RACHIS

Barley and Wheat Newsletter

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The Center and its Mission

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

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

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

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

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

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COVER

Both barley straw and grain are used for feeding sheep in the ICARDA region where barley/livestock systems are the backbone of agriculture.

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Editorial

The demand for cereal commodities continues to grow in many developing countries, and despite the production increases that have been realized, the gap between production and consumption is still widening. In the Middle East and North Africa, wheat and barley imports increased from 14 million tonne in 1975 to over 30 million tonne in 1983. Barley imports alone rose from less than one million tonne in 1975 to over eight million tonne in 1984.

Crop improvement in dry areas is much more complex and difficult than in well-watered areas. The primary reason for this is the shortage of water but the intraseasonal and interannual variations in rainfall combined with the biotic and abiotic stresses make the environments in dry areas very unpredictable. For this reason it has not been possible to develop miracle technologies for dry areas; nonetheless, some very promising technologies have been developed at ICARDA and elsewhere, that can produce much better yields than the farmers' averages. This is particularly true in the case of barley which is grown in very dry areas, and in the case of durum wheat and bread wheat which are grown in moderate-rainfall areas in the ICARDA region.

The improved technologies developed at ICARDA for barley and wheats are geared to reduce the risks from both biotic and abiotic stresses, and provide increased yields and stability of production. The crop sequences and cultural practices in the improved package assure sustained production.

The benefits from these technologies can be harvested only if the national programs test them in their own environments, refine them if necessary, and then set their transfer of technology systems into motion in order to hand the proven technologies over to the farmers. In doing so, the national programs should ensure that there is a close interface between researchers, extension workers, and farmers.

Because there are vast areas of moderate to low rainfall in the ICARDA region, even moderate increases in yield through the adoption of improved technologies can contribute substantially towards selfsufficiency in many of the developing countries.

Though it is outside the purview of ICARDA to get involved in extension activities of national programs, it has been providing support to several countries in the region for conducting on-farm trials to demonstrate to the farmers the benefits from the improved technologies. Of particular importance was a practical training course on on-farm testing-cum-demonstration jointly conducted in Morocco by INRA, ICARDA, and FAO. The trainees included both research workers and extension agents and they participated in all phases of the on-farm testing. They selected the farms, planted the trials, visited the trial sites regularly during the season to apply production inputs, harvested the crop, and discussed the outcome of the trials with instructors and farmers. The success of the course was confirmed by the motivation of participants in conducting similar trials and the increased interest of the farmers in adopting the new technology during the following season.

ICARDA believes that a follow-up of such trials by national programs on a large scale will go a long way in the transfer of technology from the research farm to the farmers.

Review Article

Barley Improvement in Krasnodar Region, USSR

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I. Barley in the USSR

One of the main objectives of modern plant industry is to increase fodder grain production to meet the rising demand for feed for animal production. Among grain forage crops (maize, oat etc.), barley ranks first in importance in the USSR, with a total area of 35 million ha, the largest area in any single country of the world. Spring barley is grown throughout the country: from Kola Peninsula and Polar Circle in the north to Caucasus Mountains in the south, and from the Baltic Sea in the west to Siberia in the east. This widespread cultivation of spring barley comes as a result of low growth requirements of the crop, short period of vegetation, good tolerance to environmental stresses, and comparatively high lysine content of the grain.

As for the north Caucasus where Krasnodar Research Institute of Agriculture is located, winter barley is grown on about 0.7-0.9 million ha, and spring barley on 2.5 million ha. The soil conditions are generally very good for grain production, but the weather is rather variable from year to year and uncertain within the same season.

Autumn is usually very dry and winter very cold with scarce frosts occurring without any snow cover. At the same time, in February, often the so-called "open windows" occur, i.e. periods within the cold season, where temperature rises and allows the planting of barley and peas. Cold spells, however, occur even in May. Summer may be very rainy in some years, causing severe barley and wheat lodging or very dry and hot in some other years. The long-term average rainfall is 500-600 mm in the central part of Krasnodar Territory and 300-400 mm in the northern part. In Stavropol Territory and Rostov area there are locations with less than 300 mm average annual rainfall.

In these environments, winter crops are usually more productive than spring crops because they use more efficiently the autumn-winter rainfall, *and avoid the* heat and drought in June which affect spring crops during the final grain-filling stage.

Winter barley is the earliest crop in the North Caucasus, ripening 8-12 days earlier than winter wheat and 15-20 days earlier than spring barley. For this reason, winter barley cultivation allows a better work distribution during harvest time. In addition, it makes it possible to plant maize just after barley as a second crop for silage making. Winter barley is a very useful component in farming systems. Because of the high percentage of cereals in crop rotations, farmers do cultivate cereals after cereals, in which case the winter wheat/winter barley rotation is preferable to the winter wheat/winter wheat rotation, because barley is more tolerant to root rot diseases than wheat.

Spring barley is widely spread in the drier locations, where winter crops fail to do well. In addition, spring barley is successfully used in all regions for purposes of "repairing" of winter wheat and winter barley fields after their poor overwintering. Also, spring barley provides the best means for establishing plant density at the normal level of 500 plants/m^2.

Taking into consideration the diverse soil and climatic conditions in the North Caucasus and uncertainties of weather, breeders strive to develop new varieties by combining both high productivity and good stability.

II. Barley Breeding

The productivity and stability of winter barley is determined in the first place by good resistance to frost and lodging. In certain years, barley yield losses may go up to 2000-3000 kg/ha due to frost and an additional 500-1000 kg/ha due to lodging. In fact, other areas of research are also of great economic importance, including selection for earliness, disease resistance, improved grain-quality, stiff straw and reliable winter hardiness.

Spring barley breeding faces the complex task of combining several traits in one variety, including high-yielding potential, drought and heat tolerance, resistance to diseases and lodging, and improved grain quality. It is well known that the method used is a very important factor for the success in breeding. We are using intraspecific hybridization and experimental mutagenesis in our breeding program at Krasnodar Research Institute. As for approaches in choosing parental forms and in dealing with selected lines in different nurseries and trials, the leading concept is the maintenance of genetic diversity reached by introduction of new germplasm, hybridization, and mutagenesis. It seems rather difficult to achieve successful breeding without actually studying and utilizing new genetic material. There should be a continuing interest in identifying new donors, and studying the genetic resources that contain extremely useful variation. Local cultivars provide a good source of useful genes for ecological adaptation while newly-released varieties may possess many economically desirable traits. Our native varieties Odessky 31, Orion, Start, American Paoly, and Harrison have been efficiently used in our breeding program to improve winter hardiness. Varieties such as Ager, Robur (France), Miraj (Romania), and Vogelsanger Gold (FRG) provided good sources of high-yield potential and resistance to lodging. In spring barley, varieties of a West European ecotype such as Triumph, Nadja (GDR), Amethyst, Favorit (Czechoslovakia), Aramir, Mazurka (The Netherlands), Patty (France), Roland (Sweden), and others proved to be valuable donors of straw stiffness, resistance to disease, and high grain yield potential.

Crossing of ecologically and geographically different varieties was rather effective in creating useful genetic variability. Many breeders have obtained good results by crossing local varieties with exotic ecotypes such as the West European and American ones. The spring barley varieties Odessky 36 (All Union Institute of Breeding and Genetics), Donetsky 4, and Donetsky 8 (Donetsky Experimental Station), which occupy millions of hectares in the moisture-deficit zones in USSR, have been obtained by crossing local varieties with the American variety Spartan. The newly widespread spring barley variety, Odessky 100, has been developed through hybridization of ecologically distant barley forms of Ethiopian origin. A similar approach in selecting parental forms proved to be effective in barley breeding in the Krasnodar Territory.

Crosses involving the American variety Spartan have resulted in a new variety (Krasnodarsky 35) that outyielded the regional check. The release of our early-maturing winter barley variety, Lokus (now recommended for commercial production) is attributed to the desirable characteristics it has inherited from Ager (France) which was used in the hybridization. The first winter barley, Zavet, possessing a rather stiff straw was developed from crossing a local variety with parents of Hungarian and Chinese origins. The development and introduction of the barley variety Zavet was a turning point in breeding on the Kuban land. We made our option in determining the agroecotype most suitable for the local environments as one having an asiatic dense-headed morphotype with upright non-nodding spikes. Such type of plant can withstand, without lodging, a very high head density (600-800 heads/m^2) as compared with the pallidum type.

Transgressive variability was observed in the hybrid combination involving the varieties contrasting in their morphological and biological traits, and in their ecological and geographical origin such as the following: Vogelsanger Gold (FRG), Poisk, our local variety, and Harrison and Paoly (USA). Incorporation of these varieties and their relatives into crosses resulted in an important rise of positive transgressive variability. Using such crosses, we have developed our promising varieties Zavet-3, Meteor, and Cyclone which were released recently. Cyclone, as an example, combines earliness, resistance to lodging, and high yield (Table 1). In the State Official Variety Trials and in collective farms, this variety had a yield advantage of 800-1500 kg/ha over the check, probably because of its stiff straw and good resistance to diseases. This variety is now the most widely grown winter barley in the USSR.

In 1986 when environmental conditions were rather favorable, grain yield for Cyclone in Krasnodar Territory was 5-6 t/ha from an average area of 10,000 - 15,000 ha. In separate collective farms and brigades yields were 7-8 t/ha.

Initially, this variety has been developed for the Krasnodar Territory only. However, its cultivation spread throughout the Baltic Sea (Lithyania), West Ukraine, Moldavia, Crimea, North Caucasus,

Table 1. Some results of variety trials of winter barley, Krasnodar, 1977-1985.

Variety	Grain yield (kg/ha)	Winter hardiness (%)	Resistance to lodging*	Heading date
Zavet-3 (check)	6170	50.2	5	May 14
Vogelsanger Gold	5840	58.7	7	May 11
Poisk	6220	67.4	7	May 13
Cyclone	7360	54.3	9	May 9
LSD (5%)	300-520	8-11		

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.

Transcaucasia, and Middle Asia. Throughout these areas, there is a range of environmental conditions. Climate is humid with moderate temperature in the west of the country and extremely dry and hot in Middle Asia. Soils consist of rather poor podzol in the Baltic Sea area, fertile black soils in the North Caucasus and sandy soils in the Middle Asian Republics.

Analysis of the results of different trials in the country showed that the plasticity of Cyclone can be attributed to a good plant architecture, i.e. dense, non-nodding spikes, narrow leaves, high tillering and increased number of spikes per unit area. Such morphotype of released winter barley varieties is dominant in the North Caucasus. Realizing that a narrow-based germplasm is rather vulnerable we have been paying attention to other morphotypes. In breeding nurseries, and preliminary trials, the number of two-rowed and lax six-rowed lines was very high but all failed to reach the advanced trials. The comparison of the best six-rowed varieties with lax and dense spikes showed some advantage of dense spike particularly for spike number/m^2, and resistance to lodging and to head breakage (Table 2).

III. Mutagenesis

Barley is a diploid self-pollinating crop with simple cytology, and is used as a model crop in experiments with mutagenesis. This method is especially good for obtaining rare and unique mutations *from* varieties properly adapted to the local environments.

Our long-term experiments being conducted in cooperation with the Chemical Genetics Department of the USSR Academy of Science have resulted in 43 types of mutations. Chemical mutagenesis has facilitated the induction of a wide range of mutants differing in plant height (35-115 cm), and kernel size and possessing improved winter hardiness, and high protein content. Many breeding centers possess thousands of mutants, but the real value of those mutants remains rather unclear and doubtful for practical purposes. In connection with this, the well-known geneticist A. Gustafsson remarked that many researchers devote their efforts to "blind induction of mutations", creating "worthless junk" instead of "meaningful selections". Indeed, a lot of work is needed to isolate an economically important mutant genotype.

Table 2. Characteristics of the different winter barley types in advanced trials, Krasnodar, 1986.

Variety	Grain yield (kg/ha)	Spike number/m^2	Kernel number/ spike	1000-kernel weight (g)	Grain weight/ spike (g)	Resistance to lodging*
			Lax-headed varieties			
Start	7010	540	40	33.5	1.32	3
Lokus	7920	608	34	38.4	1.30	7
Debut	7250	530	36	36.4	1.28	6
Ager	7850	620	34	34.2	1.20	7
Vogelsanger Gold	7784	580	36	38.4	1.36	7
Mirage	8040	596	36	36.2	1.30	7
Friberga	8144	602	38	38.6	1.36	8
Mean	7714	582	36.2	36.5	1.30	6.4
			Dense-headed varieties			
Zavet	7420	606	42	35.2	1.32	5
Meteor	8020	628	36	38.4	1.30	5
Cyclone	9240	740	38	36.2	1.26	9
Novator	7856	580	34	34.2	1.34	7
Rezerv	8130	726	34	35.8	1.16	7
Monolit	8846	720	38	35.8	1.26	9
Radical	8950	686	36	38.4	1.32	8
Mean	8352	669	36.8	36.6	1.28	7.1
LSD (5%)	420	22	4.8	2.2	0.08	

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.

Table 3. The effectiveness of selection from different mutant classes, Krasnodar, 1965-1985.

Class of mutations	Number of lines				
	Nursery		Trials		
	Breeding	check	Preliminary	advanced	state
			Winter barley		
Micromutants	123850	18820	2490	0	0
Visible mutations	3460	2882	1540	342	4
			Spring barley		
Micromutants	79840	8466	498	0	0
Visible mutations	2560	1845	1219	292	4

To find out a proper way for mutant application in practical breeding, we divided all the mutations we obtained over 20 years into two classes: (1) micromutations (micromutants) - forms without vivid differences from a parental variety, and (2) visible mutations (macromutants) - forms with phenotypically marked changes that can be identified in the field or laboratory. The methodological and philosophical background of that approach lies in the concept of dialectical materialism about unity of form and matter, that if the matter changed the form inevitably changes. Since phenotypical changes can be recorded, the way to the target can be shorter and straighter: from form to function or from morphology to physiology. The main criteria for selection of micromutants were the plant and spike appearance and it is hoped that this can lead to the improvement of a wide-spread variety without any drastic negative change from earlier performance. For this reason micromutations prevail in breeding nurseries. In our experiments, selection from the class of visible mutations has been more effective. This is proved by the number of promising lines saved after their evaluation in competitive and official state trials (Table 3).

Although the initial number of micromutants was 30-40 times higher than that of macromutants, micromutants were discarded at different stages of breeding process. The statistics obtained lead to the conclusion that for success in breeding, the use of visible mutations is more preferable. This approach is less expensive and more effective.

Some of the macromutants such as the early spring barley variety, Temp, and frost-resistant variety, Debut, were released and introduced into practice after direct multiplication. The variety Temp shows good resistance to diseases, increased rate of initial growth, and uniform stand. It economically assimilates moisture and soil nutrients, ensuring yield increments of 300-900 kg/ha. Temp is the best variety in Krasnodar region, occupying 90% of the area planted to spring barley. Macromutant MM-1 [Paoly treated with Nitroso-methyl-urea (0.02%, 12 hours)] which is superior in winter hardiness to the original variety and to the best world standards, has also been induced chemically. Through the treatment of cultivar Start with Nitroso-ethyl-urea (0.05%, 12 hours) the newly-released variety Debut was produced. This variety combines good winter hardiness, resistance to lodging, and high yield potential (Table 4).

Induced winter-hardy mutant MM-1, mutant line 26 M8 with its 'deep tillering node,' and variety Debut are widely utilized in barley breeding programs for increasing reliability of new varieties. In fact the majority of macromutants should be regarded as raw material for future breeding by recombination and selection.

The choice of some unique mutants as parents for crosses considering their morphological and biological contrast has enabled us to produce various combinations

Table 4. Performance of winter barley Debut in the advanced trials. Krasnodar, 1977-1985.

Variety	Grain yield (kg/ha)	Winter hardiness (%)	Resistance to lodging*
Start (check)	5610	68.4	5
Debut	6320	74.2	7
LSD (5%)	300-360	9-12	

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.

Table 5. **Performance of promising spring barley lines. Krasnodar, 1980-1985.**

Variety/line	Grain yield (kg/ha)	Plant height (cm)	Resistance to lodging*	1000-grain weight (g)	Heading date
Temp (check)	4290	80	5	45.2	May 23
Trumph	3630	60	9	31.2	June 1
Cascade	4810	65	9	45.4	May 26
137/9	4510	85	8	53.0	May 21
LSD (5%)	250-330				

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.

Table 6. **Characteristics of early ripening winter barley lines in preliminary trials. Krasnodar, 1986.**

Line	Heading date	Plant height (cm)	Resistance to lodging*	Winter hardiness**	Grain yield (kg/ha)
Cyclone (check)	May 12	102	7	7	7510
54M17	April 2	110	4	4	5320
52M1	May 9	95	8	8	6840
270/1	April 1	105	7	6	6720
270/4	April 2	110	6	6	6860
269/9	April	90	8	5	6420
LSD (5%)					380

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.
** Using 1-9 scale: 1 = poor resistance (plant survival = 0-5%).
9 = high resistance (plant survival = 100%.

of traits including favorable transgression. The cross Trumph x Temp resulted in the high-yielding variety Cascade (released in Krasnodar and Stavropol Territories and Armenia), and a promising line, 137/9, combining earliness, large-size kernels, and good resistance to lodging (Table 5).

Taking into consideration the importance of earliness in the ICARDA Cereal Improvement Program, it would be interesting to discuss the possibility of mutagenesis for this particular trait. Seed treatment of the variety Regia with Nitroso-ethyl-urea (0.033% for 6 hours) resulted in a very early-ripening mutant of winter barley, i.e. 54 M17. The mutant was 15-18 days earlier in heading than the parental form. The mutant was crossed with winter-hardy and powdery mildew-resistant mutant 52 M1 (Vogelsanger Gold x Nitroso-dimethyl-urea at 0.05% for 6 hours). The involvement of drastic macromutants carrying valuable traits in hybridization has resulted in desirable transgressive variability which led to the isolation of lines 270/1, 270/4, and a facultative and very early line 269/9. These lines headed much earlier than the parental forms and the check (Table 6). Undoubtedly, the newly selected lines are very valuable as they serve the purpose of early harvesting of winter barley in order to cultivate maize as a second crop.

Chemical mutagenesis has also manifested its high effectiveness in barley breeding for improved grain quality. Though the literature abundantly shows that grain yields are negatively correlated with protein contents in grain, the use of macromutants such as the large-size grain variety Prizyv and line 31 M15 with increased protein content resulted in developing the first commercial high protein, facultative-type winter barley variety, Novator. Furthermore, yield was not sacrificed for quality because Novator, essentially possessing resistance to lodging and better winter hardiness connected with deeper tillering node, outyielded the check (Table 7). These factors contributed to a significant gain in protein yield per unit area. In 1982, Novator was released for commercial production in the Krasnodar Region and its acreage was the largest compared to other varieties until Cyclone was introduced.

Table 7. Performance of winter barley variety Novator, Krasnodar, 1977-1985.

Variety	Grain yield (kg/ha)	Protein content (%)	Winter hardiness (%)	Resistance to lodging*
Zavet-3 (check)	6170	11.6	42.6	5
Novator	6470	13.2	63.8	7
LSD (5%)	250-450	0.22-0.42	8-11	

* Using 1-9 scale: 1 = heavy lodging; 9 = no lodging.

The data collected indicated a great potential of efficient exploitation of induced mutations in barley breeding.

IV. Important Cultural Practices

The tendency to have as high a spike density as the environment can permit is becoming an important feature both in breeding and in agronomy. In favorable conditions, the upper level of stem number is determined by the degree of lodging and, in dry conditions, by the decrease in grain yield and quality. Research carried out during the last 15 years has shown that seed rate had no significant effect on barley yield under moderate conditions. On the curve of yield there was a plateau when seed rate ranged between 400 and 600 seeds/m^2, 300 and 700/m^2 were similar, and 200 was not enough. In dry seasons the results were in favor of increased seed rates: 500-700 seeds/m^2, but not more than 800. Since the weather is unpredictable, our recommendations in practice are targeted for the worst environmental conditions. The main conception in choosing optimal seed rate is: the better the conditions, the lesser the seeding rate. Of course, care should be taken so that seed rate is adjusted according to the varietal peculiarities, the preceding crop, and the planting date. For winter barley it is recommended to plant 400-500 seeds/m^2 in the central part of the Krasnodar Territory, which receives 500 mm annual rainfall and 500-600 seeds/m^2 in the northern part which receives 300 mm. That is about 200 kg seeds/ha for mid-size grain winter barley varieties and 250 kg for two-rowed spring barley varieties. In addition, about 60-80% area under winter barley is planted following the bidirectional method which is compulsory when conditions for soil preparation are bad, when soil is too dry, or when there are many plant residues from the previous crop. In that case, practising the bidirectional planting gives yield increments of 200-600 kg/ha, which makes up for the expenses of fuel and labor. This method has the advantage of ensuring better seed distribution especially if during the first run some places were left empty or if plant damage by birds, mice or underground beetles occurs. The coverage of soil surface by the plants depresses weeds, limits soil evaporation, increases the utilization of sunlight for photosynthesis, helps prevent wind erosion, and ensures better over-wintering. Secondly, our planters have dish shoes: the first run makes the soil more smooth and even, and the second run, in perpendicular or diagonal direction, eliminates all drawbacks of soil tillage that happened during preparation.

As for drilling machines used in the North Caucasus, there have been a spread hoe drill (single-pass planter), and narrow-spaced drills with 7.5 and 10 cm between rows. For winter crops planting, a grain press planter is usually used. This is a disk drill with 15 cm between rows and individual roll-press for every shoe, which makes the soil above seeds more compact. Because of the good contact between seeds and soil, moisture is more available and seedlings are more vigorous. After a run of such a drill, small furrows remain on the soil surface. When the winter is frosty and windy, plants on the bottom of the furrow are much more sheltered. If wind soil-erosion occurs, the root system will be more protected and saved. Our results in breeding and agronomic practices have shown that the optimal seed rate and good plant coverage from the very beginning of vegetation increase yield stability and ensure reliable crop production.

Extensive research has been done in the USSR and other countries to increase productivity of barley, but still there are many untapped reserves that may lead to further improvement. This may successfully be achieved through joint efforts of scientists in different countries of the world. In this connection it will be useful to establish joint research links between ICARDA and different research institutions located in the moisture-limited areas of the USSR, such as those of North Caucasus, Volga Region, and Middle Asia. Since ICARDA has the international mandate for the improvement of barley in the dry areas, it is believed that further strengthening of collaborative research efforts between ICARDA and USSR scientists will be beneficial to both and lead to increased and more stable yields in moisture limited areas.

