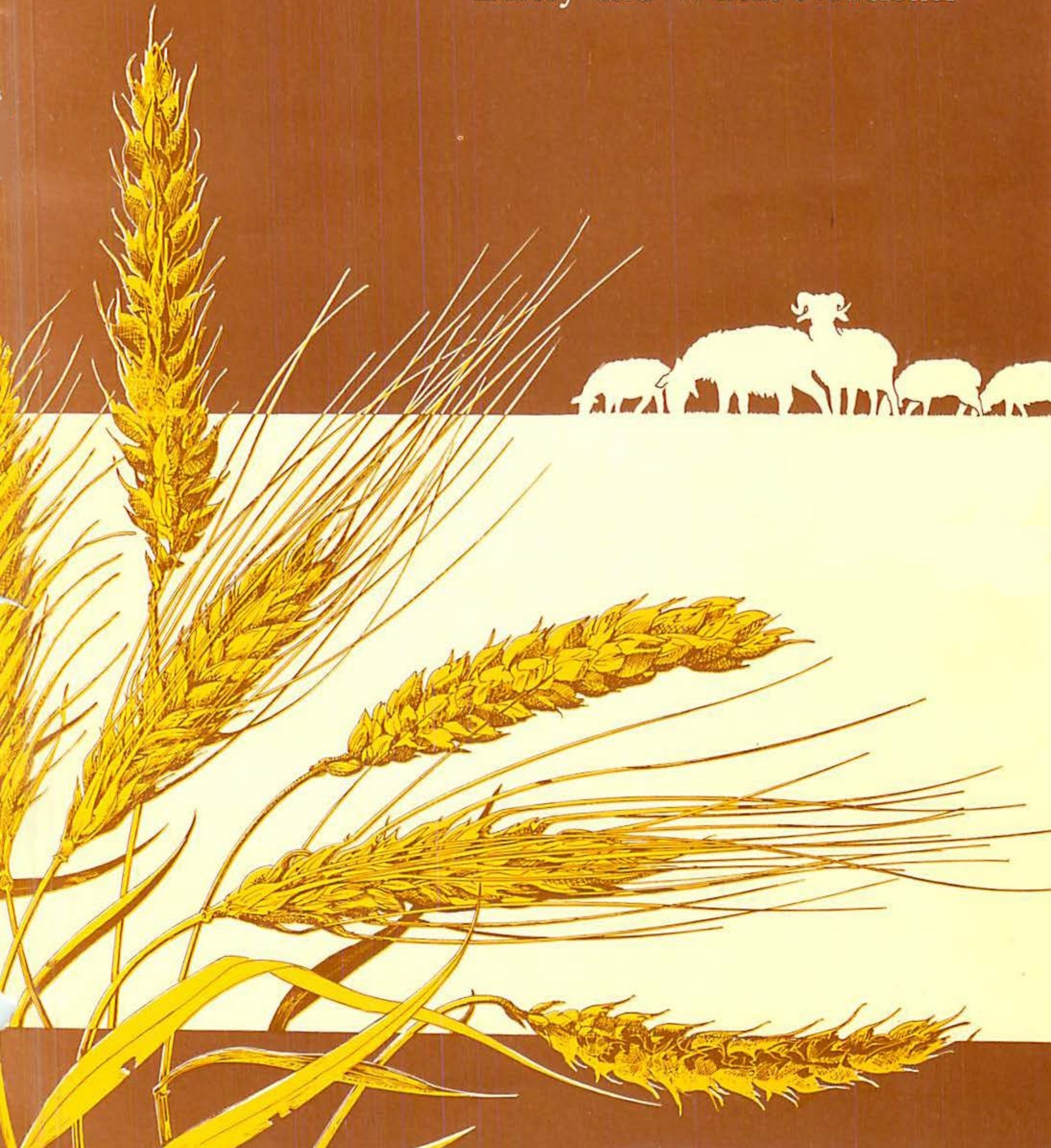
RACHIS

Barley and Wheat Newsletter



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The Center and its Mission

The International Center for Agricultural Research in the Dry Areas (ICARDA) was established in 1977 to undertake research relevant to the needs of developing countries and specifically for the agricultural systems in West Asia and North Africa. The overall objective of the Center is to contribute towards increased agricultural productivity, thereby increasing the availability of food in both rural and urban areas, and thus improving the economic and social well-being of people.

The Center focuses mainly on winter-rainfall areas with 200 to 600 mm annual rainfall. Where appropriate, research also covers environments with monsoon rainfall or irrigation.

ICARDA is a world center for the improvement of barley, lentil, and faba bean; and a regional center for the improvement of wheat, chickpea, farming systems, pasture and forage crops, and livestock. Training agricultural researchers from developing countries is an important component of ICARDA's activities.

ICARDA is one of 13 international research centers receiving support from donors through the Consultative Group on International Agricultural Research (CGIAR). CGIAR, an association of governments, organizations, and private foundations, supports agricultural research worldwide to improve food production in developing countries.

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RACHIS - the Barley and Wheat Newsletter - is published by the International Center for Agricultural Research in the Dry Areas (ICARDA). It contains mainly short scientific articles but also includes book reviews and news about training, conferences, and scientists in barley and wheat.

Published half-yearly in January and July, RACHIS can be obtained free by writing to the Distribution Unit, Scientific and Technical Information Program (STIP), ICARDA, P.O. Box 5466, Aleppo, Syria. Contributions to RACHIS should be sent to Mr Tarek Abdel Malak.

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Editorial

Millions of people around the world are undernourished in spite of considerable increases in food imports during the recent years in many areas of the world. The West Asia and North Africa (WANA) region offers a dramatic case as it imported about 16 million tonnes of cereals in 1980 and is likely to import three times as much by the year 2000, if recent trends prevail. Other commodities, particularly livestock, will also need to be imported to fill the food gap. However, imports will not help solve the problem of food shortage in the long run. Indeed, a relatively high population growth rate in WANA (about 2.4%) coupled with changing and more demanding dietary habits is bound to lead to increased food consumption in the region.

Agricultural research has helped reduce the food shortages in several countries of the WANA region, and in some areas productivity increases of up to 100% have been achieved. In most cases these spectacular achievements have been made only with those crops grown in favorable environments, usually with high rainfall and adequate production inputs. However, in the WANA region, where cereal crops cover 70% of the arable land, three-fourths of the cropped area is rainfed. Crop production is hampered by the severe lack of moisture, temperature extremes, and a multitude of other abiotic and biotic stresses.

Realizing these constraints, national agricultural research systems (NARS) in the region, together with international and regional research organizations have pooled their efforts and resources to help improve research.

In addition to dissemination of germplasm and scientific information to research partners in the region, the International Center for Agricultural Research in the Dry Areas (ICARDA) has participated in the initiation of several regional networks including the Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA), the Rainfed Agricultural Information Network (RAIN), and the Nile Valley Project. Other research networks are being initiated on a subregional basis, such as those for the Maghreb and the Mashreq countries and the high-elevation areas of WANA.

Networks offer a framework for researchers from different institutions to cooperatively tackle research problems of common interest. The workload is shared among participating programs in a complementary fashion leading to a more rational use of resources, a more efficient flow of information, and the generation of improved technology. The network approach was recently stressed and commended by the members of the Second External Program Review Panel who visited several NARSs and ICARDA to assess the value of the Center's cooperative research with national programs of the region to improve food production. RACHIS, on its part, has been playing an important role in strenghening the network of cereal research scientists in the region and seeks readers' participation and suggestions for improving this role in the future.

Review Article

Wheat and Barley Improvement: An Overview of the Cereal Improvement Program of ICARDA

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The activities of the cereal Improvement Program (CP) of ICARDA are oriented to assist NARS (national agricultural research systems) to improve yield and production dependability of barley, durum wheat, and bread wheat in the drier, predominantly rainfed areas in West Asia and North Africa (WANA). In the case of barley, however, the mandate is wider, extending to other developing countries of the world where barley is grown. The overall objective of research is to achieve greater stability and improved yields over seasons by moderating the effects of environmental stress rather than by maximizing production in the more favorable environments. This approach is expected to improve the income and quality of life of a vast population whose livelihood depends on barley/livestock or other cereal-based farming systems. The research projects have a commodity focus within the farming systems perspective. Multidisciplinary research and training in agronomy (together with the Farm Resource Management Program of ICARDA), breeding, crop physiology, pathology, entomology, grain quality, and transfer of technology are integrated into a strong team approach. Breeding remains the core activity but more resources are directed to the supporting disciplines. The Program works closely and derives valuable support from other programs and units at ICARDA.

The Program works on barley, durum wheat, and bread wheat, the three crops that account for about 70% of the area planted to annual food crops in WANA. The CGIAR (Consultative Group on International Agricultural Research) has designated ICARDA as responsible for world barley improvement (jointly with CIMMYT in the Andean region), and for the improvement of durum wheat and bread wheat in WANA jointly with CIMMYT. All three crops have their centers of genetic diversity in WANA.

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

Cereal production in the WANA region must be seen against a background of chronic and acute deficiency (Table 1). The gap between the demand for cereals and the capacity of the region to satisfy it is widening under the combined influences of population growth and an increasing requirement for animal products which, in turn, are largely dependent on the availability of animal feed (grain and straw).

Table 1. Imports (million tonnes) of wheat and barley in the ICARDA region.

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

* FAO Trade Yearbook, Vol. 28, 1974 (grain + flour)
** FAO monthly Bulletin of Statistics, Vol. 10, No. 10, 1987.

The population growth by the year 2010 is projected to be as high as 3.7% per annum in certain countries of the region, against a world average of 1.9%. A recent analysis of projected trends in population growth, income and food requirements (Khaldi 1984) in the Middle East and North Africa led to the following conclusions:

1. If past trends continue, the demand for food commodities will continue to surpass projected output, resulting in a gap of about 52 million tonnes by the end of the century.
2. The wheat deficit, traditionally the largest component of the region's gap in basic staple foods, is expected to decline from 59% of the total deficit in 1980 to about 22% in the year 2000. Meanwhile, the gap in coarse grains (mostly barley) is expected to expand rapidly, eventually reaching 36 million tonnes by the year 2000.
3. Policies to encourage coarse grain production, especially barley and sorghum, in the major food producing countries (Afghanistan, Morocco, Sudan, Syria, Tunisia, and Turkey) would help to adapt production to the rapidly rising demand for animal feed, and narrow the grain gap. Policies to promote the application of yield-increasing technology on drier land could reduce the trade imbalance in coarse grain without affecting wheat production.

Table 2. Barley area and yield in major regions of the world. (FAO Monthly Bulletin of Statistics).

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

Barley

Barley is the world's fourth most important cereal crop after wheat, maize, and rice. It is grown on more than 78 million hectares, with a production of more than 175 million tonnes, and with an average yield of 2.2 t/ha. Barley grain is used as feed, food, and for malting purposes while the straw provides an important source of roughage for animals particularly in the dry areas.

About 22% (or almost 17 million hectares) of barley is grown in Asia, Africa, and South America (Table 2) where yields are about 60% of those obtained in North America and about 70% of those in Europe.

In less developed countries (LDC), the largest barley growing areas are in Asia (66.4%) and Africa (30.2%), while only 3% is grown in South America. The largest barley growing countries in Asia and Africa are China, India, Turkey, Iran, Syria, Korea, Iraq, Afghanistan, and Pakistan in Asia; and Morocco, Algeria, Ethiopia, Tunisia, Libya, and Kenya in Africa. In the past 15 years yields have increased only modestly, or have remained stagnant in almost all the countries, except in Turkey, where they have increased from 1.43 t/ha to 1.98 t/ha.

Table 3. Area and percentage of durum wheat in different agroecological zones in the ICARDA region.

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

Durum Wheat

Durum wheat is a major basic food crop in the WANA region, and accounts for a significant proportion of the total world production (Table 3). It is used to make different products throughout the world. In the WANA region, durum wheat is mainly used for bread, burghul, frekeh, couscous, spaghetti, macaroni, and other pasta products.

Of the total wheat production in the world, about 8% is contributed by durum wheat, which occupies about 30 million hectares (of which about 11 million hectares are in developing countries). Of the area planted to durum wheat in the developing countries, which produces approximately 10 million tonnes annually, an overwhelming proportion (80%) is in the WANA region, and the remaining 20% in Southeast Asia and Latin America. With the exception of Egypt and Saudi Arabia, almost all of the durum wheat is grown without irrigation.

Bread Wheat

As one of the world's most important food crops, bread wheat is also the major cereal grown in the ICARDA region. In the period 1984-86, 49.9 million tonnes of wheat was produced in the countries of West Asia and North Africa, of which it is estimated that approximately 75% was bread wheat. This represents approximately 10% of total world production of wheat. About 77% of the bread wheat grown in the ICARDA region is rainfed and approximately 43% of the area receives less than 400 mm of rain (Table 4). Irrigated bread wheat production within the region is largely concentrated in Egypt, Sudan, Saudi Arabia, and parts of Pakistan, Afghanistan, and Iran.

Table 4. Area* and percentage of bread wheat in different agroecological zones in the WANA region.

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

*Excluding Pakistan

Source: Byerlee and Winkelmann (1980).

On a world basis, in comparison with durum wheat and barley, bread wheat is grown under higher rainfall conditions or under irrigation. There are 7.3 million hectares of bread wheat grown under less than 400 mm rainfall in the WANA region. These areas are characterized by abiotic stresses (such as drought, cold, heat, and salinity) as well as biotic stresses.

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

The Environment

The three cereal crops are grown in distinct, although to some extent overlapping, environments defined in terms of growing days (Table 5) which integrate both rainfall and temperature.

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

Table 5. The main agroecological zones of West Asia and North Africa.

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

Note: The concept of growing days period considers limitations of temperature and water.

Strategy and Accomplishments

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

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

These metnodologies have allowed the development of a breeding philosophy based on the principle that germplasm for specific stresses is difficult to identify unless the material under selection is exposed to those stresses. Among the most recent achievements of the Program are (1) the increasing evidence that selection can be made even in harsh environments, (2) the identification of physiological and morphological traits associated with higher yields under stress conditions, and (3) the emerging evidence that water-use efficiency can be both genetically and agronomically manipulated.

To meet the challenge of the harsher environments the Program made an increasing use of landraces and wild relatives with a strong focus on the preservation and utilization of the variability harbored by these genetic resources. Stresses commonly encountered within the ICARDA region include drought, heat, cold, insects, and pathogens.

To help national scientists utilize their resources more efficiently, germplasm developed at ICARDA is distributed in the form of international nurseries targeted for different agroecological zones or stresses commonly encountered in the region. During 1986/87 the proportion of genetic stocks, trait-specific or special-purpose nurseries, and segregating populations supplied to national programs considerably increased and the supply of finished lines was reduced. International nurseries were further tailored for low and moderate rainfall areas (in lowlands) and for high altitude areas. The Heat Tolerance Observation Nursery, one of a series of trait-specific nurseries, was assembled. Promising lines nominated by national scientists were included in the observation nurseries for the first time. The proportion of field books returned from cooperators reached a record level: 59% for observation nurseries and 67% for yield trials. Cluster analysis and regression were carried out on the grain yield data of the 1985/86 regional yield trials to further aid breeders target their varieties to specific environments.

The Program aims to utilize the locally adopted landraces and wild types more effectively to produce genotypes more resistant or tolerant to stresses for the drier zones and harsher environments of high altitude areas, and to understand the underlying mechanisms that contribute to improved farming systems. A closer matching of new cereal varieties with livestock requirements is under way, as shown by work on total biological yield and straw quality in barley.

Through cooperation and training, an increasing part of the development of varieties and the matching of genotypes to differing environments is being undertaken by the more advanced NARS, especially in the more favorable rainfall areas. The Program is engaged in the development of subregional networks that concentrate on problems unique to a subregion. For example, Cyprus is taking the lead in identifying early barley and durum lines for areas with mild winters and low rainfall; Egypt assumed specific responsibility to identify aphid-resistant germplasm; and Turkey is capable of assuming greater responsibility in high-elevation cereals research. In such networks, ICARDA brings scientists together, discusses directions for research, and catalyzes the transfer of results among national programs.

According to the available reports, 32 barley, 26 durum wheat, and 31 bread wheat releases have been made by national programs in the region (Table 6). Sham 1, a durum wheat released by Syria from the joint Syria/ICARDA/CIMMYT work in 1983/84, has experienced a logarithmic increase in production by the Syrian national seed production organization, which started out with 20 tonnes of seed supplied by ICARDA in 1984 and distributed 9000 tonnes of that variety in 1986/87. A similar situation is occurring for barley varieties jointly developed by ICARDA and the Tunisian National Program. The results of research for drier areas have started to pay dividends. The release of Sham 3, (Korifla) a durum wheat identified by Syria as an improved variety for the B Zone (250-350 mm) where locally adapted landrace Haurani has been successfully grown for many centuries, is a major achievement and indicates the success of our breeding methodology for severely stressed environments.

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

Efforts on evaluation, documentation, and utilization of durum wheat landraces and primitive forms of wheat expanded to cover progenitors of wheat such as *Aegilops* and other members of Triticeae. Selected trait-specific germplasm of durum wheat was provided to evaluators based at national programs through a network of cooperating institutions.

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

Two high-yielding bread wheat lines, ICWH81-1610 and ICWH81-1781, with a high degree of cold tolerance and a phenology suited to high-altitude environments of Pakistan and Iran were identified for national testing. A breeding procedure based on primordium development and other screening methods for cold and drought toler-

Table 6. Cereal varieties released by national programs.

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
China	1986	Gobernadora
Cyprus	1980	Kantara
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
Jordan	1984	Rum (6-row)
Mexico	1986	Mona/Mzq/DL71
Morocco	1984	Asni
		Tamellat
		Tissa
Nepal	1987	Bonus
Pakistan	1985	Jau-83
	1987	Jau-87
	1987	Frontier 87
Peru	1987	Una 87
		Nana 87
Portugal	1982	Sereia
	1983	CE 8302
Qatar	1982	Gulf
	1983	Harma
Saudi Arabia	1985	Gusto
Spain	1987	Rihan
Syria	1987	Furat 1113
Tunisia	1985	Taj
		Faiz
	1987	Rihane"S"
Yemen AR	1986	Arafat
		Beecher
Thailand	1987	Semang1 IBON 48
	1987	Semang2 IBON 42
Durum wheat		
Algeria	1986	Sahl
		Waha
	1982	ZB S FG'S'/LUKS GO
	1984	Timgad
Cyprus	1982	Mesoaria
	1984	Karpasia
Egypt	1979	Sohag
Greece	1982	Selas
	1983	Sapfo
	1984	Skiti
	1985	Samos
	1985	Syros

Table 6. cont'd.

Country	Year of release	Variety
Lebanon	1987	Belikh 2
Libya	1985	Marjawi
		Ghuodwa
		Zorda
		Baraka
		Qara
		Fazan
Morocco	1984	Marzak
Portugal	1983	Celta
Saudi Arabia	1987	Sham 1
Syria	1984	Sham 1
	1987	Sham 3
	1987	Bohouth 5
Tunisia	1987	Razzak
Bread wheat		
Algeria	1982	Setif 82
		HD 1220
Egypt	1982	Giza 160
Ethiopia	1984	Dashen
		Batu
		Gara
Greece	1983	Louros
		Pinios
		Arachthos
Iran	1986	Golestan
		Azadi
Libya	1985	Zellaf
		Sheba
		Germa
Morocco	1984	Jouda
		Merchouche
Pakistan	1986	Sutlej 86
Portugal	1986	LIZ 1
		LIZ 2
Sudan	1985	Debeira
	1987	Wadi El Neel
Syria	1984	Sham 2
	1986	Sham 4
	1987	Bohouth 4
Tunisia	1986	Snb'S'
	1987	Byrsa
Yemen AR	1983	Marib 1
	1988	Mukhtar
	1988	Aziz
	1988	Dhumran
Yemen PDR	1983	Ahgaf

ance has been developed to generate improved germplasm for high-altitude environments. An international symposium on cereal production in high altitude areas was held in 1987 at Ankara, Turkey. The national program participants from countries with major high altitude areas agreed to develop and participate in a network of cereal improvement for such areas. Six main ecological zones with major research stations were identified.

Stress physiology research has been considerably strengthened with the objective of supporting breeding programs in methodologies of selection for abiotic stresses. Work on gas-exchange of barley and wheat genotypes under drought consistently has shown that barley has higher leaf transpiration efficiency. Furthermore, barley genotypes continued to photosynthesize at stress levels at which the stomata of wheat are fully closed. At the crop level, below 300 mm of annual rainfall, barley has a higher water-use efficiency than wheat. A strong positive correlation between C-13 discrimination and yield was found for barley genotypes grown under severe stress. This technique is being further assessed as a potentially powerful screening tool for cereal improvement in dry areas.

Several barley and wheat germplasm pools for major diseases such as yellow rust, bunt, septoria, and scald have been developed and are available to breeders. Seedling screening techniques have been developed to detect partial resistance to scald and barley leaf stripe. Genotypes with multiple disease resistance have been identified and made available to NARS.

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

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

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

The Program strategy for the future, and consequently, resource allocation, will be mostly based on the need to make continuous adjustments to the expected changes in NARS expectations and capabilities as well as in the interactions with other regional or international institutions. The availability of new and advanced technologies will be carefully monitored and, where appropriate, will be incorporated into our strategy. Over the long term, the Program will strive to become a center of excellence for technology generation and training in the field of improving and sustaining winter cereal production in less favorable environments. Although the WANA region will be the primary beneficiary, the technology might also be utilized in areas with similar production constraints outside the region.

As NARS increasingly become self-reliant in conducting applied research, the program will shift its activities to more upstream research with the objective of complementing NARS activities. The Program will selectively establish linkages with the appropriate advanced institutions to conduct basic/strategic research.

Acknowledgements

The Program is greatly indebted to its collaborators, colleagues at ICARDA and CIMMYT, management, and donors without whose dedicated efforts, encouragement, and generous support the progress reported here would not have been possible.

References

Byerlee, D. and Winkelmann, D.L. 1980. Accelerating wheat production in semi-arid developing regions: economic and policy issues, CIMMYT Economics Working Paper No. 2, Mexico.

Khaldi, N. 1984. Evolving food gaps in the Middle East/North Africa: Prospects and policy implications. IFPRI Research Report 47, IFPR, Washington, D.C.

Research and Production

Optimum Values of Agronomic Traits in Barley for Dry Areas

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In early breeding stages, selection is mainly based on plant characteristics, such as yield components, earliness, plant height, and disease resistance. At later stages, when yield evaluation is possible, selection is expected to be more efficient if grain yield is evaluated in association with important traits. In areas with a significant year-to-year climatic variation, such an approach is necessary (Hadjichristodoulou 1987). Long-term studies are needed for each trait in order to determine the optimum range of values which can be used in selection at a particular site and season. The present report discusses the association of grain yield with other important traits, such as earliness, plant height, and diseases, with particular reference to dry areas with mild winters.

Materials and Methods

Fifteen barley advanced yield trials (BAT) provided by ICARDA, each with 25 genotypes and a recently released improved variety, Kantara, were carried out at Athalassa using an RCB design with two replications and 5.25-m^2 plots. In addition, two barley yield trials (BYT), each with 24 varieties, were conducted, one at Athalassa and the other at Dromolaxia, in an RCB design with four replications and 2.6-m^2 plots.

Data were recorded for heading date, plant height, disease incidence, and grain yield. Statistical analyses were carried out at the Agricultural Research Institute, except for correlation coefficients of the two BYTs which were provided by ICARDA.

Results and Discussion

Barley Advanced Yield Trials (BAT)

The 15 BATs, each with 26 entries were carried out in the 1986/87 season at Athalassa, near Nicosia, where precipitation was below normal (260 mm). In each trial there were five ICARDA checks (Rihane 3, Soufara, Harmal, Arabi Abiad, and Arabi Aswad) and one Cyprus check (Kantara). In spite of the drought, yields were satisfactory. The mean yield of the six checks over the 15 trials, ranged from 2.7 t/ha to 4.4 t/ha (Table 1). The differences among variety means were significant in each of the trials (Table 2).

Table 1. Means over 15 trials for six checks in BATs.

Variety	Grain yield (kg/ha)	Heading date (starting from 1 Jan)	Plant height (cm)
Rihane-3	4007 ab	90 c	88 a
Soufara	3117 de	99 a	69 c
Harmal	3683 bc	81 e	65 cd
Arabi Aswad	2758 e	92 b	74 b
Arabi Abiad	3409 cd	92 b	63 cd
Kantara	4417 a	87 d	65 d

Means followed by a common letter are not significantly different at P = 0.05.

Table 2. Range of variety means for grain yield, heading date, and plant height in 15 barley trials (BATs).

Grain yield (t/ha)	Heading date (starting from 1 Jan)	Plant height (cm)
1.7 - 5.2	82 - 101	53 - 93
1.7 - 3.7	85 - 100	60 - 98
1.7 - 4.7	82 - 103	53 - 90
2.3 - 5.2	83 - 99	63 - 90
2.2 - 4.4	82 - 102	50 - 90
1.6 - 4.2	82 - 96	63 - 85
1.9 - 4.2	83 - 100	38 - 88
2.5 - 4.8	65 - 97	63 - 98
2.5 - 4.4	81 - 97	53 - 85
2.7 - 5.3	80 - 91	60 - 98
1.7 - 4.9	84 - 102	55 - 93
2.3 - 6.2	86 - 98	58 - 110
1.7 - 4.3	82 - 104	53 - 95
1.7 - 4.0	81 - 105	58 - 78
2.1 - 3.8	79 - 101	58 - 95

Early and tall entries tended to give higher grain yields under our experimental conditions, as shown by the correlation coefficients (Table 3).

The correlation coefficients between grain yield and heading date were negative and significant in 11 of the 15 trials; the nonsignificant correlations were also negative. The local improved check was among the earliest entries, with heading date varying with trials from 85 to 90 days from 1 January (Table 1). As pointed out in another study (Hadjichristodoulou 1987), the optimum heading date for Cyprus conditions obtained from long-term studies was 2-3 days after and 5-8 days before heading of Kantara. This is supported by the present data.

The correlation coefficient between plant height and grain yield was positive and significant in 12 out of 15 trials (Table 3). Lodging, which is frequently associated with plant height, was not a problem in any of the trials. These data suggest that under low rainfall conditions, tall varieties tend to give higher yields than short varieties. Similar findings were earlier reported by Hadjichristodoulou (1981). Kantara, the highest yielding variety, was an exception to this trend; its height was among the shortest and varied with trials from 57.5 cm to 82 cm. In a study on durum wheat grown in a dry Mediterranean climate, Nachit and Jarrah (1986) reported a positive correlation between plant height and grain yield. In contrast, Zahour (1985) in a study at Minnesota, USA, found that semi-dwarf barley genotypes obtained from special crosses did not differ significantly from their tall counterparts for dry matter or grain yield. The significance of stem reserves, as a source of assimilates for grain production, especially in stress conditions, was discussed by Scott and Dennis-Jones (1976).

Table 3. Coefficients of correlation among grain yield (GY), heading date (HD), and plant height (PH) in 15 trials (BATs).

Correlation between		
GY and HD	GY and PH	PH and HD
-0.44**	0.46**	-0.20
-0.36**	0.27**	-0.15
-0.52**	0.54**	-0.34*
-0.66**	0.49**	-0.26
-0.18	0.32*	-0.06
-0.03	-0.01	-0.12
-0.20	0.11	-0.14
-0.47**	0.44**	-0.27
-0.52**	0.41**	-0.38**
-0.23	0.71**	-0.32*
-0.64**	0.53**	-0.46**
-0.53**	0.49**	-0.40**
-0.62**	0.44**	-0.51**
-0.47**	0.12	-0.44**
-0.56**	0.62**	-0.49**

* Significant at P = 0.05; ** Significant at P = 0.01

Late genotypes tended to be shorter than early ones (Table 3). Observations from material screened in Cyprus during the last 20 years showed that genotypes 15-25 days earlier than Kantara were much shorter. It can be concluded that genotypes with heading date within the optimum range for Cyprus conditions tend to be tall, which is eventually associated with higher grain yield.

