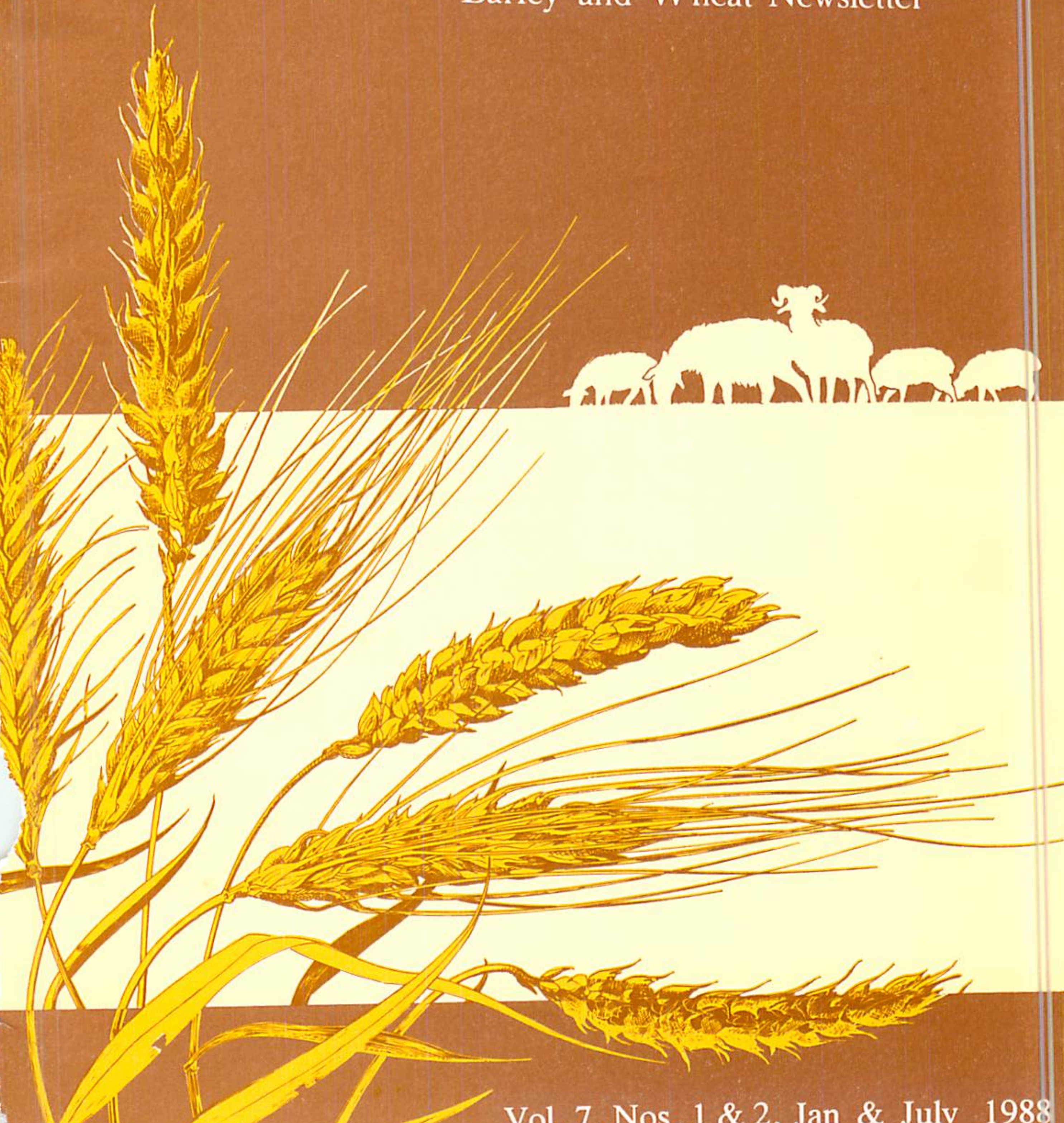
RACHIS

Barley and Wheat Newsletter



Vol. 7, Nos. 1 & 2, Jan & July 1988

ISSN 0255-6421

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.

RACHIS
Barley and Wheat Newsletter

Vol. 7, Nos. 1 & 2,
Jan & July 1988

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

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

CONTENTS

Editorial

Diseases are among the limiting factors which reduce cereal yield in many areas of the world. Fungal diseases, which form the most important disease group, have attracted attention and intensive research over the last century. On the other hand, virus diseases of cereals did not attract serious attention until the last decade. Among the cereal viruses, barley yellow dwarf virus (BYDV) is recognized as the most important disease worldwide.

Until the late 1970s little was known of the worldwide importance of BYDV. The multiple hidden effects of BYDV tolerance were also little known. The serological method ELISA allowed scientists to draw a rather precise map of the prevalence of the disease. It is now known that BYDV is a serious problem of cereal crops in several locations in North and East Africa as well as other areas of the world (China, Italy, Chile, Brazil, etc.). The virus attacks oat, wheat, barley, rice, and maize. The sensitivity level of most cultivars of barley, durum wheat, and bread wheat is well assessed from natural epidemics as well as artificial inoculation.

An international effort is being made to identify sources of resistance to BYDV. CIMMYT and ICARDA, in cooperation with research institutions in Canada, USA, Italy, and other countries, are involved in producing genetic material with BYDV resistance, which will be available to breeding programs in national research systems. So far, good resistance sources have been identified in barley, to a lesser extent in wheat, but very few in durum wheat. More research is needed in this area. In particular, cereal wild species should be assessed for higher levels of resistance which, if identified, could be transferred into cultivated species. The improved *in vitro* techniques now available to the breeders and the recent progress in biotechnology could greatly contribute to meeting that objective.

Review Article

Recent Progress in Barley Yellow Dwarf Virus Research: Interactions with Diseases and Other Stresses

A. Comeau
Agriculture Canada
Saint-Foy, Quebec
CANADA
and
Khaled M. Makkouk
Genetic Resources Program
ICARDA, P.O. Box 5466
Aleppo, SYRIA

Barley yellow dwarf virus (BYDV) occurs on cereals worldwide, but its economic importance was not acknowledged until recently. The symptoms induced by BYDV on wheat and barley have made it difficult to diagnose. The development of sensitive serological methods over the last few years have allowed accurate and rapid identification of BYDV, and also provided information on the strains involved. Information on yield losses induced by BYDV infection led scientists to believe that it should be considered as one of the principal virus diseases of cereals.

Genetic resistance is generally considered as being the most practical means of reducing losses inflicted by the virus. In order to breed resistant cultivars, sources of resistance must be identified. The Quebec IDRC-sponsored project on BYDV was initiated for that purpose. Specifically, it aims at finding and evaluating new sources of tolerance or resistance for use by breeders at CIMMYT and ICARDA. This project was extended from 1986 to 1989 to cover direct needs in West Asia, North Africa, and Chile. Surveys of BYDV incidence in these areas were conducted recently using the ELISA method. The surveys showed that BYDV should be considered as a serious problem in North Africa, and should receive more attention.

In this paper, we summarize results obtained on interaction between tolerance to BYDV and reaction to other biotic and abiotic stresses in cereals, and based on this information, we suggest possible approaches for breeding tolerant cultivars.

Genetic Variability for BYDV Reaction

Barley, durum wheat, and bread wheat differ greatly in their variability for BYDV tolerance/resistance. In trials in Quebec and Syria, little useful genetic variation was found in durum wheat (*Triticum turgidum* L. var. *durum*). In bread wheat (*Triticum aestivum* L.) trials on ICARDA Bread Wheat Crossing Block 1986-87, there was some genetic variation, and the best line from the Quebec project (IAS-20) was also the best one in a more recent trial in Syria. In barley (*Hordeum vulgare* L.), diverse reactions were found in both Quebec and Syria. In both sites, the barleys possessing the Yd_2 gene (a gene from Ethiopian barley which confers BYDV resistance) were the best. In Syria, the barley cultivar Tadmor had an intermediate tolerance, but this line is devoid of Yd_2. The best lines had symptom scores between 1 and 3; while the worst, Arabi Abiad, was rated 8.0. Although infection in the Quebec trial was more severe, no conflicting conclusions emerged from a comparison of the barley trials in Quebec and Syria (Table 1). There are exceptions to this correlation. For example, the wheat cultivar Anza was found to be BYDV-tolerant in California, Mexico, Syria (near Aleppo), and also at La Pocatiere on a clay soil in Quebec. However, the same line is quite susceptible on a light soil type near Quebec City.

BYDV Interaction with other Diseases

At the 1987 CIMMYT BYDV Workshop in Udine, Italy, the consensus was that when BYDV predisposes a cereal plant to damage by fungal diseases or aphids, or to damage by drought, heat, or cold, then a part of the damage should properly be attributed to the predisposing factor, which is BYDV. In the case of certain fungal diseases, most of the damage is actually BYDV-dependent and the damage could be almost entirely attributed to the virus. For example, *Fusarium* root

Table 1. BYDV reaction of selected barley lines in Quebec, Canada, and in Syria.

Lines	Yd_2 [a]	Barley row-type	Symptom score[1]				
			Syrian trials				Quebec trials
			Tel Hadya 1987	Lattakia 1988	Tel Hadya 1988	Plastic house	
8081 BCQB-10	+	6			3		4.0
BKL 87-115	?	6	3	4	6	3	6.0
87-256	+	6	3	4	5	3	5.0
Dorada	+	6			4		4.2[b]
Corris	+	2			4		5.2
Shannon	+	2			3		6.2
BKL 85-237	+	2			3		5.3
Arabi Abiad	-	2		7	8		8.0[b]
Tadmor	-	2		6	6		
Susceptible check (Harmal)	-	2					8.0
Susceptible check (850L303)	-	6					9.0

1 Symptom score: 0 = healthy, 5 = moderately sensitive, 9 = very sensitive and dead before heading.
a Presence of Yd_2, as evaluated visually in very severe BYDV trials in previous years.
b Evaluated by interpolation through comparison with common checks.

rot of oats disappeared almost entirely from the province of Quebec, Canada, when very susceptible oat cultivars were replaced by lines with moderate tolerance to the virus. *Fusarium* root rot is generally not very aggressive in farmers' fields, however, in experiments between 1972 and 1974, 50-65% of the plants became infected in plots artificially inoculated with BYDV. This fungal disease is therefore an example of one that has apparently been controlled by breeding for tolerance to BYDV which was the hidden causal factor. *Alternaria* spp. are other organisms that are essentially non-aggressive in absence of BYDV.

Other clear-cut examples are less easy to find because most cereal diseases possess some aggressiveness in the absence of BYDV. However, there is field evidence on the ecological interaction of BYDV with many fungi. For example, epidemics of *Septoria avenae* in Canada were considered a serious disease of oats when BYDV-sensitive cultivars were grown, from the early days until about 1976. These cultivars were replaced by new ones that were less BYDV-sensitive during the period 1977-1980. Since that time only limited damage by BYDV and *Septoria* has been observed. However, the new cultivars are not different from the old ones when sprayed with *Septoria* inoculum in controlled conditions. The only logical explanation is that BYDV most likely predisposed oats to *Septoria* by increasing the reproductive rate of the fungus (Pelletier *et al.* 1974). By breeding for high BYDV resistance, this virus-fungus interaction has been brought below the economic damage threshold.

Similar phenomena exist in bread wheat, durum wheat, and barley, but the research data has not yet been published in most cases. In Australia, BYDV was shown to have a synergistic effect with take-all in reducing yield (Sward and Kollmorgen 1989). In the USA and Canada, results showed that BYDV induced more root rot in winter wheat. In Quebec and Ontario, it was shown that the winter-kill of winter barley was partly explained by the level of BYDV sensitivity in more than 3 years out of 10. In Quebec, the recent cultivar OAC Elmira from Ontario shows better winter-survival than all checks. No significant cold tolerance was detected in this line, but it was tolerant to BYDV, which could explain its better survival.

In winter cereals, we are currently observing interactions between snow mold and BYDV in eastern Canada. One of the best survivors is OAC Wintri triticale in northern areas; it seems that its high BYDV tolerance enhances its survival even in presence of high snow mold levels that kill other winter triticales and winter wheats.

In Canada, it was recently observed that 'hot-spots' of BYDV coincide with 'hot-spots' of *Septoria tritici* in spring durum and in winter bread wheat. This phenomenon was also observed in recent cereal nurseries distributed by ICARDA. However, there is generally no correlation between *Septoria tritici* symptoms and BYDV symptoms on current cultivars, which are not BYDV tolerant. Under natural *Septoria* epidemics it is very difficult to take symptoms score on BYDV, except in cases where BYDV infection was early, severe, and uniform. Such conditions are rare except in special trials where seeding dates and other practices have been altered to increase BYDV damage. If symptoms of BYDV infection occur after the boot stage, they may be mistaken for normal plant senescence; whereas invisible damage and predisposition to fungal disease may occur 10 to 15 days earlier. This is why samples of *Septoria* infected plants should always be taken for BYDV detection by ELISA. The same procedure could be applied to epidemics of other fungi suspected to develop faster on BYDV-infected plants.

From available information, it is evident that BYDV tolerance alone would not be sufficient to eradicate *Septoria tritici*. It seems however that hybridization of BYDV-tolerant lines with lines resistant to *S. tritici* would be a most logical approach to produce tolerant lines to both pathogens. Only one line of durum wheat is presently qualified as "moderately tolerant to BYDV" in the Quebec project, which is certainly not sufficient to launch a serious breeding program. In contrast, several bread wheat lines possess good BYDV tolerance, occasionally accompanied by known resistance to *Septoria*. Simultaneous BYDV and *Septoria* epidemics reflect the reality of a complex ecological interaction. Resistance to both the virus and the fungus should be systematically transferred to more cultivars. In Quebec, it was recently realized that in selecting BYDV-tolerant bread wheat, several lines that displayed good resistance to *Septoria* were accidentally produced. Some of the useful genes might therefore be linked.

Trials on the interaction of BYDV with head scab (*Fusarium roseum*) showed that when BYDV infection occurs early, there is significantly more scabby kernels in BYDV-susceptible bread wheat than in BYDV-tolerant ones (Croullebois and Comeau, unpublished). It seems more than mere coincidence that the best BYDV-tolerant wheat, IAS-20, was recently used with success as a parent for scab resistance (Bekele *et al.* 1988) although this line is not in itself highly scab resistant (Luzzardi 1985).

In one trial in Quebec, the incidence of oat leaf rust was slightly decreased on oats artificially inoculated with BYDV (Pelletier *et al.* 1974). In contradiction to this result, the important leaf rust strain PC-59 was often more abundant on the most BYDV sensitive oat lines in northeastern USA (Comeau 1988b). Considering this new evidence, there is now a need for more research on rust-BYDV interactions in all cereal species.

BYDV Interactions with Abiotic Stresses

Drought

BYDV invades roots as well as aerial parts, but the damage on roots can be enormous in some lines such as barley line 85 0L303. Not only is roots growth reduced but their ability to function is also impaired. Therefore, BYDV causes reduction of uptake of water and minerals, which in turn reduces resistance to other abiotic stresses. Part of the drought damage should be attributed to BYDV which reduces the root system. The relative importance of BYDV versus drought may vary, but the "drought plus BYDV" combination is always devastating. Moderate BYDV tolerance is not enough to protect plants when drought reaches a critical level; while, plants combining enough BYDV tolerance with some true drought tolerance will continue to grow.

It is worthwhile to note that some of the best BYDV-tolerant lines appear to possess drought resistance. In triticale, Muskox 658 and Merino 274 possessed this useful dual resistance. Other examples of multiple resistance in bread wheat and barley are given in Tables 2 and 3. The barley cultivar Birka is very sensitive to BYDV in Quebec and yields poorly when BYDV is accompanied by lack of rain. The ICARDA barley cultivar Tadmor, known for its drought tolerance, showed better BYDV tolerance than most other lines that were devoid of the Yd_2 gene in Tel Hadya in 1987-88. In oats, the widely grown cultivar Ogle displays BYDV tolerance and some drought tolerance; both traits are heritable but not entirely linked. From all available evidence, simultaneous selection for drought and BYDV tolerance would seem to be a promising field of research. Selection for tolerance to both stresses may favor better root systems and increased water-use efficiency.

Mineral stresses

Mineral deficiencies observed in BYDV-infected plants usually are the result of BYDV infection rather than the cause of damage. The damaged root system of BYDV-infected oat plants did not allow proper assimilation of N, P, and K (Comeau and Barnett 1979).

Some wheat plants possess a better-than-average ability to extract minerals from the soil, especially phosphorus in the case of some Brazilian wheats. Many

Brazilian wheat cultivars also have roots resistant to acid soil and excess of aluminum. It is striking that a large number of the best BYDV-tolerant lines in the Quebec project were found to also have resistance to acid soil (Table 2). although initial selection was made at a soil pH of about 6.0, which is good for bread wheat. The aggressive root system of these lines may have contributed to improved BYDV tolerance by better root growth throughout the soil profile. The correlation between BYDV tolerance and vigorous root system may have the strongest practical implications.

BYDV and Aphid Damage

BYDV-infected sensitive cereal plants often have higher levels of amino-acids in the phloem sap because of impaired translocation (Comeau 1988a). As a result, the insect reproduces much more rapidly on BYDV-infected plants than on healthy plants. In response to crowding, alates are produced, and migration follows. In humid, cool, and windy days, daily migration may go beyond 100 kilometers.

Table 2. Examples of multiple disease and stress tolerance in bread wheat.

		Disease				Stress	
Reference	Name/cross	BYDV	*Septoria* spp.	Spot blotch (*Helminthosporium*)	Scab	Acid/ poor soil	Drought
a	BH1146	VT*	MR	R		MR	
d	Colonias	T	R			MR	
b,c	Thornbird "S"	T	R		R	MR	
b	Alondra "S"	T	R			MR	
g	82PCH 766= (Monocho/Alondra)	T					R
g	8182 PCH 713 = (E7408-PAMX HORK-PF73266)	T			MR		
g	Londrina	T			MR		
g,h	IAS-20	VT	MR		MR	VR	
g,h	Maringa	VT	MR		MR	VR	
g	Mascarenhas	VT	MR				
g	Dove-Tsi "S"	T					R
f	Anza	T					R
g	CM 66246	VT					R
g	IAS-54	T				VR	
g	IAS 58 X (KAL-BBXCJ-ALD)"S"	VT				R	MR[i]
g	COC-BJY X NAC-BUC"S"	VT					MR[i]
g	CMH 80, 278	VT				R	
g	CMH 78, 443	VT				R	
g	PFT 70354-BOW	VT				R	
g	PFT70354-Ald	VT				R	
g	RPB709.71-COC	VT		MR			
g	GOC-PCI/CEE"S"	VT	MR				R
e	IAC-51	VT					VR
e	IAC-60	VT					VR
e	IAC-68	VT					VR

a Villareal *et al.* 1985.
b CIMMYT 1983.
c CIMMYT 1985.
d Hanson *et al.* 1982.
e Camargo *et al.* 1985.
f Ehdaie *et al.* 1988.
g Evidence from Comeau and St-Pierre BYDV trials, 1987.
h Miller *et al.* 1985, and personal communication with Miller.
i Earliness in those lines is potentially useful for drought avoidance.
* VT = very tolerant, T = tolerant, R = resistant, MR = moderately resistant, VR = very resistant

Table 3. Examples of multiple disease and stress tolerance in barley.

Reference	Name/cross	Disease: BYDV	Stem rust	Stripe rust	Leaf rust	Mildew	Scald	Net blotch	Stress: Acid soil	Drought
a	Gloria/Come = CMB81-0294	R	R	R	R		R			
a	Gloria/Copal = CMB81-0295	R	R	R	R		R			
b	8th IBON 32	R				R	R	R		
a	Tadmor	MR					R			R
c	Chapais	MR				MR	R		R	MR

a ICARDA 1987.
b CIMMYT 1981.
c Comeau and St-Pierre 1987.

In controlled trials, scientists from the UK showed that large numbers of virus-free aphids can cause damage by themselves. For example, 10 or more aphids per head impede grain filling. However, aphids often come from BYDV infected fields some distance away. These can cause direct aphid damage plus BYDV damage to the root system. BYDV-tolerant crops could theoretically reduce the importance of aphid migration, but this is a long-term hope. Other aphid flights may originate from virus-free grasses. BYDV-tolerant crops could at least reduce *in situ* aphid multiplication and prolong root activity.

BYDV Interactions with Root Length

Semi-dwarf cultivars usually have short roots. In normal growing conditions, it has been shown (Mackey 1988) that oat plant height was correlated with root depth ($r = 0.50$, $P < 0.001$), and weight of shoots was correlated with weight of roots ($r = 0.87$, $P < 0.001$). Similar relationship was also reported in bread wheat (Mackey 1973).

In preliminary trials in Quebec, BYDV was found to have a devastating effect on root length of susceptible barley cultivars, confirming similar observations on various cereals in the USA (Kainz and Hendrix 1981). Little success was achieved in our attempts to create BYDV-tolerant semi-dwarf cereal cultivars in Quebec. This may be related to the cumulative root-dwarfing effects due in part to the dwarfing genes and in part to the root starving effect of the virus (Comeau and Jedlinski 1988). In Quebec BYDV-infected trials of 1987, the best dwarf oat yielded 2284 kg/ha; the best tall oat, 5208 kg/ha; the best dwarf barley (CM72), 3622 kg/ha; the best tall barley, 6755 kg/ha; the best CIMMYT-bred dwarf bread wheat, 2030 kg/ha (Ciano 79); and the best tall bread wheat, 3339 kg/ha (IAS 20). However, the Quebec project also allowed the selection of a few exceptional semi-dwarf bread wheat cultivars which yielded up to 3333 kg/ha in the same screening trial. The BYDV tolerance of some of these lines was confirmed in BYDV trials in Tel Hadya, Syria. Therefore, it may be feasible to create moderately short plants with good BYDV tolerance when using the appropriate parental lines and severe screening.

Complex Interactions

We have explained how BYDV may increase the reproductive rate of aphids by modifying plant sap. BYDV also interferes with the deposition of cell wall constituents (Harper *et al.* 1976), making the plants more fragile and subject to seed shattering.

Triple interactions involving virus, aphids, and fungi, are common; climate should be considered as the fourth component. Aphids can carry fungal spores around (Fuentes and Exconde 1969; Huang *et al.* 1981). Moreover, aphids move to floral parts at flowering, and the sticky honeydew may act as a "spore trap" to further increase fungal attack. Plant height reduction by BYDV may be in itself a further cause of increased fungal attack, for example by *Fusarium* and *Septoria* (Couture 1982; Tavella 1978).

Breeding for Multiple Stress Resistance

Diseases cause stress to plants just the same way as abiotic factors, by impairing normal photosynthesis, translocation, and growth. We have discussed relationships among various biotic and abiotic stresses; scientifically dealing with these one by one, ignoring interactions, is a simplistic and unrealistic approach.

As the deep physiological disturbances created by BYDV favor increased levels of aphids and fungi, and reduce resistance to abiotic stress, selection based on two or more stresses would be more efficient. Parents with multiple resistance genes exist (Tables 2 and 3), and should be used. The progeny from F2 to F6 should be treated in such a way as to recover the resistance and tolerance genes in the progeny. This can be facilitated by artificial BYDV inoculation, and alternately planting at stress sites and in key disease locations during these five years. Artificial fungal infection would also be useful. Shuttle-type breeding projects could be built on the above principles. The approach may seem complex, but it is not necessarily so; it does however require collaboration between scientists.

It is not implied that BYDV resistance or tolerance genes are identical to fungal resistance genes. These are separate factors. However, it may not be just mere coincidence that the current check cultivar for spot blotch resistance, BH1146, also has a very good tolerance to BYDV (Villareal *et al.* 1985). This pyramiding of genes is probably the result of selection by Brazilian scientists under natural multiple stress conditions which included BYDV.

Breeding for aphid resistance is not an easy research goal in itself, but could become part of a multiple stress breeding project. Resistance to *Rhopalosiphum padi*, which is the key vector of BYDV in many countries, is difficult to find, but it does exist (Weibull 1987; Comeau 1988a).

References

Bekele, G., Singh, R.P. and Alcala, M. 1988. Results of the first international Scab Resistance Screening Nursery (SRSN), 1985-86. Mexico D.F.

Camargo, C.E. de O., Felicio, J.C., Freitas, J.G. de, Barros, B. de C., Castro, J.L. de and Sabino, J.C. 1985. Breeding wheat. XII. Performance of new lines and culitvars in Sao Paulo State. Bragantia 44: 669-685.

CIMMYT (Centro Internacional de Mejoramento de Maiz y Trigo). 1981. Results of the eight international barley observation nurseries. CIMMYT, Mexico.

CIMMYT (Centro Internacional de Mejoramento de Maiz y Trigo). 1983. CIMMYT report on wheat improvement. CIMMYT, Mexico.

CIMMYT (Centro Internacional de Mejoramento de Maiz y Trigo). 1985. Research highlights. CIMMYT, Mexico.

Comeau, A. 1988a. La resistance aux pucerons: aspects theoriques et pratiques. [Aphid resistance: Theoretical and practical aspects.] *In* Principes et applications de lutte biologique (Vincent, C. and Coderre D., eds) (in press).

Comeau, A. 1988b. Tolerance of oats to barley yellow dwarf. *In* Proceedings of the Third International Oat Conference, Lund, Sweden (in press).

Comeau, A. and Barnett, G. 1979. Effect of barley yellow dwarf virus on N, P, K fertilizer efficiency and on the harvest index of oats. Canadian Journal of Plant Science 59: 43-54.

Comeau, A. and Jedlinski, H. 1989. Successful breeding for barley yellow dwarf virus resistance: a systematic approach related to other agronomic characteristics. *In* Barley Yellow Dwarf, Proceedings of the Workshop, 1987, Udine, Italy (in press). CIMMYT, Mexico.

Comeau, A. and St-Pierre, C.-A. 1987. Trials on the resistance of cereals to barley yellow dwarf virus. Report no. 9, Agriculture Canada, Quebec.

Couture, L. 1982. Receptivite de cultivars de cereales de printemps a la contamination des graines sur inflorescence par les *Fusarium* spp. Canadian Journal of Plant Science 62: 29-34.

Ehdaie, B., Waines, J.G. and Hall, A.E. 1988. Differential responses of landrace and improved spring wheat genotypes to stress environments. Crop Science 28: 838-842.

Fuentes, F.D. and Exconde, O.R. 1969. Etiology of spot blotch of barley in the Philippines. The Philippines Agriculturist 52: 483-504.

Hanson, H., Borlaug, N.E. and Anderson, R.G. 1982. Page 89 *in* Wheat in the Third World. CIMMYT, Mexico. 174 pp.

Harper, A.M., Atkinson, T.G. and Smith, A.D. 1976. Effect of *Rhopalosiphum padi* and barley yellow dwarf virus on forage yield and quality of barley and oats. Journal of Economic Entomology 69: 383-385.

Huang, H.C., Harper, A.M., Kokko, E.G. and Howard, R.J. 1981. Aphid transmission of *Verticillium albo-atrum* to alfalfa. Canadian Journal of Plant Pathology 5: 141-147.

ICARDA (International Center for Agricultural Research in the Dry Areas). 1987. Cereal improvement program, annual report for 1987. Aleppo, Syria.

Kainz, M. and Hendrix, W. 1981. Response of cereal roots to barley yellow dwarf virus infection in a mist culture. Phytopathology 71: 229 (abstr).

Luzzardi, G.C. 1985. Wheat breeding for scab resistance. Pages 158-168 *in* Wheats for More

Tropical Environments, A Proceedings of the International Symposium, UNDP/CIMMYT, 24-28 Sept 1984, Mexico, DF. CIMMYT, Mexico. 354 pp.

Mackey, J. 1973. The wheat root. Pages 827-842 *in* Proceedings of the Fourth International Wheat Genetics Symposium, Missoury Agrigricultural Experiments Station, Columbia, USA.

Mackey, J. 1988. Shoot:root interrelations in oats. Proceedings of the Third International Oat Conference, Lund, Sweden (in press).

Miller, D.J., Young, J.C. and Sampson, D.R. 1985. Deoxynivalenol and *fusarium* head blight resistance in spring cereals. Journal of Phytopathology 113: 359-367.

Pelletier, G.J., Comeau, A. and Couture, L. 1974. Interaction entre le virus de la feuille rouge de l'avoine (BYDV), *Septoria avenae* et *Puccinia coronata* sur *Avena sativa*. Phytoprotection 55: 9-12.

Sward, R.J. and Kollmorgen, J.F. 1989. The effects of the interaction of barley yellow dwarf virus and take-all fungus on the growth and yield of wheat. *In* Barley Yellow Dwarf, Proceedings of the Workshop, 1987, Udine, Italy (in press). CIMMYT, Mexico.

Tavella, C.M. 1978. Date of heading and plant height of wheat varieties, as related to *Septoria* leaf blotch damage. Euphytica 27: 577-580.

Villareal, R.L., Rajaram, S., and Nelson, W. 1985. Breeding wheat for more tropical environments at CIMMYT. Pages 89-99 *in* Wheats for More Tropical Environments, A Proceedings of the International Symposium, UNDP/CIMMYT, 24-28 Sept 1984, Mexico, DF. CIMMYT, Mexico. 354 pp.

Weibull, J. 1987. Work on plant resistance to *Rhopalosiphum padi* L. in oats and barley-present status. Bulletin SROP 10: 160-161.

Research and Production

Tritordeum: the First Ten Years

A. Martin
C.S.I.C.
E.T.S.I. Agronomos
Apdo 3048
14080 Cordoba, Spain

Alloploidy has exerted a major influence on the evolution of higher plants. Man has exploited this mechanism in plant breeding, either directly by synthesizing new crops or indirectly by interchanging genetic material among species. In spite of that, there is no match between the importance of alloploidy in nature (Stebbins 1971) and the results obtained in plant breeding through exploitation of alloploidy. However, the poor results obtained so far in the synthesis of new species should not discourage plant breeders. The use of alloploidy should not be expected to yield new species combining the positive attributes of the two parental species. However, it may help improve the adaptation and yield potential of these species.

The tribe Triticeae is a plant group which can be successfully used to test this hypothesis for many reasons: it includes genera of great agronomical value such as *Triticum*, *Hordeum*, and *Secale*; it is a polyploid complex in which crosses among different genera are possible: and it comprises the first man-made crop, triticale (X*Triticosecale* Wittmack).

It is remarkable that the first amphiploid of agronomical value in the Triticeae arose when two distant genera (*Triticum* and *Secale*) where crossed. None of the previous ones involving *Triticum* and its most closely related genus *Aegilops* had similar success. The vigor of the new plant attracted plant breeders' attention, and, today, triticale can be counted among the cultivated plants.

Hordeum is genetically more distant than *Secale* from *Triticum*. Crosses are more difficult to achieve, but if the trend found in .crosses with *Secale* works out, one would expect a higher hybrid vigor in the resulting amphiploids.

Plant breeders have long been interested in barley-wheat crosses (Shepherd and Islam 1981). Although all previous attempts to produce fertile amphiploids from crosses between cultivated wheats and cultivated barley (*H. vulgare*) have failed, we were able to produce the first fertile amphiploid by crossing a wild barley from South America, *H. chilense*, with cultivated wheat and named it Tritordeum (Martin and Cubero 1981).

Hexaploid Tritordeum

Following the track of triticale breeders we concentrated on developing hexaploid tritordeum, the amphiploid derived from the cross *H. chilense* x *T. turgidum* ssp. When comparing the hexaploid tritordeum with primitive triticale, we noticed the high potential of this new species, which in many aspects (dwarf stature, many florets per spike, and small leaves) approaches Donald's (1968) wheat ideotype.

Primary tritordeum, unlike triticale, has long and non-shrivelled grains. In comparison with parental wheat, plants are taller and possess more spiklets/spike. But aneuploidy rate is lower than in primary triticale (Padilla and Martin 1986). Some characters of primary hexaploid tritordeum and their wheat parentals are shown in Table 1.