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Research and Production

Stability and Yield Performance of Some Barley (Hordeum vulgare L.) Cultivars and Mixtures

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The use of barley mixtures to improve yield was first proposed in 1938 by Harlan and Martini. They grew a mixture of 11 barley varieties in different environments in the United States and found that the stability of the mixture is greater than any of the components alone. Later, Jensen (1965) and Borlaug (1959) suggested the use of multilines to control rust diseases of oats and wheat. The advantages of multiline cultivars over pure-line cultivars include (1) slowing down the rate of epidemic development and thus reducing losses caused by the disease, (2) providing a higher and stable yield, and (3) increasing the genetic diversity of populations. Qualset and Granger (1970) found that mixtures are relatively more stable than their components; however, yields did not increase significantly over the best performing component of the mixture. Finlay (1964, 1971) stressed the importance of genetic diversity as a yield-stabilizing factor and later reported that population breeding methods increase the number of high-yielding and adapted lines, with many of them surpassing the best parent. Jensen (1965) using a five-component multiline of oats found that there was no significant increase in yield of the mixture. Qualset (1981) reported that diversity in maturity can improve the performance of mixed populations, and that there are strong prospects for identifying mixtures that will outperform pure lines.

Alejo (1975) using mixtures of isogenic lines found that yields of the mixtures were generally higher than those of the pure lines and more tolerant to *Pyrenophora teres*.

This study aims to compare the yield and stability of some barley mixtures and their pure line components.

Materials and Methods

Eight genotypes, four 6-rowed and four 2-rowed, were selected for the study (Table 1). The experiments were conducted at four sites (Mornag, 1984/85; Kef 1982/83; Mateur 1982/83; and Cap-Bon 1983/84). The experiments included the eight cultivars in pure stands, all possible two-way mixtures at 1:1 proportions and all possible three-way mixtures at 1:1:1 proportions. Two four-way mixtures were also used at equal proportions. The six-rowed and two-rowed barley cultivars and their mixtures were grown separately. The seeding rate was approxiamately 100 kg/ha. The experimental unit was a 6-row plot, 5 m long with 0.3 m between rows. The experimental design was a randomized complete block with four replications. At maturity, grain yields were determined by harvesting the central four rows of each plot.

Analysis of variance was made separately for the parents and the mixtures. Stability analysis was made at each site by means of the regression of the yield of each entry on the mean yield of all the entries of the experiment. To improve the efficacy of the linear regressions accounting for the variety-environment interactions, all data were transformed to a logarithmic scale.

Results and Discussions

Table 1 shows that mean yields for the cultivars at the four locations ranged from 19.9 to 25 g/ha for the 6-rowed and from 20.5 to 26.1 q/ha for the two-rowed cultivars. Gem and WI 2231 are known from previous experiments to have a good yield potential. Table 1 also shows the location mean yield; Mateur, a high-rainfall site being the highest yielding environment and Cap-Bon the lowest yielding environment.

Table 1. Code, row type, and mean grain yields for eight barley cultivars over four sites in Tunisia.

Component code	Cultivar name	Row type	Grain yield (q/ha) Mornag	Mateur	Kef	Cap-Bon	Average
1	Gem	6	21.5	28.5	26.0	14.1	22.5
2	Line 251/14	6	22.5	22.0	27.0	16.0	21.9
3	Beecher	6	22.0	18.5	24.5	14.6	19.9
4	Cross 257/37	6	24.5	27.0	23.3	15.6	22.6
5	WI 2291	2	27.5	29.0	27.0	20.6	26.0
6	WI 2198	2	21.5	31.5	25.5	17.0	23.9
7	WI 2197	2	22.0	36.5	25.1	18.5	20.5
8	WI 2231	2	25.0	36.0	25.1	18.3	26.1
		$\bar{x}$	23.3	28.6	25.4	16.8	23.6
		S E	2.0	2.3	1.8	2.6	3.2

Table 2. Two-component mean grain yields for each site expressed in q/ha and as a percentage of the expected yields based on pure stand performance of the cultivars.

Component code	Cultivar combination	Mornag q/ha	Mornag %	Mateur q/ha	Mateur %	Kef q/ha	Kef %	Cap-Bon q/ha	Cap-Bon %	Average q/ha	Average %
9	1 + 2	26.5	117.8	28.0	110.9	25.0	94.3	20.5	136.2	25.0	114
10	1 + 3	25.0	114.9	28.0	115.0	26.0	103.0	18.4	128.2	24.4	115
11	1 + 4	25.5	110.9	28.0	100.9	27.0	109.5	18.5	124.6	24.8	111
12	2 + 3	28.5	128.1	25.5	125.9	28.9	112.3	21.4	139.9	26.1	126
13	2 + 4	26.0	110.6	25.5	106.0	27.9	110.9	20.1	127.2	24.9	113
14	3 + 4	27.0	116.1	20.5	90.1	25.5	106.7	17.6	116.6	22.7	107
15	5 + 6	32.5	132.7	28.0	92.6	27.3	103.8	20.2	107.5	27.0	109
16	5 + 7	27.5	111.1	25.0	76.4	26.8	101.9	26.6	136.1	26.5	106
17	5 + 8	31.0	118.1	23.5	72.3	25.0	96.0	23.1	118.8	25.7	101
18	6 + 7	26.0	119.5	29.5	86.8	27.0	105.9	21.6	121.7	26.0	108
19	6 + 8	30.0	129.0	22.0	65.2	27.0	106.7	21.3	120.7	25.1	105
20	7 + 8	31.0	126.5	30.0	82.8	27.2	107.5	24.4	132.6	28.2	112
	$\bar{x}$	28.0		26.1		26.7		21.1		25.5	
	S E	7.5		3.4		3.8		5.2		8.1	

The yield of the two-component mixture is higher than the mean of the components when grown in pure stands (Table 2). All the six-row mixtures had significantly ($P < 0.05$) higher yields than the mid-component mixtures. The lowest yielding environment (Cap-Bon) gave the highest percent (29) increase over the best component in the mixture. No yield increase was observed in the high-yielding environment (Mateur). At this location intra-population competition was at a minimum. Plant competition in heterogenous populations increases as the environment becomes limiting. This is evidenced by the increase of the two-component mixture over the best performing parent. The increase or decrease was

Table 3. Three-component mean grain yields for each site expressed in q/ha and as a percentage of the mean yields based on pure stand performance of the cultivars.

Component code	Cultivar combination	Mornag q/ha	Mornag %	Mateur q/ha	Mateur %	Kef q/ha	Kef %	Cap-Bon q/ha	Cap-Bon %	Average q/ha	Average %
21	1+2+3	21.0	95.5	25.0	108.7	27.8	107.4	12.5	83.9	21.6	9.8
22	1+2+4	20.5	89.8	27.0	104.5	28.9	118.3	13.6	88.0	22.5	100.4
23	1+3+4	25.0	109.7	27.0	109.4	26.8	108.7	18.8	129.3	24.4	113.8
24	2+3+4	25.0	108.7	27.5	122.2	26.6	106.7	18.0	116.9	24.2	113.6
25	5+6+7	21.5	90.9	29.0	89.7	31.0	119.0	17.8	94.9	24.8	98.6
26	5+6+8	26.0	105.4	23.5	73.1	28.8	111.3	17.4	93.4	23.9	95.8
27	5+7+8	24.5	98.7	32.0	94.6	26.1	101.0	20.5	107.2	25.7	100.4
28	6+7+8	23.0	99.3	32.0	92.3	30.7	121.1	17.8	99.0	27.6	102.9
	$\bar{x}$	23.3		27.9		28.3		17.0		24.3	
	S E	4.3		5.3		4.4		4.5		5.1	

Table 4. Four-component mean grain yields for each site expressed in q/ha and as a percentage of the expected mean yields based on pure stand performance of the cultivars.

Component code	Cultivar combination	Mornag q/ha	Mornag %	Mateur q/ha	Mateur %	Kef q/ha	Kef %	Cap-Bon q/ha	Cap-Bon %	Average q/ha	Average %
29	1+2+3+4	27.5	121.6	25.5	106.3	30.9	122.5	19.3	127.1	25.8	119.3
30	5+6+7+8	22.5	94.7	31.0	93.2	33.7	130.8	16.5	88.7	25.9	101.9
	$\bar{x}$	25.0		28.3		32.3		17.9		25.9	
	S E	6.3		5.3		4.2		3.7		0.2	

+29%, +18%, +7%, and -18% in Cap-Bon, INAT, Kef, and Mateur, respectively. Of the three highest yielding populations, two had cultivar WI 2291 as a common component.

The results of the three-way mixtures (Table 3) were consistent with those of the two-way populations. The population (code number 24) with cultivars line 251/14, Beecher, and cross 257/37 was consistently higher in yield than the mean of the three components when grown in pure stands. It appears again that the 6-rowed cultivars have better performance than the two-rowed cultivars when grown in mixture.

None of the three-way populations had higher yields than the best yielding cultivar (WI 2197) in the highest yielding environment (Mateur). However several had yields similar to those of the highest yielding cultivar (WI 2291) in the lowest yielding environment (Cap-Bon), thus confirming the results obtained with two-way mixtures with regard to plant competition in high-rainfall locations such as Mateur.

The four-component mixtures performed better than the mean of the cultivars (Table 4). This is specially true for the six-rowed types. Again the highest percent increase (27) was observed at the low-yielding environment and the least increase (6%) at the high-yielding environment. This confirms the results of the two-way and three-way mixtures.

Examination of all populations shows specific cultivar effect. WI 2291 and line 251/14, being high-yielding cultivars, contributed positively in mixtures.

Fig. 1 shows a diagram of a two-way frequency distribution for all entries. Both line mean yield and regression coefficient indicate the different types of adaptation response. Specific adaptation to favorable and poor environments is measured by low mean yield and high regression coefficient on the one hand and low mean yield and low regression coefficient on the other. Cultivars with high mean yields, and close to 1 have wide adaptation.

It is interesting to note that none of the pure line cultivars has a regression coefficient close to 1 except WI 2198. Entries 20, 26, 27, and 29

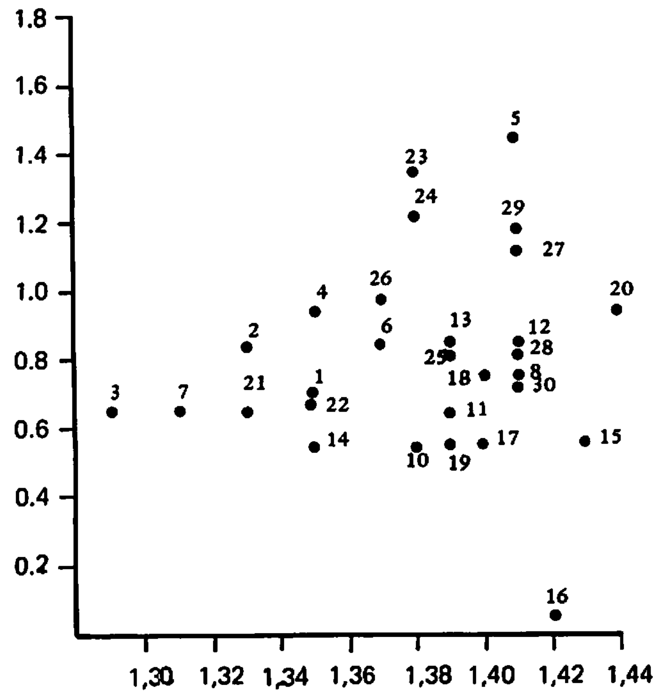

Fig. 1. Two-way frequency distribution of mean yield and regression coefficients for barley lines and their mixtures.

representing two, three, and four-way mixtures, respectively, were widely adapted. Entries 14, 21, and 22 were specifically adapted to poor environments. None of the entries was specifically adapted to favorable environments.

Furthermore the results show that mixtures have a better general adaptation than their components when grown in pure stands.

This study shows that growing barley mixtures may increase yields significantly especially in poor environments. Adaptation, whether specific or general, of barley mixtures may represent a great advantage in improving barley yields especially in the semiarid regions.

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Slow Scalding in Barley

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Slow rusting has been observed in several cereals for a number of rusts (Wilcoxon 1981), and so have slow 'mildewing' (Bennett 1984) and slow 'septoring' (Bronniman 1982). Recently the ICARDA/CIMMYT regional barley breeding program, based in Mexico, has started detecting slow scalding in response to infection by *Rhynchosporium secalis.* The data obtained indicated that this phenomenon may be operating in some barley material.

The phenomenon of slow disease development has gained increasing attention for various reasons. With the main objective of many breeding programs being to develop new varieties with high levels of resistance to various diseases, this resistance was often found to be based on a few genes associated with major effects and has often appeared to be quite easily overcome by the pathogen. In the rusts especially, these rapid changes of virulence have resulted in 'boom and bust' cycles, making replacement of cultivars necessary every 3 - 5 years. It has been suggested that a moderate level of disease occurrence may allow a less severe selection environment for the pathogen, thereby reducing the necessity to increase virulence. For the most important diseases, a late onset of the epidemic has usually been associated with reduced yield losses. Many researchers have suggested that slow rusting could be a stable trait that contributes to durable resistance, with long-term effectiveness in the presence of disease (Wilcoxon 1981). In his publications, van der Plank (1963, 1968) presented the methodology to quantify the phenomenon of slow rusting.

In the regional ICARDA/CIMMYT Barley Program, disease assessments for scald were recorded several times during the season, for a number of years.

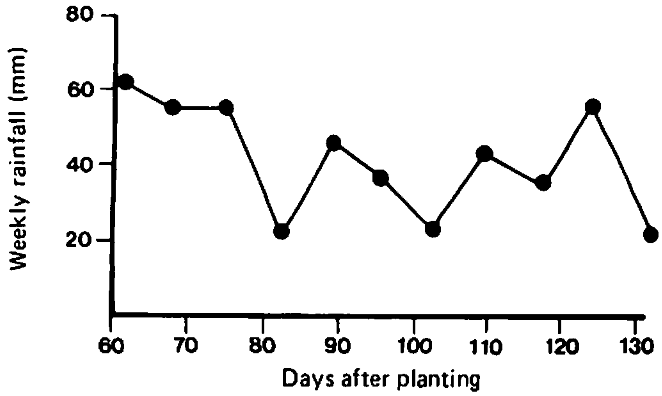

Fig. 1. Total weekly rainfall (mm) during the period of disease development at Toluca, 1986.

Note: Data points indicate total weekly rainfall (mm) set out against the central day (Wednesday) of the particular week. For example, day 61 is the Wednesday of the week when total rainfall was 62 mm.

Based on the final disease notes, types with low infection were selected and used as sources of resistance in the crossing program.

Environmental conditions at Toluca Experiment Station (2640 m elevation, 19°N latitude, 40 km west of Mexico City) are ideal for scald development, with almost daily rains (750 mm during the growing season) and moderate temperatures (Fig. 1). In 1986 as in previous years, all program material was artificially inoculated. Following tillering, infected straw conserved from the previous season, was spread between the rows. Fresh inoculum was prepared from scald-infected leaves using Piennings technique (1979) and the resultant spore suspensions were regularly applied to the material under test with back-pack sprayers. Following the onset of the epidemic, percentage area of the infected foliage was scored on a weekly basis until maturity. Heading dates were also recorded. In addition, at the beginning of grain maturity single-disease notes, expressed in terms of R; MR; MS; S; and VS, were taken in the fashion used in earlier seasons to determine sources of resistance. Using the data collected, areas under the sigmoidal disease progress curve (AUDPC) were calculated, with a locally developed computer program. Entries identified during the 1986 and previous seasons as resistant (R and MR) showed slow disease progress and had very low AUDPCs, ranging from 0 to 800. Such lines could be called "slow scalders". Susceptible (MS, S, and VS) entries in general had very high AUDPCs (in the range 2800-5000) and many were obviously "fast scalders."

The objective was to add material to our group of scald-resistant parents that had not previously been considered as sources of resistance to scald. Thus, the operational definition of 'slow scalding' was formulated as "lines that had consistently scored susceptible (S and VS) over several years, but which, upon analysis over time within a given year showed slow disease development during the major part of the growing *season*, with only a rapid increase in infection percentage at the final stages of crop growth."

The AUDPCs of such lines were low-to-intermediate, in the range of 800 - 2800. Of these entries, the late-maturing types were discarded from further analysis, as lateness was considered an undesirable trait.

For the remaining entries, the sigmoid curve of disease progress over time was transformed using logits of the percentages. The resulting line was essentially straight and the slope was determined as representative of the apparent infection rate (Zadoks and Schein 1979). The apparent infection rate ranged between 0.07 and 0.13, confirming that these lines were slow scalders as evidenced from the raw data and the intermediate AUDPC values. Truly susceptible entries had infection rates of 0.20 and higher.

Fifteen entries, also expressing other desirable characteristics, were subsequently selected among these for further evaluation (Table 1).

One line with good combining ability and a medium or high apparent infection rate (0.18) was also included because the slow, early development of the disease was followed by extreme susceptibility in the final stages, resulting in values somewhat outside the designated range. Fig. 2. represents the three different reactions to scald observed in the material. Most of the selected slow-scalding candidates showed a double S-curve of disease progress over time. Study of the rainfall pattern established that this was not due to a temporary dry spell. The slope of the first S-curve was in the range of that of the resistant lines, and the slope of the second S-curve was similar to that of the truly susceptible entries. It seems that resistance is effective in these slow scalders only *until* the later part of the growing season. After that time disease progress appears to be unchecked, and quite high levels of infection can be reached. Our assumption is that resulting yield losses may be minimal, as grain filling is well under way when infection starts to increase rapidly. To test this hypothesis, these entries will be entered in a comparative yield-loss trial in the 1987 season at Toluca.

Table 1. Selected slow scalding candidates with respective maturity, area under the disease progress curve (AUDPC) and apparent infection rate (r), Toluca, 1986.

Slow-Scalding Candidates	Maturity*	AUDPC	r
ORGE 618	E	895	0.10
RIOBAMBENA/MIRLO	N	1210	0.08
ZVA"S"	N	1479	0.08
CI1240/FOMA//C16238.15D	N	1600	0.07
GTO"S"	E	1620	0.11
PM5/BEN	N	1719	0.07
JOSO"S"	E	1721	0.13
MZQ/BEN/3/ER/OLLI/M64.69	E	1832	0.08
BREA"S"/DL70//MOZDOSKY/3/NOPALS"S"/4/BFL"S"/5/LIGNEE 527	N	2030	0.11
K8755	N	2165	0.11
MANKER/ATHS	E	2249	0.10
CEDRO"S"	N	2275	0.11
FM437	N	2303	0.09
API/CM67//AGER	E	2472	0.18
UNA 80	N	2713	0.09

* E = Early; N = Normal

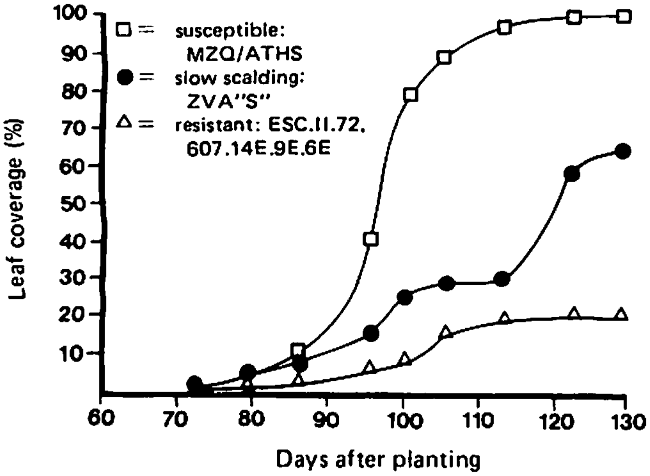

Fig. 2. Disease progress over time for the different reactions to scald.

During the season, while observing our segregating material, it became increasingly evident that adequate level of resistance to scald was only obtained when more than one source of resistance was represented in the original cross. However several advanced lines expressed low levels of infection, while containing only one apparent source of resistance. After analyzing the data on disease progress over time in the parental material, it was determined that, in fact, these particular advanced lines contained a 'slow scalder' as a source of resistance. Thus some of these 'slow scalders' appear to have already significantly contributed to scald resistance in some of our advanced material.

Since inoculum was artificially applied from the top until about the flowering time, genetic factors limiting the upward spread may have been suboptimally expressed. In addition, the nurseries were planted in short adjoining rows, also containing many truly susceptible entries, and interplot interference due to allo-infection is suspected to have been considerable. The latter effect has been called the cryptic error in field experiments (van der Plank 1963). Both factors may have resulted in an underestimation of the slow scalding effect and, in a monoculture situation, this type of resistance may result in final disease levels much below those observed in closely planted diverse nurseries.

Slow scalding has not been adequately reported in the literature and as yet little is known about the inheritance of this phenomenon or its durability. However, we have enriched our genetic stocks with lines possessing a slow scalding type of resistance. We thus hope to confront the pathogen population with a multiple and more diverse defense system, by establishing both types of resistance in stable lines. The combination may prove more durable.

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Development of Disease-Resistant Germplasm in Barley Utilizing Recurrent Selection Techniques[1]

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Traditional methods (i.e. pedigree and backcross) of breeding improved varieties of self-pollinated crops have been very successful. This has been especially true for characters controlled by relatively few genetic factors. However, the efficiency of these traditional methods is limited when applied to quantitative characters because of type of gene action, linkage, population size, and environmental effects. Jensen (1970) outlined three limitations of

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conventional breeding systems: (1) restriction to a relatively small gene pool; (2) accumulation of linkage blocks; and (3) limitation of recombination due to lack of intermating beyond the initial cross. Allard and Hansche (1964) discussed the problems associated with transferring genes from unadapted to adapted types. They reasoned that failures were usually due to population size limitations, intense selection for the general characteristics of familiar varieties, and isolation of families in segregating generations. Characters, such as quality and yield, controlled by many genes require population sizes impracticably large to put all positive factors into a single plant from a cross between parents differing at many loci.