Barley Yield Trials (BYT)

Two trials, with 25 entries each, were conducted, one at Athalassa, where precipitation was 279 mm, and the other at Dromolaxia, where precipitation was 294 mm. Differences in grain yield and other traits among genotypes were significant.

The coefficients of correlation between grain yield and heading date were -0.39 and -0.59, significant at the 5% and 1% levels, respectively, but the correlation between yield and plant height was not significant. Also, coefficients of correlation between heading date and plant height were not significant. None of the correlations between grain yield and the incidence of powdery mildew, net blotch, or scald were significant at either location. These findings suggest that disease-tolerant, high-yielding varieties may be successful for commercial cultivation in dry environments.

Conclusions

Based on the data reported here and from earlier studies, it can be concluded that, within the environment of the present study, genotypes with the highest grain yield are a few days earlier than most of the BAT or BYT entries. Genotypes with long and strong stems outyield the short ones in the dry areas. Tolerance to diseases must be considered in evaluating varieties. This *information* may be useful in selecting genotypes from segregating populations or from nurseries and in future composition of trials in dry areas with mild winters.

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References

Hadjichristodoulou, A. 1981. Aspects of barley breeding for dry Mediterranean regions. Pages 383-388 *in* Proceedings of the 4th International Barley Genetics Symposium, Edinburgh, UK.

Hadjichristodoulou, A. 1987. The effects of optimum heading date and consistency of performance of barley and durum wheat in dry areas. Journal of Agricultural Science (Cambridge) 108: 599-608.

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

Scott, R.K. and Dennis-Jones, R. 1976. The physiological background of barley. Journal of the National Institute of Agricultural Botany 14: 182-187.

Zahour, A. 1985. Effect of the semi-dwarf character and yield components on yield of barley (*Hordeum vulgare*, L.). Rachis 4(1): 33-34.

Barley Breeding in Ethiopia

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Barley is the second most important food crop after teff in *Ethiopia*. Between 1982 and 1986, the average harversted area was nearly one million hectares, about 14% of the total cereal cultivated area. The crop is grown under a wide range of environmental conditions and mostly produced in marginal areas where the production of other cereals is limited. It is produced twice a year, using the rains falling between June and September (main season barley) and February and March (short season barley). The main and short seasons account for 85% and 15% of barley production, respectively. Environmental stresses such as low soil fertility, poor soil drainage, frost, drought, diseases, insect pests, weeds, and poor management practices severely limit barley yield in Ethiopia. Over 80% of barley producers use the seed of their own cultivars (landraces), which also contributes to low yields (1.2 t/ha).

In Ethiopia, about 90% of barley grain is used for human food while the rest is used for beer making and feeding animals. Barley straw is used as feed for animals and as bedding.

Grain Production

Over 75% of the barley grain produced in Ethiopia comes from small farmers. Since 1976, increasing efforts have been made to produce malting barley, particularly by using the Beka cultivar. Two other cultivars (Proctor and Holkr) are also under commercial production. But malting barley production has been restricted only to some areas of Arsi and Bale provinces.

Malting barley production in Ethiopia was enhanced by the success of the barley breeding program in identifying suitable malting varieties and by a comprehensive development program of the Chilalo Agricultural Development Unit (CADU) in the region. This program made malting barley production, using the Beka variety, feasible at the small farmer level in this region.

State farmers started producing malting barley using Beka, Proctor, and Holkr varieties with semi-mechanization in 1980. Today some 12,000 hectares are cultivated by the state farmers (personal communication: ministry of state farmers and development). Locally produced malting barley is believed to have cut the total annual imports by about 30-40% (Hailu and Fekadu 1985).

On the other hand, food barley cultivars, developed and recommended for production by the program, have not been adopted by farmers yet. This is mainly due to the lack of an efficient system of extension service and a shortage of seeds of the improved cultivars. Since 1986, however, the situation has been improving with the establishment of a research and extension liaison unit by IAR and the Ministry of Agriculture. Demonstration trials are now being conducted by this unit in some barley growing areas using promising food barley cultivars.

Barley Breeding

The major objective of the barley breeding program is to develop high-yielding, disease resistant varieties both for human consumption and malting. The following steps are taken for the development of such varieties.

Introduction of New Lines

In cooperation with international centers (such as FAO, ICARDA, and CIMMYT) and national programs in other countries, about 22,000 nursery lines have been evaluated since 1967 at Holetta, Bedi, and Mekele. They were evaluated for general adaptation, drought resistance, disease resistance, and other agronomic traits . Introduced lines are first tested in single-row plots. The most promising ones are promoted to a series of trials for yield evaluation at one location and, sometimes, those with desirable traits are used as parents in the breeding program. The lines selected after the preliminary yield trials are then used in pre-national variety trials with three replications at different locations. Again, the most promising lines from the pre-national variety trials are promoted to barley national variety trials with four replications in more locations, at least for two seasons. The varieties found to be significantly superior to both most recently released variety and local check, are recommended for release. So far, two outstanding barley varieties (composite 29 and A Hor 880/61) and three malting varieties (Beka, Kenya Research, and Proctor) have been identified from this program. Also, other promising food barley lines, identified mainly from the ICARDA international nurseries, are now included in a series of yield trials.

It is obvious that the success of a breeding program depends on the availability of genetic material. The role of international centers, such as ICARDA, in making such material available is very important for national programs. The recent classification of ICARDA's international nurseries for moderate rainfall, low-rainfall areas, etc. will be useful in evaluating them in the desired target areas.

Evaluation of Landraces

Evaluation of barley landraces by the breeding program was started in 1967, initially with the collection of landraces by local scientists, as well as those collected earlier in Ethiopia by scientists from the USA. These collections were handed over to the Plant Genetic Resources Center of Ethiopia (PGRC/E) that was established in 1976. The PGRC/E is responsible for the collection, preservation, and characterization of barley landraces. Due to the high diversity of barley in Ethiopia, collections will continue until landraces from all ecological areas are available. The wealth of such a large genetic diversity was first recognized by Vavilov (1951) and later by Harlan (1975), both describing Ethiopia as the center of the largest genetic diversity for barley. Other reports also described Ethiopian landraces as an important source for desirable traits, such as resistance to diseases and nutritional quality (Qualset 1975).

On the other hand, since 1976, little efforts have been made to utilize such a high potential reserve because the breeding program was initially designed to focus only on new accessions and local crosses as a source of breeding material. Therefore, in 1985, a population improvement project for barley landraces was proposed and will start functioning as soon as financial support is obtained.

Over the years, however, about 3300 local collections of barley have been evaluated by the breeding program for traits such as good grain setting, lodging, and disease and insect pest resistance, with the main aim of identifying cultivars suitable for direct use in production, and parents with desirable traits for use in the hybridization program. So far, two high-yielding food barley cultivars, IAR/4/485 and ARDU 12-60 B, have been identified by this program.

Hybridization and Selection

Food barley breeding. The food barley program focuses on developing high-yielding varieties for marginal areas with different stress conditions (such as low pH, low soil fertility, waterlogging, and drought) and areas with better drained soils. Hybridization for these areas is usually done at Holetta, the main station for barley research. In this program the following breeding methods are used with an emphasis on population improvement:

- a male-sterile facilitated recurrent selection: Two different composites have already been developed, one for grain yield and disease resistance, and the other for nutritional quality and grain yield. There is also a plan to develop other composites to counter such stress conditions as low pH, drought, and waterlogged environments.
- multiple crosses: F_2 progeny method is used in breeding programs for low pH (based at Bedi), drought (based at Mekele Research Center), waterlogged, and frost prone areas (based at Sheno), and for better drained soils with less stress conditions (based at Holetta).
- backcross breeding: This is an alternative method for the improvement of nutritional quality of food barley. It is also used to improve hull-less barley. The best lines from the program are also evaluated during the short rainy season.

In the food barley hybridization program about 100-120 new crosses are made each year among selected parents possessing desirable genes for important traits such as earliness, lodging resistance, high tillering capacity, large spikes, high yield, and disease resistance. The F_1 seeds are planted in a single-row plot and evaluated at Holetta. The next generation of the material is grown and evaluated in target areas for which the crosses are made. Some of the high-yielding food barley cultivars obtained from this program are shown in Table 1.

Table 1. Food barley cultivars released and recommended for cultivation in Ethiopia between 1975 and 1986 by the barley breeding program.

Cultivar	Year released	Trial yield (t/ha)[1]
IAR/4/485	1975	3.6
Composite 24	1975	4.1
A Hor 880/6/	1980	4.5
HB[2] 7[a]	1980	3.9
HB 15[a]	1980	3.7
HB 26[a]	1981	3.5
HB 42[a]	1984	4.2
ARDU 12-60 B	1986	3.9

1. Three years average data from five locations.
2. HB = Holetta Barley.
a. Identified by the hybridization and selection program.

Malting barley breeding. This program focuses on growing barley in the more favorable areas. Currently, Beka is used as a recurrent parent for the malting character and is crossed with cultivars having desirable traits such as resistance to diseases (mainly scald and leaf blotches) and lodging. Backcross and modified pedigree methods of breeding are used by the program. About 50-70 new crosses are made each year at Holetta as well as screening of the materials. Over the years, some 220 crosses were made, out of which four outstanding varieties with desirable malting quality and disease resistance have been identified (Table 2). Out of these four varieties, Holkr is now under commercial production. Other promising selections from the program are now featuring in the malting barley national variety trials program.

Table 2. Malting barley cultivars released and recommended for cultivation in Ethiopia between 1973 and 1982.

Cultivar	Year released	Trial yield (t/ha)[1]
Beka	1973	3.9
Kemya Research	1973	2.7
Proctor	1973	2.4
Holkr[a]	1979	3.1
Balkr[a]	1979	3.1
HB[2] 16[a]	1982	3.5
HB 28[a]	1982	3.3

1. Three years average data from four locations.
2. HB = Holetta Barley.
a. Identified by the hybridization and selection program.

References

Hailu, G. and Fekadu, A. 1985. Review of barley breeding in Ethiopia. Paper presented at the Workshop on Field Crops Research in Ethiopia, 25 Feb-1 March, 1985, IAR, Addis Ababa, Ethiopia.

Harlan, J.R. 1975. Our vanishing genetic resources. Science 188: 618-621.

Qualset, C.O. 1975. Sampling germplasm in a center of diversity: an example of disease resistance in Ethiopian barley. Pages 81-69 *in* Crop Genetic Resources for Today and Tomorrow. Cambridge University Press, London, U.K. 492 pp.

Vavilov, N.I. 1951. The origin, variation, immunity and breeding of cultivated plants. Chronica Botanica 13(1/6). 364 pp.

Breeding Hull-less Barley in India

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Although barley breeding and improvement work had been initiated in India as early as 1920 by state departments of agriculture and by the Indian Council of Agricultural Research, systematic work began only in 1966, with the formulation of the All India Coordinated Barley Improvement Project. The objectives of the project were to develop:

- Varieties resistant to diseases and pests and suited to conditions of limited or no irrigation and late planting which are common in barley-growing areas of India, where 75% of barley is consumed by humans, 15% by animals, and the remainder by industry.
- Agronomic and plant-protection practices to realize yield potential; and limited basic research to support the project in efforts to remove the deficiencies of the technology.

About a dozen hulled varieties of barley had been identified by 1975/76. Of these, Ratna (Delhi), Jyoti (Kanpur), and RS6 (Durgapura) were released by the Central Variety Release Committee. Some other varieties were released by the state committees in Uttar Pradesh (Azad, Amber, and Vijaya), Rajasthan (RDB 1, RD31, RD118, RD57, and Rajkiran), Haryana (BG25 and BG108), Punjab (Ranjit), and Himachal Pradesh (Himani, Kailash, and Sonu) for commercial cultivation. Clipper, a two-rowed malting barley, was released for Delhi areas to meet industrial requirements.

The impact of the releases was negligible: in fact, production and area declined from 2.3 million tonnes on 2.8 million hectares in 1966/67 to 1.5 million tonnes on 1.2 million hectares in 1984/85 despite a 50% per-hectare increase from 831 kg to 1232 kg. The reasons behind this decline were that:

- Improved varieties did not compare with dwarf Mexican wheat: available hulled varieties were tall, low-yielding, and susceptible to lodging.
- Husks made up 10 to 15% of the grain, causing indigestion and additional costs and labor in processing.
- Farmers received no incentive to grow hulled barley: no subsidy nor guaranteed market (the support price of hulled barley was Rs 0.67/kg till 1980/81 compared with prices 2-4 times that amount for competing crops like wheat, pulses, and oilseeds).
- No network existed for the distribution and extension of barley.

The result was that people changed their dietary habits with increased income and increased production of wheat and rice and 50% of the irrigated land cropped with barley in the 1960s started to be planted with wheat mainly, and some of it with pulses and oilseeds. Better incentives are given by the government for growing these crops. Barley is now cultivated on marginal lands only.

However, the outlook for barley is changing. About a dozen dwarf huskless varieties have a yield potential of 5.0-5.5 t/ha, produce grain with the color and texture of amber wheat, exhibit flour recovery of 98-100%, and are comparable to wheat in chapati making, but contain more protein (14-16%) and lysine (4-5%). These varieties are ready for commercial cultivation but have not yet been released by the Central Variety Release Committee. If these varieties were released and incentives similar to those for wheat, pulses, and oil-seeds were provided, production of barley would increase considerably in the next 5 years, and could be extended to about 10 million hectares by the end of the century. Barley could become a major crop on dryland, saline and alkaline soils, diara-lands (wet riverbeds), and limited irrigated areas on the Indo-Gangetic plain and in central India. It could add 30 million tonnes of foodgrains to the national pool.

Turning Point

During the last 10 years, two breakthroughs were made in genetic advancement: the discovery of the dwarfing gene and the breeding of high-yielding, hull-less barley.

In 1975, I identified two natural dwarf mutants, Azam (d1) and Azam (d13), from Azamgarh district and foresaw their possible potential to be similar to DGWG in rice and NORIN 10 and NORIN 20 in wheat.

In the past, efforts had been made to breed dwarf barley varieties responsive to nitrogen application, but little success had been achieved. RDB1, a dwarf mutant, had been induced in RS17 at Durgapura (Rajasthan) by irradiation but did not give higher grain yields than its parents or other traditional varieties. Its stature had been highly linked to short ear head and small numbers of grains, perhaps because of a pleiotropic effect.

The development of hull-less varieties considerably improved flour recovery, which previously had been about 80-85%, and brought its color, taste, and suitability for use in Chapati much more in line with consumer preferences. Agronomically, barley has advantages over wheat in early maturity and in its tolerance to drought, salinity-alkalinity, and wet riverbeds.

These developments were the culmination of work that began in 1976/77. During the crop season that first year, crosses were made to transfer the dwarfing gene to the genetic background of hull-less germplasm. Azam (d1) and RDB1 were crossed with EB7576, EB7725, EB7742, IB65, and Puskin, resulting in tremendous genetic variability.

Two crops of the segregating materials were raised each year in summer at Wellington and in *rabi* at Karnal. From these crosses and a subsequent hybridization program, a large number of hull-less lines evolved and proved suitable for the five environments in which barley is cultivated in India: limited irrigation, rainfed, late-sown, saline-alkaline soils, and diaralands.

Limited Irrigation

In the Indo-Gangetic plain and central India, irrigation water is not sufficient to support cultivation of high-yielding varieties of wheat but is suitable for barley.

The dwarf hull-less varieties developed by AICBIP were tested under limited irrigation in normal seasons and three irrigations in drought years. Seven were identified for release by the annual barley workshop (Table 1).

Two of the hull-less varieties, Karan-18 and Karan-19, were identified in 1981. The former is a dwarf, the latter a semi-dwarf, and both mature in 115-120 days, with a yield potential of about 5 t/ha under limited irrigation or on the diaralands and northeast and northwest plains. In 1982, two more dwarf varieties were identified: Karan-3 and Karan-16, with a yield potential of about 5-5.5 t/ha, the

Table 1. Average yields (kg/ha) of five hull-less varieties and one hulled variety of barley, and one high-yielding wheat under limited irrigation in India, 1980/82.

Variety	1980/81	1981/82
Karan-3	3428	3227
Karan-4	3460	3180
Karan-16	3487	3254
Karan-18	3608	na
Karan-19	3674	na
Jyoti (hulled, tall)	3201	3452
HD-2009 (wheat)	3226	2837

na = not available.

latter maturing a little earlier (110-115 days). Each of the next 3 years saw the identification of one variety for release: Karan-231 (110-115 days), Karan-163 (115-120 days), and Karan-351 (110-115 days). The first proved suitable for central as well as northwest and northeast plains and the last had an increased yield potential of 5.5-6 t/ha. Three more varieties -- Karan-741, Karan-750, and Karan-753 -- are under consideration for release.

Rainfed Barley

Rainfed farming is still the rule in the country, and much of the effort in varietal improvement is to develop barley varieties superior to C306, the best wheat variety available for rainfed conditions. F_2 and later generations from a large number of lines are being raised under rainfed conditions and, to date, three hull-less varieties have been identified for release by the annual workshop. Compared with Jyoti, these semi-dwarf varieties have performed well on the Indo-Gangetic plain and in central India, yielding between 1716 kg/ha and 2310 kg/ha on average in 1981-83. Jyoti -- before being dehulled -- averaged 2362 kg/ha. With yield potential of 2.5-3 t/ha, all three varieties are suitable for the central, northwest, and northeast plain. Karan-4 and Karan-201 mature in 110-115 days, whereas Karan-19 may take up to 120 days to mature. In 1985, Karan-521, also a semi-dwarf variety that matures in 110-115 days, was identified for release in the northeast plains.

Late Planting

In upland and midland areas, double cropping (paddy followed by wheat) is becoming popular but is not profitable if the wheat is sown after 20 December. As a result, 5-10% of the area remains unsown and could be planted with improved barley.

In fact, late-planting trials, conducted under AICBIP, indicated that a new variety (Karan-265) can be planted as late as mid-January without reduced yields, and Karan-19 as late as the first week of January.

Karan-265 is semi-dwarf and early maturing (110 days). It produces a huskless amber grain and possesses high tillering ability. Resistant to lodging, it is also tolerant to yellow rust, smut, and *Helminthosporium* leaf spot. It has been recommended for the entire Indo-Gangetic plain and central India.

Saline-Alkaline Soils

There are about 7 million hectares where the soil is saline or alkaline. Most of the land lies in the Indo-Gangetic plain and central India. In trials conducted in 1981 at Chandeshwar (Azamgarh) on alkaline soils, several varieties performed well (Table 2) and, at Canningtown (West Bengal), on coastal saline soils, Karan-18 yielded 1843 kg/ha in 1982 (Table 2).

Table 2. Yields (kg/ha) of five hull-less varieties and one hulled variety of barley on saline and alkaline soils in India, 1981 and 1982.

Variety	Alkaline soil, Chandeshwar, Azamgarh, 1981	Saline soil, Canningtown, West Bengal, 1982
Karan-3	3542	1450
Karan-4	1872	1558
Karan-16	3454	1433
Karan-18	3414	1843
Karan-19	3623	1525
Jyoti (hulled)	2633	1517

Diaralands

In eastern Uttar Pradesh and northern Bihar, about 5 million hectares are regularly flooded by the Ganga-Gandak and Ghagra. On this vast land, nothing grows during the monsoon season, so the crop during *rabi* must supply grain and fodder for the entire year. As the soil remains wet until mid-December, wheat, pulses, and oilseeds do not grow well. Barley, however, grows on the wet lands even when broadcasted.

For instance, in trials conducted on diaralands at Deoria and Varanasi in eastern Uttar Pradesh and Muzaffarpur in Bihar, Karan-3, Karan-16, and Karan-19 outyielded wheat, the difference being particularly marked when the crops were planted late (Table 3).

The work to improve varieties for different soil conditions in the country has been complemented by efforts to breed varieties resistant to the major diseases and pests -- yellow rust, smut, *Helminthosporium* leaf spot, and aphids. The result has been satisfying as many of the new hull-less varieties have shown resistance (Table 4), and all varieties under consideration for release possess a high degree of resistance.

Improved Barley for Food

All the efforts, however, would be for nought if consumers were not satisfied with the quality of food prepared from the grain. In fact, the difficulties and losses during processing, as well as the taste and color of final products, have probably been the key causes of reduced production of new hulled varieties. The varieties have amber, hard grains that give 98-100% flour recovery and can be used to make tasty, cream-colored chapati.

Since the physical appearance of the grain determines its market value, the new varieties secure 10-20% higher price than hulled barley; they are almost indistinguishable from wheat and are purchased to be used alone or with wheat.

The Pelshenke value is a measure of the chapati-making properties of a flour. For wheat, the ideal value is 120-150, and most of the hull-less varieties are within this range, whereas hulled varieties are much lower: the value for Karan-15, for example, was 36 in trials by AICBIP.

Similarly, remarkable progress has been made in improving the protein and lysine content of hull-less barley by genetic manipulation. With Riso Mutant 1508 as a donor parent, protein and lysine have been increased to as much as 16.62% and 0.56%, respectively, of total composition (Table 5). In addition, another 13 hull-less varieties contain 15-16.6% protein, and 39 lines contain 13-14%. As the values are higher than those for wheat, the government could encourage people to mix barley and wheat flour to raise the total nutritive value.

Given all the improvements of the grain and yield of barley, it is not surprising that demand is growing for short-duration dwarf varieties for intercropping in sugarcane and potato belts. Similarly, varieties that can be intercropped with pulses and oilseeds are needed to evade complete losses of the crop during epiphytotics or infestations. To date, Karan-163, Karan-947, Karan-948, and Karan-949, with early maturity (100-110 days) and triple dwarf stature, are the best for use as intercrops. The future for hull-less as well as hulled barley is, therefore, bright.

Table 3. Yields (kg/ha) of five hull-less barley varieties compared with those of high-yielding wheat sown on 20 December 1980 and 25 December 1981 on diaraland.

Variety	Sowing, 20 December 1980	Sowing, 25 December 1981
Karan-3	2482	2826
Karan-4	2536	2814
Karan-16	2674	2923
Karan-18	2772	2995
Karan-19	3080	3140
HD-2009 (wheat)	2319	1932

Table 4. Reaction of new hull-less barley varieties to three major diseases and to aphids.

Variety	Yellow rust	Smut	*Helminthosporium*	Aphids
Karan-3	MR	R	R	MR
Karan-4	R	R	R	R
Karan-16	MR	MR	R	MR
Karan-18	MR	S	R	S
Karan-19	R	R	R	R
Karan-163	R	R	R	R
Karan-201	R	MR	R	R
Karan-231	R	R	R	R
Karan-265	MR	R	R	MR
Karan-351	R	R	R	R
Karan-521	R	R	R	R

R = resistant; MR = moderately resistant; S = susceptible

Table 5. Protein and lysine content (%) of nine hull-less barley varieties compared with those of wheat.

Variety	Protein (%)	Lysine (% in flour)
Karan-16	12.58	0.433
Karan-163	14.87	0.470
Karan-231	14.00	0.486
Karan-265	16.31	0.566
Karan-3	14.00	0.462
Karan-18	14.87	0.560
Karan-4	16.62	0.556
Karan-19	14.00	0.512
Karan-201	16.13	0.455
HD-2329 (wheat)	12.12	0.348

Hulled Varieties

Hulled barley has lost its importance as a foodgrain but still has a lot of scope in India as animal feed and industrial raw material. Commendable progress has been made in developing high-yielding hulled varieties suited to limited-irrigation drylands, saline-alkaline soils, and diaraland. About two dozen hulled varieties have been identified for release. Of these, Karan-15 and Karan-92 are dwarf, Karan-280, DL-348, and DL-356 are semi-dwarf, and the remainder are tall. The dwarf and semi-dwarf varieties' potential grain yields are of 5-5.5 t/ha under good management, and the tall varieties have performed well under rainfed and late-sown conditions. Karan-15 and karan-92 are multipurpose varieties and can be grown wherever barley is cultivated.

Karan-280 is suitable for malting and brewing purposes, with a weight of 60-65 g/1000 grain and low content of nitrogen.

Similarly, Ratna, Jyoti, BG25, K125, and Karan-280 can be grown for fodder-cum-feedgrain purposes as they regenerate quickly.

Management practices for both hull-less and hulled varieties have been worked out. For hull-less varieties, planting at a rate of 70-75 kg seed/ha, fertilizing with 80-100 kg N/ha and 30 kg P/ha, and irrigating lightly two or three times during the season proved to be adequate. Under late-sown and rainfed conditions, 80-85 kg of seed should be sown per hectare with fertilizers being applied at the rate of 50 kg N/ha and 20 kg P/ha. Trials conducted at Durgapura (Rajasthan) have shown good response to potash at 30 kg/ha when irrigated and 20 kg/ha under rainfed conditions.

For hulled varieties 100 kg seed/ha, 60-80 kg N/ha, and 30 kg P/ha have proved suitable for crops that are irrigated two or three times a season. Under rainfed and late-sown conditions, seeds should be sown at 110-120 kg/ha, depending upon size, and fertilizers should be applied at 40 kg N/ha and 16 kg P/ha.

Depth of sowing for dwarf and tall varieties is 5-6 and 7-8 cm, respectively. Planting should be done in rows spaced 20-23 cm apart.

How to Increase Production

Now that high-yielding varieties and the related production technology are available, the following is needed:

a) New varieties and the packages of practices should be passed to farmers.
b) An organized seed production should be taken up by state and national seed corporations and seeds should be distributed to the growers.
c) High-yielding barley should be included in the "high-yields program" of the Union Ministry of Agriculture.
d) A support price should be offered and the produce should be procured along with wheat.
e) Hull-less barley should be distributed through fair-price shops in areas where barley is consumed as a staple foodgrain.
f) Blending of barley flour with wheat flour (75:25) should be recommended to consumers.
g) Extension agencies should be directed to popularize the new varieties in areas for which they are well adapted.

Evaluation of Barley for Fodder Potential in India

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Barley is primarily grown as a grain crop in India and other parts of the world. The major portion of the produce is utilized for human consumption and as animal feed. In some parts of West Asia and North Africa, the crop is used as temporary pastures for grazing and then left to produce grain. Undoubtedly, barley possesses an inherent advantage of producing profuse early vegetative growth even under limited inputs and moderate growing conditions. The yield and nutritive value of barley forage is higher than that of other small-grain crops, such as oats, wheat, and triticale (Khalta and Katoch 1981; Cherney and Marten 1982; Amara *et al.* 1985). With the expansion taking place in the dairy industry in India, the demand for green fodder has been increasing. Therefore, these studies were undertaken to evaluate some elite barley material for their fodder potential.

Materials and Methods

Thirty-six barley entries of genetically diverse pedigrees, including 6-row hulled and hull-less types, were grown in a randomized block design with three replications at the experimental farm of IARI, New Delhi. The plot size consisted of three 5-m rows spaced 23 cm apart. Seed rate was 100 kg/ha and the crop was sown under moderate fertility and irrigated conditions. NPK was applied at a rate of 40, 20, and 20 kg/ha, respectively. Nitrogen was split into two doses, the first applied at sowing and the second at first irrigation, 35 days after sowing. The green fodder was cut at flowering in each plot, 3 inches above ground level. The fodder was weighed immediately after cutting on an individual plot basis.

For dry-matter estimation, 500-g samples of fresh fodder were collected from each plot and oven-dried at 50-60°C for five days. Dried samples were weighed and total dry matter per plot was calculated on the basis of green fodder yield and percentage of dry matter. Nitrogen content of each plot sample was determined by Kjeldahl method. The digestibility of dry matter was estimated *in vitro* (Sleper *et al.* 1973).

Results and Discussion

Results of green-fodder yield (GFY), dry matter yield (DMY), acid pepsin dry-matter disappearance (APDMD), protein content (PC) and protein yield (PY), and digestible dry-matter yield (DDM) for the 36 genotypes are shown in Tables 1 and 2.

Green Fodder Yield

Significant differences were found for green-fodder yield, indicating a wide variation among the genotypes (21.1 t/ha for DL459 to 52.6 t/ha for DL454). While green-fodder yield did not show a relation to maturity (flowering time), genotypes with higher GFY were generally taller as reported by Baniwal *et al.* (1983). Therefore, selection of taller varieties of barley may be desirable for higher fodder potential. Even if fodder and grain are both desired, taller genotypes may be more profitable because of their faster early growth for green fodder and their ability to withstand lodging following regrowth (Amara *et al.* 1985).

