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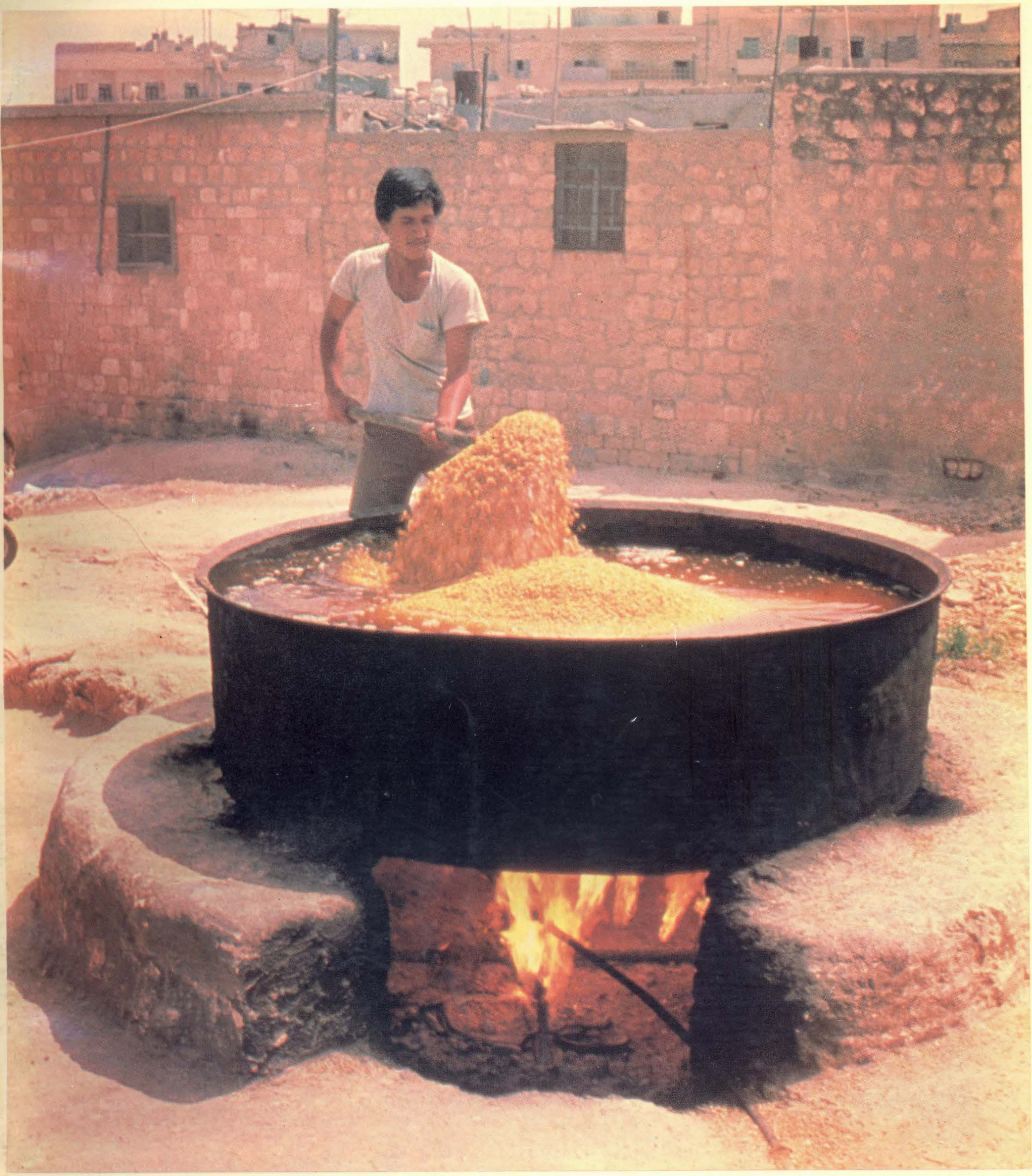

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The Center and its Mission

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).

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RACHIS - the Barley, Wheat, and Triticale 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, wheat, and triticale.

Published half-yearly in January and June, RACHIS can be obtained free by writing to the Distribution Unit, Communications and Documentation Program, ICARDA, P.O. Box 5466, Aleppo, Syria. Contributions to RACHIS should be sent to Dr. Habib Ketata.

COVER

Preparation of burghul, an important wheat food, in Aleppo, Syria. (See page 28)

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Editorial

Most of the world's wheat and barley is produced in rainfed areas,much of which face the difficult conditions of limited rainfall and drought stress. In the Middle East and North Africa, where wheat and barley annually occupy about 70% of area devoted to food crops, practically all barley, 97% of durum wheat, and 90% of bread wheat is grown under rainfed conditions.

Poor crop productivity in arid and semi-arid areas has been a matter of concern to all those involved in solving the world food problem. While total biological immunity to drought effects may not be possible to achieve, adoption of appropriate cultural practices and development of drought-avoiding/resistant varieties through breeding methods can alleviate the drought problem to a great extent.

Among the CGIAR centers, ICARDA has the world responsibility for the improvement of barley, and a shared responsibility with CIMMYT for the improvement of bread and durum wheats in the Middle East and North Africa. CIMMYT, based in Mexico, has the world responsibility for the improvement of bread and durum wheats. ICARDA and CIMMYT have pooled their resources and experiences to jointly meet the challenge of improving cereal production in the arid and semi-arid areas. The joint ICARDA/CIMMYT bread and durum wheat program, based at ICARDA, Syria, is directing its research efforts to help farmers in dry areas. The CIMMYT/ICARDA barley program, based at CIMMYT, Mexico, is endeavoring to improve barley production in Latin America.

The national programs have been showing increasing interest in improving cereal production in the rainfed areas. It is hoped that the increased efforts at national and international centers on the development of improved varieties and cultural practices adapted to highly variable dryland farming systems will lead to new and more efficient methodologies as well as technologies for exploiting the potential of rainfed agriculture.

Breeding cereals for low rainfall areas is a difficult, complex, and challenging task. The pedigree, modified pedigree, single spike descent, single seed descent, modified bulk, or bulk methods of selection are being employed in different cereal improvement programs. However, few studies have been conducted to compare the efficiency and economy of different selection methods. There is, therefore, an urgent need to compare the efficiency and practicability of the available breeding methods and selection procedures, or develop new ones especially suited to identify genotypes that would withstand the stresses of the arid and semi-arid areas.

We therefore encourage our readers to share their research results through RACHIS for the benefit of barley and wheat scientists engaged in the important task of improving food production in the dry areas.

Review Article

BARLEY - ITS WORLD STATUS AND PRODUCTION CONDITIONS IN WEST ASIA, NORTH AFRICA, AND NEIGHBORING COUNTRIES

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Introduction

Barley ranks fourth in growing area and production among the cereal crops in the world, being exceeded by wheat, rice, and corn (Table 1). The average growing area during 1979 to 1983 was 79,790,000 ha and the average annual production 160,624,000 tonnes. The world average yield per hectare was 2014 kg (Table 2). The 10 principal barley-growing countries were the USSR, Canada, USA, Spain, Australia, Turkey, France, Morocco, The United Kingdom, and China. Countries that led in production in the ICARDA region during 1983 were Turkey (5,600,000 tonnes), Morocco (1,136,000 tonnes), Iran (1,413,000 tonnes), Ethiopia (1,100,000 tonnes), and Syria (1,050,000 tonnes).

Historical Background

The role played by barley in the development of early civilization is recognized by many authors (Harlan 1971; Takahashi 1955). The crop has been domesticated from races found in 'Hither Asia,' i.e. Syria, Iraq, Palestine, Jordan, Iran, and Turkey. Archeological evidence found barley regularly with wheat and other crops at excavated agricultural sites. Wild forms with fragile ears were found around 8000 BC, while cultivated barley was found at time ranges between 6000 and 7000 BC (Harlan 1971).

Elements of Taxonomy

Barley belongs to the family Gramineae, subfamily Festucoideae, tribe Hordeae, subtribe Hordeinae, and genus *Hordeum*. The genus *Hordeum* is characterized by an inflorescence that is a spike with three one-flowered spikelets at each rachis node. Species belonging to the genus *Hordeum* are heterospiculate, that is, they have central fertile spikelets and reduced (sterile) lateral spikelets, except *H.vulgare* (including *H.vulgare*, ssp. *H.hexasticon* L.) where the spikelets are isospiculate with three fertile spikelets per node. The most commonly accepted subdivision of the genus *Hordeum* is into four sections. The cultivated barley species and their closest 'wild' relative *H.spontaneum* have all been grouped in the section Cerealia. The other barley grasses not belonging to the Cerealia section are placed in the sections Stenostachys, Campestria, and Bulbohordeum.

The cereal barleys and their 'wild' progenitor form a diploid complex with 2n = 14. Members of this complex are fully or almost fully interfertile and many genes are known to be common to both cultivated and wild populations (Bowden 1959). Because of the production of fertile hybrids between the various types of the section Cerealia, Bowden (1959) considered the barleys in this section as different subdivisions of only one species. The closest wild relative, considered as the progenitor of cultivated barley, was formerly treated as a separate species

Table 1. World area, yield, and production of the leading cereal crops (1981-83 period).

Crop	Area (× 1000 ha)			Yield (kg/ha)			Production (× 1000 tonnes)		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
Wheat	223993	239339	229454	1981	2029	2150	453753	487150	493367
Rice	145088	141726	143318	2833	2995	3041	410972	424420	435783
Maize	130733	128062	121532	3447	3535	2778	450648	452663	337597
Barley	80762	77784	79765	1910	2058	2123	154274	160114	169358

Table 2. World barley average yield, production, and area during the period 1979 - 1983.

Year	Area (× 1000 ha)	Production (× 1000 tonnes)	Yield (kg/ha)
1979/80	80846	158747	1965
1981	80762	154274	1910
1982	77784	160114	2059
1983	79765	169358	2123
Mean	79790	160624	2014

(*H.spontaneum* C. Koch). It is now considered as a subspecies of *H.vulgare*. Bowden (1959) includes all barleys, both cultivated and wild, into *H.vulgare* L. emend. Bowden. This classification is now generally accepted.

Trends in Barley Area, Yield, and Production in the World.[1]

The area covered by barley in the world has increased significantly during the last two decades despite noticeable decreases in parts of Asia, North and South America (Table 3). The average barley area harvested during 1979-1981 shows a 21 % increase in comparison with the period 1969-1971. The expansion of barley-cultivation areas occurred mainly in the USSR (+54%), Oceania (+26%), and Europe (+24%). Due to severe disease epidemics, reductions were sharpest in South America (−30%). The improvement in barley yield levels in most parts of the world brought about a larger world output than expected on the basis of area expansion alone (Table 4). Areas that made the largest yield gains are Asia (+29%), South America (+16%), and Europe. Production advances are most significant in Europe (+42%) where they resulted from improved yields and expanded areas. In Asia, excluding the USSR, a production increase of 13% was obtained despite a decrease (13%) in the area because yields sharply increased (+29%). In the USSR, however, a drastic expansion of the cultivation area (+54%) was followed by a relatively modest increase in production (+27%), while the yields severely dropped (−17%). In Africa, stagnation characterizes both yield and production in spite of a slight expansion in total area.

Table 3. Trend of harvested barley areas (× 1000 ha) in the world.

Country / region	1969-71	1979-81	1982-83
USSR	21782	33490	30768
Asia	12532	10937	11003
Europe	16438	20440	19660
North America	8676	8106	8662
Africa	4252	5629	4802
Oceania	2091	2643	2936
South America	1004	701	668
Total	66775	80846	78499

Table 4. Trend of average barley yield (kg/ha) in the world.

Country/ region	1969-71	1979-81	1982-83
USSR	1613	1335	1554
Asia	1157	1501	1491
Europe	2949	3383	3431
North America	2275	2508	2747
Africa	978	844	845
Oceania	1240	1331	1233
South America	1047	1215	1103
World	1875	1965	2090

Status of Barley Production in the ICARDA Region and Nearby Countries[1]

Barley is an important cereal in Turkey, India, Iran, Syria, and Iraq in Asia, and in Morocco, Ethiopia, Algeria, and Tunisia in Africa. Detailed data on barley production for each of these countries are presented in Tables 5 and 6 to provide information on the problems and prospects concerning barley improvement. Although significant fluctuations characterize barley growing areas both within and among countries, broad regional trends can be identified.

The harvested barley area in Africa slightly increased prior to 1977 and stabilized afterwards (Table 6); while in Asia, the area doubled between 1971 and 1977, then dropped back to the 1969-1971 level (Table 5). The sharpest decreases are observed in China and India where barley has been replaced mainly by wheat under irrigation and high fertility conditions.

Table 5. Barley area (x 10^6 ha) and production (x 10^6 tonnes) in Asian countries growing more than 0.5 million hectares in one or more years during 1969-1983.

Country	1969-71		1977		1980		1982		1983	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
China	2.375	2.628	14.501	19.001	1.501	3.500	1.141	2.500	1.501	4.000
India	2.693	2.642	2.241	2.344	1.771	1.624	1.728	1.993	1.491	1.862
Iran	1.532	1.042	1.350	1.230	1.300	1.100	1.400	1.400	1.387	1.413
Iraq	0.582	0.692	0.536	0.458	0.800	0.575	0.760	0.550	0.780	0.700
KoreaRep	0.723	1.589	0.516	0.814	0.331	0.811	0.317	0.749	0.350	0.780
Syria	0.784	0.375	1.021	0.337	1.210	1.587	0.589	0.661	1.380	1.050
Turkey	2.611	3.720	2.620	4.750	2.800	5.300	3.137	6.400	2.750	5.600
Total	11.300	12.688	22.785	28.934	9.713	14.497	10.072	14.253	9.639	15.405
All Asia	12.532	14.501	23.833	30.181	10.866	16.026	11.227	15.831	10.780	16.953

Table 6. Barley area (× 1000 ha) and production (× 1000 tonnes) in African countries growing more than 0.3 million hectares in one or more years during 1969 -1983.

Country	1969-71		1977		1980		1982		1983	
	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
Morocco	2003	2190	2341	1347	2150	2210	2047	2334	2184	1136
Ethiopia	913	727	798	690	962	772	900	1100	900	1100
Algeria	773	470	741	260	945	794	870	480	870	400
Tunisia	243	133	376	100	382	296	393	338	390	280
Total	3932	3520	4256	2397	4439	4072	4210	4252	4344	2916
All Africa	4252	3731	4812	2859	4923	4420	4709	4695	4896	3391

It is significant to note that while barley yields remain low and stagnant in North African countries (with averages between 300 and 1000 kg/ha), they have been marked by sizeable increases in Asian countries during the last 15 years (with averages generally over 1000 kg/ha).

African barley growing areas are totally under rainfed conditions and confined to where other cereals, mainly wheat, are at a disadvantage (Srivastava 1977). The 1982/83 season offers a valid example since it was particularly dry in the central and the southern parts of the Maghreb countries and consequently production was very low (Table 6). Barley in the leading Asian countries of Turkey, India, and China is grown under more favorable conditions of irrigation or high rainfall and better soil fertility. Therefore, production in these countries is largely dependent upon varietal potential and acreage (Table 5).

Barley Imports and Exports in the ICARDA Region[1]

It is a natural consequence of the production situation reviewed previously that all North African countries are barley importers, while some Asian countries such as Syria and Turkey, in particular, export substantial quantities in good years (Tables 7 and 8).

Table 7. Barley imports (× 100 tonnes) by countries in ICARDA region.

Country	Year					
	1978	1979	1980	1981	1982	1983
Africa	6655	4925	3824	5363	8219	2400
Algeria	5196	3423	2691	1039	4200	1000
Libya	509	1112	823	901	2000	400
Morocco			130	2042	1600	900
Tunisia	950	390	180	1381	419	100
Asia	9297	13972	24227	27418	40324	12722
Cyprus	954	1236	620	1318	871	1322
Iran	4500	1700	6000	1100	1300	600
Iraq	1630	2740	2330	1100	1600	600
Jordan	235	444	205	98	693	0
Kuwait	453	900	479	336	410	100
Lebanon	990	1460	253	260	150	100
Saudi Arabia	534	5445	12293	22753	35300	10000
Syria	1	47	2047	453	0	0
World	148349	145753	151349	181722	178747	70053

Table 8. Barley exports (× 100 tonnes) by countries in ICARDA region.

Country	Year					
	1978	1979	1980	1981	1982	1983
Africa	240	460	351	0	0	0
Asia	444	1278	4225	6735	17771	5277
Lebanon	280	800	50	0	0	0
Pakistan	14	473	347	439	390	300
Syria	0	0	238	1064	5556	2500
Turkey	150	5	1684	3068	4620	1300
World	144236	145033	159378	190213	219164	81293

Conditions of Barley Cultivation in the Dry Areas

Barley is basically a poor man's crop in the dry areas. There, it is the main crop grown by small farmers. Barley is generally considered a shorter season and earlier maturing grain crop than wheat, and is often grown where other cereal crops are not dependable because of environmental factors. Although barley-fallow or barley-legume are popular crop rotations, barley-barley rotation tends to dominate in the marginal areas where barley plays a unique role as a feed crop. Fields are often self-sown from the seeds of the previous crop. Barley also plays an important nutritional role in areas of India, Nepal, the Andean region as well as some areas of the Middle East and North Africa (Srivastava 1977). For these reasons, the improvement work initiated at national and international levels should endeavor fast to compensate for the limited past research efforts in the less favored regions.

Information provided by barley workers on the status of barley production and improvement research in the Afro-Asian region has shown that local cultivars cover the major part of the production areas, and although barley diseases do not cause heavy losses in these cultivars in poor years, diseases such as helminthosporium, powdery mildew, scald, and yellow rust, quickly become overwhelming and limit yields in good years. The absence of clear formulations of improved agronomic practices, the unavailability of quality seed of improved barley varieties, as well as the lower market price set for barley in comparison with wheat, are major constraints to barley productivity.

Barley Research at ICARDA

World-wide research and development work on barley has resulted in high yielding, lodging-free, and disease-resistant good malting barleys (mainly two-rowed in Europe and six-rowed in North America). Breeding for improved malting quality led to lower protein percentage, and the search for better lodging resistance ignored straw quality. Barley improvement for human food and livestock feed had to meet other contrasting requirements.

The ICARDA barley program is focusing special attention on developing suitable varieties and appropriate production technologies for the lower rainfall areas.

An urgent task at the beginning of ICARDA's barley work was to assemble and evaluate a large barley germplasm pool and to widen the genetic base of the crop. Lines derived from crosses between contrasting introductions and adapted germplasm are now being characterized for their agronomic type, disease resistance, and yield potential and are distributed to national programs to meet the urgent need for finished lines.

The present strategy is to quickly distribute segregating populations for selection in environments where they are to be grown. To meet this objective and to achieve high yields in highly variable environments, the breeders at ICARDA are following a multidisciplinary research approach geared to:

1. Strengthening collaborative programs with national research institutions. Results from the international nurseries clearly show that ICARDA's germplasm was better exploited in countries entertaining active collaborative projects with ICARDA.

2. Selecting (mainly in the F_2 generation) and screening of breeding material at several low-rainfall locations with the objective of identifying parental lines and cultivars suitable for the agroclimatic conditions of barley-growing areas.

3. Studying and exploiting heritable genotypic differences with regard to response to environmental stress in cooperation with agronomists and physiologists.

4. Improving the disease resistance of high-yielding ICARDA-developed germplasm by selective crossing and screening under conditions of heavy disease pressure.

5. Developing high-straw-yield cultivars for direct grazing in areas where straw and grazing values are equal or superior to grain harvesting.

6. Developing improved agronomic practices suitable for the major barley-growing areas.

7. Assessing the agronomic value and the potential contribution to overall productivity and adaptation of local landraces and barley's closest wild relative *Hordeum spontaneum*.

An urgent task is to develop higher-quality barley research at both national and international levels. The potential for barley production in lower rainfall areas is still largely untapped. However, research work carried out at ICARDA has already indicated that genotypes can be developed which combine adaptation to the various agroclimatic conditions of West Asia and North Africa and resistance to important diseases and pests in those areas (Mekni 1981; Mekni and Kamel 1982).

ICARDA has been assigned the world mandate for the improvement of barley both for human food and livestock feed. In collaboration with national programs, CIMMYT, and other institutions working on barley in the world, ICARDA strives to strengthen research efforts to achieve better harvests from barley in the dry areas.

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1 Statistics for 1969-71, 1980, and 1981, are taken from FAO Monthly Bulletin of Statistics, Mar 1982; 1978 data from FAO Monthly Bulletin of Statistics, June 1981; 1977 data from FAO Production Year Book, Vol. 33, 1979; 1982 and 1983 data from FAO Monthly Bulletin of Statistics, Dec 1983. Data for 1983 are available for the first 6 months only.

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UTILIZATION OF LANDRACES AND *HORDEUM SPONTANEUM* IN BARLEY BREEDING FOR DRY AREAS AT ICARDA

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Introduction

Barley is one of the most important crops in the arid and semi-arid areas of the world and ranks fourth, after wheat, rice, and maize in the world's cereal production.

In developing countries barley is grown on more than 18 million hectares with an average yield of 1200 kg/ha (Table 1).

Table 1. Barley area and average yield in developing countries FAO 1981.

Region	Area (x 1000 ha)	Yield (kg/ha)
Africa	3,252	945
Latin America	1,048	1405
Near East	6,761	1482
Far East	7,254	1128
Total	18,315	
Average		1242

Average grain yields are very variable even among developing countries (from less than 1 to 3 t/ha) and show extreme year-to-year fluctuations.

In the majority of the developing countries most of the barley area is grown with local, unimproved cultivars (landraces) and grain yields have remained static for many years.

Barley is considered to be a poor-soil and a poor-man's crop. In fact, the majority of the barley in developing countries is produced under moisture and salinity stress, on marginal areas, with very poor soil conditions, low soil fertility, and in some cases, on newly reclaimed land. In most of these areas barley is the only option left to farmers, and is mostly grown for animal feed either as winter grazing or as grain and straw, or both.

The International Center for Agricultural Research in the Dry Areas (ICARDA) has the world responsibility for improvement of barley. One of the objectives which has been receiving increased emphasis is the development of genetic material specifically adapted to dry areas where barley productivity is still at subsistence levels.

Two main strategies are being developed as an addition to the existing barley breeding program to pursue this objective:

1. Assessment and exploitation of the genetic diversity available in local landraces,
2. Evaluation of the wild progenitor of cultivated barley, *Hordeum spontaneum*, for agronomic characters and drought resistance.

This paper illustrates these two strategies, their possible implementation, and the short-term achievements they are expected to produce.

Importance and Utilization of Landraces

Local cultivars should have a good adaptation to the environmental constraints of dry areas, and hence would represent a largely untapped reservoir of useful genes for adaptation to arid and semi-arid conditions. The popularity of landraces among the farmers in the Near East and North Africa derives from their good feeding quality both as grain and straw. Therefore, the landraces are not only adapted to poor agroclimatic conditions, but also possess useful attributes in relation to their main utilization.

Some landraces have been used in the ICARDA Barley Breeding Program but no attempts have yet been made to assess and exploit, in a systematic way, the genetic diversity available within these landraces. In the few instances where the variability available within landraces has been used in a simple mass-selection scheme, response to selection has been high and fast. For example, one cycle of mass selection applied within the local barley grown in Iraq, has increased grain yield by 28% over the unselected landraces under low (237 mm) rainfall conditions (Tamimi *et al.* 1975).