Recurrent selection, reduced to its most basic form, consists of a population of plants alternately undergoing selection and recombination in repeating cycles. It is a method for improving populations by effecting changes in gene frequencies without a rapid approach to homozygosity (Penny *et al.* 1963). In recurrent selection schemes, enormous segregating generations from crosses become unnecessary, linkages are continually rearranged, and a large number of parents can be used in creating the populations, resulting in more variability in which to practice selection (Doggett 1972).

Recurrent selection is not a substitute for conventional methods of breeding. Rather it should be regarded as an additional tool especially suited to exploiting populations of broad genetic base. Its primary function is to provide a continuing supply of genotypes that can serve as parents in conventional breeding programs.

Recurrent selection is effective in breeding for characters whose expression can be modified as a result of changing the background genotype, transgressive segregation, or accumulation of minor genes. In many instances, the character expression of a gene or genes can be modified by changing the genetic background. Recurrent selection is the most feasible means of simultaneous selection for a character and its most favorable background genotype.

Historically, recurrent selection has been applied to cross-pollinated crop species (Penny *et al.* 1963). The utilization of recurrent selection has been effective, for example, in concentrating genes for resistance to leaf blight of maize (Jenkins *et al.* 1954), stalk rot of maize (Jihahyon and Russell 1969), alfalfa rust (Hill *et al.* 1963), bacterial wilt of alfalfa (Barnes *et al* 1971), and European corn borer (Penny *et al.* 1967). In these examples, resistance was usually polygenic in nature. The use of genetic male sterility in some slef-pollinated crops to facilitate crossing has generated considerable interest in recurrent selection (Mese *et al.* 1984; Doggett 1972; Brim and Stuber 1973; Jensen 1978). Also, recent developments in chemical sterilants should further expand the use of recurrent selection in many self-pollinated crops.

In barley, some 32 loci for genetic male sterility have been described (Hockett and Reid 1981). These were first utilized by Suneson (1956) in Composite Cross XIV in which he relied on natural selection to improve population fitness. Since that time, more than 15 additional composite crosses containing male sterility have been established and grown for many generations without selection. Numerous studies on yield, yield components, and conservation of disease resistance in these populations have been published (Acharya and Jana 1982; DeSmet *et al.* 1985; Muona *et al.* 1982; Jackson *et al.* 1982; Jackson *et al.* 1978; Saghai-Maroof *et al.* 1983).

A number of barley researchers, including private breeding companies, have been using "male sterile-facilitated recurrent selection populations" as part of their breeding effort (Bockelman *et al.* 1981b; Jensen 1978; Habgood and Uddin 1984). In 1958, 10% of the barley cultivars grown in the USA were derived from composite crosses (Jensen 1978).

Use of Recurrent Selection in the Montana-USAID Barley Project

The Montana-USAID Barley Project is concerned with improving barley for less developed areas of the world and, in particular, reducing losses caused by diseases by developing germplasm with polygenic broad-based resistance combined with good agronomic types that can be utilized by local barley breeders. This is being achieved using male sterile-facilitated recurrent selection populations along with annual evaluations and direct selections.

A. Major Gene Resistance

Most barley cultivars contain one or two genes for resistance to a particular disease, if any at all. Single gene resistance is easy to transfer by backcrossing. However, this type of resistance can be vulnerable to a changeable pathogen. This has been documented by numerous workers, including van der Plank (1968). Polygenic resistance is a goal for gaining stability of resistance and increasing the useful lifetime of a cultivar. The reproductive potential of most pathogens is almost unlimited. For example, a hectare of wheat with leaf rust (caused by *Puccinia recondita*) can easily contain urediospore production sufficient for the occurrence of 100 mutants/hectare/day (Parlevliet and Zadoks 1977). Thus, the development of virulence genes does not seem to be a limiting factor in overcoming resistance genes. However, the virulence genes can only spread through the pathogen population if they result in increased fitness of the pathogen population. With several to many resistance genes present in the host genetic homeostasis in the pathogen population would likely limit the appearance of virulent forms.

Components

The components of the major gene disease-resistant populations are: (1) genetic male sterility (a single recessive gene); (2) agronomic cultivars--these cultivars were selected for their proven performance in a number of barley-growing areas and for specific traits (Table 1); and (3) sources of resistance -- they were selected on the basis of field tests and in greenhouse inoculations with isolates of the pathogens collected from various barley-growing regions. The initial assembly of the populations began with hand crosses of the agronomic cultivars and resistance sources *onto* the male-sterile line. F_2 seed from these crosses was then bulked.

The Recurrent Selection Cycle

The recurrent selection cycle consists of two phases: (1) selection for resistance and (2) recombination. Selection for resistance is conducted yearly in locations in different barley-growing regions. This diversity of locations is important in the development of polygenic resistance. Assuming that the virulences of the pathogens are often different in different locations, selection of resistant plants in these locations will result in selection of different resistance genes. Seed harvested from the various disease nurseries is bulked and planted in isolation in the State of Arizona in south-western USA during the winter months. F^1 seed is harvested from open-pollinated male-sterile plants. This combines resistance genes selected in the various locations. With repeated cycles of recurrent selection, an increasing percentage of the plants will be polygenic for resistance. Population sizes are large (greater than 10,000 seeds planted for each phase) to avoid loss of variability.

Exploitation

These recurrent selection populations were designed for exploitation in a diversity of barley-growing areas. Therefore, the frequency of desirable types in any one location will be small. The inclusion of resistance sources from world collections often introduces some negative traits and thus contributes to the low frequency of desirable types.

The first step for a breeder in exploiting these populations is to increase the frequency of desirable types in his environment by selection and top-crosses. Then each season, single-plant selections can be made and evaluated. These selections can be evaluated in head-rows and carried on further as is normally done in a pedigree breeding program. Material selected from a population will likely contain polygenic resistance. Thus, part of this resistance will likely be lost if crossed to susceptible materials in a breeding program. As a population is improved agronomically and with continued selection for disease resistance, the opportunity for and probability of selecting good agronomic types with broad-based disease resistance increases.

Current Status

Recurrent selection populations for six important diseases are receiving major emphasis. Six of these populations have been registered as composite crosses (Bockelman *et al.* 1980; Bockelman *et al.* 1981a; Bockelman *et al.* 1983; Crosslin *et al.* 1986). They are summarized in Table 2. Studies have been conducted to measure progress toward the goal of broad-based resistance. RSP-5 Rrs (CC XXXVI, scald resistant) was shown to contain good levels of resistance to isolates of *R. secalis* from Montana, California, Tunisia, and Ethiopia (Harrabi 1982; Bockelman and Sharp 1984). In RSP-5 Rph (CC XLI, leaf rust resistant), levels of resistance increased significantly over three cycles of recurrent selection against four diverse isolates of *P. hordei*. RSP-5 Rpt (CC XXXVIII, net blotch resistant) has consistently shown good levels of resistance in a

Table 1. Agronomic cultivars (6-row) in RSP-5.

Cultivar	C I /P I	Origin	Pedigree	Special traits or attributes
Gem	7243	Idaho, USA	Atlas/Vaughn	Grown in Aegean region of Turkey
Beecher	6566	Idaho, USA	Atlas/Vaughn	Adapted to dryland
Hulless Glacier	13831	Montana, USA	Sermo/7* Glacier	Hulless, best under higher rainfall, fertile conditions
Unitan	10421	Montana, USA	Glacier/Titan	Until succeeded by Steptoe was most widely adapted cultivar in Pacific Northwest, USA
Steptoe	15229	Washington, USA	Unitan/Wash. Sel 3564	High yielding cultivar under irrigation or dryland in Pacific Northwest, USA
Waxy Titan		Montana, USA	Waxy Oderbrucker/7* Titan	Waxy endosperm; adapted to Montana and Canadian Provinces
Atlas 68	13824	California, USA	Atlas/CI 3920-1/Atlas 46/ CI 1179/Atlas 57	Scald, net blotch, BYD resistant; adapted to Mediterranean-type climates
Atsel	6250	California, USA	Atlas, mutant	Early maturing
Galt	11770	Alberta, Canada	Glacier/Newal 2	Adapted to dryland
CM67	13782	California, USA	Calif. Mar./Club Mar./CI 2376	Adapted to dryland and salt; BYD resistant
Arimont	15509	Montana, Arizona, USA	CC XXX-C irradiated	Combines large head and large seed; hulless; adapted to divergent conditions of Montana and Arizona
Nordic	15216	North Dakota, USA	Dickson/CI 4738/Traill UM 570	Adapted to moister environments, especially North Dakota; disease resistant
M.21	15481	Minnesota, USA		Shorter straw
Athenais	467798	Greece		Early maturing
Hulless Vantage		Montana, USA	Sermo/7* Vantage	Hulless; adapted to Canadian prairies
Manchuria msg 10	2330	Idaho, USA	Manchuria, BC derived	m.s. line; good source of genes and desirable genotypes, good combiner

Table 2. Male sterile-facilitated recurrent selection populations for broad-based disease resistance.

Name	Resistance to	Pathogen	No. of resistance sources	Locations where components were selected	Cycles of RS
RSP-5 Rrs (CC XXXVI)	Scald	*Rhynchosporium secalis*	36	Montana, Georgia, Maryland, California, Syria, Tunisia, Morocco, Cyprus, Kenya, Korea, Mexico, France	8
RSP-5 Rpt (CC XXXVIII)	Net blotch	*Pyrenophora Teres*	48	Montana, California, Syria, Egypt, Tunisia, Morocco, Cyprus Kenya, Korea, Mexico	7
RSP-5 Rph (CC XLI)	Leaf rust	*Puccinia hordei*	37	Montana, Texas, Syria, Egypt, Tunisia, Morocco, Turkey, Cyprus, Kenya, Korea, Mexico	6
RSP-5 Reg (CC XLII)	Powdery mildew	*Erysiphe graminis*	177	Montana, Texas, Syria, Egypt, Tunisia, Morocco, Turkey, Cyprus, Mexico, France, Czechoslovakia	5
RSP-5 Rxt	Bacterial stre	*Xanthomonas campetris* pv. *translucens*	21	Montana, Idaho, California, Turkey, Mexico, Kenya	6
RSP-5 Ryd (CC XLIV)	Yellow dwarf	BYDV	4	Montana, California, Washington, Arizona	2
RSP-5 Rrs-Rpt (CC XLIII)	Scald, net blotch	*R. secalis, P. teres*	84	Montana, California, Syria, Tunisia, Cyprus, Korea, Mexico	4
RSP-5 Rrs Rpt-Rph	Scald, net blotch, leaf rust	*R. secalis, P. teres P. hordei*	123	Montana	1
RSP-5 "Super"	Scald, net blotch, leaf rust, powdery mildew, bacterial streak yellow streak, yellow dwarf	*R. secalis, P. teres P. hordei, E. graminis X.C. translucens* BYDV	323	Montana	1
RSP-4 Rpt minor	Minor gene resistance to net blotch	*P. teres*	0	Montana	7

number of locations. RSP-5 Reg (CC XLII, powdery mildew resistant) has low levels of resistance at present, but resistant plants have been selected even under heavy mildew in Europe. RSP-5 RYd (CC XLIV, BYD resistant) has good levels of resistance in Montana and California. RSP-5 R x T (bacterial streak resistant) has low levels of resistance at present, but is responding positively to selection. (RSP-4 Rpt *minor is discussed separately in the next* section.

The long range goal is to develop a single major gene population containing broad-based resistance to the six diseases. RSP-5 Rrs-Rpt, RSP-5 Rrs-Rpt-Rph, and RSP-5 Super are populations designed as initial steps toward this goal.

B. Minor Gene Resistance

Crop cultivars that appear susceptible may, in fact, carry hidden minor, additive genes for resistance that are revealed only in crosses with other susceptible cultivars. Krupinsky and Sharp (1979) identified transgressive segregation for resistance to stripe rust (incited by *Puccinia striiformis*) in segregating generations of crosses between wheats intermediate and susceptible to the disease. Bjarko (1979) and Bordelon (1981) found transgressive segregation for resistance to net blotch (incited by *Pyrenophora teres*) in crosses among susceptible barley cultivars.

Minor genes are generally assumed to be "horizontal", that is, they are equally effective against different races of a pathogen (Parlevliet and Zadoks 1977; van der Plank 1968). Several minor genes together in a plant can give "field" resistance, which is not complete, but of a sufficient level to prevent yield reduction. Also, minor gene resistance places less pressure on a pathogen population since the pathogen is still capable of reproducing on the plant. This type of resistance may be longer lasting than major gene resistance.

The two-row population, RSP-4 Rpt minor, was established to accumulate minor, additive genes for resistance to net blotch. RSP-4 Rpt minor is constructed differently than the major gene populations. It contains: (1) Compana *msg 10*, the two-row male-sterile line, and (2) 15 two-row agronomic cultivars (Table 3). No sources of major gene resistance to net blotch were added to this population. Of the parents Union, Cumhuriyet 50 and Toonucier are intermediate in reaction to Montana isolates of *P. teres*. The remaining parents are susceptible. RSP-4 Rpt minor contains a high percentage of agronomically desirable plants. Thus, utilization of this population should be more direct than with the major gene populations.

Selection in RSP-4 Rpt minor has been done only at Bozeman. Efforts have been made to avoid introduction of major resistance genes by

Table 3. Agronomic cultivars (2-row) in RSP-4.

Cultivar	C I /P I	Origin	Pedigree	Special traits or attributes
Herta	8097	Sweden	Kenia/Ackerman's Isaria	High yielding in Canada
Ingrid	10083	Sweden	Balder/Binder/Opal	High yielding in Scandanavia
Bruens Wisa	10089	W. Germany	Weihenstephan MRCP/ Ackerman's Isaria	For many years widely grown in NE Europe
Zephyr	13667	Holland	Heine 2149/Carlsberg II	High yielding on dryland and irrigated in Pacific Northwest,USA
Erbet	13826	Montana, USA	Prior/7* Betzes	Early maturing
Dekap	3351	Turkey		High yielding under dry conditions
Hector	15514	Alberta, Canad	Betzes/Palliser	High yielding on Great Plains, USA
Waxy Compana		Montana, USA	Waxy Oderbrucker/7* Compana	Waxy endosperm, large seed, drought tolerant
Union	11331	W. Germany	Weihenstephan MRCP/Ackerman's Donaria/Firlbecks III	Adapted to better soils and moisture
Vireo	15555	W. Germany	Heine Flo 1625.56/Union/Ingri	Shorter straw, good yield, late maturing
Summit		England	Heron/Zephyr/Tern	Malting quality
Maris Mink	15556	England	Deba Abed/Swallow/Emir	Shorter straw
Hulless Compana	16559	Montana, USA	Sermo/7* Compana	Hulless, drought tolerant
Cumhuriyet 50	22423	Turkey		Adapted to colder conditions
Toonucier		Montana, USA	2-row Glacier/Hulless Glacier	Hulless, very large seed
Compana msg 10		Montana, USA	Compana, mutant	m.s. line; good combiner

contamination with foreign pollen (i.e. grown isolated from other barley).

Seven cycles of recurrent selection have been completed. In the first two cycles, selection was based on severity of symptoms alone since the population was essentially *100%* susceptible. In the third and fourth cycles, differences in levels of resistance became apparent with most selected plants intermediate in reaction. Resistance has continued to increase to about 50% resistant plants in 1985. However, levels of resistance are much lower in greenhouse seedling tests. This indicates that RSP-4 Rpt *minor* probably contains "field" resistance. Transgressive segregation was indicated in randomly selected lines from the population (Bockelman *et al.* 1983).

Minor gene resistance to scald and leaf rust is also being investigated. Upon identification of suitable parents, populations will be assembled.

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Monosomic Analysis in Wheat, *Triticum aestivum* L. cv. Pb. C591

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A monosomic series was developed by Swaminathan *et al.* (1968) in a hexaploid strain of *Triticum aestivum* (cv. Pb.C591), using the monosomic series of Chinese Spring developed by Sears (1954). The present communication deals with the location of genes on specific chromosomes for several traits in the wheat cultivar Pb.C591.

Materials and Methods

The monosomic series of *T. aestivum* (cv. Pb.C591) has been used in this study. Different nullisomic lines (2n=40) have been isolated among the aneuploid series of Pb.C591 and cytogenetical studies have been made to locate genes on specific chromosomes for different characters, namely: root development, auricle pubescence, seed shape, and chlorophyll synthesis.

During the production of the monosomic series, albino seedlings in monosomic line 3A of Pb.C591 were observed. Seeds of monosomic and disomic plants of monosomic line 3A were allowed to germinate separately and segregation was observed at the seedling stage, as the albino seedlings can be identified easily. Roots from different albino seedlings and green seedlings were analyzed cytologically to ascertain their somatic chromosome constitution.

Results and Discussion

Genes for root development

The roots of nullisomic plants for chromosomes 3B and 3D of var. Pb.C591 were very poorly developed and the plants had to be supported till maturity to keep them from falling flat on the ground. This indicates that for proper development of roots, chromosomes 3B and 3D of Pb.C591 are essential. For Chinese Spring, Sears (1954) has reported that roots of nullisomic plants with only 3D are poorly developed.

Genes for seed shape

The seeds of nullisomics for chromosomes 2B and 4D were very elongated and thin, whereas all the other nullisomics possessed a seed shape similar to that of disomics. This suggests that factors controlling seed shape in Pb.C591 are located on chromosomes 2B and 4D.

Genes for auricle pubescence

The auricles of disomics in Pb.C591 were pubescent. Auricles of nulli 4A were glabrous and those of mono 4A were pubescent, but the length of hairs was considerably reduced. This suggests that genes governing auricle pubescence in Pb.C591 are located on chromosome 4A, but are only partially effective in hemizygous condition .

Genes for chlorophyll synthesis:

All the disomic plants produced only green seedlings. Monosomes for chromosome 3A on the other hand segregated for albino and green seedlings with a variable frequency of 9-15%. Somatic preparation of albino seedlings showed that they were nullisomics (2n=40) and that the green seedlings were either 2n=41 (monosomics) or 2n=42 (disomics). Since albino seedlings are nullisomic for chromosome 3A, it can be suggested that the chlorophyll synthetic gene or gene complex is located on chromosome 3A of *T. aestivum* var. Pb.C591.

Sears (1954) on the basis of aneuploid analysis suggested that group 3 chromosomes control the synthesis of chlorophyll in hexaploid wheat. This has been confirmed by Joshi *et al.* (1983).

Identification of only one chromosome (3A) responsible for chlorophyll synthesis in wheat variety Pb.C591 explains why albino plants are obtained after mutagenic treatment in this variety and not in others (Natarajan *et al.* 1958).

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An Application of Factor Analysis to Morphological Data of Wheat and Barley Landraces from the Bheri River Valley, Nepal

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In determining the potential value of genetically different landraces for improvement in yield and other beneficial characteristics, breeders have a choice of using several standard methods. Many workers have studied correlations between characters of yield since Engeldow and Wadham (1923) first divided these traits into their components. Recently, Hsu and Walton (1970) and others have presented strong evidence of such associations.

The relationships between yield and other characters can best be studied by the use of multiple regressions and correlations. Such statistical calculations reveal vital information regarding the relative contribution of several independent variables to the dependent variable (Walton 1971). Where multivariate data must be analyzed, the application of techniques such as Factor Analysis and Principal Components Analysis is necessary. When applied to data from cereal landraces for instance, Factor Analysis is an efficient statistical procedure which can be used to assess the structure underlying the observed variability. The plant breeder then has information available which enables him to decide which set of morphological characters he should select in order to gain maximum output from his plants (Walton 1971). He would also have knowledge of which other characters might increase or decrease in value *together* with the desirable character. For instance, Briggs and Shebeski (1972) used this method on breadmaking quality data of the wheat cultivar 'Manitou' grown over two seasons in Canada. For the 13 qualitative characters measured the number of factors and their component structure was different in each year.

Earlier, we described the variation found in wheat and barley landraces collected in Nepal and the Yemen Arab Republic (Damania and Porceddu 1983; Damania *et al.* 1983; Damania *et al.* 1984). We have chosen for this paper the example of the material from the Bheri river valley in Nepal to illustrate the use of Factor Analysis in the evaluation of this valuable germplasm, because this was the only area where both wheat and barley were collected from the same village, thus allowing us to make a comparison of the behavior of the factors in these two crops. The Bheri river valley system, situated between 28° to 29°N and 81° to 82°E, is an ideal choice for a study of this nature, as the area of the Hindu-Kush has long been considered by many crop evolutionists as the center of diversity for hexaploid bread wheats and six-rowed barleys (Schiemann 1951; Vavilov 1951; Harlan 1975). It is our endeavor that this information and the definition of 'factors' will help plant breeders move a step closer to obtaining data on landrace germplasm, to enable more efficient utilization in breeding programs aimed at better yields and other desirable characteristics.

Materials and Methods

Four landraces of bread wheat (*Triticum aestivum*) and six-rowed barley (*Hordeum vulgare*), collected from the villages of Kalagaon; Dailekh; Channa; and Bhavassaini; located in the Bheri river valley in western Nepal, by a team sponsored by the International Board for Plant Genetic Resources (IBPGR) were used in this study. The provenances of these landraces have already been published (Damania *et al.* 1984). The quantitative 12 characters studied from 50 individual plants per landrace were as follows: number of days to heading (heading time), flag-leaf length (cm), flag-leaf width (cm), plant height (cm), uppermost internode length (cm), No. spikes per plant, spike length, spike density, No. spikelets per spike, No. seeds per spike, weight of seeds/spike (g), and 1000-grain weight (g).

For barley, awn length (cm) was also recorded. However, this observation was not possible for the wheats because awned as well as awnless types were often found in the same landrace.

The varimax rotation method proposed by Kaiser (1958) was used for data analysis. When the loadings of the first factor had been determined, the one with the maximum variability, the process was repeated on the residual matrix to ascertain further factors of lesser importance in the sample. When the contribution of a factor to the total variability was less than 10%, the process automatically stopped. Thus, only the most important factors were retained for consideration.

In recent years the availability of high-speed computers and a number of iterative statistical programs, such as the ones used for this study, has made it possible to extract 'factors' from a correlation matrix. Once extracted, the factor axes are rotated and can also be permitted to depart from their orthogonal relationship by becoming correlated, i.e. oblique. This makes scientific sense in that the factors underlying the covariation pattern of the characters in nature are themselves undoubtedly correlated (Sneath and Sokal 1973).

