RACHIS

Barley and Wheat Newsletter

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Research and Production

Genetics of Field Resistance to Leaf Rust of Wheat under Rainfed Conditions

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Abstract

Studies were conducted on the inheritance of field resistance to leaf rust (*Puccinia recondita* Rob. ex Desm.) of wheat (*Triticum* spp.) by scoring for reaction type and rust intensity, and computing the coefficient of infection in six basic generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of a wheat cross WC 44 × WH 283. Low reaction type (resistance) was found to be under the control of two recessive genes. Epistatic model indicated that additive effect was highly significant for rust intensity and coefficient of infection. Among non-additive effects, dominance × dominance was predominant. Complementary type of epistasis was operative in both cases.

Key words: *Triticum; Puccinia recondita;* genetics; rusts; disease resistance; genetic inheritance; rainfed farming; India.

وراثة مقاومة القمح الحقلية لصدأ الأوراق تحت الظروف البعلية

الملخص

أجريت دراسات حول توريث مقاومة القمح (*Triticum* spp.) الحقلية لصدأ الأوراق (*Puccinia recondita* Rob. ex Desm) وذلك بقياس نمط رد الفعل وحِدّة الإصابة بالصدأ، وحساب معامل الإصابة في ستة أجيال أساسية (P1، P2، F1، F2، BC1 و BC2) لهجين قمح WC44 ×WH283. وقد وُجد أن مورثتان متنحيتان تتحكمان في نمط رد الفعل المنخفض (المقاومة). وأشار نموذج التفوق إلى أن الأثر المتجمع كان كبيراً جداً بالنسبة لحدّة الإصابة بالصدأ ومعامل الإصابة. ومن بين التأثيرات غير التجميعية، كان سائداً الأثر السائد × السائد. وفي كلتا الحالتين كان هناك نمط مكمِّل فعّال من التفوق.

Introduction

Leaf rust of wheat is the most widely distributed of all cereal rusts (Samborski 1985). Use of wheat cultivars carrying field resistance has received greater attention than seedling resistance in the recent past (Simmons 1975). Field resistance refers to resistance that has been measured in field nurseries and does not imply that resistance is either general or specific (Knott 1982) but, at the same time, it usually confers protection from a wider spectrum of races than seedling resistance which is generally oligogenic. In simple terms, resistance can be regarded as oligogenic if segregating populations fall into clearly defined and easily recognizable categories by reaction type. But segregating populations from parents differing in resistance more often than not show a continuous range of reaction type and disease intensity under field conditions, and classification is often difficult. The present investigation was, therefore, undertaken to study the genetics of field resistance under rainfed conditions by examining reaction type and rust intensity and computing the coefficient of infection.

Material and Methods

The material for the present study comprised six basic generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of a wheat cross, WC 44 × WH 283. WC 44 (designated as P_1) is susceptible to leaf rust of wheat and belongs to an exotic accession of unknown origin, while WH 283 (designated as P_2) is a resistant and high-yielding variety of Indian origin recommended for cultivation in the North Western Plain Zone of the country. The material was grown in a randomized block design with three replications. Non-segregating generations (P_1, P_2 and F_1) were assigned two plots each, whereas segregating generations were assigned five plots in each replication. The plot comprised a single row 6 m in length spaced 23 cm apart. Plant-to-plant distance within rows was

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10 cm. To facilitate rust development, spreader rows planted around each replication were inoculated with a mixture of races of leaf rust of wheat. For recording observations on leaf rust, five competitive plants from each of the non-segregating generations, 15 from BC_1 and BC_2, and 100 from F_2 population were taken at random and observations recorded on flag leaf, according to Loegering (1959). The coefficient of infection was computed following Yadav (1985). Generation mean analysis was done as proposed by Hayman (1958).

Results and Discussion

Thirty F_1 plants were scored for leaf rust reaction types. All were found to be susceptible (Table 1). This indicated that low reaction type (resistance) was under the control of recessive gene(s). Three hundred F_2 plants were derived from 30 F_1 plants segregated for susceptibility and resistance to leaf rust in the field in the ratio of 173:127, respectively. A Chi-square test gave a good fit to 9:7 ratio, indicating that resistance was under the control of two recessive genes. Further evidence that two recessive genes conditioned resistance to leaf rust was indicated by BC_1 population carrying all susceptible plants and BC_2 population segregating for 32 susceptible and 13 resistant plants. The data of BC_2 population gave a good fit to 3:1 ratio, suggesting the control of two recessive genes for resistance. These results substantiate the findings of Williams and Miller (1982) and Singh et al. (1993). Conversely, Peusha et al. (1996) report monogenic control of leaf-rust resistance.

Table 1. Segregation pattern for leaf rust reaction in different generations.

Generation	Number of Plants				
	Susceptible	Resistant	Total	Ratio tested	χ^2
WC 44	30	0	30	-	-
WH 283	0	30	30	-	-
F_1	30	0	30	-	-
F_2	173	127	300	9:7	0.245
BC_1	45	0	45	-	-
BC_2	32	13	45	3:1	0.364

The data on rust intensity and coefficient of infection was subjected to arcsin transformation. Analysis of variance (Table 2), involving six generations for rust intensity and coefficient of infection, revealed highly significant differences among generations, indicating that sufficient genetic variability existed in the material under study. To determine gene effects, generation mean analysis was conducted and results are summarized in Table 3.

Table 2. Mean squares for original and transformed (arcsin) values of rust severity and coefficient of infection.

Source of variation	df	Mean squares			
		Rust severity		Coefficient of infection	
		Original	Arcsin	Original	Arcsin
Replication	2	3.93	2.15	0.35	6.50
Treatment	5	671.81*	349.90*	866.43*	589.18*
Error	10	6.61	2.56	5.83	13.97

* Significant at $P \leq 0.01$

Additive-dominance model was found to be inadequate. Epistatic model indicated that additive effects were highly significant for both rust intensity and coefficient of infection. Krupinsky and Sharp (1978) report similar results for yellow rust of wheat. There was a decrease in the value of additive effects due to transformation, but the level of significance did not change. Dominance effect was significant for coefficient of infection but not for rust intensity. Additive × additive component was not significant for any of the characters, whereas a substantial amount of additive × dominance and dominance × dominance effects indicated that epistasis played an important role in determining the inheritance of resistance.

Among the non-additive components, dominance × dominance effects accounted for the largest proportion of gene effects for both the characters. Bai and Knott (1994) report preponderance of the dominance component of variation. The signs of dominance and dominance × dominance components were similar in both cases suggesting that the complementary type of non-allelic interaction was important.

An increase in the additive effects in the epistatic model indicated that the additive effects were not free from interaction effects and their elimination changed the values considerably in each case. Predominance of additive effects and presence of complementary type of epistasis indicated that selection for increased manifestation of field resistance could be possible. In order to get transgressive segregants, break undesirable linkages and simultaneously exploit additive and non-additive gene effects, biparental mating among potentially desirable plants may be used in early segregating generations. Gill et al. (1974) and Redden and Jensen (1974) also suggest the adoption of biparental mating under similar situations.

Table 3. Estimates of genetic parameters for rust severity and coefficient of infection.

Character	Model	Parameter						χ^2	df
		(m)	(d)	(h)	(i)	(j)	(l)		
Rust severity	**3 parameters**								
(Original)		24.11	-18.68	8.58	-	-	-	64.99*	3
		±0.44	±0.46	±0.56		-	-	40.37*	3
(Arcsin)		27.11	-13.96	5.10					
		±0.30	±0.28	±0.66	-	-	-	163.88*	3
Coefficient of infection									
(Original)		21.77	-20.25	5.20	-	-	-	96.40*	3
		±0.40	±0.40	±0.85					
(Arcsin)		23.17	-16.28	11.64	-	-	-	96.40*	3
		±0.27	±0.28	±0.29					
Rust severity	**6 parameters**								
(Original)		24.53	-22.44	7.39	-1.69	-3.69	21.75	-	
		±1.69	±1.47	±7.38	±7.36	±1.54	±9.02		
		28.76	-16.40	5.57	-1.55	-2.75	12.28	-	
		±1.39	±0.69	±5.77	±5.72	±0.75	±6.38		
Coefficient of infection									
(Original)		20.17	-25.74	12.54	1.19	-5.15	29.18	-	
		±1.08	±1.28	±5.11	±5.02	±1.35	±6.98		
(Arcsin)		25.37	-0.43	-9.18	-1.48	-3.73	19.25	-	
		±0.77	±1.04	±3.73	±3.72	±1.08	±5.21		

* Significant at $P \leq 0.01$.

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Agronomic and Economic Characteristics of Improved Wheat Cultivars under Rainfed Conditions in the Southern West Bank

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Abstract

Five improved wheat cultivars and one local cultivar were planted under rainfed conditions at Al-Thahirya in the southern West Bank, Palestine. The research consisted of an experiment for the five improved cultivars, and demonstrations in the 1992/93 and 1993/94 growing seasons for all cultivars. The 1993/94 demonstration included an evaluation of the impact of fertilization (essential and top-dressing). The durum-wheat (*Triticum turgidum* subsp. *durum*) cultivars were 870, Breket and local, and the bread-wheat (*Triticum aestivum* subsp. *aestivum*) cultivars were Beth-Hashita, Attir and Shaffir. In the 1992/93 demonstration, Shaffir and Beth-Hashita gave the highest grain yield (303 kg/dunum). In the 1993/94 demonstration, the addition of fertilizer increased average grain yield by 18.4% for Breket and 121.2% for local. Straw yield increased by 15.9% for Breket and 94.6% for Shaffir. Attir gave the highest grain yield (264 kg/dunum)[1] and Shaffir the greatest straw yield (473 kg/dunum). In the experiment, Beth-Hashita produced the highest yields of both grain and straw (312 and 526 kg/dunum, respectively), though these yields were not significantly different from those of the other improved cultivars. Fertilized Shaffir gave the highest net revenue, US$ 51.70 per dunum. Fertilization resulted in increased net revenues for all cultivars, with the exception of Breket. The demonstrations showed that use of new cultivars with improved fertilization could improve the productivity of rainfed farming by as much as 198%, and increase profits by as much as US$ 50 per dunum.

Key words: *Triticum turgidum*; *Triticum aestivum*; testing; evaluation; varieties; agronomic characters; profit; rainfed farming; straw; grain; yields; fertilizer application; territories occupied by Israel.

[1] 1 dunum = 0.1 ha.

الصفات الزراعية والاقتصادية لأصناف قمح محسنة تحت الظروف البعلية في جنوبي الضفة الغربية

الملخص

زُرعت خمسة أصناف محسنة من القمح وصنف محلي تحت الظروف البعلية في الظاهيرية في جنوبي الضفة الغربية في فلسطين. وتألف البحث من تجربة للأصناف الخمسة المحسنة ومن حقول مشاهدة لجميع الأصناف خلال الموسمين الزراعيين 93/1992 و94/1993. وقد شملت حقول المشاهدة لموسم 94/1993 تقييماً لتأثير التسميد (سماد الأساس وسماد ما بعد الإنبات). وكانت أصناف القمح القاسي (*Triticum turgidum* subsp. *durum*) مكونة من 870، بركت، والمحلي، في حين كانت أصناف القمح الطري (*Triticum aestivum* subsp *aestivum*) مكونة من بيث-هاشيتا وعطير وشافير. وقد أعطى شافير وبيث-هاشيتا أعلى غلة حبية (303 كغ/الدونم) في حقول المشاهدة التي نُفِذت في موسم 93/1992. وزادت إضافة السماد في حقول المشاهدة التي نُفِذت في موسم 94/1993متوسط الغلة الحبية للصنف بركت بنسبة 18.4% وللصنف المحلي 121.2%. كما ازدادت غلة التبن بنسبة 15.9% للصنف بركت و94.6% للصنف شافير. وأعطى الصنف عطير أعلى غلة حبية (264 كغ/الدونم)، أما الصنف شافير فأعطى أكبر غلة من التبن (473 كغ/الدونم). وقد أعطى بيث-هاشيتا أعلى غلة من الحب والتبن (312 و526 كغ/الدونم على التوالي)، على الرغم من أن هذه الغلال لم تختلف كثيراً عن غلال الأصناف المحسنة الأخرى. وأعطى شافير المسمد أكبر عائد صافي، إذ بلغ 51.70 دولاراً أمريكياً لكل دونم. وقد أسفر التسميد عن زيادة الإيرادات الصافية لجميع الأصناف باستثناء الصنف بركت. وبينت حقول المشاهدة أن استخدام أصناف جديدة مع تسميد محسن قد يُحسن إنتاجية الزراعة البعلية بمقدار 198% ويزيد في الأرباح بمقدار 50 دولاراً أمريكياً لكل دونم.

Introduction

Rainfed agriculture accounts for around 95% of total cultivated land in the West Bank, and 45% in Gaza. Hence, improving this sector is extremely important for the development of the Occupied Palestinian Territories (OPT). The prevailing socioeconomic conditions under occupation have placed limitations on the development of both human and natural resources. Scientific applied research has also been constrained by these conditions. Wheat, one of the most important staple crops in Palestine, has been badly affected by these conditions. In the 1960s, the total area cultivated with wheat in the West Bank was 464,000 dunums, compared with 184,600 dunums in 1993 (ARIJ 1994; RRC 1985-90).

Wheat yields vary between districts due to differences in annual rainfall. Grain yield averages as much as 211 kg/dunum in Tulkarem in the northern West Bank, where rainfall is high, but just 82 kg/dunum in Hebron in the southern West Bank, where average rainfall is low, although the actual numbers fluctuate from year to year (ARIJ 1994). The annual consumption of wheat in the OPT is estimated at 240,000 tonnes, yet only 39,000 tonnes are produced locally (ARIJ 1994).

Improving all levels of production is important. The Applied Research Institute of Jerusalem (ARIJ) has taken a lead in this work, through introducing new cultivars of wheat and other field crops (among them sorghum and chickpea) and studying their adaptation to local climatic conditions; and also through investigating the effects of applying new technologies in agricultural practices, and studying the extent to which these new techniques and cultivars are acceptable to farmers.

In carrying out on-farm demonstrations and experiments with wheat, ARIJ hoped to achieve the following objectives:

- Evaluate the new wheat cultivars in an experiment and through demonstrations on farmers' fields.
- Study the effects of fertilizer application on different wheat cultivars in terms of agronomic and economic characteristics.

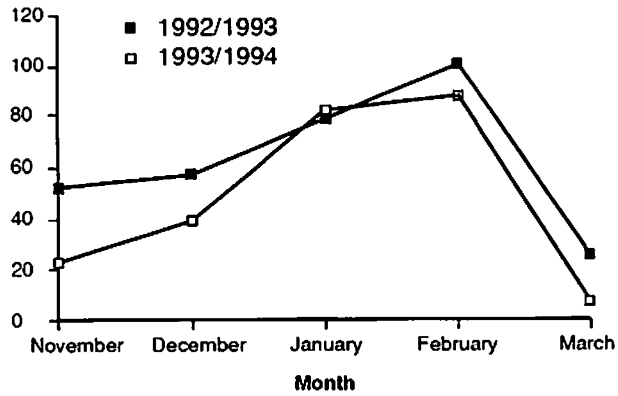

Fig. 1. Rainfall for the 1992/93 and 1993/94 growing seasons at Al-Thahirya.

Material and Methods

The research was conducted at Al-Thahirya to the south of Hebron, an area with average annual rainfall of 300-350 mm. The 1993/94 season was drought-affected, characterized by low, poorly distributed and late-starting rainfall. Also, *al-khamasin* winds (strong hot winds that signify the beginning of the hot season) prevailed during the period 11-22 April, leading to average maximum temperatures in the range of 23-32.6°C (Table 1). The total amount of rainfall in 1993/94 was 235.1 mm, while in the previous season, it had been 315 mm (Fig. 1).

Table 1. Rainfall and temperatures for 1993/94 growing season at Al-Thahirya.

Month	Rainfall (mm)	Avg temp (°C)	Average temperature (°C)		Extremes of temperature (°C)	
			Min	Max	Min	Max
October	0	20.4	16.3	24.5	14.0	28.0
November	23.0	13.2	9.8	16.6	2.0	21.0
December	39.5	12.0	9.5	14.9	1.0	19.0
January	82.0	8.5	5.5	11.5	7.0	18.5
February	87.4	8.0	5.0	11.0	2.5	18.0
March	7.2	10.3	7.7	12.9	2.2	20.6
April	0	17.5	14.5	20.4	4.0	32.6
May	0	20.0	15.5	20.4	9.0	32.2

There were two elements to the research: an experiment and demonstrations. The demonstrations were conducted on an area of 20 dunums, with the help of six farmers. Five improved and one local wheat cultivar were used. Each cultivar's area in the demonstrations was split into fertilized and unfertilized areas.

The experiment involved a randomized complete block design for the five improved cultivars, replicated four times. Each plot covered 45 m^2, the total experiment area (including borders) was 1260 m^2.

Agricultural practices were conducted in the same manner in both the demonstrations and the experiment, with two exceptions. Fertilizer was used throughout the experiment but only for half of the demonstration areas; and harvesting and threshing were carried out manually in the experiment but mechanically in the demonstrations. Land preparation was as follows:

Tillage: Primary tillage was conducted with a mold-board plow, used to 20-30 cm depth on 20 October 1993. Secondary tillage was performed with a duck's foot harrow, used to 10-15 cm depth on 22 October 1993. This broke up clods of dirt, creating a good seedbed.

Essential fertilization: Compound fertilizer (13-7-0) was broadcast at the rate of 50 kg/dunum (6.5 kg N/dunum and 3.5 kg P_2O_5/dunum).

Characteristics of planted cultivars: All improved cultivars were bought from Hazera'Seed Company and are as follows (Hazera' 1993):

1. Durum-wheat cvs 870 and Breket: resistant to rust diseases and lodging; flour is of sufficient quality for making pastries (Hazera' 1993).
2. Soft wheat cvs Beth-Hashita, Attir and Shaffir: flour is well-suited to bread-making (Hazera' 1993).
3. Local wheat cv Baladi or "local": obtained from the farmer; this wheat has durum-wheat characteristics but tends to be impure.

Sowing method: Seeds were sown with a driller at the rate of 10 kg/dunum on 1 December 1993.

Weed control: All research areas were sprayed with Albersuper (2,4-D) at the rate of 200 cm^3/dunum on 10 February 1994 (during tillering).

Top-dressing fertilizers: Ammonium sulfate (21% N) was broadcast at the rate of 20 kg/dunum (4.2 kg N/dunum) on 19 February 1994.

Harvesting: In the demonstrations, all cultivars were harvested on 24 May 1994, this being the day when the harvester was available. The experiment was harvested manually with a sickle at soil level. Total production was calculated for each of the planted areas.

Threshing: The demonstrations' harvested biomass yield was threshed, using a divider thresher, on 29 May 1994. The experiment's biomass yield was threshed by hand in order to minimize grain loss.

For the demonstrations, grain and straw yields were calculated for all cultivars, under fertilized and unfertilized conditions, while for the experiment, growth characteristic results were recorded as an average of five plants selected randomly in each plot. Productivity characteristics were assessed by taking an average of three square meters (3 × 1 m^2) randomly selected in each plot. A large number of productivity and growth characteristics were calculated for all cultivars.