Dry Matter Yield

Highly significant differences were observed for dry-matter yield which ranged from 3.7 to 8.6 t/ha with varieties DL468, DL454, and DL452 as the higher yielding genotypes. Varieties with high GFY invariably produced higher DMY which is in conformity with reports of Baniwal *et al.* (1983).

Acid Pepsin Dry Matter Disappearance

Significant differences among genotypes were observed for percent APDMD. Most of the varieties with high values of APDMD showed either low or moderate values for GFY and DMY (Table 2).

Table 1. Analysis of variance for green-fodder yield (GFY), dry-matter yield (DMY), acid pepsin dry-matter disappearance (APDMD), and protein content (PC).

Source	D.F.	GFY (kg/ha)	DMY (kg/ha)	APDMD (%)	PC (%)
Replications	2	212**	44**	54.19*	58.12**
Varieties	35	745**	24**	37.29**	13.06**
Error	70	329	9	21.55	4.75

*, ** Significant at the 5% and 1% levels, respectively.

Table 2. Performance of 36 barley entries for fodder yield and quality.

Entry	Plant height (cm)	GFY (t/ha)	DMY (t/ha)	APDMD (%)	PC (%)	DDM (t/ha)	PY (t/ha)
DL353	66	28.6	4.9	40.3	16.41	0.67	2.0
DL413	90	35.5	5.4	39.7	15.03	0.80	2.1
DL417	90	32.9	5.3	38.7	16.10	0.85	2.0
DL425	104	30.6	5.5	37.3	13.66	0.75	2.1
DL426	96	32.5	5.4	40.0	15.10	0.82	2.2
DL427	98	38.7	5.7	38.0	15.39	0.87	2.2
DL428	92	32.8	4.6	44.0	17.99	0.82	2.0
DL430	86	37.8	6.7	40.7	17.07	1.14	2.7
DL435	100	37.4	5.0	47.0	18.90	0.95	2.4
DL436	99	41.5	5.9	40.3	15.69	0.93	2.4
DL437	81	28.8	3.8	40.3	19.39	0.74	1.5
DL440*	84	30.5	5.8	34.7	14.08	0.81	2.0
DL443*	70	26.7	4.5	42.0	16.03	0.72	1.9
DL445*	82	24.2	3.8	45.0	18.76	0.72	1.7
DL446	88	31.2	4.7	46.0	20.33	0.95	2.2
DL447	85	33.8	5.9	43.0	17.62	1.05	2.5
DL448	80	41.5	5.5	43.0	18.82	1.04	2.4
DL449	80	35.1	5.3	47.8	17.76	0.95	2.6
DL451	105	38.0	6.4	34.7	15.19	0.97	2.2
DL452	104	47.5	8.1	37.0	14.76	1.19	3.0
DL453	98	43.2	6.8	37.7	14.93	1.02	2.6
DL454	106	52.6	8.2	37.0	13.98	1.15	3.0
DL455	98	35.2	6.3	37.0	15.22	0.95	2.3
DL456	92	36.2	7.0	36.7	15.31	1.07	2.6
DL457	81	27.0	5.0	41.7	16.13	0.87	2.1
DL459*	98	21.1	3.7	39.7	16.32	0.61	1.5
DL460*	93	34.3	6.4	37.3	12.46	0.80	2.4
DL461*	91	30.4	4.8	35.3	15.39	0.73	1.7
DL462*	86	36.8	6.6	40.3	15.50	1.02	2.7
DL463*	84	26.3	4.6	38.0	15.57	0.71	1.7
DL464*	75	29.6	5.2	42.0	14.41	0.75	2.2
DL465*	97	37.2	6.2	39.0	13.45	0.83	2.4
DL467*	89	28.1	5.0	34.7	12.91	0.64	1.7
DL468*	103	48.0	8.6	36.3	11.26	0.97	3.1
DL36 (check)	97	42.4	6.5	43.0	17.27	1.13	2.8
DL85 (check)	85	40.1	6.0	41.0	19.35	1.16	2.5
LSD (5%)		4.2	0.7	7.43	3.49	-	-
C.V.(%)		22.7	26.3	11.6	13.7	-	-

* Hull-less variety.

Protein Content

Significant variation was recorded for protein content which ranged from 11.3 to 20.3%. High association was observed between APDMD and protein content. In general, varieties with high GFY and DMY (e.g. DL452 and DL454) showed low values for APDMD and protein content. Genotypes with high APDMD and protein content revealed low GFY and DMY with few exceptions. When protein yield (PY) and digestible dry-matter yield (DDM) were computed on a per hectare basis, the cultivars DL452, DL454, and DL36 showed high values for both traits (Table 2). The low protein content and APDMD of DL452 and DL454 were compensated by higher GFY and DMY contributing ultimately to their higher PY and DDM on per hectare basis. It may be desirable to have barley varieties with high DDM and PY for their suitability as fodder types.

This preliminary study revealed that barley does show promise as a forage crop in India. Studies are also being made to evaluate the selected set of genotypes under different environments for fodder as well as fodder and grain yield potential.

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References

Amara, H., Ketata, H. and Zouaghi M. 1985. Use of barley (*Hordeum vulgare* L.) for forage and grain in Tunisia. Rachis 4(2): 28-33.

Baniwal, C.R., Karwasra, R.R., Solanki, K.R. and Jatasra, D.S. 1983. Correlation and path coefficient analysis for forage attributes in barley under spaced and drill sowing conditions. Forage Research 9(1): 21-24.

Cherney, J.H. and Marten, G.C. 1982. Small grain crop forage potential: I. Biological and chemical determinants of quality and yield. Crop Science 22: 227-231.

Khalta, V. and Katoch, B.S. 1981. Nutrient components of some forages available in sub-mountain region of Himachal Pradesh. Forage Research 7(2): 149-154.

Sleper, D.A., Drolsom, P.N. and Jorgenson, N.A. 1973. Breeding for improved dry matter digestibility in smooth bromegrass. Crop Science 13: 556-559.

Growth Periods, Harvest Index, and Grain Yield Relationships in Barley

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Plant breeders and physiologists have suggested that it should be possible to maximize yield of grain crops by identifying an optimum duration for vegetative and grain-filling periods and by increasing harvest index. Aksel and Johnson (1961) reported that long sowing-to-heading periods were associated with high yields in barley. Bingham (1969) indicated that grain yield was dependent on sink size, which is largely determined during the vegetative period, and on photosynthetic capacity during the grain-filling period. On the other hand, Nass and Reiser (1975) and Metzger *et al.* (1984) reported that the length of the grain-filling period was not an important factor in determining yield in wheat and barley, respectively. Rasmusson *et al.* (1979) obtained high heritability estimates for the duration of the vegetative period and comparatively low estimates for grain-filling period.

Several investigators have indicated that increases in yield of cereal crops are mainly due to increases in harvest index and, to a lesser degree, to increases in biological yield. Comparing old varieties with new ones, they found a constant increase in harvest index (Fischer and Kertesz 1976; Kertesz 1984). Strong relationship between harvest index and yield was observed in barley by Singh and Stoskopf (1971) and Donald and Hamblin (1976), implying the significance of increase in harvest index in producing high-yielding cultivars. This study was conducted to analyze the effects of growth period, harvest index, and biomass on grain yield of barley.

Materials and Methods

An extensive search for barley lines adapted to the semi-arid climate of the western region of Saudi Arabia was initiated in 1981 in Hada El Sham Experimental Station, Faculty of Meteorology, Environment, and Arid Land Agriculture, King Abdulaziz University. This search included more than 2,000 barley lines collected from different parts of the world. Of these, 28 cultivars were subjected to a more complete evaluation. They were grown in a randomized complete block with three replications in Hada El Sham in 1983. Each entry consisted of three 5-m long rows spaced 50 cm apart. About 20 g of seeds were sown per row on 15 Nov 1983. Superphosphate was applied with the seeds at sowing at the rate of 18 kg/ha. Urea (46%) was added three times during the growth period at a rate of 130 kg/ha. Conventional agricultural practices were applied in the field. Data were recorded on a plot basis for the following characters:

Vegetative period: The number of days from germination to flowering. Anthesis was scored when 50% of the culms were fully headed (spikes fully exerted).

Days to maturity: The number of days from germination to physiological maturity. Maturity date was scored when 50% of the peduncles were ripe and showed complete loss of green color.

Grain-filling period: Days to maturity minus vegetative period for a given plot.

Grain-filling index: Days to grain filling divided by days to maturity.

Plant height: The average height of plants in a plot.

Grain yield: Grain yield harvested from each plot. Yield was collected about one week after physiological maturity and grains were dried to uniform moisture content before weighing.

Total biomass (total dry weight): Whole plants were cut at soil level and dried in the oven. The dry weight was expressed as the weight in t/ha.

Harvest index: Total grain yield divided by the total biomass.

Statistical parameters including mean, range, and coefficient of variability were calculated for each trait. Heritability estimates were computed in the broad sense using the components of variance method.

Phenotypic correlations were calculated for all studied traits. Computations took place at the computer center of King Abdulaziz University using the SAS (Statistical Analysis System).

Results and Discussion

The performance of the 28 barley cultivars grown in western Saudi Arabia in a semi-arid climate is presented in Table 1. The cultivars took an average of 120 days to reach maturity, 73 days (about 60% of their life cycle) for vegetative growth, and 47 days (about 40% of their life cycle) for grain filling. The range in maturity among all cultivars was 33 days, while the range in vegetative period was 54 days and in grain-filling period, 36 days. The total variability for days to maturity was less than that for grain-filling periods.

The difference in grain-filling period among cultivars was largely due to the difference in vegetative period rather than the difference in days to maturity. This was suggested by the magnitude of variability and the correlation value (Table 2). The grain-filling period was highly correlated with the vegetative period ($r = -0.62$) but it was not correlated with days to maturity ($r = 0.09$). Similar results were obtained by Metzger *et al.* (1984) who reported that maturity periods of long and short grain-filling period lines were almost equal and the predominant variation between them was in vegetative period rather than in days to maturity.

Days to maturity was positively correlated with days in vegetative period indicating that late-maturing lines tended to have a long vegetative period. Grain-filling index was negatively correlated with vegetative period but not correlated with days to maturity.

Table 1. Means, ranges, coefficients of variabitlity (CV), and heritability values (h^2) for eight characters measured on 28 cultivars of barley.

Character	Mean	Range	CV	Heritability (h^2)
Vegetative period	73.0 days	33 - 87**	7.6	0.74
Grain-filling period	46.8 days	32 - 68**	12.7	0.63
Grain-filling index	0.387	0.28 - 0.52**	10.0	0.65
Days to maturity	119.9 days	99 - 132**	4.5	0.58
Height	68.1 cm	40 - 92**	14.7	0.36
Total biomass	6.17 t/ha	1.27 - 8.89**	17.1	0.42
Harvest index	26.6%	12.5 - 42.4**	30.7	0.53
Grain yield	4.63 t/ha	2.87 - 5.88**	34.4	0.46

** Difference among cultivars significant at the 1% level.

Table 2. Correlation coefficient between eight characters measured in 28 cultivars of barley.

	Grain-filling period	Grain-filling index	Days to maturity	Height	Total biomass	Harvest index	Grain yield
Vegetative period	-0.621**	-0.871**	0.701**	-0.417*	0.044	-0.370*	-0.293
Grain-filling period		0.879**	0.124	0.103	-0.245	0.092	-0.039
Grain-filling index			-0.302	0.253	-0.185	0.206	0.078
Days to maturity				-0.435**	-0.166	-0.389*	-0.409*
Height					0.548**	0.299	0.484**
Total biomass						0.020	0.478**
Harvest index							0.856**

*, ** Significant at the 5% and 1% level, respectively.

The correlation between grain yield and the two growth periods are shown in Table 2. There was a negative correlation between yield and vegetative period but this did not reach the level of significance. The correlation between yield and grain-filling period was extremely low and insignificant. The results of the regression analysis also revealed that growth period had no significant contribution to yield (Table 3). Similar results were obtained by Metzger *et al.* (1984) who reported no significant association between yield and grain-filling period.

Strong correlation was found between grain yield and plant height. Plant height was also correlated with days to anthesis, days to maturity, and total biomass.

Characters varied with respect to heritability estimates (Table 1) which were highest for vegetative period (0.74) and lowest for plant height (0.36). Heritability values were intermediate for grain-filling period (0.63) and grain-filling index (0.65). These data suggest that vegetative and grain-filling periods could be modified by selection. Rasmusson *et al.* (1979) indicated that selection for grain filling would have been effective only when replicated plots were used.

Table 3. Regression analysis (Max r^2) of grain yield on seven characters measured in 28 cultivars of barley.

	Variable added	Total % reduction in residual	Variance explained by adding the variable (%)
X_1	Harvest index	73.324	73.324
X_2	Total biomass	94.618	21.404
X_3	Grain-filling index	94.704	0.076
X_4	Plant height	94.724	0.020
X_5	Days to maturity	94.791	0.067
X_6	Grain-filling period	94.904	0.113
X_7	Days to heading	94.906	0.002

Partial b values in final equation:

$- 0.229 + 5.56{*}X_1 + 267{**}X_2 - 2.07{*}X_3 - 0.003X_4 + 0.25X_5 + 0.033X_6 + 0.016X_7$

(*,** significant at 5% and 1% level, respectively).

Harvest index (HI) varied markedly among the 28 cultivars. The mean value was 26.6% with a range of 18.7 to 42.4%. The average was less than that reported by many investigators (Singh and Staskopf 1971; Riggs *et al.* 1981). Strong correlation (r = 0.86) was found between yield and harvest index. This strong association is confirmed by the regression analysis (Table 3). A moderate heritability estimate (h^2 = 0.56) accompanied with a high estimate of coefficient of variability was obtained for HI. This finding indicates that genetic advance in harvest index could be achieved through selection. Harvest index can be considered as a promising yield selection criterion because of the high CV value, acceptable heritability value, and positive correlation with yield.

Total biomass ranged from 1.27 to 8.89 t/ha with an average of 6.17 t/ha. A significant relationship was found between biomass and yield (Table 2). Total biomass accounted for 21.1% of the total variability in yield and showed a moderate heritability.

References

Aksel, R. and Johnson L.P.V. 1961. Genetic studies on sowing-to-heading periods in barley and their relation to yield and yield components. Canadian Journal of Genetics and Cytology 3: 242-259.

Bingham, J. 1969. The physiological determinants of grain yield in cereals. Agricultural Progress 44: 30-42.

Donald, C.M. and Hamblin J. 1976. The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Advances in Agronomy 28:361-405.

Fischer, R.A. and Kertesz, Z. 1976. Harvest index in spaced populations and grain weight in microplots as indicators of yielding ability in spring wheat. Crop Science 16: 55-59.

Kertesz, Z. 1984. Improvement of harvest index. Pages 93-104 *in* Proceedings of the Tenth Congress of the EUCARPIA, 19-24 June, 1983, Wageningen, the Netherlands. Pudoc, Wageningen. ISBN 90-220-0856-8.

Metzger, D.Z., Czaplewski, S.J. and Rasmusson, D.C. 1984. Grain-filling duration and yield in spring barley. Crop Science 24: 1101-1105.

Nass, H.G. and Reiser, B. 1975. Grain-filling period and grain yield relationships in spring wheat. Canadian Journal of Plant Science 55: 673-678.

Rasmusson, D.C., McLean, I. and Tew, T.L. 1979. Vegetative and grain-filling periods of growth in barley. Crop Science 19: 5-9.

Riggs, T.J., Hanson, P.R., Starts, N.D., Miles, D.M., Morgan, C.L. and Ford, M.A. 1981. Comparison of spring barley varieties grown in England and Wales between 1880 and 1980. Journal of Agricultural Science (Cambridge) 97: 599-610.

Singh, I.O. and Stoskopf, N.C. 1971. Harvest index in cereals. Agronomy Journal 63: 224-226.

Wheat and Barley Diseases in Tunisia*

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In Tunisia, wheat and barley are the major cereal crops grown under rainfed conditions. Depending on the rainfall, the area planted annually ranges from 1.2 to 1.5 million hectares of which about 50% is located in the north where the rainfall is relatively high, ranging from 350 mm to above 1000 mm annually. In this region, 55% of the cereal hectareage is planted to durum wheat, while bread wheat and barley occupy 19% and 26%, respectively. In general, about 60% of the durum wheat is grown in the north along with 72% of the bread wheat and 31% of the barley, while the central (150-350 mm annual rain) and southern zones (less than 150 mm rainfall) together account for 40%, 28%, and 69% of the total durum wheat, bread wheat, and barley areas, respectively. The overall production ranges from 1.2 to over 2.0 million tonnes annually depending on the amount and distribution of the annual rain. About 60-70% of cereals, essentially wheat, are produced in the northern zone.

Wheat and barley in Tunisia are liable to the attack of various diseases and pests that reduce yield considerably. The severity of these diseases and the losses in yields vary from one year to another depending mainly on the prevailing climatic conditions. A septoria leaf blotch epidemic in 1972 caused 50% yield loss on wheat (Mc Cuistion 1972), and a similar loss on barley yield was caused by net blotch in 1985 (Harrabi, unpublished). In 1977, the bread wheat variety Soltane had been heavily infected with stripe rust which caused a dramatic yield reduction (of around 80%) and was therefore withdrawn from production by Tunisian authorities (H. Ketata, personal communication). Various authors reported on the disease distribution and/or incidence in Tunisia but these were based mainly on country reports or observations in certain areas and/or years but not on systematic surveys conducted across the country (Prescott and Saari 1976; Saari *et al.* 1979; Kamel 1981).

Methods

The survey was conducted in March and April 1987 to coincide with full plant development and covered the major wheat and barley growing areas; the southern part of the country where cereals are grown only to a limited extent was also included to complete the survey. Disease and pest diagnosis was based on visual symptoms and confirmed when required in the laboratory using standard isolation techniques on samples collected in the field. In this report disease incidence is measured by the number of fields infected expressed as a percentage of the total number of fields assessed. The severity of infection was also estimated when scored higher than trace.

Results

One or more diseases were identified from about 46% of wheat and 80% of barley fields assessed.

Wheat

A total of 168 wheat fields were inspected and the following diseases were identified and ranked according to their incidence in a descending order: flag smut, septoria

* This work was carried out within the framework of the Tunisia/ICARDA Collaborative Projects on Cereals and Food Legumes Improvement.

leaf blotch, leaf rust, root rot, powdery mildew, bacterial leaf blight, loose smut, and tan spot or yellow leaf spot (Table 1). Flag smut was found mainly in the governorates of central and southern Tunisia. In the north it was detected only in few fields in Jendouba, Kef, and Siliana. The overall incidence of this disease on wheat was around 16% (Fig. 1). It was detected in 14% of the inspected bread wheat fields and 17% of the durum wheat fields. In general, only a few diseased plants were found except in a small number of fields in Kairouan and Kasserine governorates where the infection percentage reached 20 and 40, respectively. On the other hand, septoria leaf blotch incited by *Septoria tritici* was detected on 32% of the bread wheat fields. All infected fields were in the north where rainfall and temperature are conducive to the development and spread of the disease. The severity of infection ranged from traces to 80% leaf coverage, with the higher scores being recorded only in bread wheat fields. This shows that the bread wheat varieties grown in Tunisia are more susceptible to this disease than the adopted durum wheat varieties and/or the virulences to durum wheat were not present in the disease inoculum.

Leaf rust was detected on both durum and bread wheat varieties but the severity of infection did not go beyond traces. Infected fields were mainly in the northern governorates. Root rot was identified in the semiarid areas of the center and the south while bacterial leaf blight caused by *Pseudomonas syringae* was isolated from Ariana and Beja in the north. Tan spot or yellow leaf spot incited by *Pyrenophora tritici-repentis* was detected only once at Jendouba.

Barley

A total of 122 barley fields were inspected. Net blotch

Table 1. Wheat diseases in different governorates of Tunisia, 1987.

Governorate and number of fields surveyed		DISEASE*															
		Flag smut		Septoria		Leaf rust		Root rot		Powdery mildew		Bacterial leaf blight		Loose smut		Tan spot	
		N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I
Northern zone																	
Bizerte	17			6	35.29	6	35.29										
Ariana	3					1	33.33					1	33.33				
Nabeul	2																
Zaghouan	11			1	9.09	1	9.09										
Beja	9			3	33.33	3	33.33					1	11.11				
Jendouba	14	1	7.14	4	28.57	7	50.00									1	7.14
Kef	20	3	15.00	6	30.00									1	5.00		
Siliana	14	3	21.43	1	7.14					1	7.14			1	7.14		
Central zone																	
Kairouan	11	3	27.27			1	9.09	2	18.18								
Sousse	4	1	25.00														
Mahdia	6	1	16.67							1	16.67						
Sfax	9	3	33.33			1	11.11	1	11.11								
Sidi Bouzid	9	2	22.22					1	11.11								
Kasserine	14	4	28.57	1	7.14			1	7.14								
Southern zone																	
Gafsa	10	4	40.00			1	10.00	1	10.00	1	10.00						
Kebili	1																
Gabes	9	1	11.11														
Medenine	5	1	20.00														

* N= number of infected fields
I= incidence (%)

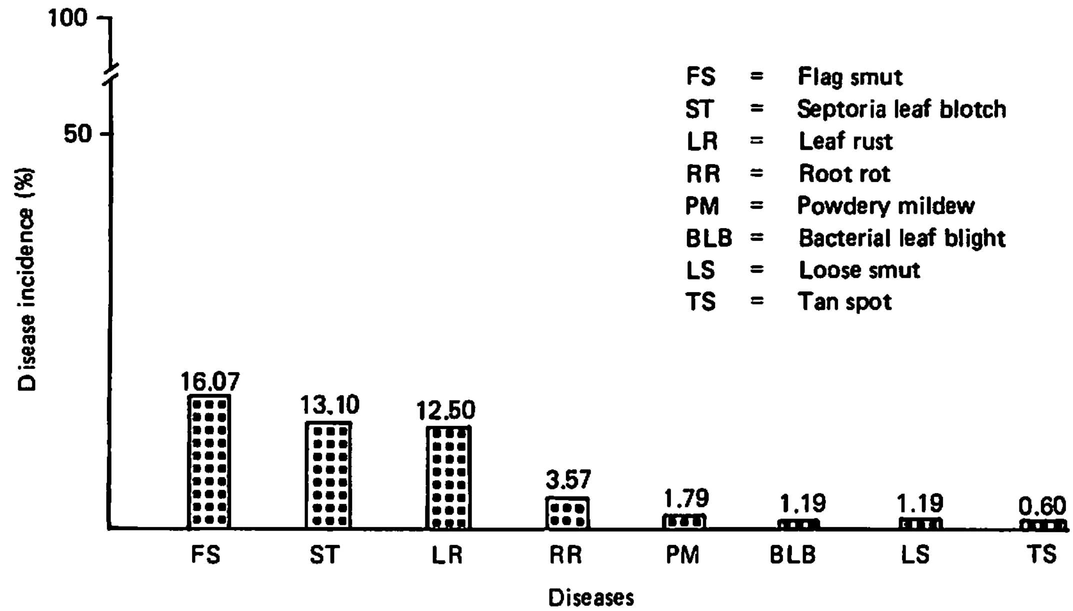

Fig. 1. Incidence of wheat diseases in Tunisia, 1987.

incited by *Pyrenophora teres* was the most prevalent disease followed by powdery mildew, covered smut, barley stripe, barley yellow dwarf, loose smut, leaf rust, and root rot (Table 2).

Net blotch was identified in 41% of the barley fields inspected. The disease was present in most of the governorates but its incidence and the severity of infection was high only in the north. Fields with 90% leaf coverage by net blotch were common mainly in Zaghouan and Kef and both the net and spot symptoms of the disease were found in various locations. Disease samples from both types of symptoms were collected and are being used to study the similarity of the virulences involved.

Powdery mildew was identified in the majority of the governorates of the north, center, and south. The severity of infection was high in very few fields at Sfax (center) and Kebili (south). Scald disease incited by *Rynchosporium secalis* was essentially restricted to the northern governorates. Although this disease ranked fourth among barley diseases, the severity of infection was very high reaching up to 90% leaf coverage in the governorates of Nabeul, Zaghouan, Beja, and Siliana of the northern zone.

Barley stripe, a seedborne disease incited by *Pyrenophora graminea*, was found wherever barley was grown but the severity of infection did not exceed traces (less than 1%). On the other hand, covered smut was more often detected in the central and southern governorates, and root rot only in the semiarid regions at Gafsa and Medenine in the south. Typical symptoms of root rot were detected in only one field located at Gafsa (with 80% of the plants infected). Barley yellow dwarf and loose smut were identified in various fields but with low severity (Fig. 2).

The survey covered both cultivated commercial fields of barley and volunteer plants (found mainly in the northern zone). Both scald and net blotch were identified on volunteer plants. The infection of both diseases on volunteers was much more developed and advanced than in neighboring planted fields, indicating that these volunteer plants were attacked prior to the cultivated fields. Disease samples from these plants and neighboring fields were collected and the fungi isolated to compare the virulences involved. These infections on volunteer plants might play a role in the epidemiology of scald and net blotch diseases in Tunisia.

Moreover, five commercial fields of triticale were inspected. In only one field an unidentified leaf spot was detected while the remaining fields were free from diseases.

Discussion and Conclusions

Although the present survey reports the disease situation

Table 2. Barley diseases in different governorates of Tunisia, 1987.

Governorate and number of fields surveyed		Net bloch N	Net bloch I	Powdery mildew N	Powdery mildew I	Covered smut N	Covered smut I	Scald N	Scald I	Stripe N	Stripe I	BYDV N	BYDV I	Loose smut N	Loose smut I	Leaf rust N	Leaf rust I	Root rot N	Root rot I
Northern zone																			
Ariana	3	2	66.67					2	66.67	1	33.33	1	33.33			1	33.33		
Nabeul	11	7	63.64	1	9.09			7	63.64	3	27.27	1	9.09			1	9.09		
Zaghouan	13	12	92.31	2	15.39			3	23.08	2	15.39	1	7.69	1	7.69				
Beja	4	4	100.00	1	25.00			3	75.00										
Jendouba	1							1	100.00										
Kef	9	8	88.89	2	22.22	5	55.56	4	44.44	2	22.22			1	11.11				
Siliana	9	5	55.56	2	22.22	5	55.56	6	66.67	2	22.22	3	33.33	3	33.33				
Central zone																			
Kairouan	12	2	16.67	3	25.00	1	8.33	1	8.33	1	8.33	1	8.33			1	8.33		
Sousse	3	2	66.67	1	33.33	1	33.33			1	33.33					1	33.33		
Mahdia	6	3	50.00	4	66.67	2	33.33							1	16.67				
Sfax	8			4	50.00	2	25.00												
Sidi Bouzid	3			1	33.33	1	33.33												
Kasserine	10	2	20.00	2	20.00	1	10.00	4	40.00	1	10.00	1	10.00	1	10.00				
Southern zone																			
Gafsa	4			1	25.00							1	25.00					2	50.0
Tozeur	1									1	100.00	1	100.00						
Kebili	5	1	20.00	2	40.00	4	80.00			1	20.00	1	40.00						
Gabes	12			4	33.33	5	41.67												
Medenine	8	2	25.00	2	25.00	5	62.50			1	12.50							1	12.5

* N= number of infected fields
I= incidence (%)

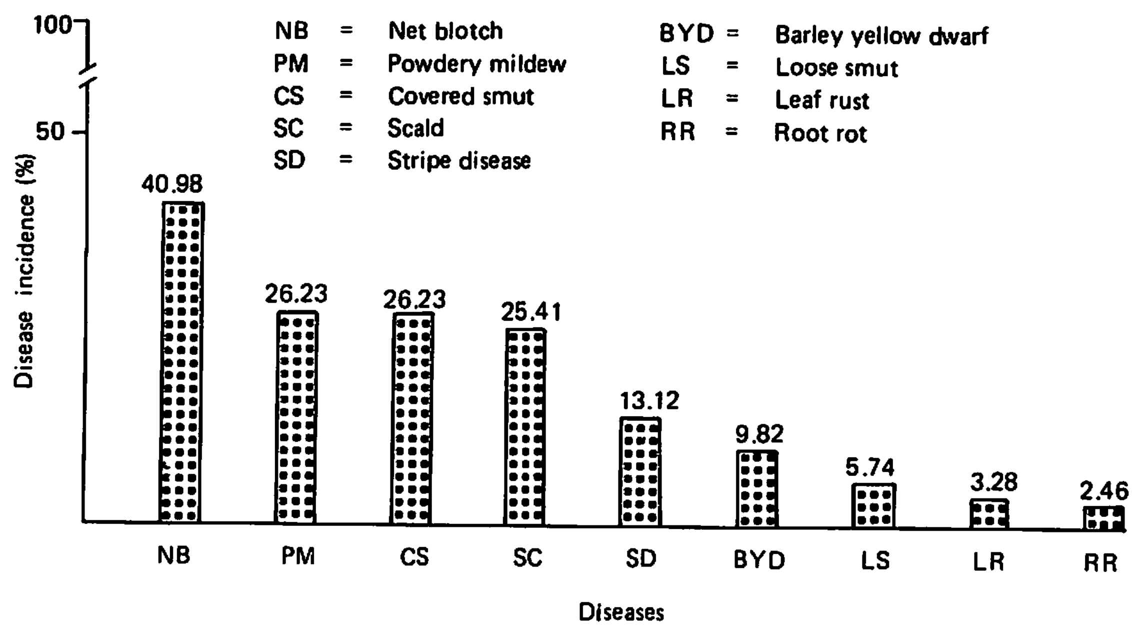

Fig. 2. Incidence of barley diseases in Tunisia, 1987.

in Tunisia during one season, 1986/87, it is the first complete survey conducted on a country basis, covering all the governorates of Tunisia including oases in the south. Wheat and barley are grown in oases under irrigation on very small holdings essentially for self-consumption. Disease samples were collected from the oases to study the similarity of the virulences they carry with those collected from the other areas.