The factor analytical method used in this study has also been previously discussed by Cattel (1965). Basically this statistical method reduces a large amount of correlated variables into a small number of unrelated 'factors.' The factor loadings of the rotated matrix, the percentage variability given by each factor, and the communalities for each variable were determined. The communality was the amount of the variance of a character accounted for by the factors taken together. While observing the relative loadings of different variables in the same factor, the sign of the loading indicates the direction of the relationship between the characters as well as the factor as a whole and the variable. Thus, two variables with high loadings (for purposes of interpretation, only those matrix loadings greater than 0.50 were considered significant in this study) in the same factor but the opposite sign would be

Table 1. **Results of Factor Analysis of wheat (*Triticum aestivum*) landraces from the village of Kalagaon, Nepal.**

		Factor				
	Communality	1	2	3	4	5
Factor 1 (26.9% variability)						
Heading time	0.510*	0.572*	-0.158	-0.157	0.289	-0.221
No. spikes/plant	0.796*	-0.808*	0.249	-0.031	0.157	-0.233
No. seeds/spike	0.844*	0.845*	0.296	-0.055	0.190	-0.042
Weight seeds/spike	0.944*	0.782*	0.367	0.425	0.115	-0.050
Factor 2 (20.8% variability)						
Spike length	0.953*	0.113	0.915	-0.010	0.314	-0.065
Spike density	0.905*	0.047	-0.846	-0.028	0.431	-0.002
Factor 3 (19.0% variability)						
Plant height	0.745*	-0.425	-0.062	0.571*	0.482	0.017
Uppermost internode length	0.805*	-0.047	-0.262	0.776*	-0.062	-0.358
1000-grain weight	0.722*	0.140	-0.200	0.810*	-0.077	-0.001
Factor 4 (16.9% variability)						
No. spikelets/spike	0.847*	0.206	0.040	-0.064	0.888*	-0.099
Factor 5 (16.4% variability)						
Flag-leaf length	0.778*	-0.073	0.120	0.130	-0.123	-0.852
Flag-leaf width	0.752*	-0.106	-0.063	0.078	0.361	-0.774

Figures in the table represent factor matrix loadings
(* = significant at P <0.001).

expected to exhibit a negative correlation. However, factor analysis provides more information than just a simple correlation matrix, since it also indicates groupings of variables and percentage contribution of variables to each factor.

Results

Wheat

The first landrace was collected from the village of Kalagaon situated at an altitude of 800 m above sea level. The Factor Analysis grouped the 12 characters into five factors. The first factor which contributed 26.9% to the variability was composed of three major components of yield, namely, number of spikes per plant, number of seeds per spike, and weight of seeds per spike (Table 1). The number of days to heading (heading time) was also included in this factor, signifying that the time of maturity was an important component of the first factor. The character with the highest matrix loading here was number of seeds per spike.

The second factor consisted of spike length and spike density, and contributed 20.8% to the variability. The third factor, which accounted for 19% of the total variability of the landrace, was composed of plant height, uppermost internode length, and 1000-grain weight. The next factor comprised only one character, number of spikelets per spike, and contributed 16.9% to the variability. The fifth and the last factor consisted of flag-leaf length and flag-leaf width. All communalities were of a high order except for heading time which was slightly lower.

The second village was Dailekh, situated at 1410 m. The characters of Factor 1 (27.2%) were spike length, number of seeds per spike, and weight of seeds per spike. Factors 3, 4, and 5 comprised at least two characters each, with variabilities ranging from 15.3 to 20%.

In the third village, Channa, located at 1960 m, Fáctor 1 had three characters which are not direct contributors to the yield, namely, flag-leaf length, uppermost internode length, and number of spikes per plant. They contributed 26.3% to the variability of the landrace. Thus, the greatest variability seems to occur in the vegetative parts above the last but one node of the stem. A relatively low matrix loading of 0.599 for flag-leaf width was observed in this landrace, indicating that this was not a very variable character nor did it have any association with yield components.

In the village of Bhavassaini, situated at 2400 m, only four factors described the variation pattern. Factor I consisted once again of grain characters such as number of seeds per spike, weight of seeds per spike, and 1000-grain weight. The contribution to the variability by this factor was 33.7% which was the highest percentage recorded for wheat. Factor 2 comprised vegetative characters such as flag-leaf length, flag-leaf width, uppermost internode length, and heading time. The variability contribution was 25%. Factors 3 and 4 included mainly spike characters although in Factor 3, plant height was also present. The communalities which were relatively high in the previous three landraces were noticeably lower in this case. For instance, heading time and number of spikes per plant had values of 0.217 and 0.451, respectively.

It was observed that none of the wheat landraces seemed to adhere to an identical or even a similar pattern of factors. The groupings are as diverse as the landraces themselves.

Barley

In the landrace from Kalagaon, Factor 1 comprised six characters altogether, of which three were seed or grain characters and the rest were spike characters (Table 2). This factor contributed 27% and included flag-leaf length and flag-leaf width. Heading time, plant height, and uppermost internode length were all

Table 2. Results of Factor Analysis of six-rowed barley (*Hordeum vulgare*) landraces from the village of Kalagaon, Nepal.

		Factor			
	Communality	1	2	3	4
Factor 1 (30.8% variability)					
Spike length	0.875*	-0.572*	0.560*	-0.361	0.320
No. spikelets/spike	0.867*	-0.653*	0.606*	-0.134	-0.230
Awn length	0.381	-0.534*	-0.157	-0.057	0.261
No. seeds/spike	0.874*	-0.707*	0.549*	-0.102	-0.248
Weight seeds/spike	0.936*	-0.895*	0.262	-0.157	-0.203
1000-grain weight	0.663*	-0.758*	-0.227	-0.178	-0.070
Factor 2 (27.0% variability)					
Flag-leaf length	0.814*	0.139	0.875*	-0.110	-0.130
Flag-leaf width	0.713*	-0.055	0.819*	-0.159	-0.112
Factor 3 (23.6% variability)					
Heading time	0.755*	0.143	-0.094	0.669*	0.527*
Plant height	0.800*	-0.242	0.216	-0.832*	0.043
Uppermost internode length	0.786*	-0.115	0.115	-0.868*	0.072
Factor 4 (18.6% variability)					
No. spikes/plant	0.594*	-0.012	0.154	-0.246	-0.713*
Spike density	0.817*	-0.078	0.075	0.348	-0.826*

Figures in the table represent factor matrix loadings
(* = significant at P <0.001)

grouped together in Factor 3. Two spike characters not included in the first factor, namely, number of spikes per plant and spike density were present in Factor 4 which contributed 18.6% to the total variability. The communalities were all high except in the case of awn length where it was only 0.381.

In the second village of the valley, Dailekh, grain characters dominated the first factor with a contribution of 32.2% to the total variability. Weight of seeds per spike once again had the highest matrix loading. Factor 2 consisted of the flag-leaf dimension characters with 24.4% contribution. Factor 3 comprised mainly of spike characters but also included plant height. The contribution to variability was 24%. And lastly, Factor 4 consisted of heading time, uppermost internode length, and awn length. The communalities were high except for 1000-grain weight, plant height, and awn length.

In the *third* barley landrace from the village of Channa, spike and grain characters dominate Factors 1 and 2 with a combined contribution of 65.5% to the variability. The character with the highest matrix loading was plant height. Factor 3 consisted as before of flag-leaf length and flag-leaf width with a contribution of 20.9% to the variability, whereas Factor 4 had heading time and awn length. The communalities were high in all cases except for the two characters in Factor 4, which had relatively lower figures.

In the last landrace of the valley from the village of Bhavassaini, yet another factorial pattern emerged with five factors. Factor 1 had two spike and two seed characters with 31% variability. Factor 2 had heading time, spike density, and 1000-grain weight with a contribution of 22.9%. Factor 3 had flag-leaf length and flag-leaf width as with the landrace from Channa, and almost equal contribution to variability. The sole character in Factor 5 was *number of spikes* per plant. The communalities were high in all cases except for heading time which was slightly lower than the rest.

Discussion

The results of the Factor Analysis on wheat and barley landraces from the same villages in the Bheri valley showed that four or five factors were required to cover the entire variation present in the landrace populations. The component structure of the factors for each landrace was distinct except in the case of flag-leaf dimensions which were included in Factor 3 in three landraces of barley out of four. The factor structure especially in wheat appeared to be more complex than that described by Briggs and Shebeski (1971) and Wrigley and Moss (1968), who worked on cultivars and improved lines, not landraces.

Factor Analysis was also able to *reveal the yield* components which were related to the morphological characters and the extent of their relationship. Thorne (1973) has demonstrated that morphological parts above the flag-leaf node play an important role in contributing to overall yield in cultivars. It was argued that while yield is built up from its components, the components themselves in turn must be obtained from the activities of the photosynthetic parts. Information which can be used to facilitate selection of characters for increasing yield will be beneficial in a breeding program.

Walton (1971) showed that an increased number of spikes per plant together with greater weight of grains were the main components of yield. Therefore, according to his results an increase would follow if greater attention was given to increasing the flag-leaf dimensions as well as spike length. A longer heading time, in this case, was also needed to allow for a longer grain-filling period. However, such clear-cut conclusions cannot be made in the case of the landraces studied for two reasons. First, as a result of the lack of any obvious relationships between factors in the two crops from the same villages there is little possibility that the same factors will repeat themselves in another trial. Secondly, the combinations of variables within these factors are not always consistent. Even in cases where studies are based on genetically pure lines the results of Factor Analysis are not identical from one year to the next (Briggs and Shebeski 1971).

The Factor Analysis approach is a useful way of analyzing a large amount of multivariate data. Together with other techniques such as Discriminant Analysis and other forms of Principal Components Analysis it should be increasingly applied to the evaluation of genetic resources. Principal Factor Analysis has been applied recently to soybean data (Bramel *et al.* 1984) and Principal Components Analysis to the study of primitive cultivars of the widely cultivated pulse, *Lathyrus sativus* (Jackson and Yunus 1984) and Ethiopian mustard, *Brassica carinata* (Tcacenco *et al.* 1985).

Conclusions

The following conclusions can be drawn from this study of wheat and barley landraces. First, the number of factors involved was generally five for wheats and four for barleys. Second, the number and composition of characters in each factor and their percentage contribution to the total variability were not identical among landraces even within the same crop. And last, no clear picture emerged about any single factor.

The present work has described the results of one such application to quantitative morphological data of diverse landraces and perhaps indicates factors different from those already reported. Further studies such as these are, however, needed for the exploitation of germplasm collections in a practical breeding context.

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Effect of Ridges on the Yield of Wheat under Rainfed Conditions in Ethiopia

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Lack of moisture is a limiting factor in crop production at Mekele, Ethiopia, where low and erratic rainfall coupled with water loss due to high evaporative demand and run-off, constitute serious problems. Also, lack of proper seedbed preparation methods for short-growing-period crops under rainfed conditions is another constraint to good yields.

In areas where rainfall is marginal for crop production, the use of appropriate cultural practices such as tied-ridges system can produce increased yields (Arnon 1972; Whiteman 1975). Earlier reports from Tanzania have shown that the use of tied ridges increased grain yield (Prentice 1946; Dagg and Macartney 1968; Northwood and Macartney 1971), and total available moisture in the soil (Northwood and Macartney 1971). Whiteman (1975) also reported that the use of tied ridges increased the total available moisture in Ethiopia.

This study was designed to investigate the effect of ridges on the yield of wheat under short-period rainfed conditions in Ethiopia.

Materials and Methods

Three treatments (flat, tied, and open ridges) were used in an RCB design with four replications and a plot size of 10 m x 7.2 m. The experiment was carried out at Mekele (Illala) in a black clay soil at an altitude of 1970 m and at Quiha in a red sandy soil at an altitude of 2080 m. K6290 Bulk, a promising wheat variety for Mekele area (IAR 1973, 1978, 1981), was used. The seed was first broadcast into dry, oxen-ploughed soil. The furrows/ridges were then constructed using a wooden "Dugris" to cover nearly 40-70 cm intervals as suggested by Whiteman (1975). Plants emerged both within and on top of ridges.

In the case of tied ridges, the furrows/ridges were cross tied every 3 meters and opened, for better drainage, whenever there was a high water accumulation, whereas in the open ridges, the furrows/ridges were closed only at each end and opened for better drainage whenever there was a high water accumulation. This is a *modification* of the ridge system found suitable at ICRISAT on poorly drained black soil (Krantz 1975).

Soil samples were taken from the *different* treatments at 1-week intervals and *soil* moisture percent was determined using the gravimetric method (Unger 1977). The dry weight of the above-ground material, which is the biomass yield, was determined using samples of 1 m^2 at maturity and expressed in kg/ha.

Results and Discussion

Combined analysis of variance showed that there were highly significant ($P < 0.01$) differences in yield due to treatments (Table 1). Tied-ridge system was the best, followed by open-ridge system. The flat (control) was the lowest yielder which could be attributed to the loss of moisture from the soil (Table 2). This is in agreement with the findings of Prentice (1946), Dagg and Macartney (1968), and Northwood and Macartney (1971).

Soil moisture percent was higher in the tied ridges than in the open ones or the control (Table 3). This is in agreement with the results obtained by Macartney (1971), Northwood and Macartney (1971), and Whiteman (1975).

Table 1. Combined analysis of variance for grain yield of wheat grown at two locations, Ethiopia, (1978-1983).

Source of variation	df	MS
Locations (L)	1	2791055ns
Years (Y)	4	4597417**
L x Y	4	725418**
Blocks/YL	30	148490
Treatments (T)	2	17832462**
T x L	2	1032229**
T x Y	8	527251**
T x L x Y	8	57787ns
Pooled error	60	128253

**: Highly significant ($P < 0.01$)
ns: Nonsignificant

Table 2. Effect of ridges on grain yield (kg/ha) of wheat under short-period rainfed conditions in Ethiopia, (1978-83).

	Year					
Treatment	1 (1978)	2 (1979)	3 (1980)	4 (1982)	5 (1983)	Mean (1978-83)
Flat (control)	346	159	842	378	430	431
Tied ridges	1830	1396	2869	1046	1683	1765
Open ridges	986	647	1663	697	1205	1040
					one location, one year	
LSD (5%)					506	
CV					17%	
SE					179	

Table 3. Mean soil moisture percent for different soil preparations (treatments) at two locations in Ethiopia, (1978-1983).

	Location		
Treatment	Mekele	Quiha	Mean
Flat (control)	14.6	9.1	11.9
Tied ridges	27.5	19.7	23.6
Open ridges	22.0	13.0	17.5

Also, the tied ridge was the best treatment for biomass yield, followed by the open-ridge treatment and then by the flat treatment (control) which gave the lowest biomass yield (Table 4).

Table 4. Effect of ridges on mean biological (biomass) yield (kg/ha) of wheat under short-period rainfed conditions at two locations in Ethiopia (1978-83).

	Location		
Treatment	Mekele	Quiha	Mean
Flat (control)	2605	2255	2430
Tied ridges	5180	4620	4900
Open ridges	3330	3940	3635

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Association of Some Morphological Characters to Grain Yield in Durum Wheat Under *Mediterranean* Dryland Conditions

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Breeding high-yielding varieties of wheat under the Mediterranean climatic conditions requires information on the effect of drought on the grain yield and yield-related characters.

Identification of suitable morphological and physiological characters is needed to help breeders in the Mediterranean region to select stress-tolerant lines. The most obvious morphological change with the onset of drought is the reduction in the peduncle length and, therefore, in the height.

Several research workers have found that plant height is associated with grain yield in areas where lodging is not a constraint (Johnson *et al.* 1966; Duwayri 1983). Seedling emergence rate, plant height, and coleoptile length were also found to be correlated (Allan *et al.* 1986; Duwayri 1983). This study was made to identify suitable morphological characters for selection under stress conditions, and their association with grain yield.

Materials and Methods

Twenty durum wheat lines were grown at ICARDA's substation at Breda, a dry site with an annual average precipitation of 277 mm, located 50 km southeast of Aleppo, Syria. The lines were classified on the basis of the length of peduncle. Measurements were taken on grain yield (kg/ha), tiller (score 1 to 9: 1, poor; 9, excellent), 1000-kernel weight, plant height, and coleoptile length. A randomized complete block design, with three replications, was used. The plot size was 6 m^2.

Results and Discussion

Selection for peduncle length under drought conditions has shown that grain yield responded positively as well as some yield-related traits, particularly the plant height, the tillering ability, and the coleoptile length.

Table 1 shows that the lines with a long peduncle yielded significantly higher than those with a short peduncle. The lines with long peduncles produced a larger number of fertile tillers per unit area than those with short peduncles and were taller. However, there were no significant differences in kernel weight between the two groups.

The data indicated that resistance to moisture stress by durum wheat is manifested through less reduction in plant height, peduncle length, and number of fertile tillers. Plant height and peduncle length are each controlled by a small number of genes and have large heritabilities (Nasr and Haddad 1977). This makes both of them important indicators for selection of tolerant lines to moisture stress.

Table 1. Effect of selection under dry conditions for peduncle length on grain yield and some related traits.

Trait		Difference
Peduncle score [1]	5.4[a] 2.5[b]	2.9 ***
Tillering score [2]	4.8[a] 4.0[b]	0.80 *
Coleoptile (cm)	6.3[a] 5.9[b]	0.40 *
Plant height (cm)	68[a] 58[b]	10 ***
1000-kernel weight (g)	36.07[a] 37.45[b]	-1.38 ns
Yield (kg/ha)	1230[a] 909[b]	321 ***

a. Lines with long peduncle.
b. Lines with short peduncle.
*,*** Significance at 5% and 0.1% levels, respectively.
1. Scale 1 to 9 (1, short; 9, long).
2. Scale 1 to 9 (1, low; 9, high).

Table 2. **Grain yield relationship to some morphological characters under dry conditions.**

1. Yield						
2. Height	0.491 *					
3. Peduncle	0.376 *	0.591 **				
4. Coleoptile	0.269	0.534 *	0.269			
5. 1000-kernel weight	0.390	0.239	-0.248	-0.175		
6. Tillering score	0.622 **	0.352	0.234	0.236	0.335	
	1	2	3	4	5	6

However, it is not *per se* the plant height and peduncle length that are important for drought conditions, but the stability of their size under these conditions.

The length of the coleoptile in wheat is important to maximize yield under semi-arid conditions (Duwayri 1983). Wheat selections with long coleoptiles emerge faster from early fall sowing to ensure a better stand, whereas those with short coleoptiles emerge slowly and generally produce poor stands (Allan *et al.* 1961). The correlation between plant height and coleoptile length found in our results (0.534*) is in accordance with the findings of Feather *et al.* (1986) and Duwayri (1983) (Table 2).

Plant height and peduncle length are highly correlated (r = + 0.591**) and the relationship between peduncle length and coleoptile length was also positive and significant (r = + 0.469*).

The associations between coleoptile length, plant height, and peduncle length with grain yield under dry conditions are important attributes, particularly for selection of plants from the segregating populations and if the selection of lines is intended for dryland areas.

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Xanthomonas campestris pv. Undulosa on Wheat

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Wheat planted at the National Agricultural Research Centre (NARC), Islamabad showed severe leaf blight symptoms on leaves during spring (March-April) 1985. The affected plants exhibited translucent stripes on leaves, which were watery at start, then turned yellow, and finally became brown. Isolations from the diseased leaves consistently yielded yellow-pigmented, gram-negative, rod-shaped bacteria. Bacterial leaf blight caused by *Xanthomonas campestris* pv. *undulosa* (S.J.R) Syn. *X. translucens* was suspected (Young *et al.* 1978).

This study aimed to identify the causal organism and to evaluate resistance in wheat cultivars against the pathogen.

Materials and Methods

Isolation and Identification of Pathogen

Isolations were made from a naturally infected wheat field at NARC. Blighted leaves were excised and observed for bacterial streaming. Lesions with water-soaked tissue were surface sterilized in 0.1% chlorox for 1 min., washed twice in sterile water, and placed for 4 hr in test tubes containing 5 ml of sterile water. Loopfuls of the suspension were streaked on to yeast extract dextrose Ca CO_3 medium (YDC) (Schaad 1980), and incubated for 72 hr at 26°C. Single colonies were serially subcultured on YDC to obtain pure culture. Identification of the culture was made by gram reaction and bio-chemical and physiological tests, and confirmed by hyper-sensitive reaction (Kiraly *et al.* 1974; Stainer *et al.* 1968; Klement *et al.* 1964; and Anonymous 1957).

Cultural Studies

The bacterium was grown at 26°C on six different media: nutrient agar (NA), nutrient dextrose agar (NDA), nutrient yeast dextrose agar (NYDA), yeast extract dextrose Ca Co_3 (YDC), Kings B medium (KB), and potato dextrose agar (PDA).

Inoculation Test

Bacterial culture grown on YDC for 48 hr at 26°C was suspended in sterile water and adjusted to 7 x 10^8 colonies forming units (cfu/ml) with a spectrophotometer (spectronic 20 Baush and Lomb) having 5% transmittance at 590 mm. Seedlings of 15 commercial cultivars were grown in triplicates in plastic pots of 10 cm x 7 cm in the greenhouse, and were inoculated at five-to six-leaf stage by hypodermic injection of the suspension into the leaves whorl. Inoculations were made in such a way that only a few microliters of inoculum was infiltrated into the leaves. After inoculation the plants were kept in a humid chamber for 48 hr then returned to the greenhouse at 27°C. Presence of the disease was confirmed by isolating the pathogen from leaves of one or more plants of each cultivar showing bacterial leaf blight symptoms. Disease ratings were made on a 0-3 scale after 10 days. To check the pathogenicity in the field, 15 wheat varieties were planted on 7 December at NARC in 1 m long, 30 cm apart rows in triplicate. Plants were inoculated at growth stage 9 (Large 1965) with a bacterial suspension of 7 x 10^8 cfu/ml, using a 0.46 mm diameter (22 gauge) needle attached to a 2.5 ml syringe. Final data were recorded at flowering (Feek's growth stage 10.5) using a 0-3 scale. The bacterium was reisolated from the infected leaves of each cultivar.

Results and Discussion

Identification

The organism isolated from water-soaked lesions on the wheat leaves formed smooth, circular, convex, yellow, glistening colonies with entire margins. The yellow pigment which did not diffuse into the medium was neither soluble in water nor in chloroform, but in acetone. The bacterium was gram negative, motile rods, measuring 0.5 to 0.8 x 1.0 to 2.5 um with a single polar flagellum. It gave a slight reaction with indole and was catalase positive, oxidase negative, and gelatin positive. It produced acid from glucose, fructose, manose, galactose, sucrose, and lactose.