Results and Discussion

Demonstrations

All yielded more grain and straw when fertilized. Grain yield increased between 18.4 and 121% over the non-fertilized plots, while straw yield increased between 15.9 and 94.6% (Table 2). Bread-wheat cultivars yielded 57% more grain and 70.2% more straw, while durum cultivars yielded 54.7% more grain and 43.9% more straw. The local wheat showed the highest potential for responding to fertilizer: grain yield increased 121% and straw yield 89.4% when fertilizer was applied.

When fertilized, bread-wheat cultivars yielded more grain than durum cultivars. Attir produced the most grain (264 kg/dunum), and Shaffir gave the highest straw yield (473 kg/dunum). For unfertilized plots, bread wheat yielded more grain, with the exception of Beth-Hashita, while the durum cultivars yielded more straw, with the exception of the local cultivar.

Grain productivity took the following order, with highest yield first: Attir, Shaffir, Beth-Hashita, 870, Breket and local. For straw yield the order was: Shaffir, Beth-Hashita, Attir, Breket, 870 and local. The local cultivar produced the lowest grain and straw yields in all treatments. Clearly, it needs to be replaced with improved, more productive ones.

Table 2. Planted area, production and productivity of wheat cultivars grown at Al-Thahirya, 1993/94.

Cultivar/ Treatment	Area (dunum)	Production (kg)		Productivity (kg/dunum)		% increase in productivity	
		Grain	Straw	Grain	Straw	Grain	Straw
Durum wheat							
870							
Fertilized	3.5	687	1088	202	320	24.7	26.0
Unfertilized	0.7	113	178	162	254		
Breket							
Fertilized	2.6	468	874	180	336	18.4	15.9
Unfertilized	1.0	152	290	152	290		
Local							
Fertilized	2.0	292	428	146	214	121.2	89.4
Unfertilized	0.7	46	79	66	113		
Bread wheat							
Attir							
Fertilized	1.8	475	655	264	364	53.5	48.6
Unfertilized	0.4	69	98	172	245		
Shaffir							
Fertilized	3.6	918	1703	255	473	39.3	94.6
Unfertilized	0.3	55	73	183	243		
Beth-Hashita							
Fertilized	2.6	585	1050	225	404	38.9	67.6
Unfertilized	0.9	146	217	162	241		
Total							
Fertilized	16.0	3425	5798				
Unfertilized	4.0	581	935				

Because of the dry conditions prevailing in 1993/94, the productivity of all cultivars was low compared with the previous season, with the exception of Attir. In 1992/93, the planted cultivars 870, Breket, Attir, Shaffir and Beth-Hashita gave grain yields of 215, 210, 250, 303 and 303 kg/dunum, respectively.

Experiment

The experiment aimed to evaluate the improved wheat cultivars and their potential under local climatic conditions. Means separation between the cultivars for all studied characteristics was done using Duncan's Multiple Range Test to a 5% accuracy level (Little and Hills 1978).

All cultivars were sown on 1 December 1993, and 50% emergence occurred within 27 days for all cultivars, compared with 15 days in the previous season. This difference was due to the late onset of rain during the 1993/94 growing season, and the consequent insufficient soil moisture for germination and emergence.

The low rainfall and high average temperatures had other repercussions, especially during the critical growth stages. The drought conditions reduced the plant growing period, and shortened the periods between emergence, tillering, heading, and physiological maturity. The period from emergence to heading lasted between 77 and 100 days, depending on cultivar. The period from emergence to physiological maturity was 125-137 days.

Bread-wheat cultivars reached the heading stage in 77 days and durum-wheat cultivars in 90 days, compared with 111 and 122 days, respectively, in 1992/93. Both planting seasons showed that durum-wheat cultivars have longer growth stages than bread-wheat cultivars (Table 3).

Table 3. Days from 50% emergence to 50% heading and physiological maturity, 1993/94.

Cultivar	Days from 50% emergence to	
	50% heading	physiological maturity
870	82	137
Breket	87	133
Local	100	135
Attir	72	130
Shaffir	81	130
Beth-Hashita	77	125

Data for various productivity characteristics is given in Table 4. Grain yield, straw yield, biomass, and harvest index of the bread-wheat cultivars were significantly higher than those of the durum-wheat cultivars. Beth-Hashita gave the highest grain yield (312 kg/dunum), although this was not significantly greater than the yields obtained from Attir and Shaffir. Beth-Hashita also yielded the most straw (526 kg/dunum), but this was not significantly above the yield obtained from other cultivars.

Durum cultivars were significantly taller than bread cultivars; 870 produced the tallest plants, averaging 91.6 cm. However, the local cultivar produced the tallest plants in the demonstrations, averaging 94 cm.

The bread-wheat cultivars produced more tillers than the durum cultivars, though the difference was not significant. Beth-Hashita produced the most: 5.9 tillers/plant.

Bread-wheat cultivars produced significantly more spikes/plant than durum-wheat cultivars, with the exception of Attir. Beth-Hashita produced the most, averaging 5.5 spikes/plant.

Peduncle length was 18.1 cm for Breket, the longest, and 12.1 cm for Beth-Hashita, the shortest. In the demonstrations, the local cultivar had the shortest peduncles, 3.6 cm. Comparing the improved cultivars with the local cultivar, peduncle length correlated positively with the period between heading and maturity. The local cultivar took longer to reach heading stage. *Al-khamasin* winds coincided with the heading stage resulting in sun scald, a retarded growth rate and a premature maturity stage only 35 days after the heading stage had been reached. This reflected negatively on all production characteristics.

Cultivar 870 had the longest spikes (19.6 cm) and Shaffir the largest number of spikelets/spike (20.4). Cultivar 870 also had the longest awns, with an average of 11.6 cm, but Breket's awns were not significantly shorter. The bread-wheat cultivars recorded shorter awns. Average awn length for the local cultivar was 7.4 cm.

The average number of normal grains/spikelet was significantly higher for bread cultivars than for durum cultivars. Attir had the most normal grains/spikelet, with an

Table 4. Productivity and growth characteristics of wheat cultivars at Al-Thahirya, 1993/94.

Characteristic	870	Breket	Beth-Hashita	Attir	Shaffir
Productivity (kg/dunum)					
Biomass	653 b †	653 b	838 a	800 a	819 a
Grain	214 b	203 b	312 a	299 a	294 a
Straw	439	450	526	501	525
Harvest index	0.49 b	0.40 c	0.51 a	0.90 a	0.56 a
Plant height (cm)	91.6 a	89.4 b	77.4 c	86.8 c	85.5 d
No. tillers/plant	3.4	3.7	5.9	4.6	5.6
Peduncle length (cm)	17.4 a	18.1 a	12.1 b	16.0 a	14.6 ab
No. spikes/plant	3.2 b	3.2 b	5.5 a	4.3 ab	5.4 a
Spike length (cm)	19.6 a	18.2 a	17.2 ab	15.1 bc	14.1 c
No. spikelets/spike	18.2 b	16.4 c	17.1 cb	17.7 cb	20.4 a
Awn length (cm)	11.6 a	10.9 a	5.1 b	4.6 b	4.4 b
No. *normal grains*/spikelet	2.7 b	2.6 b	3.2 a	3.4 a	3.1 a
No. unfertile florets/spikelet	2.0	2.1	2.0	1.9	1.9
No. grains/spike	44.9 ab	39.4 ab	44.8 ab	49.6 ab	53.5 a
1000-grain weight (g)	32	36	33	33	30

† Values in a row followed by the same letter(s) do not differ significantly at 5% level (Duncan's Multiple Range Test).

average of 3.4. There was no significant variation among cultivars in the number of infertile florets/spikelet, the average being 2.0.

Total normal grains/spike was highest (53.5) for Shaffir, though this was not significantly different from that of the other cultivars.

Breket produced the highest 1000-grain weight (36 g), which was not significantly different from that of the other cultivars. The season's drought conditions were directly reflected in the 1000-grain weight, which can be clearly seen when one compares the results of the previous season (1992/93): 870 with 47 g, Breket with 42 g, Beth-Hashita with 42 g, Shaffir with 41 g, and Attir with 37 g. In 1992/93, average 1000-grain weights were 10.5 g higher for durum-wheat cultivars and 8.0 g higher for bread-wheat cultivars than in 1993/94.

Differences between demonstration and experiment results

For all cultivars, the experiment resulted in higher grain and straw yields than the demonstration. For grain yield, the difference ranged between 12 kg/dunum for 870 and 87 kg/dunum for Shaffir. For straw yield, the difference ranged between 52 kg/dunum for Shaffir and 122 kg/dunum for Beth-Hashita (Table 5).

Experiment results surpassed demonstration results for the following reasons:

Land topography: The experiment area was level, while the demonstration lands were irregular, one being sloped and the other V-shaped.

Growth conditions: Based on the greener color of plants in the experiment, demonstration plants were more affected by *al-khamasin* winds, even though both were located in the same general area.

Harvesting: Harvesting of the experimental area was conducted at the soil-surface level, manually, with a sickle. The demonstration area was mechanically harvested, being cut more than 10 cm above the soil surface, although this varied with land topography.

Threshing: Plants harvested from the experiment were threshed by hand in the laboratory, while those from the demonstration were threshed mechanically.

Plants in the demonstration suffered from the following: sun scale, spike breakage and loss during harvesting (some cultivars, e.g., Beth-Hashita, were harvested late, beyond the maturity stage), straw loss due to mechanical harvest and threshing loss due to small grains being separated with the hay.

Financial analysis of the demonstration

The inputs of wheat production could be classified as materials, mechanization, labor, land rent and miscellaneous costs (e.g., transportation of fertilizers, seeds and straw, which are calculated as 8% of total input costs excluding rent). The costs of the various inputs are shown in Table 6. The calculations show that one dunum of fertilized wheat required inputs of US$ 75.30, while unfertilized wheat required US$ 59.50 per dunum.

Total revenue was calculated for each cultivar, fertilized and unfertilized, by adding the combined grain yield at wholesale prices to combined straw yield at wholesale prices. These were US$ 0.27/kg for durum-wheat grain, and US$ 0.22/kg for bread-wheat grain. One kilogram of straw was US$ 0.15. Net revenue was calculated by subtracting the grain total costs from total revenue.

Net revenues from fertilized bread-wheat cultivars were greater than from fertilized durum-wheat cultivars. With the exception of Breket, fertilized wheat gave greater net revenue than unfertilized wheat (Table 7).

Table 5. Comparative experiment and demonstration yields, 1993/94.

Cultivar	Grain productivity (kg/dunum)			Straw productivity (kg/dunum)		
	Experiment	Demonstration	Difference	Experiment	Demonstration	Difference
870	214	202	12	439	320	119
Breket	203	180	23	450	336	114
Attir	294	255	39	525	473	52
Shaffir	312	225	87	526	404	122
Beth-Hashita	299	264	35	501	364	137

Table 6. Financial input for fertilized and unfertilized wheat cultivars.

Financial input		Cost (US$ per dunum) Fertilized	Unfertilized
Materials:	grain	3.40	4.30
	pesticide (Alber-super)	1.80	1.80
	compound fertilizer	10.40	-
	top-dressing fertilizer	3.60	-
Total		19.20	6.10
Mechanization:	primary tillage	8.20	8.20
	secondary tillage	2.30	2.30
	harrowing	2.30	2.30
	seed driller	3.30	3.30
	pesticide application	1.60	1.60
	harvester	6.60	6.60
	thresher	7.90	7.90
Total		32.20	32.20
Labor:	compound fertilizer broadcasting	0.70	-
	top-dressing	0.70	-
	thresher workers	0.70	0.70
	bailing	3.30	3.30
	yield-filling	0.70	0.70
Total		6.10	4.70
Miscellaneous		4.60	3.30
Land rent		13.20	13.20
Total		75.30	59.50

Table 7. Total and net revenues for different wheat cultivars under different fertilizer treatments for the demonstration at Al-Thahirya, 1993/94.

Cultivar	Productivity (kg/dunum) Grain	Straw	Total revenue (US$/dunum)	Net revenue (US$/dunum)
Durum wheat				
870				
fertilized	202	320	102.50	27.20
unfertilized	162	254	81.80	22.30
Breket				
fertilized	180	336	99.00	23.70
unfertilized	152	290	84.50	25.00
Local				
fertilized	146	214	71.50	-3.80
unfertilized	65	112	34.40	-25.10
Bread wheat				
Attir				
fertilized	264	364	112.70	37.40
unfertilized	176	245	75.50	16.00
Shaffir				
fertilized	255	473	127.00	51.70
unfertilized	183	243	76.70	17.20
Beth-Hashita				
fertilized	225	404	110.00	34.70
unfertilized	162	241	71.80	12.30

Fertilized Shaffir gave the highest net revenue, US$ 51.70, while the unfertilized local cultivar gave the lowest net revenue, with a loss of US$ 25.10.

The net revenues of unfertilized durum-wheat cultivars (870 and Breket) were higher than those of bread-wheat cultivars. This showed bread wheat to be highly responsive to fertilization. The durum wheat was less responsive to fertilization, but better adapted to unfertilized cultivation.

Conclusions

The drought conditions in the 1993/94 growing season had an adverse effect on plant strength and the length of the growth period, compared with the 1992/93 season. Specifically, the following effects were evident from the research:

- *Al-khamasin* winds had a greater effect (negative) on fertilized than on unfertilized plots.
- Bread-wheat cultivars needed fewer days to reach different stages of growth, which made them more tolerant to dry conditions.
- The yields of fertilized wheat were greater than those of unfertilized wheat with differences of 49% in grain yield and 57% in straw yield.
- Fertilized bread-wheat cultivars surpassed fertilized durum-wheat cultivars in both grain and straw yield. When unfertilized, bread wheat surpassed the durum-wheat cultivars in grain yield, but not in straw yield.
- The grain yield of bread-wheat cultivars did not vary significantly in the demonstration. Attir gave the highest grain yield with 264 kg/dunum, and Shaffir gave the greatest straw yield of 473 kg/dunum.
- All cultivars yielded more grain and straw in the experiment than in the fertilized part of the demonstration. Beth-Hashita was the most productive, yielding 312 kg grain/dunum and 526 kg straw/dunum, followed by Attir, and finally Shaffir. The differences between these three cultivars were not significant either in grain or straw yields.

The total cost of production was US$ 75.30 per dunum for fertilized land, and US$ 59.50 per dunum for unfertilized land.

- Fertilized Shaffir produced the highest net revenue of US$ 51.70 per dunum. Of the unfertilized cultivars, Breket produced the highest net revenue, US$ 25.00 per dunum. All cultivars yielded higher net revenues under fertilization, with the exception of Breket.
- The local cultivar was the most affected by the dry conditions, yielding the least grain, straw and net revenue, and recording losses both with and without fertilization.
- The local cultivar, cultivated using commonly practiced methods in farmers' field, gave yields of 70-110 kg/dunum. This estimate is based on weights collected from farmers neighboring the demonstration and experiment.

A farmer from the previous season's experiment planted some land with Attir, using grains produced from the 1992/93 growing season, and fertilized it only with an essential treatment of animal manure. The grain yield was 210 kg/dunum, a result which encourages ARIJ to continue and expand its cooperative work with farmers in the OPT.

Recommendations

This experiment is worth repeating in the coming years. Emphasis should be on the effects of fertilizers. Studies should be expanded to different parts of the OPT, working with farmers in order to foster improvement of wheat production.

ARIJ hopes to reach farmers through coordination with both governmental and NGO extension agents. Workshops and field days will expose farmers to new agricultural practices and cultivars, and this could ultimately improve production and net revenue.

ARIJ also plans to establish cooperation with NGOs and with the national agricultural authority, so as to develop a national strategy for improving the agricultural sector.

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Effect of Leaf Rust Epidemics on the Yields of Bread Wheat in the Volga Region of Russia

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تأثير الإصابة الوبائية بصدأ الأوراق في غلة القمح الطري في منطقة فولغا بروسيا

Abstract

Average bread wheat (*Triticum aestivum* L. subsp. *aestivum*) yields in the Volga Region of Russia are affected by periodic drought and by leaf-rust epidemics and powdery mildew in non-drought years. By combining genes for disease resistance from local wild wheat and related cultivars with germplasm of local bread-wheat Saratov cultivars resistant to heat and drought, three pairs of near isogenic lines were developed. The performance of the most productive line, L 503, was observed over four years, 1990–93. During the severe drought of 1991, the yield from L 503 was 2.3% higher than that of its non-resistant analogue S 58. During conditions of leaf-rust epidemics in 1990 and 1993, the yield was 50% higher. Genes for disease resistance can be combined with germplasm from local heat and drought-resistant bread-wheat strains to produce new, higher yielding cultivars for local conditions.

Key words: *Triticum aestivum*; rusts; epidemics; disease resistance; drought resistance; genetic improvement; yields; Russian Federation.

الملخص

يتأثر متوسط غلة القمح الطري (*Triticum aestivum* L.subsp. *aestivum*) في منطقة فولغا بروسيا بفترات جفاف دورية، كما يتأثر بالإصابة الوبائية لصدأ الأوراق والبياض الدقيقي في السنوات التي لاتحدث فيها فترات جفاف. وبواسطة دمج مورثات مقاومة للأمراض مأخوذة من قمح بري محلي وأصناف متعلقة به، في أصول وراثية لأصناف محلية من القمح الطري في ساراتوف مقاومة للحرارة والجفاف، تم استنباط ثلاثة أزواج من سلالات موحدة الصفات الوراثية تقريباً. وقد لوحظت كفاءة أفضل السلالات إنتاجاً، وهي L 503، على مدى أربع سنوات، من 1990-93. وخلال الجفاف الشديد الذي حدث في 1991، كانت غلة L 503 أعلى بنسبة 2.3٪ من غلة شبيهتها السلالة غير المقاومة S 58، كما كانت أعلى بنسبة 50٪ خلال ظروف الإصابة الوبائية بصدأ الأوراق في 1990 و 1993. وهكذا يمكن ضم مورثات مقاومة للمرض في أصول وراثية من سلالات محلية من القمح الطري مقاومة للحرارة والجفاف بغية إنتاج أصناف جديدة أوفر غلة وملائمة للظروف المحلية.

Introduction

Long-term observations in the Volga Region revealed that when drought years alternate with moisture years, severe epidemics of leaf rust and other leaf diseases occur. These two factors of abiotic and biotic stress significantly reduce wheat yield. Thus, the union of resistance to drought and diseases in one cultivar is an urgent problem.

In Russia, Saratov bread wheat cultivars are the most heat and drought resistant, but a majority of them are not resistant to leaf rust. Plant breeding for resistance to *Puccinia recondita* is limited to a few highly effective resistant genes (Lr). In the Volga Region, only Lr 9, Lr 19 and Lr 24 are highly effective against local leaf rust populations. New bread wheat cultivars need to be developed that contain a combination of resistance genes to drought and leaf rust.

Material and Methods

The Laboratory of Genetics and Cytology at the Agricultural Research Institute for the South-East Regions has developed such cultivars by transferring effective genes resistant to leaf rust and other diseases into selected local bread wheat cultivars. Genes resistant to leaf rust and powdery mildew were derived from a number of species of wild wheat. *Triticum monococcum*, *T. sinskajae*, *T. dicoccum*, *T. persicum*, *T. timopheevii*, as well as *Aegilops speltoides*, *Ae. auscheri*, *Agropyron intermedium* and *Ag. elongatum* were initially selected. Disease-resistant genes were transferred from *T. dicoccum*, *T. persicum* and local strains of *Ag. intermedium* to produce the new cultivars.