This season was in general characterized by a good rain in amount and distribution in the north, which permitted the expression of the majority -- but not all -- of the potentially important diseases. The rain in the center and south was below average.

In wheat, septoria leaf blotch, leaf rust, bacterial leaf blight, and tan spot were in general confined to the northern zone. This is expected as the climatic conditions (rainfall and temperature) in those areas are more conducive to this group of diseases. The same applies to scald and leaf rust on barley. On the other hand, root rot diseases on both wheat and barley were detected only in the semiarid and arid zones of central and southern Tunisia, respectively.

The occurrence of some of the seedborne diseases of wheat (flag and loose smuts) and barley (stripe disease, covered and loose smuts) need to be addressed. Although these diseases were detected mainly on small holdings in which farmers tend to save part of their seeds for their coming sowing, their effect should be minimized through chemical seed treatment or certified seeds. This group of diseases was in general of limited distribution in the main wheat producing areas of the north.

Septoria leaf blotch was severe on the bread wheat varieties known to be susceptible to this disease, i.e. cv. Tanit, Ariana 66, and Dougga. On the other hand, yellow rust was not detected this year even on wheat varieties known to be susceptible although the amount and distribution of rainfall and cool temperature that prevailed early in the season were optimum to the development and spread of the disease. This is probably due to the absence of the initial inoculum originating outside the country. Yellow rust and septoria were the most important diseases that caused measurable losses to wheat production during the 1984/85 season (Anonymous 1985).

Net blotch attacked barley wherever cultivated but the severity of infection was higher in the north where rainfall and cool weather were optimal. Scald on the other hand was in general confined to the cooler zone in the north. Isolates of scald and net blotch will be used to compare their virulences with those from the other Maghreb countries of North Africa. This represents part of a regional virulence survey of some diseases in the Maghreb countries conducted in collaboration with ICARDA. Samples collected from volunteer barleys and commercial fields will help determine the role of the former in the epidemiology of both scald and net blotch in Tunisia. Previous reports (Anonymous 1984) have shown that the early occurrence of net blotch on seedlings and in isolated fields indicate that seedborne spores are the source of primary inoculum. The early scald and net blotch infection on volunteer barley plants, very frequently found in the northern zone, might also be a source of primary infection to neighboring cultivated fields.

Powdery mildew on barley was identified in the wet and cool region of the north, the semiarid and warm region of the center, and the arid and hot area of the south. This is due to the nature of the fungus which is known to germinate and infect the host in the absence of free water.

In conclusion, although the amount of rain and its distribution this season as well as the temprature were optimum for disease development and spread mainly in the northern zone, wheat and barley production did not suffer measurable losses from diseases. This is essentially because septoria leaf blotch did not develop except on the susceptible bread wheat varieties and yellow rust was not present. This is also evident from the number of disease-free fields of both crops found during the survey (54% in wheat and 20% in barley).

Five commercial fields of triticale were inspected during this survey and all were free of diseases except one that showed some necrotic blotches on the leaves. As the area grown to triticale increases in the country, the crop might become liable to the attack of various diseases.

The results of this survey are of major importance as they provide a basis for the national crop improvement program in the area of breeding for disease resistance with a view to increase and stabilize cereal production.

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References

Anonymous. 1984. Progress report 1983/84. Tunisia/ ICARDA Cooperative Project. ICARDA, Syria. 49 pp.

Anonymous. 1985. Progress report 1984/85. Tunisia/ ICARDA Cooperative Project. ICARDA, Syria. 25 pp.

Kamel, A.H. 1981. Barley diseases in the dry areas. Pages 27-42 *in* Proceedings of the Barley Diseases and Associated Breeding Methodology Workshop, USAID-MSU/ICARDA/CIMMYT, 1981, Rabat, Morocco.

McCuistion, W.L. 1972. Septoria: experiences in North Africa. Proceedings of the Regional Wheat Workshop: Vol. I, Diseases, 14-17 February 1972, Beirut, Lebanon. ALAD, Beirut, Lebanon.

Prescott, J.M. and Saari, E.E. 1976. Major disease problems of durum wheat and their distribution within the Region. Pages 104-116 *in* the Proceedings of the Third Regional Wheat Workshop, FAO/ Rockefeller Foundation/CIMMYT/Ford Foundation/ Cereal Board of Tunisia, 28 April - 2 May 1975, Tunis, Tunisia. CIMMYT, Mexico.

Saari, E.E., Prescott, J.M. and Kamel, A.H. 1979. The significance of diseases and insects in cereal production. Pages 149-157 *in* The Gap between Present Farm Yield and the Potential: Fifth Cereal Workshop (Vol. II). Ministère de l'Agriculture et de la Révolution Agraire/ICARDA/CIMMYT, 5-9 May 1979, Algiers, Algeria.

Preliminary Evaluation of Sawfly Damage to Small Grains in Morocco*

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In late April 1987, damage to small grains caused by sawflies, *Cephus* spp., was apparent in a large area extending from near Essaouira to Settat. By late May, as plants matured, the injury extended northward at least as far as Fes. We conducted studies to understand whether (i) the feeding activity by larvae and the cutting of stems could reduce grain yields; (ii) small grains differed in the amount of damage caused by the sawfly; and (iii) solid stemness and a systemic insecticide would give adequate control.

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Materials and Methods

Comparisons of infestations in four types of small grains were made at the Sidi el Aydi Experimental Station and adjacent fields in late May to early June. Damage assessments were made in three fall-planted fields each of bread wheat, durum wheat, triticale, and barley. Fields varied from about 1/2 to 3 ha but all were drill-planted, with rows spaced about 50 cm apart. In each field, five samples of 50 cm^2 each and spaced about 10 m apart were used to determine the percentage of girdled stems and to compare the grain weights, 1000-kernel weights, and the number of kernels on cut versus uncut stems.

Weights of 1000 kernels and number of kernels per area sampled for each plant species were analyzed individually as a randomized complete block design with fields as blocks and infested/uninfested as the treatments. The measurements from the five samples were pooled to get one estimate from each field. As such, this analysis does not allow the removal of the experimental error within field, the error being estimated by the treatment x location (field) interaction.

In addition, a comparison was made of three varieties each of durum and bread wheat, planted in single 3m-rows, between treated (carbofuran 5G, about 1 kg a.i./ha, applied in the furrow at spring planting) and non-treated trials. Also, a test with carbosulfan (Marshal 25 ST), using a seed treatment at 0.25, 0.5, 0.75, and 1.0 g a.i./100 g of spring-planted bread wheat seeds, was evaluated for sawfly damage. Solid and semi-solid wheats that are resistant to a related species of sawfly in North America, *Cephus cinctus* Norton, were examined for cut stems at Jemaa Shaim. At Khemis Zemamra, a field of SD8036, a bread wheat cultivar, was evaluated for percent of cut stems remaining in the field after combining.

Results and Discussion

Observations indicated that the life history of the Moroccan sawfly was similar to that of *Cephus* spp. in North America. There was a single generation, with oviposition starting in late spring. Larvae were found within stems at a frequency of one larva per stem. Some plants had all stems infested whereas adjacent plants would be sawfly-free. The larva ultimately tunneled downward inside the stem near the soil surface. There, the stem was girdled and the hole above plugged with frass. In triticale, girdling sometimes occurred higher in the stem. The appearance of the cut stub resembled that produced by *C. tabidus* (Udine 1941).

All four types of small grains had similar levels of cut stems varying from 35 to 41% of the stems girdled by the sawfly at Sidi el Aydi (Table 1). These results agree with those of Rashwani (1983a). The average loss in kernel weight was about 12%, and the reduction in the number of kernels per spike about 35%, but significance ($P<0.05$) was only recorded for kernel weight in bread wheat and number of kernels in durum wheat. In Canada, Holmes (1977) reported about the same results in loss of kernel weight, but much less reduction in the number of kernels in wheat. Even so, comparisons of yields from sawfly infested and uninfested stems might underestimate losses since large stems are preferred for oviposition (Wallace and McNeal 1966).

Table 1. Sawfly damage to wheat, barley, and triticale at Sidi El Aydi, Morocco, 1987.

Small grain	% of stems cut	% weight loss/ 1000 kernels	% reduction in no. kernels/ spike
Bread wheat	40.6	5.8	30.1
Durum wheat	38.5	17.1	45.2
Triticale	35.3	12.9	34.4
Barley	37.0	12.1	31.5

At Khemis Zemamra, the bread wheat field had about one-half of the stems cut. About one-half of these girdled stems were missed during combine harvest. Sawfly loss may therefore be higher with machine harvesting than hand harvesting. Yield loss, excluding quality, averaged about 25% for combine harvested small grains. Assuming that hand harvesting would have recovered all cut stems with little kernel loss from shattering, the loss in kernels and shrunken grains would have been 16%. From previous experience, we cannot think of 1987 as a year of exceptionally great sawfly damage; hence, control measures would seem justifiable. Holmes (1982) concluded that populations of *C. cinctus* are capable of increasing markedly in one year and that control measures were justified.

Carbofuran granules applied in furrows of spring-planted wheat insured a good sawfly control (Table 2). These treated plots were irrigated. Rainfed plots and carbofuran-treated plots treated in the fall at Sidi El Aydi did not show satisfactory sawfly control. Damage might be reduced by using carbofuran on spring-planted wheat only with adequate ground moisture. This may limit the practice to research plots. In a separate test, carbosulfan, used as seed treatment on spring-planted bread wheat, caused no appreciable reduction in sawfly damage even at the highest dosage.

Table 2. Effect of carbofuran on sawfly at Sidi El Aydi, Morocco, 1987.

	% of stems cut by sawfly larvae	
Wheat variety	**Carbofuran**	**Untreated**
Spring planted		
Durum wheat		
Cocorit	6	33
Jori	3	31
Marzek	1	38
Bread wheat		
Jouda	4	29
Nesma	6	34
Potam	2	28
Fall planted		
Bread wheat		
Nesma	41	35

Little girdling was observed in solid and semi-solid stemmed wheats. Greatest damage among 12 Canadian varieties with sawfly resistance was found in 'Leader', but even so, less than 5% of the stems were cut. Conversely, hollow-stemmed 'Nesma' (bread wheat) and 'Cocorit' (durum) in adjacent plots had about 43 and 46% cut stems, respectively. A considerable spread in maturity dates of solid versus hollow-stemmed wheats may have accounted for some injury difference. Nevertheless, the data indicate that solid stemness in wheat could possibly be used as an effective control of sawfly in North Africa, again agreeing with the results of Rashwani (1983b). Solid stems were later found in two varieties of bread wheat growing in a farmer's field near Beni Mellal. The origin of these is unknown but these varieties will be used in crosses since they seemed adapted. Also, solid stemness in local wheat varieties needs to be evaluated. There is a need in much of Morocco to incorporate sawfly resistance into good agronomic lines that also contain Hessian fly and disease resistance. The acceptability of solid straw by livestock would also need to be evaluated.

We observed distinct forms of wheat resistance to sawfly other than solid stemness in our breeding plots. Eckroth and McNeal (1953) reported that solid stemness was the only plant character in bread that related to sawfly resistance. However, both durum wheat and barley are reported to exhibit a type of resistance unrelated to the solid stem character (Wallace and McNeal 1966). Until sawfly resistance can be incorporated into Moroccan small grain cultivars, some losses could be avoided by early harvesting, but this, unlike plant resistance, would probably not affect sawfly population (Holmes 1982). Other suggested cultural practices, including deep plowing, crop rotation, and delayed seeding are probably not practical for use in Morocco.

References

Eckroth, E.G. and McNeal, F.H. 1953. Association of plant characters in spring wheat with resistance to wheat stem sawfly. Agronomy Journal 45: 400-04.

Holmes, N.D. 1977. The effect of the wheat stem sawfly, *Cephus cinctus* (Hymenoptera: Cephidae), on the yield and quality of wheat. Canadian Entomologist 109: 1591-98.

Holmes, N.D. 1982. Population dynamics of the wheat stem sawfly, *Cephus cinctus* (Hymenoptera: Cephidae) in wheat. Canadian Entomologist 114: 775-88.

Rashwani, A. 1983a. Resistance to wheat stem sawfly (*Cephus pygmaeus* L.) and related species in cereals. Rachis (2): 15-16.

Rashwani, A. 1983b. Effect of durum and bread wheat stem solidness on the percentage of infestation by wheat sawfly (*Cephus* spp.). Rachis (2): 22-3.

Udine, E.J. 1941. The black grain stem sawfly and the European wheat stem sawfly. US Department of Agriculture. Circular 607. 9 pp.

Wallace, L.E. and McNeal, F.H. 1966. Stem sawflies of economic importance in grain crops in the United States. US Department of Agriculture, technical bulletin 1350. 50 pp.

Evaluation and Characterization of Durum Wheats for Rainfed Production

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A number of durum wheat (*Triticum turgidum* L. var *durum*) accessions (3560) and lines from screening nurseries (776) were made available to us by ICARDA (courtesy: Dr. J.P. Srivastava). The material was grown at Swift Current during the 1984 growing season (May to August) on previously fallowed land. Single 3-m rows, each bordered by spring-planted winter wheat (*T. aestivum* L.), were sown on 29 and 30 April. Four local durum check cultivars, Hercules, Kyle, Pelissier, and Wakooma were planted every 100 rows.

Observations were recorded on 13 morphological and four agronomic characters (days to heading, maturity score, plant height, and overall agronomic score), and on excised-leaf water retention capability. Water retention capability was measured during the vegetative growth phase using manual (Clarke and McCaig 1982) and semi-automated (McCaig 1986) techniques. Five leaves were sampled from each of 200 rows at 0800 and 1300 hr. The leaves were transported to the laboratory, weighed, wilted for 2 hr at 30° C, weighed again, oven-dried, and weighed to determine dry weight. From these weights, initial water concentration, wilted water concentration, and water loss (initial minus wilted) were calculated. To standardize the data, the water concentration and loss values within each set of 200 rows were divided by the mean value for the check cultivars, each of which appeared twice in 200 rows, sampled at the same time. Yield was also determined for the 776 screening nursery lines.

May-July precipitation was 100 mm (99 yr mean, 166 mm) and annual precipitation was 262 mm (99 yr mean, 359 mm) in 1984. Frost following emergence in early May vernalized most lines with a cold requirement. Consequently, some of the scorings for this character in our report, published separately, are in error. Limited numbers of copies of this report are available from Swift Current. A broad range of excised-leaf water retention was observed among the 3560 accessions, ranging from better than the best local check (Pelissier) to worse than the worst local check (Hercules) (Table 1). Similarly, the excised-leaf water loss values and yields of the screening nursery lines were normally distributed around the check mean (Table 2). Ninety of these lines showing low water loss and high yield relative to the checks were evaluated further in 1986.

A total of 760 of the 3560 accessions were selected for testing in 1985. These comprised the top and bottom 50 lines for excised-leaf water retention capability and 660 of the high and low retention types within the various classes of leaf size, leaf rolling, leaf waxiness, maturity, and agronomic score. The top and bottom 50 lines were grown in single-rows, two replicate trials at Swift Current and Saskatoon. The other 660 lines were grown in eleven 8x8 3-replication lattice experiments at Swift Current, again with single 3-m rows bordered with spring-planted winter wheat. The check cultivars Hercules, Kyle, Pelissier, and Wakooma appeared in each trial. Heading and maturity dates, plant height, and yield were measured. Excised-leaf water loss was measured three times as mentioned above. It was not possible to measure yield of some of the lines showing a weak winter habit, due to very late heading and subsequent grasshopper damage.

Table 1. Excised-leaf water loss of 3560 durum wheat accessions grown at Swift Current in 1984.

Class [1]	Number of lines
Under 0.53	116
0.53-0.84[a]	815
0.85-1.13	1217
1.14-1.61[b]	1045
Over 1.61	367

1. Relative to mean of four checks (Hercules, Kyle, Pelissier, and Wakooma).
a. Range of best check (Pelissier).
b. Range of poorest check (Herucles).

Table 2. Excised-leaf water loss and yields of lines from durum screening nurseries grown at Swift Current in 1984.

Class[1]	Number of lines: Excised-leaf water loss	Number of lines: Yield
0.3 - 0.5	28	18
0.6 - 0.8	155	183
0.9 - 1.1	252	351
1.2 - 1.4	167	172
1.5 - 1.7	83	13
1.8 - 2.0	46	-
Over 2.0	10	-

1. Relative to mean of four checks (Hercules, Kyle, Pelissier, and Wakooma).

Growing season and annual precipitation were 73 mm and 272 mm, respectively, at Swift Current in 1985. Fifty-four of the 660-line group had a cold requirement, and consequently did not head until late July. Of the remaining lines, excised-leaf water loss tended to be greater than the check mean, while yield tended to be less than the check mean (Table 3).

Twenty of the best lines grown in 1985, comprising those with acceptable maturity combined with yield equal to or better than the checks and low water loss values, have been used as parents in the Swift Current durum breeding program. Other high yield, low water loss; and low yield, high water loss lines were used in physiological studies at Swift Current and Saskatoon, and were evaluated at three ICARDA sites in northern Syria in the 1985/86 season (Clarke *et al.* 1987).

Table 3. Excised-leaf water loss and yields of 606 durum wheat accessions grown at Swift Current in 1985.

Class[1]	Number of lines: Excised-leaf water loss	Number of lines: Yield
Under 0.3	-	26
0.3-0.5	20	154
0.6-0.8	95	221
0.9-1.1	195	169
1.2-1.4	188	30
1.5-1.7	86	2
1.8-2.0	18	-
Over 2.0	4	-

1. Relative to mean of four checks (Hercules, Kyle, Pelissier, and Wakooma).

References

Clarke, J.M. and McCaig, T.N. 1982. Excised-leaf water retention capability as an indicator of drought resistance in *Triticum* genotypes. Canadian Journal of Plant Science 62:571-578.

Clarke, J.M., Romagosa, I., Jana, S. and McCaig, T.N. 1987. The relationship between excised-leaf water loss and yield in durum wheat. *In* Proceedings of the International Symposium on Improving Winter Cereals Under Temperature and Salinity Stresses, ICARDA, Aleppo, Syria (in press).

McCaig, T.N. 1986. A microcomputer controlled leaf weighing system. Agronomy Journal 78:551-557.

Combining Ability and Heterosis for Root Potential in Durum Wheat

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A spectacular improvement in wheat production in irrigated and high-fertility areas has been accomplished due to the development of high-yielding, semi-dwarf, nonlodging, photoinsensitive, nitrogen-responsive, disease-resistant varieties coupled with an appropriate production technology, but the varietal improvement of dryland cultivars has not been very encouraging. Lack of suitable indices for identification of a drought resistant variety is a major obstacle in breeding for a desired plant type for dry areas. While breeding for a better genotype under dryland conditions, the breeder must put emphasis on the incorporation of a better root system for absorption of water and nutrients from the deeper soil layers. Kuruvadi (1980) reported that as the depth, width, and branching of the root system increased, water stress decreased. According to Levitt (1972) deep-rooted plants showed greater drought avoidance than shallow-rooted ones, if ground water was available.

Though useful information has become available on the influence of the root system on the performance of a genotype under dryland agriculture, little is known about the variability, combining ability, and heterosis for the root potential of currently grown genotypes of durum wheat (*Triticum turgidum* L. var. *durum*). Hence, the present investigation was undertaken to identify better general combiner/s, select superior crosses, and estimate heterosis for root potential in wheat.

Materials and Methods

These studies were conducted at the Agricultural Experiment Station, Swift Current, Saskatchewan, Canada. Forty high-yielding genotypes were selected from the durum wheat varietal improvement program, based on their previous performance under dry and irrigated environments, and were tested for their rooting abilities at 7 and 35 days from seeding. Five outstanding genotypes (Pelissier, Wascana, 7461-Q4A, DT367, and 7561-EZ2E) were chosen as parents based on their high root values and yield potential for effecting diallel crosses. The seeds of these genotypes were sown in the greenhouse and crossing was carried out in all possible combinations, excluding reciprocals, to obtain seeds of the 10 hybrids. In the following season, a few hybrids were selfed to obtain F_2 seeds from all crosses. The parents, F_1, and F_2 generations, were grown in cartons (1 liter capacity) containing sieved and fumigated soil. Randomized block design was chosen with four replications. In each carton three plants were maintained per variety and per replication. These plants were grown in environmentally-controlled growth chamber with 16 hr of light and 8 hr of dark period. The temperature during light and dark periods was 20°C and 16°C, respectively. The plants were irrigated when necessary. The cartons were removed from the growth chamber after 30 days from seeding and the root media was washed free from soil with a gentle spray of water. Kuruvadi (1980) evaluated 16 genotypes of durum wheat at four different dates 15, 30, 45, and 60 days from seeding and found a positive correlation between 30 days of root development and the adult plant root system. The root and shoot portions were sectioned and oven dried at 70°C for 24 hr and the weights were determined with an electronic balance.

The means of the genotypes for root and shoot values, and root/shoot ratio were used in the analysis of variance for randomized block design and in combining ability analysis following Model I and Methods II of Griffing (1956). The heterosis percentage was calculated over mid- and better parent for dry root and shoot system.

Results and Discussion

The analysis of variance for root, shoot, dry matter, and root/shoot ratio in the F_1 and F_2 generations indicated highly significant differences among the populations, revealing considerable variability in the two filial generations (Table 1). The general combining ability (GCA) variances were highly significant for root and root/shoot ratio in F_1 and F_2 generations and the specific combining ability (SCA) variances were highly significant for root and shoot in F_1 and F_2 and for root/shoot ratio in F_2, indicating the role of additive and non-additive genetic variance for these characters. The estimated variance due to SCA was higher than the GCA variance for the three measured traits in the two successive generations, indicating the predominant role of non-additive genetic variance in the inheritance of these characters.

The parental line 7561-EZ2E recorded maximum dry root mass, followed by DT367 and Pelissier. DT367 produced maximum shoot dry matter followed by 7561-EZ2E and Wascana (Table 2). Estimates of GCA effects revealed that Pelissier had the significant and highest GCA for root potential and root/shoot ratio in F_1 and F_2 generations. The GCA comprises additive variance and additive x additive interaction. The higher GCA values for Pelissier indicate that this cultivar can produce superior segregants for root potential in the succeeding generations. Bhullar *et al.* (1979) indicated that the estimates of combining ability over successive generations can greatly help the breeder to judge the reliability of early generation estimates for predicting the potentiality of the crosses in advanced generations.

The four crosses, Wascana x Pelissier and Pelissier x 7461-Q4A in F_1, and DT367 x Pelissier and Pelissier x 7561 EZ2E in F_2, recorded positive and significant SCA effects for root mass (Table 3).

The parental variety Pelissier resulted in better hybrid combination in all four crosses. The crosses DT367 x Pelissier (F_1), Pelissier x 7461-Q4A (F_1 and F_2), and 7461-Q4A x 7561-EZ2E (F_1) recorded positive and significant SCA effects for shoot dry matter. These crosses could be exploited for higher root and shoot potential.

The performance of F_1 and F_2 was compared over mid-(heterosis) and better parent (heterobeltiosis) for the three traits studied (Table 4). Considerable and positive heterosis was manifested in the characters in F_1 and F_2 over better parent. Six crosses, Pelissier x 7461-Q4A, DT367 x Pelissier, Pelissier x 7561 EZ2E, Wascana x Pelissier, 7461 Q4A x 7561 EZ2E, and Wascana x 7461-Q4A manifested 52.4, 36, 25.3, 16.7, 15.8, and 6.9 % heterobeltiosis in F_1 and 47.6, 66.3, 21.1, 52.4, 15.8, and 48.6 % positive transgressive segregation for root potential in the F_2 generation, respectively. The same crosses

Table 1. Analysis of variance for means and combining ability for root and shoot in F_1 and F_2 in wheat.

Source of variation	Degrees of freedom	Mean squares: Root F_1	Root F_2	Shoot F_1	Shoot F_2	Root/shoot ratio F_1	Root/shoot ratio F_2
Replications	3	3.17	1.65	11.85	4.94	10.65	4.93
Genotypes	14	6.43**	5.17**	6.65**	3.07**	5.06**	4.07**
GCA	4	5.88**	4.56**	1.17NS	1.09NS	12.78**	6.14**
SCA	9	6.64**	5.42**	8.84**	3.86**	1.96NS	3.24**
Error		0.024	0.056	0.048	0.115	0.003	0.005
σg^2		0.0007	-0.0012	-0.0132	-0.0008	0.0010	0.0004
σs^2		0.0338	0.0374	0.0944	0.0493	0.0006	0.0018

** Significant at 1% level.
NS Nonsignificant at 5% level.

Table 2. Means for root and shoot and general combining ability effects of parents in two filial generations.

Genotype	Root: Parental mean (g)	Root F_1	Root F_2	Shoot: Parental mean (g)	Shoot F_1	Shoot F_2	Root/shoot ratio: Parental mean	Root/shoot ratio F_1	Root/shoot ratio F_2
DT367	0.89	-0.003	0.015	2.11	0.065	0.061	0.42	-0.015	-0.009
Wascana	0.72	-0.067	-0.068	1.79	-0.034	-0.057	0.40	-0.026	-0.002
Pelissier	0.84	0.093*	0.128*	1.57	0.009	0.059	0.54	0.049*	0.047*
7461-Q4A	0.57	0.069	-0.068	1.56	-0.049	-0.039	0.37	-0.031*	-0.026
7561-EZ2E	0.92	0.047	-0.007	1.83	0.009	-0.024	0.52	0.023	0.007
$SE(g_i)$		0.052	0.070		0.074	0.087		0.017	0.018
$SE(g_i-g_j)$		0.083	0.111		0.117	0.137		0.027	0.028

* Significant at 5% level.

Table 3. Specific combining ability effects for cross combinations in F_1 and F_2 for root and shoot in wheat.