The bacterium was identified as *Xanthomonas campestris* pv. *undulosa* (Buchanan and Gibbons 1974; Young *et al.* 1978); Syn-*X. translucens* (Breed *et al.* 1957). Tobacco plants inoculated with the bacterium showed hypersensitive reaction after 48 hr, indicating the pathogenic nature of the isolate (Klement *et al.* 1964). This is the first report of *X. campestris* pv. *undulosa* from Pakistan.

Cultural Studies

The growth of the bacterium was excellent on YDC and NYDC, good on NDA, fair on KB, and poor to scanty on NA and PDA (Table 1).

Inoculation Tests

The bacterium produced narrow translucent, water-soaked lesions in the form of elongated stripes extending along leaf. Bacterial exudate was observed on most of the leaves. The amount of the exudate increased at higher humidity. In some susceptible reactions, a

Table 1. Biochemical and physiological characters of *Xanthomonas campestris* pv. *undulosa*, NARC, Islamabad, 1984/85.

Biochemical and physiological tests	Reaction
Hydrogen sulphide	P
Catalase *reaction*	P
Casein	P
Gelation	P
Oxidase	N
Nitrate reduction	N
Tween-80	P
Medium	**Growth**
YDC	+++
NYDC	+++
NDA	+++
KB	++
NA	+/-
PDA	+/-

P = positive reaction; N = negative reaction.
YDC = yeast extract dextrose $CaCO_3$; NYDC = nutrient yeast dextrose agar; NDA = nutrient dextrose agar; NA = nutrient agar; PDA = potato dextrose agar; KB = Kings B medium. +++ = excellent growth; ++ = good growth; + = fair growth, +/- poor to scanty growth.

Table 2. Response of wheat cultivars to *Xanthomonas campestris* pv. *undulosa*, NARC, Islamabad, 1984/85.

Variety	Average disease severity[1]	
	GR	FR
Arz	2.6	2.3
Blue Silver	1.0	1.0
BWP-79	1.6	1.6
C-271	1.3	1.3
C-273	1.6	1.0
C-518	2.0	1.6
C-591	2.3	1.6
Jouhar-79	1.3	1.0
Local white	2.3	1.6
PARI-73	2.6	2.3
Pavon	2.3	1.6
Punjab-83	2.6	2.3
Sarhad-82	2.0	1.6
Sind-81	1.6	1.3
Sonalika	1.0	1.0

1. Disease severity scale 0 = no disease; 1 = lesion, L < 5 mm in diameter (resistant); 1.1-1.5 = water-soaked lesion, 5-10 mm (moderately resistant); 1.6-2 = water-soaked lesion, 10-15 mm (moderately susceptible); 2.1-3 = water-soaked lesion 15 mm (susceptible).
GR = greenhouse reaction, FR = field reaction.

slight water soaking was observed until the lesions became older. The resistant reactions varied from no symptoms to mild chlorosis or necrosis. The chlorotic and necrotic reactions developed 2-5 days after inoculation. The chlorotic area sometimes enlarged to 5-7 mm in diameter around the infection site. Necrotic lesions were occasionally 77 mm in diameter.

The susceptible and resistant reactions were similar to those reported by Bamberg (1936), Boosalis (1952), and Cunfer and Scolari (1982). Out of 15 wheat cultivars evaluated in the greenhouse, 2 were found resistant, 2 moderately resistant, 5 moderately susceptible, and 6 susceptible. Under field conditions 4 cultivars were found resistant, 2 moderately resistant, 6 moderately susceptible, and 3 susceptible (Table 2). Sonalika and Blue Silver remained resistant both under greenhouse and field conditions.

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Wheat Production and On-Farm Research in the Sudan*

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Wheat in the Sudan

Wheat has been the traditional crop in the northern part of the Sudan for many thousands of years. However, since the 1960s production has spread to the Gezira Scheme in the Central Region and to the New Halfa Scheme in the Eastern Region, making the consumption of wheat increase throughout the country. All wheat is grown under irrigation. In the Northern Region irrigating water is taken from the main Nile, in the Central Region from the Blue Nile, and in the Eastern Region from the seasonal Atbara river water stored in the Khashm El Girba Dam.

The rainy season in the Sudan starts in July and continues until September. The cooler winter season is from November until February and it is during this time that wheat is cultivated. The growing season lasts between 90 and 100 days. Individual seasons differ greatly both in temperature and humidity, but the relative humidity is usually low.

In the Northern Region soils are of the riverine types, combining river silts, clay, and sand. Salinity problems occur less frequently by the Nile than higher up on the terraces. In the Gezira and New Halfa regions the soils are of heavy cracking clay types.

The most popular varieties grown are Condor, Debeira, Giza 155, and Mexicani. However, there are currently no organized seed distribution channels.

In 1960/61 the total area under wheat cultivation was 19,000 ha (1 ha=2.38 feddans) and by 1983/84 this figure increased to 135,000 ha. Of this 78% is in the Gezira Scheme, 12% in New Halfa, and 10% in the Northern Region. However, this increase in area cultivated did not bring about the expected increase in productivity. The cost of wheat production rose from SDP 40 per ton in early 1968 to SDP 440 per ton in the 1984/85 season. The expected increase in production failed mainly due to the lack of transfer of technology and to the inadequate logistical support to farmers.

In the past 20 years there has been a rapid increase in the consumption of wheat. Factors contributing to this include rising urban populations and the rising prices of sorghum (the traditional Sudanese grain) and costs of its production. Wheat production has not managed to meet the demand, and satisfied only about 20% of it. Consequently, wheat imports rose by about 75% between 1961/62 and 1983/84. Accordingly, the value of this important crop rose from SDP 8 million to SDP 91 million (8% of all agricultural imports).

Most land under wheat cultivation is owned by the government with the exception of scattered free-hold ownerships in the Northern and New Halfa areas. Tenants of government land pay minimal rent and subsidized water rates. Traditional practices used in wheat cultivation include dry ridging, split ridging and rough levelling, seed broadcasting at a rate of 140 kg/ha, and basin irrigation.

In the Eastern Region there are occasional outbreaks of rust and farmers are therefore advised to grow rust-resistant varieties. Aphids constitute the greatest threat and can be responsible for up to

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* Based on a summary of Proceedings of the First National Wheat Coordination meeting held on 3-5 August 1986 at Wad Medani, Sudan.

26% of losses to the crop although control through chemical spraying is easy. Weeds are also a serious threat but are currently controlled to some extent by cultural practices.

In order to stretch available wheat resources, attempts have been made to blend wheat and sorghum flour on a ratio of 7 parts to 3. In the experimental stage this has proved successful but has yet to be widely introduced.

There are nine flour mills throughout the Sudan with a total milling capacity of 450,000 tons per annum. This facility is considered adequate at the present time. However, farmers often prefer to sell to local merchants rather than to the government-controlled mills to avoid repayment of loans given to them for wheat production.

During recent years, as the demand for world food supplies has risen, interest in wheat production in the Sudan has increased. This interest has been heightened by the development of new wheat varieties in cooperation with the International Center for Agricultural Research in the Dry Areas (ICARDA) and Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT). These new wheat varieties have very high yield potentials, but require specific growing techniques. Accordingly, there has been a renewed interest in improved wheat agronomy, mechanized cultivation, irrigation, and protection of crops from losses due to pests. Wheat researchers are carrying out trials at several experimental sites to find the best methods for wheat cultivation in their areas. In turn they will pass on their findings to farmers which would lead to an improvement of growing methods at the commercial level.

The Pilot Project for Wheat Improvement in the Sudan

In 1985, the ARC in Sudan initiated, (in collaboration with ICARDA, OPEC, and CIMMYT) a pilot project for wheat improvement in the Sudan. Later in 1985/86, funds were provided to ARC to verify research results under actual farming conditions. On-farm trials were carried out in the major wheat-producing areas (Gezira, New Halfa, and the Northern Region) with the participation of farmers and extension and research staff.

The major results are reported below:

Location	Area in hectares	Average yield (t/ha)
Gezira Scheme	100,000	0.98
New Halfa Scheme	13,100	0.95
Northern Region	21,000	(not available)
White Nile Schemes	15,500	(not available)

On-Farm Trials

Farmer-Managed Trials

The trials were carried out by farmers with advice from research and extension staff. They acted as on-farm demonstrations of improved cultural practices and were held at the Gezira and New Halfa Schemes and in the Northern Region. The trials provided an excellent tool for extension activities as 5 field days were held for more than 500 farmers in the three areas. In the Northern Region the trials also provided a good opportunity for the seed multiplication of the new variety Wadi El Neil (Giza 160) which is being released.

In the Gezira Scheme the package was very successful in two out of three locations, giving average yields of 1.9 and 2.1 t/ha in the first two locations, while in the third location it gave a yield of 1.2 t/ha as compared with the Scheme average of 1.0 t/ha. The marginal rates of return for the farmers in the two successful locations were more than 800%. Such high benefits give the package good stability.

At the New Halfa Scheme the package gave an average yield of 1.4 t/ha compared with the scheme average of 0.9 t/ha.

In the Northern Region early sowing resulted in heavy bird damage as neighboring farmers sow their crops about 3 weeks later. At Zeidab the average gain in yield through the introduction of the package was 272 kg/ha. At Selaim and Burgaig all plots except one were heavily damaged by birds. At the plot which escaped bird damage, the yield advantage of the package was 679 kg/ha.

Research-Managed Trials

At the Gezira Scheme, water management and phosphorus application had highly significant effects on grain yield. Application of nine irrigations instead of five resulted in an increase of 758 kg/ha in grain yield. The addition of 43 kg P_2O_5/ha on average increased yield by 386 kg/ha.

In the New Halfa Scheme advancing the sowing date from the first week of December to the first half of November increased yield by 383 kg/ha, and shortening the irrigation interval from 21 to 14 days increased yield by 367 kg/ha. The addition of phosphorus had no effect on yield.

In the Northern Region (at Zeidab and Selaim) nitrogen fertilization, frequent irrigation at 14-day intervals, and aphid control significantly increased grain yield, while sowing either in early or late November had no appreciable effect on yield.

On-Farm Verification Yield Trials

The most promising eight cultivars from the Wad Medani and New Halfa breeding programs were included with two checks and the trial was conducted in 12 locations covering all wheat-producing areas in the country.

In the Central Region the check variety Debeira was significantly outyielded by four entries at one site only and was top ranking in three. In the Eastern Region Debeira was outyielded by three entries in one out of three sites. In the Northern Region no entry was superior to Debeira.

Thus Debeira seems to be a variety with great potential, and therefore it must be multiplied for its seed to replace the existing commercial varieties.

Back-Up Research

Crop Improvement

With the objective of screening as many genotypes as possible, a series of yield trials were conducted at Wad Medani and New Halfa Research Stations. A number of entries were found superior in yield to the check Debeira and these will be tested for another season before advancing them to the on-farm verification yield trial.

Mechanization

Tillage system had no significant effect on grain yield. Sowing by seeddrill had a positive effect on crop establishment.

Water Management

The effect of irrigation intervals at three stages of wheat development was studied, and the results indicated that shortening the irrigation intervals to 10 days (from 14 days) during the boot stage increased grain yield by 11%.

Crop Protection

(a) Plant pathology
Screening the commercial and promising wheat cultivars for stem rust resistance has shown that 16 varieties exhibited good levels of resistance, among which the important commercial variety Condor was included.

(b) Pest management
Tests were held to identify potent selective insecticides against aphids. The results indicated that the chemicals Danitol-S, Dursban, Reldan, and Marshal gave satisfactory performance and will be further tested before being released for commercial control.

Socioeconomic Survey

The survey results showed that wheat production is characterized by a diversity in the production techniques, both among the various producing areas and within the individual areas of production. This diversity in addition to the effect of soils, climate, and social aspects, contributes to great yield variability.

Average yields among regions ranged between 986 kg/ha and 1,892 kg/ha. Within regions the coefficient of variation ranged between 30 and 47%, reflecting the substantial variability. Yield levels and production practices affected profitability and were affected by production constraints and input levels. These aspects are related to family and farm structure, relative wheat importance, wheat profitability, production constraints, and possible improvements.

Farmers' ages ranged between 39 and 59 years with relatively high figures in Gezira. Farmers were predominantly illiterate with large family sizes most members of which were either students or laborers. The level of family help in farm activities was very low in Gezira, New Halfa, and Zeidab. Generally labor peaks were not problematic except in the

Northern Region where reliance on labor was very high and expected to affect wheat production.

Wheat takes up about one third of the farm area in all regions. However, its contribution to farm income ranges between 6 and 24%.

Net returns on wheat were generally low because of low yields and prices and high production costs. Inputs such as fertilizers, water, seeds, and sacks constitute two thirds of production costs.

Productivity constraints were as follows:

a) Poor crop establishment as a result of bad levelling and poor water management.
b) Water stress
c) Late sowing
d) Seed rate and fertilizers

The individual effects of these factors were quite substantial. With the high level of inputs, increases in yield ranged between 409 and 1,854 kg/ha with increases in net benefits of between SDP 53 and SDP 1,854, compared with the average level of input.

Acknowledgements

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Varietal Susceptibility and Spread of Karnal Bunt of Wheat in India

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Karnal bunt of wheat *Neovossia indica* (Mitra) Mundkur has recently become a major disease in India. The disease appears sporadically and causes substantial losses to wheat crop. Munjal (1976) estimated a loss of 0.2% in yield annually in Punjab and Jammu and Kashmir. According to latest estimates the total damage to the crop was only 0.2 - 0.5% of the total production (Joshi *et al.* 1983; Singh *et al.* 1983). This paper deals with the susceptibility of wheat cultivars to this disease, and the role they play in the perpetuation of the disease in the country.

Materials and Methods

A total of 19,546 wheat samples of different cultivars were collected during 1976 - 1984 from threshing floors from Punjab, Himachal Pradesh, Jammu and Kashmir, Haryana, Uttar Pradesh, Delhi, Rajasthan, Madhya Pradesh, Bihar, West Bengal, Orissa, Maharashtra, Gujarat, Andhra Pradesh, and Karnataka by mobile-survey teams. At least 2,000 grains from each sample were examined for Karnal bunt infection. Table 1 provides percentages of infection of several wheat varieties for the years when the disease appeared in severe forms.

Results and Discussion

Table 1 indicates that in *Punjab* the average infection of Karnal bunt in WL 711 was very high, being 2.7, 2.8, 5.3, 3.7, and 0.7% during 1977/78, 1978/79, 1980/81, 1981/82, and 1982/83, respectively. On the other hand the average infection in Sonalika during the same period was only 0.7, 1.8, 1.9, 2.2, and 0.4%, respectively. Even in the foothills of Himachal Pradesh and Jammu and Kashmir, Sonalika showed less susceptibility as compared to WL 711. A similar trend was observed in Haryana and Uttar Pradesh where the average infection in Sonalika remained much below that of the susceptible cultivars. These results indicate that Sonalika and Kalyansona, the predominant varieties till 1975/76, are less infected by the disease than some recent cultivars such as Arjun, WG 357, WL 711, and UP 262.

Replacement of Kalyansona with new susceptible strains such as WG 357 and WL 711 (Anonymous, 1978) and their extensive cultivation in Punjab was at least one of the major factors for higher incidence of the disease in the State. Even Sonalika had

Table 1. Average infection of Karnal bunt in different wheat cultivars from various states, 1975-84.

State/Variety	Year 1975/76	1977/78	1978/79	1980/81	1981/82	1982/83	1983/84
Jammu and Kashmir							
Sonalika		Tr	1.0	0.3	0.2	Tr	
Kalyansona		0.1	2.6	0.2	0.2	0	
Arjun		0.1	3.6	0.4	2.0	0.5	
WL 711			6.0	8.4	10.4	0	
Local		0	2.2	1.0	0.5	0	
Improved wheats*				1.0	3.0	0.7	
Himachal Pradesh							
Sonalika		0	0.7	0.8	Tr	Tr	0
Kalyansona		0	1.1	8.3	0.5	0	0
WL 711		11.2	0.1	5.6	23.8	0.5	0.4
Local		1.7	1.3	1.1	0.2	0	0
Improved wheats		2.8		3.6	0.2	0.1	0
Punjab							
WL 711		2.7	2.8	5.3	3.7	0.7	
WG 357	1.4	0.8	1.4	2.7	9.3	0.1	
Arjun		0.3	0.7	2.0	1.3	0.2	
Kalyansona	0.4	0.5	0.2	2.5			
Sonalika	1.1	0.7	1.8	1.9	2.2	0.4	
WL 1562					0.9	0.4	
DWL 5023						0.3	
Improved wheats		0.1		1.7	2.4	0.5	
Haryana							
Sonalika	Tr	0.7	Tr	0.1	0.2	Tr	Tr
Kalyansona	Tr	0.1	Tr	0.4	0.1	Tr	0
Arjun		Tr	0.1	0.3	0.7	Tr	Tr
WH 147		0	Tr	0.1	0.2	Tr	Tr
WL 711			Tr	1.2	0.9	0.3	0.1
C 306	0	0.1	0.1	Tr	0.8	Tr	0
HD 2204				0.3	0.6	Tr	0
Improved wheats	0	0.2	Tr	0.2	0.4	Tr	Tr
Uttar Pradesh							
Sonalika	0	Tr	0.3	0.2	0.3	Tr	Tr
Arjun		0.3	0.6	0.9	3.0	Tr	Tr
Janak		Tr	0.2	0.1	0	Tr	Tr
UP 262			2.2	0.2	0.2	Tr	0
WL 711			9.6	0.2	8.5	0.1	0
Kalyansona	0	Tr	Tr	0.2	0	0	0
K 68 and other locals	0	Tr	Tr	Tr	0.3	Tr	0
Improved wheats	0	0.1	2.0	0.5	1.0	Tr	Tr

* = Unidentified dwarf wheats; Tr = Less than 0.1% infection; 0 = No infection.

higher incidence in Punjab than in other states which may be due to the gradual built-up of inoculum in the soil, as the teliospores of Karnal bunt are known to survive in the soil for 2-4 years or more (Mathur and Ram 1963; Munjal 1970).

In Uttar Pradesh, Sonalika still occupies maximum area among the improved wheat cultivars and this possibly *accounts* for the low incidence of the disease in the State. Low incidence of Karnal bunt in Haryana may also be due to the cultivation of Sonalika, WH 147, HD 2204, and C 306 which are more tolerant to the disease under field conditions. Even in Punjab, the incidence of Karnal bunt has been decreasing for the last 2-3 years because new strains such as WL 1562 and DWL 5023 have been introduced to replace the susceptible variety WL 711.

It is concluded that one of the major factors for the spread of Karnal bunt in the country was the cultivation of some high-yielding, but susceptible cultivars.

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Nutritional Evaluation of Some Commercial Wheat Varieties Grown in Pakistan

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Cereal grains are the dietary mainstay of mankind. They provide three quarters of man's energy needs and more than one half of his protein needs. Wheat is the main staple food in Pakistani diets and constitutes 83% of the total cereals intake. The protein content and the lysine per unit protein of some improved Pakistani wheat varieties have been reported to range from 12.3 to 16.7% and 2.46 to 2.96%, respectively (Khan and Eggum 1979). Wheat protein has an imbalance of essential amino acids for its complete biological utilization. According to Khan (1981) the order of limiting amino acids in wheat protein is lysine, threonine, and valine. Mixed human diets, breakfast cereals, and baby foods based on wheat have been reported to be deficient in lysine (Khan and Eggum 1978a, 1979a).

Known genetic variability for lysine is substantially less in wheat than in other cereals. According to Johnson *et al.* (1973) the genetic variability for lysine in wheat is not more than 0.5 percentage point when lysine is expressed as percent of protein. The amount of lysine in wheat is influenced by the level of protein (Vogel *et al.* 1973), and the relationship is curvilinear (Johnson *et al.* 1979).

The challenge to plant breeders is to develop cereal varieties that are both more productive and more nutritious. Consequently, any addition in protein quantity and/or quality will result in improved nutritional status of the population. The present paper deals with the nutritive value of some commercial wheat varieties evolved in Pakistan.

Materials and Methods

Eight commercial wheat varieties grown in Pakistan were collected from the wheat program of the National Agricultural Research Centre, Islamabad, Pakistan. All varieties were ground to whole flour. The chemical composition was determined according to the

AOAC methods (1970). The gross energy value was calculated by multiplying protein, fat, and carbohydrate contents with factors of 4,9, and 4, respectively. The amino acid analyses were carried out as described by Khan and Eggum (1979). Trace elements were analyzed by using Perkin-Elmer, model 4000, atomic absorption spectrophotometer. All assays were performed in duplicate. The biological utilization of wheat protein was determined in N-balance experiments with growing rats according to Eggum (1973).

Results and Discussion

The chemical composition of the commercial wheat varieties studied is shown in Table 1. The protein content (N x 5.7) was highest (16%) in Barani-83 and lowest (13.2%) in Punjab-83. The fat content appeared to range between 2.6 and 3%, while the available carbohydrate from 67.3 to 74.7%. The fiber content varied from 2.2 to 2.9%, while the ash content was almost uniform in all varieties. The concentration of calcium varied considerably, with highest value of 40 mg per 100 g in Punjab-83 and the lowest of 11 mg per 100 g in Lyp-73. The phosphorus content ranged from 284 to 336 mg per 100 g, while the iron content was highest (4.8 mg per 100 g) in Sonalika and lowest (2.9 mg per 100 g) in Faisalabad-83. The concentration of zinc and manganese varied from 2,5 to 4.1 and from 5.0 to 6.6 mg per 100 g, respectively.

Protein concentration of the wheat varieties was negatively correlated with the available carbohydrate, the correlation coefficient ($r=-0.93$) being highly significant ($P < 0.01$).

