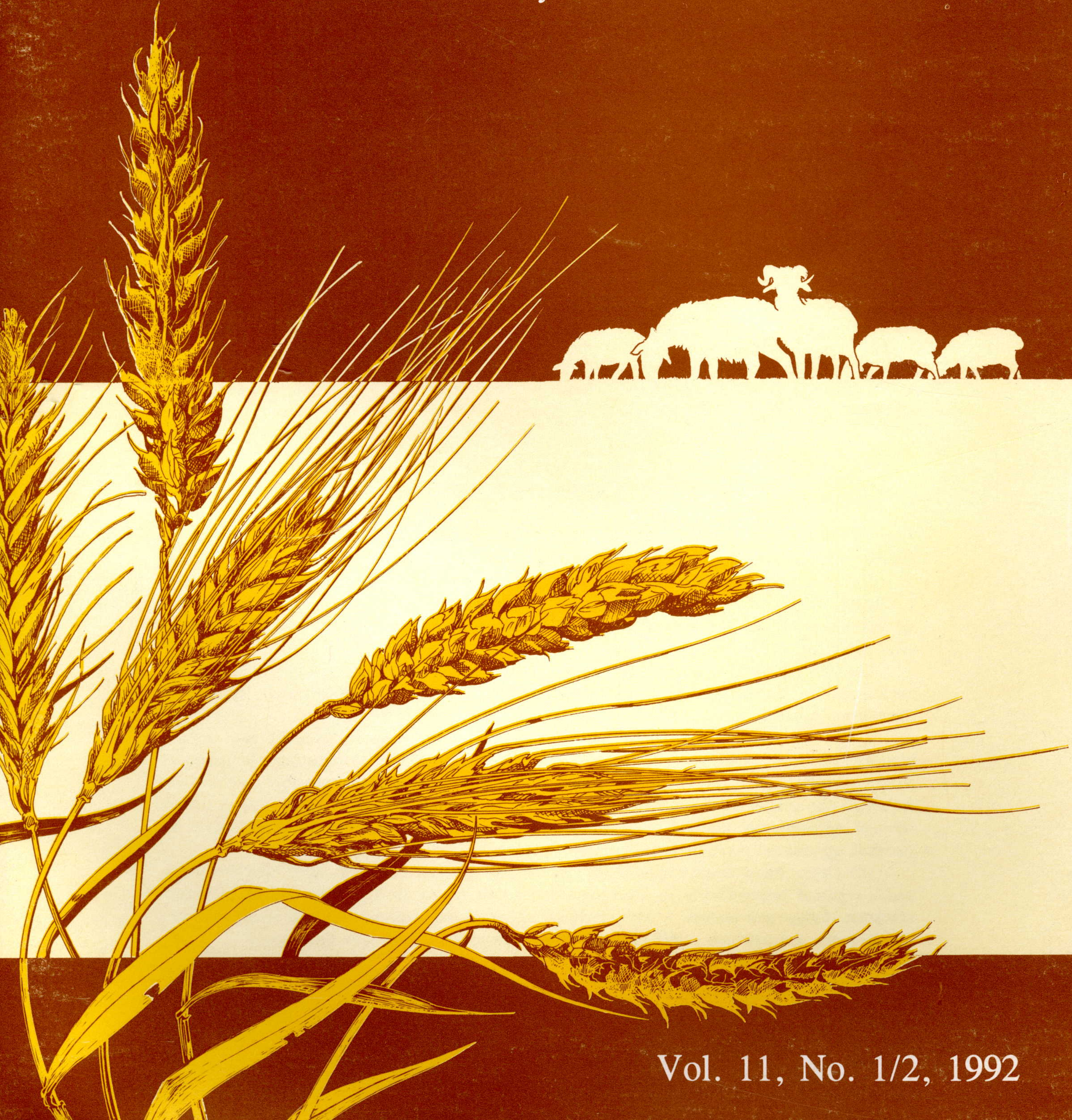
RACHIS

Barley and Wheat Newsletter



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

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CONTENTS

RESEARCH AND PRODUCTION

SHORT COMMUNICATIONS

CEREAL NEWS

Research and Production

Harvest Index as a Selection Criterion for Improving Grain Yield in Segregating Populations of Barley

N. Theoulakis, E. Iconomou and K. Bladenopoulos
National Agricultural Research Foundation (N.AG.R.F.)
Cereal Institute
P.O. Box 312
57001 Thermi - Thessaloniki
GREECE

Abstract

Three crosses of barley (*Hordeum vulgare* L.) were grown in the Cereal Institute of Thessaloniki, Greece during the 1990/91 and 1991/92 growing seasons to investigate the possibility of using harvest index as an indirect selection criterion to enhance grain yield. Selection was made in the F_3 generation for high and low harvest index. The selected progenies were evaluated in replicated field trials in the F_4 generation for grain yield, total biomass and harvest index. The response to selection was not significantly different between the high and low groups for grain yield, although the magnitude of observed progress was positive in two of the three crosses (5% and 12%). Thus selection for high and low harvest index lines in the F_3 generation was not effective in securing high and low grain-yielding lines, respectively, in the F_4 generation. However, selection was effective for harvest index. Estimates of realized heritability for harvest index were low (0.26–0.37). The correlation coefficients in the F_3 and F_4 generations between grain yield and harvest index and between grain yield and biomass were high and very high, respectively. From the F_3 to F_4 generation, the correlation coefficients were significant for harvest index in all populations, while between harvest index and grain yield they were significant in only one population. The results of this study suggest that selection for harvest index in the F_3 generation has positive effect on harvest index of F_4 generation, but its contribution to grain yield is not significant.

دليل الحصاد كمعيار انتخاب لتحسين الغلة الحبية في العشائر الإنعزالية للشعير.

الملخص

زرعت ثلاثة هجن من الشعير (*Hordeum vulgare* L.) في معهد سيسالونيك للحبوب باليونان خلال المواسم الزراعية 1990/91 و 1991/92 لدراسة إمكانية استخدام دليل الحصاد كمعيار انتخاب غير مباشر لتحسين الغلة الحبية. وقد أجري الانتخاب في الجيل الثالث F3 بحثاً عن دليل الحصاد العالي والمتدني. وقيمت الأنساب المنتخبة في تجارب حقلية مكررة في الجيل الرابع F4 فيما يتعلق بالغلة الحبية وإجمالي الكتلة الحيوية ودليل الحصاد. ولم تكن الاستجابة للانتخاب مختلفة معنوياً بين المجموعات العالية والمتدنية بالنسبة للغلة الحبية رغم أن مقدار التقدم الملحوظ كان إيجابياً في هجينين من أصل الثلاثة (5٪ و12٪). لذلك كانت عملية انتخاب سلالات ذات دليل حصاد عال ومتدن في الجيل الثالث غير فعالة في تأمين سلالات ذات غلة حبية عالية ومتدنية على التوالي في الجيل الرابع F4.

غير أن الانتخاب كان فعالاً بالنسبة لدليل الحصاد إذ كانت التقديرات لقابلية التوريث المحققة بالنسبة لدليل الحصاد متدنية (0.37-0.26). وكانت معاملات الارتباط في الجيلين الثالث والرابع بين الغلة الحبية ودليل الحصاد من ناحية، وبين الغلة الحبية والكتلة الحيوية من ناحية أخرى، عالية وعالية جداً، على التوالي. كما كانت معاملات الإرتباط بدءاً من الجيل الثالث وحتى الرابع معنوية بالنسبة لدليل الحصاد في جميع العشائر في حين كانت تلك المعاملات بين دليل الحصاد والغلة الحبية معنوية في عشيرة واحدة فقط. وتوحي نتائج هذه الدراسة بأن الانتخاب لصفة دليل الحصاد في الجيل الثالث له تأثير إيجابي على دليل الحصاد في الجيل الرابع. إلا أن تأثيره على الغلة الحبية ليس معنوياً.

Key words: *Hordeum vulgare*; barley; harvest index; yields; biomass; Greece.

Introduction

Among the various selection criteria for grain yield increase in cereals, several investigators employ harvest index which was defined by Donald (1962) as the ratio of grain yield to total biomass yield.

The gradual increase of grain yield in cereals over time has been associated with increased harvest index while biomass has not changed considerably (Austin et al. 1980; Gymer 1981; Wych and Rasmusson 1983; Wych and Stutham 1983; Deckard et al. 1985). Positive correlation between harvest index and yield has been found in pure-breeding lines and it has been suggested, as McVetty and Evans mentioned (1980), that selecting for harvest index would be an effective means of selecting for yield.

All previous studies refer to the use of pure lines or named varieties. However, in trials using harvest index as an indirect selection criterion for increasing grain yield in segregating material of wheat the results were positive in some (Bhatt 1977; Nass 1980) and negative in others (Okolo 1977; McVetty and Evans 1980; Whan et al. 1982; Sharma and Smith 1986).

The objectives of this study were to investigate the effectiveness of harvest index as an indirect selection criterion for improving grain yield in segregating material of barley and to estimate its heritability.

Materials and Methods

Three crosses of spring barley, which had as common parent Madrid variety with high harvest index, were used in this study. The pedigrees of the crosses were as follows:

Korona × Madrid
Lignee × Madrid
Pirate × Madrid

The F_2 generations of these crosses were grown in the 1989/90 crop year at Thessaloniki and 250 plants were selected randomly from each population. In 1990/91, the seed of one head from each selected plant was sown in one F_3 row, 1 m long. The distance between rows was 0.26 m. At maturity, each row was cut at ground level and harvested separately and its total above-ground plant material (biomass) was weighed. After threshing, grain weight was recorded for every row. Harvest index was calculated as the ratio of grain weight to total above-ground weight.

Having the harvest index value as a selection criterion, 15 highest and 15 lowest yielding F_3 lines of each population were chosen. The deviation of harvest index value between the two groups in the three populations was 9.5 to 11.9 points (data not shown). These 30 lines from each population were used as experimental material for the next year. The F_4 population of each cross was planted in a separate randomized complete block design with four replications. Each plot consisted of two rows, 2 m long, spaced 0.26 m apart and was sown with 16 g seed. Because the weather was very dry, 20 mm of irrigation water was applied to support normal growth of the plants.

At maturity, each plot was cut at soil surface and the above-ground biomass was weighed. After threshing, grain weight was recorded and harvest index was calculated as for the F_3 generation.

Analysis of variance was carried out to detect significant differences between the two groups for grain yield, biomass and harvest index. Response to selection was calculated as the percentage difference between the mean of the progenies of the highest and the mean of progenies of the lowest group. Realized heritability (h^2) for harvest index was calculated according to Falconer (1960) and Alexander et al. (1984) by the following formula:

$$h^2 = \frac{H_{F_4} - L_{F_4}}{H_{F_3} - L_{F_3}}$$

Correlation coefficients were calculated to assess the relationship between grain yield, biomass and harvest index within the F_4 generation as well as between the F_3 and F_4 generations.