The most interesting character of hexaploid tritordeum is perhaps its high protein content which does not result from grain malformation (Tables 1 and 2). Virdi an Larter (1984) have shown that when parentals with high protein content are used in the synthesis of primary triticale, these primary triticale are never superior in protein content to their parents. This is not the case of tritordeum whose protein content always exceeds that of the parental wheat. However, this increment is greater when the parental wheat has a higher protein content (Table 1).

Once the first two hexaploid tritordeum were produced (CHCOC and CHMA), we made a cross and started a pedigree selection program. The performance of the best six tritordeum lines derived from this cross are given in Table 2. These results were consistent over years and locations. However, it was noted that when the duration of grain filling is longer than normal, the yield of tritordeum is higher, with no

Table 1. A comparison of seven primary hexaploid tritordeums with their wheat parents.

Tritordeum and parental wheat	Plant height cm)	Spikelets per spike	Tillers number	Flag leaf width (cm)	Flag leaf length (cm)	Days to flowering	Seed weight (mg)	Protein content (%)	Aneuploidy (%)
CHDES	132 ±2.9	36.4 ±2.0	43.2 ±4.5	1.52 ±0.6	20.4 ±0.1	155 ±0.6	22.1 ±1.0	28.7	7.5
T. dicoccoides	174 ±12.1	30.0 ±0.6	34.5 ±1.5	2.25 ±1.3	36.0 ±0.1	145 ±1.1	50.0 ±1.6	15.8	
CHGEOR	118 ±2.5	43.2 ±0.4	23.2 ±2.2	1.50 ±0.9	23.2 ±0.1	164 ±1.1	20.6 ±0.7	24.6	7.5
T. georgicum	157 ±2.4	41.7 ±1.3	27.0 ±3.5	2.07 ±1.3	36.9 ±0.1	160 ±1.2	44.4 ±1.1	16.5	
CHPOL	117 ±2.0	31.6 ±0.6	27.4 ±3.3	1.92 ±1.4	26.3 ±0.1	152 ±1.1	44.2 ±0.9	24.1	11.4
T. polonicum	184 ±2.3	31.0 ±0.9	15.3 ±0.9	2.83 ±3.5	40.0 ±0.1	148 ±1.1	92.4 ±1.8	17.6	
CHCOC	87.2 ±0.9	28.0 ±0.7	11.0 ±1.4	1.60 ±0.7	19.9 ±0.0	138 ±1.1	44.2 ±1.9	17.6	17.1
Cocorit	94.1 ±0.8	20.0 ±0.6	24.3 ±0.7	2.60 ±1.1	36.9 ±0.1	126 ±0.9	71.3 ±2.5	12.9	
CHMA	83.4 ±0.2	32.0 ±1.1	19.8 ±2.9	1.96 ±1.1	24.3 ±0.1	151 ±1.1	42.7 ±0.6	22.4	18.2
MA	99.3 ±0.4	28.3 ±0.8	21.0 ±2.1	3.1 ±2.1	40.8 ±0.1	141 ±1.3	70.5 ±0.1	13.8	
CHGE	73 ±3.7	31.2 ±0.7	13.2 ±3.6	1.82 ±0.4	23.3 ±0.1	148 ±0.6	29.6 ±0.7	25.1	23.5
Gerardo	90 ±2.6	24.0 ±1.0	12.5 ±0.5	2.55 ±3.7	33.7 ±0.1	137 ±2.0	68.8 ±1.2	14.5	
CHJE	125 ±4.9	31.8 ±0.2	17.6 ±2.8	2.00 ±1.7	28.8 ±0.1	151 ±0.9	39.5 ±1.8	27.6	22.9
Jerez	155 ±0.7	26.5 ±0.5	13.5 ±1.5	2.50 ±1.9	44.5 ±0.1	144 ±1.0	89.8 ±3.4	13.8	

Table 2. Grain yield (t/ha), grain protein content (%), test weight (kg/hl), and 1000-kernel weight (g) of six recombined tritordeum lines and six bread wheat cultivars.

Line/cultivar	Grain yield (t/ha)	Protein content (%)	Test weight (kg/hl)	1000-kernnel weight (g)
Tritordeum				
HT-3	0.78	22.3	70	30.79
HT-4	0.99	22.4	69	31.89
HT-5	1.11	25.4	67	28.65
HT-6	1.28	21.0	68	31.24
HT-7	0.85	22.7	69	30.66
HT-8	0.96	21.0	69	30.22
Bread wheat				
Ciano 79	5.82	13.1	79	36.14
Tyrant 'S'	5.42	13.4	80	39.83
Weathon	5.05	14.2	81	40.99
Marcos Juarez	5.14	14.7	81	44.45
Alta 81	5.48	13.3	79	39.11
Almansor	5.94	13.1	82	48.84

change in protein content. In general, the yield of these lines is around 20% that of bread wheat, with a test weight similar to that of a good triticale and a grain protein content twice as high as that of wheat.

One of these recombined tritordeum lines (HT8) was crossed with a secondary octoploid tritordeum derived from a cross between a different accession of *Hordeum chilense* and *Triticum sphaerococcum*. The octoploid tritordeum had a protein content quite similar to that of the wheat parental *T. sphaerococcum*. Selection in this cross was made following a single-seed-descendent scheme. The performance of the best six lines derived from this cross is shown in Table 3. The grain yield of these six lines is about 60% that of wheat, while total dry matter production was superior in some cases. Some lines (not included in Table 3) reached a harvest index equal to that of wheat. The protein content of the lines selected for high yield is lower than that of previous tritordeum lines. It is still not known whether this low protein content results from the yield improvement, the effect of the low protein content of one of the parents (the secondary tritordeum), or both.

The response to selection and the characteristics of the arising material clearly indicates the high potential of this new species, especially if we

Table 3. Dry matter yield (t/ha), grain yield (t/ha), harvest index, and protein content (%) of six selected lines of secondary tritordeum compared with those of bread wheat.

Line	Dry matter yield (t/ha)	Grain yield (t/ha)	Harvest index	Protein content (%)
Tritordeum				
HT33	13.15	3.04	0.23	
84	9.02	2.80	0.31	
350	12.72	2.96	0.23	17.7
342	12.17	2.78	0.23	15.8
445	10.54	2.78	0.26	
HT32	12.72	3.72	0.29	16.0
Wheat	12.50	5.00	0.40	13.0

consider that, until now, genetic variability was derived from only two barleys and three wheat parents.

Octoploid Tritordeum

All produced tritordeums, whether they were octoploid (Martin and Chapman 1977) or hexaploid (Martin and Sanchez-Monge 1979), had in common the same *H. chilense* accession as female parent in the initial cross. However, the evolution of fertility after chromosome doubling was quite different in the two cases. The octoploid tritordeum (with Chinese Spring as male parent) lost fertility on the second generation after chromosome doubling while no decline in fertility was observed in the hexaploids. This was the main reason for devoting our attention initially to the hexaploid tritordeum. However, when a different accession of *H. chilense* was used as female in the synthesis of octoploid tritordeum, a completely different result emerged. Using *T. sphaerococcum* and an advanced wheat line (ST4) as male parents, we obtained octoploid tritordeums which were superior to their wheat parents in certain traits. The results of a greenhouse experiment comparing an octoploid tritordeum with its wheat parental are shown in Table 4. After five generations of selfing, no decline in fertility has been observed. The fertility of the octoploid tritordeum is superior to that of any hexaploid tritordeum. Other characteristics, except protein content, were better in the octoploid tritordeum. Whether the relatively low protein content as compared with that obtained in hexaploid tritordeum is a general feature of octoploid tritordeums or is due to the *H. chilense* line used in this cross is still to be investigated.

Table 4. A comparison of an octoploid tritordeum with its parental wheat.

	Tritordeum (HT-20)	Wheat parent (ST-4)
Plant height (cm)	71.6	72.6
Number of fertile tillers/plant	5.7	4.3
Number of spikelets/spike	17.7	13.0
Number of seeds/spike	29.9	39.1
Number of seeds/plant	200.9	160.9
Seed weight (mg)	27.0	45.0
Grain yield/plant (g)	4.5	5.3
Protein content (%)	20.4	17.2

We have started a breeding program on octoploid tritordeum to test its potential for commercial production. Primary octoploid tritordeum has proved very useful in improving the fertility of hexaploid tritordeum. Secondary octoploid tritordeum will be also used in this program.

Concluding Remarks

The role that *H. chilense* will play in cereal breeding is still not clear but some of its characteristics indicate that it might be important.

It is remarkable that the *H. chilense* "genetic compatibility" is not only chromosomal but also cytoplasmic. *H. chilense* crosses readily with species of the genera *Triticum*, *Hordeum* (von Bothmer *et al.* 1985), and *Secale* (Finch and Bennett 1980). The genome of *H. chilense* is similar in size to the D genome of wheat (Fernandez and Jouve 1984) and does not possess, in contrast to the rye genome, big heterochromatic blocks which are undesirable in triticale (Gupta and Priyadarsham 1982).

We could not find any difference between alloplasmic lines of hexaploid tritordeum in cytoplasms of *H. chilense*, *T. turgidum*, or *T. aestivum*. Furthermore, when an alloplasmic line of *T. turgidum* in *H. chilense* cytoplasm was obtained, it showed no difference with the wheat parent. It is difficult to understand how species as phylogenetically distant as wheat and *H. chilense* possess compatible cytoplasms. This result deserves to be investigated at the molecular level.

Hordeum chilense is a self-pollinated species, which is not the case of rye. The fact that rye is cross-pollinated and wheat is self-pollinated might have caused some sterility in triticale. It has been previously suggested that fertility of the amphiploids could be influenced by some general incompatibility between the genotypes of in-breeders and out-breeders (Riley and Chapman 1957). In addition, *H. chilense* is a polymorfic species (Bothmer *et al.* 1980). Therefore, it could be expected to find a wider genetic variation in this species.

Finally, the *H. chilense* nucleolar organizer regions (NORs) are active in tritordeum. On the other hand, in triticale only NORs from wheat are active (Thomas and Kaltsikes 1983). The meaning of this result in agronomic terms has to be investigated.

References

Bothmer, R. von, Jacobsen, N. and Nicora, E. 1980. Revision of *Hordeum* sect. *Anisolepis* Nevski. Botaniska Notiser 133: 539-554.

Bothmer, R. von, Kotimaki, M. and Persson, Z. 1985. Genome relationships between eight diploid *Hordeum* species. Hereditas 103: 1-16.

Donald, C.M. 1968. The breeding of crop ideotypes. Euphytica 17: 385-403.

Fernandez, J.A. and Jouve, N. 1984. Giemsa C-banding of the chromosomes of *Hordeum chilense* and its amphiploid x *Triticum turgidum* conc *durum* Z. Pflanzenzuchtg 86: 336-340.

Finch, R.A. and Bennett, D.B. 1980. Mitotic and meiotic chromosome behavior in new hybrids of *Hordeum* with *Titicum* and *Secale*. Heredity 44: 201-210.

Gupta, P.K. and Priyadarsham, P.M 1982. Triticale: present status and future prospects. Advances in Genetics 21: 255-345.

Martin, A. and Chapman, V. 1977. A hybrid between *H. chilense* and *T. aestivum*. Cereal Research Communications 5: 365-368.

Martin, A. and Cubero, J.I. 1981. The use of *H. chilense* in cereal breeding. Cereal Research Communications 9: 317-323.

Martin, A. and Sanchez-Monge, E. 1979. Cytology and morphology of the amphiploid *Hordeum chilense* x *Triticum turgidum* conc *durum*. Euphytica 31: 262-267.

Padilla, J.A. and Martin, A. 1986. Aneuploidy in hexaploid tritordeum. Cereal Research Communications 14: 341-346.

Riley, R. and Chapman, V. 1957. The comparison of wheat-rye and wheat-*Aegilops* amphidiploids. Journal of Agricultural Science 49: 246-250.

Shepherd, K.W. and Islam, A.K.M.R. 1981. Wheat-barley hybrids: the first eighty years. *In* Wheat Science - Today and Tomorrow. Cambridge University Press, UK.

Stebbins, G.L. 1971. Chromosomal evolution in higher plants. Addison-Wesley, Reading, Massachusetts, USA. 216 pp.

Thomas, J.B. and Kaltsikes, P.J. 1983. Effect of chromosome 1B and 6B on nucleolus formation in hexaploid triticale. Canadian Journal of Genetics and Cytology 25: 292-297.

Virdi, B.V. and Larter, E.N. 1984. The influence of wheat-rye parental species on protein characteristics of primary triticale. Canadian Journal of Genetics and Cytology 26: 258-263.

The Use of *Hordeum spontaneum* to Breed Barley for Grain and Self-Regenerating Pasture

A. Hadjichristodoulou

Agricultural Research Institute,
Ministry of Agriculture and Natural Resources,
Nicosia, CYPRUS

Hordeum spontaneum (C. Koch.), the progenitor of *H. vulgare*, originated in the Fertile Crescent in the Middle East (Harlan and Zohary 1966). This species is widely spread in the Mediterranean Basin and Asia, up to China (Harlan 1979; Qiquan 1981). Frey *et al.* (1984) suggested that genes from wild barley could increase the productive potential of cultivated species.

H. spontaneum (wild barley) is widely distributed in central-eastern Cyprus, where annual precipitation is 300 mm, and is also found in the south-west area which receives 400-500 mm/year. It grows abundantly on the edges of cultivated fields in the plain and on the foothills at an altitude of about 1000m. Harlan (1979) reported that this species was found in a few places in Cyprus and that a "weed" barley appears to be a fixed intermediate between 2- and 6-rowed barley. This "weed" barley, which is mainly 6-rowed and has a brittle rachis and shrunken kernels, is considered as belonging to *H. agriocrithon* (Leonard and Martin 1963). Samples were collected during 1984-87 from many places in Cyprus, especially in areas where *H. spontaneum* and *H. vulgare* are found in adjacent fields. Both wild barleys cross readily with cultivated barley. A variety of characters were described for wild populations including hooded types (Harlan 1979). A similar wide variation was observed in Cyprus, and, in 1985, 2-rowed hooded barley types with brittle rachis were found in the hills on the outskirts of Nicosia.

In Cyprus, around 27% of the total area is used as natural pasture land for sheep and goats because it is too hilly or rocky to be cultivated. In addition, a significant portion of the cultivated land is marginal, suitable for pasture development. Barley is the most productive crop among several self-reseeding annual legumes and cereals tested. However it lacks the brittle rachis which confers *H. spontaneum* and its natural outcrosses with *H. vulgare* a self-regeneration ability.

In order to improve the productivity of natural pastures, *H. vulgare* varieties with high forage yields are being crossed with *H. spontaneum* or its natural outcrosses to develop a pasture barley possessing a brittle rachis. The same crosses are made with grain *H. vulgare* to introduce resistance to drought, heat, and other stresses.

Materials and Methods

Genotypes of *H. spontaneum* and its natural outcrosses with *H. vulgare* were selected from a collection of about 10 000 spike-progenies obtained from several areas in Cyprus. Potential parents were selected on the basis of their growth, tillering capacity, and disease resistance.

In pasture barley, all F_2 plants with tough rachis were removed from the plot and those with brittle rachis were kept so they shed their seeds to the soil. The same was followed with the F_3 generation, but the seeds of the best F_3 plants with a brittle rachis were harvested before seed shedding and sown in two pasture areas under natural conditions for evaluation.

In grain barley, plants posssessing a tough rachis and showing promising growth were harvested from the F_2 plots and evaluated for kernel type and rachis toughness.

Both pasture and grain barley genotypes were selected for evaluation from 309 crosses made between 1984 and 1987. Backcrosses were made betwen selected F_2 and F_3 plants and the *H. vulgare* parent to increase the proportion of *H. vulgare* genes in the hybrids and the chances of selecting agriculturally promising types, tolerant to stresses and diseases of wild barley.

Results and Discussion

The 10 000 collected genotypes belonging to both wild barleys showed a large variation in growth habit (prostrate, erect, intermediate), tillering capacity, heading date, plant height, disease resistance, and spike and kernel characteristics. Hooded *H. spontaneum* was found at one site, Athalassa, near Nicosia. All *H. spontaneum* genotypes were 2-rowed and had brittle rachis and shrunken kernels.

Mixed populations of *H. spontaneum* and another type of plant which resembles both wild and cultivated barley were found close to *H. vulgare* fields. These plants are 2- or 6-rowed and show similarities to *H. vulgare*, but have brittle rachis and shrunken kernels, similar to those of *H. spontaneum*. Also, the last internode is much longer than the others, as in *H. spontaneum*. The 6-rowed wild barley with brittle rachis was identified as *H. agriocrithon* by Leonard and Martin (1963).

It was observed that the percentage of plants which originated from natural outcrosses between *H. spontaneum* and *H. vulgare* varied with populations. A survey carried out to assess the frequency of natural outcrosses in the *H. spontaneum* populations revealed that it was related to the distance of the population from the cultivated *H. vulgare* fields. There were no natural outcrosses in the *H. spontaneum* population located in the center of Nicosia, 4 km away from the nearest barley field. The frequency of natural outcrosses was 0-0.9% in populations located 500 m away from cultivated fields and increased to 80% in *H. spontaneum* populations adjacent to the cultivated barley fields. Also, male-sterile *H. spontaneum* plants were identified in several populations. *H. agriocrithon* genotypes with all combinations of the 2-/6-row trait with brittle or tough rachis were present in the wild barley populations. All these findings provide indirect evidence of continuous natural hybridization between *H. spontaneum* and *H. vulgare*.

Detailed studies by Murphy *et al.* (1982) showed that 6-rowed barley with brittle rachis (*H. agriochrithon*) originated from natural hybridization between cultivated *H. vulgare* and the "weed" *H. spontaneum*. Scholz (1986) suggested that *H. agriocrithon* resulted from repeated mutations in cultivars with tough rachis and plump kernels resulting in the restoration of seed dispersal.

Segregation in Crosses with Wild Barley

In crosses between 2- or 6-rowed awned cultivated barley and *H. spontaneum*, the F_1 generation was 2-rowed and had a brittle, tough, or intermediate type of rachis. In the F_2 generation, segregation occurred for both traits, namely, rachis and row type. When a 6-rowed hooded cultivated barley was crossed with *H. spontaneum*, the F_1 plants had hooded kernels and were 2-rowed. In the F_2 generation, segregation was observed in all traits. The inheritance of the above traits has been studied by several scientists (Nilan 1964).

Grain Barley

The most promising varieties of the breeding program were crossed with wild barley selected from the collection of 10 000 lines on the basis of plant type and disease resistance. The most advanced material is in the F_4 generation.

In the F_2 and F_3 generations, desirable plant types and disease resistance could be identified and grain types were dominated by the wild type. F_2 and F_3 plants selected on the basis of plant and spike characteristics were threshed individually and screened for grain type. The proportion of plants promoted for further evaluation was very low, and ranged from 2 to 20% in the various crosses. Selected genotypes from these crosses were backcrossed once or twice with the *H. vulgare* parent in order to improve grain characteristics. Backcrosses have also been suggested by Frey *et al.* (1984) in crosses between wild and cultivated barley.

Pasture Barley

The main pasture crops tested in the Mediterranean countries are legumes (medics and subclovers) and cereals (ryegrass). In Cyprus, these annuals, though tested for many years, generally were not successful as permanent pasture crops. Their dry matter yield was low compared to that of vetches and barley. In an unpublished study, D. Droushiotis and I. Photiades found that the dry-matter yield of five medic varieties over 3 years was 1.7-3.0 t/ha, compared to 5.0 t/ha produced by *Vicia sativa* and *V. dasycarpa*. In another study, they found that the digestible organic dry matter of 48 Alger barley lines was 2.1 t/ha compared to 1.1-1.5 t/ha produced by various mixtures of medics, lolium, and barley. Barley also competed with weeds better than the other species did. Cereals outyielded forage legumes (*Vicia sativa, V. dasycarpa*, and *Pisum sativum*) by 87% to 254% in three seasons (Hadjichristodoulou 1976). Barley was the top yielder among cereals and legumes.

The dry-matter protein content of barley at tillering stage (grazing stage) was high (24%) (Hadjichristodoulou 1983), which compares favorably with that of pasture legumes. The dry-matter protein content of unfertilized natural populations of *H. spontaneum* at the tillering stage, collected in Dec 1987 from 10 different sites at Athalasa, ranged from 17.7 to 31.7%.

Barley is well adapted to the dry Mediterranean conditions. However, *H. vulgare* lacks the self-regenerating mechanism available in the form of a brittle rachis in *H. spontaneum*. The work in progress revealed that it is possible to develop successful self-regenerating pasture barley by crossing *H. vulgare* with *H. spontaneum*. Regrowth was excellent after the first autumn rainfall, and early forage was available for grazing.

Variation was also observed among crosses. The best families are evaluated at two sites and the performance of lines tested for forage production will be compared with that of lines tested for natural pasture production. Barley is not a nitrogen-fixing plant, therefore, if high forage yields are desired, mixtures of pasture barley and medics are to be sown, whereby the legume provides the nitrogen, and the cereal produces the forage. This combination was noticed in some natural populations where wild medics and *H. spontaneum* were found in mixed stands. Controlled grazing will be needed in order to allow barley plants to produce seeds. The mature plants can be grazed as dry pasture, which will not affect pasture regeneration, as the wild barley dispersing mechanism (brittle rachis) will enable seed-spread for future stands.

References

Frey, K.J., Cox, S.T., Rodgers, M.D. and Bramel Cox, P. 1984. Increasing cereal yields with genes from wild and weedy species. Pages 51-68 *in* Genetics: New Frontiers, Procedings of the XV International Congress of Genetics. Vol. IV. Applied Genetics (Chopra, V.L., Joshi, B.C., Sharma, R.P. and Bansal, H.C., Eds.). Dec 1983, New Delhi, India. Bowker, Epping, U.K.

Hadjichristodoulou, A. 1976. Effect of harvesting stage on cereals and legume forage production in low rainfall regions. Journal of Agricultural Science, Cambridge 86: 155-161.

Hadjichristodoulou, A. 1983. Dual purpose barley. Technical Bulleting No. 46, Agricultural Research Institute, Cyprus. 9pp.

Harlan, J.R. 1979. On the origin of barley. Pages 10-36 *in* Barley, Agricultural Handbook No. 338. USDA, Washington.

Harlan, J.R. and Zohary, D. 1966. Distribution of wild wheats and barley. Science 153: 1074-1080.

Leonard, W.H. and Martin, J.H. 1963. Barley cereal crops. The Macmillan Company, New York, USA.

Murphy, P.J., Witcombe, J.R., Shewry, P.R. and Miflin, B.J. 1982. The origin of six-rowed "wild" barley from the Western Himalaya. Euphytica 31: 183-192.

Nilan, R. 1964. The cytology and genetics of barley. Monographic supplement No. 3, Washington State University Vol. 32 No.1. 278pp.

Qiquan, S. 1981. The evolution of cultivated barley. Pages 22-25 *in* Barley Genetics IV. Proceedings of the Fourth International Barley Genetics Symposium. 22-29 July 1981, Edinbourg, UK. Edinbourg University Press, UK.

Scholz, H. 1986. Origin of weed *Hordeum vulgare* subsp. *agriocrithon* emend. Botanishe Jahrbucker fur Systematik, Pflanzengeschiechte und Pflanzengeographic 106: 419-426.

Development and Production of Barley and Wheat in Shanghai, China P.R.

Cai Yizhong
Plant Breeding and Cultivation Research Institute, Shanghai Academy of Agricultural Sciences Shanghai, CHINA

Barley and wheat are the main winter cereal crops in Shanghai Prefecture (abbreviated as Shanghai), the People's Republic of China. In the Prefecture, barley is used for livestock feed mainly, and for malting, whereas wheat is used for human food. The total area under barley and wheat is about 145 000 hectares or 40% of the total cultivated land. In the last decades, barley and wheat production has increased considerably through the use of improved varieties and production practices. The average yield of barley and wheat has gone up from 1300 kg/ha in the 1950s to 2600 kg/ha in the 1970s, and reached 3500 kg/ha at present. In recent years, the annual production of barley and wheat was about 510 000 tonnes, an increase of 230% over that in the 1950s. Thus, barley and wheat occupy a very important place in Shanghai's agriculture.

Natural Conditions in Shanghai

Shanghai is situated in the delta plain of the lower course of the Yangtse river. It lies within the northern verge of the subtropical region. Together with the southern part of Jiangsu Province and the northern part of Zhejiang Province, it constitutes the major cereal crop growing area of the Tai Lake Valley. The weather is mild in Shanghai with an annual average temperature of 15.4^{o}C. Of the four seasons, winter is the longest and is spread over Nov, Dec, Jan, and Feb, which have an average temperature of 12.4^{o}C, 6.1^{o}C, 3.4^{o}C, and 4.5^{o}C, respectively; but temperature may fall to -12^{o}C in some years. The average annual rainfall is 1125 mm, with the period from Apr to Sept as the main rainy season.

Shanghai is rich in water resources for irrigation purposes; 11-12% of the area is covered with water. The low lying alluvial plain is a dish-like lowland with the Tai Lake in the center. Most of the farmland is 3-5 m above mean sea level. The majority of the soils are quite productive and have originated from marsh gley soil (13.3%), meadow soil (42.6%), and salt-affected meadow soil (22.3%).

Production of Barley and Wheat

Shanghai has a long history of barley and wheat cultivation. In 1985, the area planted to barley was 99 000 hectares and the total production was about 305 000 tonnes, reflecting an increase of 80% and 580%, respectively, over those in 1949. The highest production (424 000 tonnes) was achieved in 1984. The productivity of barley showed a similar trend, with an average annual increase of 6.7% from 1949 to 1985.

Wheat cultivation has also made a substantial progress. The area and production, during 1949 to 1985, have increased by 17% and 340%, respectively, with an average annual increase in productivity of about 7.3%.

These improvements in barley and wheat production have been possible due to the use of improved varieties and cultural practices.

Evolution of varieties

Since the 1950s, development of improved barley varieties in Shanghai has progressed at a fast pace, along with the development of improved farming systems. The significant changes in barley varieties are: two-row instead of six-row; decrease in naked barley; more early-maturing, semi-dwarf instead of tall; and more response to fertilizers.

In the 1950s, the main varieties grown were the local unimproved ones, such as San Yue Huang, Purple Barley, and Ci Gu Qing. These varieties, of which naked barley accounts for 70%, are of semi-winter type. They were generally tall, late maturing, prone to lodge, not responsive to fertilizer, and had a low yield potential. They could be cultivated in a double cropping farming system only, namely, barley/rice.

In the 1960s, improved varieties were introduced. At that time, the farming system began changing to three crops a year, namely, barley/early rice/late rice. Therefore, the varieties had to be early maturing with high yield potential. The varieties such as Li Xia Huang, 757, and Ai Bai Yang were popularized, and the average yield increased to 1700 kg/ha.

By the 1970s, naked barley had been reduced to less than 30%, and the principal varieties were improved two-row types, such as Zao Shu No.3 and Mi Mai 114, which were early maturing, moderately resistant to barley scab, and tolerant to excessive moisture, and had high yield potential. They were suitable to the multiple cropping system of three crops a year.

Since 1980, the new varieties bred in Shanghai have been quickly popularized in other barley production areas besides Shanghai. Shanghai Barley No.4, 6, and 8 have become the key varieties in the region of the middle-lower course of the Yangtse river. These varieties have high yield potential, early maturity, resistance to certain diseases, good malting quality, and resistance to lodging. Thus, the average yield increased to 3500 kg/ha. Shanghai Barley No.4 and 6 should be planted in the first 10 days of Nov and are expected to mature before the end of May. The growing period is about 180 days, and these varieties are suitable for the farming system of three crops a year (barley/rice/rice). Shanghai Barley No.8 should be planted in the last 10 days of Oct and is expected to mature at the end of May or early June. It has a growing period of about 195 days, and is suitable for double cropping with rice, cotton, or other crops.

The evolution of wheat varieties passed through similar stages as barley. Since the 1950s, local unimproved varieties have been replaced by improved varieties, which are subsequently being replaced by locally bred improved varieties. Today, the key varieties are Shanghai Wheat No.5 and Yang Mai No.5, which have good stability and high yield potential, and are suitable for double cropping (wheat/rice or other crops). They should be planted in the first 10 days of Nov and are expected to mature in early June, with a growing period of about 195 days. Along with the acceptance of the double cropping system, the area planted to wheat has been gradually increasing in recent years.

Improvement of cultural practices

Seeding density. A seeding rate of about 15-18 g/m^2 has been found to be optimal according to the results of a several years seeding rate experiment. Yields were reduced significantly when seeding rate was increased to 30 g/m^2 or decreased to 7 g/m^2

Fertilizer application. The farmers in China have traditionally practised intensive farming and used farmyard manure, which is rich in organic matter and beneficial to soil structure. It possesses complete *slow-release* nutrients which support growth and development during the whole season, and releases large amounts of CO_2 for photosynthesis during its oxidation. In general, the application of farmyard manure, which contains about 0.3% nitrogen, is about 11 t/ha for barley or wheat. Chemical fertilizers should also be applied in addition to farmyard manure as basal application and top-dressing. $(NH_4)_2SO_4$, at a rate of 50-60 g/m^2 (in addition to the organic fertilizer), is adequate to meet the needs of barley and wheat, producing a yield of about 4000 kg/ha. When the amount of $(NH_4)_2SO_4$ is increased to 100 g/m^2, the yield decreases. Therefore, after the application of farmyard manure, the amount of chemical fertilizer that should be applied is very important to obtain high yields.

Seeding time. In Shanghai, barley or wheat is planted after the harvest of rice during late Oct to early Nov. To develop a good stand before the freezing winter season, which usually begins in the last 10 days of Dec, seeding time should be as early as possible, except for the early-maturing varieties. For example, it has been found that with seeding from 24 Oct to 7 Nov, the yield of barley fluctuates between 3300 and 3700 kg/ha. But as the seeding time is delayed to 21-29 Nov, the yield significantly decreases to 2300-3100 kg/ha. Therefore, barley or wheat should be seeded before the middle of Nov to get high yields.

Weed control. Herbicides have been lately brought into use in Shanghai with satisfactory results. For example, herbicide application in 600 ha of wheat and barley fields in Zhu Di provided a good weed control and a high 4500 kg/ha yield. Herbicide use is becoming more common in Shanghai.

Water management. Mechanization of irrigation and drainage has been developed fast since the 1950s; the use of irrigation and drainage equipment reached 75% in the 1960s and over 90% in later years. This has facilitated the achievement of high stable yields of crops, including barley and wheat.

Cultivation. Mechanization of plowing has been receiving greater attention since the 1960s. Its application has reached about 90% today. Plant protection, threshing, and processing operations of barley and wheat are also mechanized. Seeding and harvesting are partly mechanized but are expected to be fully mechanized in the near future.

Barley and Wheat Farming Systems

Early in the 1950s, barley and wheat or green manure were planted in winter and a single crop of rice was planted in summer of the following year (the cropping patterns being barley or wheat/rice, green manure/rice). The grain yield in this system was about 3000-3800 kg/ha per annum.

In the 1960s, experiments were conducted on a triple cropping system consisting of barley or rape seed in winter followed by a crop of early rice planted in mid-May, harvested in the first 10 days of August, and succeeded by another rice crop. The total growth period for the three crops adds up to 440 days, of which 80 days are in the nursery. Thus, growing successively three crops a year promises better utilization of land and other natural resources, and provides an annual grain output of 10 500-12 000 kg/ha. At that time, barley was quickly developed because its shorter growth period is more suitable than wheat to that farming system. The cropping pattern barley/rice/rice accounted for 60% in all patterns, while the pattern wheat/rice accounted for 20% only.

In recent years, along with the reform of agricultural structure and the development of larger scale cultivation for each farmer in Shanghai, emphasis was put on cultivation techniques and mechanized operations that lead to high and stable yields. Barley/rice or wheat/rice double cropping has expanded again. It accounts for about 60% of currently followed cropping patterns and is being continuously improved. However, the land area under barley has not decreased because of its importance as animal feed.