Results and Discussion

In 1990 and 1993, years of severe leaf rust epidemic conditions, the lines of bread wheat carrying Lr genes from wild relatives showed substantial advantage over susceptible cultivars (Table 1) with increased grain yields of 32–52%. For a more objective evaluation of the effect of Lr genes under leaf-rust epidemic conditions, three pairs of near-isogenic lines carrying Lr genes were studied.

In the first pair of near isogenic lines, AS 29, an analogue of cultivar Saratovskaya 29 (S 29) carried the resistant gene Lr 14, derived from *T. dicoccum*. This gene currently has only a residual effect that slows plant leaf rusting.

Under leaf-rust epidemic conditions, the yield of AS 29 was significantly lower than the yields from the other lines but significantly higher than that of its non-resistant analogue S 29.

In the second and third pairs of isogenic lines, 359 and 400, the resistant analogues, carrying different combinations of Lr genes, produced higher yields than their analogue and the non-resistant cultivar S 29 (Table 2).

The increase in Lr genes of the resistant cultivars in years with leaf-rust epidemics increased total yields over a number of years. A comparison of the yields of the resistant cultivar L 503—carrying the Lr gene from *Ag. elongatum* (Lr 19) and the standard cultivar Saratovskaya 58 (S 58) for 1990 to 1993—is shown in Table 3.

In the years with severe leaf rust epidemics, 1990 and 1993, the grain yield of L 503 was 52–56% higher than that of S 58. In the drought years—1992 and especially 1991—the grain yield of L 503 was not significantly higher than that of S 58. Over four years, the grain yield average of L 503 was 24.8% higher than that of S 58.

Development of bread-wheat cultivars from the germplasm of local drought-resistant cultivars and disease-resistant genes from wild wheat and related species can increase yields in areas of periodic drought and leaf-disease epidemics, such as the Volga Region of Russia.

Table 1. The effect of resistance to leaf rust on the yield of bread-wheat cultivars and lines during disease epidemics.

Cultivars / lines	Rust reaction	Lr genes	Source of Lr genes	Yield (t/ha) 1990	1993	Average	Yield increase over standard (%)
S 58†	S	–	–	2.56	2.81	2.69	–
L 503	R	Lr 19	*Ae. elongatum*	3.98	4.27	4.12	53
		Lr 14a	*T. dicoccum*				
L 244	R	Lr Ag[i]	*Ag. intermedium*	3.62	3.70	3.66	36
L 513	R	Lr 19	*Ag. elongatum*	4.07	4.10	4.08	152
		Lr Ag[i]	*Ag. intermedium*				
L 21	R	Lr 9	*Ae. umbellulata*	3.34	3.75	3.55	32
		Lr 19	*Ag. elongatum*				

† Standard.
S = Susceptible; R = Resistant.

Table 2. Effect of leaf-rust epidemics on yields of near-isogenic bread-wheat lines tested in Saratov, Russia, 1993.

Near-isogenic line	Rust reaction	Lr genes	Disease severity (%)	Yield (t/ha)	Yield loss (%)
AS 29	R	14a	30	3.100 b†	0
S 29	S	–	90	2.288 a	35
359	R	13, 14, 19	0	4.381 d	0
359	S	–	90	3.291 c	33
400	R	13, 23	0	4.305 d	0
400	S	–	90	3.365 c	28

R = Resistant; S = Susceptible.
† Values followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's Multiple Range Test.

Table 3. Grain yield (t/ha) of bread-wheat cultivars, 1990–93.

Cultivar	Rust reaction	Year				Average
		1990†	1991‡	1992	1993†	
S 58§	S	2.56	1.68	3.00	2.81	2.61
L 503	R	4.00	1.72	3.05	4.27	3.26
Increase in yield of L 503 to S 58						
t/ha		1.44	0.04	0.05	1.46	065
%		56.1	2.3	1.4	51.8	24.8

S = Susceptible; R = Resistant.
† Severe leaf-rust epidemic.
‡ Severe drought.
§ Standard.

Field and Laboratory Screening of Barley Genotypes for Aphid Resistance in Egypt

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Abstract

Breeding lines and cultivars of barley (*Hordeum vulgare* L. subsp. *vulgare*) were evaluated for their levels of sensitivity to aphid infestation under laboratory and field conditions in Egypt. In the 1992/93 season, laboratory screening of 80 barley genotypes revealed 9 resistant and 8 moderately resistant entries to the corn leaf aphid *Rhopalosiphum maidis*. Resistance determination was based on the average daily reproduction rate of the female aphids. Field screening of 80 genotypes in two localities revealed the existence of 5 entries in Mallawi and 15 in Giza that harbored the lowest aphid population (0-25 aphids per plant) and the least percentage of infested plants per plot. In the 1993/94 season, laboratory screening revealed 2 resistant and 4 moderately resistant genotypes to *R. maidis* out of 60 entries. Field screening of the same 60 genotypes grown at Giza Research Station revealed 4 entries resistant to aphid

غربلة طرز وراثية للشعير لمقاومة المنّ في الحقل والمختبر في مصر

الملخص

تم تقييم سلالات وأصناف تربية من الشعير (*Hordeum vulgare* L. subsp. *vulgare*) من حيث مستوى حساسيتها للإصابة بالمنّ تحت الظروف المخبرية والحقلية في مصر. ففي موسم 93/1992، كشفت الغربلة المخبرية لـ 80 طرازاً وراثياً للشعير عن 9 مدخلات مقاومة و8 متوسطة المقاومة لمنّ أوراق الذرة *Rhopalosiphum maidis*. وقد تم تحديد المقاومة على أساس متوسط معدل التكاثر اليومي لإناث المنّ. كما أظهرت الغربلة الحقلية لـ 80 طرازاً وراثياً في موقعين أن 5 مدخلات في مالاوي و15 في الجيزة قد أوت أدنى مجموعة من المنّ (0-25 حشرة منّ على كل نبات)، كما اتسمت بأقل نسبة مئوية من النباتات المصابة في كل قطعة تجريبية. وفي موسم 94/1993، كشفت الغربلة المخبرية عن طرازين وراثيين مقاومين و4 طرز وراثية متوسطة المقاومة لـ *R. maidis* من أصل 60 مدخلاً. وبينت الغربلة الحقلية لنفس الطرز الوراثية المزروعة في محطة بحوث الجيزة أن 4 مدخلات كانت مقاومة لتفشي المنّ. كذلك بينت الغربلة الحقلية لـ 80 طرازاً وراثياً للشعير (نفس مجموعة 93/1992) زُرعت في محطة بحوث مالاوي للموسم الثاني، أن 8 مدخلات كانت مقاومة. وكانت 5 من هذه المدخلات مقاومة أيضاً في الموسم السابق سواء في الجيزة أو في مالاوي.

buildup. Field screening of 80 barley genotypes (the 1992/93 group) grown at Mallawi Research Station for the second season revealed 8 resistant entries. Five of these were also resistant in the previous season either at Giza or at Mallawi.

Key words: *Hordeum vulgare*; *Aphidoidea*; *Rhopalosiphum maidis*; genotypes; testing; pest resistance; Egypt.

Introduction

In the Middle Egypt, barley fields are more liable to aphid attack than adjacent wheat (*Triticum* spp.) fields (Bishara 1987). The dominant aphid species are *Rhopalosiphum padi*, *R. maidis* and, to a lesser extent, *Schizaphis graminum* and *Sitobion avenae* (El-Hariry 1979; Tantawi 1985). In the "Barley Belt" of the northwestern coast of Egypt, however, survey studies revealed that *R. maidis* was the dominant species of aphids (Noaman et al. 1992).

Breeding for resistance to aphids has been one of the main components in the barley program in Egypt since 1988. The present work included field and laboratory screening of barley genotypes aimed at finding sources of resistance to aphids. Painter (1951) emphasized the importance of plant resistance to insects as a major factor which should be incorporated in any breeding program for main crops.

Material and Methods

Laboratory screening

Barley breeding lines were tested in the laboratory for estimating their levels of sensitivity to infestation with the corn leaf aphid *R. maidis*. A colony of *R. maidis* was raised in the laboratory in the 1992/93 and 1993/94 seasons on local barley cv Giza 121, grown in 12 cm plastic pots, under near-constant conditions of temperature (22 ± 2°C), relative humidity (65 ± 5%) and illumination (14/10 h light/dark cycle).

The tested barley genotypes were grown in groups of five seedlings per pot, with four replicates for each entry in each season. In 1992/93, 80 entries were tested, and in 1993/94, another 60 were tested. Three days after seedling emergence, five viviparous female aphids were introduced into each pot (one female per seedling). Pots were then covered by a lantern glass with muslin top for confining the aphids and their progeny to each pot. Six days after initial infestation, the number of aphids per pot was counted. Resistance was determined as the average daily reproductive rate of the female aphids, not exceeding one nymph per female per day, i.e., up to 30 aphids (five females over six days). Barley genotypes harboring 30-40 aphids were considered moderately resistant.

Field screening

The 1992/93 barley breeding materials (80 genotypes) were tested at Giza Research Station in the 1992/93 season for their levels of resistance to aphid infestation. At Mallawi Research Station, the same barley material was evaluated in the 1992/93 season and re-evaluated in 1993/94 for confirmation of the previous year's results.

The 1993/94 breeding material (60 genotypes) was also evaluated in the field at Giza Research Station in 1993/94.

Two criteria for evaluation were used:

(a) level or rate of infestation (RI) of plants with aphids was scored on a 1-5 scale:
1 = 0-25 aphids/plant; 2 = 26-50; 3 = 51-100; 4 = 101-500; and 5 = more than 500; and
(b) percentage of infested plants per plot.

Barley genotypes harboring the fewest aphids (score 1) and lowest percentage of infested plants per plot were considered resistant.

Field observations were recorded in February and March during peak aphid activity, which coincides with very sensitive stages of plant growth.

Results and Discussion

Laboratory screening

The maximum number of aphids and their progeny produced by 5 females in 6 days was 127 aphids in case of the breeding line M64-76/bon/jo/york/3/M5/Galt//As46/4/Hj34-80/Astrix/5/CN 12/ CI. The average daily reproduction rate was 4.23 individuals/female/day.

The genotypes, allowing for a reproduction rate of up to one aphid per female per day, i.e., 30 individuals/5 females/6 days, were considered as promising sources of resistance. Using this criterion, 9 entries were resistant and 8 moderately resistant (Table 1).

Table 1. Laboratory-screened barley genotypes for resistance to *R. maidis* aphids (80 genotypes, 1992/93).

Entry no.	Name/pedigree or source	No. of aphids/5 females/6 days
	Resistant genotypes:	
71	6F5 Sakha/NWC 91/92	18.50
74	DL 541	20.75
36	Coala's/Apm/IB65//11012-2/3/Api/CM67//DS/Pro/4/Jet/Cp ICB84-0655-4AP-0AP-13APH-OAP	21.75
45	Arar/386540 ICB 84-1739-OAP-3 APH-PAP	24.50
72	L 91/10	25.75
77	L 91/8	26.00
73	L 91/9	29.25
12	80-5013/5/Cr-115/Pro//Bc/3/Api/CM67/4/Giza 20 ICB 88-1696-OAP	29.25
43	CEN/Bg lo'S' ICB 84-0548-IAB-OAP-IIAPH-OAP	29.50
	Moderately resistant genotypes:	
44	N-Acc-4000-301-80-/IFB 974 ICB 84-1423-4-AP-OAP-17APH-OAP	32.00
42	Deir Alla 106//APi/EB 89-8-2-15-4/3/Chzo's'/Prn. ICB 84-0163-6AP-OAP-20 APH-PAP	35.25
33	Lignee 527/NK 1272 ICB 84-0323-8 AP-OAP-14 AP-PTR	36.25
4	Giza 126	36.50
53	WI 2269/Lignee 131 ICB 83-0800-5- AP-OAP	37.25
28	Arar//com.cr.29/C6 ICB 85-1594-5 AP-2 AP-OAP	38.25
29	Arar/PI 386540 ICB 84-1739-11 AP-2-OAP-OAP	38.50
41	Deir Alla 106//APi/EB 89-8-2-15-4/3/Chzo's	35.50

Out of 60 barley genotypes (the 1993/94 breeding material), only two entries exhibited resistance to buildup of *R. maidis* aphids, and 4 entries were moderately resistant (Table 2). Four of these genotypes are landraces (LBEG).

It is worth noting that the newly released, drought-tolerant barley cv Giza 126, adapted to rainfed areas in Egypt, is moderately resistant to aphids (Tables 1 and 2). Among the 1993/94 group (Table 2) entries no. 16, 19, 13, and 25 are early maturing, while no. 18 is very early maturing. Entries no. 16, 4, and 25 are drought tolerant, and nos. 16 and 25 are high yielding.

Table 2. Resistance levels of 60 barley genotypes to *R. maidis*, 1993/94 group (laboratory screening).

Entry no.	Name/pedigree	No. aphids/ 5 females/ 6 days
	Resistant genotypes	
16	116132 89023-20 51 LBEG 92/93	22.75
18	116134 89032-18 75 LBEG 92/93	24.50
	Moderately resistant genotypes	
19	116134 89032-21 79 LBEG 92/93	32.00
13	116131 89013-44 39 LBEG 92/93	35.25
4	Giza 126	38.50
25	Arar/Lignee 527 ICB 85-0626-6 AP-OAP-18 APH-OAP	40.00

Field screening

The dominant aphid species on barley in the experimental plots at Giza and Mallawy in the 1992/93 season was *R. maidis* since the previous crop in the two areas was maize.

(a) Giza Research Station

Aphid infestation of barley was very low in the spring of 1993 in Giza. The rate of infestation (RI) among the 80 tested barley genotypes ranged between 1 and 2 on a 1-5 scale. Aphids were always clustering at the basal part of the flag leaf at low density infestations.

On the other hand, the percentage of plants harboring aphids per plot ranged between 1 and 80%. There were 15 barley entries which scored 1 (RI) and exhibited the lowest percentage of infested plants per plot (1%) (Table 3). Four of these entries (no. 36, 41, 42 and 74) were also resistant in laboratory tests (Table 1).

Table 3. Field-screened barley genotypes showing lowest infestation rate (R.I. = 1) and the least percentage of infested plants per plot (=1%), Giza locality (92/93).

Entry no.	Name/pedigree
24	Nopas's/4/Makner/Aths//CI 14122/3/ Ager//Api/CM 67 ICB 87-1509-OAP
25	Coala's'/Attki CYB-3996-AP-IAP-OAP
26	Aths/Lignee 686 ICB 82-0979-5 AP-OAP-OAP-12 AP-OTR
27	Aths/Lignee 686 ICB 82-0979-5 AP-OAP-24 AP-OTR
34	Arar//1762/BC-2L-2Y ICB 83-0687-7AP-OTR-OAP-IAP-OTR
36	Coala's'/Apm/IB 65//11012-2/3/Api/CM 6'/ //Ds/Pro/4/Jet/CP OCB 84-0655-4AP-OAP-13 APH-OAP
37	Arar//2762/BC-2L-2Y ICB 83-0687-7 AP-OTR-OAP-1 AP-1APH-OAP
38	Mari/Aths* 2/M-Att-73-337-1 CYB-3574-CAP
39	Baca's'/3/AC 253//CI 08887/CI 25761 ICB 84-0674 OAP-15 AP-1 APH-OAP
40	Baca's'/3/AC 253//CI 25761 ICB 84-0674 OAP-18 AP-1 APH-OAP
41	Deir Alla 106//Api/EB 89-8-2-15-4/3/chzo's'/Prn ICB 84-0163-6 AP-OAP-16 APH-OAP
42	Deir Alla 106//Api/EB 89-8-2-15-4/3/chzo's'/Prn ICB 84-0163-6- AP-OAP-20 APH-OAP
48	Aths/Lignee 686 ICB 82-0979-5 AP-OAPO-OAP-5 AP-OTR
74	DL 541
76	L 91/7

The fact that some entries were not attacked by aphids in the field does not necessarily mean that they are resistant, because at such low aphid population, many barley genotypes may escape infestation.

(b) Mallawi Research Station (Middle Egypt)

Aphid infestation of barley in this locality is normally high, but in the 1992/93 season it was comparatively lower than the previous seasons. However, screening was successful as the rate of infestation of plants ranged between score 1 and 3.

Honeydew was slight on plants where the rate of infestation was 2, but abundant in score 3. The percentage of infested plants per plot ranged between 20 and 80%. There were 5 genotypes that scored 1 (RI) and had the lowest percentage of infested plants per plot (20B30%) (Table 4).

Laboratory and field screening sometimes gave similar results. Entry no. 74 was resistant in the laboratory and under field conditions at Giza and Mallawi. Entry no. 36, which was resistant in the laboratory, exhibited the same character under Giza field conditions.

Table 4. Field-screening genotypes showing lowest infestation rate (R.I.=1) and the least percentage of infested plants per plot (20-30%), Mallawi locality (92/93).

Entry no.	Name/pedigree
56	Baca's'/3/Ac 253//CI//08887/CI 05761 ICB 84-0674-OAP-22 AP-1APH-OAP
70	CI 7273
74	DL 541
79	W2291/WI 2269
80	Giza 123

In the 1993/94 season, infestation of barley at Giza was generally moderate to high. RI ranged between 1 and 4, and the percentage of infested plants per plot varied between 20 and 90%. The dominant aphid species was *R. maidis*, most probably because the previous crop was maize.

Evaluation carried out at Giza Research Station of the 60 barley genotypes (1993/94 breeding material) for their levels of resistance to aphids revealed 4 resistant and 5 moderately resistant genoty(Table 5). The results in Tables 2 and 5 indicate that laboratory screening was confirmed by field evaluation in Giza.

In Mallawi region, aphid infestation of barley was moderate in the spring of 1994, and the aphid species present were *R. padi*, *R. maidis* and *S. graminum*.

Evaluation of the 80 barley genotypes (1992/93 breeding material) for their levels of sensitivity to aphid buildup was conducted at Mallawi Research Station in 1993/94 for the second consecutive season. Field observations revealed the existence of 8 highly resistant genotypes which were free from aphids (Table 6).

It is worth noting that entries no. 26, 27, 48, 56, and 74 proved resistant in the previous season both at Giza and Mallawi.

The present laboratory screening technique has several advantages: (a) accuracy in evaluating aphid reproduction on each genotype through standardization of the initial infestation rate (5 female aphids per 5 seedlings, i.e., one female per seedling) as the unit of testing for a limited period of six days to avoid overcrowding of aphids and wilting of the host plant on which they feed, and (b) rapid screening of hundreds of genotypes all year round in the laboratory which can be controlled at favorable temperature, relative humidity and light conditions.

Table 5. Rate of infestation with aphids (R.I.) and percentage of infested barley plants per plot (93/94 material) at Giza.

Entry no.	Name/pedigree	R.I.	%
	Resistant		
4	Giza 126	I	20
16	116132 89023-20 51 LBEG 92/93	I	20
18	116134 89032-18 78 LBEG 92/92	I	20
19	116134 89032-21 79 LBEG 92/93	I	20
	Moderately Resistant		
13	116131 89013-44 39 92/93	I	30
17	116134 89032-16 76 LBEG 92/93	I	30
25	Arar/Lignee 527 ICB 85-0625-6 AP-OAP-18 APH-OAP	I	30
26	Haram-02//11012-2/Mzq/3/Arar/4/ Harma-02//11012-2/Mzq/3/ Lingee 527 ICB 85-1152-2 AP-4AP-OTR-2AP-OTR-OAP	I	30
52	WI 2197/CI 1354//Arar	I	30

Table 6. Barley genotypes resistant to aphids under field conditions at Mallawi (92/93 breeding material) in the spring of 1994.