Results and Discussion

The yield of the high selection group for harvest index (group A) was not significantly superior to that of the low group (B) based on the response of F_4 progenies (Table 1), although the magnitude of observed progress (5% and 12%) was positive in two of the three populations.

In the F_3 generation, lines with high harvest index were not necessarily high in grain yield and vice versa. The same situation was noted in the F_4 generation. Thus, selection for high and low harvest index lines in the F_3 generation was not effective in securing high and low grain-yielding lines, respectively, in the F_4 generation.

Table 1. Means of grain yield, biomass and harvest index (HI), and realized heritibility (h^2) for HI of high (A) and low (B) groups in the F_4 generations of three barley crosses.

Cross	Yield (g)		Response to selection	Biomass		HI		h^2 (HI)
	A	B		A	B	A	B	
Korona × Madrid	305	302	0.0	898	986	33.9**	30.7**	0.30
Lignee × Madrid	268	240	12.0	805	826	33.3**	29.0**	0.37
Pirate × Madrid	259	247	5.0	771	793	33.6	31.3	0.26

** Significant at 1% level.

Table 2. Coefficients of phenotypic variation between grain yield, biomass and harvest index (HI) in the F_3 and F_4 generations of three barley crosses.

Traits	Cross	F_3	F_4
HI vs grain yield	Korona × Madrid	0.55**	0.43**
	Lignee × Madrid	0.51**	0.64**
	Pirate × Madrid	0.46**	0.25ns
HI vs biomass	Korona × Madrid	-0.09ns	0.21ns
	Lignee × Madrid	-0.0002ns	0.04ns
	Pirate × Madrid	-0.13ns	-0.20ns
Grain yield vs biomass	Korona × Madrid	0.79**	0.67**
	Lignee × Madrid	0.71**	0.77**
	Pirate × Madrid	0.81**	0.89**

** Significant at 1% level.
ns Not significant.

Similar results are reported by Okolo (1977), McVetty and Evans (1980), Whan et al. (1982), Sharma and Smith (1986), while Bhatt (1977) and Nass (1980) report that harvest index was effective in improving grain yield in early segregating generations.

Biomass of group A was not significantly different from that of group B, although numerical values were lower in group A for all populations.

Harvest index was significantly different between the two groups in two of the three crosses. The high harvest index selection group generally maintained its superiority for harvest index in the F_4 generation with actual differences ranging from 2.5 to 4.4%. These differences were not able to increase yield because of the overall lower biomass of group A. Bhatt (1977) and Sharma and Smith (1986) also report that selection based on high and low harvest index in F_2 and F_3 generations, respectively, was effective. Realized heritability (h^2) values for harvest index were low, ranging from 0.26 to 0.37. Other investigators report values between 0.35 and 0.88 (Rosielle and Fren 1975; Bhatt 1977; Sharma and Smith 1986).

Correlation coefficients in the F_3 and F_4 generations between harvest index and grain yield were significant in almost all populations, but were not significant between harvest index and biomass (Table 2).

Correlation coefficients between grain yield and biomass were very high in both generations and in all populations; this indicates that the biomass of a line is a good predictor of its grain yield. These findings conform with those of Rosielle and Frey (1975), Bhatt (1977), Boukerrou and Rasmusson (1990), and Iconomou and Theoulakis (1992).

Correlation coefficients between F_3 and F_4 generations were high for harvest index in all populations, but correlation between harvest index and grain yield was significant in only one population (Table 3).

Table 3. Coefficients of correlation between F_3 and F_4 generations for harvest index (HI), grain yield and biomass.

Traits	Korona × Madrid	Lignee × Madrid	Pirate × Madrid
HI (F_3 vs F_4)	0.64**	0.77**	0.53**
Grain yield (F_3 vs F_4)	0.09ns	0.28ns	0.29ns
HI (F_3) vs grain yield (F_4)	0.15ns	0.43*	0.20ns
Biomass (F_3) vs grain yield (F_4)	-0.06ns	-0.02ns	0.21ns

*, ** Significant at 5% and 1% levels, respectively.
ns Not significant.

The data of this investigation show that selection of high harvest index in the F_3 generation does not improve grain yield significantly. However, high harvest index combined with high biomass should be considered in the future for increasing grain yield.

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Agronomic Performance of Lines Derived by Anther Culture from Barley Cultivar Elrose

M.A. Sariah[1], B.G. Rossnagel[2] and K.N. Kao[3]
[1] *Crop Science Department, University of Saskatchewan, CANADA*
[2] *Crop Development Center, University of Saskatchewan, Saskatoon, Saskatchewan, S7N 0W0, CANADA*
[3] *Plant Biotechnical Institute Saskatoon, National Research Council of Canada, Saskatoon, S7N 0W0, CANADA*

Abstract

A field evaluation of 14 barley (*Hordeum vulgare* L.) lines derived via anther culture from the cultivar Elrose was conducted at two locations of the University of Saskatchewan, Canada in 1985. Their agronomic performance was compared to the parental line. Findings from this study indicated both location and among-line variability for yield, days to heading, days to maturity and test weight. However, these lines did not differ in plant height. A few of the progeny lines differed from the parent cultivar in four of the five characteristics measured. The variability observed was attributed to *in vitro* methods and the possibility of the parental line not being completely homozygous. Other possible causes of "somaclonal/gametoclonal variation" in plants regenerated form tissue culture are discussed.

Key words: *Hordeum vulgare*; barley; anther culture; agronomy; varieties; tissue culture; Canada.

الكفاءة الزراعية للسلالات المستمدة من زراعة المئبر من صنف الشعير إلروز.

الملخص

أجري تقييم حقلي لـ 14 سلالة من الشعير (*Hordeum vulgare* L.) مستمدة عن طريق زراعة المئبر من الصنف إلروز في موقعين من جامعة ساسكاتشوان بكندا في 1985. تمت مقارنة كفاءتها الزراعية مع السلالة الأبوية. وقد أشارت نتائج هذه الدراسة إلى التباين بين كلا الموقعين وبين السلالات بالنسبة للغلة، وعدد الأيام حتى الإسبال، وعدد الأيام حتى النضج، والوزن الاختباري (النوعي).إلا أن هذه السلالات لم تتباين في طول النبات. واختلف عدد قليل من سلالات النسب عن الصنف الأب في أربع خصائص (صفات) من أصل الخمس التي تم قياسها. ويُعزى التباين الملحوظ إلى الطرق المختبرية وإمكانية عدم تجانس اللواقح في السلالة الأبوية تجانساً تاماً. وتُدرس الأسباب الأخرى الممكنة لـ "التباين الكلوني الجسدي/الكلوني المشيجي" في النباتات المتجددة عن طريق زراعة النسج.

Introduction

Anther culture or microspore culture has been successfully used for the production of haploid and dihaploid plants in several species including agronomically important crops such as barley. It is also well documented that plants regenerated from tissue or organ-culture systems show genetic variation (Powell et al. 1984).

Evidence of genetic variation of plants regenerated from somatic tissues has been reported by Larkin and Scowcroft (1981, 1983), from anthers by Baenziger et al. (1983) and Powell et al. (1984, 1986). The former kind of variability known as "somaclonal" and the latter "gametoclonal" – both act to increase the variability of a segregating population (Snape et al. 1986) or of material developed from a homozygous genotype (Collins et al. 1974; Burk and Matzinger 1976; Powell et al. 1984).

The extent of variation among lines derived by anther-culture from homozygous parents has been examined extensively in rice and wheat. Oono (1978, 1981), Kuo et al. (1980) and Wakasa (1982) found that doubled haploid lines of rice derived from one genotype showed a range of phenotypes. Similarly, Baenziger et al. (1983) working with wheat observed that the mean performance of an anther-culture derived population was significantly lower than the parental variety. In case of rice, the variation was not due to chromosomal abnormality, but in wheat abnormalities were evident in chromosome number, structure, or both.

[1] Present address: Selian Agricultural Research Institute, P.O. Box 6024, Arusha, TANZANIA.

In barley, similar studies have been documented to a lesser extent and most of the work reported has concentrated on F_1 hybrids (Friedt and Forough-Wehr 1981, 1983; Friedt et al. 1983). However, Powell et al. (1984) while working on dihaploids derived from a homozygous pure barley cultivar, noted gametoclonal variation among the lines for a number of quantitative characters including yield and its components. They also found that anther culture derived lines deviated from the mean for the same traits although the population mean performance of these lines and the seed-progenies were indistinguishable.

The present investigation was designed to examine the possible effects of somaclonal/gametoclonal variation in callus on resultant dihaploid plants derived from anthers of the barley cultivar Elrose.

Materials and Methods

The 14 progeny lines used in this study were derived via anther culture (AC) of the pure-line cultivar Elrose in 1980/81 at the Plant Biotechnical Institute (PBI), Saskatoon.

In 1985, these lines plus the parental cultivar Elrose were seeded at two University of Saskatchewan locations: the Preston Avenue research plots (Saskatoon) and the Kernen crop research farm. The test was set up in a randomized complete block design with four replicates. The Preston Avenue plots were inadvertently partially irrigated 41 days after planting.

Plot size at Saskatoon was four rows, 3.7 m long, spaced 30 cm apart; at Kernen, the same length and spacing of rows was used but the plots were five rows. Seed rate was 1.2 times the 1000-kernel weight of the individual line per plot.

Variables recorded were: days to heading (DYH), days to maturity (DYM), plant height (PHT), hectoliter weight (HLW) and grain yield (YLD). Days to heading and days to maturity were recorded when 50% of the heads were emerged and matured, respectively. Plant height measurements were taken at maturity on two middle rows at Saskatoon and on three middle rows at Kernen. For yield, whole plots were combine-harvested.

In the laboratory, hectoliter weight was determined using a 0.5-litre measure: the weight of grain required to fill the measure was multiplied by 0.2 to convert it to kg/hl. Grain yield was determined by weighing a whole plot sample and converting to kg/ha.

A combined analysis of variance was performed on the data from the two locations to separate the differences between locations, genotypes and genotype × location interactions.

Results

Location differences were detected for YLD, DYH, DYM, PHT and HLW (Table 1). These differences were a reflection of the Kernen site having a lower YLD, shorter plants and heading and maturing later.

The line × location interaction was significant for YLD, DYH, DYM and HLW, indicating that lines had differential performance in the two environments. It further testifies the differences between locations as revealed by the range data (Table 2) as well as the genetic differences among the lines although they originated from the same parent.

Table 1. Mean squares of a combined analysis of variance showing significance levels for the agronomic traits in the Elrose barley anther culture test grown at Saskatoon and Kernen, 1985.