Future Plans

In barley and wheat improvement, emphasis will be placed on solving the following major problems in the future:

Barley yellow mosaic virus

This is the most important barley disease in Shanghai and several other provinces in China. It is also a serious problem in Japan, Germany, Britain, France, and other countries. To solve this problem, the approach of breeding resistant varieties has been used. Related genetic studies have been also conducted. At present, several varieties or lines which are tolerant or resistant to barley yellow mosaic virus have been bred. Of these lines, two have become popular in all disease-occurring areas in Shanghai, where the yield of barley has increased and stabilized at 3500 kg/ha. Emphasis is being placed on breeding a series of new resistant varieties and understanding their related genetic variation.

Tolerance to excessive moisture supply

In Shanghai, monthly rainfall from Apr to Sept exceeds 100 mm. Too much rainfall in spring is unfavorable for barley and wheat production because it affects their growth and development and causes diseases and lodging. Sometimes this problem occurs at the beginning of winter at the seeding stage. To develop varieties tolerant to wetness, a screening nursery was established in the last two years, where several hundred lines were screened. From these, several promising lines have been identified for further use.

Wheat scab

Scab is a serious disease in wheat production areas, especially in the middle-lower region of the Yangtse river and Huang river. Since 1974, a series of screening methods has been established for screening resistant material. To date, thousands of lines have been screened. Resistant resources such as Su Mai No.3 have already been utilized to develop new varieties. This work will be continued and in-depth studies will be initiated. In addition, chemical control is commonly used as a supplemental method to fight wheat scab.

The production of barley and wheat is affected by several social factors as well as economic policies. Problems arising from such factors should be solved to further enhance the production of these crops in Shanghai.

Conclusion

Barley and wheat production has developed at a fast pace in the past 36 years in Shanghai and has greatly contributed to increase food and feed production. This was achieved through the use of improved varieties, improved cultivation techniques, and through the change in farming system. The main problem facing barley and wheat production today is the damage caused by several major diseases and by excessive moisture. It can be concluded that breeding of resistant varieties to barley yellow mosaic virus, wheat scab, and excessive moisture supply, as well as further improvement of cultural techniques are essential for scoring stable and higher yields.

Screening High-Yielding Lines of Durum Wheat for the Mediterranean Environments of Turkey

Ibrahim Genc, Yusuf Kirtok, Ahmet Can Ulger, and Tacettin Yagbasanlar
Department of Field Crops
Faculty of Agriculture
University of Cukurova
P.O. Box 444 Adana, TURKEY

Wheat is the most important crop grown in Turkey. It is cultivated over a total area of 9.3 million hectares, which ranks Turkey the sixth wheat-growing country in the world (FAO 1985). Durum Wheat (*Triticum durum* Desf.), the second most important wheat species in the country, covers about 25% of the total wheat area and production. In the Cukurova region, wheat is grown mostly in monoculture under rainfed conditions between 15 Nov and 15 June over an area of 504 000 ha (Agricultural Structure and Production 1985). Seasonal temperature and rainfall vary highly from year to year, specially during grain-filling period. Durum wheat represents less than 10% of total wheat production in Cukurova, and could be increased if high-yielding, good-quality varieties are selected.

The purpose of this study was to determine grain yield and quality charateristics of durum wheat lines originating from ICARDA, CIMMYT, and our own program, and to compare them with those of commercial cultivars grown in Cukurova area.

Materials and Methods

Seventeen durum wheat lines selected from our wheat experiments and two durum wheat cultivars, Balcali-85 and Gediz-75 (used as checks), were tested for grain yield, 1000-kernel weight, test weight, and grain weight/spike under the rainfed conditions of Cukurova region in 1985-87. The experimental design was a randomized complete block with four replications. Plots were 5-m long with 8 rows spaced 15 cm apart. Seeds were drilled at a rate of 450 grain/m^2. At maturity, the six central rows of each plot were harvested with a combine. Data collected for various traits were compared following Duncan's multiple range test.

Results and Discussion

Grain yield differences among the entries were not significant in each year nor when averaged over the 3 years. The mean grain yield ranged from 5870 to 6510 kg/ha (Table 1). Balcali-85, a newly developed semi-dwarf cultivar 2-3 days earlier than Gediz-75 gave the highest yield. It produced 5% more than Gediz-75, the *current leading* cultivar. Other promising entries were number 3, 7, 14, 15, and 19.

Thousand-kernel weights differed significantly among entries (Table 1) with the three-year mean ranging from 45.2 to 56.8 g. Only entry 19 had a significantly higher kernel weight than the two checks. Five other entries had a kernel weight over 50.0g, compared with 49.3 g for Gediz-75 and 49.8 g for Balcali-85.

There were significant differences among the entries in test weight in each year and when averaged over the years. The 3-year mean test weight ranged from 79.5 to 83.9 kg/hl (Table 1). Entry 19 was the only one with a test weight below 80 kg/hl. We observed that, when subjected to moisture stress during the grain-filling stage, high-yielding wheat lines tended to show a higher hectoliter weight than low yielding ones. This tended to agree with the results of Genc (1974) and Alkus and Genc (1979). It appeared that the 1000-kernel weight and hectoliter weight might be important for selecting high yielding genoytpes in dry environments. Significant differences in grain weight/spike also existed among the entries (Table 1). Selecting for high grain weight/spike might help increasing the grain yield of cereal crops. An improved grain weight/spike indicates an increased physiological capacity to mobilize and translocate photosynthates to economically important parts of the plant.

In conclusion, some durum wheat lines high in yield, 1000-kernel weight, and hectoliter weight were identified and will be used as parents in future crosses. The lines "1976 MBMN 1417" and Oyca'S'/Magh'S'//Ruff'S'/Fg'S' might have the potential of becoming new varieties.

Table 1. Mean grain yield, 1000-kernel weight, test weight, and grain weight/spike of 19 durum wheat lines tested in Cukurova from 1985 to 1987.

Entry	Grain yield (kg/ha)	1000-kernel weight (g)	Test weight (kg/hl)	Grain weight/ spike (g)
1*	6220	49.3 bcde**	81.9 de	2.15 a
2*	6510	49.8 bcde	83.4 ab	2.10 ab
3	6480	49.8 bcde	83.4 ab	2.00 abc
4	6210	54.6 ab	81.7 e	2.16 a
5	6180	44.1 e	82.1 cde	1.80 cd
6	5960	47.4 cde	80.9 f	1.99 abc
7	6400	51.7 abcd	82.7 bcd	1.92 abcd
8	6050	50.1 bdce	81.9 de	1.95 abcd
9	6270	47.7 cde	80.5 f	1.77 cd
10	6060	49.3 bcde	82.5 cde	1.68 d
11	6160	49.5 bcde	83.8 a	1.84 bcd
12	5870	47.9 cde	82.4 cde	1.73 cd
13	6230	48.2 cde	82.2 cde	1.97 abc
14	6430	45.2 e	82.0 cde	1.84 bcd
15	6380	47.8 cde	80.9 f	2.19 a
16	6240	47.1 d	83.9 a	1.90 abcd
17	6300	53.6 abc	82.8 bc	1.90 abcd
18	6250	53.0 abcd	82.5 cde	1.77 cd
19	6400	56.8 a	79.5 g	2.01 abc
Mean	6240	49.6		1.93

* Check. no. 1 = Gediz-75, no. 2 = Balcali-85

** Means within the same column and followed by the same letters are not statistically different at the 0.05 level of significance determined by Duncan's new multiple range test.

References

Agricultural Structure and Production. 1985. State Institute of Statistics, Ankara, Turkey.

Alkus, E.Y. and Genc, I. 1979. Studies on the effects of seeding date and seeding rate on yield and yield components of four common wheat (*T. aestivum* L. em Thell) cultivars in Cukurova. The Journal of Agricultural Research 1(3): 233-254.

FAO (Food and Agriculture Organization). 1985. FAO Production Yearbook 1985. Rome, Italy.

Genc, I. 1974. [Studies on yield and yield components of some Turkish and foreign durum and common wheat varieties]. In Turkish, English summary. University of Cukurova, Agricultural Faculty Publication: 82, Scientific Investigation and Research Dissertations.

Assessing Small Grain Cultivars for Yield in Variable Environments through Joint Regression Analysis

Luis Gusmao
Department of Genetics
Estacao Agronomica Nacional
P-2780 Oeiras, PORTUGAL

Small grains are mainly grown under rainfed conditions which are generally known to be very variable. Large fluctuation in grain yield in different seasons and different locations is expected. So for multi-seasons and -locations variety evaluation trials conducted under such conditions, consideration of the variety mean yield alone is inadequate. The joint regression analysis (JRA) was developed to extract more information about the tested entry in addition to mean yield.

The principles of JRA were first developed by Mooers (1921) (which has been often ignored), and after an ephemerous revival by Yates and Cochran (1938), the technique was used by Finlay and Wilkinson (1963) 42 years later. Despite criticism (Westcott 1986), this method has been accepted as a complement to traditional statistical analyses. Besides mean yield, it assesses genotypes through two orthogonal components. The first component, expressed by the regression coefficient (B) which shows the yield response, is related to yield stability. The second, expressed by the deviation from the regression line (S^2y/x), is related to the concept of "specific instability", developed successively by Eberhart and Russel (1966), Joppa *et al.* (1971), Shukla (1972), and Kang *et al.* (1987).

In spite of its higher biological relevance, JRA has not been used by breeders. This could be caused by controversial results published in the literature. However, its lack of robustness, as claimed by some workers, might have been the result of ignoring some required conditions (Gusmao 1985, 1986, 1987). These conditions will be summarized in the present paper. In my opinion, JRA is the method for yield trial evaluation in variable environment.

Required Conditions to Increase the Accuracy of JRA

The prediction of the relative performance of the cultivars through the regression lines in JRA will be accurate only if confidence intervals for statistical inferences are sufficiently narrow. A detailed analysis of the causes which determine deviations from the expected values suggests that there are conditions which can lead to an increased precision of the method. These will be discussed in three aspects.

Statistical assumptions

Gusmao (1985) showed the inadequacy of blocking in trial designs when using JRA. To illustrate this, yield data from the same triticale yield trials in Portugal (Cidraes and Gusmao 1982; Gusmao and Cidraes 1982) will be used. There were 10 lines grown in 25 trials at 11 locations during 2 years. The differences between the parameters estimated by the "standard procedure" and the "correct procedure" are presented in Table 1. In the "standard procedure" where blocking was assumed, mean performance y_{ij}, of the ith line in the jth trial was regressed on the mean, x_j, of that trial. In the "correct procedure", where blocking was not considered and each block assumed as a different trial, the performance y_{ijr}, of the ith line in the jth trial at the block r, was regressed on the mean x_{jr} of that block. From the result shown in Table 1, the following conclusion emerged:

a) There were only minor differences between the two procedures in intercept and slope.

b) In the "correct procedure", the residual variances (S^2y/x) were higher.

c) The standard errors were reduced by the "correct procedure" by 30-50%. With the increased degrees of freedom, this meant that the confidence intervals were drastically reduced.

Table 1. Differences between JRA parameters when assessed by two different procedures: the "standard procedure" (regression of the mean performance y_{ij} of the ith line at the jth trial on the mean x_j of that trial) and the "correct procedure" (regression of the performance y_{ijr} at the block r on the mean x_{jr} of that block).

Strains	*d*I	*d*S1	*d*S^2y/x	*d*SE			
				x = $\bar{x}$		x = $\bar{x}\pm$1.5 kg/10 m^2	
				kg/10 m^2	% *st*	kg/10 m^2	% *st*
72IT7	.00	.00	.058	- .0637	35	- .1262	34
72IT13	.00	.00	.075	- .0784	31	- .1548	30
74IT8	.01	.01	.156	- .0432	48	- .0852	47
75IT6	.00	.00	.122	- .0362	49	- .0716	48
75IT7	.01	.01	.098	- .0962	30	- .1899	29
75IT8	.02	.01	.118	- .0505	42	- .1002	41
75IT12	.01	.00	.081	- .0632	34	- .1253	34
75IT13	.01	.01	.103	- .0626	36	- .1238	36
75IT14	.03	.01	.122	- .0760	34	- .1494	34
75IT16	.01	.01	.099	- .0784	32	- .1540	32

Differences calculated by "correct procedure" (*c*) values minus "standard procedure" (*st*) values.
*d*I = difference in intercepts.
*d*S1 = difference in regression coefficients.
dS^2y/x = difference in residual variances.
*d*SE = difference in standard error.
% *st* = % reduction of the standard error relative to *st*.

In general, the accuracy of the environmental index can be improved either by increasing the number of cultivars under testing or by increasing the number of replicates, so that there is a sufficient degrees of freedom. In addition to complete randomization, the precision of the method can also be increased by securing a broad range of environments. These can be simulated by technical means, e.g. by sowing at different times. However one should not create conditions which are too distinct from prevailing growing environments.

Physiological assumptions

No matter how reduced is the genotype x environment interaction (as for instance when developed by disruptive environment selection), one always anticipates a geoclimatic delimitation within which a stable genotype response pattern to the environments is to be expected. As shown in a previous paper (Gusmao 1985), although the determination coefficients were progressively increased as locations from the southern region were included successively into the JRA, the inclusion of locations from the northern part of the country (known to be geoclimatically different from the southern part) lowered the determination coefficient. This indicates that the JRA is an adequate technique only within a region of similar geoclimatic conditions.

Besides latitude (and its direct photoperiod effect), altitude, location, and other geographic situations affect floral differentiation and development. Vernalization and photoperiod, and other adaptive processes, through the effect of temperature, may act in a physiologically interactive way, as in subterranean clover, but seem to act independently in cereals (Flood and Halloran 1984).

Previous attempts to classify environments following their interaction with the genotype (Horner and Frey 1957; Abou-El-Fittouh *et al.* 1969) have failed because they were based on static statistical models where the information is reduced to the mean values. However, delineating zones of similar cultivar performance should be a practical goal in a regional breeding program.

Genetical assumption

The general culivar performance at different environments can be predicted according to the regression lines, however specific environmental stresses of random occurence may affect the agreement between observed and expected values. In inbred material (pure lines). this is particulltarly pertinent, especially if local adaptation has not been adequately tested. Lines of autogamous species at early generations are constituted by heterogenous phenotypes, and are expected to have high residual variances and low determination coefficients. In the study by Teich (1983), cultivars had smaller deviations from regression and higher r^2 than advanced lines.

Methodology for Regional Assessment of Cultivar Yield

The most relevant corollaries which emerge from the above discussion and relate to cultivar yield evaluation at diversified environments, are:

Zoning

Based on the effect of each location on the regression lines, a preliminary study must be undertaken to delineate areas within which the residual variance in JRA can be maintained at low levels. An alternative approach is to classify areas according to the climatic identities and prevalent stresses.

Experimental design

The completly randomized design is adequate for cultivar yield trials, and also is the most convenient for JRA. Replication does not have particular relevance here; however, a minimum number of replications is needed for judging local deviations. Homogeneity of the growing conditions for each trial should be complemented with complete randomization to secure unbiasedness at each evaluation point of the joint regression line.

Besides, the range of environments should be extended beyond the putative yield range at the target region by means of agricultural techniques to avoid extrapolations, and to attain better coefficients of determination.

Minimum number of trials for each region

For each region, a reasonable number of degrees of freedom is needed. Thus, in the two main zones devoted to small grains in the Portugal, two different strategies are advocated. For the more extensive southern region (south of the mountainous system "Montejunto-Estrela"), there should be a maximum number of trials in order to cover all relevant microclimatic situations. The number of replications may be reduced within trials. For the more restricted region of the so-called "Nordeste Transmontano", a large number of trials is not justifiable. In this case, an increased number of replications within trials is needed to have the adequate amount of degrees of freedom.

Interpretation of the results

It is not adequate to calculate cultivar means over trials. JRA is recommended. However, accuracy of the trial for the JRA should not be based on traditional parameters, like the coefficient of variation (CV), which are valid only when the regression lines of the cultivars are coincident or parallel, a case seldom expected, and never known *a priori*. Deviations from the regression lines are, then, the only parameter which deserves consideration in judging the accuracy of each trial, eventhough deviations can be caused by specific interactions rather that random errors.

For practical recommendations, the description of the relative behaviour of the cultivar should be qualified in terms of productivity classes of the environment. These classes cannot be established in a rigid manner, but are dependent on the accepted yield levels in the target region.

Acknowledgements

The author is indebted to Prof M. Mota, Department of Genetics, Estacao Agronomica Nacional, for his encouragement and criticism, and to Dr L. Costa-Rodrigues, Department of Genetics, Estacao Agronomica Nacional, for his kind revision of the manuscript.

References

Abou-El-Fittouh, H.A., Rawlings, J.O. and Miller, P.A. 1969. Classification of environments to control genotype by environment interaction with an application to cotton. Crop Science 9: 135-140

Cidraes, A.G. and Gusmao, L. 1982. Adaptacao de triticales em Portugal: 1 Comportamento das linhas e variedades em ensaio no trienio 1976/77 a 1978/79. Melhoramento 27: 161-201.

Eberhart, S.A. and Russel, W.A. 1966. Stability parameters for comparing varieties. Crop Science 6: 36-40.

Finlay, K.W. and Wilkinson, G.N. 1963. The analysis of adaptation in a plant breeding programme. Australian Journal of Agricultural Research 14: 742-754.

Flood, R.G. and Halloran, G.M. 1984. The association of vernalization and photoperiod responses in wheat. Cereal Research Communications 12: 5-11.

Gusmao, L. 1985. An adequate design for regression analysis of yield trials. Theoretical and Applied Genetics 71: 314-319.

Gusmao, L. 1986. Inadequacy of blocking in cultivar yield trials. Theoretical and Applied Genetics 72: 98-104.

Gusmao, L. 1987. A interaccao genotipo x ambiente e a comparacao de cultivares de cereais. Dissertacao para o doutoramento em Engenharia Agronomica. Instituto Superior de Agronomia, Universidade Tecnica, Lisboa. 53pp.

Gusmao. L. and Cidraes. A.G. 1982. Adaptacao de triticales em Portugal: II. Analise do comportamento quantitativo em relacao as especies parentais. Melhoramento 27: 203-223.

Horner, T.W. and Frey, K.J. 1957. Method for determining natural areas for oat varietal recommendations. Agronomy Journal 49: 313-315.

Joppa, L.R., Labsock, K.L. and Busch, R.H. 1971. Yield stability of selected spring wheat cultivars (*Triticum aestivum* L. em Thell) in the uniform regional nurseries, 1959 to 1968. Crop Science 11: 238-241.

Kang, M.S., Miller, J.D. and Darrah, L.L. 1987. A note on relationships between stability variance and ecovalence. Journal of Heredity 78: 107.

Mooers, C.A. 1921. The agronomic placement of varieties. Journal of the American Society of Agronomy 13: 337-352.

Shukla. G.K. 1972. Some statistical aspects of partitioning genotype environmental components of variability. Heredity 29: 237-245.

Teich. A.H. 1983. Yield stability of cultivars and lines of winter wheat. Cereal Research Communications 11: 197-202.

Westcott. B. 1986. Some methods of analyzing genotype-environment interaction. Heredity 56: 243-253.

Yates, F. and Cochran. W.G. 1938. The analysis of groups of experiments. Journal of Agricultural Science 28: 556-580.

Changes in Virulence Spectrum of *Puccinia hordei* in Tunisia

A. Yahyaoui,
Plant Breeding Department
ESAK, Le Kef, 7119 TUNISIA

A.L. Scharen,
USDA-ARS, Plant Pathology Department
Montana State University
Bozeman, MT 59717 USA

and

E.L. Sharp
Plant Pathology Department
Montana State University
Bozeman, MT 59717 USA

A major goal of race surveys is to detect new virulence phenotypes. By using host differential lines, each with "a single gene" or "gene combinations" for resistance, it is possible to detect changes in virulence of the pathogen, and then try to find out if the new virulence combination is capable of overcoming the combination of resistance in commercially grown barley cultivars or advanced breeding material.

Barley leaf rust isolates virulent on Pa_7 have been reported by Parlevliet *et al.* (1981). Yahyaoui and Sharp (1987) found that none of the *Puccinia hordei* cultures that were isolated from *H. vulgare* in North Africa and the Middle East were virulent on Pa_7 or Pa_3. Sharp and Reinhold (1982) showed that Pa_3 and Pa_7 were resistant to 12 isolates from the United States and the Mediterranean area. Pretorius and Wilcoxson (1983) showed that Pa_3, Pa_7, and Pa_9 were effective against all races of *P. hordei* known to occur in the United States. They recommended incorporating these genes into cultivars grown in the Upper Midwest of the USA to eliminate the potential threat of leaf rust in this region.

Disease surveys could be an important tool for plant breeders and could provide useful information on the distribution of pathogens and their population shifts. The objectives of this study were 1) to determine the virulence pool of leaf rust in various barley growing areas in Tunisia and 2) to determine the changes in virulence within each region and within the country over a period of two to five years. The effectiveness of resistance genes to *P. hordei* isolates identified in Tunisia was also tested.

Material and Methods

Thirteen spring barley genotypes possessing the different Pa genes were subjected to detailed analyses of their reactions to Tunisian cultures of *P. hordei*. The Pa designation by Clifford (1974, 1977) and the USDA CI number are given in parentheses following the common names of each genotype used. The set of differentials used in this study included the following barley cultivars: 1) Estate (Pa_3, CI 3410), 2) Cebada Capa (Pa_7, CI 6193), 3) Hor 2596 (Pa_9, CI 1243), 4) Ricardo (Pa_{2+}, CI 6306), 5) Boliva (Pa_2+Pa_6, CI 1257), 6) Quinn

(Pa_2+Pa_5, CI 1024), 7) Magnif (Pa_5, CI 13806), 8) Peruvian (Pa_2, CI 935), 9) Sudan (Pa, CI 6489), 10) Egypt (Pa_8, CI 6481), 11) Batna (Pa_{2+}, CI 3391), 12) Gold (Pa_4, CI 1145), and 13) Reka I (Pa_{2+}, CI 5051). Throughout this paper the differential cultivars are listed in order of their spectrum of resistance, the most resistant genotypes being listed first.

Leaf Rust Cultures

Samples of *P. hordei* were collected from four different geographic regions in Tunisia. Two representative sites were chosen in each region. Collections were made over a period of five years (1982-87). Samples were taken at the same site every year when feasible. Region, site, year, and number of mono-uredial isolates tested for each collection are presented in Table 1.

Isolate Designation

The designation given to the isolates includes the country, site and year of collection, and isolate number within each site. Throughout this paper, isolates are listed in an ascending order of virulence, i.e. the least virulent isolate is listed first and the most virulent last.

Table 1. Collection sites of Tunisian *P. hordei* isolates, 1980-87.

Region	Leaf rust site	Collection year	No. of mono-uredial isolate(s) tested
North	Mateur	1980	1[a]
	Mateur	1983	16
	Mateur	1984	6
	BouRbia	1982	2
	BouRbia	1987	1
Northwest	Beja	1982	11
	Beja	1984	8[b]
	Le Kef	1982	10
	Le Kef	1984	3
	Le Kef	1987	5
	Maktar	1987	2
Center	Kairaouan	1982	2
	El Jem	1983	1
South	Oasis	1982	8
	Oasis	1984	2
	Mareth	1983	10

a. Isolate collected by E.L. Sharp (Reinhold and Sharp 1982).
b. Five of the eight isolates were collected from *Ornithogalum* spp.

Inoculum

Rust spores from a single uredium were isolated from green or dried leaves collected in Tunisia. In one case mono-uredial cultures were derived from a single aecium from the alternate host at Beja. Mono-uredial cultures were multiplied on the universally susceptible barley cultivar, Moore (CI 7251). The inoculum that could not be used within a few days was vacuum dried and stored at 4°C, until used.

Inoculation

Three to five seeds of each of the differential cultivars were sown in 10-cm diameter plastic pots in sterilized Bozeman silt loam soil. Initial single uredium inoculation of Moore (CI 7251) was done by gently rubbing spores that had been suspended in a drop of distilled water on the leaf, using the thumb and index finger.

Prior to inoculation, the spores were hydrated for 4 hr in 100% relative humidity. Barley seedling differentials at the single-leaf stage were misted with distilled water, then dusted with rust spores that had been mixed with talc (1 mg spores/5 mg talc), using a small hand powder duster. Urediospores were collected only from Moore which was kept in isolation following each inoculation. Inoculated seedlings were kept for 20 to 24 hr in a dew chamber maintained at 20 ± 1°C and in 100% relative humidity. They were then placed in controlled environment chambers maintained at 20/15°C and a 16/18 hr photoperiod ($2.2\text{-}3.3 \times 10^4$ erg/cm^2 sec) day/night regime.

Assessment of Reaction Types

Readings of developed pustules were made 10 to 12 days after inoculation. Six infection classes and three reaction types were used (Table 2).

All readings of symptoms and signs were made on the first leaf of each genotype. When the reaction proved distinct, one test was considered sufficient. In less distinct cases, the test was repeated. The interaction between the 13 barley differentials and 88 mono-uredial Tunisian rust isolates was determined.

Classification and Analyses of the Isolates

The reaction of tested genotypes to rust was ranked as resistant, intermediate, or susceptible. In the analysis, only resistant and susceptible reactions were used for ranking the isolates and checking for duplicates.

Table 2. Assessment of reaction types of *P. hordei* on host differentials.

Infection class	Reaction type	Symptom description
0	R*	no visible rust pustules
0	R	no visible rust pustules, necrosis
1	R	some small pustules, chlorosis and/or necrosis
2	I	moderate size pustules, chlorosis
3	S	large pustules, chlorosis
4	S	large pustules, no chlorosis

* R = resistant; I = intermediate; S = susceptible.

In the virulence formula, intermediate and resistant reactions were both considered as resistant. Differential genotypes with a resistant or intermediate reaction type were considered effective, whereas only those with a susceptible reaction type were considered ineffective. The total number of genotypes for each reaction type is listed in Tables 3 to 10 for each leaf rust isolate.

Data were processed using a computer program based on Flor's gene-for-gene theory (Flor 1946, 1971) and capable of sorting and classifying a large number of isolates in an increasing order of virulence. This program also sorts out and lists any duplicate isolates separately.

Results and Discussion

A total of 88 single uredium isolates of *P. hordei* were tested. Leaf rust samples were collected from different geographic regions in Tunisia. The virulence patterns of the *P. hordei* isolates at each site of collection (Table 1) are shown in Tables 3 through 9. In each case investigated, the duplicate isolates were omitted, and the ranking of the isolates was based on the resistant/susceptible reaction types.

Virulence patterns of *P. hordei* in northern Tunisia: BouRbia (Br) and Mateur (Ma)

The virulence patterns of three different *P. hordei* isolates collected at BouRbia in 1982 and in 1987 are shown in Table 3. The isolates collected at Mateur are shown in Table 4. At this site the isolate TuMa80-1 was collected in 1980 and had been previously studied (Reinhold and Sharp 1982).

In the northern region, the two isolates identified in 1982 at BouRbia differed from all the other isolates analyzed in this study. As shown in Table 4, these two isolates were similar and somewhat virulent. They differed in infection types on the barley cultivars Quinn (Pa_2+Pa_5) and Magnif (Pa_5). The isolate identified in 1987 (TuBr87-1) was more virulent than the previous ones, and differed in its reaction on CI 1243 (Pa_9), Ricardo, Bolivia, and Batna. The virulence patterns of leaf rust at the Mateur site varied over the years. The virulence pattern observed in 1980 was not detected in collections made the following years. It is possible that this isolate evolved to a more virulent type following sexual recombinations on the alternate host, or it was just not detected in the 1983 or 1984 samples. Isolates identitifed in the 1983 collection were all more virulent than the 1980 isolate. The virulence patterns of these isolates (Table 4) suggest that the leaf rust population at this site was highly variable. Among the isolates identified in 1984, only TuMa84-5 differed from those of 1983. This isolate may not have been detected the previous year or it actually could have been a new virulence type.

The virulence pool of *P. hordei* detected in this area presents a potential danger to barley growers. Theoretically, barley cultivars that can be cultivated in this area would be those carrying either or both Pa_3 and Pa_7 resistance genes. It was shown (Table 4) that these two genes are presently the only ones effective against virulent *P. hordei* isolates identified in this region. Virulence differences in *P. hordei* that were identified in the north are most probably due to the presence of the alternative host, *Ornithogalum* spp., which was found in many barley fields around Mateur.

Table 3. Virulence patterns of three *P. hordei* isolates sampled at BouRbia, northern Tunisia, in 1982 and 1987.

Isolate	Differential host genotypes													Total		
	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuBr 82-1	R	R	R	R	R	I	S	S	S	S	S	S	S	5	1	7
TuBr 82-2	R	R	R	R	I	S	I	S	S	S	S	S	S	4	2	7
TuBr 87-2	R	R	S	S	S	S	I	S	S	S	R	S	S	3	1	9

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

Table 4. Virulence patterns of 16 *P. hordei* isolates sampled at Mateur, northern Tunisia, in 1980, 1983, and 1987.

Isolate	Differential host genotypes													Total		
	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuMa 80-1	R	R	R	I	I	I	S	I	R	S	S	S	S	4	4	5
TuMa 83-15	R	R	R	R	S	R	R	I	S	S	I	S	S	6	2	5
TuMa 83-14	R	R	I	I	R	R	R	S	R	S	S	S	S	6	2	5
TuMa 83-2	R	R	R	R	S	I	S	I	R	S	I	S	S	5	3	5
TuMa 83-16	R	R	I	I	S	R	R	S	R	S	S	S	S	5	2	6
TuMa 83-12	R	R	S	S	S	R	R	S	R	S	S	S	S	5	0	8
TuMa 83-11	R	R	R	R	S	I	S	S	S	S	S	S	S	4	1	8
TuMa 83-5	R	R	I	I	I	S	S	S	I	S	S	S	R	3	4	6
TuMa 83-3	R	R	I	I	R	S	S	S	I	S	I	S	S	3	4	6
TuMa 83-6	R	R	S	S	S	S	S	S	S	S	S	R	I	3	1	9
TuMa 83-1	R	R	S	R	S	S	S	S	S	S	S	S	S	3	0	10
TuMa 83-7	R	R	I	S	S	S	S	S	S	S	S	S	S	2	1	10
TuMa 83-4	R	R	S	S	S	S	S	S	I	S	S	S	S	2	1	10
TuMa 83-8	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11
TuMa 84-5	R	R	R	R	S	S	S	S	S	S	S	S	S	4	0	9
TuMa 84-3	R	R	R	S	S	S	S	S	S	S	S	S	S	3	0	10
TuMa 84-1	R	R	S	R	S	S	S	S	S	S	S	S	S	3	0	10

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective)

Virulence patterns of *P. hordei* in northwestern Tunisia: Beja (Bj) and Le Kef (Ke)

The virulence patterns of 16 leaf rust isolates identified at Beja in 1982 and in 1984 are shown in Table 5. In 1984, seven isolates were identified from collections made at this site, four of these isolates originated from the alternative host (*Ornithogalum* spp.). At Le Kef site, 13 isolates were identified in 1982, two in 1984, and four in 1987 (Table 6). The virulence patterns of the 1984 isolates were similar if not identical to some isolates identified the previous year. TuKe 84-1 had the same virulence as TuKe82-9 and TuKe84-2 differed slightly from TuKe-8 isolate. The 1987 isolates differed from those of 1982 and 1984, and had more variable virulence patterns.

In the Northwest, significant variability in virulence patterns of *P. hordei* was observed (Tables 5 and 6). In Beja, leaf rust isolates originating from collections made from *Ornithogalum* spp. were as variable as those isolated from commonly grown barley cultivars. None of these isolates were virulent on Pa_3 or Pa_7. Virulence patterns detected in 1982 samples were not recovered in 1984 or in 1987 collections. A change in virulence of *P. hordei* might have taken place at Beja (Table 5). At Le Kef, however, no major changes were observed (Table 6).