This result is not surprising as it is expected that most of the landraces are heterogeneous populations composed by different genotypes. The genetic variability does not necessarily result in a high and easily detectable phenotypic variability because some of it may occur at loci which control physiological attributes not necessarily related to phenotypic differences.

The possibility to detect the genetic diversity available for useful characteristics within landraces and to use it for breeding purposes therefore requires the extraction of a large number of lines, derived from single plants, and their evaluation in several different environments.

The main objectives of this research will be: (1) to collect and characterize landraces of barley from different countries, and (2) to exploit the genetic diversity available within landraces to increase barley yield and yield stability in the drier areas.

The first objective will include studies of the differences between landraces and commercial varieties of cultivated barley, as well as a proper evaluation and documentation of the landraces. This will be conducted in cooperation with the Genetic Resources Unit at ICARDA.

The second objective will be pursued by extracting and evaluating lines from the landraces and by using them:

(1) to assess their agronomic value and their contribution to the overall productivity and adaptation of the population they are extracted from,

(2) in a mass selection scheme with the purpose of discarding the obviously inferior genotypes without a drastic reduction of the existing diversity,

(3) in a recombination and selection program to use the genetic variability available within landraces, and

(4) in a conventional hybridization program to increase the yield potential and to incorporate specific characteristics such as disease resistance, cold tolerance, etc.

Although this research is still in the planning stage, some of the activities have already been identified. These are:

1. Collection of landraces from different countries and their evaluation and characterization. Single-plant progenies will be generated both to assess the variability within landraces and to provide material for breeding work.
2. Evaluation of single-plant progenies extracted from landraces. The progenies will be evaluated for characters such as cold tolerance, disease resistance, plant height, tillering, stem thickness, lodging resistance, heading time, head size, drought tolerance, rachis brittleness, 1000-seed weight, grain yield, and straw yield. The evaluation will be initially conducted at dry sites near Aleppo (Syria) such as Breda (260 mm rainfall), Khanasser (220 mm rainfall), and Abu Dhur (200 mm rainfall). The evaluation will be conducted adopting traditional agronomic practices but, as soon as seed availability permits, it will be duplicated to include improved agronomic practices.
3. Evaluation of the ability of the lines extracted from landraces to respond to changes in agronomic practices such as phosphate applications, seed rates, etc.
4. Identification of promising lines to be evaluated as pure lines or to be used for developing experimental multiline cultivars.
5. Within landrace selection of lines with contrasting expression of one or more characters (such as heading time, plant height, growth habit, etc.) to evaluate the role of such traits in relation to yield and stability.
6. Identification of lines to use as parents in a within-population recombination and selection program. This will also include crosses between lines extracted from different landraces.
7. Identification of lines for use in crosses with cultivars and breeding lines already identified as promising materials in dry environments.

This research is expected to generate a number of lines, selected from landraces, which either as pure lines or most probably as experimental multilines could be under multilocation testing within a period of three years.

Utilization of *Hordeum spontaneum*

During the last decade there has been an increasing interest in using wild relatives in breeding programs of many crops. Although wild relatives have been exploited more often as a source of resistance to diseases, insects, and nematodes, they have proven to be valuable sources of variation in breeding for wide adaptation, resistance to stress, short stature, high yield, etc. (Harlan 1976).

In barley breeding, the potential of *H. spontaneum*, the progenitor of cultivated barley, as well as other wild barleys as donors of useful characters, has been recognized since long.

H. spontaneum is a two-row, diploid (2n = 14), colonizing annual, fully interfertile with *H. vulgare.* Although the species is predominantly self-pollinated, the amount of outcrossing can vary between 0.4% in populations growing in xeric regions, and 2.1% in populations growing in mesic regions. The chromosomes of the two species show perfect pairing in the F_1, and natural hybrids are not uncommon (Harlan and Zohary 1966). Therefore, *H. spontaneum* and *H. vulgare* are considered to belong to the same species.

Morphologically, the main difference between cultivated two-row barley and *H. spontaneum* is the presence of a tough rachis in the cultivated barley, while the wild forms have a brittle rachis that disarticulates at maturity into individual units each containing one seed and two sterile lateral spikelets.

A recent literature review (Grando *et al.* 1984) on wild barleys in general, and *H. spontaneum* in particular, shows that:

(1) most of the published research on *H. spontaneum* deals either with estimates of genetic diversity for biochemical attributes (Frost *et al.* 1975; Frost and Holm 1975), or with the transfer of resistance to powdery mildew (Moseman and Craddock 1976; Russel 1978), rust (Anikster *et al.* 1976), and scald (Baenzinger *et al.* 1981).

(2) although only a few studies have been conducted on the ulilization of wild barley in breeding programs, they have shown that *H. spontaneum* can contribute useful genes for grain yield, plant height, bundle weight, harvest index, drought resistance, and cold hardiness (Bakhteyev 1974; Vega and Frey 1980), and

(3) the other wild barley species have been mainly investigated from a cytological or genome-relationship point of view (von Bothmer *et al.* 1981; 1983; von Bothmer and Hagberg 1983).

The potential of *H. spontaneum* to contribute successfully to breeding barley for dry areas has never been systematically investigated in the area where the species is likely to show its full value, i.e. the Fertile Crescent where *H. spontaneum* is still abundantly distributed and where *H. vulgare* is one of the most important cereal crops.

Preliminary observations (Weltzien 1982) seem to suggest that *H. spontaneum* germplasm has played a major role in the formation of the landraces still widely grown along the Fertile Crescent and that these landraces are intermediate forms between *H. spontaneum* and *H. vulgare*.

It seems, therefore, that ICARDA is in a unique position to assess the value of *H. spontaneum* as a source of useful genetic variation for drought resistance and for agronomic traits to improve barley yield and stability in the driest part of the Fertile Crescent.

However, the use of wild species such as *H. spontaneum* in hybridization programs would present a number of disadvantages the most obvious being the introduction of many undesirable genes. Therefore, this research will be given less priority as compared with the utilization of landraces and will be initially limited to the evaluation of *H. spontaneum* germplasm to identify specific useful characters. The research is not expected to generate materials of use in the short term, but to put the basis for future work.

The main short-term objective of this research is to screen a large number of *H. spontaneum* accessions already available at many institutions including ICARDA, for characters such as cold and drought tolerance, plant height, heading time, maturity time, seed size, spike length, and tillering, as very little is known about the variability of these characters in this species. The evaluation will be carried out at ICARDA's driest experimental site near Khanasser, and depending on seed availability, at an even drier site.

The numbers of *H. spontaneum* accessions which are currently available at ICARDA are:

> 14 from the USDA collection, USA, 4 collected in 1983 in Syria, 46 collected in 1980 and 1981 in Syria and Jordan, 100 from the Plant Breeding Institute collection, Cambridge, UK, 2 from Denmark, (origin unknown), and 10 from Japan genebank.

Another 64 accessions are most likely to be added in the next few months. Therefore, the total number of accessions available by October 1984 sould be 240.

During the first year the material will be planted at ICARDA's principal research farm at Tel Hadya (about 30 km south of Aleppo, Syria), which receives a long-term annual precipitation of 350 mm. As little amount of seed is often available in many accessions, the facilities available at Tel Hadya ensure a safe seed multiplication to implement the second stage of the research where more emphasis will be given to the evaluation of agronomic performance under plot conditions in multilocation testing below 200 mm annual rainfall.

In 2 to 3 years this research is expected to generate enough information on the presence of useful genetic diversity to formulate a more in-depth hybridization program.

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EVALUATION OF BARLEY GERMPLASM AT ICARDA

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New sources of genetic variability are needed for continuing progress in barley breeding. The systematic evaluation of germplasm under a range of environmental conditions allows the identification of specific and desirable traits and enhances the exploitation and utilization of diverse gene pools. At ICARDA, the assessment of barley germplasm has paid off enormous dividends and resulted both in the production of valuable breeding material and in the multiplication of productive and stable cultivars adapted to certain Mediterranean conditions. The appraisal of the Center's germplasm is a continuing activity.

During the 1982/83 cropping season, 2696 barley accessions from nine countries were evaluated under rainfed conditions at Tel Hadya, Syria, for 17 characters which were also cataloged. The accessions constitute a portion of the germplasm collection obtained from the USDA. Each accession was sown in a 2.5 m row plot in late November - early December 1982. Fertilizer (40 kg N/ha, urea 46% ; and 40 kg P_2O_5/ha, triple superphosphate), was incorporated into the soil just prior to sowing. Field observations were recorded throughout the cropping season. A total of 322.9 mm rainfall was received. Seeds were harvested in late May 1983 and 1000-kernel weight was determined for each accession in the laboratory. Data for five traits (days to heading, days to maturity, plant height, resistance to lodging, and 1000-kernel weight) were collected.

Considerable variability for these traits was observed in the germplasm material originally obtained from Bulgaria, Canada, Germany, Ethiopia, Tunisia, Turkey, USA, and Yugoslavia (Table 1). The spread observed for each trait was very large and the analysis of data showed that the differences were wider between countries than within each country.

Heading Time and Days to Maturity

Days to heading were calculated as the number of days from germination to 50% of heads out of the boot. Similarly, the number of days to maturity were determined by calculating the number of days from germination to 90% plant maturity. Plants heading in 150 days or less were considered early whereas plants heading in 170 days were categorized as late. Early and late maturity types required 185 days or less and 200 days or more, respectively.

Eighty percent of the material from Tunisia was of the early type, whereas 90% of the germplasm from Bulgaria was of the late type, and 45% of the accessions from Canada were early heading. As seen from variation curves (Fig. 1), the germplasm from Ethiopia, Germany, Turkey, USA, USSR, and Yugoslavia showed large variation in heading time. In this latter group of countries, the late types seemed to constitute an important component of the adapted germplasm. For the

Table 1. Mean and standard deviation for some characters according to country of origin, Tel Hadya, Syria, 1983.

Country	No. of acc.	Days to heading Mean ± S.D.	Days to maturity Mean ± S.D.	Plant height Mean ± S.D.	1000-kernel weight Mean ± S.D.	Resistance to lodging Mean ± S.D.
Bulgaria	26	170 ± 3.9	194 ± 2.2	96 ± 6.1	33 ± 3.8	3.3 ± 2.38
Canada	83	155 ± 7.7	189 ± 4.0	88 ± 11.1	35 ± 3.7	4.7 ± 2.73
Germany	804	160 ± 6.4	189 ± 3.8	95 ± 10.4	39 ± 6.7	6.6 ± 1.81
Ethiopia	164	158 ± 6.9	187 ± 4.1	94 ± 9.3	46 ± 6.2	5.9 ± 2.17
USSR	160	167 ± 6.3	192 ± 3.8	97 ± 8.5	38 ± 5.1	4.3 ± 1.77
Tunisia	92	149 ± 4.6	186 ± 2.9	75 ± 11.1	37 ± 4.7	8.3 ± 1.50
Turkey	370	160 ± 7.3	189 ± 3.6	89 ± 12.0	39 ± 5.1	7.1 ± 1.91
USA	893	161 ± 6.5	190 ± 4.5	93 ± 15.3	35 ± 8.5	4.4 ± 2.46
Yugoslavia	104	165 ± 7.4	193 ± 4.0	95 ± 10.9	40 ± 5.7	4.8 ± 2.16
Total	2696	160 ± 7.4	190 ± 4.3	92 ± 13.0	38 ± 7.5	5.7 ± 2.45

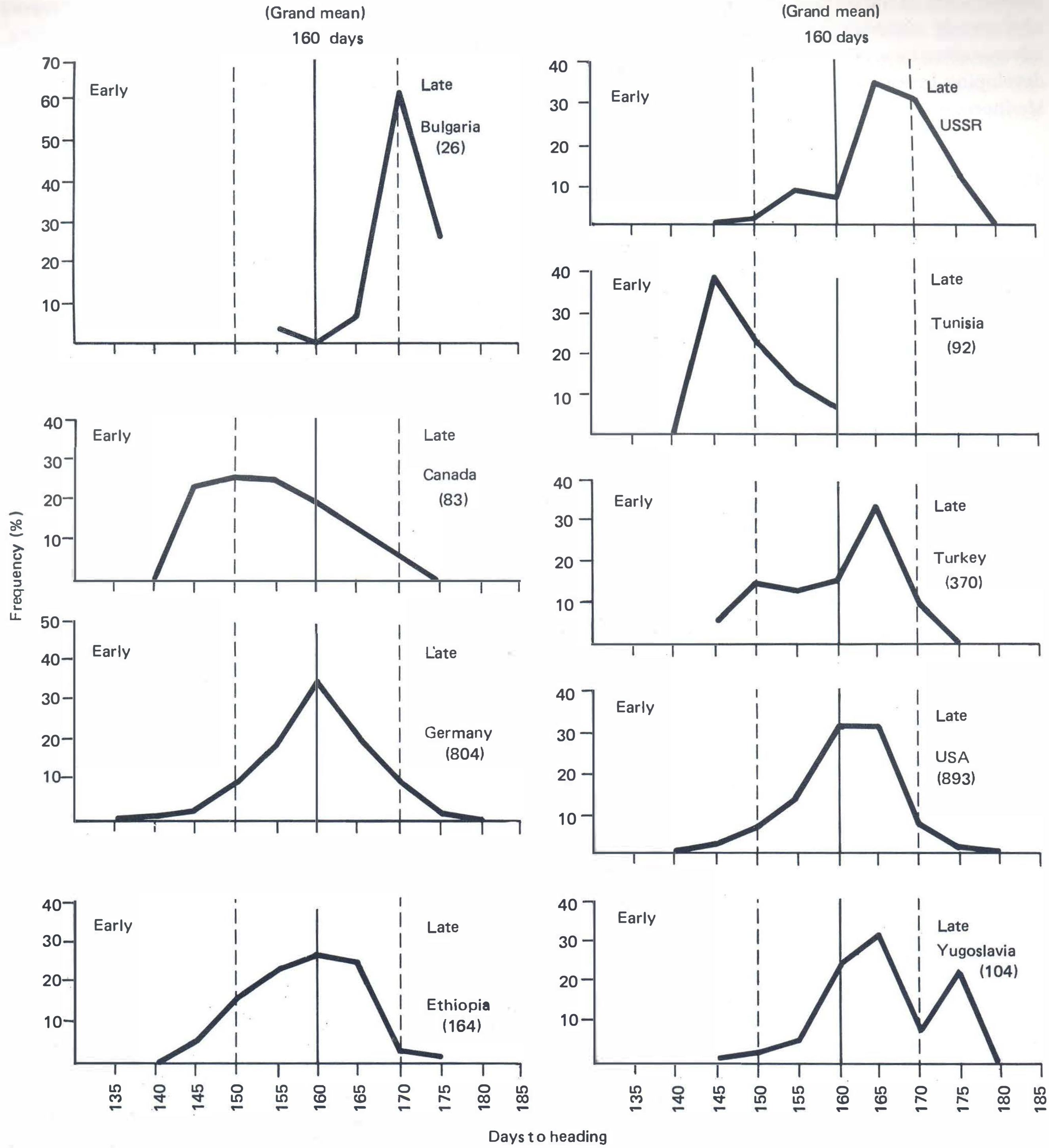

Fig. 1. Frequency distribution of accessions for days to heading.

Yugoslavia material a bimodal curve was obtained suggesting that intermediate and late types form two distinct groups which may have different ecological requirements. Data indicate generally that late and intermediate heading material predominates in continental areas except for Canada where early types have been deliberately selected by breeders for spring planting. On the other hand, in Tunisia, where rainfall is often a limiting factor and the annual rainfall distribution is unpredictable, early heading plants predominate in the collection. The relative advantage of the early material to flower and produce seeds in adverse climatic areas is often an important feature in developing breeding strategies for countries with dry Mediterranean climate.

In general, the variation for days to maturity is similar to that for heading time; the early heading accessions had early grain maturity and late heading accessions had late seed maturity. However, variation in the rate of seed filling was not easily detected from these two sets of data. One could speculate that there is variation for this trait as seen from the Bulgarian and the USSR germplasm material, practically all of which falls within the intermediate range for days to maturity, although 90% of the Bulgarian germplasm and 45% of the USSR material was late heading. This variability for grain filling ability appears to be evident when the mean number of days to heading is subtracted from the mean number of days to maturity (Table 1). The difference for the Bulgarian germplasm is 24 days and that for the USSR accessions is 25 days. Both these figures are smaller than the mean differences for all other countries.

Plant Height

The height of the plants was measured at maturity from ground to the top of the spike excluding the awns.

Variation of plant height (30-130 cm) indicates that a large variability exists for this trait both within and between countries. Short plants (less than 80 cm in height) are dominant in Tunisia where early heading types constitute the bulk of the accessions. This relation between plant height and heading time can be detected in the Canadian material where short plants are also early in heading. An interesting observation is that tall types from both Bulgaria and USSR seem to have relatively faster grain filling ability.

Resistance to Lodging

Resistance to lodging was scored as: 1 = very good resistance to lodging, 3 = good resistance, 5 = moderate resistance, 7 = poor resistance, and 9 = very poor resistance.

From the frequency distribution of the accessions for resistance to lodging (Fig. 2), it can be seen that tall plants both from Bulgaria and USSR displayed good resistance to lodging whereas the germplasm from Germany and Turkey which had a significant proportion of tall plants showed little resistance to lodging. Interestingly, the Tunisian material had for the major part a very poor resistance to lodging despite a significant proportion of short-statured early heading types. Despite their tendency to lodge, early barley types with low straw lignin content are highly desirable for grazing in marginal areas. It might be possible to break up probable gene linkages between shortness and straw weakness in this material to develop strong-stemmed short plants which are adapted to adverse climatic conditions and which produce good grain yields.

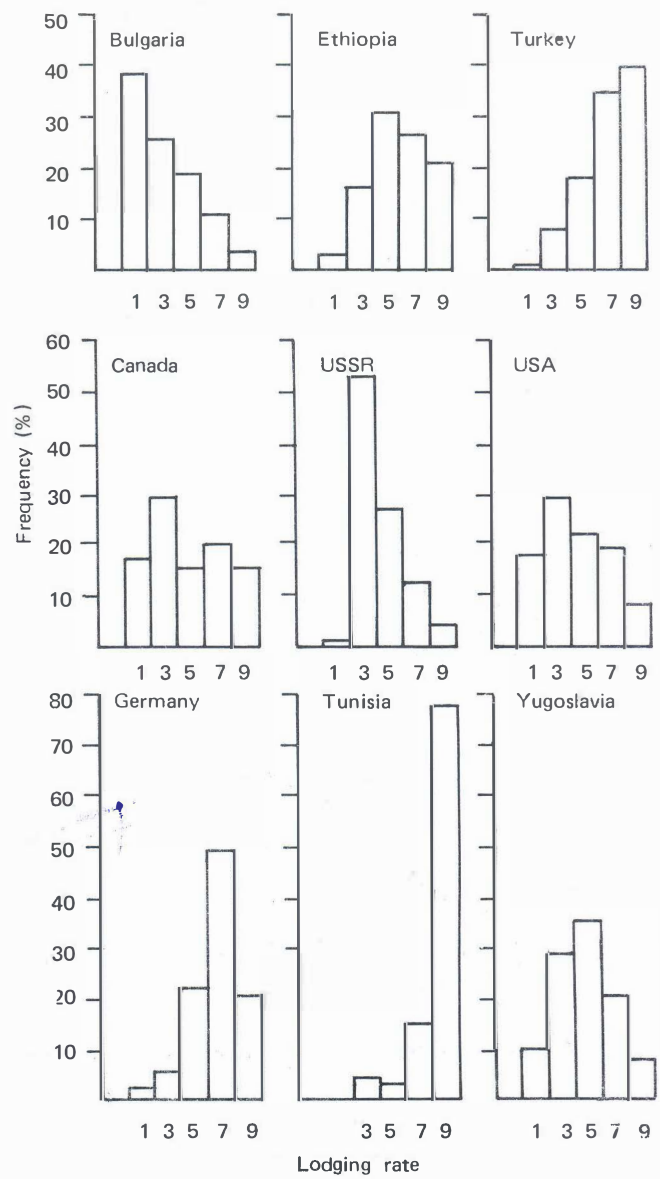

Fig. 2. Frequency distribution of accessions for resistance to lodging.

Kernel Weight

Mean 1000-kernel weight varied considerably within and between countries (Table 1). The Ethiopian material which consists of about 94% six-rowed types had a mean 1000-kernel weight of 46 g while the germplasm from Bulgaria all of which are six-rowed, had a mean 1000-kernel weight of 33 g. It is generally stated that the kernel weight for two-rowed barleys is generally heavier than for six-rowed barleys. The accessions from Germany, Turkey, USA and Yugoslavia consist of about 40, 27, 35, and 68% two-rowed types and the mean 1000-kernel weights were 39, 39, 35, and 40 g, respectively. No significant difference in 1000-kernel weight could be detected between the two-rowed and six-rowed barleys. Further analyses are being conducted to study this difference.

Inferences made from these results are tentative and more detailed analyses of the data will be conducted to provide more reliable information that will enhance the use of these germplasm materials.

SOURCES OF RESISTANCE TO SCALD IN SOME BARLEY CULTIVARS (*HORDEUM VULGARE* L.)

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Introduction

Scald, caused by *Rhynchosporium secalis* (Oud) J.J. Davis, seriously limits barley yields in some areas of North Africa and the Middle East, especially in humid seasons. Control of the pathogen has been attempted by using genetic resistance, but due to the highly variable nature of the pathogen, the race-specific resistance was found to be short lived (Jackson *et al.* 1978). The same workers found about 18 races of the pathogen in California. Also, by mixing four different races and multiplying them on a susceptible host, they found 75 new races. This illustrates the magnitude of the difficulty in breeding for race-specific resistance. In the barley world collection, only 11 alleles capable of conditioning resistance are known, most of which belong to a complex locus Rh - Rh_3 - Rh_4. Other workers (Dyck and Schaller 1961a; Baker and Larter 1963; Wells and Skoropad 1963) have reported on a linkage group at this locus. Habgood and Hayes (1971) found five alleles at the same locus. Starling *et al.* (1971) found this locus to be predominant in 32 winter barley cultivars.

This locus (Rh - Rh_3 - Rh_4) was assigned to linkage group 3 by Dyck and Schaller (1961b). Bockelman *et al.* (1977), using trisomic analysis, found a fourth recessive gene (rh_7) to be on chromosome 3.

Materials and Methods

The barley cultivars used in this study are listed in Table 1. These cultivars were crossed to Betzes, a cultivar susceptible to many isolates of *R. secalis*. The F_1 and F_2 were inoculated with three isolates from Morocco, Tunisia, and USA (Montana). Plants were inoculated 2 days after sowing in metal flats (35 x 25 x 8 cm) with a water suspension, standardized to a concentration of 6 x 10^6 conidia/ml. Two weeks later, scald readings were recorded using a 0-3 scale (0 = no visible lesions, 1 = marginal lesions, 2 = small lesions on the leaf, and 3 = large typical scald lesions).