Trait	Location (loc)	Source of variation			
		Rep (loc)	Lines	Lines × loc	Error
Df	1	6	14	14	84
YLD	7427179**	360314	843412**	68243*	35849
DYH	47**	4	4**	2*	1
DYM	295**	35	11**	3**	1
PHT	2980.03**	65.63	14.88ns	20.81ns	16.42
HLW	21.08**	2.52	1.30**	0.92**	0.38

*,**,ns Significant at P=0.05, P=0.01 and non-significant, respectively.

Table 2. Location means and ranges for agronomic traits in the Elrose barley anther culture derived lines tested at Saskatoon and Kernen, 1985.

Character description	Saskatoon	Kernen
No. of lines	15	15
YLD	2346(2018 –2600)*	1848(1507 –1975)
DYH	54(53 –55)	55(55 –58)
DYM	92(90 –93)	95(93 –98)
PHT	61.4(57 –66)	51.4(50 –53)
HLW	70.8(69 –72)	69.9(69 –71)

* Figures in brackets indicate the ranges and those outside the brackets are the means.

Among-line variability was observed for YLD, DYH, DYM and HLW. However, the lines did not differ in PHT.

Mean separations by Duncan's new multiple range test revealed a tendency of one line to deviate significantly from the rest for all characters including YLD and DYM (Table 3). Comparison of other lines to the parent showed a range of performance such that for each character measured, there were a few progeny lines which deviated significantly from the parent. As for DYH, 7 headed at the same time, 6 were early and 1 was later than the parental line. For DYM, 4 were early, 5 similar and 4 were intermediate when compared to the parental line. Only one line was different from Elrose for HLW.

Discussion

Progeny lines derived via anther culture method from the cultivar Elrose differed from the parent line in four of the five characteristics measured. While environmental factors were important for the differences noted, other sources of variation could not be discounted.

Table 3. Line means for agronomic traits in the Elrose anther culture experiment grown at Saskatoon and Kernen, 1985.

Line	YLD	DYH	DYM	PHT	HLW
E505	2135b†	55b	93bc	57.5	69.3a
E10	2067ba	54a	93bc	56.1	70.2ab
E13-1	2131b	55b	94cd	56.3	70.2ab
E13-2	2122b	57c	93bc	54.3	70.4b
E13-3	2162b	55b	95de	56.9	70.5b
E507-1	2167b	55b	94cd	55.6	70.3ab
E517-1	2166b	54a	94cd	57.6	70.2ab
E517-2	2103b	54a	94cd	58.4	70.3ab
E517-3	2037ba	54a	95de	54.4	70.4b
E517-4	2233b	54a	94cd	58.3	70.4b
E539-1	2140b	55b	92ab	55.4	71.1b
E550-2	1996ba	54a	91a	55.7	70.2ab
E556	2052ba	55b	92ab	54.8	70.1ab
K356	1796a	55b	96e	57.9	71.1b
Elrose	2150b	55b	94cd	57.1	70.4b
CV%	9	1.8	1.1	7.2	0.9

† Means in the same column followed by the same letter are not significantly different at P=0.05 level as determined by Duncan's new multiple range test.

Studies on tobacco AC lines derived from a pure line showed between-line variation and significant deviations from the parent (Collins et al. 1974; Burk and Matzinger 1976). Powell et al. (1984) noted similar differences in barley. In all these studies, the variation was attributed to mutations induced during the culture cycle. For tobacco, the possibility of residual heterozygosity or the effect of colchicine treatment was rejected (Deaton et al. 1982). In the present investigation, as Powell et al. (1984) note, the lines were obtained after spontaneous chromosome doubling *in vitro*, hence, colchicine effects were excluded. However, residual heterozygosity could not be discounted for the deviations observed since the source cultivar may not have been completely homozygous (Sariah 1987).

Since the possibility of cytological changes in lines studied could not be ascertained by mitotic or meiotic analyses, such changes could only be assumed not to have caused major abnormalities and may have contributed to the variation observed. These same changes, however, did not drastically affect the fertility of these lines as they were all highly fertile.

The present study is not conclusive because it is limited in scope. Further work of a similar nature would be useful to clarify the sources of variation and its usefulness to plant breeding programs.

If proven to be genetic, the variation that could be created by *in vitro* methods from a pure-line cultivar could be used by plant breeders to improve old cultivars by developing better performing lines from them. However, the same gametoclonal variation may not prove useful if the AC method is used as a routine breeding technique since the population of lines may not represent a random sample of gametes from the parent.

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Evaluation of Ethiopian Barley Landraces for Yield Potential and Correlations among Agronomic Characters

Tesema Tanto and Hailu Mekbeb
Plant Genetic Resources Center Ethiopia (PGRC/E)
P.O. Box 30726
Addis Ababa, ETHIOPIA

Abstract

Sixty barley (*Hordeum vulgare* L.) landraces (selected from 2000 accessions) were evaluated over two years on clay loam soils at Holetta Research Center, Ethiopia (37°28'W, 9°02'N, 2380 m). These lines were tested for yield and other agronomic characters using augmented design with four checks (HB 42, IAR/H/485, ARDU 1260 B and HB 7). Among the entries tested, 20 had higher mean yield than the highest yielding check (HB 42: 3735 kg/ha), 31 entries were medium and 9 had yield less than the lowest check (HB 7: 2570 kg/ha). The entries took an average of 130 days to reach maturity, 85 days for vegetative growth and 45 days for grain-filling. There was a high correlation (r=0.91) between vegetative period and days to maturity. The correlation between grain-filling period and days to maturity was moderately high. Days to maturity and plant height were also moderately correlated with 1000-grain weight and number of effective tillers. It appears desirable, under Holetta conditions, to select lines with an acceptable 1000-grain weight, more effective tillers and more kernels per ear.

Key words: *Hordeum vulgare*; barley; land races; clay soils; yields; statistical analysis; agronomic characters; Ethiopia.

تقييم أصول الشعير المحلية الأثيوبية من حيث الكفاءة الإنتاجية والارتباطات بين الصفات الزراعية.

الملخص

قُيمت 60 سلالة محلية من الشعير (*Hordeum vulgare* L.) - تم انتخابها من 2000 مدخل- على مدى سنتين زرعت على ترب طمية غضارية في مركز بحوث هوليتا بإثيوبيا (28 '37 غرب، '02 9 شمال، 2380م). تم اختبار هذه السلالات لتحديد الغلة وصفات زراعية أخرى وذلك باستخدام التصميم الموسع وأربع سلالات شاهدة (HB42، IRA/H/485، ARDU 1260 B و HB7). ومن بين المدخلات المختبرة، كان هناك 20 مدخلاً تتمتع بمتوسط غلة أعلى من أعلى شاهد مغلال (HB42: 3735 كغ/هـ) و31 مدخلاً متوسط الغلة و9 غلتها أقل من أقل شاهد غلة (HB7: 2570كغ/هـ). وقد استغرقت المدخلات للوصول إلى النضج 130 يوماً في المتوسط، 85 يوماً للنمو الخضري و45 يوماً لامتلاء الحب. كان هناك ارتباط عالٍ (r: 0.91) بين فترة النمو الخضري وعدد الأيام للنضج في حين كان الارتباط بين فترة امتلاء الحب وعدد الأيام للنضج عالياً بشكل معتدل. كما يرتبط عدد الأيام للنضج وطول النبات بصورة معتدلة مع وزن الألف حبة وعدد الإشطاءات الفعالة. وتحت ظروف هوليتا، يبدو أنه من المستحسن انتخاب سلالات ذات وزن ألف حبة مقبول وإشطاءات فعالة أكثر، وعدداً أكبر من الحبات في كل سنبلة.

Introduction

After teff (*Eragrostis tef* (Zucc.) Trotter), barley is the most important food crop in Ethiopia. The area under production is about 858,000 hectares annually with an average yield of 1130 kg/ha (ECSA 1987). It is grown at altitudes ranging from 1000 to 3750 m above sea level (Pinto and Wech 1985). It is mostly produced on sloped areas where poor soil fertility, frost, waterlogging, low pH and rainfall variability are predominant problems (Fekadu and Hailu 1987). It is consumed in different forms: 'Kollo', 'Kinche', 'Ingera' and for preparing 'Tella' (a local fermented beverage).

The important barley-producing regions are Arsi, Shewa, Bale, Gojjam, Gonder, Wello, Tigrai and the former province of Eritrea (now independent). However, it is grown to a lesser extent in the highlands of Haraghe, Gamogoffa, Keffa, Sidamo, Illubabor and Wellega administrative regions. This indicates that barley is grown in every administrative region of the country.

There is a high diversity of barley in Ethiopia and Eritrea, which is confirmed by Vavilov (1951) and later by Harlan (1975). Both describe this area as the center of largest diversity. Consequently, the Plant Genetic Resources Center Ethiopia (PGRC/E) is the base collection in the International Plant Genetic Resources Institute (IPGRI, formerly the International Board for Plant Genetic Resources) network for barley collected in Africa (Moseman and Smith 1985). This variation is the outcome of the evolutionary process in response to the heterogenous environments that prevail in the barley-growing regions of the country. Barley is attacked by a number of diseases: scald (*Rhynchosporium secalis* (Oud.) J.J. Davis), net blotch (*Pyrenophora teres* Drechs), spot blotch (*Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dast.), stripe (*Pyrenophora graminea* S. Ito & Kuribay), and covered and loose smuts (*Ustilago hordei* (Pers.) Lagerh, *U. nuda* (Jens.) Rostr.) are the common ones. Among the insect pests, barley shoot fly (*Delia arambourgi* Seguy) and aphids (Homoptera: Aphidae) severely damage the crop at medium and high altitudes, respectively (Adugna and Kemal 1985). However, some lines may still be resistant or tolerant to certain races of pathogens. This was confirmed by Qualset (1975), indicating that Ethiopian barley landraces are an important source for desirable traits, such as disease resistance and nutritional quality.

Landraces of barley have different desirable traits which if properly evaluated could be a vital source for barley improvement programs. The objectives of our study were to identify landrace barleys with high yield potential in comparison with released varieties, and to study the association of grain yield with other important traits. We expect that selecting for grain yield and associated traits is more efficient than selecting for grain yield alone.

Materials and Methods

Sixty entries of landrace barley were investigated. They were selected from 2000 accessions grown in 1986, based on their better performance for four yield components. They were collected from Arsi, Shewa, Bale, Gonder, Gojjam, Eritrea and Tigrai with altitude range of 2400–3100 m above sea level.