Pathogenicity differences in *P. hordei* in northwestern Tunisia are probably enhanced by the presence of the alternate host, particularly at Beja, where *Ornithogalum* spp. were found in barley fields. The sexual state of *P. hordei* on *Ornithogalum* spp. (Table 5) contributed to the diversification of the spectrum of virulence of *P. hordei* in this region.

Virulence patterns of *P. hordei* in central Tunisia: Kairouan (Kr) and El Jem (Ej)

Only one leaf rust isolate was identified in 1982 and 1983 at Kairouan and at El Jem, respectively (Table 7). Since the rust collections were made only once at these sites, no speculation can be made as to possible changes in virulence of these two *P. hordei* isolates.

The virulence types of leaf rust encountered in central Tunisia were similar to those identified in the northwest. The isolate from El Jem (Table 7) was identical to one isolate from Beja. The Kairouan isolate was found in both sites in the Northwest.

Virulence patterns of *P. hordei* in southern Tunisia: the Oasis (Oa) and Mareth (Mr)

Seven highly variable leaf rust isolates were sorted out from leaf rust samples collected in the Oases in 1982 (Table 8). In 1984, only two virulence types were detected in the Oasis, and were the same as TuOa82-5 and TuOa82-1 identified in 1982. At Mareth, more duplicate isolates were detected than at any other site.

In southern Tunisia, leaf rust virulence varied almost as much as in the north and northwest, but fewer

Table 5. Virulence patterns of 16 *P. hordei* isolates sampled at Beja, northern Tunisia, in 1982 and 1984.

	Differential host genotypes													Total		
Isolate	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuBj 82-9	R	R	R	R	R	S	S	I	S	R	S	S	S	6	1	6
TuBj 82-10	R	R	R	R	R	I	R	S	S	S	S	S	S	6	1	6
TuBj 82-2	R	R	R	R	S	S	S	I	S	R	S	S	S	5	1	7
TuBj 82-1	R	R	R	R	R	S	S	I	S	S	S	S	S	5	1	7
TuBj 82-7	R	R	I	I	S	R	I	S	R	S	S	S	S	4	3	6
TuBj 82-4	R	R	R	R	S	S	S	S	S	S	S	S	S	4	0	9
TuBj 82-11	R	R	S	R	S	S	S	S	S	S	S	S	S	3	0	10
TuBj 82-8	R	R	I	S	S	I	S	S	S	S	S	S	S	2	2	9
TuBj 82-6	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11
TuBj 84-1	R	R	S	R	R	S	S	R	R	S	S	S	S	6	0	7
TuBj 84-2	R	R	R	R	S	I	S	S	S	S	R	S	S	5	1	7
TuBj 84-8*	R	R	I	R	S	S	S	R	S	S	R	S	S	5	1	7
TuBj 84-4*	R	R	R	I	S	S	S	S	S	S	I	S	S	3	2	8
TuBj 84-7*	R	R	S	R	S	S	S	S	S	I	I	S	S	3	2	8
TuBj 84-3	R	R	I	R	S	I	S	S	S	S	S	S	S	3	2	8
TuBj 84-5*	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).
* = Isolates originating from alternate host.

Table 6. Virulence patterns of nine *P. hordei* isolates sampled at Le Kef, northwestern Tunisia, in 1982, 1984, and 1987.

	Differential host genotypes													Total		
Isolate	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuKe 82-5	R	R	R	R	R	R	R	S	R	S	R	S	S	9	0	4
Tuke 82-4	R	R	R	R	R	R	I	I	R	S	R	S	S	8	2	3
TuKe 82-6	R	R	R	R	R	S	S	I	S	S	S	S	S	5	1	7
TuKe 82-3	R	R	R	R	S	S	S	S	S	S	S	S	S	4	0	9
TuKe 82-8	R	R	S	S	S	S	S	S	S	S	S	S	S	3	0	10
TuKe 82-10	R	I	I	S	S	S	S	S	S	S	S	S	S	2	2	9
TuKe 82-9	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11
TuKe 84-2	R	R	R	I	S	S	S	S	S	S	S	S	S	3	1	9
TuKe 84-3	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11
TuKe 87-1	R	R	R	S	I	S	R	I	R	R	R	S	S	7	2	4
TuKe 87-4	R	R	S	S	R	S	S	S	R	S	S	S	R	5	0	8
TuKe 87-2	R	R	R	S	S	S	I	S	S	I	S	S	S	3	2	8
TuKe 87-3	R	R	I	S	S	S	S	S	S	S	S	S	S	2	1	10

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

Table 7. Virulence patterns of two *P. hordei* isolates sampled at Kairouan in 1982 and one isolate sampled at El Jem in 1983 in central Tunisia.

	Differential host genotypes													Total		
Isolate	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
Kairouan																
TuKr 82-2	R	R	R	R	S	S	S	S	S	S	S	S	S	4	0	9
TuKr 82-1	R	R	I	R	S	S	S	S	S	S	S	S	S	3	1	9
ElJem																
TuEj 83-1	R	R	R	R	R	R	I	S	S	S	S	S	S	6	1	6

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

virulence patterns were identified in this region (Tables 8 and 9). The microclimate in the Oasis was favorable for leaf rust development. In 1984, some barley plots found in the Oasis were completely devastated by leaf rust. The isolates identified were all virulent and identical to some virulence types identified in 1982 (Table 8). Little variability was detected in 1984, probably due to the high frequency of the virulent types. At Mareth, the isolates were collected from irrigated barley plots that were grown as an intercrop in olive orchards. The irrigation created an environment favorable for rust development in 1983, and virulence patterns similar to those in the Oasis were observed (Tables 8 and 9). The intensive agriculture practiced in the Oasis probably made it possible for leaf rust to cycle on the primary host.

Common Virulence Patterns Across Regions

All *P. hordei* isolates found at least at two collection sites are shown in Table 10 and classified into five groups. The *P. hordei* isolate in Group 4 was the most virulent one identified in Tunisia. It was found in all barley growing areas in the north, northwest, and south. Only Pa_3 and Pa_7 were effective against this isolate. Group 3, found in all locations but central Tunisia, was virulent on all resistance genes but Pa_3, Pa_7, and Pa_9. The north and northwest had a common *P.*

Table 8. Virulence patterns of seven *P. hordei* isolates sampled in the Oasis, southern Tunisia, in 1982.

Isolate	Differential host genotypes													Total		
	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuOa 82-6	R	R	R	R	R	S	S	S	S	R	R	S	S	7	0	6
TuOa 82-4	R	R	R	S	S	I	I	R	S	S	I	I	S	4	4	5
TuOa 82-3	R	R	I	I	I	R	S	S	I	S	R	S	S	4	4	5
TuOa 82-8	R	R	I	R	I	I	S	S	S	S	I	S	S	3	4	6
TuOa 82-7	R	R	S	I	S	R	S	I	I	S	S	S	S	3	3	7
TuOa 82-5	R	R	R	S	S	S	S	S	S	S	S	S	S	3	0	10
TuOa 82-1	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

Table 9. Virulence patterns of five *P. hordei* isolates sampled at Mareth, southern Tunisia, in 1983.

Isolate	Differential host genotypes													Total		
	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
TuMr 83-10	R	R	R	R	R	S	S	I	S	I	S	S	S	5	2	6
TuMr 83-6	R	R	R	S	S	R	R	S	S	S	I	S	S	5	1	7
TuMr 83-2	R	R	R	I	S	S	S	S	S	S	S	S	S	3	1	9
TuMr 83-9	R	R	I	R	S	S	S	S	S	S	S	S	S	3	1	9
TuMr 83-8	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

Table 10. Common virulence patterns of *P. hordei* isolates identified in Tunisia in 1982, 1983, and 1984.

Isolate	Differential host genotypes													Total		
	Estate Pa_3	C.Capa Pa_7	Hor Pa_9	Ricardo Pa_{2+}	Bolivia Pa_2+Pa_6	Quinn Pa_2+Pa_5	Magnif Pa_5	Peruvian Pa_2	Sudan Pa	Egypt Pa_8	Batna Pa_{2+}	Gold Pa_4	Reka Pa_{2+}	R	I	S
Group 1[a]	R	R	R	R	S	S	S	S	S	S	S	S	S	4	0	9
Group 2[b]	R	R	S	R	S	S	S	S	S	S	S	S	S	3	0	10
Group 3[c]	R	R	R	S	S	S	S	S	S	S	S	S	S	3	0	10
Group 4[d]	R	R	S	S	S	S	S	S	S	S	S	S	S	2	0	11
Group 5[e]	R	R	R	R	R	S	S	I	S	S	S	S	S	5	1	7

R = resistant (effective); I = intermediate (effective); S = susceptible (ineffective).

a. Isolate identified at Le Kef (1982, 1984), Beja (1982), Mateur (1984), Mareth (1983), and Kairouan (1982).

b. Isolate identified at Beja (1982) and Mateur (1982, 1984).

c. Isolate identified at Le Kef (1982), Beja (1982), Mateur (1983, 1984), and Oasis (1982).

d. Isolate identified at Le Kef (1982, 1984), Beja (1982, 1984), Oasis (1982), and Mareth (1983).

e. Isolate identified at Le Kef (1982) and Beja (1982).

hordei isolate, Group 2, that was avirulent on Estate (Pa_3), Cebada Capa (Pa_7), and Ricardo (Pa_{2+}) only. The isolate in Group 1 that is found in all geographic areas in Tunisia was virulent on all genotypes but Estate, Cebada Capa, Hor 2596, and Ricardo. These genotypes and Bolivia were resistant to the isolate common to the northwestern region, Group 5, which was the least virulent among all isolates.

The results obtained (Tables 3-10) show the presence of several virulence types of *P. hordei* in Tunisia. The leaf rust isolates identified within each site were variable and their virulence patterns differed from year to year. Some similar virulence types were identitifed in at least two sites. Identical isolates were also found at almost every collection site throughout the country. Nonetheless, most of the isolates studied were site-specific, even though the virulence patterns changed.

With the exception of Pa_3 and Pa_7, the frequency of *P. hordei* virulence against the other Pa genes varied from moderate (Pa_9) to very severe (Pa_4, Pa, Pa_8, Pa_{2+}). Although leaf rust isolates virulent on Pa_7 have been reported (Parlevliet 1981), all Tunisian isolates tested in this study were avirulent on Pa_7 and on Pa_3.

The observed changes in virulence patterns of *P. hordei* in Tunisia should be carefully monitored. Under favorable climatic conditions, a leaf rust epidemic could be expected, especially if susceptible barley cultivars were grown over large areas.

References

Clifford, B.C. 1974. The choice of barley genotypes to differentiate races of *Puccinia hordei* Otth. Cereal Rust Bulletin 2: 5-6.

Clifford, B.C. 1977. Monitoring virulence in *Puccinia hordei*: A proposal for the choice of host genotype and survey procedures. Cereal Rust Bulletin 5: 34-38.

Flor, H.H. 1946. Genetics of pathogenicity in *Melampsoralini*. Journal of Agricultural Resources (Washington D.C.) 73: 335-357.

Flor, H.H. 1971. Current status of the gene-forgene concept. Annual Review of Phytopathology 9: 275-296.

Parlevliet, J.E., Beek, J.G. van der and Pieters, R. 1981. Presence in Morocco of brown rust, *Puccinia hordei*, with a wide range of virulence to barley. Cereal Rust Bulletin 9: 3-8.

Pretorius, Z.A. and Wilcoxson, R.D. 1983. Sources of resistance in barley to races of *Puccinia hordei* found in the United States between 1979 and 1982. Barley Newsletter 27: 131-133.

Reinhold, M. and Sharp, E.L. 1982. Virulence types of *Puccinia hordei* from North America, North Africa, and the Middle East. Plant Disease 66: 1009-1011.

Sharp, E.L. and Reinhold, M. 1982. Sources of genes resistant to *Puccinia hordei* in barley. Plant Disease 66: 1012-1013.

Yahyaoui, A.H. and Sharp, E.L. 1987. Virulence spectrum of *Puccinia hordei* in North Africa and the Middle East. Plant Disease 71: 597-598.

Seedling and Adult Stage Screening for *Septoria nodorum* Resistance in Wheat

Bogdan Koric
University of Zagreb
Faculty of Agricultural Sciences
Institute for Breeding and
Production of Field Crops
Zagreb, YUGOSLAVIA

The present study aimed at screening wheat accessions for resistance to glume blotch caused by *Septoria nodorum* isolates, and at determining the correlation between resistance at seedling and at adult stage.

Testing at Seedling Stage

More than 500 wheat genotypes of local and foreign origin were tested over a 3-year period, using locally collected *Phaeosphaeria nodorum* (perfect stage of *S. nodorum*) isolates. Seeds were planted in plastic pots in several replications. Between 200 and 500 seedlings of each sample, depending on seed availability, were tested. Plants were inoculated at the 3-leaf stage using a spore suspension at a concentration of $10^{4.5}$/ml. The pots were covered with plastic sheets and stored at $13^{o}C \pm 1.5$. The sheets were removed after 72-96 hrs, and ratings were taken 12-14 days later using the modified Bronnimann scale (Bronnimann 1968).

Material from the USSR, Hungary, Australia, and the USA expressed a high degree of resistance and can, therefore, be used in breeding for resistance to *Septoria nodorum*. Some of the local genotypes, which were bred for *Septoria nodorum* resistance/tolerance (Koric 1986), also gave good results.

Testing at Adult Stage

Testing for resistance to *Phaeosphaeria nodorum* at adult stage was conducted under artificial inoculation in the field with a known concentration of spores, thus providing the desirable degree of infection. Disease severity on spikes was rated according to the Bronnimann scale (Bronnimann 1968), whereas on leaves, it was determined by using the modified Prescot scale adjusted for rating *Septoria nodorum.* In the latter case, two scores were recorded: the first indicated how high on the plant the disease has spread on the leaves, while the other gave the percent leaf area infected. This is of paramount importance because not all parts of the plant are equally susceptible nor is their role similar in yield production. In some varieties the flag leaf remains completely free of the disease, while other leaves become infected. Also, there are differences in susceptibility between leaf and spike; a wheat genotype may be susceptible to leaf infection with no disease manifestation on spike, and vice versa.

Results showed that very few entries were completely susceptible or resistant. All the genotypes with severely infected spikes and/or flag leaf were discarded from further testing, whereas genotypes with less than 10% infection on lower leaves were considered as possible sources of resistance. Consequently, from 310 genotypes tested in 1982, 300 in 1983, and 438 in 1984, 14, 18, and 39 genotypes, respectively, were retained.

Association Between Resistance at Seedling and at Adult Stage

It would be desirable if screening at seedling stage for resistance to *Leptosphaeria nodorum* is adequate, because in this case several testings can be conducted in one year. Spearman's rank correlation (Snedecor and Cochrain 1967) between disease rating at seedling and adult stage on 25 varieties over 3 years showed that screening at seedling stage may be used only as an auxiliary means for testing resistance to *Septoria nodorum*. Therefore, testing at adult stage is imperative for this purpose. This applies especially to moderately susceptible wheat genotypes.

References

Bronnimann, A. 1968. Zur Kenntnis von *Septoria nodorum* Berk., dem Erreger der Spetzenbraune und einer Blattdurre des Weizens. Phytopathologische Zeitschrift, Bd. 61: 101-146.

Koric, B. 1986. Testing some wheat genotypes (*Triticum aestivum* spp *vulgare*) for resistance to *Septoria nodorum* Brek. Ph.D. Thesis. 133 pp.

Snedecor, G.W. and Cochrain, W.G. 1967. Statistical methods. Iowa State University Press. Iowa, USA.

Relation between High Molecular Weight Glutenin Subunits and Bread Wheat Quality

Douadi Khelifi
Institut des Sciences de la Nature
Universite de Constantine, ALGERIA
and
Gerard Branlard
INRA, Station d'Amelioration des Plantes
Domaine de Crouelle 63039
Clermont-Ferrand, FRANCE

Wheat quality is a polygenic character difficult to evaluate during segregating generations. It is generally measured at a later stage, but by then a large part of the genetic variability would probably have been already eliminated. Several studies have shown that certain high molecular weight glutenin subunits are correlated with quality in wheat (Payne *et al.* 1981; Moonen *et al.* 1982; Branlard and Dardevet 1985). If this association exists in general, then it may be possible to conduct early generation quality screening, and select parents for crossing, simply based on the presence or absence of certain glutenin subunits.

The objectives of this study were (i) to identify the high molecular weight glutenin subunits that are correlated with the main rheological characteristics and (ii) to suggest which subunits needed to be assembled to obtain a high-quality wheat variety.

Materials and Methods

Eight bread wheat varieties of different genetic origins were used in this study: Anza, Arz, Blue-Bird, Dougga, Mahon-Demias, Pavon, Siete-Cerros, and Strampelli. They were grown in eastern Algeria at Constantine, Ferdjioua, and Souk-Ahras.

Three quality tests were performed. They were: (i) Chopin alveograph, which measures the rheological characteristics of tenacity (P), swelling (G), and the energy necessary to deform dough (i.e. dough strengh, W); (ii) Zeleny (1947) and SDS (Axford *et al.* 1979) sedimentation tests; and (iii) the Pelshenke swelling test.

Proteins were extracted from individual grains with a sodium dodecyl sulfate (SDS) solution and

2-mercaptoethanol (Payne *et al.* 1980). Glutenin subunit electrophoresis in SDS medium (SDS-PAGE) was carried out following Laemmli's method (1970) on vertical 10% acrylamide gel. Glutenin subunits were analysed on 2 or 3 grains per variety and their mobilities defined according to the nomenclature of Payne and Lawrence (1983).

Results and Discussion

Quality characteristics of the eight varieties are given in Table 1 which shows that the tested varieties were quite distinct. Siete-Cerros and Pavon were strong wheats whereas Mahon-Demias was weak. Most of the varieties had high tenacity and low swelling. The quality differences were less evident with the Zeleny and SDS tests than with the Pelshenke test. Mahon-Demias had the highest protein content but the poorest quality.

Thirteen glutenin subunits with different mobilities (bands 1, 2, 2*, 5, 7, 8, 9, 10, 12, 14, 15, 17, and 18) were observed among the eight tested varieties. This diversity is relatively wide, as a total of 24 bands were observed among a large number of wheat varieties collected from more than 20 countries.

Several of these subunits correspond to linked genes: subunits 7 with 8, 17 with 18, 2 with 12, and 5 with 10. Subunits 9, 14, and 15 were only observed in Siete-Cerros and Mahon-Demias, respectively, and were not considered in the following analysis. Thus, only subunits 1, 2*, 2 or 12, 5 or 10, 7 or 8, and 17 or 18 needed to be considered.

The influence of each of these subunits on quality characteristics was studied by comparing the means of the varieties with or without the given subunits (Table 2). It was found that differences in Zeleny and SDS sedimentation test scores were not associated with the presence or absence of any one of the glutenin subunits. This was probably because these tests depend on protein content, which varied little among the varieties studied. All varieties had a protein content of 13 to 14%, except Mahon-Demias (15.6%, Table 1).

Table 1. Quality characteristics of eight bread wheat varieties (means of three locations in Algeria).

Genotype	Chopin alveograph			Sedimentation tests		Pelshenke swelling test	Protein content (%)*
	Strengh	Tenacity	Swelling	Zeleny	SDS		
Anza	152	92	19	28	39	9	13.44
Arz	237	133	13	29	41	156	13.11
Blue-Bird	249	92	24	24	37	148	13.34
Dougga	229	101	19	29	40	164	13.26
Mahon-Demias	89	71	16	18	30	27	15.60
Pavon	297	131	18	32	46	238	13.98
Siete-Cerros	267	140	18	24	37	114	13.38
Strampelli	217	142	17	26	39	139	13.62

* Protein content expressed as % dry matter.

Table 2. Association between quality measures and the different high molecular weight subunits.

Quality measure	Glutenin subunit											
	1 / 2*			7 and 8			17 and 18			2 and 12 / 5 and 10		
				P		A	P		A			
Strength	233	*	258	212	NS	226	260	*	173	194	*	254
Tenacity	117	*	126	123	*	106	115	NS	110	107	*	123
Swelling	21	*	17	16	NS	18	20	*	15	17	NS	19
SDS	38	NS	41	39	NS	38	40	NS	37	38	NS	40
Zeleny	25	NS	29	27	NS	25	27	NS	25	27	NS	27
Pelshenke	141	*	168	128	NS	138	102	**	166	110	**	174

A = Absence.
P = Presence.
*, **, NS = Significant, highly significant, nonsignificant.

Subunits 1, 2, 2*, 5, 10, 12, 17, and 18 were found to be associated with strength; subunits 1, 2*, 17, and 18, with stretching; subunits 1, 2, 2*, 5, 7, 8, 10, and 12, with dough tenacity; and subunits 1, 2, 2*, 5, 10, 12, 17, and 18 with Pelshenke test score.

When subunits 2 and 12 were present, subunits 5 and 10 were absent, and vice versa. So they could be produced by two different alleles of two linked genes. Strength, tenacity, and the Pelshenke test scores were reduced. They should thus be excluded if a strong wheat variety is desired. In contrast, subunits 5 and 10 were associated with high strength, dough tenacity, and the Pelshenke test value.

Subunits 1 and 2* also appeared to be produced by two different alleles of the same gene. Subunit 2*, in contrast to subunit 1, was associated with high strength, tenacity, and the Pelshenke test scores, whereas subunit 1, in contrast to subunit 2, was associated with a high swelling score.

Tenacity was increased in the presence of subunits 7 and 8. Besides tenacity, the two subunits were not associated with any other quality characteristics. Subunits 17 and 18 were associated with high strength and swelling, but low Pelshenke values. These two subunits should thus be selected to obtain a strong wheat, especially because they were associated with increased swelling, a criterion rarely found among Algerian wheat varieties.

Our results obtained with the eight wheat varieties grown in Algeria confirmed those obtained by Branlard and Dardevet (1985). To select a high quality wheat variety, parents containing subunits associated with good strength (2*, 5, 10, 17, and 18) should be used. Other subunits such as 1, 7, and 8 may also provide some favorable quality characteristics.

References

Axford, D.W.E., Mc Dermott, E.E. and Redman, D.G. 1979. Note on the sodium sulfate test of bread making quality: comparison with Pelshenke and Zeleny tests. Cereal Chemistry 56: 582-584.

Branlard, G. and Dardevet, M. 1985. Polymorphism of proteins and bread wheat quality. Correlation between glutenin bands and technological characteristics. Journal of Cereal Science 3: 345-354.

Laemmli, U.K. 1970. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature 680-685.

Moonen, J.H.E., Sheepstra, A. and Graveland, A. 1982. Use of the SDS sedimentation test and SDS-polyacrylamide gel electrophoresis for screening breeder's samples of wheat for bread-making quality. Euphytica 31: 677-690.

Payne, P.I., Law, C.N. and Mudd, E.E. 1980. Control by homeologous group 1 chromosomes of the high molecular weight subunit of glutenin, a major protein of wheat endosperm. Theoretical and Applied Genetics 58: 113-120.

Payne, P.I., Corfield, K.G., Holt, L.M. and Blackman, J.A. 1981. Correlation between the inheritance of certain high molecular weight subunits of glutenin and bread-making quality in progenies of six crosses of bread wheat. Journal of the Science of Food and Agriculture 32: 51-60

Payne, P.I. and Lawrence, G.j. 1983. Detection of a novel high molecular weight subunit of glutenin in some japanese hexaploid wheats. Journal of Cereal Science 1: 3-8.

Zeleny, L. 1947. A simple sedimentation test for estimating the bread-baking and gluten qualities of wheat flour. Cereal Chemistry 24: 465-475.

Electrophoretic Variability in Landraces of Durum Wheat from Ethiopia

L. Dominici, A. Grottanelli, C. Tomassini, D. Lafiandra, E. Porceddu,

Department of Agrobiology and Agrochemistry
University of Tuscia, Viterbo, ITALY

and

A.B. Damania

Cereal Improvement Program
ICARDA, P.O. Box 5466, Aleppo, SYRIA

Gliadins and glutenins, the storage proteins of wheat, are the main components of gluten. These proteins consist of subunits with varying molecular weights and it is from their structure and interaction that the viscoelastic properties of gluten are derived (Porceddu *et al.* 1983). Gliadins, defined by their solubility in 70% ethanol, have been subdivided into α, β, γ, and ω fractions according to their relative mobility in an electrophoretic gel with acidic buffer (Woychik *et al.* 1961).

The genes coding for gliadin proteins have been associated with homoeologous chromosomes of group 1 and 6 (short arms) in tetraploid and hexaploid wheats (Wrigley and Shepherd 1973; Lafiandra *et al.* 1983). Genetical analyses have also indicated that gliadin genes are clustered in complex loci termed as blocks. In durum wheats the chromosome 1B is primarily responsible for the qualitative traits as genes coding for proteins correlated with strong or weak gluten are located on it.

The gliadin band with relative mobility (Rm) 45 has been associated with strong gluten and hence good pasta cooking quality, while band Rm 42 was correlated to weak gluten and poor pasta cooking quality (Damidaux *et al.* 1978; Kosmolak *et al.* 1980). These two bands are allelic forms of a gene on chromosome 1B, and durum wheats possessing bands with electrophoretical mobility other than 42 and 45 have been reported (Margiotta *et al.* 1987).

Materials and Methods

ICARDA is located within the primary center of diversity for tetraploid wheats and is, therefore, the ideal place for the collection, evaluation, and utilization of genetic ressources of wheat. A collection of approximately 3500 accessions of durum wheat from Ethiopia was evaluated by the Cereal Improvement Program of ICARDA during the 1984/85 season. Subsamples of this collection were also sent to the Department of Agrobiology and Agrochemistry, University of Tuscia, Viterbo, Italy, for electrophoretic analysis. The principal objective of this work was to decipher variability for storage proteins in wheat kernels.

Polyacrylamide gel electrophoresis (PAGE) with aluminum lactate buffer (pH = 3.1) was used (Lafiandra and Kasarda 1985). Mobility of components was calculated using the methods suggested by Sapirstein and Bushuk (1985). The Italian durum wheat cultivar "Karel" was used as a reference as it possesses good pasta cooking qualities and also has the band Rm 45 in the γ-region of its electrophoretic profile.

Results and Discussion

The variability for storage proteins banding patterns in landraces of Ethiopian durum wheat was considerable (Fig. 1). Some mixtures with hexaploid seeds were also identified by the electrophoresis as the presence of two or more bands in the ω-region reveals gliadins of HMW which are coded only by genes on the 1D chromosome of wheat (Wrigley 1980; Zehatschek *et al.* 1981).

In the Ethiopian durum wheats many accessions showed the band Rm 45, some showed both bands Rm 42 and Rm 45, whereas in some accessions both were absent and other bands were observed.

Accessions without the Rm 45 band were not immediately discarded but were subjected to SDS-sedimentation tests which also give the extent of gluten strength

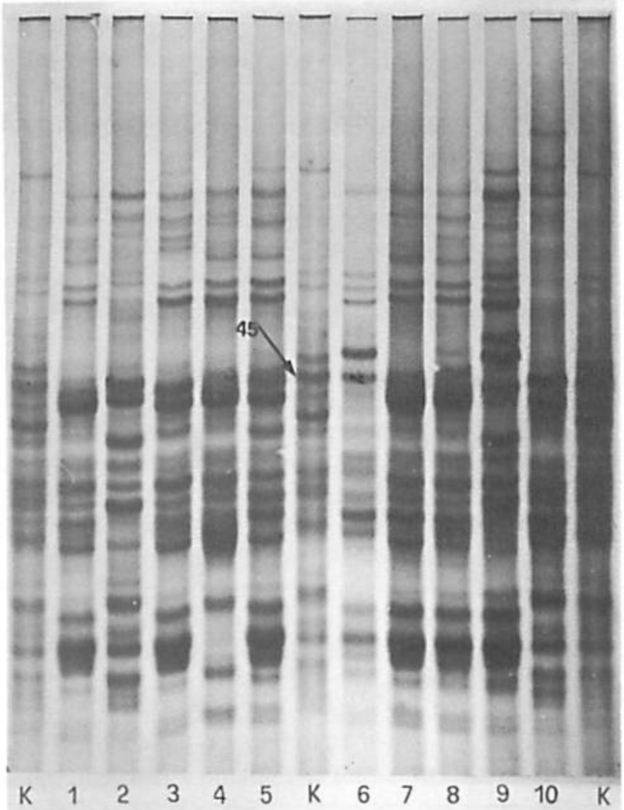


Fig. 1. Electrophoretic profiles of durum wheat accessions from Ethiopia. Cultivar Karel (K) is loaded as a reference. The profile of Karel showed the bands related to food protein qualities. Profiles 1, 4, and 7 lack the γ-gliadins 42 and 45. Profile 6 has both γ-gliadins 42 and 45.

(Josephides *et al.* 1987). This test appears to have a high correlation with micro-mixogram scores. (The mixogram pattern measures the resistance to shearing of pasta dough mixed in a bowl).

Interesting results have also been reported on Ethiopian wheats by other workers. For example, Negassa (1986) proposed Ethiopia as a gene center for germplasm suitable for wheat grain quality breeding work.

Recently it has been shown that gliadin genes on group 1 chromosomes are tightly linked to a group of genes which code for LMW glutenin subunit (Payne *et al.* 1984a). It is probable that these groups of proteins are responsible for quality properties in durum wheat (Payne *et al.* 1984b) and variability for these proteins is also being evaluated.

It has been demonstrated that different genes for high protein content act in a cumulative pattern and give transgressive segregations with 2.5 to 4.25% higher proteins in the progenies than in the parents (Johnson *et al.* 1979; Brunori *et al.* 1982). Thus we suggest that lines from Ethiopia possessing high protein content, such as those we have identified, be utilized in crosses by breeding programs to enhance the quality and quantity of protein in durum wheat.

References

Brunori, A., Figueroa, A. and Micke, A. 1982. Evaluations of potential genetic donors for high protein grain in wheat. Zeitschrift fuer Pflanzenzuechtung 88: 287-301.

Damidaux, R., Anstron, J.C., Grignac, P. and Feillett, P. 1978. Relation applicable en selection entre l'électrophoregramme des gliadines et les proprietes viscoelastiques du gluten de *Triticum durum* Desf. C.R. Seances Academy of Science Series D 387: 701-704.

Johnson, V.A., Wilhelmi, K.D., Kuhr, S.L., Mattern, P.J. and Schmidt, J.W. 1979. Breeding progress for protein and lysine in wheat. Pages 825-835 *in* Proceedings of the Fifth International Wheat Genetics Symposium (Ramanujam, S., ed.). 23-28 Feb 1978, New Delhi, India. Indian Society of Genetics and Plant Breeding, New Delhi, India.

Josephides, C.M., Joppa, L.R. and Youngs, V.L. 1987. Effect of chromosome 1B on gluten strength and other characteristics of durum wheat. Crop Science 27: 212-215.

Kosmolak, F.G., Dexter, J.E., Matsuo, R.R. and Marchylo, B.A. 1980. A relationship between durum wheat quality and gliadin electrophoregrams. Canadian Journal of Plant Science 60: 427-432.

Lafiandra, D., Benedettelli, S., Spagnoletti-Zeuli, P.L. and Porceddu, E. 1983. Genetical aspects of durum wheat gliadins. Pages 29-37 *in* Breeding Methodologies in Durum Wheat and Triticale. Proceedings of a Workshop (Porceddu, E., ed.). 17-19 Nov 1983, Viterbo, Italy. University of Tuscia, Viterbo, Italy.

Lafiandra, D. and Kasarda, D.D. 1985. One- and two-dimensional (two-pH) polyacrylamide gel electrophoresis in a single gel: separation of wheat proteins. Cereal Chemistry 62: 314-319.