Entry no.	Name/pedigree
15	Deir Alla 106/Cel/3/Bco. Mr/Mzq//Apm/5106 ICB 83-0215-4 Ao-OTR-OAP
26	Aths/Lignee 686 ICB 82-0979-5 AP-OAP-OAP-12 AP-OTR
27	Aths/Lignee 686 ICB 82-0979-5 AP-OAP-24 AP-OTR
33	Lignee 527/NK 1272 ICB 84-0323-8 AP-OAP-14 AP-OTR
48	Aths/Lignee 686 ICB 52-0979-AP-OAP-OAP-5 AP-OTR
54	Early Arar/PI 386540-1739-2 AP-OAP ICB 84-1739-2 AP-3 APH-AP
56	Baca's'/s/AC 253//CI0761 ICB 84-0674-OAP-22 AP-1 APH-OAP
74	DL 541

Another method of screening cereals for aphid resistance (Starks and Burton 1977) is more suitable for the greenbug (*Schizaphis graminum*), in which unknown numbers of aphids are left to crawl freely from source plants to the test seedlings, grown in rows inside flat trays left uncovered, and no count of aphids is recorded; only damage rating. For this reason, this technique was not adopted in the present studies.

Several researchers have studied screening of barley genotypes for aphid resistance. Hormchong and Wood (1963) suggest that the gene pair responsible for *Schizaphis graminum* resistance in barley is apparently different from the pair that impacts resistance to *R. maidis*. Webster and Starks (1984) report that greater resistance in an R-strain of barley to *S. graminum* occurred when antibiosis, non-preference and tolerance were considered together.

Resistance to aphids in barley has been attributed to physical factors, e.g., thickness of schlerenchyma cells and number of vascular bundles (El-Serwiy et al. 1985) or surface wax on the leaves (Tsumuki et al. 1987), or to the chemical composition of the leaves. Todd et al. (1971) conclude that resistance of barley genotypes to *S. graminum* might be due to the presence of phenolic and flavonoid compounds in the leaves, while Juneja et al. (1972) identify benzyl alcohol as a possible cause of resistance.

Another chemical causing resistance to cereal aphids in barley is gramine in the leaves (Salas 1991). For this reason, biochemical investigations seem essential in the future plan of work in order to identify resistance factors in the breeding material available.

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Productivity and Quality of Spring Bread Wheat Differing in Photoperiodic Sensitivity

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Abstract

By introducing the dominant *Ppd* alleles into the genetic background of Saratov bread-wheat (*Triticum aestivum* subsp. *aestivum*) cultivars with early heading, heading was shortened by 2.5-6.4 days with no significant influence on yield or quality. This shows that this method could be used in wheat breeding for early maturity.

اختلاف إنتاجية قمح طري ربيعي وجودته في الحساسية للفترة الضوئية

الملخص

تم تقصير فترة الإسبال 2.5-6.4 من اليوم بإدخال المورثات القرينة السائدة Ppd في الخلفية الوراثية لأصناف ساراتوف من القمح الطري (*Triticum aestivum* Subsp. *aestivum*) المتسمة بالإسبال المبكر، بدون تأثير معنوي في الغلة أو الجودة، مما يبين إمكانية استخدام هذه الطريقة في تربية القمح للحصول على صفة الباكورية.

Key words: *Triticum aestivum*; spring crops; productivity; quality; yields; photoperiodicity; Russian Federation.

Introduction

The majority of spring bread-wheat cultivars in the Volga Region of Russia are day-length sensitive, since they do not carry dominant *Ppd* alleles (Krupnov et al. 1988). The influence of *Ppd* alleles on ear emergence is prominent; the effects of these genes is about 25%. Thus, by introduction of *Ppd* alleles into the genetic background of spring bread wheat, it is possible to breed early maturing cultivars.

Under drought conditions, which occur rapidly in the Volga Region, the grains of medium- and late-maturing cultivars shrivel and yields are decreased (Kuzmina 1972). Therefore, it is important to study the productivity and quality of Saratov spring bread-wheat cultivars and their *Ppd* analogues, which differ in their sensitivity to day length, heading and maturity.

Material and Methods

The donor of the *Ppd* alleles was Mexican spring bread-wheat cultivar Sonora 64, which carries two or three *Ppd* genes (McIntosh 1975). Over a number of years, the following cultivars and their *Ppd* analogues were examined:

Saratovskaya 29 (S 29) and S 29 PI[1] = S 29 × 6/Sonora 64
Saratovskaya 42 (S 42) and S 42 PI = S 42 × 6/Sonora 64
Saratovskaya 55 (S 55) and S 55 PI = S 55 × 6/Sonora 64
Saratovskaya 56 (S 56) and S 56 PI = S 56 × 6/Sonora 64

The photoperiod-insensitive analogues (PI analogues) were developed at the Laboratory of Genetics and Cytology of the Agricultural Research Institute for South-East Regions in Russia. These analogues each carry two or three *Ppd* genes from Sonora 64 and are earlier maturing than their recipient cultivars. This collection of cultivars and their PI analogues was studied during 1986-1990 in the field using a randomized complete block design with three or six replications. Plots size was seven 7-m rows with 0.15 m row spacing. A standard seeding rate of approximately 400 plants/m^2 was used. Sixteen vegetative and yield traits, bread-making qualities and physical traits of dough were measured every year.

[1] PI = photoperiodic insensitivity

Results and Discussion

During the study period, there were periodic years of drought and high rainfall; 1988 was a dry year and 1990 a wet year, while 1986 and 1987 were intermediate.

The study of the vegetation period of the cultivars and their PI analogues showed that the PI analogues were earlier heading than their cultivar recipients. On average, days to heading within the five-year study period were reduced by 2.5-6.4 days, and in some years (e.g., 1990) by 9.5 days (Table 1). Grain-filling period of the PI analogues was not different from the cultivar recipients, even slightly longer. The number of spikes/m^2 was not significantly different between the cultivars and their PI analogues, except for lines S 29 PI (nos. 939 and 942), which had significantly more spikes/m^2 than S 29. In spite of the significant reduction of days to heading of the PI analogues compared to the cultivar recipients, the majority of PI analogues had the same productivity, thousand-kernel weight and test weight as the cultivars.

During four years of the study, the PI analogues were not significantly different in flour yield from the cultivars, except S 29 PI (Table 2). Regarding gluten content, there were no significant differences between the cultivars and their PI analogues. Similarly, for strength of gluten, the PI analogues were not significantly different from the cultivars, except S 55 PI. Thus, the majority of the PI analogues satisfy the requirements for hard wheats, and appear as good fillers.

Studying the physical traits of the dough (farinographical analysis) of the cultivars and their PI analogues as an average of four years (1986-1988 and 1990) revealed that there were no significant differences between the PI analogues and their parent cultivars in water absorption, formation and resistance of the dough (Table 3). However, the dilution of the dough and the valorimeter number of the *Ppd* analogues were slightly lower than those of the cultivar recipients.

Loaf volume and porosity number of the cultivars and their *Ppd* analogues were not different, except for S 55 PI (no. 954), which was less than S 55. However, the majority of *Ppd* analogues were close to the parent cultivars, and thus satisfy the requirements for hard wheats.

By introducing the dominant *Ppd* alleles into their genetic background, Saratov bread-wheat cultivars were early heading. Shortening of days to heading by 2.5-6.4 days without affecting their yield and quality reveals the validity of this method in wheat breeding for early maturity.

Table 1. Vegetation period, grain yield and yield components of cultivars and their *Ppd* analogues, 1986-1990.

Cultivar/line	Line no.	Vegetation period (days)		No.	1000-kernel	Test weight	Grain yield
		Heading‡	Grain-filling	spikes/m^2	weight (g)	(g/L)	(t/ha)
S 29	938	45.2 i-i†	39.5	369.7 a-a	34.50	772.4	2.07
S 29 PI	939	41.1 f-f	40.4	398.1 c-c	33.35	770.7	2.38
S 29 PI	942	40.5 d-f	40.6	398.1 b-c	33.83	773.2	2.23
S 55	953	44.3 h-i	39.8	371.5 a-b	34.88	774.0	2.36
S 55 PI	954	37.9 a-a	40.7	359.1 a-a	35.15	768.5	2.13
S 55 PI	956	38.5 a-b	40.3	369.8 a-a	35.96	768.4	2.27
S 42	945	42.8 g-g	39.2	357.1 a-a	34.67	779.2	2.15
S 42 PI	946	39.5 b-e	41.3	364.2 a-a	34.46	773.3	2.07
S 42 PI	947	40.4 c-f	41.5	359.8 a-a	35.47	787.2	2.11
S 56	961	40.6 e-f	40.1	362.3 a-a	36.21	781.0	2.34
S 56 PI	962	38.1 a-a	40.1	362.1 a-a	35.39	779.2	2.35
S 56 PI	965	37.8 a-a	41.3	379.1 a-c	36.23	779.1	2.47

† Means in a column followed by the same letter(s) are not significantly different at $P = 0.05$.
‡ Number of days from planting to emergence of at least 50% of the main culms.

Table 2. Bread-making qualities of cultivars and their *Ppd* analogues, average of four years (1986-1988 and 1990).

Cultivar/line	Line no.	Flour yield (%)	Gluten values		Bread-making quality	
			Content (%)	Strength (IGD-1)‡	Loaf volume (cm^3)	Porosity (number)
S 29	938	60.2 b-b†	37.3	73.5 a-b	867.0	4.6 c-d
S 29 PI	939	51.7 a-a	37.7	78.4 a-c	846.0	4.4b-d
S 29 PI	942	60.2 b-b	34.7	79.4 a-d	776.0	4.2 a-d
S 55	953	61.2 b-b	34.6	71.2 a-a	850.0	4.7 d-d
S 55 PI	954	60.9 b-b	37.8	84.7 c-e	795.0	4.0 a-c
S 55 PI	956	62.4 b-b	36.6	81.4 b-c	786.2	4.5 c-d
S 42	945	62.0 b-b	36.0	84.4 c-e	731.2	3.6 a-a
S 42 PI	946	61.2 b-b	34.6	87.6 d-e	710.0	3.6 a-a
S 42 PI	947	62.4 b-b	34.6	84.4 c-e	760.0	4.0 a-c
S 56	961	63.1 b-b	37.3	83.9 c-e	803.7	4.6 c-d
S 56 PI	962	61.7 b-b	35.8	89.2 e-e	777.5	4.1 a-d
S 56 PI	965	62.3 b-b	36.1	83.6 e-e	775.0	4.2 a-d

† Means in a column followed by the same letter(s) are not significantly different at $P = 0.05$.
‡ IGD-1= Index of gluten deformation.

Table 3. Physical traits of the dough of cultivars and their *Ppd* analogues, average of four years (1986-98 and 1990).

Cultivar/line	Line no.	Physical trait of dough (farinograph)				
		Water absorption (%)	Formation (min)	Resistance (min)	Dilution (un. ph.)[1]	Valorimeter no. (un. v.)[2]
S 29	938	70.8 e-e†	5.7	5.7	55.6 a-a	60.6 c-c
S 29 PI	939	70.6 c-e	5.3	5.3	65.0 a-b	57.9 b-c
S 29 PI	942	70.3 a-e	5.6	5.6	73.7 a-d	57.8 b-c
S 55	953	70.4 b-e	6.0	6.4	65.6 a-b	60.2 c-c
S 55 PI	954	71.2 e-e	5.0	5.0	83.1 a-d	56.4 b-c
S 55 PI	956	70.1 a-e	5.8	5.9	58.7 a-b	60.9 c-c
S 42	945	70.7 d-e	4.4	4.4	103.7 d-d	53.0 c-c
S 42 PI	946	68.9 a-a	3.6	3.6	101.2 c-d	41.7 a-a
S 42 PI	947	8.8 a-a	4.3	4.3	90.0 b-d	52.0 a-b
S 56	961	69.8 a-e	5.9	5.9	64.4 a-b	60.5 c-c
S 56 PI	962	69.1 a-c	5.4	5.3	66.2 a-b	58.5 b-c
S 56 PI	965	69.1 a-b	5.5	5.7	70.6 a-c	59.5 b-c

† Means in a column followed by the same letter(s) are not significantly different at $P = 0.05$.
1 Units of farinograph apparatus.
2 Units of valorimeter apparatus.

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Effect of Salinity Stress on the Accumulation and Distribution of Proline in Wheat

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Abstract

Two wheat cultivars, Akbar and Barkat, were grown in solution culture for 28 days with five different concentrations of NaCl to determine the effect of salinity on the accumulation of proline. Salinity caused a 2.3- and 3-fold increase in proline level in the root and shoot, respectively, of Akbar. Similarly, a dramatic nine-fold increase in proline level in the root and a two-fold

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تأثير إجهاد الملوحة في تراكم وتوزع البرولين في القمح

الملخص

زرع صنفان من القمح وهما أكبر وبركات، في مُستنبت محلول مكون من خمسة تراكيز مختلفة من NaCl لمدة 28 يوماً، وذلك لتحديد تأثير الملوحة في تراكم البرولين. وقد سببت الملوحة زيادة قدرها 2.3 – 3 أضعاف في مستوى البرولين في جذور وفروع الصنف أكبر على التوالي. وعلى نحو مماثل، لوحظ في الصنف بركات زيادة مذهلة قدرها تسعة أضعاف في مستوى البرولين في الجذور وضعفان في الفروع في أعقاب معاملة الملوحة. وانطلاقاً من هذه النتائج يُظن أن البرولين المُنتج في الأوراق يُنقل إلى الجذور مما يساعد نبات القمح على تنظيم الجُهد الإسموزي لخلايا الجذور تحت الملوحة.

increase in the shoot were observed in Barkat following salinity treatment. In view of these results, it is speculated that proline produced in the leaf is transported to the root, thereby helping the wheat plant to regulate the osmotic potential of root cells under salinity.

Key words: wheats; salinity; proline; osmotic stress; salt tolerance; stems; roots; leaves; Bangladesh.

Introduction

Proline is an indicator of stress damage (Hansen and Tully 1979). Barnett and Naylor (1966) observed an increase in proline level in Bermuda grass following salt stress. By raising osmotic potential in a culture medium, an increase in proline concentration was observed by Treichel (1975) in *Aster trifolium*. Osmotic potential increased in *Aster trifolium* when NaCl was added to the culture medium. Stewart and Lee (1974) also observed an increase in proline level with increase in NaCl concentration. Palfi and Juhasz (1970) recorded an increase in proline accumulation in leaves of *Capsicum annuum* L. by increasing salt concentration of irrigated water. Chu et al. (1976) observed a rapid accumulation of proline when barley plants were subjected to salinity level with osmotic potential greater than -5.7 atmosphere. The increase in proline content due to NaCl stress was reported in many plants such as barley (Yasseen et al. 1987), mustard (Shadded and Zidan 1989), sunflower and mung bean (Shaha and Gupta 1993). It was observed that the increase in free-proline concentration is strongly related to the concentration of Na+ and K+ in the plant sap (Treichel 1975), and thus proline might be involved in the process of osmotic adjustment.

Wheat has been introduced as a second cereal crop in Bangladesh. Efforts are being made to bring a large area in the country, currently uncultivable because of salinity, under cultivation by introducing salinity-tolerant crops, among them wheat.

In the present study, proline content in the root and shoot of the two cultivars Akbar and Barkat, both high-yielding and recently released cultivars, was measured for finding the relationship between proline level and salinity tolerance of the two cultivars.

Material and Methods

Akbar and Barkat were used as plant material. The plants were grown for 28 days in half-strength Hoagland solution (Hoagland and Arnon 1950) containing 25, 50, 100 and 150 mM NaCl. These were used as control. Proline was extracted from dried powdered plant material in 4 ml of 90% alcohol. The aliquot was then centrifuged at 4500 and the clear solution containing proline was separated and evaporated to dryness and diluted to 2 ml with distilled water. Proline content was measured in a 0.5 ml sample of extract by the Troll and Lindsley method (Troll and Lindsley 1955).

Results and Discussion

Accumulation of proline decreased by 25% in the roots of Akbar and Barkat under the 25 mM NaCl treatment (Figs 1 and 2). Proline accumulation increased 2.3-fold in the roots of Akbar at 50 mM NaCl, and by 15% in the roots of Barkat. A 3- to 9-fold increase in proline level was observed under the 100 mM NaCl treatment (Fig. 1). In Barkat, the accumulation of proline in the roots increased by 23% and 2.6-fold under the 100 and 150 mM NaCl treatments, respectively (Fig. 2).

At 25 mM NaCl stress, proline content in the shoot increased by 42 and 46% in Akbar and Barkat, respectively (Figs 1 and 2). Similarly, at 50 mM NaCl, the proline level increased by 84% in Akbar and 18% in Barkat. Both the 100 and 150 mM NaCl treatments caused a dramatic 3-fold increase in proline level in the shoot of Akbar (Fig. 1). Salinity caused an 18 and 89% increase in proline content in the shoot of Barkat at 100 and 150 mM NaCl, respectively (Fig. 2).

Salinity caused a dramatic increase in proline level in the root and shoot of both Akbar and Barkat (Figs 1 and 2). These results agree with those obtained by Shaha and Gupta (1993) who found that proline content increased in sunflower and mung bean under NaCl stress. Kishore et al. (1986) found an increase in proline level except for an initial decrease in leaves of grape vines. Our result is also supported by the work of Chu et al. (1976) who found that salinity caused an increase in proline content in barley. Furthermore, salinity-induced increase in proline level was also reported in *Brassica juncea* (Jain et al. 1991), *Hordeum vulgare* (Yasseen et al. 1987; Pesci and Beffagna 1986), *Capsicum annuum* (Palfi and Juhasz 1970), rice (Dubey and Rani 1989) and in Bermuda grass (Barnett and Naylor 1966).

Yasseen et al. (1989) observed that proline accumulates in the endosperm and radicals with increase in NaCl concentration in the external medium. Proline concentration in barley consistently increased with increase in salinity by conversion of some amino acids to proline.

The concentration of proline in the shoot of Akbar and Barkat were higher than that in the root under salinity (Figs 1 and 2). This result shows that proline synthesized in the shoot under salinity and was transported to the root, which played a vital role in maintaining osmotic potential of the root cells.

Proline acts as an endogenous osmotic regulant (Stewart and Lee 1974). Accumulation of proline under salinity stress in the roots and shoot of wheat may be attributed to an increase in abscisic acid because salinity is known to increase both ABA and proline level. For example, abscisic acid level was found to be increased by salinity stress (Kefu et al. 1991; Mizrahi et al. 1970). Similarly, proline level was found to be stimulated by salinity stress (Chu et al. 1976, Kishore et al. 1986). Stewart and Larher (1980) report an accumulation of proline level when barley plants were treated with ABA. Similarly, an increase in abscisic acid-induced proline accumulation under salinity stress was observed in barley (Pesci and Beffagna 1986). Huber (1974) observes that proline content was in the seedlings of *Pennisetum typhoides* when treated with NaCl and ABA.

Therefore, it is suggested that the observed stimulatory effect of salinity on accumulation of proline in Akbar and Barkat cultivars (Figs 1 and 2) is positively corrected with salinity-induced increase in abscisic acid level.