The amino acid contents of the eight wheat varieties are presented in Table 2. Lysine per 100 g protein ranged from 2.46% in Barani-83 to 2.75% in Punjab-83. In Barani-83 which has the highest protein content (16%) the glutamic acid, glycine, and serine contents were highest, while the lysine, threonine, and cystine contents were lowest. The lowest concentration of protein (13.2%) in *Punjab-83* resulted in an increase in lysine, *threonine*, and valine, and in a simultaneous decrease in proline content. Sonalika had the highest methionine and cystine content (3.88 g/16 g N) and Sarhad-82 the lowest (3.45 g/16 g N). There was a negative correlation ($r = -0.67$ significant at the 5% level) between lysine content (g/16g N) and protein concentration. The relationship is given in the following regression equation:

$$\text{Lysine (\%)} = 3.59 - 0.07 \times \text{protein (\%)}$$

Results obtained on true protein digestibility (TD), biological value (BV), and net protein utilization (NPU) of the wheat varieties studied are summarized in Table 3. The TD was highest (95.0%) in Sind-81 and Punjab-83 and lowest (92.0%) in Sonalika and Sarhad-82. The BV and NPU ranged from 56 to 68% and 53 to 65%, respectively. The negative correlation ($r = -0.76$) between BV and protein concentration was significant at the 5% level. However, a positive correlation ($r = +0.95$, significant at $P = 0.01$) between BV and lysine content (g/16g N) of commercial wheat varieties was recorded. The relationship between the two traits is given in the following regression equation:

$$\text{BV (\%)} = -35.01 + 37.47 \times \text{lysine (g/16g N)}$$

Table 1. Chemical composition (dry basis) of eight Pakistani commercial wheat varieties.

	g per 100 g						mg per 100 g				
	Protein (N x 5.7)	Fat	Available carbohydrate	Crude fiber	Ash	Gross energy (Kcal/100g)	Ca	P	Fe	Zn	Mn
Sonalika	15.7	2.7	68.6	2.2	1.6	362	37	336	4.8	3.3	5.8
Lyp-73	14.8	2.7	70.0	2.5	1.7	364	11	315	3.9	2.8	6.0
Pak-81	14.3	2.9	72.5	2.5	1.6	373	18	287	4.1	3.0	6.3
Sind-81	13.3	2.7	72.9	2.2	1.5	369	25	310	4.5	3.5	5.5
Sarhad-82	14.5	2.7	72.7	2.7	1.5	374	20	284	3.8	4.1	6.6
Faisalabad-83	14.3	2.6	70.8	2.6	1.6	365	30	319	2.9	2.9	5.3
Punjab-83	13.2	2.7	74.7	2.8	1.6	375	40	325	4.2	3.7	5.5
Barani-83	16.0	3.0	67.3	2.9	1.7	360	19	309	3.8	2.5	5.0

Table 2. Amino acid composition (g per 16 g N) of eight Pakistani commercial wheat varieties.

	Sonalika	Lyp-73	Pak-81	Sind-81	Sarhad-82	Faisalabad-83	Punjab-83	Barani-83
Aspartic acid	4.79	4.61	4.94	4.91	4.78	4.60	4.83	4.53
Threonine	2.75	2.63	2.68	2.77	2.61	2.58	2.79	2.56
Serine	4.69	4.54	4.60	4.75	4.48	4.66	4.71	4.90
Glutamic acid	29.80	29.84	30.29	29.74	28.99	30.50	30.11	30.81
Proline	10.16	10.12	10.49	10.05	10.15	10.52	10.00	10.19
Glycine	3.90	3.82	3.96	4.06	3.90	3.82	4.01	4.10
Alanine	3.37	3.27	3.36	3.45	3.28	3.26	3.41	3.31
Valine	4.41	4.37	4.22	4.43	4.17	4.26	4.49	4.30
Isoleucine	3.48	3.45	3.57	3.57	3.38	3.43	3.51	3.44
Leucine	6.41	6.38	6.49	6.68	6.12	6.36	6.44	6.38
Tyrosine	2.94	2.94	3.13	3.06	2.99	2.88	3.13	3.09
Phynylalanine	4.37	4.35	4.38	4.42	4.15	4.47	4.33	4.34
Lysine	2.62	2.54	2.63	2.71	2.60	2.48	2.75	2.46
Histidine	2.28	2.21	2.20	2.28	2.14	2.18	2.15	2.23
Arginine	4.70	4.42	4.55	4.65	4.54	4.43	4.54	4.68
Methionine	1.56	1.50	1.49	1.55	1.32	1.43	1.46	1.37
Cystine	2.32	2.27	2.13	2.28	2.13	2.13	2.24	2.11
Tryptophane	1.02	1.20	1.18	1.35	1.25	1.30	1.15	1.05

Table 3. Protein quality of eight Pakistani commercial wheat varieties.

	True digestibility		Biological value		Net protein utilization	
	(%)	(± sd)	(%)	(± sd)	(%)	(± sd)
Sonalika	92	0.8	62	1.1	57	1.0
Lyp-73	93	0.9	61	1.5	57	1.8
Pak-81	93	1.3	63	1.1	59	1.5
Sind-81	95	1.0	66	1.6	63	1.5
Sarhad-82	92	1.4	65	1.4	60	1.4
Faisalabad-83	94	0.8	58	1.4	55	1.6
Punjab-83	95	0.9	68	1.7	65	1.9
Barani-83	94	0.9	56	1.6	53	1.3

The quantity and quality of wheat protein depend on its genetic potential (Johnson *et al.* 1979), production climate (Drewitt and Rickard 1971; Partridge and Shaykewich 1972), and soil fertility (Eppendorfer 1975).

The results indicate that the high-protein wheat cultivar (Barani-83) was low in lysine whereas the wheat cultivar highest in lysine (Punjab-83) was lowest in protein. The lysine content per unit protein is negatively correlated with protein concentration. The decrease in lysine content associated with elevation of protein content may result from altered ratios of the four solubility fractions that comprise the protein. According to Johnson *et al.* (1979) the proportions of water-and salt-soluble albumins and globulins are highest in low-protein wheats. Lysine in these fractions is significantly higher than in the glutenin and gliadin fractions. The ratio of gliadin to total protein increases with higher protein content, but that of albumin and globulin decreases. The lysine depressing effect occurs because gliadin is essentially devoid of lysine.

As lysine is the first limiting amino acid in wheat protein, decrease in this amino acid must result in a reduction in the BV. The BV shows a linear decrease with increase in protein concentration, due to the lower lysine per unit protein in wheat high in protein. A similar relationship was reported by Khan and Eggum (1979b). According to Eppendorfer (1975) increased levels of N fertilization resulted in an increase in the nonessential amino acids, glutamic acid, and proline, but a simultaneous decrease in lysine, threonine, and cystine. In the present study, the glutamic acid, glycine, and serine contents were highest, while levels of lysine, threonine, and cystine were lowest in wheat high in protein. Consequently, the BV in wheat high in protein was lower than in wheat low in protein. Similar results have been reported by Eggum (1970). The net dietary protein calorie percent of wheat bread has been reported by Khan and Eggum (1978b) to be above 5%, and should theoretically meet the protein requirement of adults if consumed in adequate amounts.

Improving the quantity and quality of wheat grain may be achieved through breeding new varieties possessing both high-yield potential (per unit of time, land, water, and energy) and high-protein content with good balance of essential amino acids.

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Research Highlights on Agronomic Aspects of Wheat at Hudeiba Research Station during 1961-1985

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Agronomy research at Hudeiba, a research station in northern Sudan, started in 1961 with a program of field experiments on the effects of sowing date, seed rate, sowing method, irrigation, and fertilizer application on various varieties of wheat.

Research on wheat was discontinued during 1977-1981--a period during which wheat cultivation was introduced to the Gezira and New Halfa in central Sudan--but was resumed later in 1982.

Although considerable information on the optimum cultural practices in wheat was available, no actual implementation of these on farmers' fields took place until 1985 when a project, financed by OPEC, was initiated with the objective of increasing grain yield of wheat at farmers' level.

This study is designed to review the research carried out during 1961-1985 in order to identify the factors responsible for yield increase in wheat, and show the deficiency areas where further research is needed.

Sowing Date

The growth period is short as it is limited by high temperatures, both at the beginning and end of the season; therefore timely sowing of the crop is very important. Grain yield was greatly affected by sowing time. Sowing in early October or late December reduced yield and the reduction in late December was considerable. Sowing in late October to November gave significant yield increase (Heipko 1961-66; Dafalla and Abdel Gabbar 1966-68, 1967, 1969; Abdel Gabbar 1970, 1972; Mohamedali 1983/84). The highest yields were obtained at 1 and 15 November sowing.

Varieties responded differently to sowing date. The short-duration varieties (LRNIQ, Mexipak, and 8156) gave highest yields when sown in mid-November or later, while the late-maturing variety (Falchetto) gave the highest yield when sown in mid-October to mid-November (Abdel Gabbar 1969-70). Mohamedali (1983/84) also found that S61 and S69 gave highest yields at 15 November sowing, Takamul and Mexicani at 1 November sowing and S80 at 15 October and 1 November.

It can be concluded that 1 to 15 November is the optimal sowing date for wheat in the Nile province, but weather fluctuations in the Nile and northern provinces make it imperative to carry out research to identify the response of different varieties to sowing date in the various areas.

Seed Rate

There have been controversial results on the effects of seed rates on grain yield of wheat. Heipko (1961-66); Dafalla and Abdel Gabbar (1967/68); Lazim (1972/73); Ageeb and Sarrage (1973/74), and Ageeb (1974-76) found that seed rates of 10 - 90 kg/feddan had very little effect on grain yields of wheat. This was attributed to compensatory effects of tillers. However, Dafalla and Abdel Gabbar (1966/67) obtained significant yield increases by increasing that seed rate from 25 to 75 kg/feddan.

Also Ageeb (1976/77) reported a significant increase in yield with the increase of seed rate from 2.5 to 160 kg/feddan.

Increasing seed rate in absence of nitrogen was found to have very slight adverse effects. Although seed rates of 40 to 80 kg/feddan were found to be optimal for high yields under research conditions, further research is needed to study the effect of seed rate in relation to land preparation, method of sowing, irrigation, and nitrogen application under farmers' field conditions.

Fertilizer Application

Application of nitrogen resulted in substantial increase in grain yield of wheat under Hudeiba conditions. Heipko (1961-66) found that application of 30 kg N/feddan produced significantly higher yields than 10 or 20 kg N/feddan. Dafalla and Abdel Gabbar, (1967-70) found that yield was significantly increased by applications of up to 30 kg N/feddan, but with increments above 30 kg N/feddan there was a slight, insignificant increase in yield. Imam

(1965/66) also reported significant yield increase with application of up to 40 kg N/feddan. Lazim (1972/73) found that nitrogen application significantly increased grain yield, but the highest response occurred between 0 and 18 kg N per feddan.

Response to nitrogen depends on sowing date, variety, and irrigation interval. Dafalla and Abdel Gabbar (1966-68) found that in mid-October to mid-November any increment of nitrogen dose increased yield considerably, but that in December and January yields were much lower at all nitrogen levels. Ishag, (1970/71) found that on the average wheat responded positively to applications of up to 36 kg N/feddan, but the Mexican variety LRN10 gave the highest yield with early sowing and 54 kg N/feddan.

Mohamedali (1983-85) studying the effect of different levels of nitrogen on four wheat varieties found a general positive response to N although varieties tended to differ in their response.

Dafalla and Abdel Gabbar (1966/67) and Ishag and Ayoub (1971/1972) found that the response to nitrogen was much affected by irrigation frequency, being higher with shorter watering intervals.

Dafalla and Abdel Gabbar (1966/67) found that split application of nitrogen (half at sowing and half at heading) gave slight but nonsignificant increase in yield over a unique application of either 18 or 36 kg N/feddan. Dafalla and Abdel Gabbar (1967/68) also found that split application (half at sowing and half at 'flagging') was not significantly different from a unique application at sowing, but both were significantly better than one application at flagging. Ayoub (1971/72) using N fertilizer at two levels (27 kg N/feddan) found that the best yield was obtained by an application at tillering or jointing compared to an application at sowing or ear emergence.

Phosphorus and potassium fertilizers were found to have no effect on grain yield of wheat (Kaufmann and El Karouri 1963-65 ; El Karouri 1966-69 ; and Mohamedali 1982/85).

Application of nitrogen at 36 kg N/feddan is optimal for high yield in wheat, but economic evaluation of further addition of nitrogen to high-yielding varieties such as "Takamul" which showed positive response to high levels of N, is worth considering.

Irrigation and Sowing Methods

Studies on the effect of irrigation on yield of wheat have indicated that stopping watering at heading resulted in substantial decrease in grain yield due to the reduction in seed weight (Dafalla and Abdel Gabbar 1966-68). However, since irrigation is expensive due to the high costs of fuel, irrigation equipment, and spare parts, and in order to economize on the use of water without adversely affecting the yield, research on the effect of water stress at different stages of plant development is urgently needed.

Research on methods of sowing has shown no clear-cut advantage for any of the methods over the other (Heipko 1961/66 and Ageeb 1976/77). However, different sowing methods are still being utilized by farmers under varying soil conditions. Research is thus needed to assess the effect on yield of seed rate in combination with sowing methods under such conditions.

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Highlights of ICARDA's Cereal Improvement Program for the 1985/86 Season

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Projects carried out by the Cereal Improvement Program (CIP) staff during the 1985/86 season were diverse in nature and oriented towards assisting national programs to increase the productivity and yield stability of barley, durum wheat, and bread wheat, particularly in the rainfed areas. The structure of the projects within the Program had a commodity focus. Multidisciplinary research on and training in agronomy, crop physiology, pathology, entomology, grain quality, and germplasm development, all integrated in a strong team approach, were maintained.

Detailed research results from each project for the 1985/86 season are presented in the Cereal Program Report, available from the Program on request. A summary of significant achievements is presented below.

Highlights

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

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

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

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

- Integrated efforts by national programs and ICARDA resulted in the release of new cereal varieties in several countries during 1985/86. The barley lines Badia and Rihane'S' Sel 2L-1AP-3AP-0AP were released in Syria and Tunisia, respectively. In addition, and through the cooperative ICARDA/CIMMYT project, the barley line Gobernadora was released in China and Mona//Mzq/DL71 was released in Mexico. Durum lines Waha and Sahl were released in Algeria and the line 21563-AA'S' x Fg'S'/Dmx69-331 was released in Tunisia. The bread wheat line, Sham 4, was released in Syria, and Tunisia is considering release of a sunbird line. Lebanon released the barley variety Rihane'S', the durum varieties Sebou and Belikh, and the bread wheat variety Flk'S'-Hork'S'. Durum lines Sebou and Kourifla are under consideration for release in Syria. Kourifla, a durum wheat, adopted to dry areas and possessing improved gluten strength, is also being considered for release in Jordan and Cyprus.

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

- Through developing collaborative projects with French and Japanese institutions, the Program plans to use newer tools in plant breeding, such as haploid breeding using *H. bulbosum*, embryo rescue in wide crosses, and selection at the cellular level for important biotic and abiotic stresses. However, conventional breeding will continue as a mainstay.

- Cereal scientists of ICARDA were invited by Morocco, Tunisia, and the Yemen Arab Republic to review the barley and wheat research being carried out in those countries and to recommend priorities and research methods with the objective of developing more efficient and cost-effective national programs.

- On a request from Morocco, a senior cereal scientist was posted to assist in coordinating the national cereal program. On the other hand, the cereal scientist assigned to the Tunisian program was withdrawn after 6 years of work on the establishment of a national barley improvement program.

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

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

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

- Results of the barley improvement project verified that selection for barley to be grown in dry environments should be made under dry conditions. Different sets of morphological and physiological characters are required to maximize yield under stress conditions. Utilization of the variability in landraces has proved to be useful in improving barley yield in harsher environments. Some barley genotypes yielded, with improved agronomy, over 2 t/ha in areas of less than 250 mm rainfall, where farmers' average is normally 0.5 t/ha.

- The durum wheat improvement project has provided national programs with germplasm developed to meet their specific needs. Genetic stocks possessing earliness; drought, heat, and frost tolerance; septoria and common bunt resistance; and high yields have been identified through multi-location tests. Several durum wheat entries gave larger grain yields as compared to national check varieties in on-farm trials conducted by national programs.

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

- In the high-elevation cereal research project, three disease-resistant, high-yielding lines were identified at Tehran, Iran. Incorporation of high-grain protein, disease resistance (yellow rust), and cold tolerance from *Triticum turgidum* var. *dicoccoides* into durum and bread wheat lines by interspecific hybridization has been very successful.

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

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

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

- In addition to screening for covered smut and barley yellow dwarf virus, the cereal pathology project is now screening for eight major cereal diseases. The germplasm pools for sources of resistance have been improved. Four such pools for yellow rust, septoria tritici blotch, common bunt in wheat, and scald in barley are now available to breeders.

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

Physical, Rheological, and Baking Characteristics of Some Triticale Lines Grown in Pakistan

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The physical grain quality and baking attributes of triticale lines have considerably improved during the past few years. This progress was achieved through extensive breeding programs (Zillinsky *et al.* 1980). One of the main objectives of triticale breeders is to develop triticale varieties well adapted to climatic and agronomic conditions that are ill-suited for wheat production. In Pakistan, there is a need for such a cereal crop that can offer a significantly better yield than wheat in unfavorable growing areas. Triticale lines developed at CIMMYT, Mexico, and grown at various research stations in Pakistan have shown some favorable response for local production. However, triticale will only be acceptable in Pakistan if it can be made into acceptable flat breads, e.g. chapati, naan, etc. This study aims to evaluate the technological quality of triticale lines grown in Pakistan in comparison with a popular wheat variety widely acceptable for traditional flat breads.

Materials and Methods

Three triticales (T-183, T-306, and Juanillo) and one wheat variety (Pak-81) grown in Pakistan were tested for their physical, rheological, and baking characteristics. The wheat variety was used as a reference standard. All the physical and chemical tests were conducted according to the standard methods of AACC (AACC 1982). The Brabender farinograph was used to determine the rheological characteristics of doughs prepared from triticale and wheat flours. Flour yield was determined by Qd. Junior mill and the wholemeal flour was prepared in a disc-pin mill. A standardized baking test for chapati production, based on previous methods (Rashid 1974; Elber and Walker 1983) was developed. This consisted of mixing 300 g of flour and water in a farinograph bowl to 500 B.U. consistency and optimum development (peak time), and then resting the dough at room temperature for 60 min. Dough was divided into 65 g-pieces, each shaped to a round ball and then rolled to a 7 inche-diameter disc. Each dough disc was baked for 3.5 min. on a hot plate at 205°C.

Samples of chapaties were presented to a panel of seven judges for evaluation of quality.

Results and Discussion

Data for physical grain quality; milling characteristics; and protein, ash, and wet gluten contents of experimental wheat and triticale are summarized in Table 1. The test weight of triticale ranged from 65 to 70 kg/hl and the values were lower than for wheat (75 kg/hl). All samples, except T-183, had hard kernels. Flour yield of Juanillo was better than those of T-183, T-306, and wheat. All triticale flours had higher protein as compared to wheat. All wheat and triticale flours had gluten contents below 30%, and glutens were short and weak.

The rheological and baking data indicated the high water absorption of wheat flour, but slight differences in peak time (dough development time) and stability of triticale and wheat flours were observed. The extremely weak nature of the gluten with little tolerance to mixing was evident. During baking, stickiness of dough, particularly in triticale, was a major problem. All triticale samples produced chapaties of an acceptable texture, with a slightly bitter aftertaste however. In addition, triticale

Table 1. Physical and chemical composition of triticale and wheat flours.

Cultivar	Test weight	Hardness	Flour yield (%)	Protein (% dry basis)	Ash	Wet gluten (%)
T-183	65	Soft	55.4	12.7	1.8	24.6
T-306	70	Semihard	48.0	15.4	1.8	29.0
Juanillo	66	Semihard	66.7	16.3	1.6	21.4
Pak-81	75	Semihard	57.4	11.4	1.6	28.8

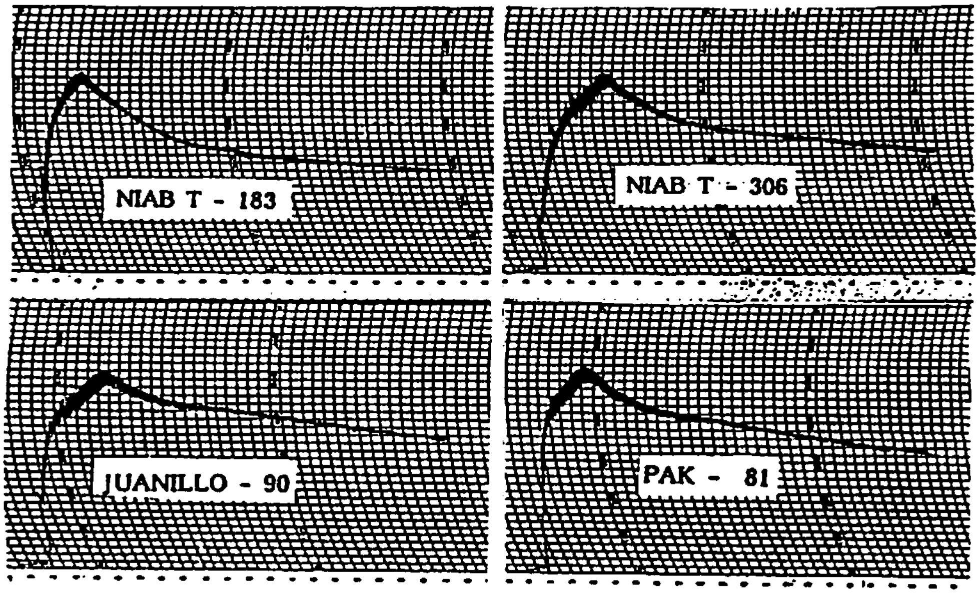

Fig. 1. Farinograms of triticale and wheat flours.

Table 2. Rheological and baking characteristics of triticale and wheat flours.

Cultivar	Water absorption (%)	Do. Dv. (min.)*	Stability (min.)	R**	Color	Smell	Texture	Taste
T-183	63.4	3.1	1.1	250	US	S	S	Q
T-306	67.7	4.4	1.5	165	US	S	S	Q
Juanillo	62.0	4.2	1.3	145	US	S	S	Q
Pak-81	70.0	3.3	1.3	190	S	S	S	S

* = Dough development time (minutes)

** = Tolerance index (B. Units)

US = Unsatisfactory; S = Satisfactory; Q = Questionable.

chapaties were darker in color compared with wheat, and this was probably the predominant factor in lowering their overall acceptability. However, the handling qualities of dough were reported to be improved with a marked decrease in stickness in a 75:25 wheat triticale blend, and the quality of the chapati was similar to a wheat chapati. (Khan and Rashid 1986).