The trial was conducted at Holetta Research Center at an altitude of 2380 m. It was sown on 25 June 1987 and 23 June 1988 (main season). The soil type was clay loam, and 60 kg N/ha and 26 kg P/ha were applied. The plot size was 2 m^2. Spaces between rows, plots and blocks were 20, 50 and 100 cm, respectively. The experimental design used was augmented design (Peterson 1985) with four varieties as checks, namely, HB 42, IAR/H/485, ARDU 1260 B and HB 7.

Data were recorded on a plot basis for grain yield and the following characters.

Vegetative period: The number of days from germination to flowering. Flowering was considered to be when 50% of the heads were halfway out of the boot.
Days to maturity: The number of days from germination to physiological maturity. Maturity was considered to have been reached when 50% of the heads were ripe and showed complete loss of green color.
Plant height: Mean height of ten typical plants from ground to tip of head excluding awns.
Kernels per ear: Mean number of kernels for ten typical heads.
Thousand-grain weight: Mean weight of five replicates of 1000 seeds.
No. of effective tillers: Mean number of head-bearing nodal tillers for ten typical plants.
Grain-filling period: Days to maturity minus vegetative period.
Grain-filling index: The ratio of grain-filling period to days to maturity.

Results and Discussion

Among the 60 entries tested over two years, 20 had higher mean yield than the highest-yielding check, HB 42 (3735 kg/ha), 31 entries were medium and 9 had yield less than the lowest yielding check, HB 7 (2570 kg/ha). The top-yielding entry gave 82%, 112%, 115%, 164% and 118% yield increase over the four checks and mean of the checks, respectively.

The means, ranges and coefficients of variation for the nine characters measured for the 60 barley landraces are presented in Table 1. The entries took an average of 130 days to reach maturity, 85 days (about 65% of their life cycle) for vegetative growth, and 45 days for grain-filling. The range in maturity among all entries was 28 days, while the range in vegetative period was 23 days and in grain-filling period 28 days, i.e., the total variability for days to maturity and grain-filling period was equal.

The correlation among the nine characters measured is presented in Table 2. There was a high correlation (r = 0.91) between vegetative period and days to maturity. The correlation between grain-filling period and maturity was also moderately high. Moderate correlation was detected between days to maturity and 1000-grain weight; and between plant height and 1000-grain weight. Kernels per ear was negatively correlated with 1000-grain weight and number of effective tillers. Grain yield was negatively correlated with 1000-grain weight, but positively correlated with number of effective tillers.

The relationships among grain yield, number of effective tillers, kernels per ear and kernel weight have been investigated by other researchers. Grafius and Okoli (1974) found that 72% of the variation in grain yield was explained by the three yield components. They showed that kernels per spike and kernel weight, and grain yield and kernels weight were negatively correlated; we found the same.

On the other hand, it has been found that number of effective tillers and kernels per ear were highly correlated with grain yield (Hockett and Nilan 1985). In our study number of effective tillers was negatively correlated with kernels per ear, and was the only yield component positively correlated with yield. Under Holetta conditions, it may be desirable to select lines with an acceptable 1000-grain weight, but with more effective tillers and kernels per ear.

Table 1. Means, ranges, and coefficients of variability (CV) for nine characters measured on 60 entries of landrace barley.

Character	Mean	Range	CV
Vegetative period (days)	84.9	75-98*	6.8
Grain-filling period (days)	45.0	28-56*	9.7
Grain-filling index	0.35	0.24-0.43*	8.5
Days to maturity	129.8	116 -144*	5.1
Plant height (cm)	97.2	76-115*	8.3
Kernels per ear	52.3	23-75*	22.9
1000-grain weight (g)	34.2	23-55*	15.1
No. of effective tillers	3.7	3-7	22.6
Grain yield (kg/ha)	3549	2044-6801*	30.9

* Differences among entries significant at 10% level.

Table 2. Correlation coefficients among nine characters measured in 60 entries of landrace barley.

Character	Grain-filling period	Grain-filling index	Days to maturity	Plant height	Kernels per ear	1000-grain weight	No. of effective tillers	Grain yield
Vegetative period	-0.20	0.01	0.91**	-0.18	0.01	0.17	-0.02	0.07
Grain-filling period		0.12	0.67**	-0.59**	0.13	0.28*	0.09	0.06
Grain-filling index			0.18	0.03	0.01	0.04	0.03	0.02
Days to maturity				-0.45**	0.06	0.48**	0.03	0.15
Plant height					0.14	0.37**	0.09	0.19
Kernels per ear						-0.42**	-0.51**	0.14
1000-grain weight							0.08	-0.42**
No. of effective tillers								0.25*

* Significant at 5%.
** Significant at 1%.

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Statistical Analysis of Randomized Complete Block Designs for Barley Cultivar Yield Trials

L. Gusmão[1], J. Baeta[1], J.T. Mexia[2], F. Bagulho[3], B. Maçãs[3] and J. Coutinho[3]

[1] *Dept. Genética, Estação Agronómica Nacional, 2780 Oeiras, PORTUGAL*

[2] *Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2825 Monte da Caparica, PORTUGAL*

[3] *Estação Nacional de Melhoramento de Plantas, 7351 Elvas Codex, PORTUGAL*

Abstract

The evidence of the "block × cultivar" interaction, in barley (*Hordeum vulgare* L.) randomized complete block design yield trials, and the admitted pattern of such interaction, in practical terms, allows for alternative procedures to the classical ANOVA for these trials, according to the presence or absence of significance for block effects. When the block effects are not significant, it may be convenient to pool the ERROR and BLOCK SQ into a new ERROR SQ with the corresponding increase in degrees of freedom to estimate the error. In the alternative procedure, for RCBD yield trials in which the block effect is significant, a joint regression analysis (JRA) should be carried out.

تحليل إحصائي لتصاميم القطع العشوائية الكاملة لتجارب مقارنة الغلة لأصناف الشعير.

الملخص:

إن إقامة الدليل على التأثير المتبادل بين "القطعة x الصنف" في تجارب مقارنة غلة الشعير المنفذة في تصميم للقطع العشوائية الكاملة والنمط المقبول لمثل هذا التأثير، يسمح من الناحية العملية، بإجراءات بديلة لتحديد تحليل التباين ANOVA التقليدي لهذه التجارب، وذلك حسب وجود أو عدم وجود المعنوية لتأثيرات القطعة. فعندما لاتكون تأثيرات القطعة معنوية، قد يكون من الملائم تجميع الخطأ والقطعة SQ في خطأ SQ جديد مع الزيادة المقابلة في درجة الحرية لتقدير الخطأ. أما في الإجراء البديل فيجب إجراء تحليل إنحداري مشترك لتجارب مقارنة الغلة المنفذة في تصميم القطع العشوائية الكاملة التي يكون فيها تأثير القطعة معنوياً.

Key words: *Hordeum vulgare*; barley; statistical analysis; trials; yields; Portugal.

Introduction

Due to the "cultivar × environment" interaction, the results of one cultivar yield trial are only valid for the specific conditions under which the trial is performed. To overcome this limitation, a network of regional trials is needed, based on which the interaction could be assessed in terms of practical relevance. Nevertheless, individual trials are frequently useful in assessing relative cultivar performances under specific environmental conditions. Despite the criticism it is subjected to, the randomized complete block design (RCBD) is still the most frequent design for such trials (Gusmão 1986).

Based on results from regional yield trials and several simulated studies, Baeta et al. (1990) illustrated how "genotype × environment" interaction (as expressed by the "cultivar × block" interaction) may be responsible for the increase in the estimates of the experimental error in the ANOVA of RCBD trials. In order to overcome such difficulties, and to increase the accuacy of the statistical analysis of RCBD trials, practical solutions were suggested, either when the F test (MS) for blocks is not significant (Gusmão et al. 1990) or when that test is significant (Mexia et al. 1990, 1991).

The objective of this paper is to discuss such alternatives. After a brief survey of the theory involved, we will apply it to two barley RCBD yield trials.

Statistical Models

In what follows we consider first the finite model (Kempthorne 1967) for RCBD. In this model we have for the i-th treatment in the j-th block an observation

$$Y_{i,j}= \mu+t_i+b_j+e_{i,j}\ ,\ \ i= 1,\dots,I \ \text{ and } j= 1,\dots,J,$$

μ being the general mean while t_i and b_j are the treatment and block effects. Since there are treatment and block effects we can carry out the corresponding F tests. Underlying this model is the assumption (A) that the interactions $\gamma_{i,j}(i=1,\dots,I$ and $j=1,\dots,J)$ between blocks and treatments are null. When this assumption is violated the ERROR SQ will be the product of the variance σ^2 of the errors $e_{i,j}(i=1,\dots,I$ and $j=1,\dots,J)$ by a non-central chi-square (Mexia 1989) and the F tests for treatments and blocks loose power. Thus, if a hypothesis is rejected such a conclusion is valid while there are or are not interactions. Actually, the presence of interactions may lead to non-rejection of an otherwise rejected hypothesis.

The mean value of a chi-square with g degrees of freedom and non-centrality parameter δ is g+δ (Seber 1980). Thus the presence of interactions will tend to decrease

$$F_B = \frac{\text{BLOCK MS}}{\text{ERROR MS}}$$

and so, $F_B < 1$ points to the presence of interaction. Since there is reproducibility for degrees of freedom and non-centrality parameters (Seber 1980), by pooling the BLOCK and ERROR SQ we "dilute" the non-centrality parameter in the new ERROR SQ while, at the same time, increasing the degrees of freedom for error estimation, and thus achieving a more powerful test for treatment effects.

When F_B is significant we can assume that the different blocks correspond to different environment levels. Then as an alternative to the finite model considered above we can consider the model used in JRA.

Actually when we apply the JRA to sets of RCBD trials, the blocks must be considered as points (Gusmão 1985). When there is a significant block effect within a RCBD trial it is natural to use blocks as environments. This is the case since the different blocks will be situated in the same Equipotential Zone for Yield Pattern Evaluation (Gusmão et al. 1987). Thus, the main assumptions for carrying out a JRA (Gusmão 1986) will be satisfied and the "specific instability" (as defined by Eberhart and Russell 1966) will be greatly reduced. The significance for cultivars is then tested against the "pooled deviation term" (Eberhart and Russell 1966). As to the criticism by Freeman (1973), we point out that it has been shown that the amount and pattern of the residues for the different regressions do not differ when the points we consider are inside an Equipotential Zone for Yield Pattern Evaluation (Baeta et al. 1990).

Numerical Results

The trials under analysis were chosen from a regional network of RCBD trials carried out by the Estação Nacional de Melhoramento de Plantas (National Plant Breeding Station) in 1988/89 and 1989/90. Trial no. 1 (Coruche 1989/90) was chosen from those without significant block effects, while trial no. 2 (Comenda 1988/89) was chosen from those with significant block effects.

In Table 1, the yields obtained in both trials are presented and the "classical" ANOVA is presented in Table 2. Note that, for both trials, there were significant cultivar effects.