Na Cl salinity stress increased proline level in both root and shoot of wheat (Figs 1 and 2). The stimulation of proline accumulation under salinity plays a favorable role in maintaining osmotic potential of cells and thus alleviates the salinity tolerance of plants.

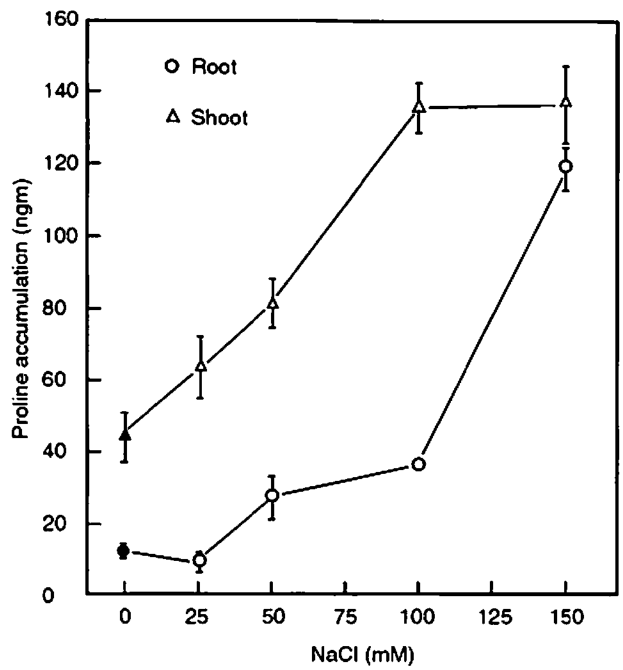

Fig. 1. Effect of salinity on accumulation of proline in the root and shoot of 28-day-old intact plants of wheat cv Akbar. Solid symbols represent the control. Bars represent standard error. Each value is a mean of four replicates.

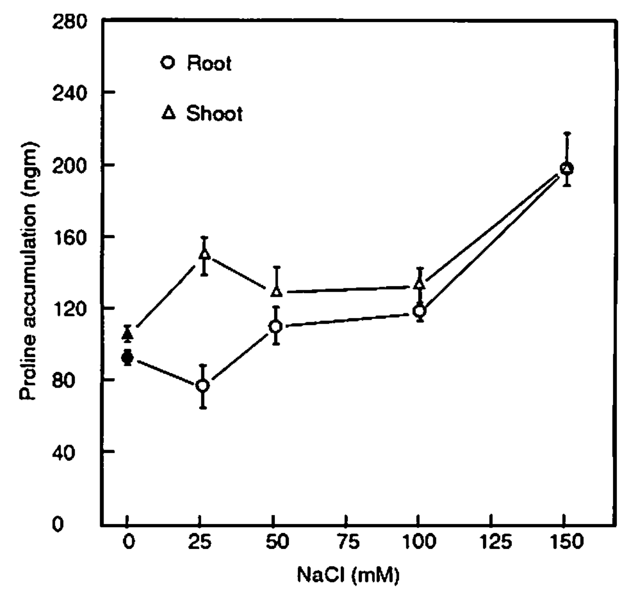

Fig. 2. Effect of salinity on accumulation of proline in the root and shoot of 28-day-old intact plants of wheat cv Barkat.. Solid symbols represent the control. Bars represent standard error. Each value is a mean of four replicates.

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Performance of Durum-Wheat Genotypes in Northern Sudan

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أداء طرز وراثية من القمح القاسي في شمالي السودان

الملخص

تم تقييم طرز وراثية مدخلة من القمح القاسي (*Triticum turgidum* L.subsp *durum*) من حيث الغلة الحبية والصفات المرتبطة بها في الهضيبة في شمالي السودان. وقد تراوحت الغلة الحبية للطرز المختبرة من 0.7 إلى 4 طن/هـ، علماً أن الكثير من الطرز الوراثية أعطت غلة أفضل بنسبة 6-30٪ من الشاهد (1.7-2.9 طن/هـ)، وبلغ عدد الأيام حتى الإسبال في هذه الطرز مابين 45-80 يوماً، في حين بلغ عدد الأيام حتى النضج مابين 81-113 يوماً وهو أمر يتوقف على الموسم. وأعطت الطرز الوراثية ذات فترة النضج المتوسطة غلة حبية أفضل من تلك الطرز المبكرة والمتأخرة. وتباينت إلى حد كبير مقدرة الطرز الوراثية على الإشطاء (260-590 سنبلة/م^2)، إلا أن التباين كان أقل بين الطرز الوراثية في طول النبات (58-91 سم). وكان المدى بين البذور/السنبلة ووزن الـ 1000 حبة 24-43 و 32-56غ على التوالي، مع وجود الكثير من الطرز الوراثية المتفوقة في وزن البذور على الشاهد (36-41غ). لذلك قد يكون انتخاب طرز وراثية من القمح القاسي تتسم بفترة نضج متوسطة ومقدرة عالية على الإشطاء وعدد كبير من البذور/السنبلة فضلاً عن الغلة البذرية ذاتها، أمراً فعّالاً تحت الظروف السائدة في شمالي السودان.

Abstract

Introduced durum wheat (*Triticum turgidum* L. subsp. *durum*) genotypes were evaluated for grain yield and related characters at Hudeiba, northern Sudan. Grain yield of the tested genotypes ranged from 0.7 to 4 t/ha, with many genotypes showing 6-30 % better yields than the check (1.7–2.9 t/ha). Heading of the genotypes was within 45–80 days, while maturity was within 81–113 days, depending on season. The genotypes with medium maturity gave better grain yield than the early and late genotypes. Tillering capacity of the genotypes varied greatly (260–590 spikes/m^2), but there was less variation among the genotypes in plant height (58–91 cm). Seeds/spike and 1000-kernel weight ranges were 24-43 and 32–56 g, respectively, with many genotypes with larger seed weight than the check (36–41g). Thus, selection of durum-wheat genotypes with medium maturity, high tillering capacity and large number of seeds/spike, besides seed yield itself, could be effective under northern Sudan conditions.

Key words: *Triticum turgidum*; introduced varieties; genotypes; crop performance; grain; yields; heading; tillering; seed size; maturity; Sudan.

Introduction

Durum wheat is a potential crop in Sudan. Correlation studies in durum wheat show positive association of seed yield with plant height, tillers/plant, seeds/pike, 1000-kernel weight and biological yield (Belay et al 1993, Nachit and Jarrah 1986). Amin et al. (1992) indicate the importance of grains/spike and harvest index for ultimate yield improvement in durum wheat. Belay et al. (1993) conclude that besides seed yield itself, plant height and 1000-kernel weight may be considered good indirect selection criteria under their study conditions.

This paper discusses the performance of introduced durum-wheat genotypes under northern Sudan conditions.

Material and Methods

Durum-wheat genotypes received from the CIMMYT/ICARDA program in the 1992/93, 1993/94 and 1994/95 seasons were grown at Hudeiba (17° N, 34° E) in northern Sudan, and compared with the bread-wheat check Wadi El Neil. A randomized complete block design with two replicates was used. The plot size was 2.5 × 1.8 m with a net harvested area of 3 m^2. Planting, on flat plots, was by hand-drilling seeds in rows 30 cm apart using a seed rate of 130 kg/ha. Sowing was during the third week of November in each season. Nitrogen fertilizer was added at the rate of 86 kg N/ha, applied as urea in two equal doses on the second irrigation and at heading. Irrigation was applied at 2-week intervals till maturity. Weed control was by hand-weeding once. Aphids were controlled by spraying with Ekatin once. Characters studied were days to heading, days to maturity, plant height, grain yield and yield components. Mean minimum and maximum temperatures and relative humidity during the growing season are given in Table 1.

Table 1. Metrological data during the 1992/93 and 1994/95 growing seasons at Hudeiba.

Month	1992/93			1993/94			1994/95		
	Min.	Max.	R.H.	Min.	Max.	R.H.	Min.	Max.	R.H.
October	24	40	40	25	40	37	25	40	35
November	19	34	41	22	36	50	19	31	35
December	13	29	48	17	33	51	14	29	47
January	13	29	43	16	32	53	15	31	51
February	12	30	40	14	31	53	14	30	44
March	18	36	25	15	34	28	18	37	31
April	22	40	29	23	41	21	21	40	21

Min.: Mean minimum temperature (°C).
Max.: Mean maximum temperature (°C).
R.H.: Relative humidity (%) at 0600 h.

Results and Discussion

The performance of the genotypes in each season are presented in Tables 2, 3 and 4. There were significant differences among the genotypes for all the studied characters.

1992/93 season

In this season, grain yields of the tested genotypes were in the range of 1.9–3.9 t/ha, with Mrb15/Ru(1) being the best (Table 2) . Many of the genotypes were significantly higher than the check (2.9 t/ha) in grain yield, with a yield advantage of 10–30%. The genotypes reached heading within 57–80 days and maturity within 97–113 days, with the earliest genotype being Stojocri-3 and the latest Awalbit-6 and Aw12/bit (1). The variation in plant height between the genotypes ranged between 76 and 91 cm, which was not high. None of the lines were better than the check (Wadi El Neil) in tillering with a range of 378–574 spikes/m^2. High variation existed among the genotypes in seeds/spike (24–47), the best genotype being Awalbit-6, which was the latest in maturity. Most of the lines had more seed weight than the check (Wadi El Neil); durum wheat has mostly bolder seeds than bread wheat (35–47g/1000 seeds). Stojocri-5 was the best genotype in seed weight (Table 2)

1993/94 season

The season was relatively warmer than the previous season and this adversely affected the performance of the tested genotypes (Tables 1 and 3). Grain yield ranged from 0.7 to 2.9 t/ha, with Omruf-2 being the best genotype (Table 3). In addition to Omruf-2, the genotypes Somo/Auk (1) and Qfn/kill outyielded the check (Wadi El Neil), with yield advantages of 32, 16 and 6%, respectively. The warm weather accelerated the development of the genotypes, with heading reached within 45–64 days and maturity within 81–103 days. The genotypes with higher yield were of medium maturity (Table 3). Similar results were observed in a study on bread-wheat genotypes (Sheikh Mohamed 1993). Plant height was in the range 58–73 cm. Tillering capacity was the most affected by growing-season conditions, and ranged between 260 and 403 spikes/m^2, with only one genotype (Omrabi-6) exceeding the check Wadi El Neil. The number of seeds/spike was low (23–37), while seed weight was higher (39–56 g/1000 seeds). Genotype Lagost-2 had the largest seed number and seed weight (Table 3).

1994/95 season

All the tested genotypes this season were better than the bread-wheat check (Wadi El Neil), with grain yields of 1.7–3 t/ha and grain-yield advantages of 6–75%. The genotype with the highest grain yield was Omruf-1 (Table 4). The genotypes reached heading within 49–64 days and maturity within 88–101 days, with Stork being the earliest and Omrabi-5 the latest. Plant height ranged from 62 to 83 cm. None of the lines were better than the check in tillering capacity with a range of 330–590 spikes/m^2. The number of seeds/spike ranged from 24 to 43, and seed weight ranged from 32 to 48 g/1000 seeds (Table 4).

Conclusion

In general, the medium-maturity genotypes gave good yield than the early or late genotypes, mainly under the adverse conditions of the 1993/94 season. Therefore, selection of durum-wheat genotypes with medium maturity, high tillering capacity and large number of seeds/spike, besides seed yield itself, could be effective under northern Sudan conditions.

Acknowledgment

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Table 2. Performance of durum-wheat genotypes during the 1992/93 season.

Name/cross	Grain yield (kg/ha)	Days to heading	Days to maturity	Plant height (cm)	Spikes/ m^2	Seeds/ spike	1000-seed weight (g)
Strok	2492	63	104	77	540	36	38
Belikh-2	2217	72	109	84	467	34	38
Awalbit-6	2925	80	113	91	415	47	35
Omrabi-3	2538	72	109	88	507	38	42
Stojocri-3	3067	57	97	76	392	30	43
Stojocri-5	2980	71	104	83	497	34	47
Aw12/Bit (1)	1920	80	112	86	363	35	36
Omrabi-5	2922	72	108	89	484	31	43
Genil-1	2527	69	106	88	472	43	40
Omrabi-6	2717	67	107	91	470	30	40
Mrb15/Ru (1)	3873	67	107	88	449	44	36
Waha Cham-1	2840	64	97	76	460	33	40
Awl 2/Bit (2)	2743	63	101	84	475	34	41
Mrb15/Ru (2)	2863	71	106	86	430	41	40
Waddalmez-2	3387	62	103	89	510	24	41
Stk/-//-/Cit 71	3233	69	107	88	482	27	47
Stojocri-6	3717	75	108	90	455	31	45
Stojocri-7	2712	71	105	85	398	31	44
Gd.512/Dw 15023(1)	3442	66	104	86	457	38	40
Korifla	2720	59	100	80	465	35	42
Heider//Mt/Ho	2580	74	107	87	487	31	43
Genil-4	3253	63	104	84	502	33	41
Gd.512/Dw 15023(2)	3055	66	103	83	478	28	42
Wadi El Neil (check)	2917	63	107	88	574	34	37
Mean	2920	68	105	85	468	34	41
S.E.±	313	2	2	2	38	4	2
C.V. %	15	4	3	4	12	18	8
Significance	*	**	**	**	*	*	*

*, ** Significant differences among the lines at *P*=0.5 and *P*=0.01, respectively.

Table 3. Performance of durum-wheat genotypes during the 1992/93 season.

Name/cross	Grain yield (kg/ha)	Days to heading	Days to maturity	Plant height (cm)	Spikes/ m^2	Seeds/ spike	1000-seed weight (g)
Strok	942	54	86	59	277	28	46
Genil-3	1492	58	92	71	330	29	47
Genil-5	1400	53	87	63	223	26	45
Genil-4	1840	54	89	65	243	31	49
Genil-6	768	54	103	73	323	28	49
Lagost-2	1712	58	95	65	283	37	56
Lagost-3	1230	57	93	61	273	30	50
Omrabi-5	703	63	102	69	377	29	46
Omrabi-6	1438	64	92	66	403	32	43
Massara-1	1670	64	100	65	260	28	46
Heider//Mt/Ho	1863	60	94	62	293	25	45
Waha Cham-1	1868	52	85	58	307	29	41
Omruf-2	2873	60	96	62	343	38	39
Omruf-3	1605	55	89	61	303	34	40
Omruf-4	865	55	86	62	303	24	48
Stojocri-3	920	45	81	62	290	23	48
Wadelmez-6	1422	55	86	58	267	26	42
Balloran	1503	54	89	64	303	27	41
Qfn/kill	2312	57	90	64	333	35	43
Korifla	1318	52	89	63	297	28	46
Som/-//-/Auk(1)	2540	64	92	63	373	37	41
Som/-//-/Auk(2)	1730	67	102	69	350	30	41
Stn/-//-/Altar 84	1973	64	98	68	330	35	47
Wadi El Neil (check)	2182	59	96	68	400	28	41
Mean	1590	58	93	65	312	30	45
S.E. ±	333	1	2	2	38	2	3
C.V. %	30	3	4	5	17	12	9
Significance	*	**	**	**	*	*	*

*, ** Significant differences among the lines at P=0.5 and P=0.01, respectively

Table 4. Performance of durum-wheat genotypes during the 1994/95 season.

Name/cross	Grain yield (kg/ha)	Days to heading	Days to maturity	Plant height (cm)	Spikes/ m^2	Seeds/ spike	1000-seed weight (g)
Strok	1950	49	88	65	390	28	41
Omruf-2	2300	60	95	74	470	43	41
Lagost-2	2112	56	83	73	390	36	46
Lagost-3	2233	57	95	71	370	35	44
Stojocri-7	2155	64	97	75	330	34	42
Sebah	2476	60	96	71	350	40	41
Omrabi-6	1974	63	100	80	410	38	34
Omrabi-5	1837	64	101	83	437	41	35
Zeina-1	2094	55	93	73	480	37	44
Zeina-2	1996	56	94	72	400	33	42
Zeina-3	1999	57	96	72	407	36	32
Waha Cham-1	1921	51	88	62	413	33	44
Gercan	2347	56	94	79	380	34	39
Gersabil-2	1774	57	95	70	403	24	43
Gerboy	1790	58	95	73	420	42	41
Moulsabil-2	2392	54	93	64	403	33	43
Gerbrach-2	2172	60	95	75	413	42	43
Omruf-1	2959	59	96	74	423	36	34
Gerbrant	2216	57	94	74	447	37	39
Korifla	1949	51	89	69	423	34	48
Zeina-4	2707	57	94	76	403	34	40
Heican-2	2289	57	93	72	443	33	42
Boy/-//-/PI33055	2832	57	93	71	540	31	40
Wadi El Neil (check)	1683	59	100	80	590	38	36
Mean	2173	57	94	73	423	36	41
S.E.±	333	1	1	3	37	4	3
C.V. %	27	4	3	6	15	19	14
Significance	*	**	**	**	**		

*, ** Significant differences among the lines at *P*=0.5 and *P*=0.01, respectively

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Genetic Advances in Grain Yield of Durum Wheat under Low-rainfall Conditions

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Abstract

The seven most widely-adopted varieties of durum wheat (*Triticum turgidum* L. subps. *durum* (Desf.) Husn.), released in Tunisia between 1960 and 1993, were evaluated for genetic gains in terms of grain yield and related characters in the semi-arid areas. They were grown for three seasons, 1993/94, 1995/96 and 1996/97, on plots laid out in a randomized complete block design with three replications, and data recorded for the following characters: number of grains/spike, number of spikes/m^2, plant height, vegetative period, days to maturity, plant biomass, thousand-kernel weight, and grain yield. Grain yields were found significantly and positively correlated with number of grains/spike and number of spikes/m^2, and negatively correlated with vegetative period. But they were indirectly affected by plant height and days to heading through their significant and positive correation with vegetative periods. Thus, the number of grains/spike, the number of spikes/m^2, the length of the vegetative period, plant height and days to heading were the major contributors to durum grain yield in the semi-arid regions. But regression analysis showed that as newer varieties were released in Tunisia, grain yields did not rise significantly in the semi-arid regions as they had in the sub-humid regions. The absence of significant gains in grain yield was reckoned to be because of lack of significant gains in terms of number of spikes/m^2, plant height, and days to heading. Thus, the newer varieties did not outperform the older varieties for these characters in the semi-arid regions, indicating that they are not well-adapted to water-stress conditions.

Key words: *Triticum durum*; genetic gain; grain; yields; rain; semiarid zones; Tunisia.