Margiotta, B., Colaprico, G. and Lafiandra, D. 1987. Variation for protein components associated with quality in durum wheat. *in* Proceedings of the third International Workshop on Gluten Proteins, 1987, Budapest (in press).

Negassa, M. 1986. Patterns of diversity of Ethiopian wheats (*Triticum* spp.) and a gene center for quality breeding. Plant Breeding 97: 147-162.

Payne, P.I., Jackson, E.A., Holt, L.M. and Law, C.N. 1984a. Genetic linkage between endosperm storage protein genes on each of the short arms of chromosomes 1A and 1B in wheat. Theoretical and Applied Genetics 67: 235-243.

Payne, P.I., Jackson, E.A. and Holt, L.M. 1984b. The association between γ-gliadin band 45 and gluten strength in durum wheat varieties: a direct casual effect or the result of genetic linkage? Journal of Cereal Science 2: 73-81.

Porceddu, E., Lafiandra, D. and Scarascia-Mugnozza, G.T. 1983. Genetics of seed protein in wheat. Pages 77-141 *in* Seed Proteins: Biochemistry, Genetics, Nutritive Value (Gottschalk, W. and Muller, M., eds.). Nijhoff/Junk, Amsterdam, The Netherlands.

Sapirstein, H.D. and Bushuk, W. 1985. Computer aided analysis of gliadins electrophoregrams. I. Improvement of precision of relative mobility determination by using a three reference band standardization. Cereal Chemistry, 62:372.

Woychik, J.H., Boundy, J.A. and Dimler, R.J. 1961. Starch gel electrophoresis of wheat gluten proteins with concentrated urea. Archives of Biochemistry and Biophysics 94:477-482.

Wrigley, C.W. and Shepherd, K.W. 1973. Electrofocusing of grain proteins from wheat genotypes. Annals of New York Academy of Science 209: 174-162.

Wrigley, C.W. 1980. The genetic and chemical significance of varietal differences in gluten composition. Annals of Technology and Agriculture 29:207-212.

Zehatschek, W., Gunzel, G. and Fischbeck, G. 1981. Electrophoretic analysis of gliadins in wheat *Triticum aestivum* L. for determining their inheritance and chromosomal localization. Zeitschrift fuer Pflanzenzuechtung 87:45-47.

PARC/ICARDA Wheat and Barley Collection Expedition to Northern Pakistan

Rashid Anwar,
Plant Genetic Resources Laboratory, PARC, P.O. Box 1031, Islamabad, PAKISTAN

B.H. Somaroo,
Genetic Resources Program, ICARDA, P.O. Box 5466, Aleppo, SYRIA

and

R.J. Metzger
Oregon State University, Oregon, USA

Several plant collection expeditions have been organized in Pakistan in the past, but the northern areas (i.e. Gilgit and Baltistan) have remained unexplored for wheat and barley. The Plant Genetic Resources Unit of the Pakistan Agricultural Research Council (PARC) and the International Board for Plant Genetic Resources (IBPGR), Rome, have identified the Karakuram and Himalayan ranges in Pakistan as a high priority area for collecting germplasm of wheat, barley, rice, and other crops.

The development works under the Agha Khan Rural Support Programmes (AKRSP), such as the distribution of improved varieties and the construction of link roads and irrigation channels in these areas, have posed a severe threat to the indigenous plant genetic resources. Realizing this, the Pakistan Agricultural Research Council, Islamabad, in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, organized a wheat and barley collection expedition in an attempt to safeguard the valuable genetic material.

Geography and Climate

The valleys of Gilgit, Hunza, Ishkomen, Yasin, Gupis, Astor, Chitral, Chiles, and Skardu constitute the northern area of Pakistan. Pakistan is linked with China by the commonly known Silk Route, i.e. Karakuram highway which passes through Gilgit and Hunza. Three well known mountain ranges, namely, Hindu Kush, Pamir and Karakuram, and Haramosh are located in this area. The world's second highest mountain peak, K-2 (8611 m), is situated near Skardu, and two other famous peaks, namely, Rakaposhi (7862 m) and Nagaparbat (8203 m) also lie in the same area. The Indus, Hunza, and Gilgit rivers flow through these mountain ranges and valleys.

The northern part of Pakistan lies between 34° to 37° North and 72° to 78° East. Gilgit's coordinates are 35° 91'N and 34° 36' E; Yasin, 36° 35' N and 73° 31' E; and Skardu, 35° 19' N and 75° 38' E. Minimum temperature varies from 0 to -20°C, whereas maximum temperature ranges from 25 to 33°C. Annual rainfall varies between 100 and 150 mm. A terrace-type of cultivation is generally adopted throughout the region.

The soil material consists of rocks, gravel, coarse sand, fine sand, silt, fine silt, and, at some places, clay, and is almost laid in the form of alluvial fans intersected occasionally by water streams emerging generally from glaciers. Details on the geography and climate of this area are given by Anwar *et al.* (1983).

Organization and Area Explored

The explored area includes Chilas, Gilgit, Hunza, Sust, Gupis, Yasin, Thui, Askor, Skardu, and Shigar valleys. The collection expedition lasted 15 days in July/August with an itinerary along the route shown in Fig. 1 over a total distance of 3500 km.

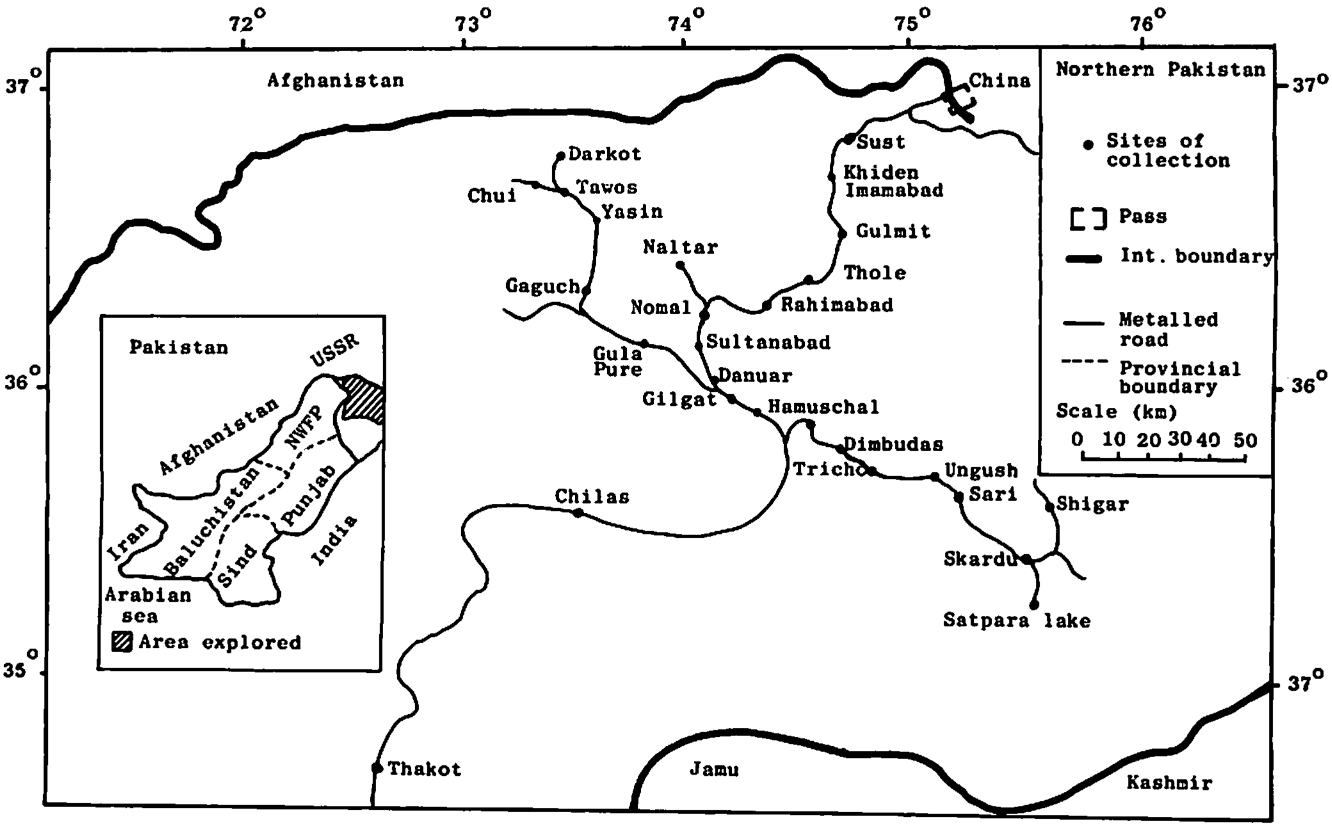


Fig. 1. Map showing collection sites.

Material Collected

In most of the cases, it was possible to collect the material directly from the field except at a few sites where it was gathered from threshing floors. Random samples were collected from various fields at intervals of 15-20 km or more, depending on edaphic and ecological conditions, genetic variability, and availability of the material as suggested by Bennett (1970) and Hawkes (1980). The 165 samples, collected from 68 sites at altitudes ranging from 950 to 2500 m, included 61 samples of wheat and 28 samples of barley. Other crops of interest, i.e. *Vicia*, *Secale*, *Medicago*, and *Avena* spp. were also collected (Table 1). IBPGR Collection Forms (General) were used for recording passport data.

During the expedition, a large genetic variability in wheat was observed especially in Baltistan area. The indigenous wheat cultivars were highly diverse in spike color, spike length, spike density, plant height, and awnedness. NAS, a local naked barley variety, was common in the area. *Secale* and *Avena* spp. were observed to be infesting wheat and barley fields, respectively. *Medicago falcata*, a rare species in the area, was found near Kachora Lake in Skardu valley.

Conservation

The material collected during this expedition was processed, cleaned, dried, documented, and conserved at the Plant Genetic Resources (PGR) laboratory, NARC, Islamabad. The material was divided into three parts, one complete set was maintained at the PGR laboratory for conservation, and the other two parts were supplied to the Genetic Resources Program of ICARDA, and to the Oregon State University, USA.

Genetic Erosion

In the Chilas and Gilgit area, the rate of genetic erosion of the indigenous wheat was high because of a widespread cultivation of improved varieties. Local genetic material in the Skardu area was also threatened by erosion. The indigenous barley landrace, NAS, is still under cultivation, most probably because of the unavailability of improved barley cultivars.

Acknowledgements

Thanks are due to the Chairman, PARC, and the Director General, NARC, Islamabad, for their help in organizing the expedition. We are also highly grateful to the Director General of ICARDA, Syria, for providing funds for this project.

Table 1. Species collected at various sites in northern Pakistan.

Crop	Number of samples	Number of sites
Triticum aestivum	61	50
Hordeum vulgare	28	27
Secale cereale	8	8
Vicia spp.	13	13
Medicago spp.	21	21
Trifolium spp.	4	4
Avena spp.	6	6
Miscellaneous	24	19

References

Anwar, R., Alam, Z. and Ahmed, A. 1983. Collecting vegetable germplasm from northern Pakistan. Pakistan Agricultural Research Council, Islamabad.

Bennett, E. 1970. Tactics of plant exploration. Pages 157-179 *in* Genetic Resources in Plants, their Exploration and Conservation (Frankel, O.H. and Bennett, E., eds.). Blackwell, Oxford and Edinburgh, UK.

Hawkes, J.G. 1980. Crop genetic resources: Field collection manual. IBPGR/Eucarpia, pp. 1-37.

Variability of Embryonic Roots and Coleoptiles in Durum Wheat

Sathyanarayanaiah Kuruvadi
Department of Plant Breeding, Universidad Autonoma Agraria "Antonio Narro", Saltillo, Coahuila, MEXICO

The wheat revolution has resulted in the development of superior dwarf and semidwarf genotypes. Allan *et al.* (1961) studied the seedling attributes in wheat and indicated that the semidwarf wheats produced relatively short coleoptiles, were slower in emergence, and produced inadequate stands as compared to the traditional tall varieties. Sunderman (1964) examined the seedling characters in winter wheat varieties and found the coleoptile length positively correlated with plant height in three out of five tests, and the coleoptile lengths positively associated with seedling emergence in one of two tests. Takahashi (1978) mentioned that environmental factors such as temperature, light, and air composition influence mesocotyl elongation and coleoptile length in rice.

The objective of this investigation was to study the variability of embryonic roots and coleoptiles in breeding lines and varieties of durum wheat (*Triticum turgidum* L. var. *durum*), and the association among different seedling attributes.

Materials and Methods

These studies were conducted at the Agricultural Research Station, Swift Current, Saskatchewan, Canada on 40 durum wheat cultivars with a broad spectrum of variability for yield and its components and other agronomic traits including plant height, days to flowering, and resistance to drought and diseases. In terms of plant height, they included 22 tall entries (95 cm or above), 5 single-gene dwarfs (86 to 95 cm or D1), 5 double-gene dwarfs (76 to 85 cm or D2) and 8 triple-gene dwarfs (up to 75 cm or D3). A random sample of 10 well-formed seeds of each of the 40 cultivars was arranged in a row in a wooden flat containing sand. The layout was a randomized block design with four replications. The wooden flats were kept in environmentally controlled chambers at 20°C and 16°C temperature on day and night, respectively, with 16 hr of light per day. On the eighth day, the sand was washed with water and the seedlings of each cultivar were separated carefully along with the roots. Five seedlings from each cultivar were randomly picked up for recording the observations on five seedling characters, namely, the number of seminal roots per seedling, length of the longest seminal root, total root length, coleoptile length, and shoot length.

The means of the seedling characters were used for the analysis of variance and for computing the coefficients of simple correlation.

Results and Discussion

The analysis of variance (Table 1) showed significant differences for all the measured traits among treatments (in particular for the comparison of tall vs dwarf) revealing considerable variability for seedling traits one week after seeding. However, the differences were not significant for coleoptile length in all comparisons except for tall vs dwarf.

The means of seedling characters are presented in Table 2. Coleoptile length of the different varieties tested varied from 2.2 to 3.1 cm and averaged 2.7 cm; however, differences among group means were negligible

Table 1. Analysis of variance and coefficient of variation (%) for various seedling characters in durum wheat, Swift-Current 1986.

Source of variance	Degree of freedom	Calculated F Values				
		Number of roots	Length of the longest root	Total root length	Coleoptile length	Shoot lenght
Replications	3	1.50	7.94	2.64	5.74	17.60
Treatments	39	5.17**	2.80**	5.05**	1.52**	7.17**
Tall vs dwarf	1	3.21*	4.77**	13.70**	9.82**	28.33**
Within tall	21	3.75**	2.14**	3.48**	1.32NS	5.64**
D_1 vs D_2+D_3	1	1.94NS	8.16**	0.89NS	0.16NS	17.50**
Within D_1	4	2.29*	1.73NS	3.08**	0.95NS	5.26**
D_1 vs D_3	1	53.92**	6.09**	52.35**	2.05NS	28.09**
Within D_2	4	9.26**	4.10**	6.78**	1.98NS	10.44**
Within D_3	7	2.49**	3.17**	2.51**	1.13NS	3.50**
Error	117	0.07	0.85	12.01	0.08	0.45
Total	159	22.81	211.81	3869.31	16.77	204.66
CV	-	5.36	10.11	10.86	11.18	9.20

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

NS = Non significant at the 5% level.

CV = Coefficient of variation.

Table 2. Means of seedling characters for different types of durum cultivars, Swift-Current, 1986.

Cultivar	No. of roots	Length of the longest root (cm)	Total root length (cm)	Coleoptile length (cm)	Shoot length (cm)	1000-kernel weight (g)
Tall						
DT 367	5.2	8.7	36.7	2.7	7.4	58
Wascana	5.0	10.0	33.6	2.5	7.8	50
Wakooma	4.7	9.6	29.6	2.3	6.7	36
Hercules	4.9	8.5	29.8	2.5	7.6	45
Pelissier	5.2	8.9	30.8	2.5	6.3	59
Lakota	5.0	9.9	34.0	2.6	7.4	43
7264-67B5	5.0	10.2	35.0	2.6	8.2	54
7464-K3A	5.0	8.5	29.1	2.8	6.7	51
7464-K4E	4.8	10.0	29.4	2.6	7.6	52
7464-CE1B	4.9	9.5	30.2	2.8	8.6	46
7465-CR2E	5.1	9.9	35.2	2.5	8.1	52
7465-CR2C	4.5	9.2	27.0	2.7	7.0	54
7466-BJ1C	4.9	9.1	28.2	2.7	6.4	52
7466-BL2B	4.4	8.8	26.1	2.6	6.6	51
7466-CF3C	4.0	7.7	21.0	2.8	4.9	51
7561-C1A	4.6	7.1	24.6	3.1	5.3	61
7561-CC1B	5.1	9.1	33.2	3.0	7.4	61
7561-EZ2E	5.0	9.8	36.7	2.7	7.6	57
7561-FK2C	5.4	8.5	31.4	2.6	6.7	57
7466-GH1A	5.1	8.5	31.8	2.8	6.6	62
7466-GH3A	5.0	8.3	31.2	2.8	6.4	57
7466-HA2D	4.9	8.2	32.7	2.9	7.0	57
Mean	4.9	9.0	30.8	2.7	7.0	53
Dwarf (D1)						
Macoun	5.0	9.8	33.6	2.5	7.9	49
7262-8A4	4.9	9.4	35.9	2.7	7.9	60
7272-AQ5C	5.0	9.6	33.6	2.5	7.6	56
7462-AY5D	4.9	9.6	31.9	2.9	9.1	56
7462-DF4A	4.8	10.3	34.8	2.5	8.4	56
Mean	4.9	9.7	34.0	2.6	8.2	55
Dwarf (D2)						
DT 363	5.6	9.4	34.2	2.5	8.2	57
7267-90D2D	5.0	9.1	33.3	2.5	7.9	55
7268-94A1	5.1	9.1	33.2	2.4	8.1	55
7462-FD4	4.9	8.7	32.3	2.2	7.4	54
7463-W2E	5.0	8.4	31.6	2.6	8.0	57
Mean	5.1	8.9	32.9	2.4	7.9	56
Dwarf (D3)						
Cando	4.7	8.3	29.5	2.5	6.5	52
7461-B2D	4.6	8.3	24.5	2.9	5.6	63
7461-Q4A	5.6	10.2	40.7	2.8	8.3	61
7461-BH5	4.9	8.3	31.0	2.7	6.2	56
7462-FD3C	4.9	9.2	30.9	2.7	8.1	51
7562-P3C	5.2	10.0	35.9	2.4	8.1	58
7562-HB5D	5.2	10.1	38.3	2.8	7.8	54
7562-HU1B	5.5	7.8	32.3	2.5	7.7	55
Mean	5.1	9.0	32.9	2.7	7.3	56
Grand Mean	5.0	9.1	31.9	2.7	7.3	54

(2.7 cm for tall and D3 groups, 2.6 cm for the D1 group, and 2.4 cm for the D2 group). The cultivar 7561-C1A (tall) scored the maximum coleoptile length, followed by 7561-CC1B (tall), 7466-HA2D (tall), 7462-AY5D (D1), and 7461-B2D (D3). Several researchers (Allan *et al.* 1965; Chowdhry and Allan 1966; Roy *et al.* 1969) stated that wheat varieties with longer coleoptiles and more rapidly growing seedlings generally produced better stands under adverse conditions, indicating that the length of the coleoptile has a great adaptive value under these conditions. Turner *et al.* (1982) mentioned that rice genotypes with short mesocotyls had difficulty in emergence when planted 10 cm deep. Several workers (Allan *et al.* 1965; Chowdhry and Allan 1963; Grama and Ephart 1968) reported a positive correlation between coleoptile length and plant height. In our study, coleoptile length was not associated with any of the characters studied (Table 3).

Three seedling root characters, namely, the number of seminal roots, length of the longest root, and total root length are potentially important for rapid absorption of water and nutrients and are likely to contribute to drought avoidance in early development stages. Nefedov (1970) and Tikhonov (1973) reported that wheat varieties producing a larger number of roots were most productive in both rainfed and irrigated conditions. Hurd (1964) mentioned that the variety Thatcher produced more roots at seedling stage and had a higher root weight at maturity than two other bread wheat varieties included in his study. On the other hand, Kuruvadi (1976) found that durum wheat had higher values than bread wheat for similar seedling traits.

The number of seminal roots in our study ranged from 4 to 5.6 and averaged 5 per seedling. The cultivars DT 363 (D2) and 7461-Q4A (D3) produced the highest number of roots, followed by 7562-HU1B (D3) and 7561-FK2C (tall). The mean number of roots for D2 and D3 was 5.1, and for the tall and D1 groups 4.9. This study identified six cultivars: 7561-FK2C (tall), DT 367 (tall), DT 363 (D2), 7461-Q4A (D3), 7562-HU1B (D3), and 7562-HB5D (D3) from different height groups possessing a superior combination of the three root characters.

Shoot length was positively correlated with number of roots, length of the longest root, and total root length. The number of roots per seedling is positively associated with longest root length, total length, shoot length, and kernel weight (Table 3).

From this preliminary study it is suggested that a breeder might not have to depend only on tall varieties for improving seedling characters and could attempt to exploit crosses within the dwarf group for this purpose.

Table 3. Phenotypic correlations among seedling characters in durum wheat.

Character	Longest root	Total root length	Coleoptile length	Shoot length	Kernel weight
Number of roots	0.5069*	0.8129**	-0.1709	0.6996*	0.5273*
Longest root		0.7693**	-0.0027	0.8322**	0.0287
Total root length			0.0492	0.8466**	0.3568
Coleoptile length				-0.1986	0.0275
Shoot length					0.2245

Acknowledgements

The author is highly grateful to the authorities of the International Development Centre, Ottawa, Canada, for the financial help and to the authorities of the Agricultural Research Station, Swift Current, Canada, for providing the facilities to carry out these investigations.

References

Allan, R.E., Vogal, O.A., Burleigh, J.R. and Peterson, C.J. 1961. The inheritance of coleoptile length and its association with culm length in four winter wheat crosses. Crop Science 1: 328-332.

Allan, R.E., Vogal, O.A., Russel, T.S. and Peterson, C.J. 1965. Relationship of seed and seedling characteristics to stand establishment of semidwarf winter wheat selection. Crop Science 5: 5-8.

Chowdhry, A.R. and Allan, R.E. 1963. Inheritance of coleoptile length and seedling height and their relation to plant height in four winter wheat crosses. Crop Science 3(1): 53-58.

Chowdhry, A.R. and Allan, R.E. 1966. Culm length and differential development of the coleoptile, root, and sub-crown internode of near isogenic wheat lines. Crop Science 6: 49-51.

Grama, A. and Ephart, J. 1968. Coleoptile length and its influence on the emergence of some soft wheat varieties. Bulletin de l'Ecole Centrale Nationale Superieure d'Agronomie, Nancy 10: 33-36.

Hurd, E.A. 1964. Root studies of three wheat varieties and their resistance to drought and damage by soil cracking. Canadian Journal of Plant Science 14: 240-248.

Kuruvadi, S. 1976. Genetic studies on rainfed wheat. Ph.D. thesis. Indian Agricultural Research Institute, New Delhi, India.

Nefedov, A.V. 1970. Breeding wheat for characters of the root system. Selekcija. Semenovodstvo. [Breeding and seed growing] 6: 49.

Roy, N.N., Yadav, S.B. and Ram, J. 1969. Influence of temperature on the growth of wheat coleoptile. Indian Journal of Agricultural Science 40: 948-953.

Sunderman, D.W. 1964. Seedling emergence of winter wheats and its association with depth of sowing coleoptile length under various conditions and plant height. Agronomy Journal 56: 23-25.

Takahashi, N. 1978. Adaptive importance of mesocotyl and coleoptile growth in rice under different moisture regimes. Australian Journal of Plant Physiology 5: 511-517.

Tikhonov, V.E. 1973. The role of the number of embryonic roots in spring bread wheats in the semidesert conditions of northern Priarale. Bulletin of the Vsescyuzno ordena Lenina Institute Restenievodstve, Imeni. NI. Vavilave 33: 3-7.

Turner, F.T., Chen, C.C. and Bollich, C.N. 1982. Coleoptile and mesocotyl lengths in semidwarf rice seedlings. Crop Science 22: 43-46.

Response of Five Wheat Lines to Specific Ion Effect Under Saline Conditions*

Banaras Hussain Niazi, Akbar Shah Momand, and Manzoor Ahmad

Stress Physiology Lab, Soil Science Section
National Agricultural Research Center (PARC)
Islamabad, PAKISTAN

Saline soils contain a mixture of salts which may consist of sodium, calcium, chloride, sulfate, nitrate, and other ions (Richard *et al.* 1954). The concentration of these ions is closely related to the osmotic pressure of soil solutions which determines water absorption by plant roots. According to Bernstein and Hayward (1958), a high salt concentration decreases physiological water availability, and causes an accumulation of toxic levels of various ions within the plant.

Greenways (1973) found that a high Na^+ and Cl^- concentration in plants is harmful because of the change in water balance, specific ion effect, and reduced transport of solutes. Barakat *et al.* (1971) reported that salinity delays and reduces germination. Rashid and Butt (1963), Datta (1972), Tornes and Bingham (1973), Datta and Chandra (1975), and Bhattacharyya (1976) noted varietal differences in salt tolerance. Qureshi *et al.* (1980) suggested that the study of salt tolerance of wheat at seedling stage could serve as a useful guideline for preliminary screening. The selection and development of salt tolerant species may help improve crop production on saline soils.

In the light of the above findings, the responses of wheat lines to specific ion effect were studied.

* Experimental data not presented, but are available with the authors and editors

Materials and Methods

The study was carried out on five wheat lines, namely PK-15869, PK-15885, PK-16171, PK-16172, and PK-16187. NaCl, $CaCl_2$, and Na_2SO_4 were used as a source of Ca^{++}, Na^+ Cl^-, and SO_4^{--}. Each salt was used alone and in combination with each of the two other salts in 1:1 mixtures at seven EC levels (0, 5, 10, 15, 20, 25, and 30 ds/m). The growth medium consisted of agar to which the various amounts of salt(s) were added. The mixture was autoclaved at 15 psi and 121°C for 15 minutes, then poured into autoclaved test tubes. Seeds of each variety were treated with fungicide and then soaked in water overnight. Two seeds per tube were germinated, and the tubes were plugged with sterilized cotton. Each plant represented one replicate. The experiment was replicated 10 times.

The test tubes were incubated at 25°C. The cotton plugs were removed after seven days to allow a free growth of the seedlings for 15 days. At the end of the 15th day, data on germination percentage, root and shoot length, and fresh and dry weight were recorded.

Results and Discussion

Germination

Among the five lines, PK-16171 achieved the highest germination percentage which did not drop below 60 even at the highest tested salinity level, while only 30% of the PK-15869 seeds germinated at NaCl levels higher than 15 ds/m and at $CaCl_2 + Na_2SO_4$ levels higher than 20 ds/m. PK-15885 and PK-16172 performed equally. The germination percentage of the five lines was as follows: PK-16171 > PK-15885 and PK-16172 > PK -16187 > PK-15869. Salts impeded germination in the following order: NaCl > $CaCl_2 + Na_2SO_4$ > Na_2SO_4 > NaCl + Na_2SO_4 > NaCl + $CaCl_2$ > $CaCl_2$.

In an earlier study, Qureshi *et al.* (1980) reported an 80% germination of the variety Blue Silver at 15 ds/m in solution cultures. PK-16171 achieved at least 90% germination at the same level of salinity with any one of the salts applied alone or in combination with another. The tested seeds which failed to germinate were perhaps affected by the toxic level of ions present in the medium (Uhvits 1946). In addition, the osmotic effect might have decreased water availability to seeds (Chapmann 1968) and caused a water stress which upset the physiological germination process.

Root length

In the absence of salts, PK-15885 developed the longest roots, followed by PK-15869, PK-16172, PK-16171, and PK-16187. In the presence of salts, root length of the five lines varied depending on the source and concentration of salt. For example, PK-15869 had a significantly longer root than PK-16171 under the 5 ds/m NaCl treatment, but the reverse happened with the 20 ds/m NaCl + $CaCl_2$ treatment. The salts reduced root growth in the following order: Na_2SO_4 > NaCl + Na_2SO_4 > NaCl > $CaCl_2$ > NaCl + $CaCl_2$ > $CaCl_2$ + Na_2SO_4. Na_2SO_4 alone or in combination with NaCl hindered root growth extensively at all tested concentrations, but its detrimental effect was alleviated when
trations, but its detrimental effect was alleviated when
$CaCl_2$ was added. When $CaCl_2$ was combined with NaCl, similar reduction in root growth was obtained, though to a lesser extent. A similar finding that $CaCl_2$ with Na_2SO_4 decreased the deliterious effect of salinity on root growth was reported in rice (Ahmad *et al.* 1985). $CaCl_2$ might have improved the performance of the plants by precipitating SO_4^{--} ions, hence decreasing the concentration of salts in the medium, and enhancing growth conditions. Morard *et al.* (1980) found that low concentrations of salts (5 ds/m) enhanced tobacco root growth. However, this was not observed in our study.

Shoot length

In the absence of salts, PK-16172 had the longest shoots, followed by PK-16171, PK-15885, PK-15869, and PK-16187. NaCl and Na_2SO_4 generally reduced shoot length to a lesser degree than $CaCl_2$ at low salt concentrations (< 15 ds/m), but the trend was reversed at high concentrations (> 20 ds/m). For example, in the presence of $CaCl_2$ alone or in combination with NaCl, PK-16187 and PK-15885 had their shoot length reduced by no more than 50% (as compared to the control) even at the highest tested salt level. However, they had their shoot length already decreased by more than 50% at 15 ds/m NaCl + Na_2SO_4. PK-15885 and PK-16171 generally had longer shoots than the other lines in the presence of salt.

At a concentration of 5 ds/m, NaCl tended to enhance shoot growth, which agrees with the results obtained by Morard *et al.* (1980) who had noted an increase in shoot length of tobacco under similar conditions.

Fresh weight

In the control, the highest fresh weight was recorded for PK-16171 and the lowest for PK-16172. Under NaCl, fresh weight was reduced by 50% at, or above, 20 ds/m in all tested lines. Na_2SO_4 and NaCl + Na_2SO_4 treatments were even more detrimental. $CaCl_2$, in combination with Na_2SO_4, decreased the toxicity of the latter. PK-15885 and PK-16187 were noted to be slightly more tolerant than the rest.

Dry weight

The highest dry matter yield was recorded for PK-16171 in the absence of salts. NaCl at 5 ds/m had no significant negative effect on dry weight, and slightly enhanced that of PK-15869, PK-16172, and PK-16187. Na_2SO_4 caused the most drastic reduction of shoot growth. The dry weight of all lines was reduced by more than 50% at 10 ds/m, except that of PK-16172. However, this detrimental effect was alleviated when Na_2SO_4 was applied together with $CaCl_2$. Results showed that the different ions present in the growth medium significantly affect dry matter yield, and agreed with those obtained by Hoffman *et al.* (1978) and Bano (1980).

Conclusion

PK-15885 and PK-16171 appeared to be more salt-tolerant than the other tested lines. They should be further tested on soils with salinity levels similar to those used in our experiment before recommending them for areas suffering from high soil salinity. $CaCl_2$ can play an important role in reducing SO_4^{--} toxicity by reacting with Na_2SO_4 and precipitating SO_4^{--} ions, which reduces the EC of the medium and enhances growth.

References

Ahmad, M., Niazi, B.H. and Baig, M.B. 1985. Coordinated research programme on saline agriculture, NARC-phase Islamabad, annual progress report. pp 1-35.

Bano, F. 1980. A trial to improve salt tolerance of tomato plants giving pregermination soaking and post-germination treatment with choline chloride. M. Sc. thesis, Quaid-i-Azam University, Islamabad, Pakistan.

