries. A detailed description of the system is given in the booklet "An Introduction to the International Cereal Nurseries System," which is available from the program.

6.1. Types and Numbers of Nurseries

Efforts to tailor germplasm for different environmental zones continued to receive priority from breeders. Though the types of nurseries sent to co-operators in 1985-86 remained the same as in the previous seasons, namely yield trials, observation nurseries, segregating populations and crossing blocks, the total number of nurseries increased. With the subdivision of the barley yield trial and the bread wheat observation nursery into 3 and 2 nurseries, respectively, there were a total of 21 different nurseries. Some special nurseries were also assembled upon request of the national programs. The name, abbreviation and number of entries of each nursery is presented in Table 112. The increase in the number of different nurseries available for distribution since 1977-78 as a result of targeting germplasm for specific environments is shown in Fig. 32.

6.2. Germplasm Distribution

During 1985/86, 850* sets of nurseries were sent to 91 co-operators in 44 countries. Approximately 76 % of all the nursery sets were distributed to countries within the ICARDA region (Table 113). The number of sets distributed for barley, durum wheat and bread wheat represented 39, 31 and 30 percent of the over-all total, respectively. Fig. 32 shows the total number of sets of nurseries distributed by ICARDA since 1981-82. Seed production for international nurseries in 1984/85 was affected by frost damage, thus for 1985-86 we were not able to

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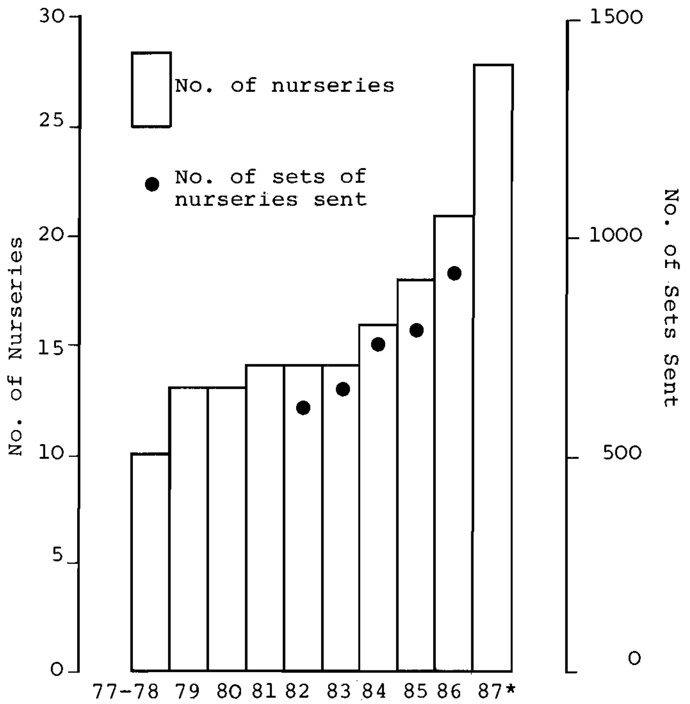
* assembled and distributed only from Aleppo. Barley nurseries sent from Mexico through joint CIMMYT/ICARDA activity at CIMMYT are reported by CIMMYT. Wheat nurseries were developed through joint ICARDA/CIMMYT breeding activity at ICARDA.

meet all requests for international nurseries from national programs. Seeds of specific germplasm was supplied to additional 87 scientists on special request in 28 countries.

Table 112. Names, abbreviations and number of entries of ICARDA's international cereal nurseries and trials for the 1985-86 season.