Table 1. Yield data (kg/ha) in Trial no. 1 (Coruche 1989/90) and Trial no. 2 (Comenda 1988/89).

Cultivars	Blocks				Mean
	I	II	III	IV	
Trial No. 1					
Ribeka	3897	4689	3344	3606	3884
Carina	3380	3659	2814	3641	3374
Tágide	4599	5111	4195	4344	4562
Arivat	3362	2951	2957	3154	3105
CE 8501	4153	4195	3927	3879	4038
CE 8601	3320	4355	4522	4320	4129
CE 8701	3427	3873	4629	3237	3792
CD 8702	4242	3838	3826	3903	3952
Sereia	3987	3856	4189	3719	3938
Arupo S	5183	4945	4766	5617	5128
Mean	3955	4147	3917	3942	3990
Trial No. 2					
Ribeka	2499	3213	1547	1618	2219
Carina	2856	3213	1785	2083	2484
Tágide	3213	3142	2142	1904	2600
Arivat	2939	2428	1547	1523	2109
CE 8501	2332	1833	774	883	1443
CE 8601	2856	2785	2023	2023	2422
CE 8701	3142	2916	2023	1785	2467
CD 8702	3142	2916	2023	1785	2467
Sereia	3190	2975	1666	1666	2374
Arupo S	2927	2975	2130	1904	2484
Mean	2910	2861	1740	1695	2301

Table 2. ANOVA of yield for Trials 1 and 2.

Source of variation	SS	DF	MS	F
Trial No. 1				
Cultivar	11,440,035	9	1,271,115	7.61***
Block	335,840	3	111,947	0.67 NS
Error	4,508,913	27	166,997	
Total	16,284,790	39		
Trial No. 2				
Cultivar	3,981,662	9	442,407	10.72***
Block	13,665,384	3	4,555,128	110.40***
Error	1,114,004	27	41,259	
Total	18,761,051	39		

Table 3. Suggested ANOVA of yield for Trial No. 1.

Source of variation	SS	DF	MS	F
Cultivar	11,440,035	9	1,271,115	7.87***
Error	4,844,755	30	161,492	
Total	16,284,790	39		

The modified ANOYA, with pooled ERROR SQ, for trial no. 1, is presented in Table 3, while the results of JRA for trial no. 2 are presented in Table 4.

Lastly, in Table 5, we compare the results of the classical ANOVA and the JRA, for trial no. 2. The assumption of additivity, on which the conventional ANOVA of RCBD trials is based, leads to the identity of the b parameters. This hypothesis was rejected for trial no. 2 by the F test ($F = 3.26$, for $F_{0.05[7/16]} = 2.67$).

Conclusions

The evidence of the "block × cultivar" interaction in barley RCBD yield trials and the admitted pattern of such interaction in practical terms, allows for alternative procedures to the classical ANOVA for these trials, according to the presence or absence of significance for block effects.

Table 4. Estimated parameters for the regressions, assessed by the JRA, in a RCBD yield trial.

Cultivar	$\hat{\alpha}$	ß	r^2
Ribeka	-253.92	1.075	0.840
Carina	345.29	0.929	0.895
Tágide	317.09	0.992	0.986
Arivat	-172.16	0.991	0.926
CE 8501	-1,091.50	1.101	0.940
CE 8601	849.52	0.683	0.998
CE 8701	234.97	0.970	0.974
CD 8702	-452.81	1.244	0.997
Sereia	-420.49	1.214	0.993
Arupo S	639.98	0.820	0.976

Table 5. Comparison of the estimated experimental error and the F value for cultivars, of the yield values of Trial No. 2, when assessed both by the classical and the JRA approach.

Approach	SS	DF	MS	F
Classical	1,114,004	27	41,259	10.72***
JRA	523,817	20	26,191	16.89***
Total	16,284,790	39		

When the block effects are not significant, it may be convenient to pool the ERROR and BLOCK SQ into a new ERROR SQ with the corresponding increase in degree of freedom to estimate the error. In the alternative procedure, for RCBD yield trials in which the block effect is significant, a JRA should be carried out.

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Effect of Sowing Date and Rate, and Site Environment on the Performance of Barley Cultivars Grown in the Algerian High Plateaux

H. Bouzerzour and B. Refoufi
ITGC
B.P. 03, Setif
ALGERIA

Abstract

This study was undertaken to determine the effects of location, environment, variety, seeding date and rate on grain yield and grain yield components of barley (*Hordeum vulgare* L.) in the high plateaux of eastern Algeria. Three varieties, namely Acsad 176, Barberousse and Tichedrett, were used as well as 3 seeding dates (October, November and December) combined with 3 seeding rates (200, 300 and 400 viable seeds/m²). Environments were 1 site × 3 years and 2 sites × 2 years; making a total of 7 locations or environments. The experiment was conducted at the ITGC Agricultural Research Station near Setif. Plot site was 6 rows 10 m long, with 0.18 m between rows. Results showed high variation in grain yield and grain yield components caused by location and seeding date. Seeding rate made little difference to grain yield. Frost damage was the major limiting factor which rendered early planting risky. In general, variety Tichedrett preferred intermediate planting while Barberousse and Acsad 176 performed well in late planting. Early planting resulted in good performance in sites where frost was not a problem.

Key words: *Hordeum vulgare*; barley; sowing date; seeding rates; yields; varieties; vernalization; frost damage; Algeria.

Introduction

It is generally accepted in the semi-arid zone of the high plateaux of eastern Algeria that early planted barley incurs frost injury which causes serious yield losses in years with a lot of frost. Farmers have adopted intermediate planting dates which are less risky compared to early or late planting of the local 6-row barley variety Tichedrett. Knapp and Knapp (1978) reported an increase in the number of spikes as the major reason for increased yield with proper planting time. Early planted wheat had more tillers and heads/m², fewer kernels per head, heavier kernels and higher grain yield than late-planted wheat. This was related to the plants' higher tiller density, an important component of yield as suggested by Fischer and Maurer (1978).

تاثير موعد و معدل البذار و بيئة الموقع على كفاءة اصناف الشعير المزروعة في المناطق المرتفعة من الجزائر

الملخص

أجريت هذة الدراسة لتحديد تاثيرات الموقع والبيئة أو الصنف وموعد ومعدل البذار علي الغلة الحبية ومكوناتها من الشعير (*Hordeum vulgare* L) في المناطق المرتفعة من شرقي الجزائر. واستخدمت ثلاثة أصناف هي: أكساد 176 وباربيروس وتيشدريت، بالإضافة الى ثلاثة مواعيد زراعية (تشرين الأول/اكتوبر، تشرين الثاني/نوفمبر، وكانون الأول/ ديسمبر) وثلاث معدلات بذار (200 و 300 و 400 بذرة سليمة/م² وكانت البيئات موقعاً واحداً x 3 سنوات، وموقعين x سنتين، مما يجعل المجموع 7 مواقع أو بيئات. وأجريت التجربة في محطة البحوث الزراعية التابعة لـ ITGC قرب اصطيف. وكان موقع التجربة يتألف من 6 سطور طول السطر الواحد عشرة أمتار، والمسافة فيما بينها 0.18 م. وأظهرت النتائج تبايناً كبيراً في الغلة الحبية ومكوناتها الناجمة عن الموقع وموعد البذار. وقد أحدث معدل الزراعة فرقاً ضئيلاً بالنسبة للغلة الحبية. وكان الضرر الناجم عن الصقيع العامل المحدد الرئيسي الذي جعل الزراعة المبكرة محفوفة بالمخاطر. وبصورة عامة، كان الصنف تيشدريت يفضل الزراعة المتوسطة، في حين كانت كفاءة الصنفين برباروس وأكساد 176 جيدة في الزراعة المتأخرة. وقد أسفرت الزراعة المبكرة عن كفاءة جيدة في المواقع التي لايشكل فيها الصقيع مشكلة.

Knapp and Knapp (1978) also reported that number of spikes/m^2 was significantly reduced with later planting. Martinez Carrasoo and Perez (1983) found that early planting increased grain yield mainly because it increased number of grains per head, while Maeztu (1985) found that high grain yield in early planting was due to more heads/m^2. Dewayri (1981) found that decrease in grain yield was associated with decrease in heads per unit area, plant height and kernels per head. Chatha and Quick (1976) found that higher grain yields were related to increased ear or plant density. Anderson (1986) reported that spike production was positively related to grain yield and found a strong positive association between seeds/m^2 and grain yield. He concluded that high grain yield arose from more spikes/m^2. Thill et al. (1978) found that early planted wheat had superior grain yield potential because its rooting system was capable of extracting sufficient soil water during spring and summer to sustain a good plant water status, thus maintaining a greater leaf area during the grain-filling period. Late planting frequently leads to yield reduction due to the onset of high temperature and drought before maturity. Recently, two newly released varieties were proposed to farmers in Algeria. These varieties are phenologically different from Tichedrett. The first, Acsad 176, is a 6-row, early maturing, high-yielding, spring type; the second, Barberousse, a French 6-row variety, is late maturing, semi-winter and high-yielding cultivar; Tichedrett can be seen as an intermediate type between Acsad 176 and Barberousse.

No studies have been conducted in the region to test the hypothesis that early planted barley experiences frost damage. For example, can the adverse effects of early or late planting be offset by choosing the appropriate variety?

Grain yield can also be increased by adopting appropriate planting density. Thus, an understanding of the effects of crop density and location combined with seeding date on plant characters that are thought to be related to grain yield could help in making good recommendations to local farmers.

The objectives of this study were to examine: the expression of grain yield and related components in relation to location, planting date and seeding rate; the relationships between grain yield and its components as affected by planting date; the planting date × cultivar interaction for grain yield over a range of locations.

Materials and Methods

The experiments were undertaken during the growing seasons of 1987/88, 1988/89 and 1989/90 under rain-fed conditions, at the Agricultural Research Station near Setif (1100 m elevation) on the high plateaux of eastern Algeria. The trials were conducted at three locations, namely Rmada (1987/88 to 1989/90), Dahal (1987/88 and 1988/89) and Sersour (1988/89 and 1989/90), making a total of seven environments, hereafter coded as R88, R89 and R90 for Rmada; D88 and D89, and S89 and S90 for Dahal and Sersour, respectively. A split-split plot design was adopted with locations as main plots, planting dates as subplots and seeding rates as sub-subplots. There were three replications. Plots were 1.5 m (6 rows) by 10 m long. Treatments were: sites (as above), seeding dates October (Oct), November (Nov) and December (Dec) combined with three seeding rates: 200, 300 and 400 viable seeds/m^2 (coded R1, R2 and R3, respectively). The study was conducted with the three varieties named above. Trials were fertilized as per the recommendations for the region, and weeds were controlled with 2,4-D. Data were collected on plant stand from three areas of 0.36 m^2 each per plot. The same procedure was followed for head count. Heading date was recorded when 50% of the spikes were fully emerged. Height was measured at maturity and observations of frost damage at heading were made, where appropriate, for each planting date and variety using a 5-point scale (1=no frost damage, 5=no grain set). Complete plots were mechanically harvested to estimate grain yield (GY). Thousand-kernel weight (TKW) was estimated from a seed sample of 250 seeds per plot. Data concerning GY, number of plants and heads, TKW and plant height (PH) measured on three replications were analyzed for each variety separately. Variety comparison was made by an analysis of variance of grain yield with varieties, locations and seeding dates as main factors averaged over seeding rates.