التقدم الوراثي في الغلة الحبية للقمح القاسي تحت الظروف المتدنية الأمطار

الملخص

تم تقييم الأصناف السبعة من القمح القاسي (*Triticum turgidum* L. subps. *durum* (Desf.) Husn.) الأكثر تبنياً على نطاق واسع والمعتمدة في تونس بين 1960-1993، بهدف تحديد المكاسب الوراثية من حيث الغلة الحبية والصفات المتعلقة بها في المناطق شبه القاحلة. وقد زرعت لثلاثة مواسم، 94/1993، 96/1995، 97/1996، في قطع تجريبية مخططة في تصميم للقطاعات العشوائية الكاملة بثلاثة مكررات، وتم تسجيل البيانات المتعلقة بالصفات التالية: عدد الحبات/السنبلة، عدد السنابل/م^2، طول النبات، الفترة الخضرية، عدد الأيام حتى النضج، الكتلة الحيوية النباتية، وزن الألف حبة، والغلة الحبية. ووُجد أن الغلة الحبية ترتبط معنوياً وإيجابياً بعدد الحبات/ السنبلة وعدد السنابل/م^2، كما ترتبط سلبياً بالفترة الخضرية، إلا أنها تتأثر بشكل غير مباشر بطول النبات وعدد الأيام حتى الإسبال وذلك من خلال ارتباطهما المعنوي والإيجابي بالفترات الخضرية. لذلك يعتبر عدد الحبات/السنبلة، عدد السنابل/م^2، طول الفترة الخضرية، طول النبات وعدد الأيام حتى الإسبال، مساهمات رئيسية في الغلة الحبية للقمح القاسي في المناطق شبه القاحلة. إلا أن التحليل الانحداري قد أظهر أنه مع توزع أصناف جديدة في تونس، لم ترتفع الغلة الحبية بشكل كبير في المناطق شبه القاحلة كما حدث في المناطق الرطبة. ويُفسَر غياب مكاسب كبيرة في الغلة الحبية علىأنه نتيجة لنقص المكاسب الكبيرة في عدد السنابل/م^2، طول النبات، وعدد الأيام حتى الإسبال. لذلك لم تستطع الأصناف الجديدة أن تتفوق على الأصناف القديمة في هذه الصفات في المناطق شبه القاحلة، مما يشير إلى أن هذه الأصناف الجديدة غير متكيفة على نحو جيد مع ظروف الإجهادات المائية.

Introduction

During the period 1960-1993, the Tunisian National Durum Wheat Research Program released several varieties that helped increase total production of the cereal in Tunisia. But this program addressed only the northern parts of the country though its main objective was to select widely-adapted varieties. While there has been significant genetic advances in terms of grain yield in the sub-humid areas (Maamouri and Gharbi 1992) and in all the northern parts (Office de Céréales, Rapport Annual of various years), these have not been demonstrated for the semi-arid regions. The objective of this note is to measure the genetic gains for durum-wheat grain yield and related characters in the semi-arid areas of Tunisia.

The seven most widely adopted varieties, which were released between 1960 and 1993, were chosen to evaluate their genetic progress. The varieties were Chili (1960), INRAT 69 (1696), Ben Bechir (1978), Karim (1980), Razzak (1987), Khiar (1993), and Om Rabi 3 (1993). They were grown for three seasons (1993/94, 1995/96 and 1996/97) at the semi-arid research station at Le Kef, northwest Tunisia, on plots laid out in a randomized complete block design, with three replications. Data were recorded on plot-basis for the following characters: number of grains/spike (NG); number of spikes/m^2, (NS); plant height (PH — in cm); vegetative period (VP — days from emergence to ear initiation); day to heading (DH — counted from 1 January); days to maturity (DM — counted from emergence); plant biomass (BS — in g); thousand–kernel weight (TKW); and grain yield (GY —in t/ha, calculated from harvest of a net plot size of 2.5 m x 1.0 m). Varietal mean values across replications and seasons were used to calculate the correlation coefficients between all characters. For grain yield and significantly-correlated characters, the absolute and relative genetic gains were estimated by regressing the varietal mean values and their natural log, respectively, on the release year of the variety (Ortiz-Monasterio et al. 1997), where the regression slope represents the genetic gain.

Results and Discussion

Grain yields were significantly and positively correlated with number of grains/spike (0.75) and number of spikes/m^2 (0.96), and negatively with vegetative period (-0.79) (Table 1). However, it was indirectly affected by plant height and days to heading through its significant and positive correlations with vegetative period (0.84 and 0.91) respectively. Thus, it was estimated that the number of grains/spike, number of spikes/m^2, the length of the vegetative period, plant height, and days to heading were the major contributors to durum-wheat grain yield in the semi-arid regions of Tunisia. These results indicated that genetic gains in grain yield can be obtained by an increase in the number of grains and spikes and by a reduction in the other three characters.

Table 1. Correlation coefficients among nine different characters of durum wheat under semi-arid conditions, measured across three seasons.

Character	TKW	NG	NS	PH	DH	BS	DM	VP
GY	0.11ns	0.75*	0.96**	-0.63ns	0.6mns	0.37ns	-0.18ns	-0.79*
TKW		-0.40ns	-0.08ns	-0.35ns	-0.18ns	-0.45ns	0.5ns	-0.07ns
NG			0.83*	-0.59ns	-0.67ns	0.43ns	0.02ns	-0.86*
NS				-0.58ns	-0.66ns	0.45ns	-0.02ns	-0.85*
PH					0.86*	0.09ns	0.51ns	0.84*
DH						0.10ns	0.07ns	0.91**
BS							0.37ns	-0.18ns
DM								0.11ns

GY = grain yield; TKW = thousand-kernal weight; NG = number of grains/spike; NS = number of spikes/m^2; PH = plant height (cm); DH = days to maturity; BS = biomass (g); DM = days to maturity; and VP = vegetative period.

ns = not significant at 0.05 probability level

*,** = significant at 0.05 and 0.01 probability levels, respectively

Table 2 shows the genetic gains for grain yield and related characters on both an absolute and relative basis. Non-significant gains in absolute and relative terms were obtained for grain yield (23.1 kg/ha/year, 0.54%/year) and number of spikes/m^2 (1.45 spikes/year, 0.38%/year). However, genetic gains were significant for number of grains/spike (0.29 grains/year, 0.31% year) and vegetative period (-0.08 days/year, -0.06%/year). The genetic gains for plant height (-0.71 cm/year, -0.3m2%/year) and days to heading (-0.17days/year, -0.05%/year) were non-significant.

Table 2. Absolute and relative genetic gains in grain yield of durum wheat and correlated characters for the period 1960 to 1993 in the semi-arid zones of Tunisia, measured across three seasons.

Character	Absolute (unit)	Relative (%/year)
GY	23.1 ns (kg/ha/year)	0.54 ns
NG	0.29 * (grains/spike/year)	0.31*
NS	1.45 ns (spikes/m^2/year)	0.38 ns
VP	-0.08* (days/year)	-0.06**
PH	-0.71 ns (cm/year)	-0.3m2 ns
DH	-0.17 ns (days/year)	-0.05 ns

GY=grain yield; NG=number of grains/spike; NS=number of spikes/m^2; VP=vegetative period; PH=plant height (cm); DH=days to maturity.

ns= slope not significantly different from zero at 0.05 probability level.
*,** = Slope significantly different from zero at 0.05 and 0.01 probability levels, respectively.

From the regression analysis it appears that as newer varieties were released in Tunisia, grain yield did not increase significantly in the semi-arid regions as they did in sub-humid zones (Maamouri and Gharbi 1992). This result confirms that the released varieties were mainly adapted to high-rainfall areas of Tunisia, and could not be considered as widely-adapted varieties.

The modest genetic advances in terms of grain yield were achieved through significant gains for number of grains and vegetative period. In fact, the released high-yielding varieties such as Karim, Razzak, and Khiar had more grains/spike and shorter vegetative periods than the older varieties, Chili and INRAT 69. Nevertheless, these gains did not contribute to significant progress in terms of grain yield. Consequently, additional gains needs to be achieved for these two characters by selecting varieties with higher number of grains/spike and shorter vegetative periods in order to obtain significant gains in grain yield. The importance of number of spikes/m^2 and vegetative period is indicated by their strong correlation with grain yield.

The absence of significant progress in grain yield was estimated as due to lack of significant gains for number of spikes/m^2, plant height, and days to heading. Thus, newer varieties did not outperform older varieties for these three characters in semi-arid regions, indicating that they are not well adapted to water-stress conditions.

Obviously, there is still good scope for further increases in grain yield of durum wheat by selecting for high number of spikes/m^2, short plants, and early heading. However, we cannot apply more selection pressure for plant height, since farmers do not prefer shorter varieties for maximizing production of straw used in livestock feeding, especially in unfavorable seasons. Thus, the selection pressure should preferably be applied to number of spikes/m^2 and days to heading. The importance of number of spikes is explained by its highly significant contribution to grain yield, whereas days to heading allows the plant to escape the terminal water stress in April and May which, according to Ben Amar (1996), is the most important and frequent stress in these regions of Tunisia.

It can be concluded that for significant advances in yields of durum wheat in the semi-arid conditions, more selection pressure needs to be applied in terms of the number of grains/spike and number of spikes/m^2, as direct selection criteria for grain yield, and days to heading as indirect selection criterion for grain yield through its relationship with vegetative period. In this way, the National Research Program would be more successful in selecting varieties better adapted to the stressed areas of Tunisia and, consequently, obtain significant genetic gains in durum-wheat yields in the semi-arid regions of Tunisia.

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Genetics of Some Metric Traits in Spring Wheat under Normal and Drought Environments

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Abstract

To test the nature of gene action under normal and stress environments, four wheat (*Triticum aestivum* L. subsp. *aestivum*) varieties/lines were crossed in a diallel fashion. The graphic representation showed that traits like flag leaf area, number of fertile tillers/plant and spike length were controlled by partial dominance with additive gene action. While 100-grain weight and grain yield exhibited over-dominance type of gene action under irrigated conditions, under drought conditions the mode of gene action was changed in some traits. Flag-leaf area and spike length showed over-dominance type of gene action, whereas number of fertile tillers/plant, 100-grain weight and grain yield/plant exhibited partial dominance type of gene action.

Key words: *Triticum aestivum*; spring crops; genetics; defense mechanisms; drought stress; drought resistance; dominant genes; phenology; plant developmental stages; Pakistan.

وراثة بعض الخصائص القياسية في القمح الربيعي تحت بيئات طبيعية وجافة

الملخص

تم تهجين أربعة أصناف/سلالات من القمح الطري (*Triticum aestivum* L.subsp. *aestivum*) بطريقة ثنائية الأليل، وذلك بهدف اختبار طبيعة عمل المورثات تحت البيئات الطبيعية والبيئات المعرضة للإجهادات. وقد بيَّن التمثيل البياني أن الصفات من قبيل مساحة ورقة العلم، عدد الإشطاءات المثمرة/النبات، وطول السنبلة، تتحكم فيها سيادة جزئية مع عمل المورثات ذات الأثر المتجمع. وفي حين أظهر وزن الـ 100 حبة والغلة الحبية فرط في سيادة نمط عمل المورثات تحت الظروف المروية وتحت ظروف الجفاف، إلا أن أسلوب عمل المورثات قد تغير في بعض الصفات. فلقد أظهرت مساحة ورقة العلم وطول السنبلة نمطاً مفرط السيادة لعمل المورثات، بينما بيَّن عدد الإشطاءات المثمرة/النبات، وزن الـ 100 حبة والغلة الحبية /النبات، نمط سيادة جزئي لعمل المورثات.

Introduction

Breeders are always interested in the task of developing new varieties for changing environments. Thus, they have to deal with new crosses to select desired combinations. Grain yield is a complex character that is influenced by the fluctuating behavior of the environment. To overcome this situation, it is necessary to breed wheat varieties which perform better than existing ones under adverse conditions. Chowdhry et al. (1992) observe that flag leaf area and number of tillers/plant are conditioned by non-additive genetic effect in wheat, while Bural et al. (1989) report, from two different crosses, that additive effects are important for flag leaf area. Khan et al. (1992) report that additive gene action with some degree of partial dominance was observed in spike length. Alam et al. (1990) show that flag leaf area and 1000-grain weight are governed by additive type of gene action with partial dominance. Bajwa et al. (1985) and Redhu et al. (1986) report both over- and partial-dominance with change of environment. The present research was initiated to examine the genetic mechanism controlling response to intermittent stress at various stages of growth.

Material and Methods

The experiment was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. Four wheat varieties/lines, namely, Faisalabad 85, Inqalab 91, 4770 and 6128-2, were crossed in a diallel fashion during March 1993. Seeds of F_1 crosses along with their parents were sown in pots. Treatments comprised irrigated and under moisture-stress conditions in a wire house using completely randomized design during 1993/94. Three plants were maintained in one pot and equal doses of fertilizer and measured quantities of water were given to both sets.

Under drought, intermittent stress was induced by skipping irrigation at different growth stages, i.e., tillering, milking and maturity, while the irrigated treatment received normal irrigation up to maturity. Three plants from each pot were harvested from each replication at maturity, and data were recorded on flag leaf area, number of fertile tillers/plant, spike length, 100-grain weight and grain yield/plant.

Data were analyzed statistically using analysis of variance. Significant differences among genotypes were further subjected to diallel analysis technique as described by Hayman (1954) and Jinks (1956).

Results and Discussion

Flag leaf area

Flag leaf area is of prime importance for a plant owing to its photosynthetic role. Analysis of variance for flag leaf area showed significant differences ($P < 0.05$) among genotypes under both environments (Table 1). Inqalab-91 had the highest array mean value (8.48) under drought environment. Graphic representation (Fig. 1a) for flag leaf area under irrigation conditions revealed that the regression line intercepted the Wr-axis above the origin showing partial dominance with additive gene action. The line 4770, being closest to the origin, had dominant genes while Inqalab-91, the farthest, had recessive genes.

Under drought conditions (Fig. 1b), the regression line intercepted Wr-axis below the origin showing over-dominance type of gene action. Line 4770 possessed dominant alleles being closest to the origin, while line 6128-2 had recessive alleles as it is farthest from the origin. Partial dominance type of gene action has also been reported by Martin and Salmeron (1981), Bural et al. (1989) and Alam et al. (1990), while Monyo and Whittington (1973) reported over-dominance type of gene action for this trait.

A comparative study of both figures indicated a change in gene with change of environment. The estimated regression line did not deviate from unit slope, indicating the absence of non-allelic interaction under both environments. Under irrigated conditions, selection will be effective in

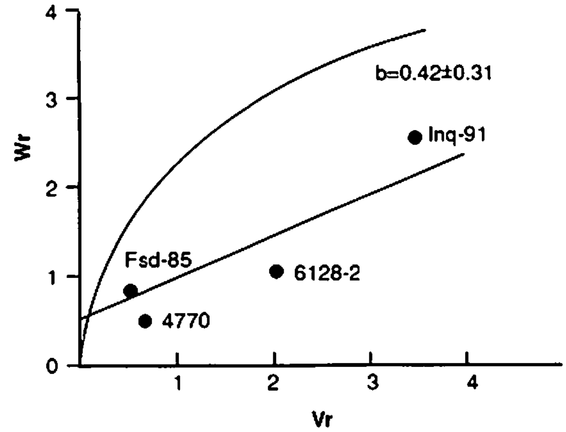

Fig. 1a. Vr/Wrn graph of flag leaf area under irrigation environment.

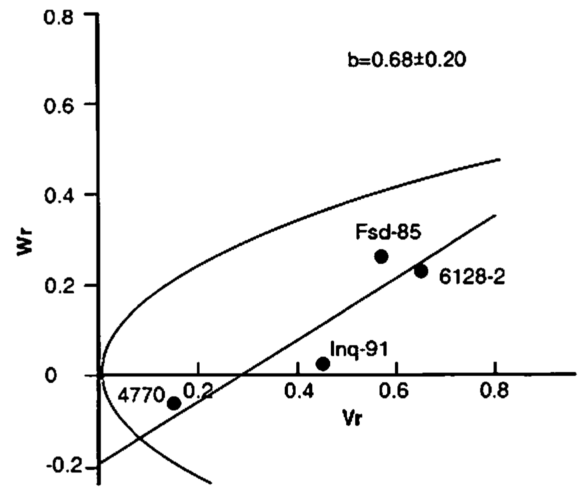

Fig.1b. Vr/Wr graph of flag leaf area under drought environment.

Table 1. Mean square values for flag leaf area and yield components in wheat under normal and drought environments.

Sources of Variation	DF	Mean squares: Flag leaf area (cm)^2	Number of fertile tillers	Spike length (cm)	100-grain weight (g)	Grain yield (g)
Normal						
Genotypes	15	20.79*	7.38**	1.27**	0.80**	48.6**
Error	32	10.10	0.53	0.13	0.26	2.77
Drought						
Genotypes	15	1.67*	5.65**	69.22**	1.25**	5.99**
Error	32	0.69	0.85	0.55	0.26	1.27

* Significant at P=0.05.
** Significant at P=0.01.

early generations, while under drought conditions it will be more fruitful in later segregating generations due to the presence of partial dominance with additive effect and over-dominance type of gene action.

Number of fertile tillers per plant

The analysis of variance for number of fertile tillers/plant showed highly significant ($P < 0.01$) differences among genotypes under both conditions (Table 1). Line 47700 had the highest array mean value of 6.41 under irrigation, while line 6128-2 possessed the highest value of 3.86 under drought. Vr/Wr graphs of both environments (Fig. 2 a and b) showed that the regression line cut the Wr-axis above the origin, indicating partial dominance with additive type of gene action. Non-allelic interaction was also involved in both cases as the regression line deviated significantly from the unit slope. Line 4770 possessed maximum dominant genes, while Faisalabad-85 carried maximum recessive genes being closest and farthest from the origin, respectively. Singh et al. (1985) and Khaliq (1989) also reported partial dominance type of gene action for number of tillers/plant, while non-additive effects for this trait were reported by Chowdhry et al. (1992). Partial dominance type of gene action with epistasis suggest that early generation selection should be done very carefully.

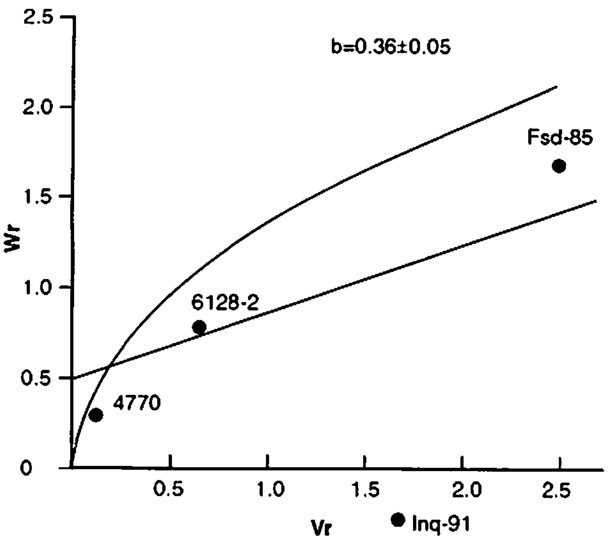

Fig 2a Vr/Wr graph of number of fertile tillers per plant under irrigation environment.

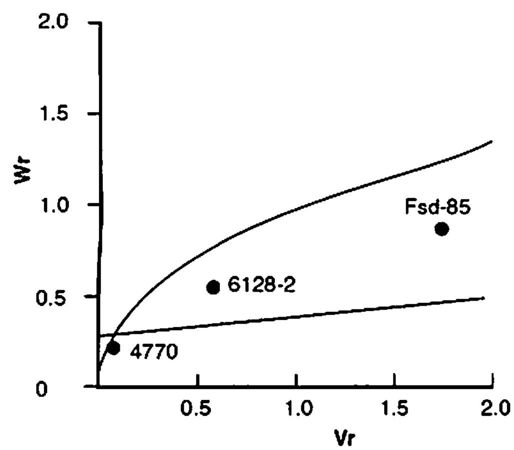

Fig. 2b. Vr/Wr graph of fertile tillers per plant under drought environment.