Results and Discussion

The disease reaction of the barley cultivars used in this study is shown in Table 1. Betzes was susceptible to all

Table 1. Scald reactions of some barley cultivars to three isolates of *Rhynchosporium secalis.*

Genotype	CI No.	Isolate		
		Montana (USA)	Morocco	Tunisia
Abyssinian	668	0	2	0
Abyssinian	3940	0	0	0
Abyssinian	4354	0	0	0
Trebi	936	0	0	3
Jet	967	0	3	3
Kitchin	1296	0	1.2	3
Steudelli	2226	0	3	1.2
Atlas	4118	2	3	1.2
Bey	5581	0	3	3
Betzes	6398	3	3	3
Gem	7243	1.2	1.2	1.2
Atlas 46	7323	0	0	3
La Mesita	7565	0	0	3
Unitan	10421	3	2	0
Nigrinudum	11549	0	3	3
Turk	14400	0	0	3
Steptoe	15229	3	3	3

isolates. The isolate from Montana appeared to possess the least number of virulent genes, the Tunisian and the Moroccan isolates showed virulence against 10 and seven of the parents, respectively. When Betzes was crossed with resistant cultivars (Table 2), some crosses showed monogenic resistance (CI 3940, Bey, Atlas 46, Turk, and Nigrinudum), while others appeared to possess two genes for resistance (Trebi, Jet, CI 4354, CI 668, La Mesita, Steudelli, and Gem). These genes differ in gene action depending on the isolate used and the genetic background into which they were introduced. Cultivars CI 3940, CI 4354, Steudelli, and Gem seemed to have recessive resistance. Furthermore, it was observed that Gem, Jet, and Steudelli have temperature-sensitive genes. As temperature increased over 25°C, these genes broke down and showed susceptible reactions. Utilization of these cultivars in breeding for resistance to scald appears to be of limited value.

The gene designations of the cultivars used in this study are shown in Table 3. It appears that not many scald-resistance genes are available in the cultivars studied so far. It is also confirmed that most of the resistance alleles belong to the Rh - Rh_3 - Rh_4 locus complex, and very few genes are independent of this locus. Further investigations on minor additive genes for resistance to *R.secalis* in barley are necessary.

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Table 2. Reaction of F_1 and F_2 populations to three isolates of *R.secalis* in crosses between Betzes and several resistant cultivars.

Cross	Generation	Isolate	Reaction		Ratio	P
			Resistant	Susceptible		
Betzes x CI 3940	F_1	Morocco	0	7		
	F_2	Morocco	39	109	1: 3	0.78
	F_2	Montana	130	19	13: 3	0.12
	F_2	Tunisia	82	29	3: 1	0.87
Betzes x CI 4354	F_1	Morocco	0	14		
	F_2	Morocco	53	47	9: 7	0.52
	F_2	Montana	126	26	13: 3	0.86
	F_2	Tunisia	110	60	9: 7	0.04
Betzes x Gem	F_1	Morocco	0	10		
	F_2	Morocco	21	131	3:13	0.22
	F_2	Montana	81	78	9: 7	0.09
	F_2	Tunisia	32	90	1: 3	0.83
Betzes x Steudelli	F_1	Morocco	0	9		
	F_2	Morocco	7	146	1:15	0.75
	F_2	Montana	26	126	3:13	0.86
Betzes x Atlas 46	F_1	Morocco	6	0		
	F_2	Morocco	123	36	3: 1	0.55
	F_2	Montana	181	24	15: 1	0.01
Betzes x Bey	F_2	Montana	107	41	3: 1	0.51
Betzes x Trebi	F_2	Montana	95	64	9: 7	0.49
Betzes x Jet	F_2	Montana	33	153	3:13	0.99
Betzes x La Mesita	F_2	Morocco	4	109	1:15	0.47
Betzes x Turk	F_2	Morocco	84	32	3: 1	0.59
Betzes x Nigrinudum	F_2	Montana	146	41	3: 1	0.37
Betzes x CI 668	F_2	Morocco	13	132	1:15	0.99
	F_2	Tunisia	20	127	3:13	0.20

Table 3. Gene designations for scald resistance in some barley cultivars.

Cultivar	Gene symbol
Trebi	Rh_4 Rh
Jet	rh_6 Rh
CI 3940	rh_6 Rh_4
CI 4354	rh6 Rh_4
Bey	Rh_3
Atlas 46	Rh_2 Rh_3
La Mesita	Rh_2
Turk	Rh_3 rh_6
CI 668	rh Rh_3
Nigrinudum	Rh_3
Steudelli	rh_7 Rh
Gem	rh rh

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EFFECT OF POWDERY MILDEW ON YIELD AND YIELD COMPONENTS OF BARLEY IN MOROCCO

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Introduction

Powdery mildew, caused by *Erysiphe graminis* DC f. sp. *hordei* Em. Marchal, is the most common barley disease in Morocco. However, only a limited number of studies were conducted on yield loss assessment in Moroccan environments. Boumer (1976) reported yield losses of 30 and 10 % on the two most common barley varieties Rabat 071 and Arig 8, respectively. More research has been conducted elsewhere and yield losses reported varied from 7 to 50% (Boumer 1976; Carver and Griffiths 1981; James 1974; Kradel and Pommer 1968; Schaller 1963; Slootmaker and Van Essen 1969; Slootmaker *et al.* 1976; Wilkinson 1973).

This study was conducted to determine the effect of powdery mildew on grain yield and yield components and to test the efficiency of using the following models in estimating yield losses caused by powdery mildew in Morocco.

model 1 (Large and Dooling 1962):
$y = 2.5\sqrt{M}$ where M is disease severity at the 10.5 stage on Feekes' scale taken on the last three leaves.

model 2 (James 1974)
$y = 0.3\,x - 3$ where x is disease severity taken on the flag leaf, three weeks after heading.

Materials and Methods

Nine pairs of near-isogenic lines (Moseman 1972) were used in the study (Table 1). Two pairs were grown at two locations, Rabat and Meknes, Morocco, while the other seven pairs were planted at Meknes only.

Experiment 1

This trial involved seven pairs of near-isogenic barley lines grown in Meknes according to a randomized complete block design with four replications and paired observations. Each plot (five rows, 3 m long and 30 cm apart) comprised alternative rows of the susceptible and resistant lines. One row of Mazurka, a barley variety known to be highly resistant, was

Table 1. Isogenic lines used for study at Rabat and Meknes, Morocco, 1982.

No.	Source of resistance gene	C.I. of resistant lines	C.I. of susceptible isogenic lines	Gene for resistance
1	Hanna	16141	16142	Ml - h
2	Kwan	16143	16144	Ml - k
3	Algerian	16137	16138	Ml - a , Ml - at
4	Durani	16149	16150	Ml - a^{10}
5	Franger	16151	16152	Ml - a^{6}
6	Rupee	16155	16156	2 genes = Ml - a + Ml - ?
7	Psaknon	16145	16146	Ml - p
8	Long Glumes	16153	16154	3 genes: Ml - a + Ml ? + Ml -?
9	Multan	16147	16148	2 genes: Ml - a^{7} + Ml -?

planted between adjacent plots. A mixture of three susceptible varieties (Morex, Larker, and Kristina) was planted in the alleys for better distribution of the disease.

Experiment 2

Two pairs of lines (Long Glumes and Multan) were grown at Rabat and Meknes in trials conducted in the same way as experiment 1.

Results and Discussion

In 1982, powdery mildew was more severe in the Atlantic coast than in other areas. At Rabat, a coastal area, heavy infections were observed which reached the levels of 80 and 50% severity on the last three leaves (M) and the flag leaf (X), respectively. Infections were lower at Meknes with levels of 27 and 9% for the M and X readings, respectively. The effect of powdery mildew on yield and other traits is shown in Tables 2 and 3.

All resistant lines having only one gene for resistance have shown a similar reaction to that of the respective susceptible lines. This was the case of Hanna, Kwan, Durani, and Psaknon. The line Algerian with two genes for resistance was also susceptible. Only Franger was resistant.

Number of spikes/m^2

This component was reduced in four lines: Multan (32% reduction at Rabat), Long Glumes (12 and 7% reductions at Rabat and Meknes, respectively), Rupee (14% reduction at Meknes), and Durani (18% reduction at Meknes). However, for Durani, yield reduction may not be due to powdery mildew as both lines of this pair were equally attacked by the disease.

Kernels/spike

Although heavy infections occurred at Rabat, the number of kernels per spike was not affected. At Meknes significant reductions occurred, particularly for the susceptible lines Rupee, Franger, Algerian, Durani, and Kwan.

Kernel weight

Susceptible Multan and Long Glumes were severely affected at Rabat with 18 and 22% kernel weight reductions, respectively. Infections at Rabat were particularly severe during the grain-filling period.

Grain yield

Yield losses were important under heavy infection at Rabat. Multan and Long Glumes showed 55 and 38% yield reductions, respectively. At Meknes where the disease was not severe, losses of 19 and 13% occurred for susceptible lines of Rupee and Franger, respectively.

Harvest index

No effect of powdery mildew was shown on this ratio.

Prediction of yield losses

The two formulae led to underestimating yield losses. However, the Large and Dooling model yielded closer results to the observed losses. James' model, which assumes no losses below 10% severity, was far from the real losses. Where the observed losses were 55%, the estimates for the two methods were 22 and 12%, respectively.

Table 2. Effect of powdery mildew on yield and other traits of barley isogenic lines, Meknes, Morocco, 1982.

Donor parent	C.I.	Reaction	Spikes/ m²	Kernels/ spike	Grain weight (mg/grain)	Actual yield (q/ha)	Harvest index (%)	Estimated yield loss (%) (a)	(b)
	16147	R	245.4	53.2	33.7	35.06	31.9	0	0
Multan	16148	S	227.1	51.6	33.9	34.42	30.4	12.2	0
	16153	R	220.8 **	56.0	34.4	32.65**	31.1	0	0
Long Glumes	16154	S	205.4	56.0	34.5	31.68	31.3	11.8	0
Mean			224.70	54.20	34.10	33.40	31.2		
SE ($\bar{X}$)			8.19	0.98	0.69	0.72	1.3		
	16155	R	231.7 *	60.3 **	30.0	33.17**	36.0	0	0
Rupee	16156	S	198.9	54.2	30.3	27.04	37.1	11.8	0
	16151	R	276.1	58.7 **	33.7	41.51*	37.3*	3.5	0
Franger	16152	S	275.5	51.3	32.3	35.95	33.6	9.7	0
	16137	R	243.3	58.3	33.6	37.65*	36.8	9	0
Algerian	16138	S	240.6	52.8	33.3	35.06	35.1	9.7	0
	16149	R	236.7 *	58.7	33.3	37.58	38.4	11.8	0
Durani	16150	S	194.4	53.9	35.2 *	31.13	36.4	13	0
	16145	R	227.2	47.7	34.4	35.40	32.7	8.7	0
Psaknon	16146	S	260.6	59.0	32.9	38.11	35.5	7.9	0
	16143	R	224.4	56.8 **	31.2	31.09	33.7	11.7	0
Kwan	16144	S	226.7	49.8	31.3	34.93	31.3	8.7	0
	16141	R	210.5	58.3	33.4	28.33	33.6	10	0
Hanna	16142	S	203.3	56.5	35.2 **	32.52	35.0	5	0
Mean			235.70	55.40	33.20	34.33	35.2		
SE ($\bar{X}$)			14.99	1.19	1.14	2.02	1.6		

Table 3. Effect of powdery mildew on yield and other traits of barley isogenic lines, Rabat, Morocco, 1982.

Donor parent	C.I.	Reaction	Spikes/ m²	Kernels/ spike	Grain weight (mg/grain)	Actual yield (q/ha)	Harvest index (%)	Estimated yield loss (%) (a)	(b)
	16147	R	521.7 **	59.0	33.7*	53.74**	26.0	0	0
Multan	16148	S	356.7	56.4	30.8	24.02	22.4	22.4	12
	16153	R	416.7 **	71.7	44.9	36.70**	23.5	0	0
Long Glumes	16154	S	367.3	71.9	35.0	22.59	24.2	18	6.6
Mean ($\bar{X}$)			415.6	64.75	37.10	34.30	24.02		
SE ($\bar{X}$)			9.22	1.93	0.92	0.17	1.36		

a Based on Large and Dooling's formula.
b Based on James' formula.
* Significant at P = 0.05
** Significant at P = 0.01

Conclusions

Yield losses caused by powdery mildew were estimated using near-isogenic barley varieties. An average yield loss of 47% was recorded under heavy infection at Rabat. This loss was mainly due to reductions in heads/m^2 and grain weight. Under lighter infection at Meknes, yield loss averaged only 7% and was due mainly to reductions in heads/m^2 and grains/head.

As for genetic control, it seems that a single gene in a genotype is not sufficient to provide good resistance to powdery mildew under Moroccan conditions.

Although Large and Dooling's formula for predicting yield losses gave better estimates than James' formula, both underestimated the observed yield losses.

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WHEAT BREEDING FOR SEPTORIA RESISTANCE IN TUNISIA: IDENTIFICATION OF RESISTANT GENOTYPES

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Introduction

Septoria leaf blotch (*Septoria tritici* Rob. & Desm.) is one of the major wheat diseases in the northern part of Tunisia (Djerbi *et al.* 1974) which is characterized by 500-700 mm annual rainfall and a moderate to cold winter. Average temperatures during Jan, Feb, Mar, and Apr are 9.3, 10.1, 12.5, and 16.5 °C at Beja and 11.3, 11.6, 13.3, and 15.4 °C at Bizerte. Such weather encourages the epidemics of this disease causing reductions in grain yield (Murray and Martin 1978; Shaner and Finney 1976; Shaner *et al.* 1975; Caldwell and Narvaez 1960; Fellows 1962; Metha 1976; Kuiper 1978). However, in certain years, climatic factors in Tunisia do not favor septoria disease development. During the last 20 years, occurrence of the disease was frequent but grain losses were usually limited. In 1973, a collaborative project involving scientists from the

USDA and Tunisian institutions (INAT, INRAT and Office des Céréales) was established to study septoria epidemiology and evaluate breeding material for resistance to this disease. A large number of durum and bread wheat lines were found to be resistant (Djerbi and Ghodbane 1975; Anonymous 1979-1982) and used in the national cereal breeding program.

The present study evaluated a large number of wheat cultivars for their reaction to septoria during the 1981/82 season.

Materials and Methods

Durum, bread wheat, and triticale lines in the 1981/82 advanced and preliminary yield trials were planted in two rows (2 m long) at Mateur.

S. tritici was isolated from infected durum leaves collected in 1981 at Mateur and multiplied on yeast malt agar at 20°C. Sporal suspension obtained from 10-day culture was diluted to about 2 x 10^6 spores and mixed with 0.5% gelatin and a few drops of shampoo. Two artificial inoculations were made at stages 5-6 and 6-7 in evenings of rainy days. Reactions were recorded during the last week of April 1982 using the 0-9 scale (Table 1).

Selection was based on reaction to septoria as well as yield, earliness, grain quality, and resistance to other diseases. The selected lines that were high yielding were yield tested again in 1982/83 while the rest of lines were included in the 1982/83 crossing program.

Table 1. Reaction of highest yielding durum and bread wheat lines to *S. tritici* in Tunisia.

Variety or cross and pedigree	Reaction to septoria[1]	Yield (kg/ha)[2]	
		1982	1983 b
Bread wheat			
Pavon 76	3 MR	4605(4413)a	3168(3400)
Ures T.81 = Veery 2 CM33027-F-12M-1Y-4M-2Y-2M-0Y	0R	4425(4577)a	3343(3400)
Genero F.81 = Veery 3 CM33027-F-12M-1Y-6M-0Y	4 MR	4309(4577)a	3303(3400)
Cno-8156 × Tob-Cno (No/12300–LR8156) Pv 'S' CM40577-6M-2Y-4M-1Y-8M-3Y-0B	0R	5474(5077)b	3442(3414)
Chat'S' CM33090-T-1M-4Y-0M-118B-0Y	2 Tr	5171(4954)b	3246(3414)
Pak F4.6313. Nuri/Dougga 74 T76-122-4bj-15j-0bj	0R	4837(4614)c	2874(3414)
Jar 'S' - Barani 'S' T76-132-1bj-3bj-0bj	0R	4614(4614)c	2949(3414)
Durum			
Valnova-BD2080 D75-40-11b-4b-0b	2 MS	4067(4194)a	2761(3023)
USA 1V893-Mgh 'S' × Fg 'S' - Cr 'S' CD14198-A-1Y-8M-0Y	0R	4430(4843)c	3118(3286)

1 Reaction is described by severity (0-9 scale) and type, where R = resistant, MR = moderately resistant, T = trace,and MS = moderately susceptible.
2 Data in parentheses represent the yield of the best check.
a Average yield of 5 stations: Beja, Koudiat, Kef, Mateur, and Krib.
b Average yield of 4 stations: Beja, Koudiat, Kef, and Mateur.
c Average yield of 3 stations: Beja, Koudiat, and Kef.

Results and Discussion

Sixty out of 300 bread wheat lines and 17 out of 262 durum wheat lines were resistant to septoria leaf blotch. Table 1 shows resistant bread wheat and durum wheat lines that had acceptable yields during 1981/82 and 1982/83 seasons. Among resistant bread wheats, eight lines are derived from ICARDA germplasm and 26 from Tunisian crosses or CIMMYT segregating germplasm. Three resistant bread wheat lines (two Snb 's' and one Bow 's') have been previously reported as moderately resistant (CIMMYT 1980).

Among resistant durum wheats, five lines are derived from Tunisian crosses and the rest from CIMMYT germplasm. However, four of the 17 resistant durum wheat lines showed different degrees of susceptibility to tan spot (*Helminthosporium tritici repentis)*

Triticale germplasm generally possessed better resistance with only two susceptible out of 68 tested lines.

Table 2 shows the reactions of commercial wheat varieties grown in Tunisia. Durum varieties Karim 79 and Ben Bechir 78 which have high grain yield are susceptible to septoria leaf blotch. In previous testing, these two varieties showed an acceptable level of resistance (Anonymous 1979-1982). Our results concerning bread wheat commercial varieties are in accordance with those previously reported (Anonymous, 1979-1982).

Table 2. Commercial durum and bread wheat varieties under cultivation in Tunisia[1].

Durum Wheat		Bread Wheat	
Variety	**Reaction to** ***S. tritici***	**Variety**	**Reaction to** ***S. tritici***
Karim 79	S	Tamit 80	MS
Ben Bechir 78	S	Salambo 80	R
INRAT 69	MS	F. Aurore	MS
Maghrebi 72	VS	Ariana 66	MR
Badri	VS	Dougga	MR
Amal 72	VS	Carthage	MR

1 R = resistant
MR = moderately resistant
MS = moderately susceptible
S = susceptible
VS = very susceptible

In conclusion, our results confirm the opinion that bread wheat in general is more resistant to septoria leaf blotch than durum wheat (Anonymous 1979-1982; Djerbi and Ghodbane 1975; ICARDA 1983). Triticale showed still more resistance and could be an alternative crop where septoria leaf blotch is a limiting factor for wheat production.

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DEVELOPMENT OF QUALITY DURUM WHEAT VARIETIES IN CANADA[1]

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Introduction

In recent years amber durum wheat (*Triticum durum*) has become an increasingly important crop to western Canadian farmers. In the late 1960s Canadian durum wheat production rose sharply (Table 1) due to a dramatic increase in exports. This increase in production corresponds to the introduction of new varieties of durum wheat which exhibited improved spaghetti-making quality over previously grown varieties (Matsuo 1974). Canadian domestic durum wheat consumption continues to be very low (Table 1), so if Canada is to be a major durum wheat producer, new Canadian durum wheat varieties must meet all the quality requirements of all potential export markets.

In the Canadian Durum Wheat Breeding Program, durum wheat quality is evaluated on the basis of semolina milling potential and spaghetti-making quality. A considerable proportion of exported Canadian durum wheat is used for products such as couscous and bread, but by meeting the quality requirements of the major pasta consuming markets, Canadian durum wheat has found acceptance in all markets.

The major quality attributes considered in the Canadian Durum Wheat Breeding Program are semolina milling yield, color, protein content, gluten strength, and spaghetti cooking quality. Canadian durum wheat generally has adequate yellow pigment content and does not display undesirable browning during pasta processing. Therefore, the major emphasis in recent years has been placed on the improvement of protein content and gluten strength. Protein content is the most important factor associated with good pasta cooking quality (Dexter and Matsuo 1977). Gluten strength is related to rheological properties of pasta doughs (Dexter and Matsuo 1980) and is also an important prerequisite for good cooking quality (Dexter *et al.* 1980).

Preliminary Screening of New Varieties

It normally takes about 10 years from the time the initial cross is made until the time a line may be licensed. In the early stages of breeding, two generations are grown in one year using green houses or growth chambers and winter plantings in California and Mexico. Prior to the fourth generation, or F_4 line, the plant breeder selects lines on the basis of vigor, disease resistance, and kernel characteristics. Only licensed varieties are eligible for the top durum wheat grades, so an important consideration in variety selection is distinguishability of kernel characteristics from varieties known to have poor quality (Matsuo 1974). Some selection is also made on the basis of vitreousness. Vitreousness is an important consideration in semolina milling. Starchy kernels are soft and impart low semolina yield because of the greater proportion of flour by-product produced (Dexter and Matsuo 1981).

At the F_4 stage the first selections are made on the basis of yellow-pigment content and gluten strength. Yellow pigment is estimated colorimetrically from a water saturated n-butanol extract of ground wheat (Dexter and Matsuo 1978). For many years the micromixograph test developed by Bendelow (1967) was used to estimate gluten strength. Very recently the SDS-sedimentation test has been introduced as a gluten-strength indicator because of its simplicity, small sample size requirement, rapidity, and high degree of precision (Dexter *et al.* 1980).

For the next several generations the lines continue to be selected on the basis of disease resistance, color,

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Table 1. Canadian durum wheat production and exports for the last 20 years.

Year	Production (1000 tonnes)	Exports[1] (1000 tonnes)	Year	Production (1000 tonnes)	Exports[1] (1000 tonnes)
1964	914	929	1974	1562	1423
1965	460	921	1975	2536	1665
1966	773	724	1976	2858	1696
1967	550	359	1977	1276	1968
1968	1236	507	1978	2852	1350
1969	2259	489	1979	1799	1948
1970	2202	1354	1980	2035	2075
1971	1524	1734	1981	2977	2311
1972	2000	1634	1982	3121	2687
1973	1410	1265	1983	2648	2400[a]
10-yr average	1333	992	10-yr average	2366	1952

1 Export figures are based on the new crop year (August 1 - July 31) following each harvest.
a Projected figure based on exports to March 31, 1984.

and gluten strength. The F_7 and F_8 generations are evaluated for yield. At this point the breeder will have reduced thousands of F_2 plants from his original cross to a small number of lines which he will advance to the final stages of testing together with promising lines from other crosses.

Advanced Screening of New Varieties

The first detailed quality tests are carried out on the F_9 lines. The new lines are grown at several locations alongside licensed varieties and are evaluated for yield and other important agronomic characteristics. The lines are also assessed for milling performance and spaghetti-making quality. The most promising lines are advanced the next year for increase and are further screened for field performance and milling and spaghetti-making quality. After these tests a few survivors are entered into the final phase of the testing program, the 'Durum Wheat Cooperative Test' or 'C Test.' In this test the new lines are grown at 11 locations across western Canada. Hercules, the variety used as the index of quality for Canadian durum wheat, and other commercially important varieties, are included in the C Test. In this way the yield and agronomic potential of the new lines relative to currently grown varieties can be evaluated over a wide range of climatic and soil conditions. Following harvest, detailed milling and spaghetti-making tests are carried out on samples composited from all locations for all new lines and standard varieties. Before recommendation for licensing can be made, a new line must be judged equal to or superior to Hercules for at least three years by each of three expert committees comprising plant breeders, pathologists, and quality experts, respectively. Lines may be dropped from the C Test at the end of any year they fail to give satisfactory results.