Cross	Root		Shoot		Root/shoot ratio	
	F_1	F_2	F_1	F_2	F_1	F_2
DT 367 x Wascana	0.12	-0.03	0.13	0.00	0.03	-0.02
DT 367 x Pelissier	0.17	0.37	0.39*	0.32	-0.02	0.08*
DT 367 x 7461-Q4A	0.04	0.10	-0.14	0.12	0.07*	0.03
DT 367 x 7561-EZ2E	-0.20	0.07	-1.39*	-0.03	-0.01	0.04
Wascana x Pelissier	0.88*	0.25	-0.42*	0.33*	0.02	0.05
Wascana x 7461-Q4A	-0.04	0.22	-0.43*	0.10	-0.09*	0.09*
Wascana x 7561-EZ2E	0.11	0.07	0.19	0.90*	0.01	0.01
Pelissier x 7461-Q4A	0.31*	0.23	0.40*	0.36*	0.05	0.03
Pelissier x 7561-EZ2E	0.11	0.45*	0.11	0.17	0.02	-0.03
7461-Q4A x 7561-EZ2E	0.18	0.17	0.42*	0.32	0.00	0.10*
SE (s_{ij})	0.14	0.19	0.20	0.23	0.05	0.05
SE (s_{ij}-s_{kl})	0.19	0.25	0.26	0.13	0.06	0.06
SE (s_{ij}-s_{ik})	0.20	0.27	0.29	0.34	0.07	0.07

* Significant at 5% level.

Table 4. Heterosis over better parent (%) for root and shoot in F_1 and F_2 generations.

Cross	Root		Shoot		Root/shoot ratio	
	F_1	F_2	F_1	F_2	F_1	F_2
DT 367 x Wascana	11.2	3.4	1.4	-4.7	11.9	4.4
DT 367 x Pelissier	36.0	66.3	16.1	15.2	-7.4	-16.7
DT 367 x 7461-Q4A	2.3	16.9	-11.5	2.4	16.7	2.1
DT 367 x 7561-EZ2E	-16.8	16.8	-21.3	-2.4	-9.6	-13.0
Wascana x Pelissier	16.7	52.4	6.7	29.2	-3.7	-7.1
Wascana x 7461-Q4A	6.9	48.6	3.4	12.3	0.0	-22.6
Wascana x 7561-EZ2E	9.5	7.4	17.5	12.0	-7.7	-4.0
Pelissier x 7461-Q4A	52.4	47.6	49.1	47.8	1.9	3.8
Pelissier x 7561-EZ2E	25.3	21.1	15.3	19.1	5.6	7.6
7461-Q4A x 7561-EZ2E	15.8	15.8	29.0	23.5	-9.6	-2.1

also manifested heterotic performance of 12 to 47.8% in the F_2 generations for shoot dry matter over better parent and these crosses could be exploited for simultaneous improvement of root and shoot system in durum wheat.

Pelissier has a massive root system, is a good general combiner for root potential, and manifested higher heterotic performance. This cultivar is, thus, an excellent donor for breeding improved varieties under drought conditions based on root potential. Hurd (1964) and Kuruvadi (1983) studied the root patterns of 14 genotypes in durum wheat in rhizotrons under drought conditions and identified Pelissier as capable of increasing its root quantity at depths varying between 60 and 120 cm below soil surface. Pelissier has a spectacular rooting ability and avoids stress by absorption of water from deeper layers of the soil.

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References

Bhullar, G.S., Gill, K.S. and Bhatia, A. 1979. Combining ability over successive generations in diallel crosses of bread wheat. Cereal Research Communications 7(3): 207-213.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Australian Journal of Biological Sciences 9: 463-493.

Hurd, E.A. 1964. Root study of three wheat varieties and their resistance to drought and damage soil cracking. Canadian Journal of Plant Science 44: 440-448.

Kuruvadi, S. 1980. Genetic studies on dryland wheat. Post Doctoral Research Investigation. Agricultural Research Station, Swift Current, Saskatchewan, Canada.

Kuruvadi, S. 1983. Modelo de Raices en Trigo Macarronero en Rizotrones. Simposium. La Sequia y su Impacto en la Agricultura. Universidad Autonoma de Chapingo, Mexico, 21 y 22 de Noviembre. pp 33-34.

Levit, J. 1972. Response of plants to environmental stresses. Academic Press, New York, USA.336 pp.

Effect of Weeds on Yield and Water-Use Efficiency of Wheat Under Semi-Arid Conditions of Morocco

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Soil moisture is a major factor limiting rainfed crop production under semi-arid conditions where the average annual rainfall is 250 to 400 mm and its distribution often highly irregular. Weed competition reduces the amount of water available for crops such as wheat. It begins as soil water falls below levels needed for optimum crop growth, and as it continues, its effects are reflected by reduction in growth and development of the above-ground parts (Pavlychenko and Harrington 1935: Pavlychenko 1937).

Weeds competing with wheat decrease yields (Zimdahl 1980). Pavlychenko (1937) reported that "Marquis" wheat, under weed competition produced smaller root systems than wheat plants grown alone. Competition for water is usually considered to be the most important factor in dryland agriculture (Radosevich and Holt 1984).

The objective of our study was to compare the yield and water-use efficiency of weedy wheat under semi-arid conditions of Morocco.

Materials and Methods

One experiment was conducted near Chemaia on a crusting shallow soil and another near Oulad Said on a deep vertisol. "Nesma" bread wheat was drilled at the rate of 80 kg/ha on 7 and 8 November 1985. Plot size was 3 x 10 m, and rows were 25 cm apart. A randomized complete block design was used with four replications. The two treatments studied were: weed control, with bentazone + dichlorprop at the rate of 2400 g/ha at the early-tiller stage of wheat ('weed-free' wheat), and no weed control (weedy wheat). Above-ground samples of 1 m^2 of wheat and weeds were collected from each plot at early tillering and at heading. At maturity, grain and straw yields were measured from each plot. Soil samples for gravimetric determination of soil moisture were taken from each plot at tillering, heading, and harvest to a depth of 25, 50, 75, and 100 cm. Water-use efficiency of wheat, defined as the ratio of the dry matter produced to the amount of water lost (kg/cm/ha) by wheat in the field (Kramer 1983), was determined for each treatment.

Results and Discussion

Precipitation Characteristics

Monthly values of rainfall for the 1985/86 growing season are given for both locations in Table 1. Rainfall was close to the long-term averages and with good distribution for both sites.

Table 1. Monthly rainfall (mm) at Chemaia and Oulad Said in 1985/86.

	Chemaia	Oulad Said
September	0	1
October	6	0
November	70	67
December	36	39
January	13	59
February	79	111
March	11	49
April	22	63
May	0	0
June	12	4
July	0	0
August	0	0
Total	249	393

Effect of Weeds on Wheat Yield

Weed density at wheat tillering stage was 65 plants/m^2 at Chemaia and 169 plants /m^2 at Oulad Said. Common poppy (*Papaver rhoeas* L.), crown daisy (*Chrysanthemum coronarium* L.), milkvetch (*Astragalus boeticus* L.), and wall rocket (*Diplotaxis tenuisiliqua* Delile) were the major weed species at Chemaia, and common poppy, charlock (*Sinapis arvensis* L.), chicory (*Cichorium endivia* L.), and field marigold (*Calendula arvesis* L.) at Oulad Said.

Weed competition resulted in grain yield losses of 35% and 16%, and straw yield losses of 23% and 7% at Chemaia and Oulad Said, respectively (Table 2). Harvest index was significantly reduced by weeds at Oulad Said.

Table 2. Grain and straw yield and harvest index (HI) of wheat for Chemaia and Oulad Said experiments.

	Chemaia			Oulad Said		
	Grain	Straw	HI	Grain	Straw	HI
	(kg/ha)		(%)	(kg/ha)		(%)
Weed-free wheat	1378	3250	29.8	3374	6476	34.3
Weedy wheat	898	2485	26.5	2844	5999	32.2
LSD (0.05)	216	534	NS	NS	NS	1.7
CV (%)	8.4	8.3	6.6	9.6	7.3	2.3

NS = nonsignificant

Losses due to weeds were greater at the drier site (Chemaia). Tanji (1987) reported that weeds caused wheat grain losses as high as 63% in a semi-arid zone of Morocco, although losses were less than 8% when averaged over 40 on-farm experimental sites. Other studies showed that weeds reduced wheat vigor, tillering, head size, and kernel weight (Godel 1935; Burrows and Olson 1955; Zimdahl 1980).

Effect of Weeding on Wheat Dry-Matter Production

Table 3 shows the total above-ground dry weight of wheat and weeds at the three sampling dates. Since the first sampling was done just before herbicide application, data from weed-free and weedy wheat were pooled. Weeds increased interspecific competition in weedy plots; consequently, the amount of dry matter produced per individual plant decreased.

For infested wheat, the dry-matter production of weeds increased as much as it decreased in wheat. Wheat and weed plants were "mutually exclusive" (Martin and Field 1987).

The total dry-matter yield of weeds and wheat from weedy plots was not significantly different at heading and maturity from the yield of the weed-free wheat. This relationship was reported as "the law of constant final yield" (Radosevich and Holt 1984).

Water Use

Total water used from tillering to maturity was the same in both weedy and weed-free wheat (Tables 4 and 5). About 70% of the water was used from tillering to heading, leaving only 30% for the heading to maturity period. Weed control did not affect water use during these two stages. The amount of water used by this bread wheat was slightly higher than that reported by Bouchoutrouch (1986) for durum wheat in semi-arid Morocco. In their study in Montana (USA), Coble and Fay (1985) found that weed competition did not affect the pattern of water use by wheat.

Total (weeds and wheat) dry-matter production (Table 3) and total water used (Tables 4 and 5) were not statistically different for the two treatments at either site. This could be explained by the fact that roots of wheat plants and those of weeds competed for water, and, consequently, some of the available water was depleted by weeds. However, control of weeds released the limited amount of water in the soil for increased growth and yield of wheat.

Competition between weeds and wheat plants was probably very high during the reproductive period, since available soil water was very low at that time. The limited amount of water was used from heading to maturity, and probably affected grain-set and grain-fill. Other researchers have found that later in the season, the size of wheat roots was smaller when grown with weeds, than in the weed-free condition (Radosevich and Holt 1984; Coble and Fay 1985).

The nature of interspecific competition necessarily involves the root systems for both wheat and weeds; the top growth is then in proportion to the extent of the root system. Allowing weeds to grow beyond full tillering caused intense competition for water in dryland agriculture and reduction of wheat yield (Zimdahl 1980; Wiese 1983).

Water-Use Efficiency of Wheat

For the two sites, water-use efficiency for grain and straw was increased by weed control (Tables 4 and 5). The increase was significant at the drier site (Chemaia). It seems that as water stress increases, weeds become more competitive in the utilization of available moisture.

Table 3. Above-ground dry-matter (wheat + weeds) at 3 growth stages of wheat for Chemaia and Oulad Said experiments.

	Dry matter (kg/ha)					
	Chemaia[1]			Oulad Said[2]		
	Tillering[3]	Heading	Maturity	Tillering[3]	Heading	Maturity
'Weed-free' wheat						
Wheat	88	4283	4628	705	7801	9850
Weeds	11	115	115	104	67	67
Total	99	4398	4743	809	7868	9917
Weedy wheat						
Wheat		2909	3382		7170	8843
Weeds		1286	1286		1211	1211
Total		4195	4668		8381	10054
LSD (0.05)[a]		NS	NS		NS	NS
CV (%)		14.1	7.9		11.7	6.6

1. Dates for 50% tillering, heading, and maturity were 24/12/85, 26/3/83, and 15/5/86, respectively.
2. Dates for 50% tillering, heading, and maturity were 16/1/86, 24/3/86, and 22/5/86, respectively.
3. Data were pooled from weed-free and weedy wheat.
a. Total dry-matter of wheat and weeds were statistically compared.
NS = nonsignificant

Table 4. Water use (WU) and water-use efficiency (WUE) for Chemaia experiment.

	WU (cm)			WUE (kg/cm/ha)	
	Tillering to heading	Heading to maturity	Sum	Grain	Straw
'Weed-free' wheat	14.6	5.4	20.0	69.2	163.1
Weedy wheat	14.4	4.9	19.4	46.7	129.1
LSD (0.05)	NS	NS	NS	8.1	25.2
CV (%)	7.6	27.0	4.5	6.2	7.7

NS = nonsignificant

Table 5. Water use (WU) and water-use efficiency (WUE) for Oulad Said experiment.

	WU (cm)			WUE (kg/cm/ha)	
	Tillering to heading	Heading to maturity	Sum	Grain	Straw
'Weed-free' wheat	24.5	10.9	35.4	95.1	182.7
Weedy wheat	24.0	11.9	35.8	80.1	168.9
LSD (0.05)	NS	NS	NS	NS	NS
CV (%)	11.1	18.2	3.9	14.6	10.8

NS = nonsignificant

Removal of weeds reduced competition for water among plants and led to higher wheat yield per unit of water consumed. Karrou (1986) found that decreasing plant population of rainfed corn improved water-use efficiency in the semi-arid zone of Morocco. Certain plant species are able to use less water per unit of dry matter produced than others (Black *et al.* 1969). Those plants with high water-use efficiencies would be more competitive and more productive during periods of limited water availability than those with high water requirements (Radosevich and Holt 1984).

Conclusion

This study indicated that in interspecific competition, weeds depleted moisture from the soil, causing a reduction in the above-ground biomass of rainfed wheat. In the two sites, water use was not affected by weed control. Water-use efficiency of wheat grain and straw was significantly increased by weed control at the drier site.

References

Black, C.C., Chen, T.M. and Brown, R. H. 1969. Biochemical basis for plant competition. Weed Science 17: 338-344.

Bouchoutrouch, M. 1986. Yield response of three durum wheat varieties in a semi-arid environment. M.Sc. thesis. University of Nebraska, Lincoln, Nebraska, USA.

Burrows, V.D. and Olson, P.J. 1955. Reaction of small grains to various densities of wild mustard and the results obtained after their removal with 2,4-D or by hand. I. Experiments with wheat. Canadian Journal of Agricultural Science 35: 68-75.

Coble, D.L. and Fay, P.K. 1985. Patterns of soil moisture depletion by downy bromegrass, jointed goatgrass, and rye. Pages 135-136 *in* Proceedings of the Western Society of Weed Science, volume 38. Logan, UT, USA.

Godel, G.L. 1935. Relation between rate of seeding and yield of cereal crops in competition with weeds. Scientific Agriculture 16: 165-168.

Karrou, M. 1986. Plant population and genotype effects on water-use efficiency, growth, and development of corn in the semi-arid area of Morocco. M.Sc. thesis, University of Missouri-Columbia, USA.

Kramer, P.J. 1983. Water relations of plants. Academic Press, New York, USA. 489 pp. ISBN: 0-12-425040-8.

Martin, M.P. and Field, R.J. 1987. Competition between vegetative plants of wild oat (*Avena fatua* L.) and wheat (*Triticum aestivum* L.). Weed Research 27: 119-124.

Pavlychenko, T.K. 1937. Quantitative study of the entire root systems of weed and crop plants under field conditions. Ecology 18: 62-79.

Pavlychenko, T.K. and Harrington, J.B. 1935. Root development of weeds and crops in competition under dry farming. Scientific Agriculture 16: 151-160.

Radosevish, S.R. and Holt, J.S. 1984. Weed ecology, implications for vegetation management. Wiley and Sons, New York, USA.

Tanji, A. 1987. On-farm evaluation of wheat production as affected by three weeding systems and top-dressed nitrogen in Chaouia (semi-arid zone of Morocco). M.Sc. Thesis, Kansas State University, Manhattan, Kansas, USA.

Wiese, A.F. 1983. Weed control. Pages 363-487 *in* Dryland Agriculture (Dregne, H. E. and Willis, W. O. eds). American Society of Agronomy, Inc., Madison, Wisconsin, USA.

Zimdahl, R.L. 1980. Weed-crop competition, a review. International Plant Protection Center, Corvallis, Oregon State University, USA.

Wadi El Neel, a New Bread Wheat Variety for Northern Sudan

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Total area under wheat production in the Sudan is estimated at 143,220 ha, of which 78% is in the Gezira, 12% in New Halfa, and 10% in the Northern Region (Faki 1986). Despite the fact that only 10% of the total area is in the Northern Region, the average yields are consistently higher than those of either Gezira or New Halfa. From 1975 until 1984, yields averaged 1640 kg/ha in the Northern Region with a coefficient of variation of 22% compared to 1081 and 881 kg/ha in Gezira and New Halfa for the same period with coefficients of variation of 23 and 40%, respectively. The highest average yield reached in Gezira was 1429 kg/ha in the 1982/83 season as compared to 2381 kg/ha in the Northern Region in the same period (Faki 1986).

The Northern Region government aims at attaining a horizontal expansion of 84,000 ha and a vertical minimum yield average of 3.57 t/ha to achieve self-sufficiency for the Region and help partly alleviate the burden of wheat imports (Mohamedali 1985).

Consumers in the Northern Region prefer white kernel wheat varieties. Red varieties, e.g. Mexicani, usually cost 40% less than white varieties, such as Giza 155. Improved high-yielding white varieties are deemed necessary to replace the local types and the traditionally grown Giza 155.

A large number of introduced genetic stocks and varieties were evaluated at Hudeiba Research Station (17° 34' N, 33° 56' E, and 350 m above sea level) and at farms throughout the Northern Region. Five-year results justified the release of the new Wadi El Neel variety for the Northern Region by the Technical Committee for Variety Release in Oct 1987.

Results

Ten out of 13 experiments revealed that Wadi El Neel was the top yielder in 4 cases, the third in 5 cases, and the fifth in 1 case. It outyielded Giza 155, the traditionally grown variety (Table 1) with a yield advantage averaging 20 - 22%. Except for the red kernel varieties, Wadi El Neel outyielded all the genotypes tested. It reached maturity in around 107 days, fitting adequately in the growing season of the Northern Region. Its high protein content averaged 13.1% and its excellent baking characteristics were evaluated by a volunteer consumers panel. It has a significantly high harvest index ($P < 0.01$) of 40% as compared to 29% for Giza 155. Results also showed that Wadi El Neel is resistant to lodging, bird attack, and shattering and tolerant to various stresses, particularly high temperature, low fertility, prolonged irrigation intervals, and poor soil conditions.

Table 1. Wadi El Neel and Giza 155 yields in different experiments and seasons (kg/ha).

	Experiment/Season					
Variety	82/83	83/84a	83/84b	85/86	85/86	Mean
Wadi El Neel	4055	4076	3912	3086	3010	3628
Giza 155	3699	3010	3117	2129	3156	3022
Percent increase	+10	+35	+26	+45	-5	+(20-22)

Table 2. Effect of sowing date on Wadi El Neel yield at Hudeiba Research Station (kg/ha).

Season	1 Oct	15 Oct	1 Nov	15 Nov	1 Dec	15 Dec	Mean
1983/84	1621	2681	3205	2867	2381	1857	2435
1984/85		2483	3124	2676	2655	2257	2639
1985/86	1560	2005	2869	2852	3414	3255	2659
Mean	1591	2390	3066	2798	2817	2456	

Standard error for sowing date means: 60, 157, and 102 for 1983/84, 1984/85, and 1985/86, respectively.

Recommended Management Practices

Management practices for yield maximization of Wadi El Neel were determined at the Research Station level and verified at the on-farm level at Suleim, Burgeig, Gurer, Zeidab, and Shendi. On-farm verification was made under two types of experiments where both researchers and farmers conducted trials during the 1985/86 and 1986/87 seasons within the ICARDA/OPEC-Pilot Project for Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields in the Sudan.

Sowing Date

Three years data presented in Table 2 indicated that optimum sowing date for Wadi El Neel is 1 Nov and the recommended range, 1-15 Nov. However, with sowing delayed until 1 Dec, Wadi El Neel proved to be the best of the varieties tested.

NPK Nutrition

Three years data summarized in Tables 3 and 4 show that Wadi El Neel responded to nitrogen application positively up to 144 kg N/ha, while neither P nor K was needed. Considering the present prices of urea fertilizers and the expected increments from the added fertilizer, we recommend a nitrogen application of approximately 86 kg N/ha. Experiments indicated that maximum yields are obtained by applying the whole dose at the second irrigation.

Table 3. Effect of NPK on Wadi El Neel yield at Hudeiba Station (kg/ha).

	N-P-K (kg/ha)										
Season	0-0-0	48-0-0	48-48-0	96-0-0	96-48-0	144-0-0	144-96-0	144-96-96	192-96-0	192-96-96	Mean
1982-83	2119	4000	3881	4286	4595	4786	5357	4738	5310	4833	4391
1983-84	2098	3148	3857	3986	3969	4748	4664	4314	4719	4993	4050
1984-85	2067	2793	2960	3231	3188	2990	3629	3293	2900	2657	2971
Mean	2095	3314	3566	3834	3917	4175	4550	4115	4310	4161	

Standard errors for fertilizer means: 205, 164, and 155 kg/ha for 1982/83, 1983/84, and 1984/85 seasons, respectively.

Table 4. Effect of nitrogen fertilizer on yield of Wadi El Neel at Hudeiba Research Station (kg/ha).

	Nitrogen level (kg N/ha)					
Season	0	48	96	144	192	Mean
1983/84	1938	2407	3471	4202	4014	3206
1984/85	1571	2819	3136	3114	3462	2810
Mean	1755	2613	3304	3658	3738	

Standard errors for nitrogen means: 145 and 162 kg/ha for 1983/84 and 1984/85, respectively.

Method of Planting and Seed Rate

One year preliminary data (Table 5) indicated that yields attained with broadcasting and row planting (drilling) were significantly different ($P < 0.01$). Row planting was superior at equal seed rates, but yield differences as affected by seed rate were nonsignificant ($P < 0.05$), the high tillering capacity of Wadi El Neel compensating for low seed rates. Results also showed that seed rates of 108-144 kg/ha could be recommended.

Irrigation Interval

Two-season data (Table 6) revealed that shortening the irrigation interval increases yield. It is recommended that private schemes irrigate once every 7-10 days and public schemes once every 14 days.

Weed Control

Yields of fields treated with different herbicides and doses did not prove to be significantly different ($P < 0.05$) from those mechanically weeded (Table 7). Only one mechanical weeding, one month after sowing, is required. The wheat crop has an adequate smothering effect on weeds after its establishment.

Table 5. Effect of method of planting and seed rate on yield of Wadi El Neel (kg/ha).

	Seed rate (kg/ha)				
Method of planting	72	108	144	180	Mean
Broadcasting	2610	2424	2819	2745	2650
Rows	3400	3486	3212	3500	3400
Mean	3005	2955	3016	3123	

Table 6. Effect of irrigation interval on Wadi El Neel yield at Hudeiba Research Station (kg/ha).

	Irrigation interval (days)				
Season	7	10	14	21	Mean
1983/84	4296	3612	3310	2441	3415
1984/85	3943	2648	2467	1652	2678
Mean	4120	3130	2889	2047	

Standard errors for irrigation means: 38 and 207 kg/ha for 1983/84 and 1984/85, respectively.

Table 7. Effect of weed control on Wadi El Neel yield at Hudeiba Research Station (kg/ha).

Treatments	1983-1984	1984-1985	1985-1986
Weedy check	3257	3948	1926
Hand weeded*	3857	3910	2221
2,4-D	3722	-	-
Brominal W**			
1.2 l/ha	-	-	2095
2.4 l/ha	-	3912	2243
3.6 l/ha	-	-	2471
Mean	3612	3923	2191
Significance	N.S.	N.S.	N.S.
SE ±	190	117	214

* Hand weeded once, one month after planting.

** Brominal applied one month after planting.

N.S. = Non significant.

Acknowledgements

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References

Faki, H. 1986. Economic aspects of wheat. Paper presented at the First Coordination Meeting, ICARDA/OPEC Pilot Project for Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields in the Sudan, 3-5 August 1986, ARC, Wad Medani, Sudan.

Mohamedali, G.H. 1985. Basics for wheat production in the Northern Region, Sudan. Lecture in training course for extensionists of Merowe-Dongola area within IFAD Rehabilitation of the Northern Region Schemes, 9-12 March 1985, Sudan.

Tolerance of Wheat (Triticum aestivum L.) Cultivars to Sodium Salts

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The problem of salinity has for sometime been tackled by plant scientists and a massive literature is now available (Flowers *et al.* 1977; Francois and Maas 1985; Greenway and Munns 1980). Depending upon their composition, different salts have varying effects on plants because reduced growth in saline substrate is correlated with ionic effect *per se* as well as with the osmotic effects which may vary with equivalent concentration of different salts.

Most of the studies on salt tolerance in plants have, however, been confined to the effect of chloride and sulfate of sodium, potassium, calcium, and magnesium but other anions have generally been ignored. (Magistad 1943; Wadleigh and Gauch 1944; Younis and Hatata 1971). The effect of a number of sodium salts on germination and 5-day growth of two wheat cultivars has been reported (Ansari *et al.* 1980). This paper extends this study to include later growth stages up to maturity.

Materials and Methods

A pot culture experiment was conducted on two wheat cultivars (*Triticum aestivum* L., cvs. H-68 and Mexipak) grown on sand and receiving 50 or 100 mM Na as phosphate, sulfate, carbonate, citrate, acetate, chloride, nitrate, or bicarbonate of sodium. Ammonium sulfate at 120 kg N/ha, single superphostphate at 60 kg P_2O_5/ha, and potassium sulfate at 40 kg K_2O/ha were mixed in sand prior to sowing. Irrigation with 500 ml of full strength Hoagland solution per pot was applied fortnightly. Other irrigations with distilled water were supplied whenever needed. Harvests were made at 30, 60, and 90 days after full emergence for straw dry weight and at maturity for grain weight. Straw from the intermediate harvest (60 days) was also analyzed for Na and K contents following Jackson (1962).

Results and Discussion

There was no difference in the growth of both cultivars under control (no salinity) and hence direct comparison between the salts can be made from Fig. 1. It is evident that both cultivars were sensitive to salts at the early developmental stages (30 days) and this sensitivity became more pronounced at the time of grain formation (90 days). The intermediate stage (60 days) was not so adversely affected, probably because of rapid growth during this period which may have minimized the adverse effects of salinity. This also confirms our earlier findings (Ansari and Ahmed 1978).

Nearly all the salts were comparatively more toxic for Mexipak than for H-68 except for $NaHCO_3$. The order of toxicity of the ions, did not change with the development stage of the plants. Comparing this ranking with the response observed at germination and 5-day growth (Ansari *et al.* 1980), it is evident that, at early as well as later growth stages, the phosphate and sulfate were relatively less harmful than the other anions. Carbonate was moderately toxic while bicarbonate was very harmful for growth of both cultivars. On the other hand, nitrate and chloride affected growth less adversely at early stages but were more harmful at later growth stages in comparison with citrate and acetate.

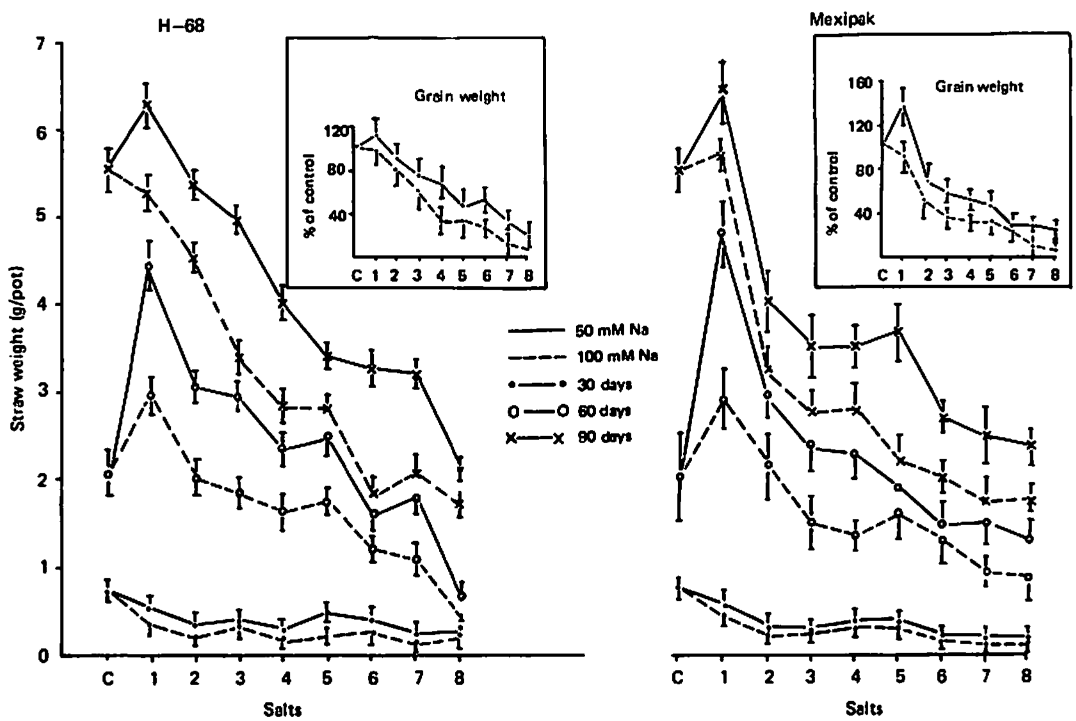

Fig. 1. Effect of 50 or 100 mM Na supplied to wheat varieties H-68 and Mexipak as phosphate (1), sulfate (2), carbonate (3), citrate (4), acetate (5), chloride (6), nitrate (7), or bicarbonate (8) on straw weight (g/pot) 30, 60, and 90 days after emergence, and on grain weight (inset, % of control) at maturity. ' C ' denotes control treatment, bars indicate standard error of mean.