Spike length

Highly significant differences in spike length among genotypes were present under drought and normal conditions (Table 1). Line 4770 possessed highest array mean under normal and drought conditions (Table 2 a and b). Partial dominance type of gene action was observed for this character under normal conditions. Line 6128-2 had dominant genes being closest to the origin, whereas Faisalabad-85 had recessive ones being the farthest (Fig. 3a). The Vr/Wr graph (Fig. 3a) showed that over-dominance type of gene action was controlling the inheritance of spike length under drought conditions as the regression line cut the Wr-axis below the origin. The line 4770, being closest to the origin, possessed dominant genes, while Inqalab-91 and 6128-2, being farthest from the origin, had maximum recessive genes. In both cases, the estimated regression line deviated non-significantly from unit slope, suggesting the absence of epistasis. Over-dominance type of gene action was also reported by Gupta and Zia-ud-Din (1982), while Bajwa et al. (1985) and Khan et al. (1992) reported partial dominance type of gene action.

From the study of both graphs it appears that change in the environment altered the genetic mechanism of the plant. Under irrigated conditions partial dominance type of gene action suggests that selection should best be done in early generations, while under drought, selection should be practiced in later generations.

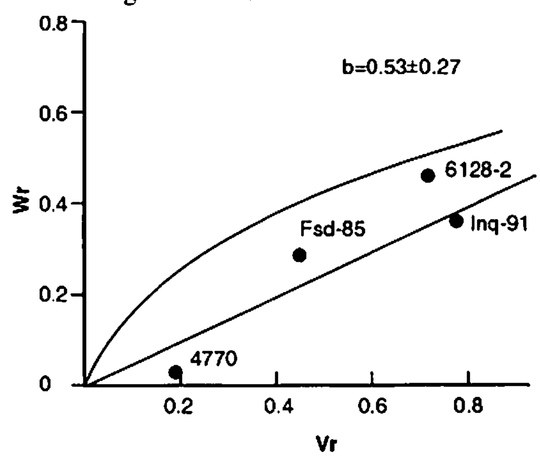

Fig. 3a. Vr/Wr graph of spike length under irrigation environment.

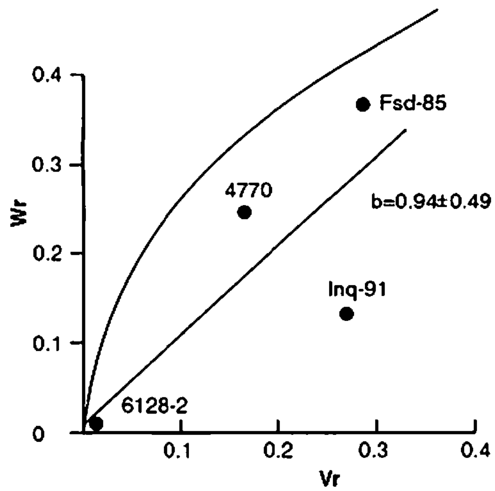

Fig. 3b. Vr/Wr graph of spike length under irrigation environment

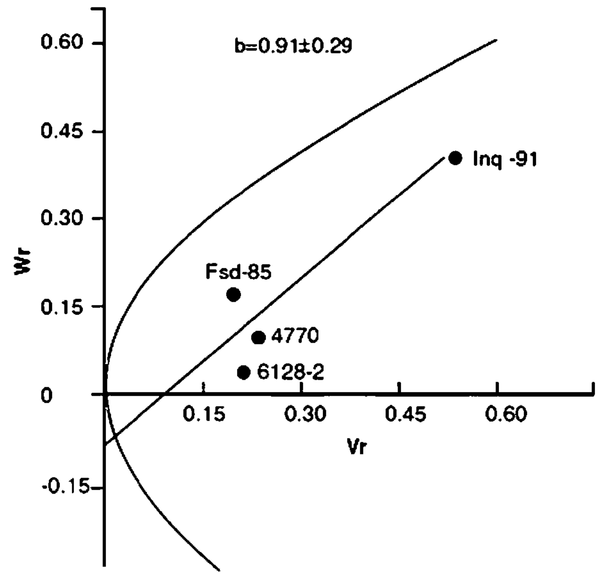

Fig. 4a. Vr/Wr graph of 100-grainweight under irrigation environment

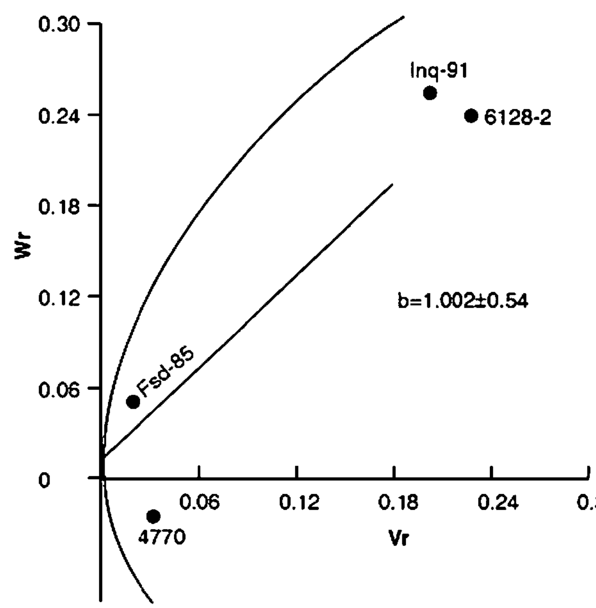

Fig 4b. Vr/Wr graph of 100-grain weight under drought environment

Hundred-grain weight

Highly significant differences among genotypes for 100-grain weight were observed under irrigation and drought environments. Variety Inqalab-91 possessed highest array means under irrigated conditions, while line 6128-2 had the highest array mean under drought (Table 2b). The graphic representation indicated that the regression line cut Wr-axis below the origin, showing over-dominance type of gene action. Line 6128-2 had dominant genes, while Inqalab-91 carried recessive alleles according to their distal position from the origin (Fig. 4a) under irrigated conditions. The experiment under drought (Fig. 4b) indicated partial dominance type of gene action for this trait, as the regression line intercepted the Wr-axis above the origin. The variety Faisalabad-85 possessed maximum dominant genes, while Inqalab-91 and 6128-2 had maximum recessive genes. In both environments, the estimated regression line did not deviate markedly from unit slope, reflecting absence of non-allelic interaction. Under different environments, the genetic behavior is different for this character. Lone (1988) and Iqbal et al. (1989) report over-dominance type of gene action. However, Sayed (1978) reports partial dominance type of gene action. Under irrigated conditions, selection should be delayed until later generations, while under drought it may be beneficial to select earlier due to partial dominance type of gene action.

Grain yield per plant

The analysis of variance showed highly significant differences among genotypes for grain yield/plant under both irrigated and drought conditions (Table 1). Line 4470 scored highest array mean under both irrigated and drought environments with values of 12.58 and 5.33, respectively (Table 2a and b). From the graphic representation (Fig. 5a), over-dominance type of gene action was observed for grain yield under irrigated conditions. Line 4770 possessed dominant genes, while Faisalabad-85 carried recessive alleles. Under drought (Fig. 5b), partial dominance type of gene action was observed for this character. Variety Inqalab-91 being nearest to the origin had maximum dominant genes, while genotype 4770 being farthest from origin possessed recessive alleles. Bajwa et al. (1985) and Redhu et al. (1986) also reported both over- and partial- dominance type of gene action under changed environment. The estimated regression line in both cases did not deviate significantly from unit slope, showing absence of non-allelic interaction. A comparative study of both graphs indicated a change in gene action over environments. Thus, under irrigated conditions (with over-dominance type of gene action), selection will be difficult because the character is not easily fixable as selected plants would have the tendency to segregate in subsequent generations. However, under stress situations, from the preponderance of additive gene control and absence of epistasis, it is possible that careful selection of this trait in early segregating generations would provide fruitful results.

It is evident from the present study that gene action may change over different environments.

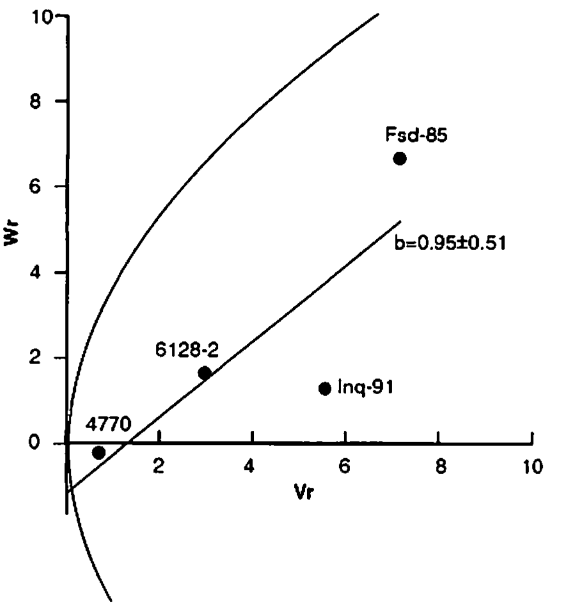

Fig. 5a. Vr/Wr graph of grain yield per plant under irrigation environment.

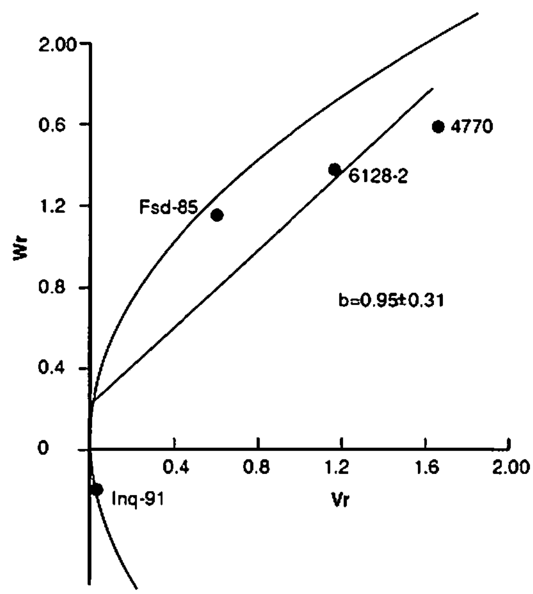

Fig. 5b. Vr/Wr graph of grain yield under drought environment.

Table 2(a). Array means of flag leaf area and yield components in wheat under normal conditions.

Sources of Variation	Flag leaf area (cm)^2	Number of fertile tillers	Spike length (cm)	100-grain weight (g)	Grain yield (g)
Faisalabad-85	13.00	5.56	12.08	4.31	9.45
Inqalab-91	14.45	6.05	12.65	4.70	11.58
4770	14.18	6.41	13.38	3.96	12.58
6128-2	14.16	5.05	12.20	4.13	10.93

Table 2(b). Array means of flag leaf area and yield components in wheat under drought conditions.

Sources of Variation	Flag leaf area (cm)^2	Number of fertile tillers	Spike length (cm)	100-grain weight (g)	Grain yield (g)
Faisalabad-85	8.03	3.29	8.12	3.28	4.45
Inqalab-91	8.43	3.21	7.74	3.00	3.60
4770	8.48	3.85	8.79	2.98	5.33
6128-2	8.16	3.86	8.41	3.41	4.93

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Short Communications

Medicinal Weeds in Wheat Fields of Chhattisgarh (India)

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Weeds, popularly known as unwanted plants, compete with crops for light, moisture and food, and harbor harmful diseases and insects. According to ancient Indian literature, particularly the *Charak Samhita*, every plant on earth is useful to humans, animals and also to other plants. Weeds, therefore, can be considered as valuable plants. Many studies conducted by Department of Agronomy, IGAU, Raipur (India) have clearly revealed that weeds with medicinal and industrial uses are a boon to farmers (Oudhia and Tripathi 1999a). Farmers can earn additional income by selling different plant parts of weeds to national and international drug retailers with the help of co-operatives (Oudhia and Tripathi, 1999b and 1999c). The uprooting of weeds for its utilization serves the cause of both their ecofriendly management and enables farmers to recover the cost of weeding.

Due to non-availability of any information regarding medicinal weed flora of wheat fields in Chhattisgarh, a survey was conducted by the Department of Agronomy, Indira Gandhi Agricultural University, Raipur (India) during 1996-98.

Materials and Methods

The detailed ethnobotanical survey was done in the Chhattisgarh region, and covered the selected districts of Raipur, Bilaspur, Durg, Rajnandgaon, Jagdalpur, and Ambikapur. From each selected district, two blocks and from each selected block, a random sample of four villages was taken. A proportionate sample of villagers from each selected village was taken to make the total sample size as 100 respondents. The data was collected through personal interviews, based on a prepared interview schedule. The medicinal uses of the common weeds in wheat fields were obtained from literatures on traditional Indian systems of medicine such as Ayurveda and Unani, as well as other systems such as Homoeopathy and Allopathy. The weeds were collected through intensive visits to the targeted villages at an interval of 15 days. Visual observations, both on crop fields and wastelands, were made.

Results and Discussion

The survey revealed that out of the 22 problematic weeds in the wheat fields of Chhattisgarh, 18 weeds possess valuable medicinal properties. The medicinal properties of these 18 weeds have been found well-documented in reference literatures. Some of the important medicinal properties of these weeds are given in Table 1.The study also revealed that out of 18 medicinal weeds, the villagers were using 9 weeds to treat their health problems. Out of total 22 weeds, 5 weeds (Table 1) were identified as weeds with potential to provide additional income to the farmers. These weeds were *Chenopodium album*, *Sphaeranthus indicus*, *Cyperus rotundus*, *Melilotus alba/indica* and *blumea lacera*. It was noted that there is a heavy demand for different plant parts of these weeds in national and international drug markets. The study suggested that there is a strong need for: (a) documenting valuable knowledge about medicinal weeds in wheat fields, (b) identifying suitable markets, and (c) forming co-operative societies. These objectives can be achieved through the joint efforts of governmental, non-governmental agencies and the local people.

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Table 1. Medicinal weeds in wheat fields of Chhattisgarh (India).

Scientific name	Common name	Family	Medicinal uses	Remarks†
Phalaris minor	Gahunsa	*Gramineae*	-	-
Melilotus alba and M. indica	Senji	*Leguminoseae*	Useful as emollient; applied externally as fomentation, poultice, or plaster for swelling	M,m‡
Spilanthes acmella	Akarkara	*Compositeae*	For diseases of mouth	M
Vicia sativa	Zillo	*Leguminoseae*	Seed used as emollient in the form of poultice	M
Chenopodium	Bhathua	*Chenopodiaceae*	For hook worm, leucoderma and other skin problems	M,m‡
Sphaeranthus indicus	Mundi	*Compositeae*	For respiratory diseases	M,m
Cynodon dactylon	Doobi	*Gramineae*	Whole plant juice as astringent, decoction of root as diuretic	M,m
Cyperus rotundus	Motha	*Cyperaceae*	Root is useful in treatment of leprosy, thirst, fever, diseases of the blood, billousness, dysentery, intense itching, epilepsy, ophthalmia	M,m‡
Medicago denticulata	-	*Leguminoseae*	As antidote to venom	M
Parthenium hysterophorus	Gajar ghas	*Compositeae*	Root decoction useful in dysentery	M
Vicoa vestata	Takla	*Compositeae*	-	-
Angallis arvensis	Krishna neel	*Primulaceae*	For diseases of respiratory organs and genitals; also in hydrophobia	M
Euphorbia heterophylla	Duddhi	*Euphorbiceae*	For respiratory diseases	M,m
Gomphrena decumbes	-	*Amaranthaceae*	-	-
Lathyrus	Khesary	*Leguminoaceae*	A reputed drug in Homoeopathic system of medicine; oil from the seed is a powerful but dangerous cathartic.	M
Launea	Jangli palak	*Compositeae*	Used as lactagogue	M
Oxalis corniculata	Khatti-buti	*Oxalidaceae*	For skin diseases	M,m
Sonchus arvensis	-	*Compositeae*	Used as laxative and diuretic; roots and leaves used as a tonic and febrifuge	M
Vernonia baldwini		*Compositeae*	Useful in treatment of asthma, bronchitis and constipation.	M
Tridax procumbens	Bhengra	*Compositeae*	For all types of bleeding	M,m
Blumea lacara	Kukurmutta	Compositeae	For diseases of bronchitic diseases, fevers, thirst and burning sensations	M,m‡
Cirsium arvense	Kanta van	Compositeae	-	-

†M = Weeds with medicinal properties; m = weeds in use in Chhattisgarh as medicinal plant.
‡Weeds in heavy demand in national and international drug markets.

Effect of Different Levels of Fertilizer on Growth, Yield and Quality of Late-sown Wheat

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Wheat (*Triticum* spp.) is one of India's most important cereal crops. It is grown annually on 3.77 million hectares in Madhya Pradesh State with yields of 3.52 million tonnes (Anonymous 1982). Many researchers have reported the beneficial effects of fertilizer on growth characters, yield and yield-attributory characters and protein content of early- and mid-sown wheat (Singh 1974; Nema and Cheema 1983; Singh et al. 1984). However, there is little information on late-sown wheat. Therefore, an experiment was conducted during *rabi* (winter) season of 1985 at the farm of the College of Agriculture (JNKVV), Sehore, Madhya Pradesh, to study the influence of fertilizer on late-sown wheat.

The experimental soil had a pH of 7.2, ECe 0.40 dS/m, organic carbon 6.0 g/kg, available nitrogen 240 kg/ha, P_2O_5 25.6 kg/ha and K_2O 517 kg/ha.

The trial was sown at the end of December 1984. Four different levels of fertilizer were applied to four different varieties of late-sown wheat in a factorial randomized block design with four replications. Row-to-row spacing was 20 cm. Nitrogen, phosphorus and potash were supplied through urea (46% N), super-phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Protein content was determined using the guidelines of the Association of Official Chemists (AOAC 1984).

Growth Characters

Increase in plant height and tillers/plant were noted with increasing levels of nutrients (Table 1). The higher nutrient supply increased both growth characters by enriching the cell sap of the meristematic tissue, especially with protein, amide and amino acids, ultimately increasing the growth characters. Similar results were reported by Singh (1974).

Variety HD 2236 was significantly taller than the other varieties. This variation in height was due to the plants' different genetic make up.

Yield-attributory Characters

The increasing levels of fertilizer appreciably increased yield-attributory characters (length of spike, grains/spike and 1000-grain weight), revealing the considerable plant response to higher nutrient supply (Table 1). This finding is similar to that of Singh et al. (1984).

Variety Raj-1555 produced significantly higher yield-attributory characters than the other varieties. These differences may be due to inherent characteristics of the genotypes.

Grain and Straw Yield

The influence of fertilizer levels on grain and straw yield was significant. Increasing levels of soil fertility up to 120 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha significantly increased grain yield (Table 1). Further increases in fertilizer levels enhanced grain and straw yield but not significantly. This increase in yield was due to the availability of larger amounts of inorganic elements to the plants, which influenced the yield-attributory characters. Similar results were reported by Singh et al. (1984).

Varietal differences in grain yield were significant. Variety Raj-1555 gave significantly higher yield followed by WH-147, HD-2236 and Lok-1.

Protein Content

Increasing the level of fertilizer increased the protein content of the grains (Table 1). This may be because the increased and rapid uptake of nutrients and their accumulation in the grains in the form of gluten was responsible for the production of more protein content. This finding is similar to that of Agrawal (1976).