Results and Discussion

Variation in grain yield, yield components and plant characters

Significant differences existed between environments and between planting dates. The interaction environment × date was also highly significant for the five characters analyzed and for the three varieties. Seeding rate played a major role in the number of plants/m^2, heads/m^2 and grain yield, but the effect on TKW and plant height was not consistent and varied with sites (environments) and planting dates. The 2-way and 3-way interactions were significant for some characters but not for others. Overall (averaged over sites, dates and seeding rates) the three varieties had the same number of plants/m^2. The means varied from 199 to 203 plants/m^2. The mean numbers of heads were 254, 238 and 223 for Acsad 176, Tichedrett and Barberousse, respectively.

Tichedrett and Acsad 176 had higher TKW than Barberousse. TKW means were 40.3, 38.6 and 32.9 g. Plant height means were 62 cm for Tichedrett followed by 59.1 cm for Acsad 176 and 58.1 cm for Barberousse. Grain yield was highest for Barberousse with 2.04 t/ha (Table 1).

Variation in the five characters analyzed due to sites and planting dates is also important (Table 1). The differences between low-performing and high-performing environments, averaged over varieties were 90 plants/m^2, 247 heads/m^2, 18.8 g, 28.6 cm and 3.17 t/ha versus 22.6 plants/m^2, 42 heads/m^2, 9.8 g, 11.6 cm and 0.69 t/ha, respectively, for environment and planting date effects. Seeding rate affected numbers of plants and heads, and GY, but not TKW and plant height. The results indicated that after environment, seeding date is the factor which brought more variation in GY and GY components.

Planting date

Averaged over environment and seeding rate, Acsad 176 and Barberousse produced more plants and heads/m^2 and a better TKW on Nov and Dec planting compared to earlier planting. This was also true for Tichedrett for number of heads, but no significant differences were observed between planting dates for plants/m^2 and TKW (Table 2). The differences in grain yield were more important between early and intermediate planting (–0.55 t/ha) and less important between intermediate and late planting (0.05 t/ha). Early planting led to taller plants than intermediate and late planting.

Table 1. Range in environment, planting date and seeding rate main effects, for five characters measured on three barley varieties.

Character	Variety	Location	Planting date	Seeding rate	G. mean
Plants/m^2	Tichedrett	134–243**	195–202ns	140–254**	199
	Acsad 176	157–230**	183–212**	142–240**	202
	Barberousse	160–247**	184–216**	146–250**	203
Heads/m^2	Tichedrett	86–318**	206–245**	197–253**	223
	Acsad 176	91–340**	228–278**	222–286**	254
	Barberousse	98–357**	217–256**	208–266**	238
1000-kernel wt	Tichedrett	35.5–43.7**	39.2–41.5**	40.1–40.3ns	40.26
	Acsad 176	31.0–42.7**	37.0–40.3**	38.5–38.8ns	38.61
	Barberousse	31.2–37.8**	31.7–33.6**	32.8–33.2ns	32.98
Height (cm)	Tichedrett	46.4–92.5**	55.8–69.3**	61.4–62.4ns	62.0
	Acsad 176	54.8–71.5**	54.9–65.6**	60.2–60.9ns	59.3
	Barberousse	48.8–72.1**	53.1–63.6**	57.9–58.4ns	58.1
GY (t/ha)	Tichedrett	0.87–4.08**	1.52–2.09**	1.71–1.87*	1.71
	Acsad 176	1.15–4.15**	1.32–2.14**	1.75–1.84*	1.80
	Barberousse	0.86–4.16**	1.63–2.32**	1.99–2.09*	2.04

*, **, ns: significant at 0.05, significant at 0.01, and not significant at 0.05, respectively.

Table 2. Seeding date main effects for five characters measured on three barley varieties.

Variety	Date	Plants/m²	Heads/m²	TKW	GY	Height
Acsad 176	Oct	183.43 c	228.3 c	37.0 c	13.6 c	65.6 a
	Nov	212.1 a	277.9 a	40.3 a	19.1 b	60.9 b
	Dec	203.8 b	257.6 b	38.6 b	21.4 a	54.9 c
Tichedrett	Oct	195.1 a	205.9 c	39.3 a	15.2 c	69.3 a
	Nov	201.9 a	245.5 a	41.5 a	20.9 a	61.1 b
	Dec	201.6 a	220.9 b	39.9 a	18.2 b	55.8 c
Barberousse	Oct	183.9 c	216.7 c	31.7 c	16.3 c	63.6 a
	Nov	216.3 a	255.5 a	33.6 a	21.6 b	57.8 b
	Dec	208.8 b	243.9 b	33.6 a	23.2 a	53.1 c

Means followed by the same letter are not significantly different (P>0.05).

Table 3. Seeding rate main effects for five characters measured on three barley varieties.

Variety	Rate	Plants/m²	Heads/m²	TKW	GY	Height
Tichedrett	200	140 c	196 c	40.3 a	17.1 b	61 a
	300	204 b	222 b	40.5 a	18.6 a	62 a
	400	254 a	258 a	40.2 a	18.9 a	62.5 a
Acsad 176	200	142 c	222 c	38.9 a	17.5 a	60.3 a
	300	202 b	254 b	38.5 a	18.3 a	60.9 a
	400	250 a	286 a	38.6 a	18.4 a	60.1 a
Barberousse	200	146 c	207 c	32.8 a	19.9 c	57.9 a
	300	208 b	242 b	33.2 a	20.4 b	58.2 a
	400	257 a	266 a	33.0 a	20.9 a	58.4 a

Means followed by the same letter are not significantly different (P>0.05).

Seeding rate

A linear response to seeding rate was shown by plants/m² and heads/m² (Table 3). Plant height and TKW were not affected and grain yield tended to be higher at medium to high rates. The optimum plant population for maximum GY seemed to vary from 126 to 333 plants/m², depending on location and variety. The corresponding head population varied from 92 to 351 heads/m². The correlation coefficients between maximum GY and optimum plant populations, maximum GY and corresponding head populations were 0.062 and 0.156 showing a poor association between plants or heads and GY.

Varieties

Grain yield (GY) was significantly affected by variety and the interactions of varieties with environments. Mean grain yield data for all environments and varieties are shown in Table 4. It can be seen that in low-yielding environments, late planting was more favorable, but in high-yielding environments, early planting was advantageous. The mean environment grain yield was correlated with frost damage. The relationship was negative and highly significant ($r=-0.87$; $P<0.01$) indicating that frost damage at heading was the major factor for lowering yields at early planting.

Table 4. Mean grain yields (t/ha) of three barley varieties sown in seven environments at three seeding dates.

Variety	Date	Environment						
		D.89	R.90	S.90	S.89	R.89	D.88	R.88
ZTichedrett	Oct	3.03	0.10	0.72	1.17	1.56	4.45	0.25
	Nov	2.62	1.82	1.86	1.21	1.15	4.89	1.20
	Dec	2.02	2.03	2.12	0.88	1.48	3.46	1.08
Acsad 176	Oct	2.59	0.09	1.12	0.89	0.57	4.46	0.21
	Nov	2.18	1.97	1.97	0.79	0.86	4.16	1.71
	Dec	2.40	2.31	2.21	0.78	1.53	4.38	1.51
Barberousse	Oct	2.62	0.31	1.64	0.98	0.88	4.58	0.22
	Nov	2.64	2.43	2.72	0.91	1.48	3.63	1.34
	Dec	2.38	2.92	3.07	0.88	2.05	4.06	1.01

Conclusion

Variation in grain yield and its components was greater between locations than between seeding dates or seeding rates within location. Variation between cultivars is also very small giving little justification for repeating this type of study with several varieties.

Early planting led to less plants and heads per unit area and a lower 1000-kernel weight compared to intermediate and late planting. The differences in grain yield and its components were more important between early and intermediate than between intermediate and late planting. A linear response to seeding rates was observed for numbers of plants and heads. Grain yield was slightly higher in intermediate and high seed rates than in low seeding rate. TKW and plant height were not affected by seeding rate. The plant (or head) population leading to maximum grain yield varied from 126 to 333 plants/m^2 (or 92 to 351 heads/m^2). No obvious relationship existed between optimum plant (or head) population and maximum grain yield, indicating that some limiting factors were affecting this relationship. This was probably frost damage which affected the number of grains per head.

The environment × seeding date interaction indicates that in sites or environments where frost is likely to occur, it is best to delay barley planting; while earlier planting is more advantageous in locations free from frost hazard. The variety × date interaction showed that varieties were not all adapted to early planting. Tichedrett preferred intermediate sowing date, Acsad 176 and Barberousse performed better at delayed planting.

It is very difficult to recommend the best seeding date which maximizes barley grain yield in the high plateaux of Algeria, since frost damage cannot be adequately predicted. However, we recommend the November to December period as less risky in areas with frequent frost. Seeding rate can be set at 300 viable seeds/m^2 despite the lack of association between plants/m^2 and grain yield. The best procedures would be to look for and adopt varieties with a good tolerance to frost, as the present study indicates that where frost is not a problem or where a frost-tolerant cultivar is used early seeding offers better prospects; this is especially recommended for regions where drought at the end of the plant cycle is a major problem.

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Nitrogen Fertilization and Seeding Rate of Barley at Diverse Dryland Moroccan Sites

J. Ryan[1], M. Mergoum, M. El Gharous and J.P. Shroyer
INRA/MIAC, Aridoculture Center
P.O. Box 290, Settat, MOROCCO
(USAID Project No. 608-0136)

Abstract

Barley (*Hordeum vulgare* L.) is a dominant cereal in Morocco, occupying over half the land area in the semiarid dryland zone (200-450 mm annual rainfall). Though relatively few farmers fertilize barley, recent research at Settat has shown marked biological and economical responses to nitrogen and, to a lesser extent, phosphorus fertilization. This on-farm trial examined the interaction of N (0, 30, 60, 90, 120 kg/ha) and different seeding rates of Acsad-176 barley (33–165 kg/ha) at two sites with different rainfall (277 and 225 mm). While the optimum seeding rate appeared to be between 99 and 132 kg/ha for both sites, the optimum N rate was higher at the wetter site (90-120 kg/ha) than at the drier site (30-60 kg/ha). Thus, the environment, especially rainfall and soil moisture, should be considered when proposing fertilizer regimes.