Barakat, M.A., Khalid, M.M. and Altia, M.H. 1971. Effect of salinity on the germination of 17 rice

varieties. Agricultural Research Review (Cairo, UAR) 49(2): 219-224.
Bernstein, L. and Hayward, H.E. 1958. Physiology of salt tolerance. Annual Review of Plant Physiology 9: 25-46.
Bhattacharyya, R.K. 1976. Promissing rice selections suited to coastal saline soils. Journal of the Society of Experimental Agriculturists 1(1): 21-24.
Chapmann, V.J. 1968. Vegetation under saline conditions. Pages 201-216 *in* Saline Irrigation for Agriculture and Forestry (Boyko, K., ed.). Dr. W. Junk, The Hague, The Netherlands.
Datta, S.K. 1972. A study of salt tolerance of twelve varieties of rice. Current Science 41(12): 456-457.
Datta, S.K. and Chandra, D.P. 1975. Salt tolerance of different varieties of rice at seedling stage. *In* Procedings of the 62nd Indian Science Congress. Part III, Botany.
Greenways, H. (1973). Salinity, plant growth, and metabolism. The Journal of the Australian Institute of Agricultural Science 39(1): 24-33.
Hoffman, G.J., Jobbs, J.A., Hanscom, Z. and Mass, E.V. 1978. Timing of environmental stress effects on growth, water relations and salt tolerance of Pinto bean. Transactions of the ASAE (Michigan) 21: 713-718.
Morard, P., Gracia, M. and Kheradmadi, M. 1980. Effect of increasing doses of mineral salts of the nutrient solution on the growth of an oriental tobacco. Bulletin de la Soc. Hist. Nat. Toulouse. 115: 7-14.
Qureshi, R.H., Ahmad, R., Ilyas, M. and Aslam, Z. 1980. Screening of wheat (*Triticum aestivum* L.) for salt tolerance. Pakistan Journal of Agricultural Sciences 17(3-4): 19-26.
Rashid, A. and Butt, S.D. 1963. Effect of salinity on the growth, yield, and composition of wheat. Research Studies, 1. WPAU., Lyallpur, Pakistan.
Richard *et al.* 1954. Diagnosis and improvement of saline and alkali soils. USDA.
Tornes, B.C. and Bingham, F.T. 1973. Salt tolerance of Mexican wheat. 1. Effect of NO_3 and NaCl on mineral nutrition, growth and grain production of four wheats. Soil Science Society of America Proceedings 37: 711-715.
Uhvits, R. 1946. Effect of osmotic pressure on water absorption and germination of alfalfa seed. American Journal of Botany 33: 278-285.

Farmers' Practices for Wheat Production in the Cotton Zone of Pakistan's Punjab

M. Ramzan Akhtar, Muzaffar Iqbal, and M. Azeem
Pakistan Agricultural Research Council
Islamabad, PAKISTAN

The dominant cropping systems in irrigated areas of Pakistan are cotton/wheat, rice/wheat, and maize or sugarcane/wheat. Cotton/wheat represents about 50% of the wheat planted in the area and, unfortunately, is the least productive of the rotations for wheat (Akhtar *et al.* 1986). The reasons are not fully understood. Relatively little research has been done on the cotton/wheat cropping system, and current recommendations for wheat sown after cotton are the same as those for other rotations (Hashmi 1985; Hobbs 1985). One potential cause is late planting: in the cotton/wheat rotation, nearly two-thirds of the wheat is sown after 15 December when the risks of yield losses are very high (Byerlee *et al.* 1986, 1987).

The objectives of this study were to (i) delineate major factors limiting wheat productivity in cotton-wheat areas, (ii) explore the costs and returns of the farm-level low- and high-yielding wheat technology in cotton-wheat areas, and (iii) draw policy inferences for agricultural research and extension.

Research Methods

These studies were conducted in the Multan district which is one of the leading cotton-growing areas in the Punjab. The survey was undertaken at wheat harvest time, 15-28 April 1985, and the inputs and output were calculated on the basis of the 1984/85 prices. Using a pretested questionnaire, 150 randomly-selected farmers were interviewed. One field per farmer was also randomly-selected for further inquiry. Questions on planting time, land preparation, fertilizer use, irrigation, previous crop, etc. were asked for the specific fields.

At the same time, 3 to 5 plots, 1x1 m, per field (depending upon the variability in the field) were also randomly-selected. These plots were harvested and the produce was threshed to determine the yield of wheat. We followed the methods described by Catling *et al.*

(1983), and estimated the costs and returns on the basis of prices received and paid by the farmers.

For the purpose of this study, we defined high-yielding wheat fields as those producing more than 2640 kg/ha, and low-yielding as those producing less than 1840 kg/ha; we calculated return per hectare as:

$$N_i = \sum_{i=1}^{m} P_i Q_i - \sum_{j=1}^{n} A_j C_j$$

Where N_i = net return per hectare; P_i = price per unit output of ith (i=1, ... m) activity; Q_i = quantity of output of ith activity measured in physical units; A_j = price per unit of jth (j=1, ... n) input used on the activity; and C_j = quantity of jth input used on the activity.

The gross income included the income from wheat grain and straw. The cost matrix comprised expenses on land preparation, seed, fertilizer, irrigation, hired labor, family labor, and land rent. The data were analyzed on a microcomputer using Lotus 1-2-3 and AIDA (Apple interactive data analysis).

Results and Discussion

The differences in practices (Table 1) that we found useful in testing the hypothesis for variation in yields were as follows:

(a) The high-yielding fields were cultivated by farmers who had large tracts of land, tractors, and access to the perennial canal system.
(b) The high-yielding fields were planted before 30 November and harvested before 26 April.
(c) The high-yielding fields were plowed and irrigated more often than low-yielding fields.
(d) The high-yielding fields received about 40% more phosphorus than low-yielding fields but almost the same quantity of nitrogen.
(e) Generally, wheat on low-yielding fields followed cotton while high-yielding fields were planted after fallow.
(f) Farmers with low-yielding fields used home-produced seed and often non-recommended varieties.

Multiple regression analysis indicated that the major factor affecting yields was the planting of wheat after cotton. The regression equation was estimated as:

$$\text{Yield} = 1996.38 + 10.38\,P - 1.78\,N - 0.04\,P^2 + 46.91\,I - 235.46\,C + 430.61\,S - 282.03\,W, \text{ with } R^2 = 0.49$$

Where Yield = grain yield (kg/ha); P = phosphorus applied (kg/ha); N = nitrogen applied (kg/ha); P^2 = squared value of phosphorus applied (P); C = dummy variable for crop rotation (1 if planted after cotton, zero otherwise); S = dummy variable for certified seed (1 if certified seed used, zero otherwise); and W = dummy variable for broadleaf weed occurrence (1 if a broadleaf weed problem occurs, zero otherwise).

Table 1. Wheat production practices in low and high-yielding fields, Multan district, Punjab, 1984/85.

	Low-yielding fields (<1840 kg/ha)	High-yielding fields (>2640 kg/ha)
Average wheat yield (kg/ha)	1517	3149
Average farm size (ha)	6	10
Wheat after cotton (%)	63	22
Average plowings and plankings	7	8
New recommended varieties planted (%)	16	19
Certified seed (%)	6	22
Planted after December (%)	72	59
Average irrigations	6	7
Average N applied (kg/ha):		
Basal dose	29	30
Top dressing	70	64
Average P applied (kg/ha)	48	68
Fields with broad leaf weeds (%)	19	6
Average harvest index (%)	27	32

The wheat/cotton rotation not only resulted in late planting but also reduced soil fertility and limited land preparation. Farmers who used certified seed obtained higher yields than others, but the increases may have been caused by other factors associated with the use of improved seed. The positive response to phosphorus and apparently negative response to nitrogen needs further investigation. One possible explanation is that late planting increased the risk of high temperatures and drought stress. The high doses of nitrogen led to a vigorous vegetative growth that may have reduced grain yield when the crop was under stress. Certainly, wheat straw (*Bhusa*) yield in our study was positively and significantly correlated with nitrogen application. These results need to be substantiated by fertilizer trials, as the data suggest risks from the use of large amounts of nitrogen fertilizer in the area.

Phosphorus significantly affected ($P < 0.01$) yields, and its application was economically optimal at 65 kg/ha. The only other variable significant ($P < 0.05$) in the equation was broadleaf weed infestation, which occurred in only 13% of the fields.

Overall, the variation in yield among wheat fields was 49%. This reflected the relative uniformity of yields (coefficient of variation = 27%) and the unfavorable weather in 1985, which appeared to mask the effect of many management variables.

The major variable costs were those for land preparation, fertilizer use, irrigation, harvesting, and threshing (Table 2). The farmers paid one-third of the total variable cost for harvesting and threshing, transportation, loading, and marketing.

The returns from fields with low and average yields covered variable costs but were not high enough to cover land rent and family labor. Returns to farmers on capital investment were negative.

As expected, the fields with high yields received the highest level of inputs and better seedbed preparation; also, they were generally planted after fallow. The net returns in high yielding fields were positive but not high enough to give a reasonable return on capital to farmers. These results show that cost-reducing technologies (such as zero tillage) must be developed and popularized if wheat is to compete with alternatives as sunflower, soybean, spring maize, and others.

Conclusions

Cotton-wheat rotation, the most important cropping system for irrigated wheat in Pakistan, deserves increased allocation of resources for research and extension. Farmers in cotton areas normally obtain an average yield of 2.5 t/ha, but in 1984/85, which was a

Table 2. Budget for fields producing low, average, and high yields of wheat, Multan district, Punjab, 1984/85.

	Low-yielding fields (<1840 kg/ha)	Average-yielding fields (2287 kg/ha)	High-yielding fields (>2640 kg/ha)
		(Rupees/ha)	
Land preparation	414	489	489
Seed	192	192	275
Fertilizer	746	763	809
Irrigations	430	555	555
Harvesting	413	413	413
Threshing	249	378	520
Transportation and loading charges	64	85	107
Hired labor for threshing	62	94	130
Other costs	153	201	235
Total variable cost	2723	3170	3533
Family labor	160	180	200
Land rent	950	950	950
Total cost	3833	4300	4683
Gross return			
Grain	3036	3762	4356
Straw	368	456	528
Total gross return	3404	4218	4884
Net return including land rent and family labor	-429	-82	201
Net return excluding land rent and family labor	671	1048	1351
Return on capital (%)	-11.19	-1.91	4.29

poor year, the average yield was 2.2 t/ha. Yields estimated for the area were about 3.5 t/ha, which was 30% more than what was actually achieved. This gap might be closed by the application of known and new techniques designed for recommendation domains based on crop rotations and access to irrigation.

The major factors limiting wheat productivity in the cotton areas were the late planting of wheat after cotton, the use of rust-susceptible varieties, inefficient use of fertilizer and irrigation water, broadleaf weeds, and relatively high harvesting costs.

A key finding from our survey was that the income from wheat does not give reasonable returns on capital to the farmers. This underlines the necessity of cost-reducing technologies if wheat is to compete with altervative crops, and of speeding up the distribution of high-yielding, rust-resistant varieties (e.g. Pak-81, Faisalabad-83).

Acknowledgment

We wish to thank Dr. Derek Byerlee, Director, Economic Program, CIMMYT, Mexico, for his comments on the earlier draft of this paper.

References

Akhtar, M.R., Byerlee, D., Qayyum, A., Majid, A. and Hobbs, P.R. 1986. Wheat in the cotton-wheat farming systems of the Punjab: implications for research and extension. Pakistan Agricultural Research Council, Islamabad, PARC/CIMMYT Paper 86-8.

Byerlee, D., Hobbs, P.R., Khan, B.R., Majid, A., Akhtar, M.R. and Hashmi, N.I. 1986. Increasing wheat productivity in the context of Pakistan's irrigated cropping systems: a view from the farmers' field. Pakistan Agricultural Research Council, Islamabad, PARC/CIMMYT paper 86-7.

Byerlee, D., Akhtar, M.R. and Hobbs, P.R. 1987. Reconciling conflicts in sequential cropping patterns through plant breeding: the example of cotton and wheat in Pakistan's Punjab. Journal of Agricultural Systems, University of Reading. Reading, UK (in press).

Catling, H.D., Hobbs, P.R., Islam, Z. and Alam, B. 1983. Agronomic practices and yield assessment of deep water rice in Bangladesh. Field Crops Research 6: 109-132.

Hashmi, N.I. 1985. 1984-85 wheat crop: problems and issues. Paper presented at the Annual Meeting of Coordinated Wheat, Barley, and Triticale Programs, 16-18 Sept 1985, NARC, Islamabad.

Hobbs, P.R. 1985. Agronomic practices and problems for wheat following cotton and rice in Pakistan. Pages 273-277 *in* Wheat for More Tropical Environments, Proceedings of an International Symposium, UNDP/CIMMYT, 24-28 Sept 1984, Mexico. Centro International de Mejoramiento de Maiz y Trigo (CIMMYT), Mexico.

The Response of Wheat to Sowing Date and Irrigation in Eastern Sudan

Ahmed Mohamed Gorashi
New Halfa Research Station
P.O. Box 17, New Halfa
SUDAN

Bread wheat is the second most important food crop after sorghum in the Sudan where 80% of locally consumed wheat is imported. It has been traditionally grown in northern Sudan where conditions are favorable. As consumption increased, bread wheat has been recently introduced to new areas, mainly the Gezira and New Halfa Schemes. Although machinery is used for various cultural practices, yields in these areas are still low due to less favorable climatic conditions (Ali 1987).

In New Halfa Scheme (15° 19' N, 38° 41' E) yields are also affected by late sowing and shortage of irrigation water. Farmers usually delay planting by a month or more, and irrigate their crop 4-5 times only, while the recommendation is to apply 10 irrigations at 12-day intervals.

The objective of this study was to examine the effects of sowing dates and irrigation treatments on wheat yields and yield components.

Materials and Methods

The experiment was conducted at the New Halfa Research Farm in eastern Sudan in 1980/81 and 1981/82. Five sowing dates spaced at 15-day intervals starting 1 Oct were studied in combination with the following nine irrigation treatments:

W1 = Normal irrigation scheme i.e. light irrigation at seeding and 8 days after seeding, then at 12-day intervals until maturity (10 irrigations).

W2 = Seventh irrigation skipped (68 days from sowing) i.e. after ear emergence and before milk stage.
W3 = Eighth irrigation skipped (80 days from sowing) i.e. at milk stage.
W4 = Ninth irrigation skipped (92 days from sowing) i.e. after milk stage.
W5 = Tenth irrigation skipped (104 days from sowing) i.e. around physiological maturity period.
W6 = Seventh and tenth irrigations skipped.
W7 = Eight and tenth irrigations skipped.
W8 = Ninth and tenth irrigations skipped.
W9 = Eighth, ninth, and tenth irrigations skipped.

The variety used was Giza 155, an Egyptian wheat cultivar grown by most of the local farmers. Seeds were planted in rows spaced 20 cm apart at a rate of 119 kg/ha. Urea (45% N) was added at a rate of 190 kg/ha at sowing. Other cultural practices and insecticides were applied as recommended.

Results

1980/81

Sowing dates affected grain yield, 1000-grain weight, number of grains/head, and weight of grains/head significantly (Table 1). The best sowing date averaged over the irrigation treatments for grain yield was 15 Nov. The two early sowings gave the lowest yield.

Irrigation treatments also affected grain yield, 1000-grain weight, and weight of grains/head significantly (Table 2). The highest grain yield was produced when the last irrigation was skipped. Skipping the last three irrigations gave the lowest yield.

Sowing date x irrigation interaction was significant for grain yield and 1000-grain weight and nonsignificant for the other yield components (Tables 3 and 4). The highest grain yield was produced when seeds were sown on 15 Nov and the last irrigation was skipped.

Table 1. The effect of five sowing dates on average grain yield and some yield components, 1980/81.

Sowing date	Grain yield (t/ha)	1000-grain weight (g)	Number of grains/ head	Weight of grains/head (g)
1 Oct	1.71	32.49	32	1.20
15 Oct	1.69	32.40	33	1.22
1 Nov	1.97	32.44	36	1.32
15 Nov	2.09	30.59	34	1.22
1 Dec	1.90	29.60	38	1.20
Mean	1.88	31.50	34	1.23
SE ±	0.02	0.25	0.85	0.03

Table 2. The effect of nine irrigation treatments on average grain yield and some yield components, 1980/81.

Irrigation treatment	Grain yield (t/ha)	1000-grain weight (g)	Weight of grains/head (g)
W1	2.16	33.66	1.33
W2	1.83	34.45	1.23
W3	1.76	29.04	1.16
W4	1.95	32.33	1.27
W5	2.24	34.63	1.25
W6	1.83	34.63	1.33
W7	1.76	29.24	1.17
W8	1.81	29.72	1.15
W9	1.50	25.81	1.10
Mean	1.88	31.50	1.23
SE ±	0.05	0.33	0.04

Table 3. Grain yield (t/ha) under different sowing date x irrigation treaments, 1980/81.

Irrigation treatment	Sowing date				
	1 Oct	15 Oct	1 Nov	15 Nov	1 Dec
W1	1.93	2.21	2.26	2.19	2.26
W2	1.69	1.33	1.97	1.95	2.26
W3	1.55	1.81	1.93	1.74	1.83
W4	1.69	1.90	2.21	2.40	1.52
W5	2.00	2.14	2.21	2.47	2.36
W6	1.57	1.52	2.02	1.95	2.09
W7	1.64	1.57	1.76	1.81	2.05
W8	1.93	1.38	1.90	2.33	1.55
W9	1.43	1.31	1.57	1.86	1.31

Mean = 1.88
SE for sowing date x watering treatment = ± 0.09

1981/82

Sowing dates had significant effects on grain yield, number and weight of grains/head, number of plants and heads/meter, 1000-grain weight, and plant height (Table 5). As in 1980/81, the best sowing date for grain yield was 15 Nov, while the two early sowings gave the poorest yield.

The irrigation treatments significantly affected grain yield, 1000-grain weight, and weight of grains/head (table 6). No significant difference in the other yield components was found. The highest grain yield was obtained when the ninth irrigation was skipped.

Sowing date x irrigation treatment interaction was highly significant for grain yield (Table 7) and 1000-grain weight (Table 8). Sowing at 1 Nov and skipping the ninth irrigation gave the highest yield.

Table 4. Thousand-grain weight (g) under different sowing date x irrigation treatments, 1980/81

Irrigation treatment	Sowing date: 1 Oct	15 Oct	1 Nov	15 Nov	1 Dec
W1	33.90	35.65	34.12	32.15	32.47
W2	33.52	36.65	35.70	32.65	33.75
W3	28.57	33.15	30.25	25.07	28.17
W4	34.35	33.35	33.07	32.35	28.52
W5	36.27	34.57	34.32	33.70	34.30
W6	34.04	36.40	37.25	31.50	33.95
W7	32.32	30.62	28.92	26.55	27.77
W8	32.80	25.67	31.70	32.55	25.87
W9	26.57	25.57	26.57	28.77	21.55

Mean = 31.50 SE for sowing date x watering treatment = ± 0.74

Table 5. The effect of five sowing dates on average grain yield and some yield components, 1981/82.

Sowing date	Grain yield (t/ha)	1000-grain weight (g)	No. of grains/ head	Weight of grains/head (g)	No. of plants/ meter	No.of heads/ meter	Plant height (cm)
1 Oct	1.28	32.98	24.60	0.84	38.53	124	75
15 Oct	1.50	32.56	31.10	1.11	42.17	133	82
1 Nov	2.14	34.55	33.90	1.19	44.06	138	90
15 Nov	2.21	32.93	35.70	1.41	43.56	137	93
1 Dec	2.16	33.40	32.10	1.15	45.28	140	96
Mean	1.86	32.28	31.50	1.14	42.72	134	87
SE ±	0.05	0.35	0.80	0.03	1.14	4	0.9

Table 6. The effect of nine irrigation treatments on average grain yield and some yield components, 1981/82.

Irrigation treatment	Grain yield (t/ha)	Weight of grains/head (g)	1000-grain weight (g)
W1	1.95	1.17	34.92
W2	1.55	1.05	30.84
W3	1.92	1.17	33.21
W4	2.02	1.24	34.30
W5	1.97	1.21	31.90
W6	1.64	1.05	31.51
W7	1.86	1.15	33.58
W8	1.95	1.12	33.88
W9	1.90	1.08	33.13
Mean	1.86	1.14	33.29
SE ±	0.50	0.04	0.47

Table 7. Grain yield (t/ha) under different sowing date x irrigation treatments, 1981/82.

Irrigation treatment	Sowing date: 1 Oct	15 Oct	1 Nov	15 Nov	1 Dec
W1	1.33	1.67	2.21	2.33	2.21
W2	0.90	1.19	1.90	1.97	1.76
W3	1.24	1.52	2.19	2.36	2.31
W4	1.33	1.71	2.52	2.21	2.33
W5	1.33	1.71	2.21	2.38	2.21
W6	1.24	1.21	1.86	2.21	1.71
W7	1.14	1.36	2.24	2.19	2.33
W8	1.45	1.62	2.19	2.24	2.33
W9	1.69	1.45	1.97	2.00	2.38

Table 8. Thousand-grain weight (g) under different sowing date x irrigation treatments, 1981/82.

Irrigation treatment	Sowing date: 1 Oct	15 Oct	1 Nov	15 Nov	1 Dec
W1	34.48	28.13	32.38	30.25	34.03
W2	33.43	30.28	34.83	33.75	34.40
W3	37.33	31.65	34.98	29.85	32.38
W4	33.80	35.65	33.55	31.85	34.18
W5	35.88	33.88	36.73	31.85	31.73
W6	30.88	34.65	33.08	35.95	31.93
W7	31.43	45.82	33.18	33.38	34.38
W8	32.12	33.78	32.35	34.75	32.13
W9	31.63	34.15	31.35	34.40	35.50

Discussion

In our study, the best sowing date for Giza 155 at New Halfa Scheme was 15 Nov for both seasons. This agrees with the results obtained by Daffala (1970-1973), Heipko (1961-64), and Gabbar (1977). Early to mid-Oct sowing gave low yields due to heat stress.

Averaged over the two seasons, the highest grain yield was obtained when the tenth irrigation was skipped. Therefore nine irrigations are optimal for Giza 155. It would be acceptable if the ninth, or both ninth and tenth irrigations were skipped.

Skipping the seventh or the eight irrigation i.e. after ear emergence to milk stage (W2, W3, W6, W7) drastically reduced grain yield, especially with early sowing dates (Tables 2, 3, 6, and 7). Farmers are advised not to delay irrigation at this critical growth stage.

Acknowledgement

Thanks are due to the Director General of the Agricultural Research Corporation of the Sudan for his permission to publish this paper.

References

Ali, F.M. 1987. Wheat research and production in the Sudan. Technical bulletin No. 5 (New Series). Agricultural Research Corporation, Wad Medani, Sudan.
Daffala, D.A. 1970-73. Khashm el Girba Research Station annual reports. Agricultural Research Corporation, Wad Medani, Sudan.
Gabbar, A.G. 1977. Experiment Agriculture Vol. 13, No.4. pp 401-407.
Heipko, G.H. 1961-64. Hudeiba Research Station annual reports. Agricultural Research Corporation, Sudan.
Sharma, T.R. and Gandhi, S.M. 1977. Variation and interrelationships among yield and various agronomic characters in common and durum wheats. Zeitschrift fiir Pflanzenziichtung 79(1): 40-46.
Taha, M.B. 1986. Research highlights on agronomic aspects of wheat at Hudeiba Research Station during 1961-1985. Rachis 5(2): 46-48.

Effect of Planting Method and Seed Rate on Yield of Bread Wheat in Northern Sudan*

Gaafar Hussein Mohamedali
Hudeiba Research Station
P.O. Box 31, Ed-Damer, SUDAN

Traditional seed-bed preparation for wheat planting in the arid northern region of Sudan involves disc-plowing and levelling followed by hand broadcasting of the seeds, then light ridging using a bull-drawn plow to cover the seeds and to open furrows for irrigation. The seed rate commonly used by farmers in this area is 140 kg/ha which is rather high compared to that used in similar parts of the world. This high rate is adopted to compensate for the high percentage of seeds which are not burried or burried too deep to germinate.

Several experiments were conducted at Hudeiba Research Station in the northern region of Sudan to determine the optimum seed rate for different varieties (Otto 1965; Heipko 1965; Dafalla and Abdel Gabar 1967, 1968; Lazim 1973). In the present investigation, we studied the effect of two planting methods and four seed rates on the grain yield of Wadi El Neel, a bread wheat variety recently released for the arid regions of northern Sudan (16-22° North).

The experiment was conducted during the 1984/85 season at Hudeiba Research Station (17° 34' N, 33° 56' E, 350 m above mean sea level) in the arid region of northern Sudan. Two planting methods: broadcasting and row-planting (rows were spaced 20 cm apart), and four seed rates: 72, 108, 144, and 180 kg/ha, were compared for Wadi El Neel (Giza 160). A split plot design of four replicates, with the planting methods as the main plots and seed rates as subplots, was used. Each subplot consisted of four 4-m rows. Sowing was done on 1 Nov 1985, and 143 kg urea/ha were applied in three equal doses: at planting and at third and fourth irrigation. Grain yield, yield components, and other agronomic characters were measured. There were significant ($P < 0.01$) yield differences between the two planting methods, but not among seed rates ($P > 0.05$), and there was no interaction between planting method and seed rate (Table 1). Row-planting consistently gave higher yields, with 30, 44, 14, and 28% yield increases over broadcasting at the seed rates of 72, 108, 144, and 180 kg/ha, respectively. Increasing the seed rate above 72 kg/ha did not give a significant yield increase with either broadcasting or row-planting.

*This work was partially supported by ICARDA/OPEC Wheat Improvement Project, Sudan.

Table 1. Grain yield (kg/ha) of Wadi El Neel under different planting methods and seed rates.

Planting method	Seed rate (kg/ha)				
	72	108	144	180	Mean*
Broadcasting	2610	2424	2819	2745	2650
Row-planting	3400	3486	3212	3500	3400
Mean**	3005	2955	3016	3123	

* SE = ±102
** SE = ±95

Table 2. Yield components and agronomic characters of Wadi El Neel under different planting methods and seed rates.

Planting method	Seed rate (kg/ha)	No. of spikes/ m^2	No. of spikelets/ spike	No. of kernels/ spike	Weight of kernels/ spike (g)	1000-kernel weight (g)	Days to heading	Days to maturity	Plant height (cm)	Spike length (cm)
Broadcasting	72	464	16	36	1.48	41.0	77	127	83	8
	108	541	16	41	1.69	41.2	78	127	78	7
	144	555	16	40	1.28	31.9	76	127	76	7
	180	544	15	35	1.42	40.6	76	127	77	7
	Mean	526	16	38	1.47	38.7	77	127	79	7
Row-planting	72	593	16	33	1.45	43.9	77	127	77	7
	108	666	16	38	1.50	39.3	77	127	77	8
	144	631	16	33	1.35	41.0	76	127	79	8
	180	636	16	33	1.36	41.3	76	127	74	7
	Mean	632	16	34	1.42	41.4	77	127	77	8
Grand mean		579	16	36	1.45	40.1	77	127	78	8

Diffrences due to planting method, seed rate, and planting method x seed rate were nonsignificant ($P < 0.05$) for all characters.

Apart from grain yield, all the other characters measured, namely, number of spikes/m^2, number of kernels/spike, weight of kernels/spike, 1000-kernel weight, number of spikelets/spike, spike length, days to heading, days to maturity, and plant height, were not significantly different between the two planting methods and among the four seed rates, and there was no planting method x seed rate interaction (Table 2). Row-planting tended to favor germination more, hence ensuring a denser population than broadcasting, though the difference was nonsignificant. It was also observed that the high tillering capacity of Wadi El Neel compensated for low seed rates as evident in the number of spikes/m^2.

References

Dafalla, D.A. and Abdel Gabar, A.G. 1967. Annual report 1966/67. Hudeiba Research Station, Ed-Damer, Sudan.

Dafalla, D.A. and Abdel Gabar, A.G. 1968. Annual report 1967/68. Hudeiba Research Station, Ed-Damer, Sudan.

Heipko, G.H. 1965. Annual report 1964/65. Hudeiba Research Station, Ed-Damer, Sudan.

Lazim, M.E. 1973. Annual report 1972/73. Hudeiba Research Station, Ed-Damer, Sudan.

Otto, J. 1965. Annual report 1964/65. Hudeiba Research Station, Ed-Damer, Sudan.

Short Communications

Russian Wheat Aphids on Barley in Ethiopia

R.H. Miller
ICARDA, P.O. Box 5466
Aleppo, Syria
and
Adugna Haile
Institute of Agricultural Research
Holetta, Ethiopia

Several aphid species attack barley in Ethiopia (Table 1). Of these the Russian wheat aphid, *Diuraphis noxia* Mordvilko, is by far the most serious pest while other species usually cause no significant yield reductions. This paper reports on aphids affecting barley in Ethiopia with emphasis on *D. noxia.*

Table 1. Aphids occurring on wheat and barley in Ethiopia.

Scientific name	Common name
Diuraphis noxia Mordvilko*	Russian wheat aphid
Rhopalosiphum maidis Fitch	Corn leaf aphid
Rhopalosiphum padi L.	Bird cherry oat aphid
Schizaphis graminum Rondani	Greenbug
Metaplophium dirhodum Walker	Rose wheat aphid
Hystraneura setariae Thomas	Rusty plum aphid
Sitobium spp.	

* Most serious barley pest.

D. noxia currently causes 41 to 71% yield losses in small plot studies (IAR 1987). Yield losses on wheat are also high, averaging about 68%. Infestations are highest in the higher elevation growing areas (above 2000 m) but the insect is present throughout the growing area, and populations may be enhanced by drought.

D. noxia was first recognized as a serious pest during the 1973/74 season, a period corresponding with the onset of serious drought in northern Ethiopia. Within a year it had been reported in all barley-growing areas of the country.

Damage to the plant is caused by direct feeding on the stem and leaves. Plants are frequently attacked early in their development at the onset of tillering, but may also be attacked throughout their development if aphids are present. Infested plants exhibit stunted growth, severe curling of the leaves harboring the aphids, yellowish longitudinal striping on infested leaves, and death of the leaf and spike. Symptoms of Russian aphid infestation superficially resemble those of barley yellow dwarf virus, but close examination of the plant will reveal the aphids themselves, usually clustered at the base of the leaves or inside curled leaves. Plants infested before tillering may fail to produce tillers, while infestations at more advanced development stages frequently result in deformed and bleached ears. Although detailed data from Ethopia are lacking on the number of aphids required to produce the various symptoms and plant death, preliminary observations suggest that a single aphid can cause leaf striping and stunting.

Adult aphids range from 1.4 to 2.3 mm in length with a pale lime green color, and possess reduced cornicles and a double cauda (Blackman and Eastop 1985). *S. graminum,* and *M. dirhodum* can be distinguished by the darker green stripe down the middle of their back. Damage caused by *D. noxia* to the plant also differs from that of the other aphids, which may cause chlorosis of the leaves without distinct leaf striping and curling.

Because of the wide range of host plants (Table 2), populations of *D. noxia* and other aphids are present in the field in Ethiopia during the entire year. Overlap between the short winter cropping season and the longer summer cropping season also insures that barley plants will be available to the aphids over an extended period.

A number of predators and parasitoids attack aphids in Ethiopia (Table 3) but none presently exert adequate population control to reduce yield losses. The most important parasitoids of *D. noxia* are *Aphidius hortensis* Marshall and *Aphidius setiger* Mack. However,

Table 2. Host plants of aphids in Ethiopia (after Haile and Megenasa, in press).