Name & abbreviation		No. of entries
Barley		
Yield Trial	BYT	
- Low Rainfall Areas	(LRA)	24
- Moderate Rainfall Areas	(MRA)	24
- Cold Tolerance	(CT)	24
Observation Nursery	BON	
- Low Rainfall Areas	(LRA)	90
- Moderate Rainfall Areas	(MRA)	90
- Cold Tolerance	(CT)	90
Segregating Populations	BSP	
- Low Rainfall Areas	(LRA)	150
- Moderate Rainfall Areas	(MRA)	150
- Cold Tolerance	(CT)	150
Crossing Block	BCB	144
Durum Wheat		
Yield Trial	RDYT	
- Low Rainfall Areas	(LRA)	24
- Moderate Rainfall Areas	(MRA)	24
Observation Nursery	DON	
- Low Rainfall Areas	(LRA)	96
- Moderate Rainfall Areas	(MRA)	113
Segregating Populations	DSP	118
Crossing Block	DCB	163
Bread Wheat		
Yield Trial	RWYT	24
Observation Nursery	WON	
- Low Rainfall Areas	(LRA)	91
- Moderate Rainfall Areas	(MRA)	113
Segregating Populations	WSP	87
Crossing Block	WCB	160

Figure 32. Number of nurseries and number of sets sent to national programs since 1977-78.



*Nurseries for HAA included, plus Heat Tolerance Observation Nurseries

Table 113. Distribution of ICARDA's international cereal nurseries for 85-86.

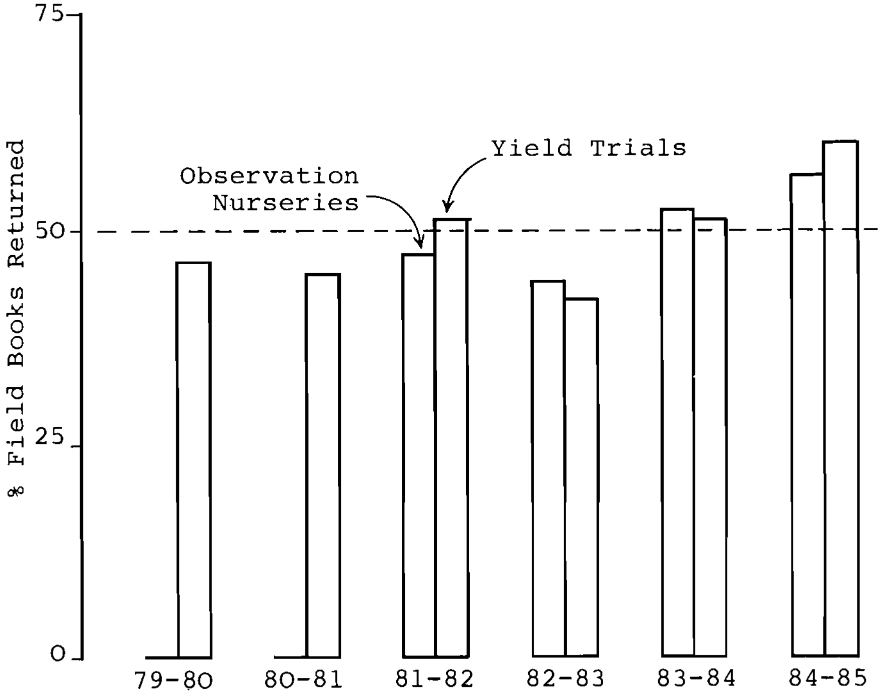
Region	No. of sets	
West Asia	321	553
North Africa: Magheeb, and Nile Valley	232	(65%)
Med. Europe	89	
Other Africa (Inc. Ethiopia)	45	
South Asia (Inc. Pakistan)	74	
East Asia	21	
South America	24	
North America	37	
Others	7	

Total	850	

6.3. Data Collection, Analysis and Report

Field books returned from co-operators reached a record level for the 1984-85 season: 56 % for observation nurseries and 60 % for yield trials. This was achieved as more effort was exerted in encouraging co-operators to return their data. The improvement in the % of field books returned is shown in Fig. 33.

Figure 33. Percentages of field books received from co-operators.