Citrate and acetate ions are generally not encountered in saline soils. In the present study they were included to investigate the response of plants to some organic anions in addition to the customary inorganic anions (viz. Cl, SO_4). However, it seems that either citrate and acetate were not stable for very long in sand culture, or Na remained bound with acetate or citrate and, thus, was not absorbed, which explains the nontoxicity of these salts at later growth stages. The response of plants to salts varies with the development stage (Pearson and Ayers 1960) as well as the growth medium (Ansari *et al.* 1982) which may account for the above differences.

It is further evident from Fig. 1 that NaH_2PO_4 was generally beneficial for plants. Perhaps, instead of producing any toxicity, it served as a source of phosphorus, which is one of the most important nutrient elements. This, however, was not the case of nitrate which is the source of another very important nutrient, nitrogen. Here, the toxic effects were prominent even at 50 mM on both cultivars. Nitrogen requirement was perhaps fully met by the basic dose of $(NH_4)_2SO_4$ and the Hoagland solution added periodically to irrigate the sand, hence, further addition of $NaNO_3$ produced only toxic effects. Furthermore the salts of nitrogen added either through Hoagland ($Ca(NO_3)_2$, KNO_3) or to create salinity ($NaNO_3$) were readily soluble. Hence, they all became available and caused toxicity. On the other hand, phosphorus is easily fixed and then slowly released, hence, the addition of NaH_2PO_4 provided the phosphorus requirement of plants without producing any toxicity symptoms. The toxicity of other salts was as expected. Chlorides are reported to be more toxic than sulphates (Wadleigh and Gauch 1944; Younis and Hatata 1971) while bicarbonates attain importance because of the tendency to render calcium, and to some extent magnesium, unavailable by precipitating them in the soil solution in the form of carbonates (Allison 1964).

The Na and K contents of the plants were analyzed only at the 60 days harvest and it was observed (Fig. 2) that Na increased with concomitant decrease in K for all salt types. This could be due to the enhanced Na content of the growth medium because of the addition of salts, resulting in an increase in Na and a consequent decrease in K uptake, probably due to a competitive K/Na uptake by plants (Ansari and Ahmed 1978; Flowers *et al.* 1977; Greenway and Munns 1980; Lunin *et al.* 1964). The trends of cation uptake at this stage were directly related to the order of toxicity of the anions discussed above, i.e. at this stage, K decreased and Na increased with increasing toxicity of the salts and the resulting effect on shoot dry weight. Under the present experimental conditions, the order of toxicity of these anions is confirmed for their effects on straw and grain weights throughout the duration of this experiment as well as for the Na and K contents of the straw at 60 days.

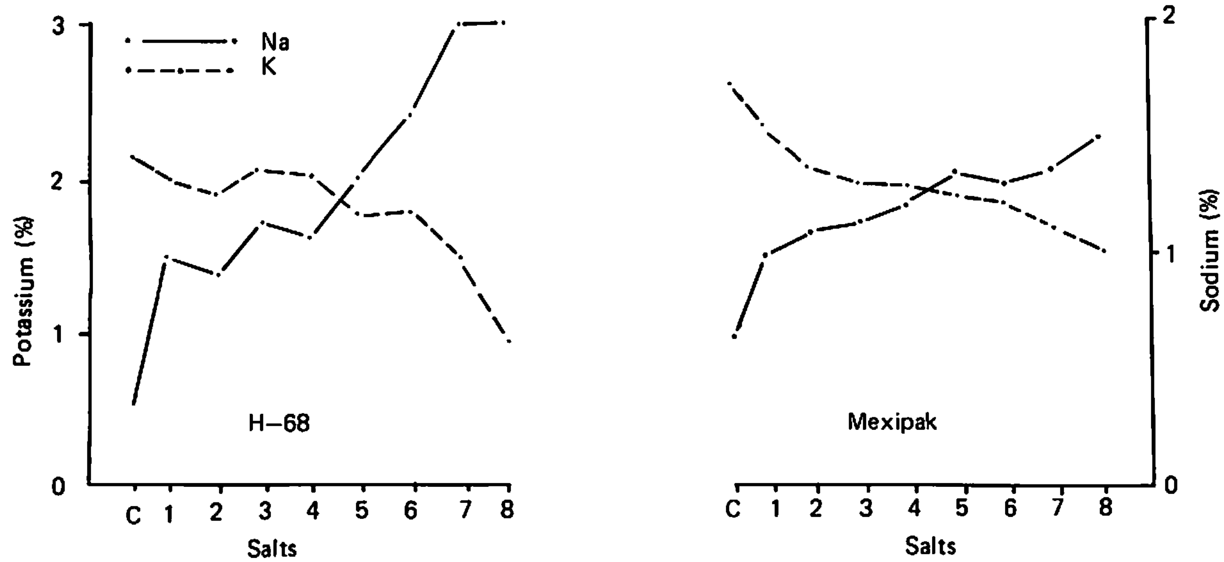

Fig. 2. Sodium and potassium content in the straw of wheat varieties H–68 and Mexipak 60 days after emergence when 100 mM Na was supplied as phosphate (1), sulfate (2), carbonate (3), citrate (4), acetate (5), chloride (6), nitrate (7), or bicarbonate (8).

References

Allison, L.E. 1964. Salinity in relation to irrigation. Advances in Agronomy 16: 136-180.

Ansari, R. and Ahmed, S. 1978. Salt tolerance studies in plants. Pages 65-81 *in* Membrane Biophysics and Salt Tolerance in Plants (Qureshi, R.H., Muhammad S., and Aslam, M., eds.). Agricultural University Press, Faisalabad, Pakistan.

Ansari, R., Naqvi S.M. and Ala, S.A. 1980. Response of wheat cultivars to the presence of sodium salts at germination and in early development. Biologia Plantarum 22: 470-472.

Ansari, R., Naqvi S.M. and Ala, S.A. 1982. Germination and seedling growth of various crop seeds as influenced by different growth media. Acta Agronomica 31: 351-354.

Flowers, T.J., Troke, P.F. and Yeo, A.R. 1977. The mechanism of salt tolerance in halophytes. Annual Review of Plant Physiology 28: 89-121.

Francois, L.E. and Maas, E.V. (eds.). 1985. Plant responses to salinity: An indexed bibliography. Science and Education Administration, U.S. Department of Agriculture, Berkeley, California.

Greenway, H. and Munns, R. 1980. Mechanism of salt tolerance in non-halophytes. Annual Review of Plant Physiology 31: 149-190.

Jackson, M.L. 1962. Soil Chemical Analysis. Prentice Hall, N.J.

Lunin, J., Gallatin, M.H. and Batchelder, A.R. 1964. Interactive effects of soil fertility and salinity on growth and composition of beans. American Society of Horticultural Science Proceedings 85: 350-360

Magistad, O.C. 1943. The effect of salt concentration, kind of salt, and climate on plant growth in sand culture. Plant Physiology 18: 151-166.

Pearson, G.A. and Ayers, A.D. 1960. Rice as a crop for salt-affected soil in process of reclamation, USDA Agriculture Production Research Report No. 43.

Wadleigh, C.H. and Gauch, H.G. 1944. The influence of high concentrations of NaCl, Na_2SO_4, $CaCl_2$, and $MgCl_2$ on growth of guayule in sand culture. Soil Science 58: 399-403.

Younis, F.A. and Hatata, M.A. 1971. Studies on the effect of certain salts on germination, on growth of roots, and on metabolism. I. Effect of chlorides and sulfates of sodium, potassium, and magnesium on germination of wheat grains. Plant and Soil 34: 183-200.

Short Communications

Two New Wheat Varieties in Oman

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Oman is a Gulf state where a limited amount of wheat is grown under irrigated conditions. The traditional varieties used in the Sultanate are Cooley, Missani, Sarraya, and Hamira. These varieties are tall and low yielding, tend to lodge, and are susceptible to rusts and smuts. The Ministry of Agriculture and Fisheries introduced Mexipak in the early seventies and then Sannine in the early eighties. The present report describes the performance of another two new wheat selections, W.Q.S.160 and W.Q.S.151, released in 1985/86. They are high yielders, with desirable agronomic traits and good milling quality, and are resistant to diseases. The seeds of the new varieties were received from ICARDA through its regional bread wheat yield trial in 1981/82. The pedigrees of the varieties are:

W.Q.S.160 = Nad/Jar's'//An 64/3/Son 64/4/Bb/5/ P106-19 L 491-2L-1AP-OAP

W.Q.S.151 = Sannine (D630)/Nai//Weique RM/3/2* Cno/Chr L 932-0L-11AP-OAP

Performance of the Varieties in the Sultanate

W.Q.S.160 and W.Q.S.151 were evaluated in replicated trials at the Agricultural Research Station, Wadi Quriyat, for 3 years (1981/82, 1982/83, and 1983/84) using Cooley as the national check. In 1984/85 the two varieties were planted in large areas in farmers' fields in Hamra and Wadi Quriyat along with the local Cooley. The yield data obtained at the Agricultural Research Station and in farmers' fields are presented in Table 1.

Agronomic Traits

Different agronomic traits of the test varieties were recorded during the trial period; average values are presented in Table 2. The new varieties are shorter in stature, and are resistant to lodging at higher fertilization. They have bolder, amber grain, which is preferred by the Omani farmers, and are earlier in maturity than Cooley.

Table 1. Yield (kg/ha) of the new wheat varieties at the research station and in farmers' field.

	Research station				Farmers' field 1984/85		
Varieties	81/82	82/83	83/84	Mean	Wadi Quriyat*	Hamra	Mean
W.Q.S.160	2575	2115	2544	2411	1350	3160	2255
W.Q.S.151	2240	2150	2860	2416	2060	1600	1830
Cooley	2672	987	1475	1711	1710	1350	1530

* Crops of both varieties at Wadi Quriyat were damaged by birds.

Table 2. Agronomic characteristics of the new wheat varieties (averages).

Varieties	Height (cm)	Weight of spike (g)	No. of effective tillers	Days to heading	Days to maturity	Color of grain	1000-kernel weight (g)
W.Q.S.160	80	7.7	8	75	110	Amber	39
W.Q.S.151	75	6.9	7	68	110	Amber	40
Cooley	115	6.0	10	75	140	Amber	31

Disease Reaction

It was not possible to evaluate disease susceptibility of the new varieties in Oman because no incidence of rusts and powdery mildew was reported during the test period, though these diseases are known to occur quite frequently. Reaction to rusts, therefore, was measured by ICARDA for the two new varieties at other locations, and by CIMMYT for Cooley in Kenya in 1977 (Table 3). W.Q.S.151 appears to be resistant and W.Q.S.160 moderately resistant to rusts. Both varieties are resistant to powdery mildew, whereas the local variety is extremely susceptible to both yellow and stem rusts. A moderate incidence of leaf rust was observed in Cooley during the 1985/86 cropping season.

Table 3. Disease reaction of the new varieties.

Varieties	ACI*			
	YR	LR	SR	PM
W.Q.S.160	20	16	17	5
W.Q.S.151	3	6		4
Cooley	Entire plant killed		Entire plant killed	

* ACI = Average coefficient of infection
YR = Yellow rust; LR = Leaf rust; SR = Stem rust;
PM = powdery mildew.

Table 4. Chemical analysis of the new wheat varieties.

Varieties	Moisture content (%)	Protein content (%)	Ash (%)	Test weight (kg/hl)
W.Q.S.151	8.4	12.4	1.65	78.2
W.Q.S.160	8.8	11.5	1.81	77.7
Cooley	7.5	11.1	2.03	67.0

Quality Test

Grains from the new varieties were analyzed for crude protein content, ash, moisture, and test weight (Quality unit, Oman Flour Mill). The results are presented in Table 4. W.Q.S.151 and W.Q.S.160 are higher in protein and lower in ash than Cooley, and have bolder grain. These qualities are desired for good flour. W.Q.S.151 seems to have a better quality than W.Q.S.160.

Acknowledgements

The authors are thankful to ICARDA for supplying the seeds, to Dr. G. Kingma for disease analysis of local varieties, and to Oman Flour Mill for quality analysis. Also, thanks are due to the senior staff of the Ministry for providing facilities and permission to publish this article, and to technical assistants for their help in collecting the data.

Barley as Human Food

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Barley is probably the oldest cereal food raw material, having been recorded graphically as far back as 3,000 BC (Kent-Jones and Amos 1957). In those far-off days the majority of the grain was likely consumed by humans, since domestication of animals was not widely practiced. At present, about 88% of the world's barley is used as animal feed, about 10% forms the raw material of the fermentation industry, and the remainder is consumed as human food.

These approximations refer to the use of barley worldwide; in some localities, barley-based human foods account for more than 50% of the crop, praticularly in North African countries and Ethiopia. For example, in Tunisia, about 35% of barley is consumed by humans, chiefly in the form of soups, granular staples, and bread.

Recently, a short survey of barley-based food was carried out to establish the grain characteristics that are most suitable for both primary and secondary processing. Primary processing includes decortication or dehulling, and grinding.

The barley processing factory at Sfax, Tunisia, has a capacity of 40 t/day when milling barley, and 90 t/day when milling durum wheat. Both cereals are milled into semolina-

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type products. Barley is milled into three main fractions: frik, malthouth, and tchich. Before being milled, the barley is decorticated by carborundum discs. The steps are similar to those for processing durum wheat into semolina and the various products are separated by sieves of appropriate sizes. Barley is not tempered before being milled, and the process is short, with two sets of fluted break rolls. Only two passes are needed for purifiers and plansifters to size the products.

Frik, which is used mainly in soups, is granular, having particles about one-third of the size of the original grains. Malthouth is coarse semolina, with particles of up to 2 mm in diameter. It is used in a cous-cous also, called malthouth, which is lighter in texture than wheat cous-cous and preferred for meals in summer. Tchich is a finer product, with particles of up to 1-1.2 mm. It is used, for example, in bread, usually single-layered raised bread, baked after sourdough fermentation.

Quality of barley for use in human food is judged by color and texture. For semolina milling, barley, like durum wheat, should be a vitreous grain. The preferred color is blue aleuron. Other favorable characteristics are high protein content, plump kernels, low husk content, and shallow ventral creases. The hard kernel and high protein content are diametrically opposed to the characteristics required by the fermentation industry. Consequently, from the breeding point of view, high-yielding genotypes that are unsuitable for malting and fermentation may be well suited for human food. Instead of being discarded, they should be rerouted to selection programs in areas where barley is consumed as human food.

References

Kent-Jones, D.W. and Amos, A.J. 1957. Modern cereal chemistry. 5th edition. Northern Publishing Co., Liverpool, UK.

Wheat Demonstrations in Southeastern Turkey

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A series of demonstrations was performed in six provinces in southeastern Turkey, in the 1985/86 season. Some of the cultivars had been obtained from ICARDA.

Table 1. Yield of cultivars at different locations of the demonstrations conducted in southeastern Turkey in 1985/86.

Cultivar	Locations															
	Diyarbakir			Mardin				Adiyaman			Gaziantep			Sanliurfa		Siirt
	Research station	Merkez	Hazro	Kiziltepe	Merkez	Derik	Altintoprak	Merkez	Samsa	Kahta	Merkez	Nizip	Oguzeli	Merkez	Akcakale	
	Yield (kg/ha)															
Dicle-47		2660	4660	2400	2700	3520		4158	2120	3130	2400	3500	3375	1950	1640	3400
Diyarbakir-81		2300	4830	2600	2800	3070	4000	4213	2250	3060	2000	3360	3475	2160	1300	3560
Sham I		2750	4390	2800	2800	3240	4800	4675	2200	3320	2300	3260	3675	2070	2090	3480
Sham II		2950	6010	3170		2750	4800	5665	2370	4070	2140	3500	3525	2000	1680	3260
Bezostaya I		2860	4320				3200	4765	2050	3060				2030	1250	3200
Sebou	5318															
Flk/Hork"s"	5170															
OmRabi	4458															
Korifla	4449															
Bloudan	3816															
Sorgul				2400	2400											
Iskenderi				2200			2400									

Sham 1, Sham 2, Dicle-74, Diyarbakir-81, and Bezostaya were distributed to the six Provincial Directorates of the region. Some additional ICARDA cultivars and lines including Sebou, Flk"s"/Hork"s", OmRabi, Korifla, and Bloudan were planted at the research station because of limited seed supply. Phosporus and nitrogen were applied to demonstration plots at the rates of 60 and 90 kg/ha, respectively.

The growing season was very favorable with mild winter and good rainfall distribution in spring. Grain yields are shown in Table 1.

Sham 2, a bread wheat cultivar had the highest yields in Diyarbakir, Adiyaman, and two locations in Mardian whereas Sham 1, an improved durum cultivar developed in Syria, outyielded Sham 2 in Sanliurfa, Siirt, and Gaziantep. Sebou had the highest yield among ICARDA's cultivars planted at the research station in Diyarbakir.

Sham 1 and Sham 2 seeds were again obtained from ICARDA and distributed to these six provinces for demonstrations in 1986/87. They were planted at three locations or more in each province along with Dicle-74, Diyarbakir-81, and Bezostaya. The results are awaited.

Testing for Vitreous Kernels in Durum Wheat at ICARDA

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For durum wheat (*Triticum turgidum* L. var. *durum*) in the Middle East and Maghreb countries, one key parameter of quality is vitreousness, and a high percentage of vitreous kernels is required for all products (Williams *et al.* 1984). Field screening techniques for selection of vitreous kernels in segregating and advanced test lines are still lacking and, hence, were the focus of the present study.

In the 1984 season, 318 advanced durum wheat entries were grown under four environments (Table 1) at Tel Hadya and Breda stations of ICARDA in northern Syria.

The design of the trials was a randomized complete block, with three replications and a plot size of 6 m^2. For zero-nitrogen environment, one 1.5 m-row plot was used. The seed rate (100 kg/ha) and row spacing (30 cm) were the same for all environments.

Table 1. Environments used for vitreousness testing, with their N-fertilization and water regimes.

Environment	Nitrogen application (kg/ha)	Water regime (mm)
Irrigated conditions (Tel Hadya)	120	450
Rainfed conditions (Tel Hadya)	60	300
Dry (Breda)	30	218
No-nitrogen application (Tel Hadya)	0	450

Percent vitreousness for each entry was computed using bulk seed from all replicates. For heritability studies, six crosses were studied. The crosses and their parents were grown under the zero-nitrogen environment. Regression was performed for heritability estimates (Falconer 1960).

The vitreousness of kernels was influenced by genotype, environment, nitrogen fertilization, and water regime. Zero-nitrogen environment was the most effective in differentiating the genotypes (Fig. 1). Under very dry conditions and with relatively high doses of nitrogen, the differences among genotypes were small, and hence, the selection efficiency was reduced. These results agree with those reported by Mosconi and Bozzini (1973) and Hadjichristodoulou (1979) and suggest the use of environmental conditions favoring low kernel vitreouness to enhance selection efficiency for the trait.

Also, vitreousness was associated with protein content of grain, particularly under zero-nitrogen environment ($r=0.69$), but this association was decreased when nitrogen fertilization increased, and was +0.181 under irrigated conditions. Selection for vitreous kernels using this technique in advanced entries of durum wheat is now a routine practice at ICARDA/CIMMYT joint durum wheat project (Nachit 1984).

The heritability estimates from regressions of vitreousness in F_1 plants on the values for their male, female, and mid-parents (male: 0.47 ± 0.06; female: 0.77 ± 0.09; mid parent: 0.49 ± 0.10) show that selection for vitreousness in early segregating populations is possible and suggest that the most successful crosses are made when the female parent has highly vitreous kernels.

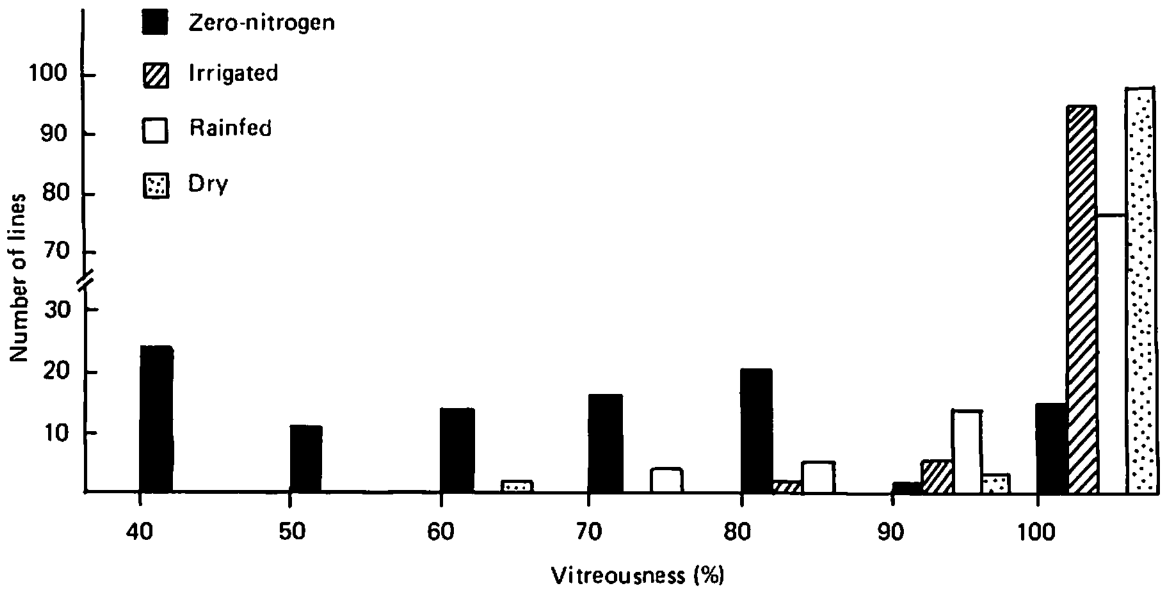

Fig. 1. Frequency distribution for vitreousness (%) in four environments, 1984.

References

Falconer, D.S. 1960. Introduction to quantitative genetics. Oliver and Boyd, Edinburgh, UK. 365 pp.

Hadjichristodoulou, A. 1979. Genetic and environmental effects on vitreousness of durum wheat. Euphytica 1979: 711-716.

Mosconi, C. and Bozzini, A. 1973. Effects of application of late nitrogen fertilizer to durum wheat. Revista di Agronomia 7: 75-82.

Nachit, M.M. 1984. Durum wheat improvement. Pages 90-105 *in* ICARDA Annual Report 1983. Aleppo, Syria.

Williams, P.C., Srivastava J.P., Nachit M.M. and El Haramein F.J. 1984. Durum wheat quality evaluation at ICARDA. Rachis 3(2): 30-33.

Effect of Fungicides on Downy Mildew in Wheat

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In order to identify an effective fungicide for downy mildew control in wheat, Folpet, Maneb, and Bordeaux mixture were tested against *Sclerophthora macrospora* (Sacc.) T.S.&N. (syns. *Sclerospora graminicola* (Sacc.) Schroet, *Sclerospora macrospora* Sacc.), on the cultivars Bahawalpur-79, V1315, Chenab-79, and C-518. The trial was conducted at the Ayub Agriculture Research Institute, Faisalabad, in 1982/83. The seeds were planted during the first week of November 1982 in five 2-m-long rows spaced 30 cm apart with a plant-to-plant distance of 5 cm in a randomized block design with 3 replications. Plants were inoculated with a spore suspension of 2 x 10^3 sporidia/ml at the early tillering stage (Large 1965) and sprayed with Folpet (1 lb per 100 gallons water), Maneb (1 lb per 100 gallons water), and Bordeaux mixture (5-5-50). The control plots were sprayed with sterile distilled water. Data on disease intensity were recorded after heading and analyzed statistically (Steel and Torrie 1980). Spraying of Bordeaux mixture, Maneb, and Folpet reduced the disease incidence as compared to the check (Table 1). Maneb was most effective, followed by Folpet. However, none of the chemicals was able to produce a 100% control.

Table 1. Effect of fungicides on downy mildew incidence in wheat.

	Diseases intensity* (%)		
Variety	**Maneb**	**Folpet**	**Bordeaux mixture**
Bahawalpur-79	30.82 a	32.91 a	34.89 a
V-1315	23.46 b	25.73 b	24.95 b
Chenab-79	15.75 c	16.79 c	16.77 c
C-518	14.69 c	14.88 c	15.46 d

* Average of three replications.
Means followed by a common letter are not significantly different at 1% level.

References

Large, F.C. 1965. Growth stages in cereals. Plant Pathology 3: 128-129

Steel, R.G.D. and Torrie, J.N. 1980. Principles and procedures of statistics, a biometrical approach. McGraw-Hill, New York, USA. 633pp.

Inheritance of Flag Leaf in Wheat (Triticum aestivum L.)

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Flag leaf is an important yield contributing factor in wheat. The present investigation reports on the inheritance of flag leaf in wheat.

Two wheat cultivars, HD-1553 and Local (Deshi), possessing long and short flag leaves, respectively, were crossed and data were recorded for the F_1 and F_2 generations. The goodness of fit of the assumed ratio in F_2 was tested using a X^2 test.

The F_1 plants bore long leaves and the F_2 plants segregated to a close ratio of 9 long and 7 short (104 long and 88 short, $X^2 = 0.338$). This suggests that flag leaf in this wheat cross may be controlled by two dominant complementary genes.

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Cereal Germplasm Collection Mission to Morocco

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5. INRA, Agdal, Rabat, Morocco

Following the report and recommendations of an earlier germplasm collection expedition in 1984 to southern Morocco, involving scientists from ICARDA; the Germplasm Institute, Bari, Italy; and the Moroccan national program, it was decided to mount a second expedition in the north and east of that country during June 1987. The second joint mission comprised scientists from ICARDA, the National Agricultural Research Center, Japan, and the Institut National de la Recherche Agronomique (INRA), Morocco. The use of recently released varieties is taking over the landraces much faster than anticipated, in the case of barley.

In all, 188 germplasm samples were collected: 59 barley (all *Hordeum vulgare* except one which was *H. distichum*, now a rarity in Morocco), 57 *Triticum durum*, 50 *T. aestivum*, 7 *H. bulbosum*, 5 *Aegilops* spp., 3 *H. murinum*, 2 *Avena sativa*, 2 *Brassica* spp. (used mainly as forage), 1 *Vicia faba*, and 1 *Phaseolus* spp. One of the *Triticum* spp. was a primitive form, probably *dicoccum*.

The Mid-Atlas mountains, which were previously reported to be difficult for exploration (Perrino *et al.* 1986), were partially covered during this mission, and the variability of germplasm still present was collected essentially from standing crops as well as from threshing floors and farmers' stores. Higher variability was observed and collected from the end limits of distribution of cultivated cereals in Oujda region, south of Ain Beni Mathar, bordering the Hamada desert. This was expected according to the hypothesis of 'peripheral diversity' put forward by Yamashita (1979).