Variety Raj-1555 had 11.34% protein and was found to be superior to WH-147, HD 2236 and Lok-1. This suggests that its genetic qualities, when supplemented with additional nutrition, force the formation of more protein.

It may be concluded that the application of 120 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha is beneficial for higher growth characters, yield and quality of wheat crop. Variety Raj-1555 is well-suited under late-sowing conditions.

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Table 1. Growth characters, yield and yield attributory characters as influenced by different fertilizer levels.

Treatment	Plant height (cm)	No. tillers/ plant	Length of spike (cm)	No. grains/ spike	1000-grain weight (g)	Protein content (%)	Grain yield (t/ha)	Straw yield (t/ha)
Variety								
Lok-1	73.87	3.58	6.64	44.01	44.50	9.55	26.79	39.90
HD-2236	75.17	3.67	6.67	45.00	45.15	10.65	29.98	41.26
WH-147	74.22	3.89	7.90	47.23	45.40	11.11	29.99	41.83
Raj-1555	74.25	4.04	8.46	45.77	45.80	11.34	35.47	41.99
CD (5%)	0.23	0.09	0.41	0.61	0.81	0.41	1.78	0.69
Fertilizer level (kg/ha)								
N P K								
F_0 (0 0 0)	64.92	2.28	6.66	36.00	43.20	8.98	23.16	22.00
F_1 (60 30 30)	75.78	3.50	7.42	44.65	47.30	10.50	30.54	41.50
F_2 (120 60 60)	78.05	4.39	8.21	49.38	45.27	11.30	33.68	50.55
F_3 (180 90 90)	78.77	5.01	8.40	50.00	45.10	11.90	34.54	51.00
CD (5%)	0.23	0.09	0.41	0.61	0.81	0.41	1.78	0.69

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Formation of Branched Ears in Two-rowed Barley

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Primitive and improved forms of two-rowed barley (*Hordeum vulgare* L. subsp. *vulgare*) are considered better for malting and brewing purposes. Varietal development with symmetrical growth of a plant is the most important stage in a cereal-improvement program. The stage of organogenesis, particularly the formation of grain, determines the success of future harvest.

In general, two-rowed barley has longer ears with fertile median spikelets and plump grains. However, an exotic ICARDA breeding material, namely, PT 000505/ALPHA, showed abnormally branched ears as a new morphological variation with varying frequency, shape and size. This entry was selected from the second IWFBON (1991/92) trial and used as elite germplasm.

Among 133 exotic germplasm evaluated under field conditions in 1991/92, the ICARDA germplasm PT 000505/ALPHA exhibited an abnormal growth habit, particularly at the time of ear formation. The complete set of germplasm was grown at the Genetics and Plant Breeding Farm of ND University of Agriculture and Technology in Faizabad, India. The experimental site enjoys a sub-tropical climate, i.e., hot summers and cold winters, with an average annual rainfall of 1000 mm.

The experiment was laid out in three rows of 2.5-m long beds with a row spacing of 30 cm. Plant-to-plant distance was kept at 15 cm. Fertilizers were applied at the rate of 40 kg N and 20 kg P/ha. Normal cultural practices were adopted.

The ear formation stage was characterized by abnormal, asymmetrical, branched ears. These ears had empty lateral spikelets with reduced lemma, palea and sexual organs (Fig. 1), but the median spikelets of the same ear were fertile and filled with grain of variable size. The main spike (ear) was longer but the branched spikes were of variable size. Out of 51 plants, only two (4% of the total number) showed such traits. These plants attained the same height as the others.

It is obvious that the number of spikelets is controlled by genetic and non-genetic factors. With respect to non-genetic factors, environmental conditions during apex organogenesis play an important role in creating the variation. This stage is affected by those factors which facilitate head overproductivity, leading to abnormal branched ear formation.

Sometimes, an adequate moisture and nutrient supply together with lower than normal temperatures during apex organogenesis encourage the formation of ear productivity compensation, i.e., over-production of the ear. Hansel (1965) revealed that there are differences among genotypes both in their compensatory potential and their ability to compensate for specific organs. Some genotypes can compensate for the production of an inadequate number of organs, but others cannot.

Fig. 1. Branched ear in two-rowed barley: normal (left) and abnormal (right).

This investigation was conducted in only one site. More results are needed in the future from other sites.

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Exploitation and Utilization of Genetic Variability in Exotic Germplasm in Pakistan

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Wheat (*Triticum* spp.) is grown in Pakistan over a wide range of environmental conditions where stresses influence stable yield. Wheat occupies the largest area under any single crop in the country. The wheat, barley and triticale program of the National Agricultural Research Centre (NARC), Islamabad focuses primarily on developing superior germplasm that will provide high and stable yields. The program seeks to identify sources of new and useful genetic variability for use in the program. In addition to hybridization to create genetic variability, the program utilizes the germplasm provided by CIMMYT and ICARDA, the two leading international research centers developing wheat, barley and triticale germplasm. The extensive germplasm sources are tested and evaluated at NARC and are shared with the breeders in the country in the form of an observation nursery.

The main objective of such germplasm testing and evaluation is to develop and release cultivars which are adapted and high yielding under local conditions. The approach involves testing and evaluation of germplasm directly received from the international centers. The stable lines which perform well under local environmental conditions and which have desirable traits of agronomic importance, are selected and put in the advance line yield testing trials (A-series). The second approach is to identify exotic germplasm for incorporation of desired traits into locally-adapted genotypes lacking those traits (e.g., disease resistance).

A number of bread wheat, durum, barley and triticale observation nurseries were received from CIMMYT and ICARDA during 1990/91 (Table 1) and planted at NARC Islamabad for the first year of testing and evaluation under rain-fed conditions. The observation nurseries were planted in 5-m non-replicated single rows with row-to-row spacing of 25 cm. Days to heading, days to maturity, plant height and yield were recorded for each line. Final selection was based on phenotypic expression, grain color, disease resistance, yield and yield components. A total of 1240 bread wheat, 398 durum wheat, 227 barley and 140 triticale lines were evaluated. The data were analyzed and range, mean and coefficient of variation were determined for days to heading, days to maturity (Table 2), plant height and yield per plot (Table 3). Significant variation exists for both of the first two traits. The material from ICARDA matured late compared with germplasm from CIMMYT. The range in bread wheat for days to heading varied from 111 to 154 and the range for days to maturity was 130-201. The lines identified were categorized into different maturity groups. There was also a range from 118-147 for days to heading and 167-185 for days to maturity in the durum group. Data on days to heading for barley was not recorded, but days to maturity showed a range of 163-178. Triticale had a range of 110-128 for days to heading.

A range of 71-194 cm was recorded for plant height in bread wheat. The durum wheats had a range of 72-150 cm in plant height. Barley had a height ranging from 80 to 121 cm, and triticale 102-145 cm. Yield showed a wide range in bread wheat since it is influenced by the environment more than any other trait. There were ranges of 150-970, 130-1020, 80-1100 and 250-610 g yield variation for bread wheat, durum, barley and triticale, respectively.

The local wheat cultivars fell into the same range as the exotic germplasm for these traits (Tables 2 and 3). Significant variation was observed in the germplasm, and the selections made on the basis of the criteria mentioned earlier will be further utilized for the enhancement of the bread wheat, durum, barley and triticale germplasm in the breeding programs of NARC.

Table 1. Breadwheat, durum, barley and triticale observation nurseries included in the study during 1990-91.

S.no.	Nursery	Source	Entries
	Bread wheat		
1	2nd High Rainfall Screening Nursery (RýHRFSN)	CIMMYT	148
2	9th Semiarid Areas Screening Nursery (SAASN)	CIMMYT	237
3	4th Warmer Areas Screening Nursery (WASN)	CIMMYT	136
4	24th International Breadwheat Screening Nursery (IBWSN)	CIMMYT	306
5	Breadwheat Observation Nursery [BWON(MRA)] (Moderate Rainfall Areas)	CIMMYT/ICARDA	136
6	Breadwheat Observation Nursery [BWON(HAA)] (High Altitude Areas)	CIMMYT/ICARDA	150
7	Breadwheat Observation Nursery [BWON(LRA)] (Low Rainfall Areas)	CIMMYT/ICARDA	127
	Durum		
8	Durum Observation Nursery [DON(MRA)] (Moderate Rainfall Areas)	CIMMYT/ICARDA	96
9	Durum Observation Nursery [DON(LRA)] (Low Rainfall Areas)	CIMMYT/ICARDA	96
10	Durum Wheat Drought and Cold Tolerance Observation Nursery (DWDCTON)	CIMMYT/ICARDA	48
11	International Durum Screening Nursery (IDSN)	CIMMYT	158
	Barley		
12	Barley Observation Nursery [BON(LRA)] (Low Rainfall Areas)	ICARDA	91
13	International Barley Observation Nursery (IBON)	ICARDA/CIMMYT	136
	Triticale		
14	International Triticale Screening Nursery (ITSN)	CIMMYT	140

Table 2. Variations in days to heading and days to maturity measured in different breadwheat, durum, barley and triticale observation nurseries received from CIMMYT and ICARDA during 1990-91.

		Days to heading			Days to maturity		
S.no.	Nursery	Mean	Range	C.V.(%)	Mean	Range	C.V.(%)
	Bread wheat						
1.	HRFSN	123.2	116-135	14.5	164.1	163-169	4.4
2	SAASN	125.4	111-135	2.6	167.7	165-169	0.7
3	WASN	123.9	111-133	2.8	165.3	163-168	1.1
4	IBWSN	125.2	112-136	2.9	168.7	130-170	2.0
5	BWON (MRA)	128.9	116-140	2.5	175.4	172-201	3.6
6	BWON (HAA)	139.8	119-154	4.6	-	-	-
7	BWON (LRA)	129.7	118-140	3.0	173.9	171-178	0.7
	Durum						
8	DON (MRA)	130.9	118-142	3.9	172.9	170-185	1.1
9	DON (LRA)	130.7	118-147	4.5	172.3	167-178	0.9
10	DWDCTON	133.0	121-141	3.9	172.9	171-176	0.6
11	IDSN	130.2	119-140	3.5	-	-	-
	Barley						
12	BON (LRA)	-	-	-	169.3	163-173	10.8
13	IBON	-	-	-	174.0	170-178	0.9
	Triticale						
14	ITSN	119.0	110-128	9.5	-	-	-
	Local checks:						
	Bread wheat (Pak-81)	127			171		
	Durum (Wadanak-85)	125			173		
	Brley (Jau-87)	-			171		
	Triticale (T-183)	115			-		

- Not recorded.

Table 3. Variations in plant height and grain yield measured in different breadwheat, durum, barley and triticale observation nurseries received from CIMMYT and ICARDA during 1990-91.

		Days to heading			Days to maturity		
S.no.	**Nursery**	**Mean**	**Range**	**C.V.(%)**	**Mean**	**Range**	**C.V.(%)**
	Bread wheat						
1.	HRFSN	102.5	88-132	14.1	429.4	190-910	30.9
2	SAASN	103.8	88-126	7.0	367.4	200-860	33.0
3	WASN	103.8	89-127	7.9	447.4	150-760	22.1
4	IBWSN	97.5	75-112	6.8	426.8	150-900	24.2
5	BWON (MRA)	96.0	71-128	2.1	431.7	220-700	24.4
6	BWON (HAA)	108.8	84-194	12.2	487.5	200-970	25.8
7	BWON (LRA)	97.9	79-133	10.8	536.6	310-820	18.2
	Durum						
8	DON (MRA)	97.7	73-130	14.3	328.9	180-500	1.1
9	DON (LRA)	104.6	78-150	16.8	334.3	220-500	0.9
10	DWDCTON	109.9	83-131	13.1	350.4	200-750	0.6
11	IDSN	90.6	72-131	11.2	386.3	130-1020	-
	Barley						
12	BON (LRA)	101-0	80-115	12.5	403.3	200-1000	47.8
13	IBON	106-8	94-121	5.6	375.7	80-1100	43.5
	Triticale						
14	ITSN	124.3	102-145	14.3	404.8	250-610	30.2
	Local checks						
	Breadwheat (Pak-81)	98			415		
	Durum (Wadanak-85)	87			350		
	Brley (Jau-87)	90			600		
	Triticale (T-183)	113			429		

Field Evaluation of Barley in Rainfed, Low-rainfall (Cool Winter) Conditions

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Barley is widely grown under diverse agroclimatic conditions. Its cultivation is presently spreading in problematic areas where wheat and other crops almost fail to grow. Due to its superior nutritional qualities, medicinal uses and industrial importance for brewing and other purposes, barley is considered a multipurpose crop.

The performance and adaptability of new introductions under rainfed, low-rainfall (cool winter) conditions were studied. Eighty-two barely lines, including exotic lines introduced from ICARDA and an indigenous barley check variety Lakhan, were evaluated in micro-plots at the Genetics and Plant Breeding Farm of ND University of Agriculture and Technology, Kumarganj, Faizabad, in 1994/95 under rainfall conditions with residual moisture. The site is located at 26° 47' latitude and 82° 12'E longitude and is 113 m above mean sea level. Faizabad enjoys subtropical climate, i.e., hot summers and cold winters, with an average rainfall of 1000 mm per annum.

Sowing was done in mid-November under residual-moisture field conditions. Seed was hand-drilled at the rate of 100 kg/ha. Not a single irrigation was applied throughout the crop season. During the crop-growth period, i.e., October-March, total rainfall was only 12 mm, which was extremely low (Table 1).

Minimum doses of nitrogen and phosphorus were applied at the rate of 20 kg/ha. No herbicides or pesticides were applied. The plots consisted of two rows each 2.5 m long and 30 cm apart. On the whole, weather conditions were favorable.

The performance of the genotypes is presented in Table 2. The Barley Observation Nursery for Low-Rainfall Conditions (BOLC) entry numbers 54, 55, 56, 59, 64 and 68 surpassed the yield level of the local barley check (Lakhan). The genotypes varied in grain yield from 0 to 150 g/plot. The environmental conditions (stage of plant growth, rain and temperature) during February-March seem to have had a major effect on grain yield.

Days to heading and maturity were 70-138 and 115-153 days, respectively, with significant differences among the genotypes. The earliest genotypes were nos. 1, 17, 20, 30, 51, 54 and 56. These genotypes had acceptable yields. In general, the medium and early maturing genotypes appeared to yield better than the late ones.

There was no spike emergence from entry no. 5, and it was very late. Overall, 12 entries exhibited desirable plant types and better phenotypic acceptability under rainfed, low-rainfall (cool winter) conditions (Table 2). More than 80% of the entries were given poor rating of phenotypic appearance. Of these, 6% showed aphid infestation, whose severity ranged from 10 to 40%. Maximum aphid infestation was recorded in entry no. 22 (40%) followed by 81 and 82 (30%).

BOLC no. 12 showed a complex disease on the seed surface with black spots. The plot including this entry contained 50% ear heads which showed such symptoms. All desirable entries need further evaluation in replicated trials.

Table 1. Monthly rainfall (mm) during the crop-growth period, 1994/95.

October	November	December	January	February	March	Total
2	0	0	2.2	7.8	0	12

Table 2 Characteristics of 12 promising genotypes out of 82 from the International Barley Observation Nursery for low-rainfall (cool winter) conditions (BOLC), 1994/95.

Best entry	Cross/pedigree	Important traits	Days to heading	Days to maturity	Plant height (cm)	No. tillers /m	Grain yield (g/plot)	Remarks, diseases, pests
BOLC-1	Harmal	Two-rowed, extra early, medium dwarf, good tillering ability, medium phenotypic acceptability.	78	118	53	134	100	Medium/early
BOLC-16	Tadmor/Soufara	Two-rowed, medium dwarf, better plant type, early, high yield potential, good phenotypic acceptability	92	133	55	120	100	-
BOLC-26	Gloria'S'/Copal'S'/Mari/Aths3-02	Six-rowed, dwarf, early, ideal plant type, . good yield potential	85	128	46	72	100	Good, bold grain
BOLC-36	As46/Rihane-05	Six-rowed, dwarf, medium, good plant type, low yield.	83	130	63	62	40	-
BOLC-41	Api/CM67/Mona/3/DI	Six-rowed, dwarf, medium maturing, satisfactory yield.	81	121	63	60	75	Medium dwarf, bold grain
BOLC-42	-do-	Six-rowed, dwarf, medium, early, high . yield potential	81	128	60	92	115	-
BOLC-49	Moroc 9-75/WI 22910/Cr 01387	Two-rowed, early, better plant type, (10%), susceptible to aphid infestation	80	122	70	117	100	Aphids 10%
BOLC-51	Harmal-02/4/7028	Two-rowed, medium dwarf, extra early, good . plant type, high yield potential	73	118	62	116	115	Early
BOLC-56	Mzq/Gva/PI 002917	Two-rowed, dwarf, extra early, better yield . potential, bold grains	73	118	55	177	150	Early
BOLC-59	ER/Apm/3/Arr/Esp	Two-rowed, dwarf, early, superior yield . potential, bold grains	77	127	56	124	150	Good, droopy ears
BOLC-78	Tadmor/Roho/Mazurka	Two-rowed, better plant type, late maturity, satisfactory yield.	95	140	62	108	75	Aphids 10%
BOLC-80†	Lakhan	Six-rowed, indigenous, promising medium . tall, better yielding ability, resistance to most serious diseases and pests, bold, light yellow grain	73	117	62	78	100	-

† National check.

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Conference on Food and Forestry: Global Change and Global Challenges, **University of Reading, UK, 20-23 September**; email: sm.wilkinson@elsevier.co.uk

Conference on Desert Technology: Deserts in Changing Climates, **Sparks, NV, USA, 3-8 October**; http://www.engfind.org.

National Small Conference, **Regal Riverfront Hotel, St. Louis, MO, USA, 12-15 October**; contact: Troy Darden, 573/681-5587.

Seminar on Concepts for Modernization of Irrigation Water Delivery Systems and Workshop on Modernization of Irrigation Water Delivery Systems, **Phoenix, AC, 17-21 October**; *email:* stephens@uscid.org.

Latin American Congress of Soil Science, **Temuco, Chile, 8-12 November**; www.ufro.cl/~clacs99.

International Conference on Contaminants and the Soil Environment, **New Delhi, India, 12-17 December**; MagesanG@landcare.cri.nz.

2000

World Congress of Young Farmers, **Coronada Springs Resort, Orlando, FL, 20-24 February**; bhmgt@aol.com.

International Symposium on Iron Nutrition and Interactions in Plants, **Texas Medical Center, Houston, 14-19 May**; mgrusak@bcm.tmc.edu.

International Crop Science Congress, **Hamburg, Germany, 17-22 August**; www.cch.de/CROPSCIENCE/.

International Symposium on Animal, Agricultural, and Food Processing Waste, **Marriott Hotel, Des Moines, IA, 7-11 October**; moore@asae.org.

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Article in book: Zadoks, J.C. and J.A.G. van Leur. 1983. Durable resistance and host pathogen environment reactions. Pages 125–140 *in* Durable Resistance in Crops. Plenum Publications Corporation, New York, USA.

Article 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–I, 20 April to 6 May 1982, ICARDA/the Government of the Netherlands, ICARDA, Aleppo, Syria.

Book: Evans, L.T. and W.J. Peacock (Ed.). 1981. Wheat Science—Today and Tomorrow. Cambridge University Press, Cambridge, UK.

Thesis: Haitham Sayed, Mahmoud. 1990. Ecological study of important wild genetic resources of wheat and barley. Thesis. University of Aleppo, Syria.

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