Testing Procedures for Advanced Quality Screening

All the advanced quality testing of durum wheat lines is performed by the Canadian Grain Commission. Before the samples are composited for quality testing, the Grain Inspection Division examines the seed of each line from each location, assigns a grade, judges each line on the basis of kernel characteristics, and determines vitreous kernel percentage.

Composite samples are forwarded to the Grain Research Laboratory for detailed quality testing. The wheat is subjected to a wide range of physical and chemical tests including protein content (Matsuo 1974). Each sample is milled in duplicate 1000 g lots using the Buhler laboratory mill (Dexter *et al*. 1984a) in conjunction with a laboratory-scale purifier (Black 1966). The mill is modified for semolina milling as described by Black and Bushuk (1967). Only the break system of the mill is used. A semolina of about 65% extraction (proportion of clean wheat on a constant moisture basis) is obtained from a good quality durum wheat. Total extraction including flour is about 75%.

Spaghetti is processed from each replicate milling on a microscale using 50 g of semolina (Matsuo *et al.* 1972). Mixing is carried out under vacuum in a sealed 50 g farinograph bowl at 31.5-33.5% absorption. Processing absorption is based on the farinograph curve obtained by the method of Irvine *et al.* (1961) for assessing mixing characteristics of pasta doughs (Fig. 1). The farinograph curve also is a useful index of gluten strength – a long mixing time, gradual breakdown, and wide bandwidth indicate strong gluten and good dough properties.

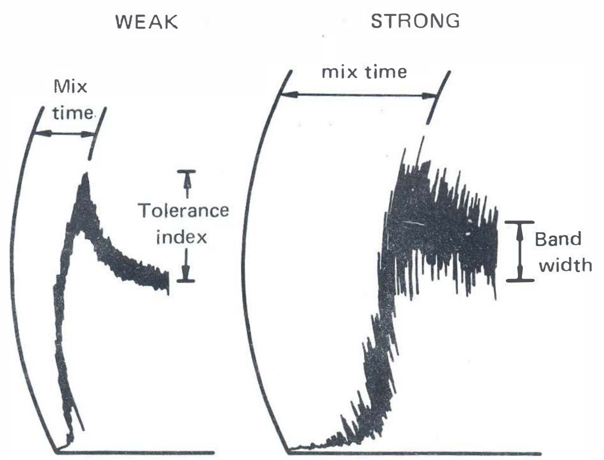


Fig. 1. Farinograph mixing curves (31.5% absorption) for a weak gluten and a strong gluten sample.

Following mixing, the micro-spaghetti dough is placed under about 130 atm pressure at 50°C for 10 min to simulate the pressure and temperature of commercial pasta presses. The homogeneous translucent dough is then extruded through a four-hole Teflon die (about 1.8 mm dia) and placed in the drying cabinet (Fig. 2).

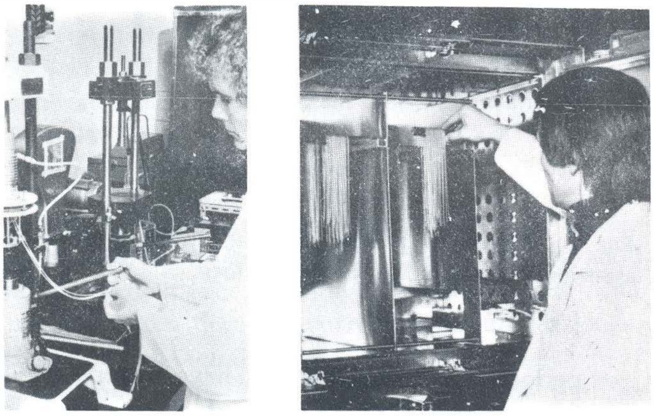


Fig. 2. Extruding spaghetti by the micro-spaghetti process and the spaghetti drying chamber.

Drying is the most critical stage of spaghetti quality evaluation. Improper drying technique can destroy the quality of spaghetti and make quality ranking impossible. The drying temperature also has an important influence on both the color (Dexter *et al.* 1984b) and the cooking quality (Dexter *et al.* 1983b) of spaghetti. Some varieties respond to high-temperature drying conditions more than others. Therefore, with the increasing popularity of high-temperature drying in the pasta industry, we have recently begun to evaluate spaghetti quality under high-temperature drying conditions in addition to our conventional low-temperature conditions (Fig. 3).

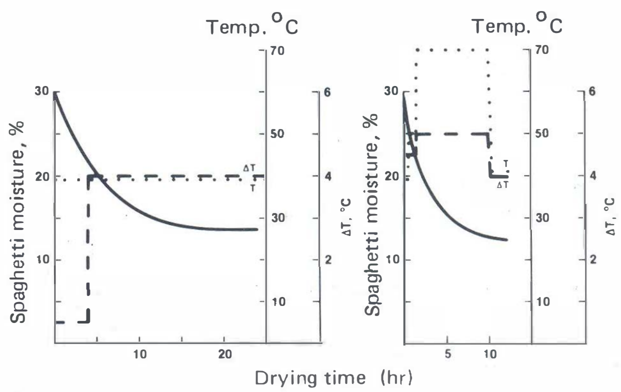


Fig. 3. Spaghetti drying programs.

Spaghetti color is determined on whole spaghetti with a reflectance spectrophotometer (Daun 1978) as shown in Fig. 4. Results are expressed in terms of brightness, purity, and dominant wavelength. The dominant wavelength is the wavelength of the pure spectrum color which, in combination with a tungsten lamp source, produces the color. The desirable color for pasta products, a bright amber yellow, is characterized by a dominant wavelength from 577-578 nm. Brownish pasta is characterized by values over 578 nm. Other desirable characteristics include a high brightness value (a measure of the amount of light reflected by a sample relative to a near-perfect white surface) and a high purity value (a measure of color intensity).

The ultimate test of acceptability of a durum wheat variety is cooking quality. At the Grain Research Laboratory, instruments have been developed to evaluate firmness (Matsuo and Irvine 1969), resilience (Matsuo and Irvine 1971), and stickiness (Dexter *et al.* 1983a) of cooked spaghetti.

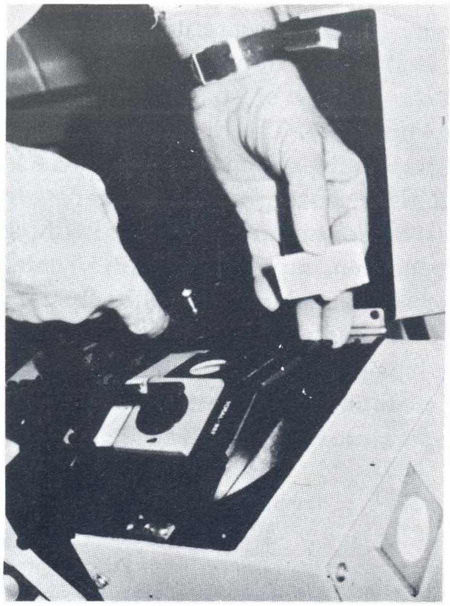
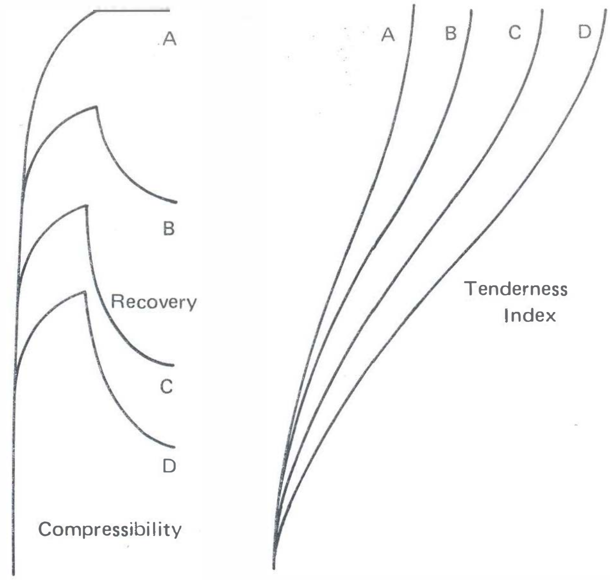


Fig. 4. Determining spaghetti color quality by reflectance spectroscopy.

Instrumental tests are preferred to taste panels because they are nonsubjective, require small amounts of sample, and are very rapid. Stickiness is highly sensitive to cooking water hardness (Dexter *et al.* 1983b), so all cooking tests are performed in a standardized buffer solution.

Fig. 5 shows the type of curves obtained during tests for cooked spaghetti resilience and firmness. In testing for resilience, the extent to which a sample can be compressed by a blunt edge under a constant force is measured, and after the weight is removed the extent to which the sample recovers to its initial diameter is determined. Tenderness index, a measure of firmness, represents the rate of shear of a cooked sample by a knife under an increasing force. The three paramenters may be combined into an overall cooking score (R/C x TI) by taking the ratio of recovery (R) to the product of compressibility (C) and tenderness index (TI).

Recently, a test for determining the surface stickiness of drained cooked spaghetti has been introduced into the screening procedure. Cooked spaghetti is compressed under a plunger and, upon lifting the plunger, the force of adhesion of the spaghetti to the plunger (stickiness) is measured. Stickiness is influenced by time, following cooking (Fig. 6). The test is conducted 10 min after cooking because the 10 -min rest period allows the operator to have several samples at various stages of testing at a given time thereby increasing sample throughout.



A. Very soft sample (overcooked, low protein, severe sprout damage)

B. Weak gluten (Stewart 63, Leeds)

C. Strong gluten (Wakooma, Macoun)

D. Very strong gluten (Candeal, Taganrog, Senatore Capelli)

Fig. 5. Recorder tracings obtained during instrumental assessment of cooked spaghetti resilience and firmness.

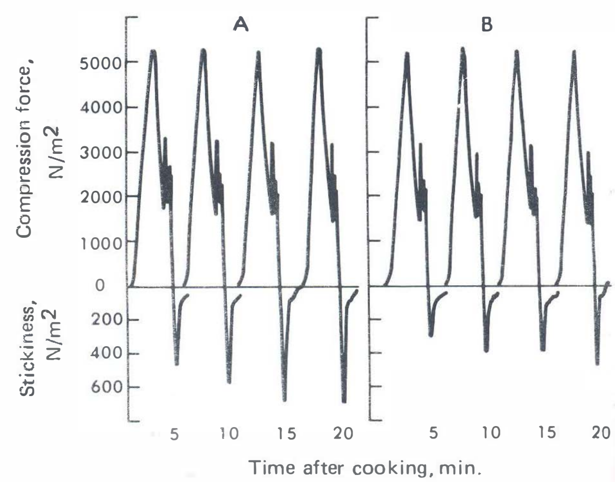


Fig. 6. Recorder tracings obtained during instrumental assessment of cooked spaghetti stickiness.

Tolerance to overcooking must also be considered. In the initial test a sample is cooked just to the point where the central white core in the spaghetti disappears (about 12 min). Firmness and resilience are also determined for samples cooked 10 min after optimum time (about 22 min). It is not unusual for some lines which exhibit satisfactory cooking scores at optimum time to exhibit unsatisfactory cooking scores when overcooked. Stickiness appears to be independent of cooking time (Dexter *et al.* 1984b) so cooked spaghetti stickiness is assessed at optimum cooking time only.

Licensing New Varieties

When a new line has performed satisfactorily for three years in the C Test, the plant breeder may apply to Agriculture Canada for a license. The application must be accompanied by a recommendation from a recognized (provincial, regional, or federal-provincial) committee which in turn is based on the recommendations of the breeders, pathologists, and quality experts who have evaluated the line. When the license is issued, the wheat is given a variety name. Once a license is granted, registered seed growers increase the seed. During the increase the fields are inspected by Agriculture Canada officials to ensure variety purity. Once sufficient seed is available, usually two years after licensing, seed is offered to farmers for commercial production.

Future Prospects

Currently, the variety Wakooma comprises 50 % of the total Canadian durum wheat crop. Two other varieties, namely, Wascana and Coulter account for about 35 and 10 % of the crop, respectively. Three new varieties have been licensed in the last three years, Medora (1982), Arcola (1983), and Kyle (1984). Medora should be released for commercial production in 1984. The other two varieties are currently undergoing seed increase.

All three new varieties have excellent agronomic characteristics and good protein content, exhibit good milling properties, and have improved color and stronger gluten than the current dominant varieties. Therefore, the quality of Canadian durum wheat should continue to improve over the next few years as the new varieties become a significant proportion of Canadian durum wheat production.

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BURGHUL AND ITS PREPARATION

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Burghul is one of the oldest cereal-based staple foods in the villages and has been a valuable adjunct to the diets of city dwellers in the Middle East for centuries. Reports on the extent of consumption vary widely according to area between 5 and 15% of wheat consumption in Turkey, Syria, Jordan, Lebanon, and Egypt. Spellings and pronunciations of burghul vary, as do other names applied to the same product. In Syria, Jordan, Lebanon, Egypt, and the North African countries, Burghul (pronounced 'Burrrgool') is the commonest term found. In North America, the product is referred to as 'Bulgur.'

The preferred raw material for preparation of burghul in the villages and towns of the Middle East is durum wheat, but common hard and even softer wheats, such as the widely grown Mexipak may also be used. The common method for preparation of burghul in the Middle East is as follows: the wheat is soaked, having been freed from straw, chaff, and other foreign material such as grass seeds and stones using sieves and air. It is then boiled, cooled, dried, moistened, peeled, dried again, cleaned by winnowing, milled, and sized. Sometimes, the peeling process is omitted.

Two typical methods of burghul preparation are given here. The first is a large-scale method used in cities and large towns in northern Syria. The second is the method used in the villages and isolated farms in the same region. Large-scale burghul preparation requires several people and a considerable area for the drying. Raw wheat is purchased for burghul-making either by cash or by a barter system in which processed burghul is exchanged for wheat. The flavor and texture of burghul vary according to the wheat used and the method of preparation. The prices vary according to quality. Extensive experience and skill, combined with hygienic methods of production, are essential to the making of good burghul.

Large-scale burghul production in Syria requires a circular steel container of about 1.8-2 m in diameter, and 50-70 cm in depth. Heating is by 'mazout' (fuel oil or diesel). The heating pipe is shaped as a cross with two vaporizing chambers for the mazout. Each arm of the cross has three jets. The mazout is kindled using pieces of wood or cardboard. When the vaporizing chambers above the jets are hot enough to vaporize the mazout, the jets begin to flare and are self-generating. About 650 kg of wheat is added to 650 litres of water in the tank. This is stirred, and the water covers the wheat to a depth of 12-15 cm. The wheat/water mix is stirred thoroughly until further pieces of light foreign material float to the surface, from which they are removed by a sieve-like scoop. The stirring is continued until no more material can be removed. Durum wheat has a higher pigment content than common wheat, and the xanthophyll-type durum pigments give a better all-round color to the burghul.

The wheat/water mixture is then heated and boiled until the combination of the wheat swelling and water evaporation causes the swollen grains to come to the surface. This usually takes about 1 hr. The surface is covered with jute bags to prevent desiccation. After 15 min the bags are removed, and a hole is dug in the middle of the container. The boiled wheat is moved by shovels from sides to middle. The mixture is covered again then left for 15-30 min. The total period from beginning to end of boiling is about 1 1/2 hr. The fire is extinguished, and the swollen grains are spread at a thickness of about 3 cm to dry in the sunlight and open air. The ideal surface is a baked gypsum clay. Every 15 min during sunlight hours, the wheat is stirred, usually by walking through it with bare feet to ventilate the boiled wheat, and allow more evaporation from the ground and the wheat. At a later stage, a wooden rake is used. When the grains are dry, they are packed in bags. At this stage, the starch has been gelatinized, and the grains become dry with a very hard texture. They will keep in this state for long periods without becoming rancid, and crude burghul is often stored in the villages in this form.

Peeling is done in a piece of equipment, which is essentially a decorticator. The dried grains are mixed with about 30% water to assist in separating the bran. Peeling takes about 15 min/350 kg of boiled wheat which is the regular capacity of the peeler. The peeled grain, together with the bran, is then bagged and transported to the drying area for redrying. This stage takes about 4 hr in sunlight. The prime time for burghul-making is immediately after harvest when local grain is plentiful and the sun is hot and more suitable for drying. Temperatures in the open sun often reach 50 – 55^{o}C. Dried peeled grain is easily freed of branny material by air elutriation using the wind, or a fan (Fig. 1). The branny material is fed to chickens so there is practically no wastage. Most villagers prefer to buy dried peeled grain and process it into the final burghul themselves.

Milling the dried peeled grain is usually controlled to produce coarse (granular) and fine burghul at about 50:50. On large-scale operations in the cities, mills using metal pulverizing burrs are preferred. A purifying or classifying stage follows this type of milling. The purifier contains sieves and a fan, and is similar in action to a modern flour mill purifier. It sorts the material into up to four-size grades: coarse or granulated burghul, fine burghul, very fine burghul (called 'Smesma'), and flour. All four streams are collected separately from the purifier. Total extraction of burghul on a whole-wheat basis is about 88%. If a

Fig. 1. Dried peeled grain is easily freed of branny material by air elutriation using a fan.

finer grade of burghul is to be prepared, the extraction rate falls to 84%, and more flour is produced.

In the villages and isolated homesteads, the peeling and purifying stages are omitted due to lack of equipment. The process is as follows: wheat is added to water in a large tin-plated circular copper pan of about 85 cm diameter and 30 cm deep. Wheat and water are added 1:1 and chaff and other foreign material are removed as for the larger scale process. The wheat is boiled, cooled, and spread in the sun to dry on the baked clay surface of the yard, or the roof of the house (jute may also be used underneath the grains). It is then wetted to about 15% (v/v) with water and wet-milled on a horizontal type of stone mill similar to the mill described above. The wet, ground burghul/bran mixture is spread to dry, freed from bran by wind aspiration, and graded into two fractions, fine and coarse, using a sieve. The degree of fineness of the burghul is controlled by adjusting the distance between the stones. The stones rotate horizontally, and are usually carborundum or limestone discs.

Coarse burghul is used directly by boiling or steaming in the presence of meat and vegetable in a similar manner to rice, couscous, or frekeh. The juices of the meat and/or vegetables combine to add flavor to the final dish. Fine burghul has an average granularity of about 0.25 mm and is used in the preparation of 'Tabuli,' some types of 'Kibbe,' 'Khishke,' and other dishes. Smesma is used in the production of foods which require a binder, such as Kibbe and many other foods. The flour normally contains some foreign material, and is usually fed to chickens. In the more isolated areas, where no mill is available, the boiled dried wheat is wetted, pounded with a large pestle and mortar (metal or stone), dried, freed of bran, and graded with a sieve in the usual way.

The nutritive value of burghul is high. Protein and other constituents dissolve into the liquid during boiling, but as the moisture level decreases, the solubilized constituents are recombined into the boiled grains (Table 1). Protein efficiency ratio (PER) has been studied by Shammas and Adolph (1954) who used rat metabolism as an indicator, and found the PER to be essentially unchanged from that of the original wheat. Thiamine, niacin, and particularly riboflavin were found to be significantly reduced by industrial preparation in the United States, but essentially, burghul is a very nutritious type of cereal food, relatively simple to prepare, and capable of being prepared from a wide range of wheat types, although the larger-grained durum varieties such as the seasoned Senator Cappelli are preferred.

Table 1. Protein content of burghul fractions.

Fraction	Protein(%)
Original wheat	12.3
Coarse burghul	12.1
Fine burghul	12.0
Flour	13.1

Reference

Shammas, E. and Adolph, W.H. 1954. Nutritive value of parboiled wheat used in the Near East. Journal of American Dietetics Association 30: 982-983.

DURUM WHEAT-QUALITY EVALUATION AT ICARDA

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Durum wheat is indigenous to the Middle East where it is more widely cultivated than in any other wheat growing region. Durum wheat production was estimated at 7 million tonnes or 26% of total wheat production in 1970, compared to a durum percentage of about 8 over the rest of the world. In 1980, about 10 million tonnes were grown in the Middle East, or about 22% of the total 45 million tonnes of wheat grown. As a result of its long history of cultivation in the Middle East, together with the diversity of cultures, a series of food types has evolved based on durum wheat which makes durum wheat quality evaluation more complicated than in other durum wheat growing regions. The gradual decline in the percentage of durum wheat grown as compared to bread wheat is a reflection of an increase in cereal (mainly bread wheat) consumption and an increase in urbanization in the region, rather than a decline in the preference for durum-derived foods. This trend is continuing, and the use of wheats of all types in the production of bread is increasing. Based on data contributed by Varughese (1975) and more recent data, present utilization of durum wheat in the Middle East is estimated as presented in Table 1.

Table 1. Principal end uses of durum wheat in the Near and Middle East.

End-use product	Total consumption (%)
2-layered flat breads	40-45
Single-layered flat breads[1]	5-10
Pasta	10-15
Cous-cous	8-10
Burghul	10-15
Others (frekeh, etc.)	2-5

1 Includes single-layered raised breads such as choriatico (Cyprus).

In addition, a certain amount of durum is exported among countries of the Middle East and the Mediterranean.

To ensure the introduction of new durum germplasm which complies with the demands of the industry and the people, it is necessary to identify the quality parameters of all major end products, then to develop a screening and evaluation schedule for the selection of cultivars optimum for the production of the most important foods. Quality parameters of these are summarized in Table 2.

Table 2. Grain quality factors necessary for preparation of foods derived from durum wheat in the Middle East.

Foods	Quality factors
2-layered flat breads[1]	medium protein, high gluten strength, light color
Single-layered flat breads	as for 2-layered breads
Pasta	high vitreous kernel count, high protein, high gluten strength, high semolina yield, yellow (amber) color
Cous-cous	as for pasta
Burghul	as for pasta, preferably large grain size
Export	as for pasta

1 'High gluten strength' means high gluten strength for durum flours which are inherently weak.

Most of the world's research on durum quality has been devoted to study pasta quality, and the factors which affect spaghetti color, texture, stickiness, and other parameters, and to study semolina milling. The most recent survey of factors affecting spaghetti quality (Matsuo *et al.* 1982) has shown that for a series of durum wheats with a wide range of spaghetti quality, the parameters most correlated to spaghetti quality were gluten strength, as measured by a custom-made device (Matsuo 1978) and sodium dodecyl sulphate (SDS) sedimentation value. In view of the fact that about 50% of the durum wheat used in the ICARDA territory is consumed as flat bread, durum wheat cultivars are screened for flat bread quality parameters, potential burghul, cous-cous, and frekeh-making and pasta quality.

Two-layer flat breads have special quality requirements. The familiar double layers and correct texture are generated by optimum fermentation, particularly during the final proofing stage. The baking process involves mixing, primary fermentation, dividing and moulding into small dough balls, a short, but critical intermediate proof period, sheeting in two directions to give a round flat piece of dough, traditionally about 28-30 cm in diameter and 1.5-2.0 mm thick, then a final proof of 25-30 min.

Fermentation and gas production are assisted by mechanically-damaged starch, and gas retention is promoted by gluten or dough strength. Another important aspect of flat-bread baking is the dough handling property, particularly at sheeting. If the dough is too weak it is difficult to obtain regular shaped circular dough pieces, but if it is too strong it contracts after sheeting and the dough pieces become too thick resulting in a too coarse and tough baked khobz texture which would in turn result in excessive consumer waste.