The cereals were usually planted in October-November and harvested in May-June depending on temperatures and rainfall during the growth cycle. The terrain explored ranged from the sea-level to elevations about 1800 m in the Mid-Atlas mountains. The sampling sites included saline ones a few meters from the sea (Tetuan area); highly irrigated, in the mountain gorges (L'Hociema area); and very dry, in the proximity of the desert (south of Oujda area).

H. murinum is specially interesting as it forms part of the secondary genepool of barley and may be useful for crossing. However, incompatibility with cultivated forms persists. According to Grando *et al.* (1985), this wild form possesses genes for disease resistance, drought resistance, and cold tolerance.

Among the many types of wheat observed there were two samples of durum landraces that had extremely tough stems at maturity. The spikes could not be broken off for collection as usual. Secateurs had to be used to cut the stalks just below the base of the spike. Later, it was noticed that the stem was completely solid almost down to the base of the plant. In other cases, especially near the areas bordering the desert in the Oujda region, the plants separated from the soil at the slightest tug at the spikes. The root system in these cases was poorly developed and extremely shallow.

Hordeum bulbosum, which is useful for haploid breeding techniques, was found growing on the borders of fields along the roadside. It derives its name from the bulbs that are found on the roots. Several bulbs per population were collected. *Aegilops* spp. were also sometimes found in association with *bulbosum* or the other wild barley, *H. murinum*. In some cases, especially in the high Atlas mountains, the crops as well as wild species were still immature. Also, wherever irrigation was used, the crops were late maturing, as can be expected.

Although many farmers professed non-existence of diseases or pests in their fields it was obvious from casual observation that this was not entirely true. In the case of barley, many areas with relatively high rainfall were infected with *Ustilago nuda* subsp. *hordei* or loose smut. Wheat was sometimes infected with *Puccinia graminis* subsp. *tritici* or stem rust and *P. recondita* or leaf rust. In some cases *Tilletia caries* or common bunt was also observed. Samples collected from such sites have been noted and will be evaluated in isolation. *Septoria tritici* or leaf blotch was also observed where maturity was delayed.

It can be said that the north and the east of Morocco have now been adequately covered so far as collection of germplasm of cultivated cereals is concerned. The low amount of variability encountered by this mission points to the extensive genetic erosion which has already taken place. However, if particular wild species such as *Aegilops* or *H. bulbosum* need to be collected, it would be worthwhile to organize collections at end of June by which time these are very close to maturity.

On completion of this mission, the collected germplasm was brought to INRA headquarters in Rabat, threshed and cleaned, and divided among INRA, NARC (Japan), and ICARDA. The samples will be multiplied and evaluated at ICARDA during the 1987/88 season.

There are two deep-freezers for long-term storage and some other equipment in use at the national genebank at INRA in Rabat. It is hoped that the germplasm, which has been left with Moroccan scientists, will be evaluated, multiplied where required, and conserved together with the 175 entries from previous missions repatriated by ICARDA in November 1986.

Acknowledgments

The assistance of Dr. M. Mekni, ICARDA cereal scientist based in Rabat, Morocco, is acknowledged. Thanks are also due to the Moroccan authorities, particularly Dr. H. Faraj, Director General of INRA, for the permission to collect germplasm and the participation of local personnel without which this mission would not have been possible. The Moroccan farmers and local persons not only gave samples of their crops most generously, but also overwhelmed the team members with their traditional hospitality.

References

Grando, S., Falistocco, E. and Ceccarelli, S. 1985. Use of wild relatives in barley breeding. Genetica Agraria 39: 65-76.

Perrino, P., Polignano, G.B., Yau, S.K. and Khouya-Ali, M. 1986. Collecting germplasm in southern Morocco. Plant Genetic Resources Newsletter 65: 26-28.

Yamashita, K. 1980. Origin and dispersion of wheats with special reference to peripheral diversity. Z. Pflanzenzuctg. 84: 122-132.

A Case for World Survey of Barley Germplasm

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In RACHIS Vol. 6(1), pp 14-17, I summarized the deliberations of a workshop on barley germplasm conservation held during the fifth International Barley Genetics Symposium in Okayan, Japan, in October 1986. Several participants argued in favor of a comprehensive survey of diversity in genetic resources of barley. One of the main reasons for such a survey is to understand the current status of genetic diversity in preserved materials, so that future strategies in collection, preservation, and enhancement of genetic diversity in *Hordeum* spp. can be formulated on the basis of sound factual evidence, rather than speculation. This is an area where many geneticists, plant breeders, and genetic conservation administrators in national and international agencies have diverse, and sometimes opposing viewpoints, but little or no factual evidence. A world survey of diversity in barley would go a long way towards elevating the discussion on genetic conservation of barley above the level of speculation.

In a recent personal correspondence, a genetic conservation officer raised two important questions relevant to the proposed world survey of barley genetic resources:

(a) What purpose would this survey serve and how can a survey be conducted without first collecting germplasm? That is, what comes first, collection or survey?

(b) Because it is impossible to survey diversity for an infinite number of characters, how does one choose a representative set of characters of manageable size? For example, one can easily envisage a population growing in waterlogged soils and exposed to disease pressure being uniform for enzyme systems that are tolerant of anaerobic conditions, but diverse for alleles at gene loci encoding for response to diseases. In these circumstances, what is the most appropriate character for a survey of genetic diversity?

It is not easy to answer the above questions. Because no such world survey of genetic diversity in any wild or cultivated species has ever been carried out, the results of a hypothetical survey are difficult to predict. One might, however, expect to find a number of useful results emanating from a global survey of diversity in barley, or similar other economic species. Some of these are listed below.

On World Survey of Diversity in Barley

(a) A world survey of genetic diversity, i.e., a survey of barley accessions available in gene banks and other sources throughout the world, may be carried out to determine levels of diversity in different regions. If we discover a region of high diversity (say, Tibet) from which very few collections are available, then this region should receive high priority in planning future collection missions. On the other hand, a region with low diversity and relatively few accessions may not receive high priority.

(b) If a survey of several successive collections in a region (say, Turkey) reveals the same level of diversity, e.g., USDA, Okayama and my own 1984-85 collections of barley (see RACHIS 6 (1), pp 12-14), we may infer with some degree of confidence that representative diversity has been captured or adequate collections have been made from the target region.

(c) Comparisons of diversity in temporally distinct collections from the same region would provide information on the rate of genetic erosion in the region, if any, leading to an appropriate future collection strategy for the region.

(d) A global map for average diversity, as well as diversity for specific characters of importance can be developed. This would be helpful in planning future explorations for general-purpose, as well as specific-purpose collections.

(e) The discovery of unusually high diversity or high frequency of hybrid swarms between cultivated and wild species in well defined areas, might encourage research in population dynamics and ecogeography to elucidate many basic questions on conservation of genetic diversity in natural and agricultural populations of barley. This in turn might help identify optimal conditions for conserving genetic resources *en masse* under natural or agricultural conditions.

On Suite of Characters

The choice of an appropriate set of characters for a world survey of diversity is more difficult to answer. Populations exposed to natural or conscious selection for many generations would adjust gene frequencies, and therefore, genetic diversity for characters related to fitness. Without compensating evolutionary processes for creating and preserving diversity, continued deployment would lead to the depletion of diversity for these characters. If through errors of sampling, one chooses most of these characters for the proposed global survey of diversity, then the downward bias in estimates of average diversity is obvious. The choice of a *representative set* of characters is important in population biology, just as the choice of an appropriate set of questions in a questionnaire is important for a valid survey of public opinion. One might hope that, if a judicious choice of characters representing different attributes of an organism (e.g., aspects of emergence, growth, development, and reproduction) is made, then despite the occurrence of some rare populations in special environments, a global survey would provide very useful information on diversity in that species. For example, a population of wild barley in a desert-like environment in Jordan is likely to be nearly monomorphic for drought tolerance, but has no apparent reason to be monomophic for resistance to scald, because of the absence of selection pressure for the disease in very arid areas. This would give an intermediate estimate of average diversity for this population, but not necessarily for an estimate of overall diversity for the country or the region. Once we quantify polymorphism, we shall be in a strong position to investigate the causes of monomorphism, applying standard principles in ecology and population genetics.

In summary, I recommend characterization and evaluation of the large number of barley accessions in the global network of gene banks, employing as many characters as possible, and then using these results as a model for strategic research in other species. This survey would also have the salutary effect of reducing the gap between the very large number of barley accessions preserved in various gene banks and genetic resources centers, and their utilization in breeding and research.

Use of Kernel Weight as a Criterion for the Selection of Productive Mutants in Wheat

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Induced mutation has been successfully used to develop improved cultivars in several crops (Micke *et al.* 1985). However, a major problem in mutation breeding is the identification of productive mutants in the early generations.

Seeds of two bread wheat (*Triticum aestivum* L. em. Thell) cultivars, Nuri and Yecora, were irradiated using different doses of gamma rays (100, 150, 200, 250, and 300 Gy) and fast neutrons (4.5, 6.0, 7.5, 9.0 and 10.5 Gy). Three spikes per M_1 plant were harvested and M_2 plants were raised as spike progeny in 2-m rows. At maturity, 320 M_2 plants were selected on the basis of field performance but only 90 were retained, which had a higher kernel weight than the respective mother cultivar. In the M_3 generation, 34 mutants were selected on the basis of their field performance. Further selection based on 1000-kernel weight led to the identification of four mutants each from Yecora and Nuri. These eight mutants, along with the two mother cultivars, were evaluated in the M_4 and M_5 generations for grain yield in replicated experiments. In the M_4 generation, one mutant derived from Nuri (M-160) and two from Yecora (M-169 and M-172) produced higher grain yields than the respective parents. In the M_5 generation, three Nuri and four Yecora mutants outyielded their respective parents (Table 1).

The results also showed that both gamma rays and fast neutrons enhanced tiller number per unit area.

This study suggests that kernel weight may be used as a selection criterion for an early identification of productive mutants in bread wheat.

Reference

Micke, A., Maluszyński, M. and Donini, B. 1985. Plant cultivars derived from mutation induction or the use of induced mutants in cross breeding. Mutation Breeding Review 3: 1-92.

Table 1. Characteristics of productive mutants derived from Yecora and Nuri (M_5 generation).

Mutant/Mother cultivar	Mutagen (GY)	Tillers per 900 cm^2	Grain yield (kg/ha)	Grain yield of mutants relative to mother
Yecora	Fast neutrons			
M-172	10.5	61.25	3760	155
M-169	7.5	54.25	3603	111
	Gamma rays			
M-166	200	48.25	3528	108
M-165	150	44.00	3360	103
mother cultivar		30.00	3257	100
Nuri	Fast neutrons			
M-163	7.5	54.50	2997	129
M-160	4.5	53.50	2452	106
M-162	6.0	54.50	2397	103
mother cultivar		42.50	2320	100

Recent Publications

Harrabi, M. 1986. (Diseases of wheat and barley). Maison Tunisienne de l'Edition, Tunisia. 163 pp. In Arabic.

The book (163 pages, 121 color photographs), covers the major wheat and barley diseases caused by bacteria, micoplasma, fungi, viruses, and nematodes as well as physiological diseases. It also contains field methods of assessing various groups of diseases, namely, rusts, smuts, and foliar diseases. Symptoms, causal organism, disease cycle, and control measures are given for each disease.

Srivastava, J.P., Porceddu, E., Acevedo, E. and Varma S. (eds.). 1988. Drought tolerance in winter cereals. Proceedings of an International Workshop on Developing Improved Winter Cereals for Moisture Limiting Environments, CNR-IPRA/ICARDA, 27-31 Oct 1985, Capri, Italy. John Wiley, Chichester, West Sussex, UK. 384 pp.

This text book covers the proceedings of an international meeting jointly held by CNR-IPRA and ICARDA in Capri, Italy, in October 1985, on a variety of techniques used to improve strains of winter cereals for dry environments. It contains papers presented by leading scientists who attended the meeting, and discusses the use of plant physiology in crop improvement for the moisture-limited areas of West Asia and North Africa. Recommendations for action in the short and medium terms are also given.

Lerin, F. (ed.) 1986. Céréales et produits céréaliers en méditerranée. Actes du colloque de Rabbat, Maroc 6-8 Mars 1985. INAV-HII.-CIHEAM/IAM, Montpellier, France. 336 pp.

This volume of proceedings of a workshop on cereals in the Mediterranean region held in 1985 in Rabat, Morocco, is divided into two parts. Part I includes presentations from 12 Mediterranean countries: Morocco, Algeria, Tunisia, Egypt, Lebanon, Turkey, Greece, Yugoslavia, Italy, France, Spain, and Portugal. Numerous aspects of cereal production are presented with main emphasis on economic problems. Useful statistics are reported for each country including area, production, imports, and exports. Part II deals with the complex factors and international relations regulating cereal trade in the region. The book can be ordered from:

Institut Agronomique Méditerranéen de Montpellier
Service des Publications
3191 Route de Mende
34060 - Montpellier CEDEX/FRANCE

Varughese, G., Bakey, T., and Saari, E. 1987. Triticale. CIMMYT, Mexico, D.F. 32 pp. ISBN 968-6127-11-9.

This publication gives a brief account of CIMMYT's role and contribution in triticale development and summarizes the history of this hybrid from the earliest reports to the last important events in 1986. The major obstacles that have impeded triticale development and the breakthroughs that have helped promote its production are discussed.

Dalrymple, D.G. 1986. Development and spread of high yielding wheat varieties in developing countries. AID, Washington, D.C. USA. 99 pp.

This report reviews the development of high-yielding wheat varieties (HYWVs) and their use and adoption in developing countries in a period extending from the mid-1960s, when the HYWVs were introduced, until the 1980s. The extent of adoption is determined according to the area planted at the national level whenever data are available. The text puts major emphasis on short, generally semidwarf varieties which are fertilizer-responsive. In general, those varieties have been bred at one of the international agricultural research centers -- or are an offspring of a center line or a variety -- and have been further developed in national breeding programs.

Eyal, Z., Scharen, A.L., Prescot, J.M. and van Ginkel, M. 1987. The septoria diseases of wheat: concepts and methods of disease management. CIMMYT, Mexico, D.F. 46 pp. ISBN 968-6127-06-2.

This publication summarizes the most important and relevant scientific reports for managing the two major septoria pathogens. Research data are interpreted into concepts and procedures. Topics include the biology of the fungi, infection process, collection and handling of infected material, isolation and maintenance of the fungi, inoculum production, artificial inoculation, disease assessment, epidemiology, pathogen specialization, breeding for resistance, and means of cultural and chemical control. Each treatment of a topic or group of alternative methods is followed by the recommendation of one or more preferred techniques or approaches. This information should be useful to wheat scientists in developed and developing countries who are unfamiliar with those diseases.

Stubbs, R.W., Prescot, J.M., Saari, E.E. and Dubin, H.J. 1986. Cereal disease methodology manual. CIMMYT, Mexico, D.F. 46 pp.

Wheat diseases are still among the major contributors to year-to-year yield instability in developing countries. In an attempt to counter this evergrowing threat, the Research Institute for Plant Protection (IPO), Wageningen, The Netherlands, and the International Maize and Wheat Improvement Center (CIMMYT), Mexico, initiated the Regional Workshops on Cereal Disease Methodology to develop or strenghen plant pathology research activities in national wheat improvement programs in developing countries. These workshops, in which approximately 290 scientists from 40 developing countries have participated, have now been held in 11 locations around the world. This manual includes the principal topics developed in these workshops, providing a concise review of principles and clear methodologies appropriate to research conditions in the developing world.

Bernard, M. and Bernard, S. (eds). 1985. Genetics and breeding of triticale: Proceedings of the Third EUCARPIA Meeting of the Cereal Section on Triticale, INRA, 2-5 July 1984, Clermont-Ferrand, France. 703 pp. ISBN: 2-85340-712-8.

This book provides proceedings of the third EUCARPIA Meeting of the Cereal Section on Triticale which brought together 109 delegates from 25 different countries. The 76 papers presented during the meeting tackled various fields of research: molecular biology, cytogenetics, *in vitro* culture, the genetics of wheat-rye interactions, methodological approaches for the improvement of certain characteristics, breeding problems, biochemical aspect tied to utilization, varieties, and cultural development.

Hill, R.D. and Munck, L. (eds). 1985. Progress in biotechnology 1. New approaches to research on cereal carbohydrates: Proceeding of the International Conference on New Approaches to Research on Cereal Carbohydrates, ICC, 24-29 June 1984, Copenhagen, Denmark. Elsevier Science Publisher B.V. Amsterdam, The Netherlands. 415 pp. ISBN 0-444-42434-2.

This volume should be of interest to a wide and diverse group ranging from the basic research scientist to the industrial technologist. The topics vary from a discussion of the number of binding sites on an enzyme and the use of starch polymers or granules in the production of biodegradable films, to the structure and utilization of straw cellulose fibers for feed and paper making.

Khatilova, L.V., Tarutina, L.A., Bojko, E.E., Atrashinov, N.V., Elshenko, V.P., Bormotov, V.E., Sherbakova, A.M., Volodun, V.G., Lobotskya, L.E., Reimkulov, K.R., Bobodjanov, V.A. and Kravtsova, A.C. 1986. (Triticale; development and utilization). Nauka i Technika, Minsk, USSR. 215 pp. In Russian.

This text book reviews the latest developments pertaining to triticale in terms of production and improvement. Biological characteristics including morphological and biochemical traits as well as cytological aspects are discussed. The book also presents various methods for selection and genetic improvement of triticale and is recommended for biologists, geneticists, breeders, and agronomists, as well as lecturers and postgraduates in the field.

Cereal News

Dr. E. Acevedo, Cereal Agronomist/Physiologist at ICARDA, visited the Field Crops Research Institute (FCRI) in Ankara on 13-17 Oct 1987 under the 1987/88 ICARDA-Turkey cereal plan, and met with Drs. B. Yilmaz, M. Guler, and N. Durutan, Director, Vice-Director, and Head of the Agronomy Department of the FCRI, respectively.

The objective of the visit was to discuss with Turkish scientists ways and means of introducing crop and plant physiology concepts into agronomical and breeding research for stress-prone rainfed environments.

A research plan to study the adaptation of potential cereal varieties to the major Turkish agroecological environments was developed and will be implemented with the participation of Turkish scientists. In addition, a workplan was drawn and will be carried out by Mr. M. Avci, a Turkish scientist at the Agriculture Department of the FCRI working on his Ph.D. thesis, during his training at ICARDA in the 1987/88 season. This plan has been specifically designed to meet the needs of Turkey in the field of physiology/agronomy.

Dr. Acevedo also presented a seminar on the "Mechanism of Adaptation of Barley and Wheat to Stressful Environment" to about 30 scientists of the FCRI, and explained ICARDA's approach to stress physiology studies.

Drs. Guler and Durutan showed a keen interest to visit ICARDA sometime during March 1988 and it was agreed that Dr. Acevedo would visit field trials in Turkey at the end of May or begining of June 1988.

Dr. Omar F. Mamluk, Cereal Pathologist, visited Saudi Arabia from 2 to 13 April, 1988 to conduct an in-country training course on identification, diagnosis, and control of barley and wheat diseases. The 5-day course, which involved 12 students in Riyad (8 B. Sc. and 4 Diploma holders) and 26 in Unayzah/Qassim (9 B. Sc. and 17 Diploma holders), consisted of three classroom lectures, one laboratory visit, and one field orientation.

Dr. Guillermo Ortiz Ferrara, CIMMYT/ICARDA Wheat Breeder, visited the National Program of Egypt from 17 to 25 April 1988. He assisted cereal scientists in the plant selection and evaluation of wheat germplasm. In 1987, Egypt released four bread wheat and two durum wheat varieties:

- Sakha 92 = Napo 63//INIA 66/Wren's'
- Giza 162 = Pavon's'
- Giza 163 = *T. aestivum* - BON X CNO - 7C
- Giza 164 = Veery 5
- Sohag 2 = Cr 's' - PLC 's' X Cr 's' - Gs 's'
- Benesuif 1 = Bittern 's'

Drs. J.P. Srivastava, Leader, Cereal Improvement Program; R.H. Miller, Cereal Entomologist; and A. Zahour, Cereal Breeder, attended the 20th Annual National Crop Improvement Conference (NCIC) in Addis Ababa (28-30 March) and held discussions with Ethiopian breeders and entomologists during their 10-day visit to Ethiopia, 27 March - 6 April 1988. Topics discussed in the 20th NCIC covered the entire range of agricultural commodities produced by Ethiopia, as well as associated problems of technology, marketing, policy, etc. A final draft of a joint ICARDA/IAR barley project (whose basis was laid during earlier visits to Ethiopia by Dr. S. Ceccarelli and Ir. J.A.G. van Leur) was prepared in consultation with Dr. Seme Debela, Manager, IAR and Mr. Fekadu Alemayehu, Barley Breeder and Project Leader. The proposal has been forwarded to SAREC. Drs. Srivastava, Miller, and Zahour also visited fields surrounding Holetta where, as is the case for Ethiopia in general, barley spot fly, *Delia arambouigi*, and the Russian wheat aphid, *Diuraphis noxia* dominate. The last named species has inflicted a 40-70% loss to barley yields in Ethiopia this year. Ethiopian entomologists have tentatively identified two barley landraces with resistance to this insect, and are trying to isolate a fungus which attacks it, in order to test it later on as a biological control agent. On the other hand, ICARDA plans to send a few aphid resistant and sawfly resistant lines for testing in Ethiopia against both insects.

Dr. Hugo Vivar, ICARDA/CIMMYT Barley Breeder based at Mexico, visited Bolivia and Peru in April 1988. He reported that in 1987 Peru released three varieties, two of which, Una 87 and Nana 87, came as a result of an early generation selection of a population sent from the ICARDA/CIMMYT program. These varieties were released by the Agrarian University which is the leading barley breeding organization in the country.

Dr. A. El-Ahmed, Associate Professor at the University of Aleppo and ICARDA's consultant for the cooperation program with the Agricultural Research Authority (ARA) for cereal improvement in the Yemen Arab Republic (YAR), visited the YAR in November 1987 and discussed with ARA officials the possibility of replacing the bread wheat variety Maarib 1 (Pavon 76), which is reported to have become susceptible to stem rust in Yemen, by two newly identified lines, Aziz (Seri 82) and Mukhtar (Veery 7). Both lines showed superior performance in on-farm trials in terms of biological yield and disease resistance. ARA is preparing the necessary documents for the official release of these lines to the Yemeni farmers.

Previously, in summer 1987, Dr. El-Ahmed had paid a visit to the YAR (from June 24 till Jully 8) during which a cooperative cereal improvement program between ARA and ICARDA was formulated. The cooperation provides ICARDA's assistance to ARA in an expanded breeding program with testing sites covering a wide range of agroclimatic zones. ICARDA will send specially selected exogenous lines to the YAR for further screening and crossing and will supervise on-farm trials covering the different environments encountered in the YAR.

In addition, three graduates at the B.Sc. level will be trained in 1988 at ICARDA in wheat and barley breeding, machinery and farm management, and pathology. An in-country training course for about 19 trainees, to strengthen the technical and practical knowledge of researchers working in the cereal program at ARA, will also be conducted in 1988.

Dr. El-Ahmed, as well as other ICARDA scientists, will be visiting ARA regularly.

Dr. W.V. Single, New South Wales Department of Agricultural Research Center, Australia, has kindly sent seeds of frost-tolerant wheat lines to ICARDA. These seeds will be used by Drs. M. Tahir and G. Ortiz-Ferrara in the breeding program.

Dr. E.A. Heinrichs, Head of the Department of Entomology, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, sent a letter of thanks to Dr. R.H. Miller, Cereal Entomologist at ICARDA, for providing the material on host plant resistance. He said "the papers received provided exactly what I needed for my presentation at Monterey, CA.", and added that he was "very favorably impressed with the excellent progress that has been made in just a few years."

Mr. Issam Naji, Cereal Agronomist at ICARDA, visited Sidi Bel Abbas Station, Algeria, in November 1987. The objective of his visit was to train the new Cereal National Program staff on seed preparation, trials layout, and calibration and use of the Ojyord drill, as well as to help in planting on-farm and demonstration trials. The work-plan for off-station sites during the 1987/88 season at Sidi Bel Abbas covered four agroecological zones where 22 different types of trials were to be planted at 12 locations. Mr. Naji met with Mr. Ben Seddik, Head, ITGC station at Sidi Bel Abbas and Dr. A.R. Belaid and Mr. Ladada Mohamed at El Harrach where he gave a summary on his mission.

Following the Workplan of the ARC/ICARDA-OPEC Project, Sudan, **Dr. M.S. Ahmed,** Cereal Pathologist at the New Halfa research station, spent three weeks (13 March - 2 April 1988) at the Institute of Plant Pathology of the Agricultural Research Center, Giza, Orman, Egypt where he got acquainted with the work of Dr. Abdel Hak on stem and leaf rust. He then visited for one week the Phytopathology Laboratory of the National Institute for Plant Improvement (ENMP), Elvas, Portugal where he was informed about the disease (leaf rust) techniques and methodologies used in that laboratory, headed by Mrs. M.J. Goncalve. The next destination in Dr. Ahmed's tour was ICARDA, Aleppo, Syria where he stayed from 10 to 17 April and got acquainted with the cereal disease work and facilities and discussed relevant research issues with Dr. O.F. Mamluk and Ir. J. van Leur.

Dr. A. Hajichristodoulou from the Agricultural Research Institute (ARI), Cyprus, attended the Eucarpia meeting in Lusignan, France (20-26 Sept. 1987), where he presented his work on *Hordeum spontaneum*, a part of the joint collaborative research program between ARI and ICARDA. He suggested that since areas under dry Mediterranean climates were short on roughages due to the little success of loliums and medics in such environments, the use of *Hordeum spontaneum*, a native crop in most Mediterranean countries, in breeding for self-regenerating pasture barley could be of great value. It is adapted to very dry areas, grows very fast, competes efficiently with weeds, and produces large quantities of forage for grazing. A breeding program was initiated for this purpose at ARI in 1983 and the available data are very encouraging.

Dr. Yousef Rushdi has replaced Mr. Zulkifl Ghosheh, director of the National Center for Agricultural Research and Transfer of Technology (NCARTT) in Jordan who retired in October 1987.

Dr. Fekadu Alemayehu from the Institute of Agricultural Research (IAR) in Ethiopia sent a letter of thanks to ICARDA on behalf of the barley research staff in Ethiopia for holding the Barley Regional Workshop in Addis Ababa, 7-10 Oct. 1987, and for the training course organized for barley research workers in Ethiopia. Dr. Alemayehu said that participants from Kenya, Tanzania, and Nigeria have participated in the workshop and discussed various issues pertaining to barley improvement in the region and to future collaborative research work with ICARDA.

Dr. Tesfaye Tesemma, Durum Wheat Breeder, Debre Zeit Agriculture Research Center, Ethiopia, sent a letter to the Leader, Cereal Improvement Program to inform that the following nurseries provided by ICARDA to the Debre Zeit research center and its off-stations (Koka and Cheffe Donsa) were planted during the 1987 season (June-December).

(a) Durum wheat yields trials, moderate rainfall, at Debre Zeit;
(b) Durum wheat observation nursery, moderate rainfall, at Debre Zeit;
(c) Durum wheat crossing block, at Debre Zeit;
(d) Durum wheat yield trial, low rainfall, at Koka;
(e) Durum wheat observation nursery, low rainfall, at Koka; and
(f) Durum wheat observation nursery, high altitude, at Cheffe Donsa.

In addition, two F_2 segregating populations were also planted at Debre Zeit (132 entries) and Cheffe Donsa, high altitude (150 entries). Leaf and stem rust were very heavy at both locations. At Debre Zeit, two single plants were selected from entry number 17, while at Cheffe Donsa two to six single plants were selected from the following entries: 13, 16, 17, 23, 32, 36, 42, 45, 46, 48, 49, 50, 51, 53, 59, 61, 65, 69, 70, 72, 75, 83, 85, 88-92, 94-96, 98, 99, 101, 102, 114, 115, 118, 119, 123, 125, 126, 132, 135, 136, 138, 139, 141, and 146.