Preliminary reports, consisting of computer print-outs for the different 1984-85 yield trials and observation nurseries, were distributed to national program scientists in October 1985. The Annual Report was distributed to co-operators in August, 1986. As the content of the report increased, one report was produced for each of the 3 crops. One new feature had been incorporated into the 84-85 Annual Report for the yield trials, i.e., a concise summary of the performance of each entry at each location was provided. Thus at one glance, one can tell at which locations or for how many times an entry was among the top 5 yielders or yielded significantly higher than the national check, the improved check, or the long-term check. Copies of the reports are available from the program.

In order to better serve the national programs scientists, a new service was initiated in 1986. Upon receipt of the field books of yield trials from the co-operators, data were immediately analyzed and results in the form of computer print-outs were sent back to the co-operators. It is hoped that this service will encourage more co-operators to return their field books and critically examine their results.

– S.K. Yau, D.K. Mulitze

7. Cereal Training

Cereal Training at ICARDA aims at improving the technical skills of research workers from the National Programs in the field of cereal improvement with emphasis on barley and rainfed wheat. During the 1985-86 season, different training courses were provided which were tailored to meet the evolving needs of the National Programs.

7.1. Individual Training

An increased emphasis was placed this year on individual training. Fourteen trainees from 6 countries participated for periods ranging from of 1 week to 6 months in activities dealing with diversified research topics (Table 114). Short-duration training, intended for trainees unable to leave their work for longer periods, provided the trainees with an opportunity to acquire skills in specific research methodologies and techniques, while longer-duration training enabled them to attend lectures and review pertinent literature in addition to learning laboratory and field techniques.

Degree training is another form of individual training conducted in collaboration with universities. Three research fellows are currently pursuing the Ph.D. degree. Within the framework of the ICARDA/MSU Barley Project, letters of invitation for nomination for M.Sc. candidates have been sent to research institutions in the region. One candidate from Morocco has been already accepted to start a M.Sc. degree program in barley pathology at MSU.

With the establishment of a Graduate Research Training Program, more research projects at ICARDA will be carried out by graduate students under the supervision of ICARDA scientists.

7.2. In-Country Training

7.2.1. Turkey

Twenty six cereal researchers from 9 different agricultural research institutions in Turkey participated in an in-country training course on "cereal improvement strategies for moisture-limited areas" which was jointly organized by the

Turkish Ministry of Agriculture, Forestry and Rural Affairs, and ICARDA. The course took place on 24-28 February at the Southeastern Anatolian Regional Agricultural Research Institute, Diyarbakir, Turkey.

Table 114. Short-duration training at the Cereal Improvement Program, ICARDA, 1986.

Subject	Duration	Country	No. of trainees
Cytogenetics and electrophoretic techniques	2 weeks	Jordan	2
Experimental design and data analysis	1 week	Syria	2
Grain quality	2 weeks	Syria	2
Cereal pathology	1 week	Syria	1
Cereal physiology	4 weeks	Turkey	1
On-farm verification trials	2 weeks	Tunisia	2
Characterization of barley and wheat germplasm	6 months	Ethiopia	1
Barley breeding	3 months	Ethiopia	1
Improvement of durum wheat	6 months	Netherlands	1
Grain quality	2 weeks	Tunisia	1

Course objectives were (a) to define the major constraints to cereal production in moisture-limited areas, (b) to review current methods of improving cereal crops in such areas, and (c) to discuss research methodology and ways to improve or complement those methods.

Thirteen scientists from Turkey and 8 from ICARDA delivered lectures and participated in discussions and question and answer sessions with trainees.

A major portion of the presentations dealt with breeding methods, but other topics were also covered and included agroecological zoning, agronomy, pathology, entomology, grain quality, and seed production. Presentations were made either in Turkish or English and were followed by discussions. Trainees and scientists expressed satisfaction with the course, which was viewed not only as a training exercise but as forum for exchange of new information and ideas on cereal improvement methodologies under limited-moisture conditions.

7.2.2. Morocco

An in-country training course on 'cereal on-farm verification and demonstration trials' was jointly organized by ICARDA, INRA and FAO. The course was designed to enable trainees to participate in activities ranging from sowing to harvesting.