High starch damage imparts a soft texture to the khobz, but unless fermentation is carefully controlled, this can result in surface burning. Three parameters, namely, gluten strength, starch damage, and yellow pigment of durum wheat are important in flat-bread baking. Of these, the first is usually too weak, and the other two are too high for successful flat-bread baking. In ICARDA's baking laboratory durum flours are baked as a 50:50 blend with a commercial bakery flour of low - medium dough strength. Baking as a 50:50 blend provided a more realistic evaluation of potential baking quality. Ideally, a durum cultivar should have superior dough strength and lower pigment content for khobz baking. For pasta making, strong gluten characteristics are also important, but a high pigment content is desirable. A high percentage of vitreous kernels is required for all products, and also for export, and is one of the most important of all quality parameters in durum wheat. Kernel size is also important for production of several foods. Finally, protein content and hardness are measured in all durum cultivars, the protein to establish a more fundamental level from which other quality parameters are assessed, since protein affects several other factors. Hardness does not seem to vary widely in durum wheats, but it may vary by up to 100% between the hardest and softest lines. Hardness affects starch damage during flour milling, and also the texture of foods such as burghul, frekeh, and possibly spaghetti. Gluten strength is assessed in wheat by the wheatmeal fermentation time and the SDS sedimentation test, and in flour by the Brabender farinograph, which gives three measurements of strength; the development time, the stability, and the mixing tolerance. The testing sequence applied to durum wheat at ICARDA is summarized in Table 3.

In 1981, as an adjunct to the quality laboratories, a series of field-sown nurseries called the cereal quality

Table 3. Quality tests applied to durum cultivars at ICARDA, Syria.

Quality test	Method	Ideal selection range
A. Early generation material (F_2-F_4)		
1. Kernel test weight and shape	manual/visual/gravimetric	40- 48 g
2. Vitreous kernel count	visual/gravimetric	Over 90%
3. Protein	near-infrared (NIR)	12- 14%*
4. Wheatmeal fermentation time	Pelshenke	60- 100
5. SDS sedimentation	manual	40- 50**
6. Yellow pigment	water-saturated butanol extraction	as high as possible
B. Advanced and parental material		
1-6. As for early generation material		
7. Hardness (PSI)	NIR/sieving	4-7 (A)
8. Protein quality [1]	10 g mixograph/wet gluten	3-4 min DT.
9. Flour milling	Buhler	68-70% Extr.
10. Semolina milling	Buhler[2]	68-70% Extr.
11. Gluten strength	Brabender farinograph	3-5 min stability.
12. Yellow pigment (semolina only)	butanol extraction/spectrophotometry	high
13. Flat-bread baking quality [3,4]	ICARDA procedure	high
14. Spaghetti quality	Grain Research Laboratory procedure	high

* Dry basis.

** Using 100 ml cylinders.

1 This is a short quality evaluation process involving grinding of 60 g of wheat, sieving through a 100 mesh sieve, and carrying out a 10 g mixograph test, followed by sodium dodecyl sulphate (SDS) sedimentation, and by wet gluten determination to determine elasticity. The wet gluten test also detects infestation by eurygaster (suni bug), which affects gluten strength.

2 Buhler mill modified according to Grain Research Laboratory procedure (Dexter *et al.* 1982).

3 Blended 50:50 with commercial medium strength bakery flour. All of the above test procedures are described in detail in the ICARDA Laboratory Operations Manual.

4 Single-layered flat breads are baked from 100% wholemeal flour milled in the Tel Hadya village stone mill. The baking of tannour is carried out by experienced village women, who also advise on the judging of the breads.

nursery (CQN) was established. The nurseries presently include 12 cultivars of each of bread and durum wheats, 10 barley, and 6 triticale cultivars. Of these, 2 cultivars are maintained every year as permanent checks, 2 are changed every year to allow the breeders to access new germplasm to the more rigorous quality screening, and the remainder remain in the CQN for 3 years before change. The nurseries are grown in 10 locations throughout the Middle East, with environments differing widely in rainfall, length of growing season, and elevation. Growing conditions include irrigation, and the wide variation is intended to induce maximum variation in protein content and other parameters. The CQN concentrates on both the

Table 4. Vitreous kernel count (%) of six durum cultivars over five locations, 1982/83.

Cultivar	Cyprus	Tel Hadya (rainfed)	Tel Hadya (irrigated)	Tunis	Tel Hadya (low fertility)	Mean	CV (%)
CM9799	92	100	99	99	2	78.4	55
ICD7477	92	90	93	92	25	78.4	38
CD4404	92	100	97	96	17	80.4	44
Hourani	90	98	98	96	27	81.8	38
Jori 69	93	99	100	97	77	93.2	10
Waha	95	99	98	99	47.6	87.6	26

cultivars and the test procedures and for the 3 years of its existence it has proved to be as valuable a tool in evaluating quality and stability of quality as the testing sequence itself.

The data derived from the CQN include information on the heritability of individual quality characteristics by cultivars, and on the stability of these characteristics when the cultivars are grown under different growing conditions. Typical of this type of information are the data presented in Table 4, which summarizes the vitreous kernel count of six cultivars grown in five locations during 1982/83. From these data it is apparent that the old variety Jori 69 was the most stable cultivar in this respect over the five locations.

Table 5 illustrates data for four varieties over two seasons, grown at five locations.

This illustrates the consistently high vitreous kernel count of Jori 69, and also that of Waha, an advanced ICARDA cultivar, as compared to other lines. All of the tests referred to in Table 3 are evaluated every year for all four cereals at all locations, and the CQN has already generated valuable information, particularly in the case of bread wheat and triticale, where parameters such as kernel hardness and dough strength are far more variable between cultivars than is the case with durum wheat. Durum cultivars generally do not differ widely in these two characteristics, and the selection of cultivars with improved dough strength is a painstaking process. It is considered likely that a durum with strength characteristics suitable for making good flat breads will also be suitable for pasta making from the aspect of strength.

Table 5. Vitreous kernel count (%) for four varieties of durum wheat over 2 seasons and five locations, 1981-1983.

Cultivar	Mean (1981/82)	CV (%) (1981/82)	Mean (1982/83)	CV(%) (1982/83)
Forat	83.1	27	85.0	32
Hourani	88.7	11	81.8	38
Jori 69	96.4	2	93.2	10
Waha	95.0	3	87.6	26

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RESISTANCE OF DURUM WHEAT GENOTYPES TO SALINE-DROUGHT FIELD CONDITIONS

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Introduction

Durum wheat is grown under low-rainfall conditions, and is reported to be stress-resistant (Srivastava 1984). Breeders are working to further improve the resistance of this crop to drought, cold, heat, and salinity stresses. To be effective, such work must be conducted under field conditions, because there is often no correlation between plant stress resistance in controlled environments and in the field (Winslow *et al.* 1982). This article reports one-year data on differences among durum wheat genotypes in resistance to saline-drought field conditions and the performance of durum relative to the more resistant barley crop. Promising selection criteria for further improvement of stress resistance in durum wheat are discussed.

Materials and Methods

A saline-drought affected field nursery site at Hegla, Syria (55 km southeast of Aleppo) was used. The nursery is near the shoreline of the Jabboul salt lake. The soil is calcareous and highly saline, with a pH of 8.31 and an average saturated-paste extract conductivity of 18 mS/cm in the nursery. The salt consists mainly of sodium and chloride ions. The salt concentration increases greatly with soil depth, and as a result rooting depth is shallow.

The long-term mean annual rainfall is 200 mm. In the 1982/83 season the total rainfall was 206 mm, and was evenly distributed from November through February. This indicates that Hegla is a drought-affected site as well as a saline site.

Eighty durum genotypes from diverse origins were tested. These lines had been visually selected in previous years' testing at Hegla as possibly salt-drought resistant (Srivastava and Jana 1983). The lines were planted in a randomized block design with eight replications. Plots consisted of single rows, 1 m long, spaced 20 cm apart, with a seeding rate of 100 kg/ha (50 seeds/row). Every four test plots were bordered by two rows of check varieties: a salt-drought resistant check (based on previous seasons' visual ratings) and an adapted local check (Haurani). Rapid planting at uniform depth was facilitated by using an automated single-row drill seeder. Resulting plant stands were quite uniform.

Agronomic data for heading time (days from sowing), 1000-kernel weight (g), and number of seeds/spike were recorded for all entries. Yields (both grain and total dry matter) on such small plots are believed to be accurate because plant growth under these conditions is extremely restricted and between-row competition was not evident. Canopy closure was never achieved and root growth was very limited. All data reported are from the 1982/83 season.

For comparison, data are also presented from a standard plot yield trial of the same genotypes conducted during the same season under nonsaline, higher rainfall (325 mm) conditions at Tel Hadya, Syria (approx. 70 km from Hegla). Data were also obtained from a saline-drought barley trial (including 80 adapted landrace lines; Weltzien 1982) conducted in a field adjacent to the durum wheat trial at Hegla using the same design.

Results and Discussion

The data are summarized in Table 1. Threefold differences in total dry matter and twofold differences in grain yield were evident in comparing the best and poorest performing durum wheat genotypes. The highest yielding line and the salt-tolerant check both significantly outyielded the well-adapted local check, indicating the effectiveness of visual selection in previous years.

However, the total dry-matter yields of even the best durum genotypes were considerably less than those of barley. This could be attributed to a much lower grain yield in durum, straw yields of the best durums being similar to those of barley.

The similar straw productivity of durum and barley suggests that the two crops have similar salinity-drought resistance in the vegetative phase of growth. The greatly reduced grain yield of durum indicates that it is much more sensitive to stress in the reproductive phase than is barley. This difference is well-illustrated in the harvest index of durum which was only half that of barley.

Table 1. Productivity of four durum wheat genotypes under saline-drought stressed conditions (Hegla) and low-stress conditions (Tel Hadya), as compared to barley, Syria 1982/83.

Genotype	Hegla					1000-kernel weight		Seeds/spike	
	Total dry matter yield[1]	Grain yield[1]	Straw Yield	Harvest index	Heading (days from sowing)	Hegla	Tel Hadya	Hegla	Tel Hadya
	(kg/ha)					(g)			
Best durum wheat line (Gdo vz 469/AA'S'//Fg'S')	1380	300	1080	0.22	178	40.2	40.8	6.1	29.2
Poorest durum wheat line (Ato 'S'/D.dwarf S-15/Jo'S')	540	130	410	0.24	174	40.8	48.6	3.7	27.9
Salt tolerant check (Bit 'S'/Adler 'S'//Mexi 'S'/3/Gta 'S'/Fg 'S')	1130	270	860	0.24	171	42.2	48.5	5.2	27.2
Haurani (local check)	890	210	680	0.24	174	31.6	45.0	5.7	29.9
Mean 80 barley landrace Lines	1830	920	910	0.50	156	38.4	46.8	12.2	24.4

1 LSD (0.05) values for comparison between means of non-check varieties (8 replications) are 330 and 95 kg/ha for total dry matter and grain yield, respectively. For comparison between means of check varieties (160 replications), the corresponding values are 105 and 60 kg/ha.

The lower grain yield of durum is mainly attributed to reduced seed set under stress, since the number of seeds/spike was reduced by approximately 80% (Table 1). Barleys experienced only about 50% reduction. Thus, reduced spike fertility in durum constitutes its main weakness in salinity-drought resistance, as compared to barley.

In contrast, reductions in kernel weight were much less (about 15%), and were similar for both durum and barley (Table 1). This may seem surprising, since the terminal drought conditions of this trial were expected to reduce this yield component the most. However, cereals can compensate for late stress by increasing carbohydrate translocation from the stem, thus maintaining seed size at almost normal levels (Gallagher *et al.* 1975). Nevertheless, the most resistant durum lines also had the least reduction in kernel weight, indicating that further selection for this criterion may be useful in identifying high-yielding lines under stress.

Reduction in spike fertility of durum could not be completely explained by its late heading, as compared to barley, which exposes the crop to a greater moisture stress during the reproductive stage. Among the 80 durum lines tested, no significant correlation was found between heading date and grain yield ($r = -0.054$) despite a wide range of heading dates (from 165 to 186 days).

Several studies have shown that wheat has a greater physiological sensitivity than barley to drought during the reproductive stage (Day *et al.* 1978; Wardlaw 1971; Campbell *et al.* 1981) apart from its later maturity. No specific reasons for this sensitivity are yet known. Selection for high harvest index, which is simple, rapid, and practical in field nurseries, might reveal genotypes with greater resistance to this stress (i.e. greater spike fertility). Data in Table 1 do not support such a strategy, however, since the highest and lowest-yielding durums had similar harvest indices. Nevertheless, it should be kept in mind that the lines entered in this trial were selected visually in previous seasons, and these visual ratings are probably ineffective in identifying higher-harvest-index types. Specific selection for harvest index might help identify genotypes with higher seed-set capability which were missed in earlier screening work. Such genotypes would be most valuable in breeding to overcome the weak link of spike infertility in the salinity-drought resistance of durum wheat.

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COMPARATIVE STUDY OF DURUM (*TRITICUM DURUM* DESF.) AND BREAD WHEAT (*TRITICUM AESTIVUM* L.EM. THELL.) LINES[1]

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Introduction

Bread wheat (*Triticum aestivum* L. em. Thell.) is one of the major cereal crops of the world. Durum wheat (*Triticum durum* Desf.) is the second most important wheat species both with regard to area sown and grain production. Of the 240 million hectares, 90% is bread wheat and 9% is durum wheat (Hanson *et al.* 1982). Comparatively lower grain yield of durum wheat compared with bread wheat has been attributed to less improvement research with the former species and to less favorable growing conditions (Hanson *et al.* 1982; Srivastava 1984). However, no experimental results have been reported on a comparative study of germplasm performance for the two wheat species. The present investigation was designed to compare a number of lines from different crosses of durum and bread wheat grown in northern Tunisia.

Materials and Methods

Three durum (D1, D2, and D3) and three bread wheat crosses (B1, B2, and B3) were studied to determine the relative performance of F_3-derived F_4 and F_5 lines. The crosses were as follows:

D1 = BD 2080/BD 2008
D2 = Gs 'S'/AA 'S'//Raineri /3/Gdo 584
D3 = Jo 'S'//ByE/Tc^5/3/BD 2129

B1 = 4777^2/3/Fr/K 58 N//Gb/4/ Pavon 'S'
B2 = Moncho 'S' - Maya 74
B3 = Choli - Maya 74

In 1980, four random plants were taken from each of four randomly chosen F_3 families/cross grown in two solid seeded 2.5 m rows at Beja, Tunisia. Fertile tillers/plant, kernels/spike, 1000-kernel weight (g), and grain yield (g) were determined on an individual plant basis.

In 1981, a total of 96 F_4 families were grown at Beja in a replicated trial, hereafter designated as experiment 1, according to a randomized complete block design with three replications and one 1.5 m-row plots. The same seed rate (100 seeds/row) and row spacing (25 cm) were used for both durum and bread wheat. Data were collected for grain yield (q/ha), plant height (cm), tillers/m^2 based on a 50-cm row segment, kernels/spike and 1000-kernel weight (both determined on 10 random spikes from each plot). Heading scores were taken in one replication on a 1-5 scale in descending order of earliness (1 = very early, etc.).

From each of the six crosses, one highest and one lowest tillering F_4 line were tested as F_3-derived F_5 lines in a replicated trial, hereafter designated as experiment 2, conducted in 1981/82 at Fretissa, Tunisia, according to a randomized complete block design with three replications and four 2 m row plots. Row spacing

1 This research was conducted when the author was professor of agronomy at INAT, Tunisia.

and seed rate were the same as in the previous trial. Yield components were also determined as in experiment 1. Grain yield (q/ha) was based on the two central rows in each plot. Heading date was considered from 1 April to the date of 50% heading and maturity date was considered from 1 June to the date when 50% of the peduncles in a plot had turned yellow.

For each cross in experiment 1, the effects of F_2 subpopulations (populations derived from individual F_2 plants) and F_3 within F_2 subpopulations were studied in the F_4 generation using the following model:

$$Y_{ijk} = u + a_i + b_{j(i)} + c_k + e_{ijk}$$

where:
u = overall cross mean
a_i = effect of F_2 subpopulation in a given cross (i = 1, 2, 3, 4)
$b_{j(i)}$ = effect of F_3 within F_2 subpopulation (j = 1, 2, 3, 4)
c_k = block effect (k = 1, 2, 3)
e_{ijk} = error.

Adding one or two appropriate parameters, two more models were developed to test the cross and species effects. The latter effects were taken as fixed while all other effects were considered random.

The following model was adopted to analyze the variation of all traits studied in experiment 2:

$$Y_{ijkl} = u + a_i + b_{j(i)} + c_k + (ac)_{ik} + (bc)_{jk(i)} + d_l + e_{ijkl}$$

where:
u = overall mean
a_i = effect of species (i = 1, 2)
$b_{j(i)}$ = effect of cross within species (j = 1, 2, 3)
c_k = effect of tiller class (k = 1, 2 for high and low class)
$(ac)_{ik}$ = effect of interaction: species x tiller class
$(bc)_{jk(i)}$ = effect of interaction: tiller class x cross within species
d_l = block effect (l = 1, 2, 3)
e_{ijkl} = error.

Simple linear correlations among traits in experiment 1 were computed separately for each cross at the progeny-line level. Path analysis (Dewey and Lu 1959; Li 1976) was conducted for tillers/m^2, kernels/spike, and 1000-kernel weight as they relate to grain yield.

For a given trait, correlations were computed using F_3 individual plant values vs F_4 means for each separate cross, and using F_4 vs F_5 means for combined data from three crosses within each wheat species.

Results and Discussion

Experiment 1

As compared to bread wheat, the durum wheat lines were significantly shorter (86.0 vs 95 cm), had heavier kernels (50.6 vs 43.6 g), and fewer tillers/m^2 (375 vs 440). Comparisons for kernels/spike were slightly in favor of durum wheats (43.3 vs 41.0), while no significant difference was detected between the overall mean yields of the two wheat species (61.2 vs 61.0 q/ha). Furthermore, nine durum lines yielded 70 q/ha or above as compared to only five bread wheat lines. Thus, durum wheat does not seem to possess an intrinsically lower yield potential than bread wheat as judged from the performance of 16 F_4 lines belonging to each of three crosses of each wheat species.

Differences among crosses within each species were large for kernel weight and kernels/spike but not for other traits. When each cross was considered separately, the results (Table 1) indicated that variation among F_3 within F_2 subpopulations in the F_4 generation (σ^2 F_3/F_2) was generally as great or even greater than variation among F_2 subpopulations in the F_4 generation (σ^2 F_2). While genetic variation is smaller for σ^2 F_3/F_2 than $\sigma^2 F_2$ (Horner *et al.* 1955), environmental variation and small sample sizes may partly account for the relatively high phenotypic variance σ^2 F_3/F_2. Nevertheless, a sizeable amount of genetic variation still remains in $\sigma^2 F_3/F_2$. These results indicated that individual selection within F_3 families could be effective in increasing selection response in the F_4 generation for the traits studied both in durum and bread wheat.

When the three yield components were correlated with yield (Table 2), kernel weight followed by tillers/m^2 showed the strongest correlation. Path analysis (data not shown) also revealed that these two components exerted the largest direct effects on grain yields. No significant correlation was found among the three components, which explains concordance of

Table 1. Statistical parameters for several characters in durum and bread wheat crosses (experiment 1) grown at Beja, Tunisia, 1981.

Character	Cross	Parameter				
		$6^2_{F_2}$	$6^2_{F_3/F_2}$	6^2	mean	CV (%)
Grain yield (q/ha)	B1	6.17	5.81	69.22	62.3	13.4
	B2	25.43*	16.44	60.43	59.9	13.0
	B3	23.58	37.84*	71.50	60.8	13.9
	D1	3.80	0.24	69.63	65.1	12.8
	D2	46.25**	8.94	52.06	63.5	11.4
	D3	4.51	22.51	108.25	55.1	18.9
1000-Kernel weight(g)	B1	2.61*	0.00 ǂ	4.96	44.4	5.0
	B2	15.49**	4.15**	5.33	46.4	5.0
	B3	1.87	5.83**	3.80	40.0	4.9
	D1	2.74	4.40	4.18	54.2	4.6
	D2	5.05	1.66	6.63	50.3	5.1
	D3	1.40	1.17	10.36	47.4	6.8
Kernels/spike	B1	0.64	0.00 ǂ	32.53	40.3	14.2
	B2	6.66	9.54*	20.23	37.1	12.1
	B3	1.13	0.00 ǂ	36.25	45.6	13.2
	D1	0.00 ǂ	2.07	26.28	40.0	12.8
	D2	0.70	0.00 ǂ	28.17	45.1	11.8
	D3	9.92	7.93	39.60	44.8	14.0
Tillers/m^2	B1	21.88**	7.73	53.90	58.0	12.7
	B2	14.61	36.86**	22.91	53.6	8.9
	B3	13.16*	4.75	42.23	53.5	12.1
	D1	2.07	15.06*	30.47	49.0	11.3
	D2	0.00 ǂ	25.10**	23.02	45.4	10.6
	D3	18.35*	15.24*	29.91	46.4	11.8
Plant height (cm)	B1	23.49**	0.00 ǂ	16.28	93.9	4.3
	B2	0.00 ǂ	14.95**	12.27	97.3	3.6
	B3	37.48**	25.14**	5.95	93.4	2.6
	D1	3.44	7.70*	9.43	87.0	3.5
	D2	1.05	9.05**	6.17	86.3	2.9
	D3	3.52	10.86**	13.70	84.8	4.4

*,** Significant at the 0.05 and 0.01 levels, respectively.

$6^2_{F_2}$ Variance of F_2 subpopulations in the F_4 generation.

$6^2_{F_3/F_2}$ Variance of F_3 within F_2 subpopulations in the F_4 generation.

6^2 Error variance.

ǂ Negative value estimating a zero variance.

Table 2. Correlations among grain yield and other characters for durum and bread wheat crosses (experiment 1) grown at Beja, Tunisia, 1981.

Character	Cross	1000-kernel weight	Kernels/spike	Tillers/m²	Plant height
Yield (q/ha)	B1	0.22	0.51*	0.43	-0.20
	B2	0.71**	-0.06	0.56	0.43
	B3	0.56*	0.31	0.57	0.29
	D1	0.32	-0.34	0.28	0.30
	D2	0.75**	0.18	0.66**	0.67**
	D3	0.69**	0.03	0.64**	-0.39
1000-kernel weight (g)	B1		0.06	-0.30	0.19
	B2		-0.41	0.33	0.29
	B3		-0.32	-0.01	-0.07
	D1		-0.49	0.23	0.56
	D2		0.15	0.36	0.59*
	D3		-0.01	0.44	0.07
Kernels/spike	B1			-0.25	0.27
	B2			-0.39	-0.02
	B3			0.14	-0.08
	D1			-0.15	-0.30
	D2			0.11	0.28
	D3			-0.40	0.06
Tillers/m²	B1				-0.33
	B2				0.31
	B3				0.32
	D1				-0.28
	D2				0.63**
	D3				-0.53*

* ** Significant at the 0.05 and 0.01 levels, respectively.

correlation and path analyses, and suggests that, for the improvement of durum or bread wheats, it may be possible to increase one component without negatively affecting the others.

When F_4 family means were related to their respective F_3 individual plant values, higher correlations were more frequently found for kernel weight and lower correlations for grain yield, tiller number, and kernels/spike (Table 3). These results indicate that, if individual plant selection is made in the F_3, heritability would be highest for kernel weight and lowest for grain yield.

Experiment 2

Genotypic differences were detected for all traits with the exception of tillers/m^2 (Table 4). Comparison of results of durum vs bread wheat followed the same trend as in experiment 1, except for kernels/spike which in experiment 2 was greater for bread wheat. This discrepancy probably results from the small sample of 12 selected lines included in the present experiment.