Dr. Tesemma said it would be appreciated to see a scientist from the Cereal Improvement Program, ICARDA, visit the experimental sites in Ethiopia to identify the material needed and to evaluate ICARDA's nurseries performance there.

The International Symposium on Problems and prospects of Winter Cereals and Food Legumes Production in High Elevation Areas of West Asia and North Africa was held at Ankara, Turkey, 6-10 July 1987. The symposium, sponsored by the Turkish Ministry of Agriculture, Forestry, and Rural Affairs, and ICARDA, mainly aimed at characterizing the agroecological conditions of the high-elevation areas, identifying major constraints to production, reviewing the research status related to those areas, suggesting a set of recommendations for future development, and working out an action plan at national and international levels.

Participants to the symposium came from several agricultural institutes and universities of Afghanistan, Algeria, China, the Federal Republic of Germany, Iran, Iraq, Morocco, Nepal, Pakistan, Turkey, the United Kingdom, and the USA, and from international organizations (CIMMYT, FAO, ICARDA, ICIMOD, and IFPRI). Drs. J.P. Srivastava, M. Tahir, A. Zahour, E. Acevedo, S.K. Yau, M. Nachit, and G. Ortiz-Ferrara represented ICARDA's participation. On 8 July the participants visited the research plots at Haymana Research Farm of the Central Anatolian Regional Agricultural Institute, Ankara.

The meeting made the following recommendations:

- A research network should be established to encourage research to solve the various problems limiting crop production in these areas which have so far remained neglected, with the exception of the Anatolian plateau, by both national agricultural research systems and international organizations.
- As a massive land area (up to 50% in many cases) is mountainous in Asia and North Africa, this area may be divided into the following six major zones for the purpose of networking: Central Anatolian Plateau, western Iran, and eastern Turkey; Baluchistan-Pakistan, Afghanistan, and central Iran; subtropical temperate Himalayas; Atlas Mountains in North Africa; and Mountainous areas of China. Additional zones and subzones may be identified when more information becomes available.

A network of research stations in the six identified zones should develop datasets for environmental parameters and crop plant responses that will permit a clear-cut definition of subzones and realignment of the major zones, and assist scientists in targetting their crop improvement efforts.

Frost tolerance/cold resistance early in the season and heat tolerance/drought resistance at later stages are the major stress factors for consideration in developing germplasm material. Diseases, insects, lack of production technology, non-availability of inputs, and socio-economic factors also constrain productivity, and should be taken into consideration. The incorporation of multiple disease resistance and drought resistance in cold-tolerant genotypes and high-yielding germplasm might be an effective contribution of international centers and other international programs participating in the network.

- Joint nursery trials should be conducted to identify varieties adapted to different regions and acceptable for end use by the farmers.
- Suitable genetic stocks/germplasm should be developed to meet various agroecological conditions of the different zones through the application of various methods including classical breeding and biotechnology.
- Agronomy trials should be conducted to define suitable agronomic practices to be adopted. The Turkish National Program has taken leadership in developing production techniques for upland areas and can therefore play a key role in this field.
- Skilled manpower should be developed to strengthen research, and appropriate training should be conducted with full participation of experts from national programs and international centers.
- Network participants should visit the various research sites and meet annually to discuss results and plan the work for the future. A quick dissemination of information among the network participants from international centers and programs is also necessary.
- Special funding is needed because of the limitation of the resources of the network.
- It is urged that participating countries attempt to reinforce work on farming systems and socioeconomic factors in high-elevation zones of the region and to carry on this work in parallel with the agronomic and breeding programs to help guide the development of technology.

A cereal coordination meeting was held in Tunisia on 17-19 Sept 1987 and was attended by researchers from ICARDA, INRAT, INAT, and the Office des Céréales to review the 1986/87 activities and make plans for the 1987/88 season.

It was noticed that, on average, yields during the 1986/87 season were better than those in the 1984/85 season. Durum wheat yield increased by 21%, bread wheat by 0.6%, and barley by 15.2%. The highlight of the research work on durum improvement was the proposal for release of a new line, Razzak, selected from a cross made locally in Tunisia. This line has yielded up to 10 t/ha under large-scale multiplication. A bread wheat line, BT 2703, was also proposed for release under the name of Byrsa. It has an excellent resistance to lodging and good resistance to yellow rust and septoria. In barley, Rihane "S" continued to show its superiority over most genotypes, and was therefore proposed for release. Rihane gave an average yield of 5.1 t/ha over five trials in dry areas. Other trials were also conducted at 11 sites to test the yielding ability of the newly released cultivars, evaluate the nitrogen response, the optimum seed rate, and the effect of weed control on yield.

In terms of seed quality, the cereal technology laboratory at INRAT has been provided with 1359 genotypes for their characterization for major quality parameters, and 6,000 tests have been carried out on this germplasm.

During 1987/88, a virulence survey was carried out in collaboration with INAT. Scald and net blotch were tested for their virulence, and the results of this work were communicated to ICARDA. The survey is being continued in 1987/88.

Due to the high rainfall which marked the 1986/87 growing season and which aided in the expression of some foliar diseases, a disease survey arranged with ICARDA identified flag smut as an important disease in the semi-arid areas.

With respect to the 1987/88 crop season, it was decided that cooperation between ICARDA, INRAT, INAT, and the Office des Céréals will continue. ICARDA will keep on supporting the National Program, and research work in the area of breeding, pathology, agronomy, and cereal quality will continue as in previous years. In addition, two senior Tunisian scientists will visit Morocco, one or two others will be expected at ICARDA in Aleppo, and a regional travelling workshop will be organized in Algeria and Tunisia.

A delegation of the Chinese Academy of Agricultural Sciences (CAAS) and scientists from the Cereal Improvement Program (CP) of ICARDA held a coordination meeting at ICARDA heaquarters, in accordance with a memorandum of understanding signed on 20 Aug 1987. The objective of the meeting was to develop a work-plan for a cooperative research project in winter cereal between the CAAS and CP to be implemented during the 1987/88 and 1988/89 seasons.

The Chinese delegation, headed by Dr. Liu Zhicheng, Vice-President of the CAAS, presented a general picture of barley and wheat status in China where feed and malting barley fields spread over an area of 2.7 million hectares, while wheat (almost exclusively bread wheat), China's second most important crop after rice, occupies 27 million hectares. Interest in durum wheat, however, has only started recently and the CAAS delegation was keen on cooperating with the joint ICARDA/CIMMYT durum project.

The work-plan agreed upon for the coming 2 years stipulates that ICARDA will provide barley, bread wheat, and durum wheat germplasm and breeding material for testing in China according to further requests from the CAAS. The CAAS will send a senior barley and a wheat scientists to ICARDA from 15 April till 15 May 1988, while a team from ICARDA (CP) will pay a 2-week visit to China starting 25 May 1988. The team will meet with Chinese breeders in Beijing to decide on two research stations for experimental as well as large-scale testing of the ICARDA material.

In addition, the CAAS will (i) send an M.Sc. graduate student to conduct research at ICARDA for a Ph.D. degree in 1988 if funds are available, (ii) provide one barley pathologist as a visiting scientist to ICARDA for a period of 4 months in 1988, (iii) provide a senior scientist for research on drought tolerance in 1989, and (iv) identify one trainee for the residential course on drought (barley) in spring 1988.

ICARDA, in collaboration with CAAS, will hold one in-country training course of about 2 weeks on barley improvement (breeding, pathology, and agronomy) in 1989 in China.

A one-day meeting, organized by INRA, was held in Rabat, Morocco on 23 March. ICARDA participants were Drs. J.P. Srivastava, M.S. Mekni, M. Solh, A.H. Kamel, M. Nachit, and R.H. Miller. Other scientists from INRA, INAV, MIAC, and CIMMYT, from different departments of the Ministry of Agriculture, and from the universities of Aghadir, Marakesh, and Tanger also participated in the meeting. Breeding, agronomy, pathology, and on-farm trials were discussed, and recommendations generated. Coordination activities were also established in different disciplines, particularly in pathology and entomology.

Dr. Kamel introduced the aims of the collaborative work to be carried out in Morocco especially to support breeding for disease resistance. A discussion was held on the importance of screening for resistance to septoria blotch, wheat rust, barley stripe, smuts, powdery mildew, and root rots and four disease centers were selected. It was agreed that the first meeting of collaborators should take place in April 1988, right after the first disease survey, and an evaluation meeting was scheduled for July 1988 to present the results and prepare the 1988/89 program.

In terms of entomology, discussions centered on the high incidence of wheat stem sawfly (WSS), that inflicted 30-40% crop losses in rainfed cereal growing regions in 1986/87. It was decided that crosses of WSS and hessian fly (HF) resistant material will be made at ICARDA and Setta, then screened for HF in Morocco and WSS at Tel Hadya. On the other hand, a hard red, HF resistant spring wheat from South Dakota has been named "Saada" and will be likely released in one year.

The dropping of the HF project was also discussed in detail and MIAC offered to write letters of support, should ICARDA wish to pursue the matter. Cooperation between ICARDA, INRA, and MIAC was deemed desirable by all parties, especially regarding HF. ICARDA staff stressed the need for Moroccan scientists to assume a leadership role in subregional network for HF.

During his stay in Morocco, Dr. J.P. Srivastava also visited the biotechnology laboratory at the faculty of Natural Sciences of the University of Rabat and the Ministry of Agriculture where he discussed the on-going trial activities in Morocco.

Joint ICARDA/UNDP/FAO Project for Afghanistan. ICARDA was requested to collaborate with UNDP/FAO in selected elements of a 4-year project designed to build up human resources and increase cereal, pulse, and vegetable crop production in Afghanistan. UNDP/FAO officers visited Tel Hadya, Aleppo, 25-28 Sept. 1987, and held discussions with senior ICARDA administrators. It was agreed that ICARDA's involvement in the project would be on an equal partnership basis with FAO so that both agencies will jointly carry out the project. Due to the shortage of qualified and experienced national personnel, a preparatory phase of one year will be first launched to concentrate on building up a nucleus of trained staff and to lay a sound groundwork for an implementation phase which is expected to become operational on 1 Jan 1989. It was also agreed that financial provision should be made by UNDP to enable one staff member from ICARDA and another from FAO to visit Afghanistan during the first half of Nov 1987, familiarize with the situation, and interact with the Afghan scientists and UNDP/FAO representatives in Afghanistan.

In a meeting held on 17 Feb 1987 at Tibar, Tunisia, and inaugurated by high Tunisian officials, the Director of the National Research Institute of Tunisia (INRAT), **Dr. M. Lasram** discussed the role of research in increasing agricultural production. He summarized the recent achievements of INRAT in the selection of a new durum wheat and a 6-row barley varieties. Dr. Lasram indicated that the overall production can be increased by 48% with the release of the new varieties. He added that improved varieties alone are not enough for high production as the right time of planting contributes by 20%, land preparation by 40%, and the use of fertilizers by 40% to express the yield potentials of these varieties.

The International Congress of Plant Physiology was held in New Delhi, India, 15-20 Feb. 1988. The congress was organized by the Society for Plant Physiology and Biochemistry, and sponsored by the International Association for Plant Physiology, the Indian Science Academy, and the International Center for Agricultural Research in the Dry Areas (ICARDA). The Congress brought together scientists from all over the world and the discussions focused on the following topics: (i) physiological basis of crop yield, crop modeling, and crop improvement; (ii) environmental stress; (iii) nutritional stress; and (iv) preharvest and postharvest physiology and biochemistry in relation to storage. Drs. A. van Schoonhoven, J.P. Srivastava, and E. Acevedo, who represented ICARDA at the Congress, took the opportunity of their stay in New Delhi to visit the Indian Agricultural Research Institute (IARI) and the Indian Council of Agricultural Research (ICAR).

A National Symposium on Plant Genetic Resources in India was held in New Delhi, 3-6 Mar. 1987. It was organized by the National Bureau of Plant Genetic Resources (NBPGR) of the ICAR during its 10th Anniversary celebrations. The Symposium was inaugurated by Dr. Gurdial Singh Dhillon, Honorable Union Minister for Agriculture, Government of India, and comprised nine technical sessions: (i) genetic resources, a global perspective; (ii) priorities for genetic resources activities; (iii) evaluation and utilization of genetic resources, cereal crops; (iv) evaluation and utilization of genetic resources, oilseeds and fiber crops; (v) evaluation and utilization of genetic resources, horticultural, vegetable, medicinal, and underutilized crops; (vi) evaluation and utilization of genetic resources, plantation and commercial crops; (vii) evaluation and utilization of genetic resources, pulses and forages; (viii) germplasm exchange and seed health requirements; and (ix) biotechnology in relation to genetic resources conservation.

Cereal residential training course at ICARDA. Twelve cereal research workers from seven countries (China, Egypt, Morocco, Sudan, Syria, Turkey, and Yemen PDR), attended the ICARDA cereal residential training course at Tel Hadya, 1 Mar. through 18 June 1987.

The trainees attended lectures for part of the time but spent 75% of the training period in practical laboratory and field sessions. Training topics centered around the improvement of barley, durum wheat, and bread wheat and covered the following aspects: genetics, breeding, agronomy, physiology, pathology, entomology, genetic resources, cereals for high-elevation areas, seed health, seed production, grain quality, field plot techniques and data analysis, farm machinery and soil preparation, and on-farm trials.

In addition to participating in all theoretical and practical sessions, each trainee was assigned a small project in which he (she) had to make observations, take appropriate data, and write a report.

An in-country training course on barley improvement, jointly organized by the Institute of Agricultural Research (IAR), Ethiopia, and ICARDA was offered from 9 to 14 Oct. 1987 at Holetta Research Center, Ethiopia to 23 cereal researchers from 6 research centers in Ethiopia. Six scientists from IAR and three from ICARDA delivered lectures on genetics, breeding, diseases and insect pests, agronomy and cultural practices, on-farm trials, field plot techniques, and data analysis and interpretation. In addition, one full day was spent in the research and on-farm field trials to demonstrate to the trainees the different aspects of barley improvement discussed in the lectures.

Short training course on barley improvement. Five barley researchers from five countries (Algeria, Egypt, Ethiopia, Morocco, and Syria) attended a specialized course on barley improvement, 1-12 Mar. 1987, at ICARDA. The course focused on breeding techniques and methodologies, agronomic principles and cultural practices, and control of diseases and insect pests. In addition, classroom lectures and laboratory sessions were offered and field visits were made to barley selection sites at Breda and Bouider.

A Short Course on Biometrical Techniques for Cereal Breeders was given on 16-23 Feb. 1988 at ICARDA, Aleppo, Syria. The course, designed for cereal breeders with a minimum educational background of M.Sc. level, included the following topics: heritability, genetic designs, genotype x environment interaction, varietal stability, and selection efficiency.

Sham 1 yields 6.77 t/ha at Hail, Saudi Arabia. Mr. M.H. Salim, ADG/FAO Program Coordinator, in a letter to Dr. A.S. Shuman, Assistant Director General for Government Liaison and Public Relations, ICARDA, said that the durum wheat variety Sham 1 received through the courtesy of ICARDA was evaluated in winter 1987 at Hail, and yielded 6.77 t/ha under heavy irrigation. It is worth noting that this variety initially developed for moderate rainfall has performed satisfactorily when heavily irrigated.

The General Organization of the Silos and Flour Milling in Saudi Arabia found the wheat variety Sham-1 acceptable for its technological characteristics, indicated Dr. S.A. Tamimi, Senior Expert, in a letter to ICARDA. The variety Sham-1 will be grown by Saudi farmers and marketed at the subsidy price.

An Evaluation Network for Selected Durum Germplasm, in which the Cereal Improvement Program of ICARDA is playing a coordinating role for distributing trait-specific germplasm and analyzing information returned by cooperators was reported in RACHIS 6(1). As a result of enthusiastic response from scientists of several projects dealing with durum wheat germplasm, we are glad to include the following cooperators into the network from the 1988/89 season:

Dr. L.W. Briggle:
Research Agronomist, Germplasm Services Laboratory, USDA/ARS, Beltsville, Maryland, USA.

Dr. R.G. Cantrell:
North Dakota State University, Fargo, ND, USA.

Prof. Dr. M. Dambroth:
Institut fur Pflanzenbau, FAL, Braunschwieg, FRG.

Dr. J.M. Clarke:
Research Station Agriculture Canada, Swift Current, Saskatchewan, Canada.

Dr. H.S. Dhaliwal:
Punjab Agricultural University, Gurdaspur, Punjab, India.

Dr. A.A. Jaradat:
College of Agriculture, Jordan University of Science and Technology, Irbid, Jordan.

Dr. M.C. Mackay:
Australian Network of Plant Genetic Resources Centers, Tamworth, Australia.

Dr. C.O. Qualset:
College of Agricultural and Enivronmental Sciences, University of California, Davis, USA.

Scientists, germplasm evaluators, and researchers from national programs wishing to join the network should please write to Dr. J.P. Srivastava, Cereal Improvement Program, ICARDA, P.O. Box 5466, Aleppo, Syria.

The Punjab Agricultural University's Regional Research Station at Gurdaspur in India has evaluated 1500 accessions of *T. durum, T. dicoccoides, T. carthlicum,* and *T. dicoccum* under the framework of the PL-480 (USA) funded project on "Collection, maintenance, and evaluation of germplasm of wheat and related species and utilization of useful variability". Lines resistant to wheat rusts, powdery mildew, Karnal blunt (*Tilletia indica*), and soil alkalinity have been identified.

Dr. H.S. Dhaliwal, Director of the station, reports that durum wheat cultivation is gaining ground in India because of its high yield potential, lodging tolerance, and resistance to Karnal bunt and loose smut. The PAU has released two durum varieties: DWL 5023 and PBW 34 for cultivation under irrigated conditions in the Punjab. These varieties are, however, poor in bread making qualities and late in maturity.

Release of Barley Composite Cross XXXI-A and B. The Agricultural Research Service, USDA and the Montana Agricultural Experiment Station, recently announced the joint release of 2-rowed barley composite cross (CC) XXXI-A and B on 1 Dec. 1987. The CC XXXI-A population should be useful for selecting genotypes adapted to environments similar to the Bozeman location where it was developed, while CC XXXI-B, whose population approaches a 1:1 ratio of fertile to sterile plants, should be useful for selecting superior 2-rowed genotypes with both female receptivity for outcrossing and male pollen production. Seed set on male-sterile plants in the CC XXXI-B population increased at Bozeman from 5.2% to 24.6% in the sib 2 to sib 4 generations, respectively. Seeds of XXXI-A and B can be obtained from Dr. E.A. Hocket, USDA-ARS, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717; or from Dr. D.H. Smith, Jr., USDA-ARS, National Small Grain Collection, Bldg. 046, Beltsville Agricultural Research Center, Beltsville, MD 20705, USA.

CIMMYT will be soon issuing another barley yellow dwarf (BYD) newsletter. According to the authors' guidelines, articles to be submitted by contributors should be brief (1-2 double-spaced pages as a maximum and not more than two tables or figures) and include research highlights or short project reports.

The International Board for Plant Genetic Resources (IBPGR) starts a new bulletin. The bulletin will cover Europe, Southwest Asia, and North Africa. The main aim of this publication, which will be issued at regular intervals, is to foster cooperative links between national programs in the region and scientists working on crop genetic resources conservation. Copies can be had free of charge from: P.M. Perret, ECP/GR Officer, IBPGR Headquaters, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

Forthcoming Events

ICARDA's second Program and Management Reviews will take place at Aleppo from 23 May to 11 June, 1988, immediately following the mid-year CGIAR meeting in Berlin (15-20 May, 1988) and preceding the 46th TAC meeting (13-21 June, 1988) at Hyderabad, India, where the reports of the Review Panels will be discussed. The Reviews will be led by Drs. Dieter F.R. Bommer and John L. Dillon, Chairmen of the External Program Review and External Management Review, respectively.

The Groupe Phenols, Congrès International will be held at Brock University, St. Catharines, Ontario, Canada, on 15 and 16 August 1988. Topics of the symposium will be: biodegradation and utilization of lignin, significance of flavonoids in foods, cereal polyphenols, phenolics in phytopathology, and phenolics in cultured tissues. For further information contact Dr. Tibor Fulek, Horticultural Research Institute of Ontario, Vineland Station, Ontario, CANADA LOR 2EO.

The Fifth Conference on Virus Diseases of Graminea in Europe, organized by the European Working Group on Graminea Viruses (EWGGV), the Hungarian Academy of Science (MTA), and the Hungarian Society of Agricultural Sciences (MAE) will be held from 24 to 27 May 1988 in Budapest, Hungary. The conference secretary is Mrs. Csilla Borsodi, Hungarian Society of Agricultural Sciences, H-1055 Budapest, Kossuth ter 6-8, HUNGARY.

The Second International Symposium on Genetic Manipulation in Crops sponsored by Academia Sinica, IRRI, and CIMMYT will be held in Mexico, 29-31 August 1988. More information can be obtained from Dr. Lesley A. Sitch, IRRI, P.O. Box 933, Manila, Philippines.

An International Symposium on Population Genetics and Germplasm Resources in Crop Improvement will be held at the University of California, Davis, USA between 11 and 13 August 1988. The purpose of the Symposium is to stimulate research interaction among population geneticists, ecologists, plant breeders, and germplasm resource managers. The main topics of the symposium are: kinds of genetic diversity, structure and geographic organization, microevolutionary processes, and genetic diversity and its utilization in plant improvement. For registration and further information contact Donna Hyatt, Dean's Office, College of Agricultural and Environmental Sciences, University of California, Davis, CA 95616 USA.

The Plant Breeding Institute, Cambridge, UK, has recently been split into two, a privatized part owned by Unilever and a public part composed of most of the research departments. The latter part, now referred to as the Institute of Plant Science Research, Cambridge Laboratory, Maris Lane, Trumpington, Cambridge, UK. CB2 2LQ, will be organizing the 7th International Wheat Genetics Symposium, July 1988.

The Fourth International Symposium on Buckwheat, organized under the auspices of the International Research Association of Buckwheat, will be held at Orel, USSR, 11-15 July 1989. The objectives of the symposium are to discuss biology, breeding, and management and utilization of buckwheat. Official language will be English.

The Brighton Crop Protection Conference-Pests and Diseases 1988 will be organized by the British Crop Protection Council 21-24 Nov 1988 at the Brighton Metropole and the Brighton Centre, Brighton, Sussex, England. The Conference will cover many aspects of pest and disease control. General enquiries concerning the conference should be addressed to the conference secretary, Mrs. R.A. Bishop, Frank Bishop (Conference Planners) Ltd., 20 Bridport Road, Thornton Heath, Surrey CR4 7QG, UK. Telex: 943763 CROCOM G.

A Symposium on Rainfed Field Crops and Farming Systems in Jordan and the Neighbouring Countries will be held at Amman, Jordan, 10-14 Sept, 1988. The major objective of the workshop is to review the present research activities and results in relation to cereals, legumes, forages, and livestock, and to study the present farming systems. The program will include the following topics: (i) cereal and legume: present research and future strategies; (ii) soil management, moisture conservation, crop rotation, and optimum input; (iii) forage crops and their role with livestock in the farming system; (iv) the farming system approach; (v) on-farm research and extension of improved technology; and (vi) crop mechanization and reduction of harvest losses. Official language is either Arabic or English. For more information please write to Dr. Nasri I. Haddad, Faculty of Agriculture, University of Jordan, Amman, Jordan.

The Eighth International Biotechnology Symposium will be held at the Palais des Congrès, Paris, France, 11-22 July 1988 under the auspices of the International Union of Pure and Applied Chemistry (IUPAC). The Symposium is organized by the Société Francaise de Microbiologie (SFM) with the support of the French Ministry of Education and Research, the Ministry of Agriculture, the National Center for Scientific Research, the National Institute for Health and Medical Research, and the Pasteur Institute. Renowned scientists and industrialists will present lectures, and workshops and poster sessions will cover the following themes: basic microbiology, genetics of animal and plant cells, genetics of microorganisms, cell culture, protein design, etc. The symposium offers excellent opportunities for companies to display their products and for congress participants to become aware of new equipment and technologies. The secretariat is reacheable on the following address: VIII Symposium de Biotechnologie, SOCFI, 14 Rue Mandar, 75002 Paris, France. Telex: 214403 F.

An International Workshop on Plant Genetic Resources in Africa will be held at the United Nations Environment Program (UNEP) headquarters in Nairobi, Kenya, 26-30 Sept 1988. The workshop, organized by the International Board for Plant Genetic Resources (IBPGR) and the UNEP will review the achievements during the last ten years and define strategies for collection, conservation, documentation, and utilization of plant genetic resources at national and regional levels.

The Third Conference of the International Plant Biotechnology Network (IPBNet) will be held 8-12 January 1989 in Nairobi, Kenya and will be entitled "The Role of Tissue Culture and Novel Genetic Biotechnologies in Crop Improvement." For more information please write to Ms. Julie L. F. Ketchum, Operations Director, TCCP, Dept. of Botany, Colorado State University, Ft. Collins, CO 80523 USA. Telex: 3711418 TISCLT.

CONTRIBUTORS' STYLE GUIDE

Policy

The aim of the newsletter is to publish quickly the results of recent research. Articles should normally be confined to a single subject, be of good quality and of primary interest to research, extension and production workers, administrators and policy makers. Articles for publishing in the newsletter should not be submitted to or published in any other journal.

Editing

Articles will be edited to preserve uniform style but substantial editing will be referred to the author for his approval; occasionally, papers may be returned for revision.

Disclaimers

The views expressed and the results presented in the newsletter are those of the author(s) and not the responsibility of ICARDA. Similarly, the use of trade names does not constitute endorsement of or discrimination against any product by ICARDA.

Manuscript

Articles should be typed double spaced on one side of the page only. The original and two other legible copies should be submitted. The contributor should include his name and initials, title, program or department, institute and postal address and telex number if available. Photographs, figures, tables etc. should be either 8.5 cm wide (single column) or 17.5 cm wide (double column including space). Figures and diagrams should be drawn in India ink; send original artwork, not photocopies. Define in footnotes or legends any unusual abbreviations or symbols used in a figure or table.

Units of measurement are to be in the metric system, e.g., t/ha, kg, g, m, km, ml (= mililiter), m^2.

The numbers one to nine should be written as words except in combination with units of measure; all other numbers should be written as numerals, e.g., Nine plants, 10 leaves, 9 g, ninth, 10th, 0700 hr.

Examples of common expressions and abbreviations

3g, 18 mm, 300 m^2, 4 Mar 1983; 27% ; 50 five-day old plants; 1.6 million; 23 μ g; 5^oC; 1980/81 season; 1981-83; Fig., No.; FAO, USA. *Fertilizers:* 1 kg N or P_2O_5 or K_2O/ha.

Mon, Tues, Wed, Thurs, Fri, Sat, Sun; Jan, Feb, Mar, Apr, May, June, July, Aug, Sept, Oct, Nov, Dec. versus = vs, least significant difference = LSD, standard error = SE ±, coefficient(s) of variation = CV(s). *Probability:* Use asterisks to denote probability * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$.

Botanical. Include the authority name at the first mention of scientific names. Cultivar(s) = cv(s), variety = var(s), species = sp./spp., subspecies = subsp., subgenus = subg., forma = f., forma specialis = f.sp.

References

Journal articles: Baker, R.J. and Briggs, K.G. 1983. Relationship between plant density and yield in barley. Crop Science 23(3): 590-592.

Books: Evans, L.T. and Peacock, W.J. (eds.). 1981. Wheat science - today and tomorrow. Cambridge University Press, Cambridge 290 pp.

Articles from books: Zadocks, J.C. and van Leur, J.A.C. 1983. Durable resistance and host pathogen environment reactions. Pages 125-140 *in* Durable Resistance in Crops. Plenum Publications Corporation, New York.

Papers in proceedings: Srivastava, J.P. 1983. Status of seed production in the ICARDA region. Pages 1-16 *in* Seed Production Technology. Proceedings of the Seed Production Technology Training Course-1, ICARDA/the Government of Netherlands, 20 Apr - 6 May 1982, Aleppo, Syria. Available from ICARDA.

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International Center for Agricultural Research in the Dry Areas
(ICARDA)

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