Key words: *Hordeum vulgare*; barley; nitrogen fertilizers; phosphate fertilizers; seeding rates; soil water content; Morocco.

[1] Present address: Farm Resource Management Program, ICARDA, P.O. Box 5466, Aleppo, SYRIA.

التسميد الآزوتي ومعدل بذار الشعير في عدة مواقع جافة من المغرب.

الملخص

يعتبر الشعير (*Hordeum vulgare* L.) محصول الحبوب السائد في المغرب بحيث يشغل مايزيد على نصف مساحة المنطقة الجافة شبه القاحلة (200-450مم أمطار سنوية). ورغم قيام عدد قليل نسبياً من المزارعين تسميد الشعير، أظهرت الابحاث التي أجريت مؤخراً في ستات وجود استجابات بيولوجية واقتصادية بارزة للتسميد الآزوتي، وإلى درجة أقل، للتسميد الفسفوري. وقد درست هذه التجربة في حقول المزارعين التاثير المتبادل للآزوت (0، 30، 60، 90، 120 كغ/هـ) ومعدلات مختلفة من البذار لصنف الشعير اكساد-176 (33-165 كغ/هـ) في موقعين يتباين معدل أمطارهما (277 و 255مم). ففي حين ظهر أن معدل البذار الأمثل يتراوح مابين 99 و132 كغ/هـ في كلا الموقعين، كان معدل الآزوت الأمثل أعلى في الموقع الأكثر رطوبة (90-120كغ/هـ) منه في الموقع الأكثر جفافاً (30-60كغ/هـ). لذلك يجب أخذ البيئة بعين الاعتبار، وخاصة الأمطار ورطوبة التربة عند وضع مقترحات لنظم التسميد.

Introduction

Cereals play a dominant role in Moroccan agriculture. Efforts to improve output hinge upon improved varieties and management practices (Shroyer et al. 1990). While the role of fertilizers, especially nitrogen has been amply demonstrated (Abdel Monem et al. 1990; Ryan et al. 1991a) for wheat (*Triticum aestivum* L. ssp. *aestivum*), its importance for other cereals, i.e. barley and triticale (× *Triticosecale* Wittm. ex A. Camus), has also been referred to (Ryan et al. 1991b).

As barley constitutes about 50% of the area devoted to cereals in the low-rainfall zone, fertilization has a major potential impact (Ryan et al. 1990). However, other agronomic factors must be considered for efficient and economic production. In contrast to some areas of the West Asia–North Africa region, most of the barley planting in Morocco is done by hand-broadcasting followed by one pass of a disc harrow which incorporates seed to variable depth, i.e. 0–15 cm. This, combined with poor-quality seed and the absence of chemical seed treatment, produces diverse and erratic stands. To compensate for such losses, farmers generally apply higher seed rates when broadcasting compared to those used with a drill. In many cases, only the roughest approximation of weight and land areas are used.

Excessive seed use can lead to lower net profits for the farmer. However, the little research done using different barley seeding rates has been with a drill and has suggested that there was no difference between 45 and 135 kg seed/ha (Zouttane 1987). Response to N with different seeding rates for barley has not been considered. Thus, this study was designed to examine the possible ranges of N fertilizer and barley seed rates in a relatively favorable and in a stressed environment.

Materials and Methods

As for most fertility-related on-farm trials at the Aridoculture Center, this trial was conducted at the Ben Ahmed road site near Settat, and at a drier site to the south near Skhour Rehamna. The first site represents one of the most common soil types in Chaouia (Petrocalcic Palexeroll) with a mean annual rainfall of 386 mm, and the second is characterized by a similarly shallow soil (Xerorthent). Actual rainfall for the season was lower than normal at Settat (277 mm) and Skhour Rehamna (225 mm). The previous crop at Settat was barley, while the land was fallowed the previous year at Skhour Rehamna. Respective values for $NaHCO_3$-P were 4.0 and 3.1 p.p.m., while those of nitrate-N were 2.8 and 2.0 p.p.m. According to criteria for dryland soils in the region (Ryan and Matar 1990), soils were deficient in N and P and crops were likely to respond to fertilizer application.

As is standard procedure for such trials, and in line with farmers' practice, the site was tilled with an offset disc harrow. As P was not a variable, triple superphosphate was broadcast at 30 kg P/ha. The N treatments were 0, 30, 60, 90 and 120 kg N/ha, applied as ammonium nitrate. Also broadcast by hand was the barley seed (Acsad-176) at rates of 33, 66, 99, 132 and 165 kg/ha, a range that spans that used by farmers. Both fertilizer and seed were then worked into the soil with the disc harrow.

Individual plots were 4 × 5 m. The design was a randomized split plot with N treatments in main plots and seeding rates in sub-plots. Treatments were in triplicate. The planting dates were 30 November (Settat) and 3 December (Skhour Rehamna), while the respective harvest dates were 24 May and 7 June. Weeds at the Settat site were controlled by standard spraying of "Certrol H". The Skhour Rehamna site was essentially weed-free and was, therefore, not sprayed. Harvesting was done by hand-sickle, with whole-plot measurements of total biomass taken. Grain yield was estimated from threshed sub-samples. The grain was analyzed for total N, and assessment of 1000-seed weight was made.

Results and Discussion

While seeding rates and N application rates significantly affected biomass and grain yields of barley, there were no differences in mean yields between the two locations. Average dry-matter yield at Settat was 3.59 t/ha compared with 4.13 t/ha at Skhour Rehamna. While barley yields at Settat are normally much higher than at Skhour Rehamna (Ryan et al. 1991b), the yields observed here should be attributed to the abnormal rainfall during the season. Responses to N differed between the locations, but responses to seeding rates were similar for both locations. It was evident that increasing the seed rate consistently increased yields of grain and biomass at both sites (Table 1). However, yield increases at the two higher seeding rates (132 and 165 kg/ha) were not significantly greater than the 99 kg/ha rate. Nevertheless, the effect of increasing seeding rate was minimal, i.e. less than 20% (Fig. 1), with no difference between sites. Nitrogen had a pronounced effect at both sites. Despite some errant values (Table 1), yields tended to increase with increasing N rate. Indeed, at Settat the effect was significant up to 120 kg/ha, essentially the same as previously reported for

Table 1. Barley yield responses (t/ha) as a function of seeding rate and nitrogen at two locations.

Seeding rate (kg/ha)	Settat		Skour Rehamna		Nitrogen rate (kg/ha)	Settat		Skhour Rehamna	
	Grain	Biomass	Grain	Biomass		Grain	Biomass	Grain	Biomass
33	1.09c	3.29c	1.22c	3.69c	0	0.55d	1.66d	0.99a	2.99d
66	1.10bc	3.35bc	1.31bc	3.98bc	30	1.11c	3.35c	1.31c	3.91c
79	1.19abc	3.63abc	1.39ab	4.21ab	60	1.07c	3.30c	1.66a	5.03a
132	1.25ab	3.86ab	1.43a	4.34a	90	1.40b	4.25b	1.49b	4.52b
165	1.27a	3.31ab	1.45a	4.41a	120	1.77a	5.36	-	-

barley and triticale (Ryan et al. 1991b). The relative differences between sites are depicted in Fig. 1. For example, at Settat, maximum relative biomass increases of 255 and 220% occurred with the 90 and 120 kg N/ha rates, respectively. Corresponding increases for Skhour Rehamna were lower, being 21, 67 and 50% for the 30, 60 and 90 kg N/ha rates, respectively.

Yield data (Fig. 2) suggest a differential N response according to seed rate, the N response being accentuated at higher seed rate. However, this N x seed rate interaction was not significant at the 5% level. There was no obvious effect of seeding rate on grain N content (Fig. 3), while N tended slightly to increase grain N content at Skhour Rehamna. The effects, however, were not significant at either site. Grain weight ranged from 37 to 40 g per 1000 seeds and showed no relationship with either N or seeding rate.

Conclusions

This brief study corroborated other studies from the semi-arid area of Morocco (Zouttane 1986, 1987) which showed little influence of seeding rate, within the range 40-150 kg/ha, on yield parameters. Though no exact measurements of tillering were made in our trial, it was evident that the lower seed rates were compensated for by increased tillering. It is safe to conclude that there is little point in exceeding the 100 kg/ha rate with broadcast barley. Similarly, N rates of up to 120 kg/ha may be justified in the more favorable zone, and considerably lower rates, i.e. 30–60 kg N/ha, in the drier (<300 mm rain/year) areas. Combining appropriate N levels with adequate amounts of seed seems a recipe for optimum and, probably, economic production. The question whether the low levels of fertilization appropriate for dryland areas would have any serious impact on N content or nutritional quality of barley grain is subject to further investigation.