The first part of the course (ICARDA Annual Report, 1985) took place on 16-25 October 1985 in Morocco when 26 trainees participated in the sowing of trials at 2 sites each in Fes and Romani provinces. In each case, one small farmer and one progressive farmer were chosen. Growing conditions were generally favorable which allowed good germination in November 1985 and adequate plant growth thereafter. The trial sites were visited by 2 scientists from ICARDA and INRA and 8 trainees on 8-13 February 1986 when plants were at boot stage. Trainees also regularly visited the sites throughout the season, made observations, and applied necessary production inputs to the trials. Some trainees also planted trials of their own, following the experience they acquired during the first part of the course.

Another major part of the course occurred on 16-25 June 1986 when 18 trainees (who also participated in the first part of the course) visited the trials, made visual scoring on plant performance, and actually harvested, weighed the grain, recorded yield data, and then discussed results with instructors. Cooperating farmers expressed the desire to have similar trials in their fields during the following season, as they were impressed by the excellent performance of certain cultivars.

7.3. On-Station Short Course

Fifteen participants from 11 countries in the region attended a 3-week training course on 'barley diseases and associated breeding methodologies.' The course was jointly conducted by ICARDA and Montana State University (MSU) from 16 March to 5 April 1986 at ICARDA headquarters, Tel Hadya, Syria. Instructors included scientists from ICARDA and MSU. Training topics covered the study of barley diseases caused by fungi, bacteria, viruses, and nematodes. Important aspects of diseases and disease development were detailed including etiology, symptomatology, and epidemiology. Methods of breeding for disease resistance in barley were also discussed. Field and laboratory sessions comprised 63% of the schedule and mainly included training on pathogen isolation, inoculation, multiplication, identification and disease scoring.

Training material distributed to all trainees included small laboratory items and printed material (lecture handouts, brochures, and books).

7.4. Residential Training Course

Eighteen trainees from 9 countries (Table 115) attended a course at ICARDA from 2 March through 5 June 1986. The MIAC Project in Morocco provided financial support for 5 Moroccan trainees and AOAD financed the participation of 4 trainees from other Arab countries.

The major training activities were carried out at ICARDA's main station at Tel Hadya, but research sites at Breda and Bouider and on-farm trials at Aleppo, Idlib and Hama provinces were also visited.

As in the previous season, the training activities were either common to all ICARDA commodity programs or specific to cereal improvement. Emphasis was placed on techniques of cereal improvement, experimental design and statistics, field equipment and cultural practices, on-farm trials, cereal pathology, and grain quality.

The trainees spent about 76% of their time in the field or laboratory. As part of the practical training, each trainee was assigned a project (or experiment) in which he had to make observations, take notes, and write a final report. The project topics dealt with breeding, physiology, agronomy and pathology (Table 115). Diversified training material was distributed and included manuals, books, lecture handouts, and recent ICARDA publications on cereal improvement.

The evaluation of the trainees' performance was accomplished by means of biweekly interim reports and a series of technical questions as done in the previous seasons.

7.5. Workshop and Visits

A workshop on "breeding strategies for cereals and food legumes under moisture-limited conditions" was held on 11-13 May 1986 at ICARDA. Twelve scientists from 5 countries (Syria, Turkey, Spain, Mexico and Pakistan), in addition to 14 scientists from ICARDA, attended the workshop. Presentations were given on physical and biological stresses in rainfed environments, physiological attributes for crop improvement in such environments, breeding techniques and methodologies, and cereal and food legume diseases. The participants visited ICARDA research sites and collaborative on-farm trials in Syria.

Several scientists visited the Cereal Improvement Program for various periods of time. One scientist from Turkey spent 2 weeks at ICARDA, getting acquainted with the work on quality of cereals, food legumes, and forages. Another scientist from Sudan visited the program for one month. He worked closely with ICARDA pathologists on cereal diseases, with emphasis placed on common bunt of wheat.