Experiment 2 was designed to test whether lines with high tillering in the F_4 generation would maintain this characteristic in the following generation.

Table 3. Generation correlations for various characters in durum and bread wheat crosses, Beja, 1981 and Fretissa 1982, Tunisia.

Generations	Character	Bread wheat			Durum wheat		
		B1	B2	B3	D1	D2	D3
F_3 vs F_4	Grain yield	-0.30	-0.14	0.30	0.01	-0.22	0.39
	Tillers/plant vs tillers/m²	0.11	-0.12	-0.06	0.69*	0.12	0.06
	Kernels/spike	0.10	-0.13	0.33	-0.13	0.20	0.56*
	1000-kernel weight	-0.31	0.49	0.20	0.02	0.63**	0.70**
		All crosses			All crosses		
F_4 vs F_5	Grain yield	0.25			-0.04		
	Tillers/m²	-0.04			0.07		
	Kernels/spike	0.34			0.57		
	1000-kernel weight	0.50			0.83*		
	Plant height	0.98**			0.74		
	Heading date	0.97**			0.71		

*, ** Significant at the 0.05 and 0.01 levels, respectively.

The results showed that no significant difference was found in any cross for tillers/m^2 in the F_5 between the high (H) and low (L) tillering F_4 lines (Table 4). This tends to confirm results in experiment 1 indicating low heritability of tillers/m^2. On the other hand, for kernel weight, the two lines in each cross tended to rank similarly in the F_4 and F_5 generations indicating a higher heritability for this trait. Also, plant height followed by heading date were found to be highly heritable traits. Although involving cross differences, the correlations between F_4 and F_5 means (Table 3) tend to lead to the same conclusions. Indications of high heritability for kernel weight and plant height were also reported in winter wheat crosses by Edwards *et al.* (1976) and Ketata *et al.* (1976).

Conclusions

The present study leads to the following conclusions:

As compared to bread wheat, durum wheat generally possesses heavier kernels but produces fewer tillers/unit area and may have slightly more kernels/spike. Furthermore, durum wheat does not seem to have an intrinsically lower yield potential than bread wheat. Therefore, durum wheat cultivars could be developed which produce grain yields comparable to those of the highest yielding bread wheats.

Tillering both in durum and bread wheat tends to be most affected by the environment as compared to other yield components, particularly kernel weight which appears to have the highest heritability. Furthermore, the lack of correlation among yield components indicates the possibility of improving kernel weight without affecting other components.

Comparison of heritabilities for various traits indicates that individual plant selection in early generations, such as F_3, should be effective when based on kernel weight, plant height and heading date, but not on grain yield or tillering.

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Table 4. Mean values for various traits of bread and durum wheat crosses (experiment 2) grown at Fretissa, Tunisia, 1981/82.

Cross	Tiller class in F_4 (H = high, L = low)	Grain yield (q/ha)	Tillers/m²	Kernels/ spike	1000-kernel weight (g)	Heading (days from 1 April)	Maturity (days from 1 June)	Plant height (cm)
B1	H	43.8	411	64	42	10	6	108
	L	37.2	493	66	41	16	13	122
	mean	40.5	452	65	41	13	10	115
B2	H	48.7	408	56	54	10	5	111
	L	39.2	392	70	42	15	12	103
	mean	44.0	400	63	48	12	8	107
B3	H	41.7	429	64	43	11	8	109
	L	50.3	405	73	47	9	4	97
	mean	46.0	417	69	45	10	6	103
Cross mean		43.5	423	66	45	12	8	108
D1	H	36.3	400	42	61	14	10	88
	L	46.7	429	53	51	13	9	88
	mean	41.5	415	48	56	14	10	88
D2	H	40.0	347	57	57	16	12	98
	L	46.0	395	53	57	17	12	92
	mean	43.0	371	55	57	17	12	95
D3	H	38.0	389	62	48	13	9	90
	L	33.8	320	67	40	20	15	94
	mean	35.9	355	65	44	16	12	92
Cross mean		40.1	380	56	52	16	11	92
H mean		41.4	398	57.6	50.8	12.3	8.4	101
L mean		42.2	405	63.8	46.1	15.0	10.8	99
LSD	(0.05)							
	class/cross means	7.5	113	5.8	4.7	3.1	2.6	6.0
	cross means	5.3	81	4.1	3.3	2.2	1.8	4.2
	class or species means	3.0	47	2.4	1.9	1.2	1.1	2.4
CV (%)		10.5	16.8	5.7	5.8	13.2	15.8	3.5

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EFFECT OF FERTILIZER APPLICATION AND SEED RATE ON WHEAT IN THE SEMI-ARID HIGH-ELEVATION ENVIRONMENTS IN PAKISTAN

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Introduction

The Baluchistan province of Pakistan with its vast culturable land resources holds great agricultural potential. However, due to harsh semi-arid to arid environments in the high plateau, the emphasis has been on improving the agricultural productivity in the irrigated low-altitude flat areas. Due to the increasing demand for more food as well as the competitive economic benefit of cash crops, as compared to cereals in the irrigated flat lands, a gradual shift for cereal production is taking place towards the rainfed high-plateau areas. The annual precipitation ranges from 150 to 600 mm in those areas, and comes during the winter months in the form of rain or snowfall. But wheat yields are very low, about 500 kg/ha, so an appropriate package of production practices needs to be developed. With this objective, the Pakistan Agricultural Research Council and ICARDA have initiated agronomic work under a collaborative project.

Materials and Methods

The experiments were conducted during 1981-83 at two sites. Pishin, a 1750 m high-elevation site, is situated almost in the middle of the Quetta valley. The annual rainfall ranges from 250 to 300 mm and the minimum temperature stays below zero from November through late February. The average maximum temperature occasionally falls below freezing point. The average temperature for the coldest month (January) is -3.9^{o}C. The second site is Kan Mehterzai on a high plateau at an altitude of 2500 m. The temperature stays below freezing point from the beginning of October until the end of March. The maximum temperature also stays below zero for most of the winter months. The snowfall in the area is relatively heavy and covers the ground during December through February. The rainfall is relatively high but the moisture-holding capacity of the soil is very poor. The high velocity cold gusty winds during winter and hot dusty winds in early summer increase the evapotranspiration from the soil and crops. The soils at both sites are calcic yermosols (Rafiq 1976), formed in alluvial material with sandy loam to sandy clay-loam texture and low organic matter content (0.3-0.5%).

For the seed rate experiments at Pishin, the bread wheat varieties used were: Local White, S311 x Norteno, Zargoon, Zamindar, and Bezostaya. For fertilizer application experiments, only two varieties, i.e. Local White and Zargoon were used. A complete factorial arrangement of treatments in a randomized complete block design was adopted for both types of experiment with a plot size of 5.0 x 3.0 m. However, for data recording the yield was taken by harvesting the central 10 rows with a net plot size of 12.5 m^2.

Results and Discussion

a. Seed Rate Experiment

The yield of different wheat varieties differed significantly. Zargoon gave the highest mean yield of 3707 kg/ha followed by Zamindar and Bezostaya with mean yields of 3227 kg/ha each (Table 1). The varieties S311 x Norteno and Local White gave the lowest mean yields of 2880 and 2773 kg/ha, respectively. None of the seed rates was found to be significantly better for all the varieties. In general, the varieties responded differently to various seed rates. However, no significant difference in yield was observed with different seed rates in the variety Local White. Varieties S311 x Norteno and Zamindar gave the highest yields of 3280 and 3600 kg/ha, respectively, with the seed rate of 60 kg/ha. However, the highest yielding variety, Zargoon, gave significantly higher yields of 4000 and 4160 kg/ha with seed rates of 120 and 180 kg/ha, respectively, as compared to a yield of 2960 kg/ha with 60 kg/ha seed rate. Variety Bezostaya also gave the highest yield of 3760 kg/ha with a seed rate of 120 kg/ha. Variable response to various seed rates was observed in the case of variety Zamindar.

At Pishin, Zargoon and Bezostaya produced the highest yields with the 120 kg/ha seed rate. Though Local White, S311 x Norteno, and Zamindar gave better yields with the lower seed rate (60 kg/ha), the difference was not significant when compared to 120 kg/ha seed rate. The germination and stand of the crop

Table 1. Effect of seed rate on grain yield of five whea' varieties at Pishin.

Variety	Seed rate (kg/ha)			
	60	120	180	Yield mean
Local White	2800	2880	2640	2773
S311 x Norteno	3280	3120	2240	2880
Zargoon	2960	4000	4160	3707
Zamindar	3600	2720	3360	3227
Bezostaya	3040	3760	2880	3227
Average	3136	3296	3056	3163

LSD (5%) = 568 (for variety x seed rate combinations).
LSD (5%) = 328 (for variety means).

is very much dependent on timely adequate rainfall which is often variable and unreliable in the semi-arid environments. Therefore, it seems more appropriate to use a higher seed rate of 120 kg/ha to obtain the optimum yield in this type of environment. However, further experimentation based on 1000-kernel weight is needed to determine more precisely the optimum seed rate for each variety.

b. Effect of N and P Fertilizers on Yield of Wheat at Pishin and Kan Mehterzai

Both Local White and Zargoon differed significantly in their yielding ability at both sites. Zargoon gave a significantly higher yield than Local White under all fertility levels at both sites. The yield level of both varieties was higher at Pishin than at Kan Mehterzai.

Both varieties showed highly significant yield response to 30 and 60 kg N/ha at both sites (Figs. 1 and 2). Though there was an increase in yields at higher rates of N application (90 and 120 kg/ha), it was not significant as compared to 60 kg N/ha.

The yield response to nitrogen fertilizer observed in this study is in conformity with earlier reports of a very low content (0.0215-0.945%) of N in the soils of Quetta, Pishin, and Sibi (Hassan and Rizvi 1974). They also found a wide range in soluble phosphorus from 5.0 to 44.50 ppm. Rafiq (1976) also reported a low content of organic matter in the soils of Quetta and Pishin valleys. These soils are deficient in nitrogen

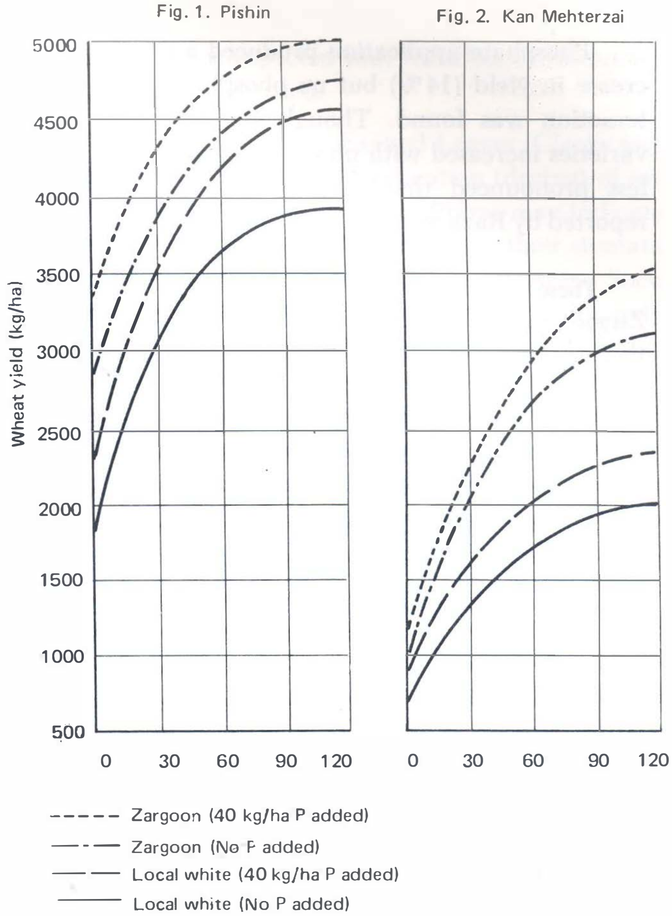

Fig. 1. Wheat yield response to nitrogen (N) and phosphate (P_2O_5) at Pishin, Pakistan (1983).

Fig. 2. Wheat yield response to nitrogen (N) and phosphate (P_2O_5) at Kan Mehterzai, Pakistan (1983).

content; therefore, the response of wheat to low doses of nitrogen fertilizer is enormous, but beyond 60 kg N/ha the yield response declines rapidly, perhaps due to the limited available soil moisture and high evapotranspiration during the growing season. Campbell *et al.* (1977) found reductions in dry-matter production and leaf area between shot blade and anthesis stages under drought stress when more than 61.5 kg N/ha was applied, but late rain increased the dry matter and N content of the wheat plants at the higher rates of N. However, at Pishin and Kan Mehterzai sites there is moisture stress from heading to maturity. Therefore, rates of N application above 60 kg/ha do not seem to be beneficial. The yield increase per kilogram of N applied declined rapidly at rates above 60 kg N/ha at both sites.

Phosphate application produced a significant increase in yield (14%) but no phosphate x variety interaction was found. Though yield of both wheat varieties increased with phosphate application, it was less pronounced than with N application as also reported by Raza and Sheikh (1972).

These results show that the two wheat varieties Zargoon and Local White are better adapted to Pishin, and that nitrogen applications of up to 60 kg N/ha are beneficial to the wheat crop in that area.

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PHYSIOLOGICAL TECHNIQUES USED TO SCREEN BREEDERS' NURSERIES FOR DROUGHT RESISTANCE

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Introduction

Breeding for drought resistance is of paramount importance in the ICARDA region. However, until recently very few techniques have been available to measure physiological indicators of drought stress in the field.

Hurd (1969) describes the traditional drought-resistance breeding strategy. It consists of observation and yield-testing of germplasm grown at low-rainfall sites. However, selection for drought resistance using such a methodology may be less efficient than is possible. Many processes unrelated to drought resistance affect yield in such nurseries, e.g. disease, insects, cold, inherent yield capacity, etc. Likewise, visual selection for leaf desiccation or 'firing' reveals differences at stress levels so severe as to be rarely encountered in farmers' fields. The human eye cannot detect small genotypic differences which may be quite important in their cumulative seasonal effect on crop growth. The lack of control of the intensity and timing of stress and inability to repeat it over the years produces confounding effects in selection.

This article reviews several recently-developed, promising physiological techniques for drought resistance breeding. To assist in familiarization with the potentials and limitations of the techniques, key references are given for more detailed information.

1. Line-Source Sprinkler

The line-source sprinkler is an irrigation system which applies water in a linearly-decreasing gradient, perpendicular to a central sprinkler line. Genotypes are planted perpendicular to the line so that they are exposed to the whole range of 'rainfall' presented by the sprinkler. In this way, physiological, agronomic, and developmental traits can be measured as a function of 'rainfall' for a set of genotypes. This system is superior to multilocation testing for drought resistance because it avoids the confounding effects of different soil types, cropping histories, and climatic regimes which occur over sites. It only requires a small experimental area and ordinary irrigation equipment. (Anonymous 1983; Worrall and Gerard 1982; ICRISAT 1981; Puckridge and O'Toole 1981; Hanks *et al.* 1980; IRRI 1979; Hanks *et al.* 1976).

Because of the labor required for frequent irrigation, implementation of the line-source sprinkler as a breeding tool will probably be restricted to testing of advanced lines and pre-release cultivars. It will be a valuable tool in determining the comparative drought resistance of lines before recommending the use of those lines in drought-prone environments. It will also be a useful technique for the agronomist in studying nutrient-water interactions under field conditions.

2. Transpiration Rate Methods

Transpiration and photosynthesis both proceed by gas exchange through the stomata. Therefore, genotypes which transpire more water are also fixing more carbon, and hence, are likely to be higher-yielding (if they don't run out of water before maturing). The ability to maintain transpiration under drought-stress conditions indicates the presence of an 'avoidance' mechanism in the plant; perhaps through a deeper or more extensive root system, through conservative water use in early development, or through osmotic adjustment. Such 'drought-avoidance' mechanisms are desirable because they help the crop maintain productive growth despite less favorable growing conditions.

a. Infrared Thermometery (IRRI 1982; Ferguson *et al.* 1973). The infrared thermometer measures the average temperature of the leaf canopy of a plot or row with great precision. Canopies which are transpiring at a higher rate are cooler, due to the evaporative dissipation of heat to the atmosphere. Those lines lowest in temperature would thus be selected. Large nurseries can be screened rapidly, since each plot measurement takes only about five seconds. This technique might be most useful in deciding which among the thousands of F_4/F_5 lines should enter preliminary yield testing. It would be a valuable supplement to the visual selection commonly used now.

b. Leaf Porometry (Sojka *et al.* 1979). Diffusive resistance porometers measure the rate of water vapor diffusion (i.e. transpiration) across the leaf surface. Genotypes with higher rates of transpiration in a drought-stressed nursery would be selected as drought avoiders, similar to the case with the infrared thermometer. However, 5-10 leaves from each plot should be sampled to minimize sampling error, and each measurement takes about one min. Thus, this method is much slower than the thermometer, and only advanced lines or potential parents could be tested. For this reason, it is expected that infrared thermometry will be more widely used.

c. Rate of Desiccation of Excised Leaves (Clarke and McCaig 1982). The rate of desiccation (drying) of excised leaves under controlled conditions may indicate genotypes which are capable of closing their stomata quickly when exposed to severe drought stress. Such genotypes avoid drought stress by transpiring only when conditions are favorable. They are probably desirable under severe drought conditions, but, by restricting transpiration, they may be less productive than other genotypes in wetter years. The test involves sampling 5-10 leaves from each plot, weighing them, drying, and re-weighing, followed by complete drying and a third weighing. Water loss is calculated as a percentage of initial water content. The technique can be fairly rapid if well-organized, and suitable for potential parents and promising lines. It has the advantage of indicating 'water savers' as compared to 'water users' identified by the methods above. Water savers may be needed for the very driest environments.

3. Leaf Water Potential (Xylem Pressure Potential)

Drought stress causes the internal solute concentration of plants to increase either by desiccation or by osmotic adjustment (synthesis of solutes by the plant to increase its ability to extract soil water). Genotypes capable of maintaining a relatively high water potential (indicating relative absence of these responses) when exposed to drought stress, are somehow avoiding the drought. Xylem pressure potential can be measured with a pressure-bomb apparatus. Each measurement takes 3-4 min, and several measurements should be made on each plot to reduce sampling error. Advanced lines could be tested in this way, but the method is too time-consuming for earlier generations. Selection for high water potential may also reject some lines with the desirable capacity for osmotic adjustment (Sojka *et al.* 1979).

4. Leaf Elongation Rate

Leaf elongation is highly sensitive to tissue water deficits. The length of the leaf blade can be quickly measured at two-day intervals during a stress period to provide a comparison of growth maintenance among genotypes. Care must be taken to measure leaves during the first several days of expansion only, since leaf growth declines with age. This method has the advantage that it is a direct indicator of growth rather than water use (Cutler *et al.* 1980).

5. Cell Membrane Stability

Severe drought stress may injure plant cell membranes and thereby affect growth. Genotypes which can tolerate drought stress with less membrane damage may be valuable in the more severely-stressed environments. In this technique, four leaf discs from each of 5-10 leaves/plot are taken to the laboratory and placed in a polyethylene glycol solution of low osmotic potential. This creates a simulated drought stress which dehydrates the leaf discs. Cell membranes damaged by this stress lose some of their selective absorption properties and cell contents leak out, including ions. Since ions conduct electricity, the amount of ions leaked, and hence, the amount of cell membrane damage, can be measured with a conductivity meter. The lines with lowest conductivity are expected to be more drought tolerant. This method is fairly time-consuming but is practical for potential parents and advanced lines. This test measures drought-tolerance mechanisms in contrast to the other tests which indicate drought avoidance. It is useful to have methods that identify a diversity of resistance mechanisms so they can be combined through breeding (Sullivan and Ross 1979).

It is hoped that this brief survey of practical drought-resistance screening techniques will help stimulate some experimentation in breeding programs within the ICARDA region. More attention to physiological parameters in breeding should accelerate progress in developing stress-resistant cereals.

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Short Communications

Useful Gene Groups in Barley Germplasm

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Jenning (1964) advocated the plant-type breeding for higher yield. According to him, the different morphological plant characters that are conducive to high yield should be combined in a single plant. Cereal crops, by virtue of their fibrous, shallow root system and hollow stem, are susceptible to lodging which may cause 15-60% yield losses (Shah and Jallil 1935). Breeding varieties resistant to lodging is therefore very important.

Malkani and Vaidya (1956) were the first to suggest ratios as lodging indices since lodging is a loss of balance in plants. Recently, Vaidya *et al.* (1982) suggested the use of shoot x height: root (SH:R) and breaking strength of the lowest internode: height x mothershoot weight (Br:HM) as lodging indices for wheat, giving more importance to SH:R. However, Vaidya and Ram (1982) suggested the same indices for barley but stressed the importance of Br:HM. Thus, it appears that in barley, strong-stemmed, dwarf plants with good root anchorage are required for resistance to lodging.

Barley germplasm for this study was obtained from the National Bureau of Plant Genetic Resources, New Delhi. Observations on shoot weight, root weight, mothershoot weight, plant height, and breaking strength were recorded (Table 1), following Vaidya and Ram (1982).

Kalyan-sona is a standard wheat variety developed from wheat lines developed by N. Borlaug in Mexico. This is a fairly lodging-resistant wheat variety (Vaidya *et al.* 1982). Barley line I.C. 38835 showed a Br:HM ratio indicative of its relative stem strength significantly superior to Kalyan-sona. It also has a superior Br:H ratio. Though this line has better root anchorage as indicated by SH:R value of 8:71 as against 12.65 for Kalyan-sona, the differences were not statistically significant as root and shoot weights are highly susceptible to environmental interaction. Thus, among the four barley lines studied, I.C. 38835 seemed to possess useful genes for stem strength as well as root anchorage, for breeding lodging-resistant barley lines.

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Table 1. Lodging-resistance indices for four barley lines and a bread wheat check.

Line	S:R	SH:R	Br:H	Br:HM
I.C. 38837	14.5	9.46	10.4*	1.22
I.C. 38835	12.8	8.71	14.9*	1.61*
I.C. 38834	20.5	15.23	15.1*	1.32
I.C. 38827	12.4	8.66	11.5*	1.34
Kalyan-sona (wheat)	13.1	12.65	7.2	0.92
LSD (5%)	ns	ns	4.29	0.63

* Significance over Kalyan-sona at the 0.05 level. ns Non significant at the 0.05 level.

Breeding for Aphid Resistance in Barley

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Corn leaf aphid (*Rhopalosiphum maidis* Fitsh) is a major pest of barley in India. Yield losses of up to 67.5% have been recorded in commercial varieties under heavy aphid infestation (Bhatia and Singh 1977). Since indigenous barley collection was susceptible to this pest, intensive search for resistant sources was undertaken in the world barley collection. Resistant cultivars, such as Balkan and Kreta, were identified from Mediterranean areas and some others from Taiwan (Murty *et al.* 1968). C.A. No. 1, a two-row barley from Taiwan maintained in our Program under the accession number E.B. 921, was extensively used as aphid-resistant donor parent in hybridization using three-way and complex crosses to develop superior aphid-resistant barleys.