Scientific name	Aphids*						
1. *Hordeum vulgare*	a	b	c	d	e	f	g
2. *Triticum* spp.	a	b	c	d	e	f	
3. *Sorghum vulgare*		b	c				
4. *Eragrostis tef*	a	b	c			f	
5. *Zea mays*		b				f	
6. *Phalaris paradoxa*	a						
7. *Aira carryophylla*		b					
8. *Avena fatua*	a	b		d	e		
9. *Eragrostis racemosa*	a	b	c		e		
10. *Eragrostis temula*	a	b	c		e		
11. *Lolium temulentum*	a						
12. *Dactylectenium aegyptiacum*		b	c				
13. *Bromus pectinatus*	a	b					
14. *Digitaria abyssinica*	a	b					
15. *Digitaria ternata*		b					
16. *Cynodon dactylon*		b					
17. *Hyparrhenia anamesa*		b					
18. *Setaria palledifusca*	a	b	c				
19. *Panicum rementallum*	a	b					
20. *Chloris virgata*		b					
21. *Pennisetum villosum*		b					
22. *Sorghum sudanense*		b	c				
23. *Avena sativa*	a	b		d	e		
24. *Sorghum brevicaudatum*		b	c				
25. *Setaria verticillata*	a	b	c				
26. *Chloris gayana*		b	c				
27. *Triticosecale*	a		c	d			

* a = *D. noxia*
b = *R. maidis*
c = *S. graminum*
d = *Sitobium* spp.
e = *M. dirhodum*
f = *R. padi*
g = *H. setariae*

field populations of these insects are low, and only *A. setiger* has shown parasitism levels approaching 10% (Haile and Megenasa, in press).

Chemical control of aphids has been shown effective in reducing populations in many developed and less developed countries. However, lack of application equipment, trained personnel, and financial resources among farmers preclude their use in Ethiopia.

Preliminary field screenings indicate that two barley varieties in 1985/86 may possess resistance or tolerance to *D. noxia*. Further screenings for resistance are planned with emphasis on the Ethiopian landraces which are generally known to possess a wide range of genotypic variation. The ultimate goal of the Ethiopian national program is to develop a sound, integrated management strategy for cereal aphids through further research into the development of resistant varieties, economically feasible chemical control, and practical biocontrol methods.

Table 3. Parasitoids and predators of aphids on Ethiopian barley (after Haile and Megenasa, in press).

Scientific Name	Aphids*					
Parasitoids						
Aphidius hortensis	a		c	d		
Aphidius setiger	a		c	d	e	f
Predators						
Coleoptera						
Adonis variegata	a	b	c	d	e	
Lioadalia signifera	a	b	c	d		
Lioadalia intermedia	a	b				
Lioadalia spp.	a	b		d	e	
Cheilomenea intermedia	a	b				
Cheilomenea lunata	a	b	c	d	e	
Cheilomenea literate	a	b				
Cheilomenea vicina		b				f
Symuna spp.	a					
Diptera						
Sphaerophoria rueppelii	a			d	e	

* a = *D. noxia*
b = *R. maidis*
c = *S. graminum*
d = *Sitobium* spp.
e = *M. dirhodum*
f = *R. padi*

References

Blackman, R.L. and Eastop, V.F. 1985. Aphids on the world's crops, an identification guide. Wiley, Chichester, UK.

Haile, A. and Megenasa, T. Ecological survey of barley aphids in parts of Shewa, Welo, and Tigrai. Ethiopian Journal of Agricultural Science (in press).

Institute of Agricultural Research (IAR). 1987. IAR progress report, barley progress for 1985/86. IAR Department of Field Crops, P.O. Box 2003, Addis Ababa, Ethiopia.

Resistance Indicators to Barley Yellow Dwarf Virus in Barley, Durum Wheat, and Bread Wheat

Jihad S. Skaf
Plant Protection Department
Faculty of Agriculture
University of Damascus, SYRIA
and
Khaled M. Makkouk
Genetic Resources Program
ICARDA, P.O.Box 5466 Aleppo, SYRIA

The Barley yellow dwarf disease, caused by several luteoviruses, is a serious threat to most of the cereal growing areas in the world. Breeding and screening genotypes for resistance to barley yellow dwarf virus (BYDV) is considered the most promising and practical among the different approaches suggested to control this disease (Lister *et al.* 1984). Screening for resistance to BYDV is based on symptom index of inoculated cereals (Rasmusson and Schaller 1959) and other indicators such as virus content (Skaria *et al.* 1985), grain weight, biomass, and harvest index (Comeau 1984). This study examined the relationships among the above mentioned indicators, and evaluated the validity of symptom severity as a principal indicator for resistance to BYDV in barley, durum, and bread wheat.

Materials and Methods

A BYDV isolate was collected from a naturally infected plant from Lattakia (northwestern Syria) and identified as PAV-like isolate by serology. The virus was maintained on either barley (Arabi Abiad) or oats (IFAV-10) by serial transfers using *Rhopalosiphum padi* L.

A total of 300 barley, 250 durum, and 169 bread wheat genotypes were planted in 50-cm long rows in the field. Twenty seedlings of each genotype were artificially inoculated at the two- or three-leaf stage using 100-150 viruliferous *R. padi* per row.

The degree of symptom expression (symptom index, SI) was visually assessed based on a 0-9 scale similar to that described by Schaller and Qualset (1980) five weeks after inoculation. Top leaves of selected genotypes (representing different severity levels) were collected from the fifth through the eighth week after inoculation, weighed, and stored at -20° C for later testing by ELISA. Grain weight (GW), biomass (BM), and harvest index (HI) of these genotypes were recorded at the end of the season. Relative BYDV content was measured using a PAV monoclonal (PAV-MC 32-39) following an indirect ELISA procedure.

Results and Discussion

The correlation between SI, GW, BM, and HI was significant in barley and durum but not in the bread wheat genotypes tested. The average ELISA values and HI was plotted against SI in Fig. 1. Correlation between SI

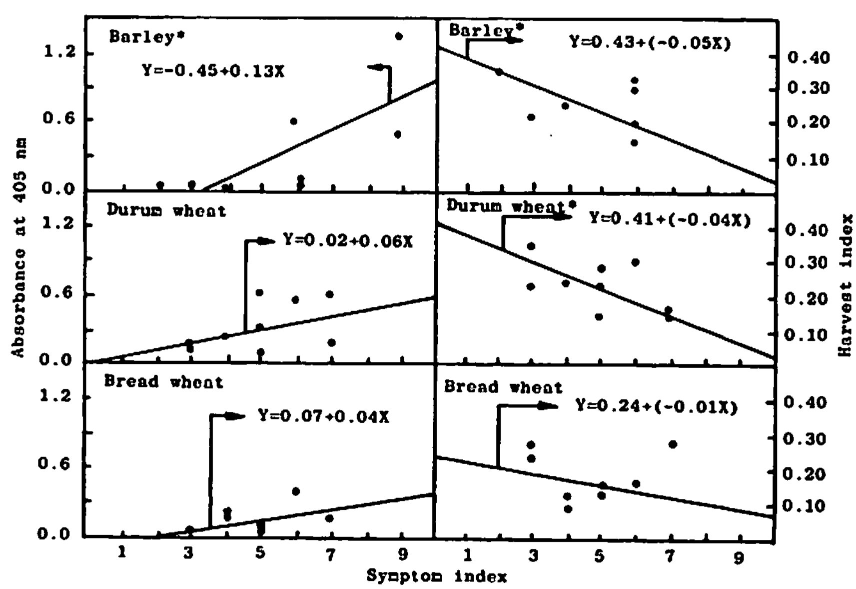


Fig. 1. Averaged ELISA values and harvest index plotted against symptom index.
* Significant correlation ($P < 0.05$).

and average ELISA values was significant only in barley.

Results of this study indicated that the severity of symptoms expression was an unreliable indicator for BYDV resistance in bread wheat, which is in agreement with the results obtained by Comeau (1984). Severity of symptoms may thus be useful only to exclude super-susceptible genotypes. To define BYDV resistant genotypes the other characters should also be considered.

References

Comeau, A. 1984. Aphid rearing and screening methods for resistance to barley yellow dwarf virus in cereals. Pages 60-91 *in* Barley Yellow Dwarf. A Proceedings of the Workshop, CIMMYT, 6-8 Dec 1983, Mexico. CIMMYT, Mexico.

Lister, R.M., Clement, D. and Skaria, M. 1984. Biological differences between barley yellow dwarf viruses in relation to their epidemiology and host reactions. Pages 16-25 *in* Barley Yellow Dwarf, A Proceedings of the Workshop, CIMMYT, 6-8 Dec 1983, Mexico. CIMMYT, Mexico.

Rasmusson, D.C. and Schaller, C.W. 1959. The inheritance of resistance in barley to yellow dwarf virus. Agronomy Journal 51: 664-667.

Schaller, C.W. and Qualset, C.O. 1980. Breeding for resistance to the barley yellow dwarf virus. Pages 523-541 *in* Proceedings, Third International Wheat Conference, Spain/Morocco/AID/USDA/ OSU/ University of Nebraska, 22 May - 3 June 1980, Madrid, Spain, University of Nebraska Agricultural Experiment Station Publication. 839 pp.

Skaria, M., Lister, R.M., Foster, J.E. and Shaner, G. 1985. Virus content as index of symptomatic resistance to barley yellow dwarf virus in cereals. Phytopathology 75: 212-216.

Preliminary Screening of Greek Durum Wheat Varieties Using PAGE

Ardeshir B. Damania
Cereal Improvement Program
ICARDA, P.O. Box 5466, Aleppo, SYRIA
and
Bhal H. Somaroo
Genetic Resources Program
ICARDA, P.O. Box 5466, Aleppo, SYRIA

Polyacrylamide gel electrophoresis (PAGE) of storage proteins has been recommended for use in screening cereal germplasm collections (Damania *et al.* 1983) at genetic resources centers as well as for identification and differentiation of cultivars and varieties (Bushuk *et al.* 1980; Tkachuk and Mellish 1980; Wrigley and McCausland 1977). This study applied the technique to differenciate Greek tetraploid landraces Atsiki-1/2/3/4/5, and to determine their relation with Capeiti, a durum cultivar released in Italy by Casale (1955) in the 1940s from a cross between Eiti 6 and Senatore Capelli.

From each sample, 26 randomly-chosen seeds were subjected to PAGE using an aluminum lactate buffer (pH = 3.1) as described by Tkachuk and Mellish (1980). The selection of 26 seeds at random were found to cover 70% of the variability for gliadins (storage proteins of wheat) in a sample by Eliss (1976), and was considered to be sufficiently representative for the purpose of this experiment. Marquis, a Canadian bread wheat cultivar, was used as the reference.

The low number of biotypes observed in the electrophoretic banding patterns of the Atsiki samples (Table 1) indicated that they were not landraces but selected varieties. True durum landraces have been reported to possess many (up to 38) biotypes in a random selection of 50 single seeds (Damania *et al.* 1983) because of their high degree of heterogeneity.

Two electrophoretic profiles in each sample, including Capeiti, were present in most of the seeds. One particular banding pattern with a distinct triplet in the slow moving ω-region was detected at the same

Table 1. Number of biotypes observed in Atsiki.

Sample	Number of biotypes
Atsiki-1	4
Atsiki-2	6 *
Atsiki-3	3 *
Atsiki-4	2 *
Atsiki-5	4 *
Capeiti	5 *

* Samples with triplet bands in the ω-region of the gliadins on gels.

frequency in all samples except Atsiki-1. The electrophoregrams of Atsiki-2 and Capeiti are shown in Fig. 1. The experiment was repeated for Atsiki-1 with a further random selection of 26 seeds, but again the triplet bands were not observed. It should be noted that the examination of 52 seeds gives an accuracy of 97% for single seed identification (Eliss 1976).

Results of this study indicate a similarity in biotypes among the Atsiki samples and between Atsiki and Capeiti. However, Capeiti possessed two distinct banding patterns not observed in the Atsiki samples. Thus, it is possible that the different Atsiki were derived from Capeiti, which might have been introduced to Greece from Italy where it was extensively grown together with another durum wheat cv. Patrizio in the 1960s and 70s (Bagnara and Scarascia-Mugnozza 1973).

Some contamination with hexaploid bread wheat was also evident in Atsiki-1 and 2 due to the presence of very slow moving bands representing high molecular weight (HMW) gliadins in the ω-region, as in Marquis (Fig. 1).

Data on ten agromorphological characters measured in the field are shown in Table 2. Atsiki-2 was

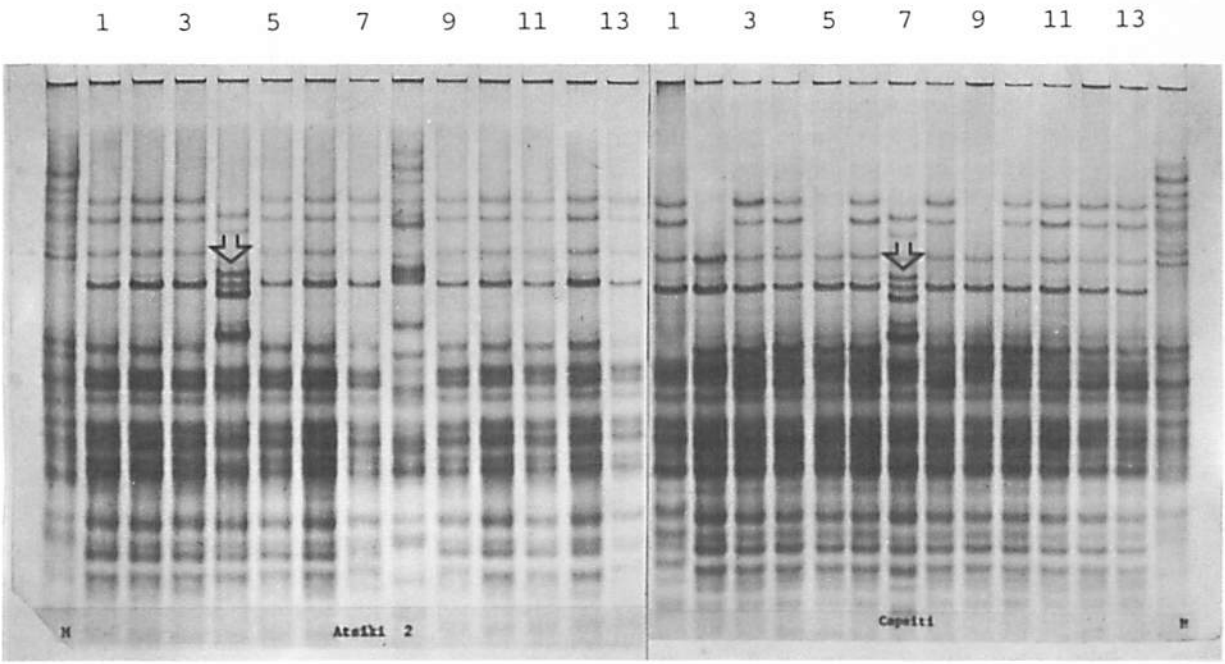


Fig. 1.Electrophoregrams of thirteen seeds of Atsiki-2 and Capeiti. The distinct triplet banding is shown by arrows. The eighth profile in Atsiki-2 belongs to a bread wheat contaminant seed. The reference cultivar, Marquis (M), is seen at the extreme ends of the polyacrylamide gel.

Table 2. Data on ten agromorphological characters of Atsiki and Capeiti recorded in 1985/86 at Tel Hadya, Syria.

Sample	Number of tillers/m^2	Biological yield (kg/ha)	Grain yield (kg/ha)	Harvest index	1000 - kernel weight (g)	Number of spikes/m^2	Days to heading	Days to grain filling	Plant height (cm)	Spike and leaf color
Atsiki-1	755	9750	3257	33	41	270	134	174	112	G
Atsiki-2	824	10488	2374	23	36	344	116	154	120	GR
Atsiki-3	559	9988	3512	35	44	284	134	174	114	G
Atsiki-4	712	9813	3754	38	40	357	134	172	98	GR
Atsiki-5	563	9363	3194	34	44	290	135	174	117	G
Capeiti	526	8825	3012	34	42	329	136	174	118	G

G = Green GR = Greyish green

different in most of the characters from the remaining five lines which were relatively homogeneous. Atsiki-4, which was shorter than the rest, had the highest grain yield, harvest index, and number of spikes/m^2. These differences in agromorphological characters could not be related to any particular electrophoretic banding pattern. But the small number of biotypes within each sample agreed with the low overall variability observed in the field.

Acknowledgements

We would like to thank Mr. Bilal Humeid for recording observations in the field and Mr. S. Ragab for assistance with the electrophoretic apparatus. We would also like to thank Professor P. Limberg of the Institute of Crop Science, Technical University of Berlin, Federal Republic of Germany, for providing the seeds of Atsiki and Capeiti.

References

Bagnara, D. and Scarascia-Mugnozza, G.T. 1973. Outlook in breeding for yield in durum wheat. Pages 249-274 *in* Genetics and Breeding of Durum Wheat, Proceedings of the Symposium (Scarascia-Mugnozza, G.T., ed.), EUCARPIA/Italian National Research Council/Agricultural Departement of the Puglia Region, 14-18 May 1973, Bari, Italy. University of Bari, Italy.

Bushuk, W., Rerie, W. and Zillman, R.R. 1980. Procedure manual for polyacrylamide gel electrophoresis of gliadins as a basis for wheat cultivar identification. Department of Plant Science, University of Manitoba, Winnipeg.

Casale, F. 1955. Tre novita granarie. Genetica Agraria 5: 339-350.

Damania, A.B., Porceddu, E. and Jackson, M.T. 1983. A rapid method for evaluation of variation in germplasm collections of cereals using polyacrylamide gel electrophoresis. Euphytica 32: 877-883.

Eliss, J.R.S. 1976. Wheat protein electrophoresis - a contribution to improved quality control. Flour and Animal Feed Milling 159: 16-18.

Tkachuk, R. and Mellish, V.J. 1980. Wheat cultivar identification by high voltage gel electrophoresis. Annals of Technological Agriculture 29: 207-212.

Wrigley, C.W. and McCausland, J. 1977. Variety identification by laboratory methods: Instruction manual for barley, wheat, and other cereals. CSIRO Wheat Research Unit, Technical Bulletin No. 4.

Barley Research at San Benito Experimental Station in Bolivia

Hugo Vivar

CIMMYT, APDO Postal 6-641,
Lisboa 27, Mexico 06600 DF, MEXICO

In Bolivia, barley occupied 94 900 hectares in 1986 (FAO), and produced an average yield of 823 kg/ha, the highest over the last 25 years. Barley is a staple food for farmers in the upper Andes. It is also utilized as coarse grain for animal feeding or raised for grazing in the Altiplano, a plateau located 4000 m above mean sea level. Barley is also used by local breweries.

This report is based on a visit to the San Benito Experimental Station, 36 kilometers from Cochabamba City (2200 m above mean sea level), which is the main breeding station for the cereal program of the National Research Organization (IBTA).

Since 1976, stripe rust (Race 24) has been the major limiting factor for barley production in the country. Alberto Cordova, Barley Breeder at the San Benito station, released several stripe rust resistant varieties. Among them IBTA 80 (Grignon), a French variety, became the predominant commercial one in the country and was recorded as 90 S at San Benito during my visit to the station. Cochabamba has evolved into a seed production area for the high plateau (4100 m above mean sea level) where barley is raised only for grazing because seed production at this high elevation is impeded by frequent frosts or hail storms. The price of barley seed (US$ 209/t) in Cochabamba exceeds that of wheat (US$ 125). At present, the main constraint to barley production in the Cochabamba area is the susceptibility of Bolivian varieties to leaf rust (race 18). The typing of the virulence of *Puccinia hordei* was done by Dr. A. Roelfs from the USDA Rust Laboratory in Minnesota, USA.

New Germplasm

Several advanced lines, resistant to stripe and leaf rust, are being tested for yield for the second year. The new genotypes under test proved more resistant to diseases and clearly superior in lodging resistance, a factor that could play an important role, as barley in Cochabamba will be grown under adequate fertilizer supply and irrigation.

During my visit there was a clear indication that barley could be grown in areas in the Cochabamba Valley which are now devoted to vegetables. The "Capinote" area, covering 2 500 hectares, is practically out of vegetable production owing to the salinity caused by water pollution from mining and industry. Since barley has a better tolerance to salinity and may be adapted to these conditions, testing new advanced lines in this area is recommendable, and might offer the possibility of solving a serious social problem. However, this may not be possible in 1988 because of budget constraints.

Leaf and stripe rust epidemics allowed the successful screening for resistant germplasm, as late rains created optimum conditions for the development of these diseases. Humidity was also favorable for the development of net blotch and powdery mildew, but the latter is not considered important in the region.

Early-Maturing Barley

Earliness in barley helps farmers of the Andean region escape frost. In the past we were not able to produce an early barley type tall enough for hand-harvesting by sickle and resistant to leaf and stripe rust.

Advanced early lines with a height of 0.85 to 1.05 m and resistant to leaf and stripe rust were recently identified at San Benito. In the 1987/88 season, some advanced F6 lines reached physiological maturity in 87 days. Selected early maturing lines will be tested in the Bolivian high plateau next year.

Regional Trials

Two different regional trial sites were visited: Tiraque, a location considered representative of the central high plateau, and Tarata, where a new experimental station for small grains is being established. Tarata is situated in a low precipitation area and has deep soils. In 1988, for the first time, the agronomist at San Benito started to implement a plan to store water, leaving half of the land fallow and planting small grains in the other half. Barley stands were relatively poor, but superior to those of durum and bread wheat.

Highlights of the Visit

In 1982/83 barley workers at San Benito tested 239 lines from the Tenth International Barley Observation Nursery (IBON) and reported all entries susceptible to stripe rust. In 1988 the bulk of the germplasm sent for the CIMMYT-ICARDA program from Mexico was reported resistant to stripe and leaf rust.

Barley Research at CATAC and Anta Experimental Stations in Peru

Hugo Vivar
CIMMYT, APDO Postal 6-641,
Lisboa 27, Mexico 06600 DF,
MEXICO

Barley in Peru covered 97 500 hectares in 1986 and yielded, on average, 1.16 t/ha. Barley utilization follows the same pattern described for Bolivia (see p 56).

The main barley varieties in Peru are Una 80 (in most of the country) and Grignon in the southern part of the Peruvian Andes (Cusco).

Two experimental stations were visited, both belonging to the Agrarian University, La Molina. The first, CATAC, located at Huaraz in Central Peru (4100 m above mean sea level) had been planted to barley in Nov 1987 to test its adaptation to high altitudes.

Barley stands were poor owing to acid soils, and the crop was severely damaged by hail storms which helped selecting wheat genotypes combining good resistance to hail damage (genotypes difficult to thresh) and satisfactory yields in the upper plateau.

Grass weeds were considered to be a problem in the nursery, but given the effect of erosion in the Peruvian Andes, I am inclined to think that edible grass cover crops should be incorporated in the agronomy of small cereals.

The second station visited was the Anta Experimental Station (2700 m above sea level), the largest barley nursery in the country. There, barley genotypes are subjected to natural epidemics of stripe and leaf rust. This year, a leaf rust infection, higher than that observed during previous visits, was detected. Dr. Ricardo Mont, pathologist at the University, identified the race of *P. hordei* as race 8 with a small variant that makes the virulence of the pathogen overcome the resistance of the Pa 9 gene.

The epidemic of net blotch this year in Anta was probably the most severe one ever observed in Peru. Germplasm resistant to stripe or leaf rust was seriously defoliated by *P. teres*. Among the thousands of plants susceptible to net blotch, 496 F5 lines showed remarkably clean leaves. These F5 lines were not only resistant to net blotch, but also combined resistance to stripe and leaf rust. The resistant lines originated from a Mexican cross sent to Peru as an F3 population: CM67/CEN//CAMBRINUS/2/ROW 906.73/3/LIGNEE 527

The net blotch resistance of those lines originates from the resistant parent ROW 906.73 and is also effective against the pathotypes of *P. teres* present in central Mexico.

The incorporation of genetic resistance to net blotch into germplasm for the Andean region should be a permanent consideration in the breeding efforts of the CIMMYT-ICARDA Barley Program.

Highlights from Peru

Three varieties were released in Peru by the Agrarian University:

YANAMUCLO 87 = UNA 8309/Itintec 77
PC79A-43LM-AN-LM-VM-1LM-OLM

UNA87 = Mazurca/Muller Heydla
CM SWB-77A-446-LM79A-AN-LM-AN-2LM-VM-OLM

NANA87 = Mona/Emir//Bco/2/Gva/3/Abyssinian
CMB78A-377-VM79A-LM-AN-LM-VM-OLM

UNA 87 and NANA 87 originated from selections made by Peruvian barley workers from early segregating generations sent from Mexico by the CIMMYT-ICARDA Program.

RECENT PUBLICATIONS

Zaitlin, M., Day, P. and Hollaender, A. (eds.). 1985. Biotechnology in plant science: Relevance to agriculture in the eighties. Academic Press, Orlando, Florida 32887, USA. 364 pp. ISBN 0-12-775310-9.

This book is based on the proceedings of a symposium held from 23 to 27 June 1985 at Cornell University, Ithaca. New York, where the application of recent developments and future uses of biotechnology to plant breeding and to agribusiness were tackled. New technologies largely related to tissue culture and which are gaining ground in agriculture practice as well as those technologies such as plant transformation which hold promise for the future are specially emphasized. This volume also includes the summaries of two panel discussions which considered various issues pertaining to the implication of current and future technological advances in this field.

Rasmusson, D.C. (ed.). 1985. Barley. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, Wisconsin, USA. 522 pp. ISBN 0-89118-085-0.

This monograph is the 26th in a series and should be of interest to researchers, teachers, students, producers and users of the crop, and many others. The book, in 16 chapters, presents information on all aspects of barley in the USA and Canada. Morphology, anatomy, physiology, cytogenetics, genetics, wide crosses, barley diseases and insects, cultivar development, breeding to control pests, cultural practices, and marketing are considered.

Somaroo, B.H., Abiad, G.F., Humeid, B.O. and Srivastava, J.P. 1988. Barley germplasm catalog part II-1988. ICARDA (International Center for Agricultural Research in the Dry Areas), Aleppo, Syria. 221 pp.

This catalog is complementary to part I which was published in 1986. It presents data on 4129 entries which have been evaluated under rainfed conditions at ICARDA research station at Tel Hadya, near Aleppo, Syria. Each entry has been scored for its morphological, physiological, and quality characteristics. Substantial genetic variability has been found for all the studied traits, and the most promising entries for each trait have been identified. Barley scientists who are interested in this publication are invited to address their enquiries to ICARDA's Genetic Resources Program.

Salunkhe, D.K., Chavan, J.K. and Kadam, S.S. 1985. Postharvest biotechnology of cereals. CRC Press, Boca Raton, Florida, USA. 208 pp. ISBN 0-8493-6288-1.

This book aims to update information on the nature and magnitude of postharvest cereals grain losses and to suggest a biotechnology to eliminate them, with particular reference to developing countries. It should be useful to students, scientists, professionals involved in research areas related to postharvest handling of food, planners and executives setting up food policies, and national and international organization interested in reducing postharvest food grain losses and improving food availability throughout the world.

Klatt, A.R. (ed). 1988. Wheat production constraints in tropical environments: Proceedings of the international conference, UNDP/CIMMYT, 19-23 Jan 1987, Chiang Mai, Thailand. CIMMYT, Mexico, D.F. 410 pp. ISBN 968-6127-22-4.

This is a book of proceedings of a conference addressing the problems associated with introducing wheat into the warmer environments of the world. Twenty-five papers which were presented at the conference are included under three main topics: (i) characterization of tropical wheat environments: identification of production constraints and progress achieved, (ii) constraints associated with rice-wheat rotations, and (iii) constraints to wheat cultivation in non-irrigated areas.

Van Ginkel, M. and Tanner, D.G. (eds.). 1988. The Fifth regional wheat workshop for eastern, central, and southeastern Africa and the Indian Ocean: Proceedings of the workshop, CIDA/CIMMYT, 5-10 Oct 1987, Antsirabe, Madagascar. CIMMYT, Mexico, D.F. 280 pp. ISBN 968-6127-03-8.

This volume contains 28 papers which tackle some of the issues encountered in wheat production in Burundi, Ethiopia, Kenya, Madagascar, Rwanda, Somalia, Tanzania, Uganda, Zaire, Zambia, and Zimbabwe. A list of recommendations and resolutions developed in the light of the presentations delivered at the workshop appears at the end of the book.

Bruening, G., Harada, J., Kosuge, T. and Hollaender, A. (eds.). 1987. Tailoring genes for crop improvement: An agricultural perspective. Plenum Press, New York, NY 10013, USA. 228 pp. ISBN 0-306-42579-3.

This volume contains papers that were presented at the Conference on Tailoring Genes for Crop Improvement: An Agricultural Perspective, held 24-28 Aug 1986 at the University of California, Davis, California. It provides readers with examples of how the new experimental strategies are being used to gain a clearer understanding of the biology of plants grown for food and fibers, and discusses how molecular biology approaches are being used to introduce new genes into plants for plant breeding programs.

Green, C.E., Somers, D.A., Hacket, W.P. and Biesboer, D.D. (eds.). 1987. Plant biology Vol. 3. Plant tissue and cell culture: Proceedings of the VIth International Congress on Plant Tissue and Cell Culture, Rockefeller Foundation/USDA, 3-8 Aug 1986, University of Minnesota, USA. Alan R. Liss, 41 East 11th Street, New york, NY 10003, USA. 509 pp. ISBN 0-8451-1802-1.

The content of this volume is divided into seven broad subject areas: development, biochemistry and physiology, secondary metabolites, genetics, molecular biology, application to crops, and technology development. The chapters were written by leading experts in the field and each was presented as a Plenary Lecture in a symposium. Collectively, these chapters will provide the reader with a broad view of recent development and progress in the field of tissue culture.

Baker, R.J. 1986. Selection indices in plant breeding. CRC Press, Boca Raton, Florida, USA. 218 pp. ISBN 0-8493-6377-2.

This book provides an overall review of topics which relate to the development of selection indices; a discussion of some of the issues related to the use of parental material for breeding; an overall evaluation of various modifications that have been proposed for selection indices and their use in plant breeding; and methods for choosing parents for plant breeding programs. A guide to computer techniques for carrying out the calculation required to develop and apply selection is also included.

Srivastava, J.P., Saxena, M.C., Varma, S., and Tahir, M. (eds). 1988. Winter cereals and food legumes in mountainous areas: Proceedings of an International Symposium on Problems and Prospects of Winter Cereals and Food Legumes in the High-Elevation Areas of West Asia, Southeast Asia, and North Africa, Ministry of Agriculture, Forestry, and Rural Affairs, Turkey/ICARDA, 6-10 July 1987, Ankara, Turkey. ICARDA, Aleppo, Syria. 317 pp.

This volume contains the Proceedings of an International Symposium on Problems and Prospects of Winter Cereals and Food Legumes Production in the High-Elevation Areas of West Asia, Southeast Asia, and North Africa, held 6-10 July 1987 in Ankara, Turkey. Twenty-eight papers presented at the Symposium are included and organized under five sections: (i) agroclimatic characterization, (ii) production systems and socioeconomic considerations, (iii) country reports on current status of production, research, infrastructure, and constraints, (iv) research for improved adaptation of crop genotypes for high-elevation areas, and (v) recommendations for future research. The book is destined to help researchers, planners, and policymakers conceive a clearer picture of high-elevation agriculture in the specified regions, and work out solutions to problems related to mountainous areas.

Cereal Publications Available from ICARDA

Information Brochures

An introduction to the international cereal nurseries system, 1986. 16 pp.

Better harvest in dry areas. 1983. 24 pp.

Cereal improvement in dry areas -- A report on the Tunisia Cooperative Cereal Improvement Project, 1980-1985, INRAT/ICARDA. 1986. 81 pp.

ICARDA, a partner in cereal improvement. 1985. 74 pp.

Meeting the challenge: Cereal improvement in Tunisia, INRAT/ICARDA. 1988. 56 pp. (bilingual, En/Fr).

Information Services

RACHIS (Barley and Wheat Newsletter). Annual vols 1-2, English editions only. Vols 3-6, 1984-88, separate Arabic editions.