As evident from the farinograms (Fig. 1), and the data in Table 2, wide differences existed in the rheological characteristics of wheat and triticale lines. Improving the gluten quality will no doubt assist in handling the dough during baking, but this remains as a matter of secondary importance, as compared to that of lightening the bran color. In summary, triticale can produce chapaties of acceptable quality, provided the color of the bran is improved, which may be achieved through breeding trials.

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Screening of Induced Germplasm of Wheat for Resistance to Stripe and Leaf Rusts

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The induction of resistance to various diseases in different crops through mutagenic agents is proven and established (Knott 1961). Possibilities of induced resistance to stripe rust (*Puccinia striiformis*), leaf rust (*Puccinia recondita*), and stem rust (*Puccinia graminis* tritici) in wheat are reported by Caffery and Wells (1956).

Wheat cultivar Lu-26 having good grain quality and yielding ability is cultivated on a large acreage in Pakistan. However, the yield performance of this variety is adversely affected by stripe rust in the cooler parts of the country. An attempt was, therefore, made to induce resistance to stripe rust in Lu-26 through gamma irradiation. This paper describes the work undertaken to screen the rust-resistant mutant lines of Lu-26 under artificial epidemic conditions.

Materials and Methods

Wheat (*Triticum aestivum* L.) cultivar Lu-26 was used in this study. Dry and uniform seeds with 11-12% moisture were irradiated with 25 krad of gamma rays (^{60}C) in a 220 gamma cell. M_1 was raised in the field. Three main spikes were harvested from each M_1 plant at maturity. M_2 was planted as spike-row progenies. At the five-leaf stage all M_2 progenies were artificially inoculated with the urediospores of *Puccinia striiformis* and *Puccinia recondita* using ultra low volume sprayer method. The inoculum (urediospores) was obtained from the Cereal Diseases Research Institute (CDRI), Islamabad. CDRI collects urediospores from all over the country to have a maximum number of prevailing races of the wheat rusts.

Plants were assayed at dough stage and consequently about 500 plants resistant to stripe and leaf rusts were selected. As a result of screening and selection upto the M_4 generation, about 112 genetically stable and rust resistant lines were selected. These true breeding lines were further evaluated for their agronomic performance in preliminary yield trials in M_5. Promising lines were advanced to M_6 and tested for rust-resistance and other agronomic traits in micro-yield trials in comparison with the parent variety and the commercial cultivar Pak-81, using a randomized complete block design with three replications.

All lines were screened for resistance to stripe and leaf rusts. Severity was recorded as percentage of rust infection on the plants according to a modified Cobb's scale (Peterson *et al.* 1948), while response, which refers to different infection types, was recorded according to the pictorial scale developed by Stubb and Vecht (1981).

Results and Discussion

Performance of the promising mutant lines, their parent, and commercial cultivar is presented in Table 1. The data revealed considerable improvement over the parent for resistance to stripe and leaf rusts in most of the mutant lines. The parent variety was completely susceptible to stripe rust with 60% severity, whereas it showed trace severity of moderately resistant type of infection to leaf rust. Among the mutant lines, 10 were found resistant, 4 moderately resistant, 4 moderately susceptible, and only 1 completely susceptible to stripe rust. Moreover, 11 mutant lines showed no symptoms of leaf rust infection. It is also clear from the results that most of the mutant lines expressed more resistance to leaf rust than to stripe rust. The commercial cultivar (Pak-81) exhibited resistance to stripe rust and showed no signs of leaf rust infection.

The mutant lines were also tested for yield and other agronomic traits. The highest yield entries were the mutant lines WM-30-6-1, WM-91-5, WM-6-17, and WM-89-1; however, six other mutant lines gave higher yields than the parent variety. As is evident from the results, some of the susceptible/moderately susceptible mutant lines have outyielded the parent variety and some resistant mutants, suggesting that these lines are more tolerant to both leaf and stripe rusts. Regarding plant height, significant variability has been induced by gamma rays which confirms the results obtained by other workers (Chaudhry 1971; Chaudhry *et al.* 1976; and Gustafsson 1963). Almost all the mutant lines were later heading than the parent variety. Hak and Kamel (1974) have reported that late maturity is usually observed in the hexaploid wheat when subjected to a high dose (20 Krad).

The results revealed that mutant lines possessed valuable biological and economic qualities such as reduced plant height, resistance and tolerance to stripe and leaf rusts, and high-yield potential, which

Table 1. Performance of wheat mutants (M_6 generation), parent variety Lu-26, and commercial cultivar Pak-81.

Mutant line/ variety	No. of days to 50% heading	Plant height (cm)	Yield/ ha (kg)	Reaction to rusts *Puccinia / striiformis*	*Puccinia recondita*
WM-92-32-2	121	67	5000	5 MR	t R
WM-92-39-3	120	65	5111	5 MR	5 R
WM-92-34-2	121	66	5180	10 R	t R
WM-92-4-2	128	67	5222	5 MR	0
WM-2-4-5	116	127	6056	5 R	0
WM-89-1	123	126	6833	15 MS	20 MS
WM-6-17	125	123	6944	20 MR	0
WM-56-1-2	120	124	6500	5 MS	0
WM-120-3	118	129	6000	15 MS	0
WM-79-7	122	118	6555	10 S	40 S
WM-23-1-1	122	124	6388	t R	15 S
WM-91-5	120	126	7055	5 R	0
WM-91-3	121	122	6166	t R	0
WM-92-3	122	123	6056	5 MS	0
WM-91-1	120	120	5944	5 R	0
WM-97	119	112	3977	10 R	0
WM-78	119	134	5277	5 R	20 MS
WM-30-6-1	118	121	7055	t R	40 S
WM-23-2	111	117	5000	t R	0
Lu-26	116	119	6026	60 S	t MR
Pak-81	128	115	6236	5 R	0

0 = No signs of infection; R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible; t = Trace

can successfully compete with the parent variety (Lu-26) and the standard commercial cultivar Pak-81. These promising mutants can also be used in cross-breeding for the improvement of rust-resistant cultivars of wheat.

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Short Communications

Comparative Quality of Sebou with Gezira 17 and Sham 1

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Data collected from Farmers' Field Verification Trials (FFVTs) carried out in zone A under irrigation, indicate that the overall poor quality of Gezira 17 is attributable mainly to low protein content and vitreous kernel counts (VKC), and generally to poor gluten strength. Sebou, although higher in gluten strength and SDS ratio (ratio of the SDS sediment volume to protein content) than Gezira 17, was consistently lower in yellow pigment, but generally superior in protein content, kernel weight, and gluten strength. Also both lines showed excessive variability in VKC, with Gezira 17 falling to 6% and Sebou to 12% in single trials. Sham 1 was superior to most lines in protein content and vitreous kernel count, and adequate in kernel weight and yellow pigment content, but significantly inferior in gluten strength, which was assessed by SDS volume and ratio. The SDS ratio indicates the performance of the gluten on a constant protein basis.

This type of quality performance highlights one of the main features of quality evaluation in a breeding program, namely, the possibility of failure of a genotype in an important quality characteristic. The most important characteristics of durum wheat for processing pasta or flat bread are the gluten strength, protein content, vitreous kernel count, and (for pasta and burghul) yellow pigment content. Of these, gluten strength, 1000-kernel weight, and yellow pigment are highly stable characteristics, and a nursery of durum genotypes will retain their high-intermediate-low ranking from one season to another at different growing locations. Protein content and vitreous kernel count are equally important, but are more strongly influenced by growing conditions. In general, the genotypes lowest in both of these characteristics tend to remain lowest. For example out of 8 lines Sham 1 ranked first or second in vitreous kernel count in all 12 FFVTs carried out in 1985, where the fertility level was low enough to create pressure on the genotypes in this respect. On the other hand, out of 6 lines, Sebou ranked sixth in VKC in 3 or 4 irrigated trials.

Table I summarizes the quality characteristics of Gezira 17, Sebou, and Sham 1. Data for Korifla and Haurani are also included for comparison.

Table I. Quality characteristics of Sebou, Gezira 17, and Sham 1 (Farmers' Field *Verification Trials, 1985*).

Characteristic	Gezira 17	Sebou	Sham 1	Korifla	Haurani
Protein (%)	12.3**	12.6	13.6	13.7	14.3
VKC	73.00**	78	90	95	89
TKW	35.2	40.2	35.4	33.5	32.7
SDS	26.5	29	20.5	37.5	36.5
SDS ratio	2.15	2.2	1.50**	2.71	2.56
PPM	6.1	4.5	6.2	7.0	6.5
Average rank*	7	4	5	1	2

* Average rank in all trials, regardless of zone.
** Particularly weak points.

A Simple Screening Test for Yellow Pigment Content in Durum Wheat

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Yellow (carotenoid) pigment content is one of the most important parameters in durum wheat quality evaluation. A high yellow pigment content is essential for the preparation of pasta products with the traditional yellow color. At ICARDA, selection of durum cultivars suitable for pasta processing involves tests for kernel characteristics (including kernel size and shape and the proportion of vitreous kernels), gluten strength, protein content, and yellow pigment. Yellow pigment content is normally determined by Approved Method No. 14-50 of the American Association of Cereal Chemists (AACC). This involves the use of a reflectance spectrophotometer, or the extraction of the pigment using water saturated n-butanol, filtration, and comparison of the color on a spectrophotometer at 440 nm. Water-saturated n-butanol has an unpleasant odor, and some people are allergic to it. A screening program involves testing several thousands of samples per year, and a test procedure was sought which would enable the identification of genotypes with high (and low) yellow pigment directly in the ground wheat meal without the necessity of using water saturated n-butanol.

Experimental

Samples of durum genotypes grown in several locations in farmers' field verification trials in Syria were ground on a Udy Cyclone grinder, using a 1.0 mm screen. The ground samples were mixed thoroughly and stored in small metal containers. Yellow pigment content was determined in all samples (20 locations, 7 genotypes), using AACC method No. 14-50. A very wide range of yellow pigment was revealed, extending from about 2 to over 8 ppm, based on a commercial beta-carotene standard (Sigma Corporation). Yellow pigment varied between genotypes within a location, and between locations, but the stability of yellow pigment content as a genetic parameter was high, as indicated by the mean coefficient of determination (r^2) of 0.65 between genotypes grown at all locations.

A color gradient scale was prepared consisting of a wooden board (55 x 8.5 x 1.5 cm) carrying seven holes (6.5 cm diameter) covered with plexiglass. The board was set into an aluminum frame for protection. The seven cells were filled with ground durum wheat samples varying in yellow pigment content from 2 to 8 ppm, as determined by water-saturated n-butanol extraction. The backs of the cells were covered and sealed, so that wheat formed a firm, flat surface at the plexiglass. This is illustrated by the cover photograph. The color gradient board is stored in a specially-constructed box, and refrigerated at -10°C to preserve the color. Moisture content of durum wheat samples used in preparation of the color gradient board was about 9%. This low moisture content, in combination with storage of the gradient board at a very low temperature minimizes the risk of oxidative reduction in pigment content by the action of lipoxidase. The board is freshly-prepared annually using new crop samples, the pigment contents of which have been determined by water-saturated n-butanol extraction.

To use the color scale, tins of ground durum wheat are simply compared visually with the seven cells of the gradient. The color which matches one of the cells is recorded to the nearest 0.5 ppm. As little as five grams of wheat can be tested. In this way it is possible for a single person to test two samples a minute, or about 600-700 per day. At ICARDA every 20th sample is tested by AACC method No. 14-50 to verify the pigment content. Some results of these comparisons are summarized in Table 1.

Table 1. Comparison of yellow pigment determination by color scale and by water-saturated *n*-butanol extraction.

Attribute	Value
Mean ppm, color scale	5.5
Mean ppm, extraction method	5.6
Standard deviation of differences	0.34
Coefficient of correlation	0.88
Number of observations	160

In summary, a simple color gradient board has been developed for the rapid visual estimation of yellow color in ground durum wheat. The test is very rapid, and can be carried out on small samples (five grains or more). The yellow pigment values thus obtained are highly correlated to actual yellow pigment content, as determined by water-saturated n-butanol extraction and spectrophotometer. The test is intended as a screening method for the large numbers of early-generation material obtained in the breeding program. Advanced lines, and composites of cultivars from field verification trials are tested by the extraction method.

Recent Publications

Kuckuck/Kobabe/Wenzel (eds). 1985. (Features of plant breeding). In German. Neuberab.U.erweit. Aufl. Walter de Gruyter 254 pp. DM 48.

This textbook of plant breeding deals with common principles of this discipline in a conventional manner. The first part consists of chapters on combination and hybrid breeding, whereas the second part deals comprehensively with special techniques of breeding and selection, including modern biotechnological methods. The third part discusses relations of plant breeding to other sections of plant production, and also practical problems on a breeding farm, and in developing countries. The book also includes chapters on variability in cell and tissue culture, production and usage of haploids, fusion of protoplasts, and genetical engineering. This publication represents an excellent basic book on plant breeding with additional chapters on modern techniques, and is recommended to plant breeders provided they have a good knowledge of German.

Graveland, A. and Moonen, J.H.E. (eds). 1985. Gluten proteins. Proceedings of the Second International Workshop on Gluten Proteins, Wageningen, The Netherlands, 1-3 May 1984. Wageningen Institute of Cereals, Flour and Bread TNO, Wageningen, The Netherlands. 218 pp. $15.

The intensive research on gluten biochemistry and genetics in recent years has prompted the need for a periodic review and discussion of the accumulating information, with strong emphasis on its application for plant breeding and the cereal food industry. This book provides proceedings of the second international workshop on gluten proteins, summarizing major developments in this field of research. Coupling genetical studies with improved methods of protein fractionation with the aid of electrophoresis has facilitated research on genetic control of the seed storage proteins, the prolamines. The proceedings may be a great asset to all those interested in the chemistry, genetics, and cereal food technology of gluten proteins.

Somaroo, B.H., Adham, Y.J., and Mekni, M.S. 1986. Barley germplasm catalog, 1986. ICARDA, Aleppo, Syria. 413 pp.

The catalog contains information on 8000 entries of spring and winter barley from 45 countries. These accessions were evaluated for descriptors which include quality parameters as well as morphological, physiological, and other useful characters. Evaluation and characterization of this germplasm on the main ICARDA research station at Tel Hadya, Syria, revealed wide genetic variability for most of the traits studied. Considering that most of the accessions were primitive landraces this result is consistent with other studies carried out in the past. The barley project in the Cereal Crops Improvement Program at ICARDA has been utilizing this genetic resource since 1982, in order to develop germplasm targeted towards enhancing stability of yield in the dry areas. It is hoped by the researchers at ICARDA that with the publication of this catalog an increasing number of barley scientists will be motivated to use the world collection in breeding programs, in order to create efficient and productive cultivars. From early reports it is possible to say that the catalog has been well received by the genetic resources community around the world. This publication can be obtained by bonafide scientists and research institutions on request from the Leader, Genetic Resources Program, ICARDA, P.O. Box 5466, Aleppo, Syria.

Hanson, J. 1985. Practical manual for genebanks, No. 1. Procedures for handling seeds in genebanks. International Board for Plant Genetic Resources (IBPGR), FAO, Rome, Italy. 115 pp.

This publication is the first in a series of practical guidelines for genebank personnel, especially technicians involved in day-to-day handling of seeds. It explains in simple language the procedures for registration, cleaning, determination of moisture content, drying, conducting viability tests, packing, monitoring of accessions in storage, etc. according to internationally agreed methods. The handbook is written in a clear and concise manner and will go a long way in contributing to the improvement of seed handling in genebanks, especially those which are recently established in the centers of diversity. It would be useful if the handbook were available in other languages in addition to English. More detailed information, however, can be found in the IBPGR publication 'Handbook of Seed Technology for Genebanks' by Ellis, Hong, and Roberts (1985). The above publication is available on request from the IBPGR Secretariat, AGP Division, FAO, 00100 Rome, Italy.

Fischbeck, G., Plarre, W. and Schuster, W. 1985. Lehrbuch der Zuchtung Landwirtschaftlicher Kulturpflanzen. Vol. 2. Spezieller Teil. 2nd revised edition. 434 pp. Verlag Paul Parey. ISBN 3-489-70910-1. DM 118.

This second volume of plant breeding has been revised and updated. The 'special part' (spezieller teil) refers to the plant breeding of every major crop. The chapters are written in a logical sequence beginning with economic importance, distribution, origin, taxonomy, cytology, and mode of reproduction in the introduction. After that the authors describe in detail the breeding objectives and methods to achieve them. The choice of crops is very comprehensive, but rather subjective. For example, cassava, yams, and groundnuts are excluded, whereas crops such as safflower and cotton are described. A very useful book for readers conversant with German.

Larcher, W., Hackel, H., and Sakai, A. 1985. Die Nichtparasitaren Krankheiten 5. Teil. Meteorologische Pflanzenpathologie. Witterung und Klima als Umweltfaktoren. Kalt und Frost. 326 pp. Verlag Paul Parey, Berlin & Hamburg. DM 248-.

After introductory chapters on climate and weather and on measuring the meteorological parameters, chapters about the effect of low temperature and frost on plants are presented. Plant breeders will be specially interested to read the chapters on cold sensitivity, frost resistance (as a genetic character as well as for different species and varieties), variation within genera and species, frost resistance of dormant seeds, and seeds in various stages of development. In German.

Margit, G. and Huba, P. (eds). 1984. The possibilities of increasing genetic variability in the plant kingdom. Agricultural Research Institute, Martonvasar, Hungary. 208 pp. ISBN 963-8351-02-0.

This book presents proceedings of the Hungarian-Italian Plant Genetic Conference held in June 1984. Artificial mutation, genome or chromosome manipulation, intergenetic hybridization, and tissue culture are among the 15 papers presented at the conference. An interesting paper describes a trisomic series of an Italian durum wheat. Most papers present results obtained through well-established techniques, demonstrating their uses in increasing yield potential of important crops including cereals. The book is recommended to those readers keen to learn the progress made in the two countries on the forementioned topics.

Yeatman, Ch.W., Kafton, D., and Wilkes, G. (eds). 1985. Plant Genetic Resources. American Association for the Advancement of Science (AAAS). Selected Symposia Series 87. Bowker Publishing Company (UK), Epping, Essex. 164 pp. ISBN 0-8133-0129-7. $32.

Since the phenomenon of genetic erosion of plants has captured the attention of the world in recent years, scientists have undertaken many steps to control the loss of genetic resources and hence to maintain genetic variability for future use in breeding. In addition to the several conferences held in the last decade on this subject, several collecting expeditions have been launched to gather the genetic variability still to be found in the centers of diversity. This book begins with the history of plant introduction in the United States. Except perhaps corn (maize), all other crops are exotic in origin to the North American continent. An interesting book for those working on genetic resources.

Cereal News

Staff changes in CIP

Dr Ardeshir B. Damania joined ICARDA's Cereal Crops Improvement Program in April 1986 as durum germplasm scientist. Dr Damania received his B.Sc. and M.Sc. degrees from the University of Bombay, India, in botany and plant ecology/geography, respectively. Later, he proceeded, as demonstrator in botany and zoology, to the UK where he did a second Master's degree in conservation and utilization of plant genetic resources from the University of Birmingham in 1975. His research project was based on high-temperature dormancy in lettuce seeds. Subsequently, Dr Damania was employed as a consultant at the IBPGR where he undertook several germplasm collecting expeditions mainly on the African continent. He also worked for 2 years as technical assistant to the IBPGR's Mediterranean Program for Genetic Resources (MPGR), based at the Germplasm Institute, Bari, Italy. In 1983 he obtained a Ph.D. degree from the University of Birmingham, UK, for his thesis on variation in wheat and barley landraces from Nepal and the Yemen Arab Republic. Immediately prior to joining ICARDA Dr Damania served as germplasm collector for the IBPGR in South Asia and the Indian Ocean Islands.

Dr Damania will be in charge of the evaluation and documentation of durum wheat germplasm project being carried out at ICARDA in collaboration with the University of Tuscia, Viterbo, Italy.

Dr Ross H. Miller joined ICARDA's Cereal Crops Improvement Program in September 1986 as entomologist. Dr Miller received his B.Sc. in Invertebrate Zoology from Brigham Young University, Provo, Utah, USA, and then his M.Sc from the University of Houston's Division of Population Biology in Texas. His master's research dealt with defining the effects of different environmental variables on the population dynamics of terrestrial isopods. He obtained his Ph.D. from Washington State University in Pullman where he researched the defensive mechanisms of conifers against acolytid bark beetles, concentrating on the effects of environmental insect-and pathogen-induced stress on the physiology of the trees' hypersensitive response. Immediately prior to joining ICARDA, Dr Miller was employed as research entomologist at the USDA-ARS Rangeland Insect Laboratory at Bozeman, Montana, where he investigated the effects of various cattle - grazing strategies on plant and insect populations. At ICARDA Dr Miller will be responsible for entomological aspects of cereals, especially those related to sawfly, hessian fly, aphids, and suni bug.

Dr Dieter K. Mulitze left ICARDA during June 1986 in order to take up a new assignment with the Middle American Consortium (MIAC) project in Rabat, Morocco.

Dr Sui Kwong Yau took over the position of International Nurseries Scientist in the Cereal Improvement Program, vacated by Dr D.K. Mulitze, on July 1st 1986. Dr Yau joined ICARDA as a post-doctoral barley breeder in January 1984, after completion of his graduate studies at the University of Western Australia.

Dr Victor Shevtsov from the USSR joined the Cereal Improvement Program at ICARDA in October 1986 for a period of 6 months as a scientist involved in barley breeding. Dr Shevtsov has been working as a barley breeder at the Krasnodar Research Institute of Agriculture since 1962. In 1969 he obtained an M.Sc. degree for his thesis on the use of chemical mutagens in barley breeding. In 1982 he received his Ph.D. for research on barley breeding in the North Caucasus. His recent work has involved releasing 15 winter and spring barley varieties in the Krasnodar region of the USSR. He has been working on the use of mutagenesis, concerning the optimal for barley dosages of different mutagens, their genetic effectiveness, and the best ways for application of induced mutations in practical breeding. Dr Shevtsov is also working on dealing with winter hardiness, resistance to lodging and diseases, and the improvement of barley grain quality.

Dr Mohammad S. Mekni has been appointed as ICARDA Cereal Scientist to coordinate activities in Morocco. He will be based at INRA, Rabat. Dr Mekni was previously barley breeder in the Cereal Crops Improvement Program.