This program resulted in the evolution of several six-row resistant lines which were evaluated for their yield potential and were also recycled in hybridization. Three varieties viz., D.L. 200, D.L. 348, and D.L. 349 have already been recommended by the All India Barley Workshops for commercial cultivation in rainfed areas of different parts of the country. Lines D.L. 200 and D.L. 348 showed high degree of resistance while D.L. 349 was moderately resistant to this pest. Genetic analyses revealed that resistance to aphid under field conditions was controlled either by a single recessive gene (Dayani and Bakshi 1978) or by two complementary recessive gene pairs. Modifying factors might also be involved in determining the intensity of infestation on susceptible plants (Gulati *et al.* 1978).

E.B. 921 and/or its six-row aphid-resistant hybrid derivatives have also been screened for their reaction to corn leaf aphid and other species of cereal aphids in Canada and Britain. These tests have provided additional information on the resistance of these lines to a wide spectrum of aphid species and biotypes. Greenhouse-studies at Winnipeg, Canada, (Gill and Metcalfe 1977) revealed that E.B. 921 and DL117 were resistant to *R. maidis* but susceptible to four other aphid species, viz., *R. padi* L., *Macrosiphum avenae* F., *Acyrthosiphon dirhodum* Walk., and *Schizaphis graminum* Rond. DL117 was also more resistant than the parent E.B. 921 and antibiosis appeared to be the critical factor for its resistance. Tests conducted on E.B. 921 derivatives, viz., DL59, DL107, and other barleys at Aberystwyth, UK, using *Macrosiphum (Sitobion) fragariae* Walk., *Metopolophium dirhodum* Walk. and *R. padi* L., showed that DL59 was resistant (Dewar 1977). Screening tests on E.B. 921 and its derivatives DL59, DL79, DL107, DL144, DL200 (all resistant to *R. maidis* in India), and DL69 at Cambridge, UK, showed that E.B.921 was resistant to *Macrosiphum avenae* and *M. dirhodum*, irrespective of whether the aphids were reared on barley or oats. However, E.B. 921 derivatives did not show similar reactions. DL107 was resistant to both species, while DL200 was susceptible when tested using adults reared on oats but not with aphids reared on barley. Line DL59 appeared resistant to barley-reared aphids, but gave variable results with oat-reared aphids.

These findings suggest that line E.B.921 and some of its derivatives may prove useful genetic stocks for resistance to different cereal aphids occurring in various parts of the world.

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Control of Barley Stripe Through Seed Treatment

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Barley stripe caused by *Helminthosporium gramineum* (*Drechslera graminea* or *Pyrenophora graminea*) is an important disease of barley. The disease is seed-borne. Seed treatment with organomercurial fungicides has been effective, but these fungicides are highly toxic to man and animals. The efficacy of seed treatment with several new, safer compounds including carboxin has been under study in recent years. Solar treatment (Singh and Goel 1972) and smoke treatment (Pillai and Suryanarayana 1983) have also been suggested. The present study was conducted to assess the efficacy of heat treatment and Vitavax application on the incidence of barley stripe under field conditions.

Seed bulk from stripe-infected plants of six-row spring barley (DL304) was used. Heat treatment involved soaking the seeds in water overnight and then drying in the oven (1) at 50°C for 5 hrs, (2) at 50°C for 1 hr, and (3) in the sun for 5 hrs in June. For chemical treatment, Vitavax 75 was used at 2 g/kg. Unsoaked stripe-infected seeds served as control.

All experiments were laid in a randomized complete block design with two replications. Each plot consisted of four 1.8 m rows. Seeds were space-planted at Delhi (10 cm between plants within a row) and drilled at Wellington (southern hills). The disease infection was estimated at the milk-ripe stage on the basis of number of healthy and infected plants or number of tillers/plot.

Table 1 summarizes the disease incidence in various experiments. Stripe infection was higher at Wellington than at Delhi. Even the Wellington source of stripe-infected seed grown at Delhi showed higher infection. This suggested that climatic conditions at Wellington were more congenial not only for the development of the disease but also for subsequent infection in the seed. Furthermore, the moisture status of the soil also influenced the disease severity at Delhi: drier soil conditions were less favorable. Neither the heat nor the chemical treatment was so effective as to completely control the disease. Seed treatment with Vitavax 75 reduced infection from 28.2 to 7.7%. Higher doses of this fungicide may be more effective in controlling the disease. With the heat-treatment methods, drying of water-soaked seed at 50°C for 5 hrs gave the best results at Wellington with infections of 9.1 and 48.3% for the treated and untreated plots, respectively. Further studies are needed to develop heat-treatment methods which could be used either alone or in combination with systemic fungicides to effectively control higher levels of stripe infection.

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Table 1. Effect of heat and chemical treatments on the incidence of barley stripe (% infection).

Treatments	Delhi 1982/83	Wellington 1983	Delhi 1983/84		
			Rainfed	Irrigated	Irrigated*
Soaking and heating					
50°C for 5 hr	1.1	9.1	0	0	0
50°C for 1 hr	1.4	27.3	0	0	27.5
Solar drying for 5 hr		39.6			
Vitavax 75 WP	7.7				
Unsoaked control	28.2	48.3	16.4	27.5	55.1

Wellington 1983 seed lot.

Genetic Study of Quality Characteristics in Durum Wheat (*Triticum durum* Desf.)

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This study was carried out to elucidate certain aspects of genetic control for kernel weight and protein and ash contents in six crosses of durum wheat (*Triticum durum* Desf.).

Four durum wheat cultivars, namely, Amal, Badri, Ben Bechir, and Karim were used to realize the following crosses and their reciprocals: Karim/Badri, Karim/Amal, and Badri/Ben Bechir. Crosses were made and F_1 seed was planted in 1981 at ICARDA summer nursery in Jordan. In the following season, parents (P1 and P2), F_1, and F_2 populations from each cross were grown at Fretissa, Tunisia, in a randomized complete block design with three replications. Each block comprised one row for each of the parents and F_1 s and three rows for each F_2. The rows were 1.5 m long and 30 cm apart, the distance between plants within a row was 10 cm.

Thousand-kernel weight (g), grain protein, and grain ash content (% dry matter) were determined on an individual plant basis. Both protein and ash contents were determined using the NIR method. Statistical analyses were conducted to compute the interplant variance for the nonsegregating (V_{PF}) and the F_2 populations (V_{F2}). Heterosis was estimated as F_1 -MP where MP represents the mid-parental mean performance. Heritability in the broad sense ($h2_{bs}$) was estimated as:

$$h^2_{bs} = \frac{V_{F_2} - V_{PF}}{V_{F_2}}$$

Variance of V_{h^2bs} was derived as follows:

$$V_{h^2bs} = h^2bs\left[\frac{2}{(V_{F_2}-V_{PF})^2} + \frac{(V^2{}_{F_2}}{df_{F_2}+2} + \frac{V^2{}_{PF})}{df_{PF}+2} + \frac{2}{df_{F_2}+2} - \frac{4V_{F_2}}{(df_{F_2}+2)\,(V_{F_2}-V_{PF})}\right]$$

where df_{F2} and df_{PF} are the number of degrees of freedom for V_{F2} and V_{PF}, respectively.

Due to limited quantity of seed, F_2 populations were grown for crosses only.

A high heritability for kernel weight was found in all four crosses (Table 1), indicating a preponderance of genetic effects in determining kernel weight. Sellami (1983) found that kernel weight was least affected by environment, while Ketata *et al.* (1976) emphasized the importance of additive gene action for this trait.

Table 1. Statistical and genetic parameters for 1000-kernel weight of six crosses of durum wheat, Fretissa, Tunisia, 1982.

Cross	P_1	P_2	MP	F_1	F_2	V_{PF}	V_{F_2}	$(F_1—MP) \pm SE$	$h^2_{bs} \pm SE$
Karim/Badri	53.2	49.3	51.25	62.4	56.6	15.80	140.00	11.15 ± 1.38	0.89 ± 0.03
Badri/Karim	49.3	53.2	51.25	60.5	50.0	19.68	32.72	9.25 ± 1.07	0.40 ± 0.15
Karim/Amal	53.2	46.3	49.75	53.9	53.1	11.11	80.39	4.15 ± 0.96	0.86 ± 0.05
Amal/Karim	46.3	53.2	49.75	50.9		12.44		1.15 ± 1.18	
Ben Bechir/Badri	51.0	49.3	50.15	61.5	57.6	14.90	96.73	11.35 ± 1.22	0.85 ± 0.04
Badri/Ben Bechir	49.3	51.0	50.15	65.1		14.49		14.95 ± 1.44	

Table 2. Statistical and genetic parameters for protein content of six crosses of durum wheat, Fretissa, Tunisia, 1982.

Cross	P_1	P_2	MP	F_1	F_2	V_{PF}	V_{F_2}	$(F_1—MP) \pm SE$	$h^2_{bs} \pm SE$
Karim/Badri	13.15	16.04	14.595	13.79	14.39	0.8122	1.700	-0.80 ± 0.31	0.31 ± 0.19
Badri/Karim	16.04	13.15	14.595	14.09	14.74	0.9632	0.6993	-0.51 ± 0.17	0.00 ± 0.33
Karim/Amal	13.15	16.33	14.74	14.11	14.95	0.3200	1.4336	-0.63 ± 0.16	0.78 ± 0.52
Amal/Karim	16.33	13.15	14.74	15.01		0.3738		0.27 ± 0.10	
Ben Bechir/Badri	13.48	16.04	14.76	15.20	14.86	0.6542	1.4504	0.44 ± 0.24	0.55 ± 0.69
Badri/Ben Bechir	16.04	13.48	14.76	14.70		1.2254		-0.06 ± 0.42	

Table 3. Statistical and genetic parameters for ash content of six crosses of durum wheat, Fretissa, Tunisia, 1982.

Cross	P_1	P_2	MP	F_1	F_2	V_{PF} (x 10^{-5})	V_{F_2} (x 10^{-5})	$(F_1—MP) \pm SE$	$h^2_{bs} \pm SE$
Karim/Badri	1.69	1.80	1.745	1.69	1.73	358	606	-0.055 ± 0.021	0.41 ± 0.16
Badri/Karim	1.80	1.69	1.745	1.69	1.76	347	418	-0.055 ± 0.016	0.17 ± 0.21
Karim/Amal	1.69	1.86	1.775	1.72	1.76	233	514	-0.055 ± 0.014	0.55 ± 0.13
Amal/Karim	1.86	1.69	1.775	1.78		347		-0.002 ± 0.020	
Ben Bechir/Badri	1.69	1.80	1.745	1.77	1.75	306	508	0.025 ± 0.016	0.40 ± 0.18
Badri/Ben Bechir	1.80	1.69	1.745	1.73		257		-0.015 ± 0.012	

Significant heterosis found in most cases, indicated heavier kernels in the F_1 than in the mid-parent. Reciprocal differences were detected in two out of three cases.

Analysis of grain protein content (Table 2) showed a negative heterosis, indicating a global dominance of low protein in the F_1 hybrid. Comparison of reciprocal crosses showed that cytoplasmic factors or sex-linked genes were not involved in the control of grain protein. Low heritability for this trait indicates the important role the environmental factors play in determining grain protein content. Improving grain protein content in segregating populations of these durum crosses seems to be difficult and time-consuming.

Results for grain ash content showed a relatively small range of variation (Table 3). Consequently, interpretations based on grain ash content should be made with caution. Although genetic factors may be involved, heritability for this trait is relatively low. Sellami (1983) found that ash content could be used as a criterion to distinguish durum from bread wheat varieties but not varieties within the same species.

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The Wheat Improvement Program of New Halfa Research Station

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The wheat breeding project of New Halfa Research Station aims at improving wheat production by developing high-yielding varieties. A major objective is to develop superior varieties with good resistance to stem rust disease which is a serious limiting factor to production.

Other objectives of the program include studies of the following characters:

1. Adjustment of growth cycle of wheat varieties to the growing season
2. Resistance to shattering
3. Resistance to lodging
4. Resistance to aphids and bird damage
5. Drought and heat tolerance
6. Bread-making quality

The activities of the program cover the full range of wheat breeding, i.e., making crosses, growing F_1 and segregating populations, breeding for stem-rust resistance (all breeding material is subjected to the disease), and selecting and evaluating advanced lines in a series of yield trials. These trials include preliminary, advanced, and final testing in the national yield trial prior to variety release. Since these activities are carried out each year, they overlap and thus form a continuous process.

The program, in cooperation with international research centers such as CIMMYT and ICARDA, works on exchanging breeding material and growing the nurseries received, providing these centers with full data of the agronomic and disease reactions.

Until recently, the activities of the program were confined to screening, selection, and evaluation of breeding material provided by the international centers. However, in the late seventies, a new project was initiated to emphasize on local crossing utilizing adapted cultivars and suitable germplasm to generate more adapted variability and to be able to develop high-yielding wheat cultivars.

The program also conducts research on the effect of date of planting and rate of nitrogen fertilization and their interaction on yield of wheat, the effects of nitrogen dose on the competition of weeds with wheat, and on evaluation of varieties to find out those which are promising and to determine the degree of sensitivity of varieties to weed competition. Furthermore, on-farm trials to evaluate the newly-developed promising wheat varieties are being planned.

Article and Book Reviews

CAB (Commonwealth Agricultural Bureaux) and CIMMYT (International Maize and Wheat Improvement Center). Vol. 1 No. 1. 1984. Wheat, barley, and triticale abstracts. CAB, Slough Sl2 3BN, UK.

This abstracts journal which is funded by CIMMYT and published by CAB represents the first of six volumes that are supposed to be published and distributed annually. The abstracts represent a mechanism for sharing the body of research knowledge that is accumulating on a global basis and hopefully will facilitate the advancement of research in small grains and result in increased food productivity.

Evans, L.T. and Peacock, W.J. (eds.). 1981. Wheat science-today and tomorrow. Cambridge University press, Cambridge, UK – New York, USA. 290 pp. ISBN 0-521-23793-9, £17.50.

This book does not intend to provide a comprehensive review of all the cereal research that has been carried out on wheat, but rather to present a series of perspectives on current international wheat research, with emphasis on the way forward into the future. Topics of the book are associated with a symposium held in November 1980 at the CSIRO Division of Plant Industry in Canberra, Australia.

The book deals with different aspects of wheat starting with its history and ending with its future development.

Hopkins, S.T., Jones, D.E. (eds) 1983. Research guide to the arid lands of the world. The Oryx Press, 2214 North Central at Encantno, Phoenix, Arizona 85004. USA. 400 pp. ISBN 0-89774-066-1, $74.50

This volume, compiled under a grant provided in 1980 by the U.S. Department of Education, provides access to reference materials on arid lands, desert, grassland, steppe, and dry forest.

The book is the first comprehensive annotated bibliography to compile and evaluate journals, bibliographies, directories, statistical sources, on-line data bases, atlases, gazetteers, and other useful sources for research on the physical and human geography of the world's dry lands. Sources of current information are emphasized, and major retrospective bibliographies are also included.

The volume provides interdisciplinary coverage of reference works from 120 nations and 28 major subject fields. Included are: geography, earth sciences, biology, anthropology, agriculture, climatology, energy, demography, medicine, architecture, economic development, irrigation, land use management, urban studies, science and technology, and bibliography and information science.

Reference sources can be located by place, subject, and author.

The volume includes a set of charts depicting the precise extent of each nation's dry and desertified lands, based on maps prepared by UNESCO. Over 55 major computerized data bases are cited, and information on the vendors of each data base is also provided.

This book is an interdisciplinary tool for researchers from a number of fields. For the first time, information on arid lands is easily accessible through a single volume designed for scientists, resource managers, social scientists, business or government workers in arid lands, librarians, students, and others interested in arid lands.

Gareth Jones, D. and Clifford, Brian C. 1983. Cereal diseases: their pathology and control. John Wiley and Sons, New York, USA, ISBN 0-471-10501-5. 209 pp.

This new edition of the book is considerably revised from the previous edition, especially the chapters dealing with techniques, disease resistance, and chemical control.

The book comprises six chapters. The first chapter is an introduction to cereal crops, their distribution, and importance to man. The next two chapters deal with the principles of cereal pathology and are designed to provide an understanding of the nature of pathogenicity and host resistance. The remaining three chapters are intended to act as a guide-a 'workshop manual'- for pathologists and breeders and consist of a chapter on pathological techniques, one on breeding for resistance, and finally, a synthesis of the various control measures and their integrated application.

This book is recommended for students and practitioners of cereal crop protection because it includes methods and information of value and provides understanding of cereal pathological problems and their solutions.

Pomeranz, Y. and Munck, L. (eds.). 1981. Cereals: a renewable resource, theory and practice. The American Association of Cereal Chemists, St. Paul, Minnesota 55121, 3340 Pilot Knob Road. 728 pp. ISBN 0-913250-22-8, £44.85.

This publication is based on presentations at the international symposium 'Cereals: a Renewable Resource, Theory and Practice' which was held in August 1981 in Copenhagen, Denmark, and sponsored by the American Association of Cereal Chemists and the Danish Cereal Society in association with the Carlsberg Research Center.

A review of cereals as a source of tomorrow's chemicals is made, and the potential use of straw and optimization of grain drying are discussed. Several papers are devoted to the use of specific grains (sorghum, barley, wheat, triticale, and rice) as source of food, feed, fuel, and chemicals, and the final series of reviews and discussions concerns the technology, economics, and general feasibility of utilizing cereals as fuel sources.

This book is recommended as a valuable source of information for agronomists, food scientists and technologists, economists, administrators, and decision makers interested in the potential of cereals as a renewable resource.

Huddleston, B. 1984. Closing the cereals gap with trade and food aid. (Research report: 43). IFPRI (International Food Policy Research Institute), Washington, D.C., USA. ISBN 0-89629-044-1. 107 pp.

This research report presents analysis of historical data and the projections of future food aid requirements that lay the foundation for deeper analysis of food aid's contribution to equitable growth and economic effects in specific countries.

IFPRI's research on food aid is particularly important as a part of its participation in the Consultative Group on International Agricultural Research. It is concerned with the price, infrastructure, and social welfare effects of food aid in the context of technologically based agricultural growth.

The Institute of Genetics, Academia Sinica, and IRRI (The International Rice Research Institute). 1983. Cell and tissue culture techniques for cereal crop improvement: proceedings of a workshop cosponsored by the Institute of Genetics, Academia Sinica, and IRRI, 19-23 October 1981, Beijing, China. Science Press, Beijing, China. 455 pp.

This proceedings volume includes reports of progress made by scientists from a dozen countries and the recommendations of 50 participants. It reviews the recent progress and the newer achievements in cell and tissue culture techniques in order to explore the potentiality of these new techniques in the improvement of cereal plants.

Cereal News

Research on Water-Use Efficiency of Plants

Researchers at the Australian National University in Canberra have found a prime indicator of the water-use efficiency of plants-a discovery that is expected to enable better selection of plants for crop improvement.

One of the researchers, Dr Graham Farquhar, said the advance stemmed from the fact that plants varied in their capacity to fix carbon dioxide from the atmosphere during photosynthesis, and this had been linked to water-use efficiency.

It had been known for some time that there existed a variation in the isotopic composition of carbon in leaves. This meant that some plants could have a carbon content with a slightly greater proportion of heavy atomic mass than others, yet still have the same photosynthetic characteristics.

This difference had been attributed in part to the variations in the isotopic composition of carbon dioxide in the atmosphere in different geographic locations.

The ANU researchers challenged this idea and have been able to demonstrate that it is the specific isotopic composition of carbon in the leaves of plants which is likely to coincide with high water efficiency. and using water, which are fundamental to plant growth.

The group set out by examining the carbon composition and ratio of water use to carbon fixing capacity in mistletoes growing on trees, then compared this information with results from similar tests on the host trees. The mistletoes were found to have a higher ratio of water use to carbon gain than did their hosts, and the isotopic composition of carbon in the plants also differed in the expected way, yet the atmospheric conditions were the same. The results were confirmed with tests on mutant tomatoes and other crop plants.

In cooperation with Dr R. Richards, a wheat breeder at the Commonwealth Scientific and Industrial Research Organization (CSIRO), four different varieties of wheat were tested. It was found that the water efficiency among these varied two-fold. This variation was reflected in their isotopic composition, as was expected.

In cooperation with the Australian Wheat Collection at Tamworth, New South Wales, the research group is now testing wheat varieties from a wide range of geographical and genetic backgrounds to assess possible variations in water-use efficiency. From the results, they hope to gain information to help develop improved crop varieties.

Using different wheats, collected world-wide, including the biological ancestors of today's modern-bred wheat, the research is concerned with finding varieties which have an isotopic composition of carbon which is likely to coincide with high water efficiency.

In the past, selecting water-efficient plant varieties was virtually impossible because it involved growing many plants and controlling the environment.

Using isotopic composition as an indicator to water efficiency is expected to make the task much easier, as analysis of the plants can be readily carried out by using a mass spectrometer which can identify the most suitable material. The mass spectrometer measures the atomic mass of carbon present in the leaf, indicating water efficiency.

Release of Lewis (CI 15856), a New Two-Rowed Spring Barley

The Agricultural Research Service, U.S. Department of Agriculture, and the Montana Agricultural Experiment Station announce the joint release of 'Lewis' (CI 15856), a two-rowed spring barley cultivar, to farmers and seedsmen for commercial production. Lewis was developed cooperatively by the Agricultural Research Service, U.S. Department of Agriculture, and the Montana Agricultural Experiment station. Lewis is recommended in Montana as an irrigated and high precipitation feed barley with malting potential (genetic potential to produce malting barley if grown under irrigation or in a favorable season). Lewis is a selection from the cross Hector/Klages and is a sister selection of Clark.

Lewis is a two-rowed, white-kerneled spring midseason barley. It has mid-lax, mid-long spikes which are semi-nodding before maturity and nodding at maturity in a manner similar to Hector. The spike has rough awns, glume awns equal to the length of the glume, which is covered with long hairs, and rachis edges with long hairs. The kernels are mid-size with hull adhering and finely wrinkled, no barbs on lateral veins, and a long haired rachilla.

Lewis is 3 days earlier in heading than Klages, has 11% plumper kernels, is the same height and has better lodging resistance. Lewis showed more tolerance to spot and net blotch than Klages at three locations in both Montana and North Dakota.

Lewis appears similar in malting quality to Klages from 34 Montana and Western Regional nursery samples grown in 1979-1982. Pilot scale evaluation of malting and brewing quality of Lewis in 1979 in cooperation with AMBA (formerly MBIA) indicated quality similar to Klages. Final approval of Lewis as a malting barley awaits further pilot and plant scale tests.

Breeder and foundation seed of Lewis will be maintained by the Foundation Seed Stocks, Department of Plant and Soil Science, Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana 59717. The U.S. Department of Agriculture has no seed for distribution.

Each agency will make news releases as considered appropriate on or after the release date, March 1, 1984.

International Winter Wheat Performance Nursery **(IWWPN) and High Protein-High** Lysine Observation Nursery **(HP-HLN).**

Dr. V.A. Johnson, Leader, wheat research, stated that 'the USDA-ARS has now made the Nebraska-based project and international winter wheat evaluation a budgeted activity as a part of increased research emphasis in ARS on plant germplasm enhancement and identification.' The HP-HLN will continue to be distributed as an observation nursery with probable exclusion of spring germplasm. The IWWPN will continue as in the past with possible modifications according to cooperators suggestions. The next International Wheat Conference would be held in late 1985 or early 1986 as needed funds become available.