Information Bulletins

Field manual of major insect pests and diseases of wheat and barley, by A. Kamel, 1985. 92 pp. (Arabic only).

Germplasm Catalogs

Barley germplasm catalog part I, by B.H. Somaroo, Y.J. Adham, and M.S. Mekni, 1986. 413 pp.

Barley germplasm catalog part II, by B.H. Somaroo, G.F. Abiad, and B.O. Humeid, 1988. 201 pp.

Bibliography

An annotated bibliography on durum wheat 1972-1984, by J.P. Srivastava, G. Kashour, and S. Dutta, 1986. 236 pp.

Technical Manuals

An introduction to wheat and barley in the Near East and North Africa. 1980. 75 pp.

Insect pests of wheat and barley in West Asia and North Africa (Rev. 1). 1987. 209 pp.

Crop quality evaluation: Methods and guidelines (Rev. 1). 1988. 145 pp.

Books and Proceedings

Fourth regional winter cereal workshop on barley, Amman, Jordan, 1977. Vol. 1, 273 pp; Vol. 2, 420 pp.

Regional workshop on cereal diseases methodology. Published jointly by the Government of the Netherlands, ICARDA, and CIMMYT, 1979, 150 pp.

Recommendations, summaries of discussion, program and participants from ICARDA/UNDP Workshop "Increasing the Effectiveness of Wheat and Nitrogen in Rainfed Farming Systems in Mediterranean-Type Environments," 1980. 48 pp.

Seed production technology. J.P. Srivastava and L.T. Simarski, eds. 1986. 287 pp.

Verification and adoption of wheat production technology in the Sudan: Proceedings of the first national wheat coordination meeting, 3-5 Aug 1986, Wad Medani, Sudan. 64 pp.

Verification and adoption of wheat production technology in the Sudan: Proceedings of the second national wheat coordination meeting, 20-22 July 1987, Wad Medani, Sudan. 42 pp.

Nematodes parasitic to cereals and legumes in temperate semi-arid regions: Proceedings of a workshop held at Larnaca, Cyprus, 1-5 Mar 1987. 217 pp.

Winter cereals and food legumes in mountainous areas: Proceedings of an International Symposium on Problems and Prospects of Winter Cereals and Food Legumes Production in the High-Elevation Areas of West Asia, Southeast Asia, and North Africa, 6-10 July 1987, Ankara, Turkey. 317 pp.

Annual Reports

Cereal Improvement Program: Annual report 1986. 229 pp.

Cereal Improvement Program: Annual report 1987. 206 pp.

Discussion Papers

Preliminary agronomic studies on wheat and barley in the 1978/79 season, by A. Hadjichristodoulou. 14 pp.

Wheat production with supplementary irrigation in two Hama villages, by E. Baily. 1982. 48 pp.

Nurseries Reports

Cereals international nurseries report 1977/78, 115 pp.

Regional wheat and barley nurseries preliminary report 1978/79, 88 pp.

Cereals international nurseries report 1979/80, 151 pp.

Regional wheat and barley nurseries preliminary report 1980/81, 47 pp.

Regional yield trials and preliminary observation nurseries 1980/81, final report, 1983, 228 pp.

Regional yield trials and preliminary observation nurseries: Preliminary report 1981/82, 58 pp.

Regional yield trials and observation nurseries 1983/84, final report, 1985, 343 pp.

Annual report for the regional barley yield trials and observation nurseries 1984/85, 177 pp.

Annual report for the regional bread wheat yield trials and observation nurseries 1984/85, 133 pp.

Annual report for the regional durum wheat yield trials and observation nurseries 1984/85, 185 pp.

Annual report for the regional barley yield trials and observation nurseries 1985/86, 212 pp.

Annual report for the regional bread wheat yield trials and observation nurseries 1985/86, 136 pp.

Annual report for the regional durum wheat yield trials and observation nurseries 1985/86, 168 pp.

Annual report for the regional barley yield trials and observation nurseries 1986/87, 127 pp.

Annual report for the regional bread wheat yield trials and observation nurseries 1986/87, 163 pp.

Annual report for the regional durum wheat yield trials and observation nurseries 1986/87, 204 pp.

CEREAL NEWS

Dr Nasrat Fadda, Director General; **Dr J.P. Srivastava**, Acting Deputy DG for International Cooperation; and Cereal Improvement Porgram Scientists **Drs Edmundo Acevedo, Omar F. Mamluk, Guillermo Ortiz-Ferrara, and Ross H. Miller** attended the Nile Valley Regional Project - Cereals Component planning meeting which was held 19-23 Sept in Cairo, Egypt. Among the many items discussed with NARS of Egypt were: aphid, heat tolerance and earliness, cereal diseases, and limited moisture screening. A training component was also developed.

Dr Philippe Lashermes joined ICARDA in Sept 1988 as biotechnologist. He received an M. Sc. degree in cell biology and plant physiology in 1983 from the University of Clermont-Ferrand and in genetics and plant breeding in 1984 from the University of Paris XI. Concurrently he conducted research in tissue culture and haploid plant production in maize at INRA Plant Breeding Station of Clermont-Ferrand. Dr Lashermes was awarded a Ph. D. degree in 1987 for his thesis on "*in vitro* gynogenesis and androgenesis in maize: a genetic and physiologic study, application in plant breeding." He will be mainly responsible for the project at ICARDA financed by France on "Biotechnologies for Cereal Improvement" with special emphasis on *in vitro* culture and doubled haploid production of barley and wheat.

Dr Omar F. Mamluk, Cereal Pathologist, ICARDA, attended the Fifth International Congress of Plant Pathology, Kyoto, Japan, 20-27 Aug 1988, a global event which attracted about 1700 participants from many countries and international center. Dr Mamluk presented a poster co-authored with Dr M. Nachit on the "Performance and reaction of some durum wheat genotypes against different isolates of common bunt (*Tilletia foetida* and *T. caries*)." In conjunction with this Congress, Dr Mamluk also attended the International Symposium on Crop Losses due to Disease Outbreaks in the Tropics and Counter Measures at the invitation of the Tropical Agriculture Research Center (TARC). The title of the paper (co-authored with Drs M.P. Haware, K.M. Makkouk, and S.B. Hanounik) he presented at the Symposium was "Occurence, losses, and control of important cereal and food legume diseases in West Asia and North Africa."

Dr R.H. Miller, Cereal Entomologist, ICARDA, attended the International Conference on Dryland Farming from 15 to 19 Aug 1988 in Amarillo, Texas, USA. He presented a paper (co-authored with Dr J.P. Srivastava and Ir J.A.G. van Leur) on "Biotic stresses in dryland cereal production - the ICARDA perspective." Dr Miller also attended the Third Arab Congress on Plant Protection held in Al-Ain, United Arab Emirates, from 4 to 9 Dec, and delivered a paper on "Plant spacing effects on wheat stem sawfly resistance."

Dr E. Acevedo, Agronomist/Physiologist, travelled to Morocco from 23-29 Apr. The objectives of his trip were to (i) visit ICARDA's field activities and some of the national program work on cereal improvement, (ii) establish links and develop a cereal physiology/agronomy project in this country, and (iii) visit nurseries grown during this season under the supervision of Dr M. Mekni. During his stay at Rabat he got acquainted with the structure, activities, and priorities of INRA as well as the efforts being made on on-farm verification and demonstration trials. He also visited the INRA-MIAC project at Settat and got an overall view of this project. Furthermore, Dr Acevedo visited INRA, Montpellier, France, from 11 to 16 July 1988 to develop a joint project on physiology-breeding for improved performance of durum wheat in dryland areas with Dr Philippe Monneveux and Dr Alfred Conesa. During 1988/89 the experiments will be started both at ICARDA and in France using identical germplasm, experimental design, methods, and scoring scales. The work will be carried out primarily by graduate students working at ENSA, Montpellier. Dr Acevedo also called at the Institute of Plant Science Research (formerly PBI), Cambridge Laboratory, UK, 18-22 Aug, to discuss progress and further plans on the on-going project on physiology-breeding of barley with Dr R. B. Austin.

Dr A.B. Damania visited the Agricultural Research Institute (ARI), Nicosia, Cyprus, from 12 to 15 Sept 1988. The purpose of the visit was to assess the suitability of the electrophoresis apparatus and chemicals available for analysis of gliadins and to list the equipment required to set up the unit. Dr Damania met Dr C.S. Serghiou, Director, ARI; had discussions with Dr A. Hadjichristodoulou, Dr C.M. Josephides, Mr D. Hadjidemetriou, and Mr I. Papaconstantinou; and delivered a seminar on "Use of electrophoretic techniques in screening cereal germplasm for protein quality, purity, and variability." Dr Damania will be paying a second visit to ARI when the required equipment and chemicals become available.

Dr M. Nachit, CIMMYT/ICARDA Durum Wheat Breeder, travelled to Jordan (9-11 Sept) and attended a symposium on Rainfed Field Crops and Farming Systems in Jordan and the Neighboring Countries. He presented a paper on the "Contribution of drought resistance breeding to yield increase under Mediterranean dry areas." Dr Nachit also visited Tunisia (13-15 Sept) where he participated in a program coordination meeting with INRAT and other Tunisian institutes. During his stay at Tunisia Dr Nachit was informed of the success of Omrabi, a drought tolerant variety developed at ICARDA from a cross between the landrace Haurani and a high-yielding Mexican variety, C-69. On 23 Oct, Dr Nachit returned to Jordan for a 6-day visit during which he discussed the program and workplan for 1988/89. He reported that data were analyzed for the newly released cereal varieties in Jordan. A wheat breeding workplan for 1988/89 for Jordanian dryland was discussed and agreed upon by the National Center for Agricultural Research and Technology (NCARTT), University of Jordan (UOJ), and the Seed Multiplication Organization. The joint project between NCARTT and UOJ is funded by Jordan. This project stresses the collaboration between research institutions in Jordan, and has high priority in the country. The newly released varieties are:

Korifla; new name, Petra (durum wheat)
Cham 1; new name, Muru (durum wheat)
N-432; new name, Amra (durum wheat)
Stork; new name, ACSAD 75 (durum wheat)
NASMA; new name, Jubeiha (bread wheat)
L 88; new name, Rabba (bread wheat)

Dr S. Ceccarelli, Barley Breeder, attended the International Workshop on Advanced Technologies for Increased Agricultural Production held in Santa Marguerita Ligure, Italy, 25-29 Sept. He pesented a paper entitled "Breeding for unfavorable conditions: philosophies, methodologies, and strategies."

Dr M. Tahir, Cereal Breeder, ICARDA, and **Mr M. Oudina**, High Altitude Research Station, Setif, Algeria, on visit to ICARDA since 12 June, travelled to Turkey on 18 to 25 June 1988 to record observations and hold discussions with Turkish collegues on a joint high-elevation research program.

Drs B. Yilmaz, Director, Field Crops Research Center, Ankara; **Dr B. Bolat**, Director, Cukurova Agricultural Research Institute, Adana; **Dr E. Firat**, Director, Aegian Agricultural Research Institute, Izmir; and Dr **F. Altay**, Director, Agricultural Research Institute, Eskishehir, visited ICARDA 12-31 June 1988 and had detailed discussions with Cereal Improvement Program scientists regarding the existing and future collaborative programs of research.

Dr Philippe Monneveux from ENSA-INRA, Montpellier, France, visited the Cereal Improvement Program 20-28 March 1989. He worked mainly with Dr E. Acevedo on finalizing technical aspects of Physiology and Cereal Breeding Training Workshop for North African Scientists to be held in 1990. Dr Monneveux also discussed durum germplasm evaluation for several lines from germplasm collection supplied last year to confirm salinity tolerance. Dr Monneveux has requested more of the same germplasm for further more sophisticated tests for rapid screening of salinity in laboratory. Lastly, he also discussed INRA/ICARDA collaboration including administrative aspects.

Dr A.K. Sgaier, Crop Production Officer, Plant Production Division, Food and Agriculture Organization, Rome, Italy, visited ICARDA from 22 to 26 Aug 1988, to discuss and identify areas of collaboration with ICARDA in West Asia and North Africa, to strengthen the research capabilities of the national scientists, and to enhance cereal productivity in the region.

Dr A.F. Krattiger, Post-Doctoral Fellow in biotechnology of the Wheat Program in CIMMYT, Mexico, attended the Cereal Improvement Program Planning Meetings which have been held in Oct 1988 and had detailed discussions with Drs G. Ortiz-Ferrara, M. Nachit, and A.B. Damania, Mr L. Pecetti, and other scientists.

Dr A. Deshayes, consultant to the UNDP, New York, arrived to Aleppo on 29 Aug. He visited ICARDA and held discussions with scientists from the Cereal Improvement Program and the Food Legume Improvement Program in order to prepare a UNDP/ICARDA biotechnology project proposal.

Dr Norman Darvey, Senior Lecturer of Agricultural Genetics, Plant Breeding Institute, University of Sydney, Australia, visited ICARDA from 4 to 7 July 1988. He presented two seminars on "Biotechnology and plant breeding" and on "Alien incorporation and germplasm utilization in wheat and triticale." During his stay Dr Darvey got acquainted with the work at the Cereal Improvement Program and showed particular interest in cereal biotechnology.

Dr H.E. Vivar, CIMMYT-based ICARDA Barley Breeder, reported that stripe rust and early frost seriously damaged the barley crop in Obregon, Mexico. He said yields sustained 50% reduction, as production in 1988 reached 140 000 tonnes only as compared to 280 000 in 1987. Some farmers, whose fields were heavily infested by race 24, suffered a total loss of the crop and did not even harvest. Race 24 was identified by Dr R. Stubbs from samples sent to Holland in 1987. As no commercial varieties are known to be resistant, five fungicides were tested under farmers conditions. Bayleton and Bayfidan were not effective, but Punch, Tilt, and Folicur gave good control. On the other hand, from the best 189 resistant lines provided by ICARDA/CIMMYT Barley Program to INIFAP (Mexican National Program) for malting quality testing, 100 have been analyzed. Four had excellent quality, and their seeds have been planted for small increase in the Yaqui Valley. Dr Vivar also reported that, in Chili, Dr Edmundo Beratto is requesting authorization for the release of a new variety that was selected from germplasm sent to him from Mexico; and that in Equador, the line Lignee/Kober//Teran is expected to be released in 1989.

Dr H.B. Sparrow, Reader in Agronomy, University of Adelaide, Australia, said in a letter (dated 1 Dec 1988) to the Cereal Improvement Program of ICARDA that there is concern in Australia that sooner or later the Russian aphid will arrive there. He added that the CSIRO Division of Entomology is begining a program on biological control and that resistant wheat material is also being introduced to ward off the threat. Dr Sparrow also showed interest in ICARDA's work on identifying resistance in barley and made a request for samples of resistant material available at the Cereal Improvement Program.

Dr V. Shevtsov from the Krasnodar Research Institute of Agriculture, USSR, said that weather conditions in 1988 were not favorable for spring barley from Europe and the Middle East, as powdery mildew infestation and lodging appreciably reduced yields. A total of 111 lines which had been selected from the ICARDA Barley Program were planted in spring 1988 in 10-m^2 plots for testing, and yielded from 2 to 6 kg/plot. Of these lines, 19 have been selected for further testing in preliminary trials in 1989.

Dr David Sands, Associate Professor, Montana State University, visited the Cereal Improvement Program of ICARDA from 30 Nov to 5 Dec 1988 to discuss on-going and future collaboration between MSU and ICARDA. He also gave a seminar on on "Biotechnology and plant protection."

Prof S. Jana, University of Saskatchewan, Saskatoon, Canada, joined the Cereal Improvement Program at ICARDA as a visiting scientist from 18 Apr to 15 June 1988. He conducted statistical analyses on durum wheat germplasm evaluation data and other biometrical studies.

Dr Cristian Hera, Director, Research Institute for Cereal and Technical Plants, and **Dr N.N. Saulescu,** Head, Wheat Research Program, coming from Romania, visited ICARDA in June 1988 to get acquainted with the research activities of the Cereal Improvement Program. They discussed with scientists of the Program the possibility of developing a cooperation between ICARDA and the Institute, and showed interest in arranging a regular germplasm exchange with ICARDA's high-elevation breeding program for barley and wheat.

Dr Pramod Kumar Agarwal receives AISMAN Award for 1987. Dr Agarwal was selected by the All India Seed Growers, Merchants, and Nurserymen (AISMAN) Association to receive one of the two 1987 AISMAN Awards in recognition of his services to India in the field of Seed Science and Technology. This award was instituted in 1980 and is presented to eminent scientists/technologists on account of their meritorious work in the field of agri/horticultural development in India.

The First National Conference on Dryland Farming in Iran was held in Mashad from 29 to 31 May 1988. The Conference was sponsored by the Ministry of Jehad Sazandegi in cooperation with the University of Mashad. It focused on the agronomic, breeding, agrometeorological, and socio-economical aspects of dryland farming as well as the use of modeling and the physiological basis of resistance to drought, diseases (especially rust and smut), and low and high temperatures.

The Third International Symposium on Genetic Aspects of Plant Mineral Nutrition, sponsored by the Institute of Crop Science and Plant Breeding of the Federal Research Center of Agriculture, was held in Braunschweig, Germany F.R., from 19 to 25 June 1988. About 125 scientist from 35 countries attended the Symposium. Dr A.B. Damania represented ICARDA's Cereal Improvement Program and presented a paper on "Genetic resources for optimal input technology - ICARDA's perstective". Scientists from other IARCs that were present were Drs S. Rajaram (CIMMYT), M.D.T. Thung (CIAT), H.-U. Neue and S. Akita (IRRI), and P. Schmiediche (CIP).

The Seventh International Wheat Genetics Symposium, held 13-19 July 1988 in Cambridge UK, was attended by Drs J.P. Srivastava, Acting Deputy Director General (International Cooperation) and A.B. Damania, M. Inagaki, M. Nachit, G. Ortiz Ferrara, and M. Tahir, scientists at the Cereal Improvement Program, ICARDA. Other International Agricultural Research Centers were represented by Dr L. Sitch from IRRI and Dr H.J. Dubin, Nepal-based CIMMYT pathologist. Dr C. Cesloni from the University of Viterbo, Italy, and Dr J. Gorham from the University College of North Wales, Bangor, UK, with whom the Cereal Improvement Program collaborates on specific research, were also present. During the Symposium Dr Srivastava delivered a paper entitled "Landraces, primitive forms and wild progenitors of durum wheat - their use in dryland agriculture," and Dr Damania, a paper on the "Improvement of durum wheat proteins utilizing wild gene resources of *Triticum dicoccoides* Koern at ICARDA," co-authored with Drs M. Tahir and B.H. Somaroo. After the Symposium, Dr Damania payed a 3-day visit to the Center of Arid Zone Studies, University College of North Wales for discussions on collaborative research.

The First Regional Coordination Meeting of Barley and Wheat Scientists in the Arabian Peninsula was held in Sana'a, Yemen Arab Republic, from 18 to 20 Oct 1988. Representatives from Kuwait, the Kingdom of Saudi Arabia, People's Democratic Republic of Yemen, Yemen Arab Republic, Egypt, and the Sudan participated in the meeting along with representatives of the Arab Fund for Economic and Social Development (AFESD), ICARDA, and CIMMYT. They gave an account of the status of research, training, and transfer of technology activities on barley and wheat in their respective countries as well as the production constraints and projections. During the meeting it was deemed necessary to coordinate the scientists' efforts in the Arabian Peninsula where salinity, drought, diseases, insects, and weed problems are considered common constraints to barley and wheat production. A workplan for 1988/89 season was drawn up and basically involved a sub-regional network on transfer of technology, back-up research, and training.

The Third Conference of the International Plant Biotechnology Network (IBPNet) entitled The Role of Tissue Culture and Novel Genetic Technologies in Crop Improvement was held in Nairobi, Kenya, 8-12 Jan 1989. The Conference focused on topics of importance to Sub-Saharan Africa. The four sessions of the Conference addressed (i) plant breeding and genetics, (ii) tissue culture technologies, (iii) practical applications of biotechnology, and (iv) novel biotechnologies.

XII EUCARPIA Congress. Drs S. Grando, P. Lashermes, and S.K. Yau from the Cereal Improvement Program, ICARDA, attended the Congress held at Gottingen, Germany F.R., 27 Feb-3 Mar 1989. The Congress registered 1087 participants from all over the world. Seven symposium sessions covered 28 lectures on breeding methods, genome organization, mutagenesis, disease resistance, stress tolerance, hybrid breeding, application of biotechnology to breeding, and proprietory rights for new plant material.

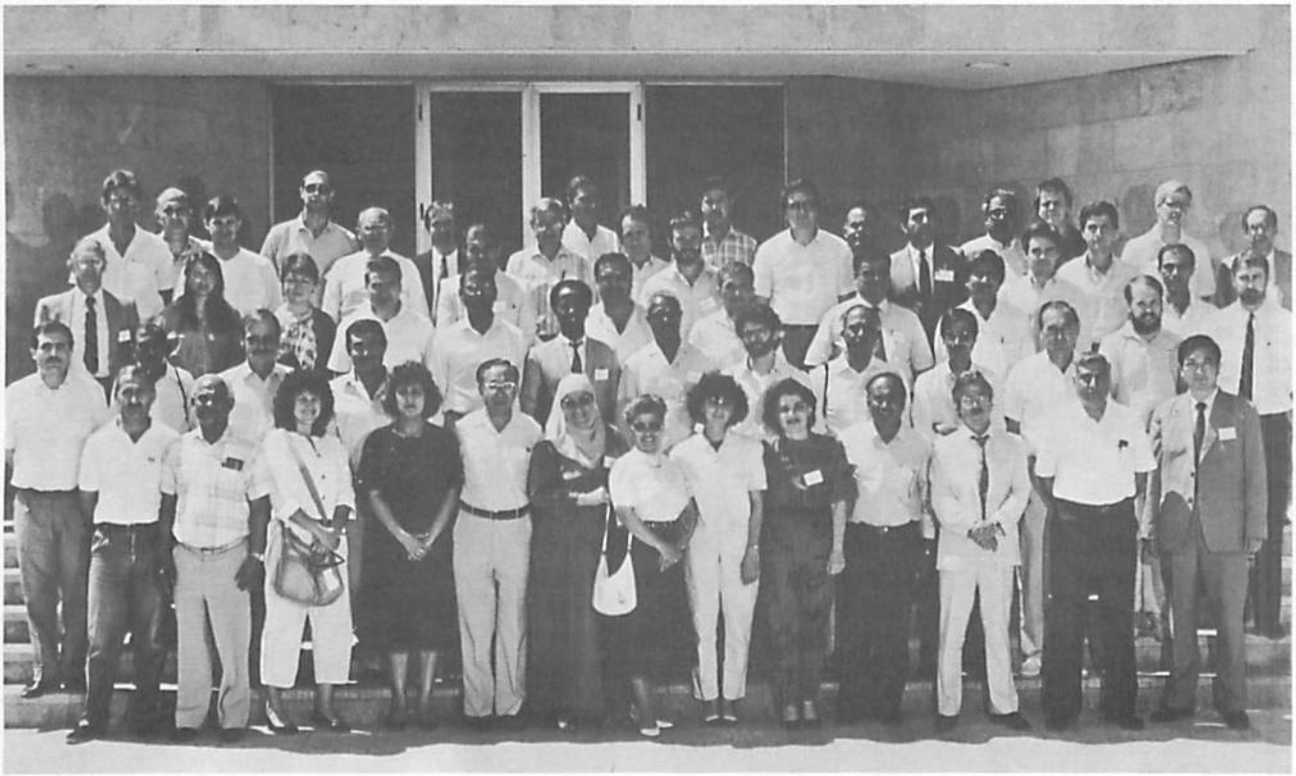
A cereal stress physiology short course organized by ICARDA between 15 and 28 Mar 1988, focused on the effects of major physical stresses on cereal growth and development and discussed desirable varietal traits and management practices to alleviate these effects.

ICARDA and MSU (Montana State University) organized a course on barley diseases and associated breeding methodologies, 21 Mar-5 Apr 1988. The course was given at ICARDA's headquarters at Tel Hadya, Aleppo, Syria, to cereal pathologists and breeders working on barley. The topics included occurence and importance of barley diseases, symptoms, causal agents, disease scoring, field sampling, crop loss assessment, and control.

A short training course on cereal improvement was conducted in Dhamar, Yemen Arab Republic, 23-27 Oct 1988. Fifteen trainees from the People's Democratic Republic of Yemen, Sultanate of Oman, and Yemen Arab Republic attended the course. Lectures covered plant breeding, disease and insect pests, agronomy, field plot techniques, and on-farm trials. Research plots were visited at Dhamar Station of the Agricultural Research Authority as well as on-farm trials at Dhamran. The instructors were: Dr H. Ketata, Dr A. El-Ahmed, and Mr I. Naji from ICARDA; and Drs M. Zumeir, M.S. Nussiri, and M. El-Khoulani from the Agricultural Research Authority. The closing session of the course was chaired by H.E. Moqbel Ahmed Moqbel, Deputy Minister, Ministry of Agriculture and Fisheries, who thanked ICARDA for continuous support and emphasized the importance of training to improve skills of researchers in Yemen and countries of the Arabian Peninsula.

Durum Germplasm Evaluation Network. Data and information received from the Plant Genetic Resources Center, Addis Ababa, Ethiopia, indicate that out of a total number of 200 selected durum accessions sent by ICARDA under the framework of voluntary collaborative evaluation network, 11 accessions performed exceptionally well at Debre Zeit site in the 1987/88 season, and have been picked up by Ethiopian breeders for inclusion in their programs. The durum germplasm had also been sent to Tunisia and tested at Monrag, a low rainfall site which was affected by severe drought in the 1987/88 season. Tunisian cooperators reported that 16 lines out of these have been selected for further testing and utilization by INRAT. Six other countries have also been provided with the durum germplasm which had been selected primarily at the low rainfall site at Breda, Syria, by the special project on Evaluation and Documentation of Durum Wheat Germplasm. The scientists involved from the Cereal Improvement Program at ICARDA were Dr A.B. Damania and Mr L. Pecetti.

International Symposium
Evaluation and Utilization of Genetic Resources in Wheat Improvement
18-22 May 1989, ICARDA, Aleppo, Syria



Participants in the Symposium.

An International Symposium on Evaluation and Utilization of Genetic Resources in Wheat Improvement was held at the International Center for Agricultural Research in the Dry Areas (ICARDA), 18-22 May 1989. The Symposium was sponsored by the University of Tuscia, Viterbo, Italy and ICARDA. On this ocassion the permanent administrative and research buildings were formally opened and a new Genetic Resources Unit was inaugurated. The purpose of the symposium was to bring together genetic resources scientists, gene-bank managers, germplasm evaluators, and plant breeders to stimulate discussion on handling of wheat germplasm and optimize its utilization in current crop improvement programs and the conservation of diversity for future contingencies.

Sixty-three scientists from 36 institutions and from ACSAD, CIMMYT, IBPGR, ICARDA, and IRRI were present. Forty-three papers were presented, 33 orally and the rest as posters. Two discussion sessions were also held on: (i) germplasm evaluation and information dissemination networks and (ii) utilization of wild relatives and primitive forms for wheat improvement.

Speakers emphasized the importance of factors that reduce productivity such as drought, temperature extremes, salinity, low soil nutrients, and diseases and pests common to West Asia and North Africa. Some scientists showed that landraces, wild progenitors, and primitive forms could be used in reconstituting a genepool of genetic resources useful for improving tolerance to stresses and minimizing losses through yield stability. The importance of exploitation of indigenous genetic resources for desirable traits conferring adaptation to a specific agro-ecological zone was also discussed.

The symposium highlighted areas of research and possible imbalances between theoretical studies and experimental verification. Relevant areas of future research on genetic resources were identified. The most effective and desirable link between evaluation and germplasm enhancement and utilization was sought.

FORTHCOMING EVENTS

The XIXth Stadler Genetic Symposium on Gene Manipulation in Plant Improvement II will be held at the University of Missouri-Columbia campus from 13 to 16 Mar 1989. Speakers from around the world will be presenting lectures on the following topics: plant breeding concepts, physiological concepts, pathological concepts (viruses), quantitative principles, chromosome and gene manipulation, tissue culture, plant transformation systems, gene mapping systems, gene expression, genome organization, and anther culture and haploid systems. Participants will be allowed to present posters in their area of research. For more information please write to J.P. Gustafson, 208 Cutis Hall, University of Missouri, Columbia, Missouri 65211, USA.

Training Course on Agroforestry Research for Development, 8-26 May 1989. The International Council for Research in Agroforestry is organizing a 3-week training course with the support of the "Direct Aid to Educational Institutions/Organizations (DSO)" Program funded by the Royal Netherlands Government. The course aims at enhancing the professional capabilities of research scientists and development planners from developing countries so they can initiate and implement agroforestry (i.e. land use systems and practices based on the integration of woody perenials with crops and/or animals) research leading to the development of systems and technologies that are suited to local conditions and adoptable by farmers. The course will consist of lectures, group work/discussions, group practicals, field exercises, and independent study. Information requests should be directed to: James Wahome or Emmanuel Torquebiau, Human Resource Development Unit, ICRAF, P.O. Box 30677, Nairobi, Kenya. Telex: 22048 ICRAF Nairobi. Telefax: 521001. Cable: ICRAF. Tel.: 521450.

The CTA/FAO Symposium of Plant Biotechnologies for Developing Countries will take place in Luxembourg from 26 to 30 June 1989. The objective of the Symposium is to develop an action plan for further development of plant biotechnology with specific reference to developing countries' needs; appraising the socioeconomic impact of biotechnological development; and identifying activities that should be promoted. The Symposium is also intended to promote activities and mobilize resources to apply these technologies in the improvement of plant production in developing countries. Further information may be obtained from: Plant Production and Protection Division, FAO, Via delle Terme di Caracalla, 00100 Rome, Italy; and Technical Division, CTA, Postbus 380, 6700 AJ Wageningen, The Netherlands.

International Symposium on Physiology/Breeding of Winter Cereals for Stressed Mediterranean Environments. The Symposium, which will take place at Montpellier, France, 3-6 July 1989, will be sponsored by the Ecole Nationale Superieure Agronomique (ENSA), Montpellier; The Institut National de la Recherche Agronomique (INRA); and ICARDA. During the five sessions of the Symposium, about 30 invited speakers will address the following subjects: physiologically based traits to improve cereal yield and yield stability under stress; methods of assessment and verification of physiologically based traits for cereal improvement, the use of physiologically based traits in breeding programs, and biotechnology and plant breeding for stress tolerance. For further information, please write to Dr E. Acevedo, Cereal Improvement Program, International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria. Tlx: 331206, 331208, 331263 SY.

The First International Symposium on the Cereal Stem-Borer, *Chilo*, will be hosted by the International Center of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya, from 26 to 29 July 1989. The objectives of the Symposium are to bring together scientists engaged in various aspects of research on *Chilo*, to determine the priorities for future research strategies, and to explore types of collaborative projects between the institutions interested in research on *Chilo*. The Symposium will be organized under the following sections, regional reports (or status reports and achievements on *Chilo* research and control); taxonomy and distribution of *Chilo*; biology and ecology; population dynamics and crop losses; physiology, reproduction, and biochemistry; rearing and quality control; host plant resistance (including breeding and resistance genetics); control (cultural, biological, chemical, behavioural manipulation, genetic, and IPM). The language of the Symposium will be English, and the proceedings will be published separately. For more details write to: Ms Rose Washika, Administrative Coordinator, Symposium on *Chilo*, ICIPE Research Center, P.O. Box 30772, Nairobi, Kenya.

CONTRIBUTORS' STYLE GUIDE

Policy

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

Editing

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

Disclaimers

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

Manuscript

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

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

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

Examples of common expressions and abbreviations

3g, 18 mm, 300 m^2, 4 Mar 1983; 27% ; 50 five-day old plants; 1.6 million; 23 µ g; 5°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: Zadoks, J.C. and van Leur, J.A.G. 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)

P. O. Box 5466, Aleppo, Syria