- H. Ketata

Table 115. List of participants in the Cereal Residential Training Course, ICARDA, 1986.

Trainees's name	Country	Project
Girmay Amaha Abesha	Ethiopia	Barley breeding
Yousif Suleiman Al Omary	Jordan	Barley breeding
Adli Ben Aissa	Morocco	Cereal improvement for high elevation areas
Yang Chongli	China	Barley breeding
Abdelrahman Cheraghali	Iran	Barley breeding
Mohamed Mahmoud Debsawi	Syria	Durum wheat breeding
Driss Mohamed Haddan	Morocco	Durum wheat breeding
Abdel Majid Hassani	Morocco	Barley breeding
Huseyin Kabakci	Turkey	Cereal agronomy/ physiology
Mohamed Iyad Husari	Syria	Durum wheat breeding
Mohamed Reza Jalal Kamali	Iran	Cereal improvement for high elevation areas
Mohamed Maisari	Morocco	Cereal pathology
Samir Rizk Mitwali	Egypt	Cereal agronomy/ physiology
Migdad Saadoun Ali	Iraq	Bread wheat breeding
Mohamed S. Ali Sharshar	Egypt	Cereal agronomy/ physiology
Huseyin Tosun	Turkey	Barley breeding
Mohamed Zazia	Morocco	Bread wheat breeding
Mohamed Abdelrahim Zhari	Morocco	Cereal on-farm trials

8. Publications

8.1 Books

Somaroo, B. H., Mekni, M. S., and Adham, Y. J. 1986. Barley germplasm Catalog 1. ICARDA, Aleppo, Syria.

Srivastava, J. P. and Simarski, L. T. 1986. Seed Production Technology. ICARDA, Aleppo, Syria.

Williams, P. C., Jaby El-Haramein, F., Nakkoul, H., and Rihawi, S. 1986. Crop Quality Evaluation Methods and Guidelines. ICARDA, Aleppo, Syria.

8.2. Journal Articles

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Damania, A.B., Jackson, M.T. and Porceddu, E. 1985. Variation in wheat and barley landraces from Nepal and the Yemen Arab Republic. Z. Pflanzenzuchtg. 94: 13-24

Damania, A.B. 1985. Electrophoretic analysis of *Triticum* landraces from Nepal and their use for improving breadmaking quality of wheats. Indian J. Genet. Plant Breeding. 45:213-218.

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Williams, P.C., Jaby El-Haramein, F., Nelson, W., and Srivastava, J.P. 1986. Evaluation of wheat quality by baking Syrian-type two-layered flat bread. Journal of Cereal Science (in press).

Williams, P.C., Jaby El-Haramein, F., Ortiz Ferrara, G., and Srivastava, J.P. 1986. On predicting wheat strength by near-infrared reflectness. Cereal Science (in press).

8.3. Conference Papers

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Ceccarelli, S., 1986. Tolerance to climatic stresses. Fifthe Barley Genetics Symposium, 6-12 October 1986, Okayama, Japan.

Ceccarelli, S., 1986. Breeding strategies to improve yield and yield stability of barley in drought-prone areas. Meeting on "Drought Resistance in Plants: Genetic and Physiological Aspects", 20-23 October, 1986. Amalfi, Italy.

Jaby El-Haramein, F., Williams, P.C., Ortiz Ferrara, G., and Srivastava, J.P. 1986. Factors affecting the experimental baking of two-layered Syrian flat breads.

American Association pf Cereal Chemists. 71st Annual Meeting, 5-9 October, Toronto, Canada.

Jaby El-Haramein, F., Williams, P. C., Srivastava, J. P., Nachit, M., and Sayegh, A. 1986. Selecting durum wheats on the basis of flat bread quality. American Association of Cereal Chemists. 71st Annual Meeting, 5-9 October, Toronto, Canada.

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8.4. Reports and Occasional Publications

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