In his letter addressed to Dr. S. Ceccarelli, Dr. **J.L. Molina Cano** from the Malting and Brewing Company, Sevilla, Spain, gave full data about acreage, yield, and production of spring (two-rowed), winter (six-rowed) barleys, and total barleys from 1965 to 1983 in Spain, indicating that about 90% of the barley grain is used as animal feed and only 10% is allocated for brewing purposes. 'No barley is grazed or cut either during winter or spring and no barley is used as hay. However, barley straw has some importance as animal feed, particularly spring barley. The local populations are of very little importance because of their being grown in remote areas. In 1983, 40% of the winter barley acreage, which is in turn about 55% of the total area, was covered with the six-row variety Albacete which was a selection on a local population released some 20 years ago.'

Dr. **Dieter K. Mulitze**, arrived in Aleppo on April 13 from Canada to join the Cereal Improvement Program of ICARDA as a post-doctoral international nursery scientist.

Dieter completed his B.Sc.in crop science at the University of Guelph in 1977. During 1977/78, he worked with Dr. Tony Hunt, University of Guelph, Crop Science Department, as a PL/1 computer programmer to design a data base system for the department's wheat breeding program. For the next two years, he took graduate courses in theology and integrated studies at Regent College, Vancouver, B.C. During 1980-83, he completed his Ph.D. in quantitative genetics with the Department of Crop Science and Plant Ecology, University of Saskatchewan, under the supervision of Dr. R.J. Baker. His thesis title was 'A Critique of Biometrical Methods for Estimating the Number of Genes Controlling Quantitative Trials.'

Dr. A. El-Ahmed from ICARDA, Tunisia, indicated in his letter addressed to Dr. J.P. Srivastava that in Tunisia there has been a very successful inoculation by a mixture of different local isolates of *Septoria tritici* this year; that all ICARDA, CIMMYT, and National germplasms as well as F_2 populations of durum and bread wheat are inoculated. He suggested that cereal staff travelling through North Africa stop in Tunisia to select germplasm which could be of great interest to them.

Dr. A. Daaloul, Professor at INAT, Tunis, visited ICARDA, Aleppo, during April 1-8. He spent 5 days at the cereal improvement program and discussed with Dr. Srivastava possibilities of strengthening cooperations between INAT and ICARDA.

Dr. B.H. Somaroo, Program Leader of the GRU (Genetic Resources Unit) of ICARDA, spent four days in Jordan (Mar 26-29) where he met with officials of the ministry of agriculture and Yarmuk University staff members to discuss past and future collecting missions and to develop and strengthen cooperation in genetic resources work to survey recommended sites for future collecting missions in Jordan.

During the meeting with staff of the ministry of agriculture, a keen interest was expressed to initiate work especially for the collection of wheat and barley landraces. A proposal for making collections in 1984/85 is being submitted to the Jordanian National Planning Council, and ICARDA is invited to participate in these collecting programs.

Meeting with Dr. Abdullah Jaradat of Yarmuk University (Irbid) resulted in arranging to send all duplicate wheat landraces germplasm, collected by the university, to ICARDA as soon as seeds become available.

In addition to meetings and discussions, surveys were made of some areas recommended for collection such as the Jordan Valley and Shawbak (south) where some very old landraces are reported to be cultivated in pockets and small hill-side terraces in the valleys.

As a result to these meetings, the GRU of ICARDA will hopefully strengthen cooperative work with Jordanian scientists and will initiate some collecting activities in 1985.

Dr. G. Varughese, CIMMYT Breeder, stated that five bread wheat, two durum wheat, one triticale, and one barley varieties have been released in Spain or Portugal during 1982/83. The varieties are derived from CIMMYT-developed germplasm.

Dr. C.J. Driscoll, Professor of Agronomy from Waite Agricultural Research Institute, Australia, spent 3 weeks last May with the cereals scientists and held discussions on different aspects of the cereal research work at ICARDA.

Dr. S. Ceccarelli, Associate Professor at Perugia University, Italy, joined ICARDA's Cereal Improvement Program as a barley breeder in January 1984. Dr. Ceccarelli is mainly involved in developing and screening genotypes for lower rainfall areas and dual-purpose barley.

Dr. Sui Kwong Yau joined the Cereal Improvement Program of ICARDA in January 1984 as a post-doctoral fellow in the barley improvement project. He recently completed his Ph.D. thesis entitled 'Genetic Variation in Nitrogen Uptake and Utilization in Spring rape (*Brassica napus* L.).' Prior to joining ICARDA, Yau was a teaching assistant in the Department of Agronomy, University of Western Australia, Perth, Australia, where he enrolled for and completed his doctorate study.

Dr. Omar S. Khalil, Field Crops Expert from the Ministry of Industry and Agriculture, Qatar, stated in a letter addressed to Dr. J.P. Srivastava that barley in Qatar is mainly grown for grain production for animals; the average grain yield is about three tonnes (metric) per hectare and the straw is used for animal feed. Dr. Khalil added that the variety Arivat x Athenais which was given the name 'Gulf barley' is the commercial variety and that it will be replaced next season by the variety As 54/Tra//2* (Cer/Toll) /3/2* Avt/Ki//Bz/4/vt/5/Pro x V2780-1R-5R-1M, which was later given the name Harma barley. Both these lines were provided through ICARDA Nurseries.

Drs. E.L. Sharp, Principal Investigator, and Amor Yehyaoui, cereal scientist, from Montana State University, USA, visited the Cereal Improvement Program of ICARDA during April 1984 to discuss the Male Sterile Facilitated Recurrent Selection Populations Program with the cereal scientists concerned.

Dr. Hugo E. Vivar, wheat breeder from CIMMYT, Mexico, spent 5 days in May 1984 at the Cereal Improvement Program of ICARDA during which he met with the barley scientists and discussed methods of cooperation between the barley programs of CIMMYT and ICARDA.

Dr. Carlos Ernesto Samayoa, Deputy Minister of Agriculture for Northern Zone, Mexico, visited ICARDA's Research and Training Program last May mainly to acquaint himself with the different aspects of the cereal research work done at ICARDA and to discuss possibilities of cooperation between INIA and ICARDA.

Dr. Constantin Josephides, senior scientist from Agricultural Research Institute, Cyprus, visited ICARDA from 5-12 May 1984 with the objective of getting acquainted with the durum wheat breeding work of ICARDA and strengthening the cooperation between the two institutions.

Dr. G. Jenkins, Head of the Cereal Breeding Program, Plant Breeding Institute, England, spent one week at the Cereal Improvement Program of ICARDA in May 1984 during which he held discussions with the cereal staff on collaborative research and screening for drought tolerance, protein quality in wheat, and feeding quality of barley straw.

Dr. S.K. Yau, post-doctoral fellow of the Cereal Improvement Program of ICARDA, participated in a germplasm collecting expedition in southern Morocco from mid-May to mid-June, 1984. The expedition was organized and funded by IBPGR with team members coming from INRA, Morocco, Germplasm Institute of Italy, and ICARDA. During the mission, a total of 3000 samples were collected. More than half of these samples were barley, durum wheat, and bread wheat, the most important winter cereals in Morocco.

Visitors to Tunisia and Algeria

A group of cereal scientists from Morocco, ICARDA, and CIMMYT visited INRAT Cereal Project during the period 14-18 May, 1984. It consisted of Drs. G. Varughese, S. Fuentes, R. Villareal, J. Ronsom (CIMMYT), A. Amri (INRA, Morocco), and J.P. Srivastava and M.S. Mekni (ICARDA).

The group visited Beja and El Kef and worked closely with national and ICARDA scientists in Tunisia. Dr. Srivastava discussed with Mr. A. Maamouri, M. Deghais (INRAT), and Drs. A. Daaloul, and M. Harrabi (INAT), future plans for better collaboration between ICARDA and Tunisian institutions. ICARDA is collaborating with INRAT in barley improvement and cereal pathology.

Also, ICARDA and CIMMYT scientists visited in May 1984 several research stations in Algeria and participated in discussions and observations of cereal nurseries with national scientists.

Notice of Release of Two- and Six-Rowed Bonneville Spring Barley Germplasm

The U.S. Department of Agriculture and the Montana Agricultural Experiment Station announce the joint release of eight two- and six-rowed Bonneville spring barley (*Hordeum vulgare* L.) germplasm lines. They were developed cooperatively by USDA-ARS and the Montana Agricultural Experiment Station at Bozeman, Montana.

The eight lines were developed by crossing Compana, CI 7248, followed by six backcrosses to the recurrent parent Bonneville. Selection in the segregating backcross generations was made for the genes *V* and *v* (two- and six-rowed, respectively), *I* and *i* (with and without lateral floret fertility, respectively), and *L* and *l* (lax and dense spikes, respectively). The non-recurrent Compana parent furnished the *V*, *i*, and *L* alleles and the recurrent Bonneville parent the *v*, *I*, and *l* alleles.

Except for the genes described for each isoline, these eight lines will be phenotypically very similar to Bonneville (Crop Science Reg. No. 26).

Seed (50 g) of each isoline may be obtained from Dr. E.A. Hockett, USDA-ARS, Plant and Soil Science Department, Montana State University, Bozeman, MT 59717, USA, or (10g) from Dr. D.H. Smith, Jr., National Small Grain Collection, USDA-ARS, Bldg. 046, Beltsville Agricultural Research Center, Beltsville, MD 20705, USA.

Each agency will make news releases as considered appropriate on or after the release date, March 1, 1984.

Training, Conferences, and Meetings

TRAINING

The 1984 Cereal Training Residential Course, conducted at Tel Hadya, Syria, from January to June, was attended by eight trainees from six countries:

Country	Trainee's Name and Address
Al Jamahyria Al Lybia	Mesbah Alfitoury Agricultural Research Center Ezzahra Research Station, Tripoli
Iran	Amir Ziaee Seed and Plant Office Dashtnaz Station Sari.
Morocco	Maamouni Aloui Mohamed Station experimentale de l'INRA a Tessaout. BP 78, Tamelat, Marrakesh
Saudi Arabia	Hijji Hussein Al-Ashoor Agricultural Research Center P.O. Box 43, Al Hassa.
Syria	Sahar Al Wafai Soil Department, Homs
	Nadr Mohamed Habbal Seed Multiplication Organization, Hama.
	Ahmed Zaatari Agricultural Research Center, Aleppo.
Tunisia	Lazhar Sakouhi INRAT Route de Tunis, 9019 Beja.

The course curriculum covered the improvemen of barley, durum, and bread wheat with special emphasis on breeding, pathology, entomology, quality, agronomy, seed production, field verification trials, and field plot techniques. Practical training was emphasized throughout the course with the trainees spending most of their time in lab or field work.

Mr. Arie Ton, a self-financed individual trainee from the Netherlands, was involved for 7 months in the triticale improvement project.

Mr. Sun Yuan Min, a visiting scientist from People's Republic of China has spent six and a half months in the Cereal Improvement Program working on the improvement of barley with special emphasis on agronomical and physiological aspects. He was particularly associated with Drs. Ketata, Mekni, and Winslow and Mr. Naji.

ICARDA is sponsoring a training course on harvest combine for agricultural research. The course will be carried out at Tel Hadya, Syria, from 3 to 14 June 1984.

Participants will be trained in practical harvesting using Hege and Wintersteiger combines as well as in calibration and maintenance of these machines.

Morocco In-Country Training Course

An in-country training course on 'Techniques of field experimentation and data analysis' was organized by the Cereal Improvement Program, ICARDA, in cooperation with INRA at Rabat, Morocco, from 3 to 10 March 1984.

Twenty trainees attended the course which covered the following topics:

1. **Principles of field experimentation,**
2. **important experimental designs used in agricultural research,**
3. **multiple comparisons,**
4. **factorial experiments,**
5. **linear regression and correlation,**

6. genotype x environment interaction,
7. stability analysis, and,
8. non-parametric methods.

In addition to regular lectures and practical sessions, the participants visited the computer lab at INRA and spent one day at INRA main research station at Merchouch, Morocco.

Active contributors to the course were Drs. H. Ketata and M. Nachit from ICARDA and Messrs. A. Amri, and B. Hrida and M. Mergoum from INRA.

The closing ceremony was hosted at Rabat, by Dr. M. Faraj, Director General of INRA. Representing ICARDA in this ceremony was Dr. L.R. Przekop, Head of Training. Also in attendance were officials from the Ministry of Agriculture and representatives from International Institutions involved in agricultural research activities in Morocco.

Following the course, Dr. Ezzahraoui (Head, Division of Research and Experimentation at INRA), in a letter addressed to Dr. J.P. Srivastava, commended ICARDA for their contribution to the training of Moroccan researchers.

Seed Production Training Course No. 2, co-sponsored by the Royal Government of the Netherlands and the German Agency for Technical Cooperation (GTZ), ICARDA, Aleppo, Syria. 15-30 May

The objectives of the course were to train suitable personnel in West Asia and North Africa in seed production technology, and to promote the development of national seed industries through the participating trainees.

The course curriculum included laboratory and field techniques, and theoretical background, planning, organizing and managing a seed production program, variety release and regulations, crop certification, seed testing-mainly in self-pollinated crops (barley, wheat, lentils, chickpeas, and forage peas), with awareness of seed testing problems in cross-pollinated crops (alfalfa and forage grasses), extension methodology, and programs for the promotion of quality seeds, principles of seed cleaning, and evaluation of germination.

A copy of the proceedings is available from ICARDA.

RECENT CONFERENCES AND MEETINGS – 1984

Third International Symposium on Parasitic Weeds, ICARDA, Aleppo, Syria, 7-10 May

'Parasitic Weeds' was the theme of a four-day symposium held on 7-10 May with the collaboration of ICARDA under the auspices of the International Parasitic Seed Plant Research Group. The symposium provided a forum for the interchange of data, techniques, and research results on all aspects of parasitic vascular plants. The following topics were covered: major parasitic groups (*Striga*, *Orobanche*, *Cuscuta*, and mistletoe), and their biology and control, as well as basic research in physiology, biochemistry, structure and ecology.

The symposium participants visited field trials to view *Orobanche* infestations and other parasitic species.

Travelling Workshop on Cereal Improvement

A travelling workshop on cereal improvement, jointly sponsored by ICARDA and CIMMYT, was held in Morocco (24-27 April 1984) and in Spain (24 April-2 May 1984). Participants were scientists from Morocco, Portugal, Spain, Tunisia, and from ICARDA and CIMMYT.

The participants visited research stations in the various countries and discussed methodologies for varietal development, disease and insect resistance, and stress tolerance.

The participants were: Francisco Bagullho, Benvindo Macas, Maria Julia Concalves, Manuel Baradas, Vicente Jameno, Jusus Herando, Jorge Juan Aracil, Mahmoud Deghais, Moncef Harrabi, Mohamed Merghoum, Mohamed Obani, Ahmed Amri, George Varughese, Santiago Fuentes, Joop Van Leur, Ahmad Kamel, and Ahmed El Ahmed.

FORTHCOMING CONFERENCES AND MEETINGS

Ninth World Fertilizer Congress of International Center of Fertilizers (CIEC)
Budapest, Hungary, 11-16 June 1984
Contact: Hungarian Society of Agricultural Scientists, Kossuther 6-8, 1055, Budapest, Hungary.

International Conference on New approaches to research on Cereal Carbohydrates, Carlsberg Research Centre, Copenhagen, Denmark, 24-29 June 1984

The conference is sponsored by the international Association of Cereal Chemistry, the Danish Cereal Society, and the Carlsberg Research Centre. It is a pre-meeting of the XIIth International Carbohydrate Symposium to be held in Utrecht, the Netherlands, and it aims to connect basic research with agricultural and industrial applications.

Topics to be covered are:

1. Reviews on the present status and future possibilities of cereal carbohydrate research.
2. Isolation, characterization, and analysis of starch, cellulose, and other carbohydrates in seed and straw.
3. Biochemistry of synthesis and enzymes.
4. Industrial utilization.
5. Food, feed, and nutrition.

Contact: Dr. L. Munck, Carlsberg Centre, Gamle Carlsberg Vej 10, DK-2500 Valby, Copenhagen, Denmark.

Sixth International Conference and Exhibition on Mechanization of Field Experiments
Dublin, Ireland, 8-13 July 1984

18th International Workshop on Seed Pathology of Internatioal Seed Testing Association (ISTA)
Puyallup, Washington, USA, 9-16 July 1984

Contact: Dr. R.L. Gabrielson, Washington State University, W. Washington Research and Extension Center, Puyallup, WA 98371, USA.

TASACONEX 84

The Tropical and Subtropical Agriculture Convention and Exhibition
Ardingly, Sussex, England, 18-20 July 1984

Contact: Fairlight World Seminars, 15 Havelock Road, Hastings, Sussex TN34 1DE, UK.

Kew International Conference on Economic Plants for Arid Lands
Kew, UK, 23-27 July 1984

Contact: Dr. G.E. Wickens, KICEPAL, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK.

First International Congress of Nematology
Guelph, Ontario, Canada, 5-10 Aug 1984

Contact: Dr. Teo Olthof, Research Station, Agriculture Canada Vineland, Ontario, Canada 1OR 2EO.

International Conference on Science and Technology Education and Future Human Needs
Bangalore, India, 8-15 Aug 1984

The main objective of the conference is to identify practical ways in which science and technology education can contribute to national development. It is hoped that one of the outcomes of the conference will be a reappraisal of what should be taught in both schools and universities in order to promote development.

Seventh International Congress of Entomology
Hamburg, Federal Republic of Germany, 18-26 Aug 1984

Contact: Dr. L.A. Mound, British Museum (Natural History), Cromwell Road, London, SW7 5BD, UK.

Sixth International Symposium on Biological Control of Weeds
Vancouver, Canada, 19-25 Aug 1984

Contact: Dr. J. Myers, Institute of Animal Resources Ecology, 2075 Westbrook Mall, University of British Columbia BC V6T 1W5, Canada.

Sixth International Congress on Virology
Sendai, Japan, 1-7 Sept 1984

Contact: Prof. S. Glover, University of Newcastle, Department of Genetics, Newcastle-upon-Tyne NE1 7RU, UK.

Second International Conference on Biological Agriculture
Wye College, Kent, UK, 3-7 Sept 1984

Contact: Dr. J.M. Lopez-Real, Wye College, Wye, Ashford, Kent TN25 5AH, UK.

International Symposium on Plant Tissue and Cell Culture Application to Crop Improvement
Olomouc, Czechoslovakia, 4-10 Sept 1984

Contact: Dr. F.J. Novak, Institute of Experimental Botany, Sokolovaka 6 CS-77200 Olomouc (CSSR).

Sixth Congress of the Mediterranean Phytopathological Union
Cairo, Egypt, 1-6 Oct 1984
Contact: Prof. Moustafa Fahim, P.O. Box 198, Orman, Giza, Egypt.

International Symposium on Genetic Manipulation in Crops, Peking, China, 22-26 Oct 1984

The Third International Symposium on Haploidy and, at the same time, the First International Symposium on Somatic Cell Genetics in Crops will be sponsored by the Chinese Association of Science and Technology, the Genetics Society of China, the Institute of Genetics of the Academia Sinica and IRRI.

Contact: Dr. Shao Ququan, Institute of Genetics, Academia Sinica, Beijing, China.

Third Scientific Arab Conference on Biological Sciences, Amman, Jordan, 3-7 Nov 1984

The Jordanian Society for Biological Sciences, in collaboration with Yarmouk University and the University of Jordan, will hold the Third Scientific Arab Conference for Biological Sciences in Amman at the Yarmouk University Liaison Office and at the University of Jordan during November 3-7, 1984. The conference represents one of the important activities of the Jordanian Society for Biological Sciences. The goal of the conference is to strengthen the links of cooperation among Arab researchers in the biological sciences.

The steering Committee of the International Biosciences Network (IBN) will hold its annual meeting at the same time, enabling members of the committee to be among the lecturers at the conference.

Contact: Dr. R. Natour, Department of Biological Sciences, University of Jordan, Amman, Jordan.
Or
Dr. S. Suleiman, Department of Biological Sciences, Yarmouk University, Irbid, Jordan.

Meeting of the Cereal Section Working Group on Rye Svalov-Sweden, 11-13 June 1985

The meeting of the Cereal Section Working Group on Rye will be held in Svalov, Sweden, during 11-13 June 1985. The following topics are proposed to be discussed:

1. Genetics and biotechnological methods.
2. Breeding of hybrid varieties.
3. Methods for selection and population breeding.
4. Genetic resources and resistance breeding.
5. Breeding for quality.

Contact: EUCARPIA Meeting 1985 Svalov, S-26800 Svalov-Sweden.

Arid Lands: Today and Tomorrow: An International Arid Lands Research and Development Conference Tuscon, Arizona, USA, 20-25 Oct 1985

Sponsored by the University of Arizona, UNESCO, the U.S. Man and Biosphere Program, the 1985 Arid Lands Conference is to be held in Tucson, Arizona, as part of a three-week long series of events with a focus on desert research, management, conservation and development. Scientists and resource managers are invited to submit 200 word abstracts of their potential presentations by no later than December 31, 1984. Abstracts will be reviewed and selections will be announced by February 1, 1985. Proposals for oral presentations for concurrent sessions and for poster session displays will be accepted.

Papers on all topics relating to arid lands water use and conservation, agricultural systems and genetic resources, natural resource management, conservation and reclamation, and human adaptations, migrations and habitations are welcomed.

Send abstracts and other inquiries to: Dr. G.P. Nabhan, OALS, University of Arizona, Tucson, Arizona 85721.

International Triticale Symposium
University of Sydney, Australia, 2-8 Feb 1986

Organized by the Triticale Association of Australia, the University of Sydney, and the Australian Institute of Agricultural Science, the symposium will be held in two parts, the first part comprising keynote addresses from all areas of industry, trade and marketing. The keynote speakers will introduce the following topics:

1. Germplasm collection and classification of triticale.
2. Cytogenetics of triticale.
3. Breeding technology and agronomy.
4. Triticale production in specific regions and grower experience.

5. Grain quality and chemistry.
6. Utilization for stockfeed, petfoods, hay, and grower experience.
7. Utilization for human food products.
8. International development and trade.

The keynote addresses will be followed by the presentation of submitted papers and a general discussion will be held at the end of each session. Time will also be allocated for poster presentations. The symposium will be of five days' duration and will include a mid-symposium tour to the Castle Hill Research Station to observe the National Rust Laboratory and other facilities. This visit will incorporate submitted papers on disease aspects in triticale.

The main objectives of the symposium are the promotion of international trade and development of triticale, the exchange of technical information (agronomy, breeding, and utilization) and the exchange of germplasm.

Contact: Dr. N. Darvey, Organizing Secretary, International Triticale Symposium, Plant Breeding Institute, The University of Sydney, N.S.W. 2006, Australia.

ERRATUM

RACHIS, Vol. 3, No. 1, Jan 1984, page 13. In the paper by R.B. Mirbahar "Incorporation of (Me-^{14}C) choline into phospholipids of wheat aleurone tissue," the following table was left out. The editorial committee regrets the omission.

Table 1. Degradation of the (Me-^{14}C) choline-labelled total phospholipid fraction. Each value is the mean ± standard deviation of the four separate experiments.

Hydrolysis period (hours)	Radioactivity recovered (dpm)	
	Unhydrolyzed lipid	Water-soluble degradation products
0	400.000 ± 5.530	
6	116.500 ± 1.840	280.800 ± 4.200
12	30.800 ± 0.350	366.200 ± 5.320
18	15.500 ± 0.210	382.500 ± 5.800
24		396.400 ± 4.200
36		395.000 ± 6.500

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.

For contributions with more than one author, all co-authors must sign at the end of the contribution, or the forwarding letter to the editor.

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°C; 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.

N.B. A list of all ICARDA publications is available from Communications and Documentation, ICARDA, P.O. Box 5466, Aleppo, Syria.

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