During 1985/86, **Dr Ahmed El-Ahmed,** barley breeder/pathologist, left ICARDA following 6 years of dedicated work in developing a Tunisian national barley program and cereal pathology component there. He has joined the University of Aleppo.

Ir. J.A.G. van Leur joined ICARDA as a barley pathologist after serving the program for 5 years as an associate expert funded by the Dutch Government.

Mr M.A. Malik, a research associate working on triticale, left ICARDA in 1986, as triticale research was discontinued.

Scientists' moves

Dr J.P. Srivastava, Leader, Cereal Program, ICARDA, attended a Workshop on "Genetic Resources and the Plant Breeder" held on 8-10 September 1986 at Montpellier, France. He presented a paper entitled 'Use of collections in cereal improvement in the semi-arid areas.' The paper was co-authored by Dr A.B. Damania.

The International Maize and Wheat Improvement Center (CIMMYT) celebrated its 20th anniversary during 22-24 September 1986 in Mexico. **Drs J.P. Srivastava, M. Nachit, and G. Ortiz Ferrara** from the Cereal Improvement Program in ICARDA participated in the celebrations which was attended by approximately 150 distinguished scientists and other guests from all over the world. On that occassion,CIMMYT also inaugurated a new building for use as a training center. This building, which was named after the eminent scientist and Nobel Prize winner Dr Norman E. Borlaug, was constructed from funds donated by the Sasakawa Foundation, Japan.

Drs S. Ceccarelli (barley breeder at ICARDA), **Hugo Vivar** (barley breeder at CIMMYT), and **B.H. Somaroo** (Program Leader, GRP), and **Ir. J. van Leur** (barley pathologist at ICARDA), attended the 5th International Barley Genetics Symposium held at Okayama, Japan, during 6-11 October 1986. Dr Ceccarelli presented a paper entitled 'Tolerance to climatic stresses' and Dr Hugo Vivar presented a paper on 'Breeding for multiple disease resistance in barley'. Both papers were well received by scientists working on barley and participating in the symposium.

Dr M. Tahir of the Cereal Crops Improvement Program visited the Yemen Arab Republic (YAR) as an FAO consultant in October 1986. The purpose of his visit was to join a team of experts to evaluate an on-going Food and Agriculture Organization of the United Nations (FAO) project on Agricultural Research and Production (UTFN/YEM/011/YAR). Besides monitoring the progress of the project Dr Tahir and his team were also responsible for evaluating future plans for the establishment of research institutions in the eastern and northern ecological zones of the Republic. At the end of the mission the team debriefed the task force of FAO in Rome, Italy, about their evaluation and recommendations.

Dr S. Ceccarelli of the Cereal Crops Improvement Program at ICARDA attended a meeting on "Drought Resistance in Plants: Genetic and Physiological Aspects" held in Amalfi, Italy, on 20-23 October 1986. He presented a paper on 'Breeding strategies to improve barley yield and stability in drought-prone environments.' The meeting was organized by the EEC-Plant Productivity Programme and attracted scientists mainly from Europe and the North American continent.

Dr A.B. Damania, Durum Germplasm Scientist in the Cereal Crops Improvement Program, visited the Germplasm Institute in Bari, Italy, in November 1986 to collate passport data with the evaluation and documentation of durum wheat germplasm already in progress at ICARDA since 1984. A catalog of the characterization information gathered on the first 5000 accessions by this project will be published shortly. Dr Damania also visited the University of Tuscia in Viterbo, Italy, where the electrophoretic work on the same durum germplasm is in progress.

Release of "Gallatin" (P.I. 491534) a new two-rowed spring barley cultivar in USA.

The Agricultural Research Servic (ARS), the U.S. Department of Agriculture (USDA) and Idaho Agricultural Experiment Station have announced the release of a new barley cultivar "Gallatin", named after Gallatin County, Montana, which is the home of Montana State University where this cultivar was developed. It is a two-rowed, white-kerneled spring midseason barley which has mid-lax, mid-long spikes with a characteristic not unlike cultivar "Hector", i.e. spikes are seminodding before maturity and nodding at maturity. The spike also has rough awns, glume awns equal to the length of the hair-covered glume and rachis edges with hairs.

The kernels are mid-size with hull adhering and finely wrinkled, no barbs on lateral veins and a short-haired rachilla.

The initial cross of "Summit" X "Hector" to produce "Gallatin" was first made in 1975 and F2 plants grown in 1976. A single F2 plant was selected in 1976 and grown in the F3 row. This selection was tested in Montana and Western Regional barley nurseries from 1978 through 1985. In 1984, thirty-two selected lines were bulked to form "Gallatin". The cultivar has been released to farmers and seedsmen for commercial production. The USDA has no seed for distribution.

Two new bread wheat varieties released in Oman

The traditional varieties grown in the Sultanate of Oman are tall and low yielding, tend to lodge, and are susceptible to smuts and rusts. Two new wheat selections released to farmers in the Sultanate during 1985/86 are WQS 151 and WQS 160. These are high yielders with desirable agronomic characteristics, good milling quality and are resistant to diseases, says a report received from the Ministry of Agriculture and Fisheries in Muscat. The seeds of the new varieties were received from ICARDA through its regional bread wheat yield trials in 1981/82.

Other news

A work plan has been developed for the Sudanese national scientists within the framework of the Cereal project funded by OPEC. The pilot project will be on "Verification and Adoption of Improved Wheat Production Technology in Farmers' Fields in the Sudan", and will be supervised by Dr J.P. Srivastava, Leader of the Cereal Improvement Program at ICARDA.

A meeting was held on 28-29 July 1986 between the Ministry of Agriculture, Forestry and Rural Affairs (MAFRA), Turkey, and ICARDA at the Central Anatolian Regional Agricultural Research Institute, Ankara. A work plan for the 1986/87 collaborative research was discussed, including research on winter cereals and food legumes.

Special Seed and International Nurseries Supplied by Cereal Improvement Program during 1 Feb - 15 Nov 1986

Requests for seeds have considerably increased over the years. National Research Centers with relatively more established programs, requested parental lines, specialized nurseries, and early-generation material, while programs with less resources and manpower, requested selected advanced lines. Several countries had selected and/or released lines from the International Nurseries supplied to them, and requested breeders' seed for seed multiplication or large-scale on-farm tests and demonstration. Scientists in developed countries requested seeds for specific studies or for use in the prebreeding programs.

A countrywise list of scientists receiving the seeds is given below. I wish to take this opportunity to thank all cooperators for the valuable information they provided and for their increasing interest in this network. It is sincerely hoped that the seeds provided to the national programs would contribute towards stable and increased production, particularly in the dry areas.

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Country	Cooperator's name	Requested material	Total weight (kg)
Afghanistan	Dr Gul Ahmad Khalidi	International nurseries	67.60
Algeria	Mr A. El Labdi	International nurseries	85.20
	Dr Assabah Amar	International nurseries	163.80
	Dr M. Benzaghou	Barley, bread wheat, and durum wheat	1300.00*
		Barley, bread wheat, and durum wheat	2084.00
		Barley, bread wheat, and durum wheat	8000.00*
	Dr M. Nemmar	Barley	10.50

Argentina	Mr Roberto Wright	International nurseries	7.10
	Dr Carlos Tomas Bainotti	International nurseries	9.40
Australia	Dr G. Howell	Barley	4.00
	Dr P.S. Brennan	International nurseries	5.10
	Dr Barbara J. Reed	International nurseries	12.80
		Barley	2.00
	Dr R.A. McIntosh	International nurseries	2.20
	Dr M.C. Mackay	Bread wheat (100 grains)	0.00
Bangladesh	Dr Sufi Ahmed	International nurseries	19.20
	Dr M.A. Hamid	International nurseries	29.20
Canada	Dr A. Commeau	Bread wheat and durum wheat	0.10
		International nurseries	10.60
	Dr P.C. Williams	Burghul sample	2.30
		Wheat ground	1.20
		Flour and Smeed	3.30
	Dr S. Jana	International nurseries	9.00
Chile	Dr M. Pinto	Barley	4.00
China	Dr Liang Xunyi	Barley	0.85
	Mr Luo Shuzhong	International nurseries	25.10
	Mr Gong Gi Sheng	International nurseries	12.80
	Dr Tong Daxiang	International nurseries	28.70
Cyprus	Dr C. Josephides	International nurseries	25.90
		Durum wheat	15.00
		Durum wheat	7.00
	Dr A. Hadjichristodoulou	Barley	145.00
		International nurseries	17.00
Ecuador	Director (INIAP)	Barley	0.85
		International nurseries	32.40
Egypt	Director of wheat section	Barley, bread wheat, and durum wheat	18.00
	Director of wheat section	International nurseries	114.50
	Dr R.A. Abo Elenin	International nurseries	70.80
	Dr Abdel-Fattah El-Sayed	International nurseries	8.30
	Dr R.J. Summerfield	Barley	0.25
	Dr S.C. Brown	Barley and bread wheat	1.50
	Dr John Pearson	Straw and dried plant	8.00
	Mr Martin Rogers	Barley and bread wheat	0.20
Ethiopia	Dr B. Anisimoff	International nurseries	36.80
	Dr Hailu Gebre-Mariam	International nurseries	25.90
	Dr S. Debella	Barley	0.85
	Dr E. Kidane Mariam	Bread wheat and durum wheat	40.00
	Dr Fekadu Alemayehu	International nurseries	47.00
	Dr Emana Jetto	International nurseries	65.30
	Dr. Tesfaye Tesemma	International nurseries	33.70
	Inst. of Agr. Res. Center	Barley	1.00
France	Dr Maxime Trottet	International nurseries	6.40
	Dr A. Sarrafi	International nurseries	7.00
		Durum wheat	3.50
		Barley	4.00
	Dr J. Chery	International nurseries	12.60
		Barley	4.00
	Dr P. Grignac, J. Poux	International nurseries	9.70
	Dr L. Jestin	Barley	4.00

Germany	Prof. P. Ruckenbauer	Durum wheat	3.50
		International nurseries	16.60
	Ms Eva Weltzien	Barley	3.00
Greece	Dr S. Stratilakis	International nurseries	12.70
	Dr T. Tsipropoulos	International nurseries	22.40
	Dr Eleni Theoulaki	International nurseries	26.30
India	Dr Mahabal Ram	International nurseries	32.50
	Dr J.P. Tandon	International nurseries	54.90
	Dr P.L. Gautam	International nurseries	21.90
Iran	Mr Gorjian Goodarz	International nurseries	11.80
	Dr T. Mahlooji	24 variety of barley	4.00
	Dr Nasser Banisadr	International nurseries	160.30
		Bread wheat	50.00
	Dr Zabih Ghezelbash	International nurseries	20.80
	Mr M.R. Jalal Kamali	International nurseries	7.40
	Dr C. Ghomi, Dr H. Saberi	International nurseries	20.60
Iraq	Dr Hamid Chaloub Ali	International nurseries	14.50
	Dr A.M. Alshamma	International nurseries	25.80
		Bread wheat	0.50
	Dr Aladin Daoud Ali	International nurseries	126.20
	Dr Adnan Adary	International nurseries	37.10
Italy	Dr Giuseppina Zitelli	International nurseries	13.50
	Prof. F. Lorenzetti	International nurseries	30.20
	Dr A. Bozzini	International nurseries	29.30
	Mrs S. Grando	Barley	0.85
	Prof. G. Mariani	Durum wheat	4.50
	Dr Benito Giorgi	International nurseries	46.10
	Prof. E. Porceddu	Durum wheat	17.00
	Dr G.T. Scarascia Mugnozza	International nurseries	10.20
Jordan	Dr Mahmud Duwayri	International nurseries	22.20
		Durum wheat	3.50
	Dr Abdel Majid Tell	International nurseries	16.00
	Dr Abdullah A. Jaradat	International nurseries	51.00
	Dr Ali Masadeh	International nurseries	106.00
		Barley, bread wheat, and durum wheat	13.50
Kenya	Dr Obongo Nyachae	International nurseries	16.90
Korea	Dr Eun Sup Lee	International nurseries	16.40
Lebanon	Mr Nicolas Rubeiz	International nurseries	53.20
		Barley, bread wheat, and durum wheat	72.00
		Barley	115.00
		Bread wheat and durum wheat	1800.00*
		Bread wheat and durum wheat	12.00
	Dr Michel Abi Antoun	International nurseries	51.90
	Dr S. El-Khoury	International nurseries	14.40
Libya	Drs Sebai, Shredi, Maddur	International nurseries	67.90
Mauririus	Dr A.L. Owadally	International nurseries	4.10
Mexico	Dr S. Rajaram	Bread wheat	5.00
		International nurseries	14.20
	Dr H.E. Vivar	International nurseries	29.90
		Barley	0.85
	Dr M. Alcala	Bread wheat	10.00
	Dr Pedro Brajich	Durum wheat	4.00
		International nurseries	33.20

Morocco	Dr A. Ouassou	International nurseries	177.10
		Barley, bread wheat, and durum wheat	17.00
	Dr M.S. Mekni	Durum wheat	14.00
		Bread wheat and durum wheat	30.00
		Durum wheat	100.00*
		Bread wheat	125.00*
		Barley	7.00
	Dr D. Mulitze	International nurseries	33.90
	Director General INRA	Barley	145.00*
	Dr A. Zahour	International nurseries	12.00
Netherlands	Prof. P. Kuiper	Barley	0.20
Nigeria	Dr Evans Victor Aguda	International nurseries	20.50
Oman	Dr Colin Driscoll	International nurseries	38.70
	Mr Ali Bin Sail Abry	International nurseries	34.40
Pakistan	Dr J.D.H. Keatinge	International nurseries	48.40
		Barley	20.00
	Dr M. Nazir	International nurseries	41.10
	Dr Karam Khan Kaleri	International nurseries	26.40
	Dr Mohamed Afzal	International nurseries	7.90
	Mr G. Ahmed Chaudhary	International nurseries	17.50
	Dr M.A. Bajwa	International nurseries	13.70
	Dr N.I. Hashmi	International nurseries	79.00
	Mr Sher Mohammed	International nurseries	48.40
Peru	Ing. Guido Calderon Perez	International nurseries	34.70
Phillippines	Dr Jose E. Hernandez	International nurseries	3.50
Portugal	Dr S. Fuentes	International nurseries	10.80
	Director Estacao Nac.	International nurseries	50.00
		Barley, bread wheat, and durum wheat	34.00
Qatar	Dr Ahmed Hassan Ali	International nurseries	19.00
Saudi Arabia	Dr M. Ghandorah	Barley	49.00
	Dr Richard Cates	Barley	2.20
	Mr Zaid Al Jowaireh	International nurseries	75.10
		Bread wheat and durum wheat	20.00
		Durum wheat	1000.00*
	Dr Lakhdar Boukerrou	International nurseries	5.60
	Dr H.I. Sayed	International nurseries	25.90
Spain	Dr L. Silvela	International nurseries	18.20
	Dr Maria Luisa Granda	International nurseries	13.70
	Dr Manuel Branas Ramos	International nurseries	8.80
	Dr Antonio M. Barcena	International nurseries	5.50
	Dr J.A.M. Sanchez	International nurseries	24.30
	Dr Jorge De Juan Aracil	International nurseries	13.70
	Dr J. Hernando	International nurseries	53.00
	Dr Antonio Royo	International nurseries	5.00
	Dr Jaime M. De Espinosa	International nurseries	34.70
	Mr Tom Rauch	International nurseries	4.30
Sudan	Dr Abdalla B. El Ahmadi	International nurseries	19.30
	Dr Abdallah I.S. Mohamed	International nurseries	20.10
	Dr N. Sharaf El Din	Barley, bread wheat and durum wheat	26.00
	Dr G. Hussein Mohamedali	International nurseries	10.50
	Dr M.S. Mohamed	International nurseries	13.80
Switzerland	Dr P.M. Fried	International nurseries	2.20
Syria	Dr M. El Khash (ACSAD)	Durum, bread wheat, and barley	31.00
	Dr L.R. Morsi (ACSAD)	International nurseries	43.60
	Dr Hassan El-Ahmed	International nurseries	77.70

Tanzania	Dr R.V. Ndondy	International nurseries	5.30
Thailand	Mr S. Thanisawanyangkura	International nurseries	24.20
	Dr N. Ratanadilok	International nurseries	19.30
Tunisia	Mr Ali Maamouri	International nurseries	98.40
	Dr M. Dalloul	Durum wheat	61.00
		International nurseries	19.30
	Dr Moncef Harrabi	International nurseries	43.90
		Barley	0.25
	Dr A. Kamel	Barley, bread wheat and durum wheat	34.80
		Bread wheat	10.00
		Barley	100.00
Turkey	Dr Gurbuz Mizrak	International nurseries	221.90
		Bread wheat	2.50
	Dr H. Hiseyin Gecit	International nurseries	14.60
	Dr Necati Celik	Barley, bread wheat, and durum wheat	2535.00*
United Arab Emirates	Dr Jumma Saeed Hareb	International nurseries	53.30
United Kingdom	Dr John Peters	Barley	0.30
USA	Dr R.G. Cantrell	Durum wheat	3.50
		International nurseries	3.60
	Dr J.W. Johnson	International nurseries	1.70
		Bread wheat	3.00
	Dr E.L. Sharp	International nurseries	3.20
	Dr S.E. Ullrich	International nurseries	18.50
	Dr Howard Taylor	Barley and durum wheat	1.00
	Prof. Pat Hayes	Barley	1.00
		International nurseries	3.20
	Mr N. Nasrallah (Stud.)	International nurseries	12.00
USSR	Dr V. Kobylianskij	Durum wheat	0.20
Yemen Arab Republic	Dr Abdul Rahman Sallam	International nurseries	37.50
Yemen, PDR	Mr Ahmed Saeed Bin Jawed	International nurseries	32.60
Zambia	Dr D.M. Lungu	International nurseries	18.20

* Large shipment for seed multiplication.

J.P. Srivastava
Leader, Cereal
Improvement Program

ANNOUNCEMENT

Fellowship for Graduate - Degree Training at Montana State University (MSU), Bozeman/Montana USA

- Graduate - degree training (M.Sc.; Ph.D.) is a major component of the collaborative project on "Barley Diseases and Associated Breeding Methodologies" between ICARDA and MSU.
- Degree trainees receiving the fellowship are supposed to continue or be involved in barley disease research at their countries after their return.
- Applicants will be screened by ICARDA and MSU, but admission to MSU is a University decision.
- Interested candidates should request application forms from:

O.F. Mamluk
ICARDA, P.O. Box 5466
Aleppo/SYRIA

or

D.C. Sands
Department of Plant Pathology
Montana State University
Bozeman
Montana/USA

Forthcoming Events

The Third International Workshop on Wheat Gluten Proteins *will be held* in Budapest during 6-9 May 1987. This workshop will be of interest to scientists working on the bread-and pasta-making quality of bread and durum wheats, respectively. Papers on synthesis of seed proteins, their transport, deposition, genetics, structure and electrophoretical fractionization will be presented from all over the world. Further details can be obtained from the organizer: Dr F. Beekees, Technical University of Budapest, Department of Biochemistry & Food Technology, Muegyetem rKP 1-3, H-1111 Budapest, Hungary. Telex: 225931 MUEGY H.

The Fourth Conference of the Australian Society of Agronomy will be held at La Trobe University, Melbourne, Victoria, between 24-27th August 1987. This conference provides a forum for all agronomists and papers will be accepted on all aspects of agronomy. However, there will be no distinct theme as such. Four to six invited reviews of major subjects will be presented at the conference. They will be published in full in the proceedings. Scientists interested in presenting papers on any aspects of the science and practice of production and utilization of pastures, field crops and horticultural crops should write for further details to: Mr D. Rooney, Secretary, Aust. Society of Agronomy, P.O. Box 1322L, Melbourne 3001, Victoria, Australia.

The Sixth International Course for Development-Oriented Research in Agriculture will be held in Wageningen, Netherlands from 19 January to 8 August 1987. Those interested in attending this course may write for further details to: International Course for Development Oriented Research in Agriculture (ICRA), P.O. Box 88, 6700 AB Wageningen, Netherlands.

A Training Course on Tissue Culture Technologies and Laboratory Practices will be held at the Colorado State University from 2 March to 21 August 1987. The course is mainly geared to training technicians working in tissue culture laboratories and may be of special interest to institutions hoping to move in to this field. For further details write to: Director of Admissions, Plant Biotechnology Training Center, Tissue Culture for Crops Projects, Colorado State University, Fort Collins, Colorado 80523, USA.

The Tenth Science Meeting of the Lebanese Association for the Advancement of Science (LAAS) will be held in Beirut, Lebanon from 19-21 March 1987. Scientists wishing to participate in the meeting may write to: LAAS, P.O. Box 13-5224, Beirut, Lebanon.

An International Symposium on Elemental Sulphur in Agriculture is being organized in France from 25-27 March 1987. More details can be obtained from Dr A. Carpentier, Le Syndicat de la Raffinerie du Soufre Francaise, 32 La Canebiere, 13231 Marseille, Cedex 1, France.

The Australasian Plant Pathology Society *will hold its* annual meeting from 11-14 May 1987. Plant pathologists interested in attending the meeting can get more information from: Dr G.E. Walker, Department of Agriculture, London Research Centre, P.O. Box 411, Loxton, Southern Australia 5333, Australia.

An International Conference on Quantitative Genetics will be held in the United States from 31 May to 5 June 1987. The conference secretary is Dr B.S. Weir, P.O. Box 8203, N. Carolina State University, Raleigh, North Carolina 27695-8203, USA.

The Fourth European Congress on *Biotechnology* is being held in the Netherlands from 14-19 June, 1987. For more details contact: KIVI Prinsessgracht 23, NL 2500 GK, The Hague, Netherlands.

The Fourteenth International Botanical Congress will be held in West Berlin from 24 July to 1 August 1987. Papers on all aspects of botanical research are invited. The secretariat for the congress is located at: International Botanical Congress, Botanischer Garden und Botan. Museum, Koligin-Luise Street 6-8, D-1000 Berlin 33, Federal Republic of Germany.

CONTRIBUTORS' STYLE GUIDE

Policy

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

Editing

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

Disclaimers

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

Manuscript

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

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

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

Examples of common expressions and abbreviations

3g, 18 mm, 300 m^2, 4 Mar 1983; 27% ; 50 five-day old plants; 1.6 million; 23 µg; 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.

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

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