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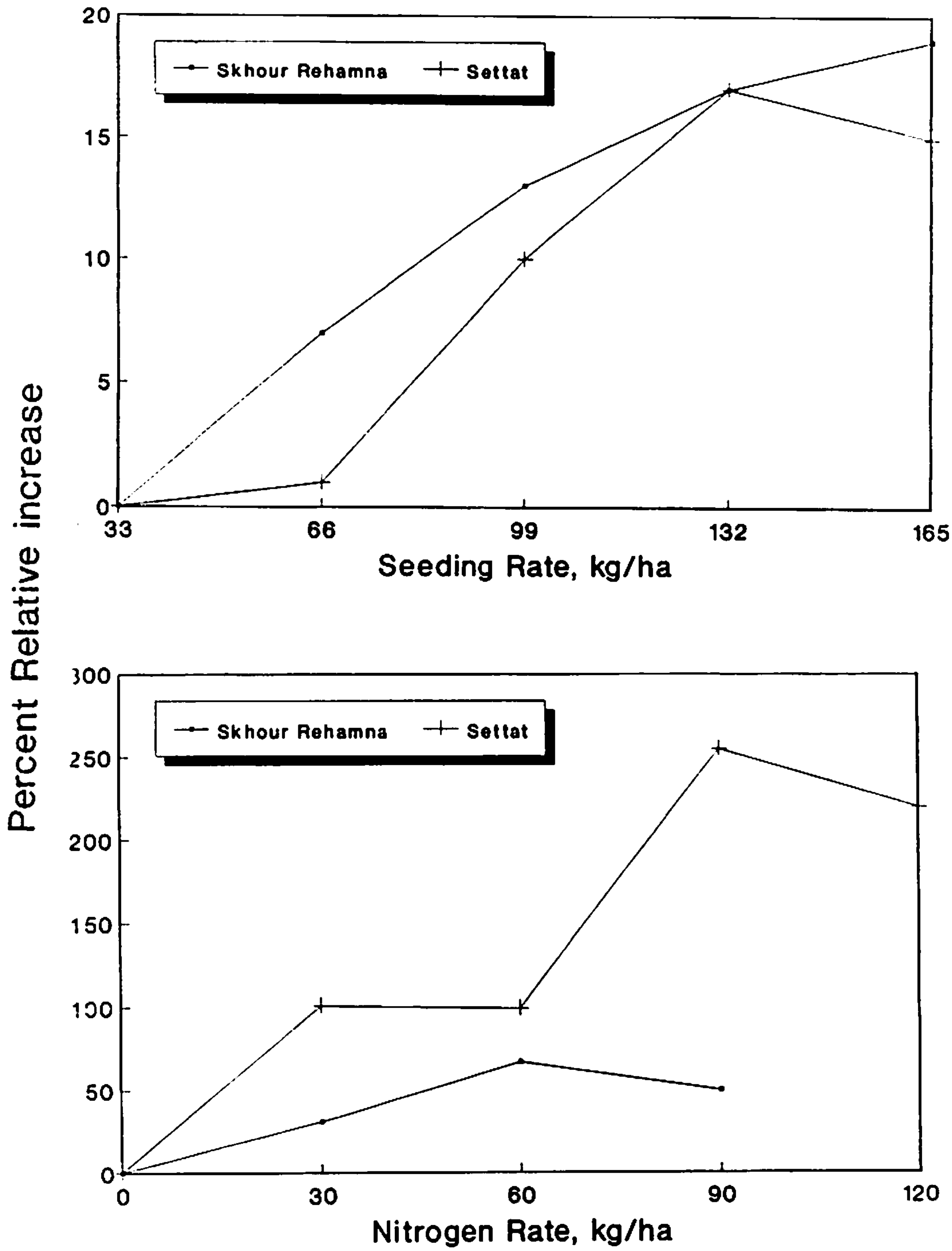

Fig. 1. Relative percentage response of barley biomass yields in relation to nitrogen application and seeding rates at two locations.

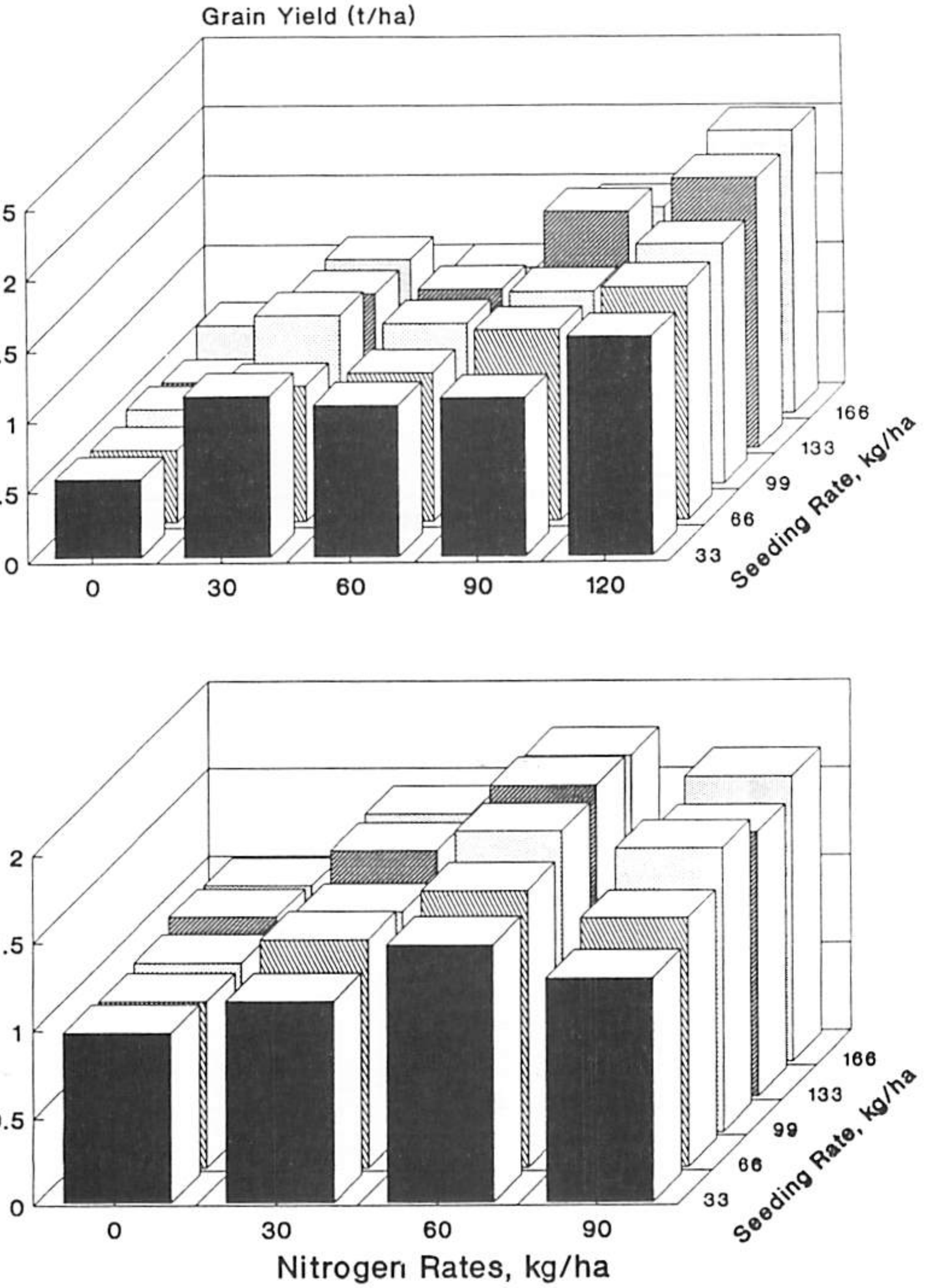

Fig. 2. Yield response at varying nitrogen application and seeding rates for barley.

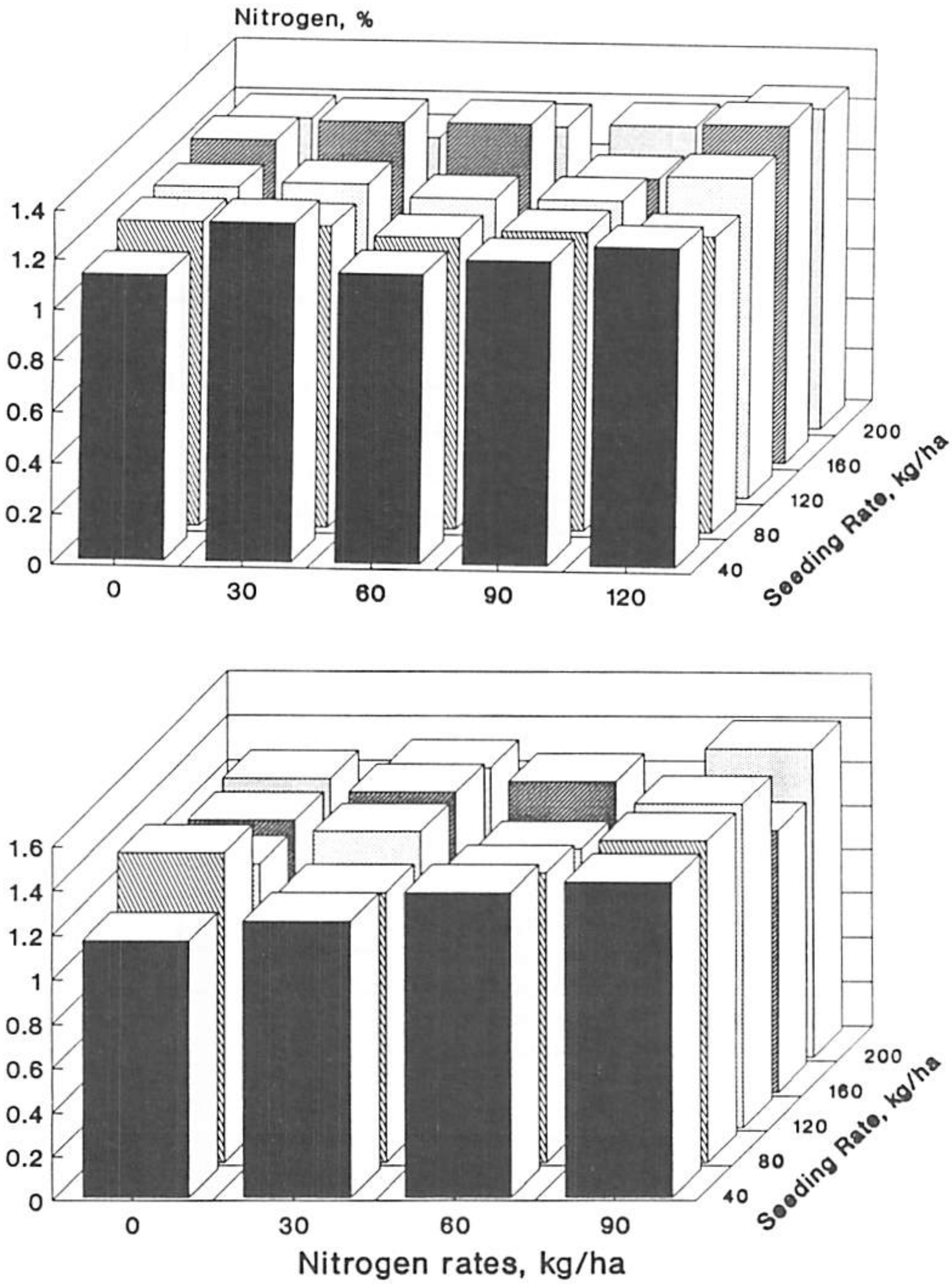

Fig 3. Grain nitrogen percentage as influenced by nitrogen fertilization at different seeding rates.

Variability, Heritability, Genetic Advance and Correlation Study in some Quantitative Characters in Durum Wheat

M.R. Amin, N.C.D. Barma and M.A. Razzaque
Wheat Research Centre
Nashipur, Dinajpur
BANGLADESH

Abstract

Genetic parameters and correlations were studied in 21 genotypes/varieties of durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) to determine the available variability and association among yield and its components. Significant differences were observed in the genotypes for all the characters studied. The genotypic co-efficient of variation was highest for grain yield followed by harvest index and grains per spike. Heritability estimates in broad sense showed high value for days to anthesis, grain yield and harvest index, while it was moderate for 1000-grain weight and biological yield. High heritability and appreciable genetic advance for grain yield and harvest index indicated the predominance of an additive gene effect in controlling these traits. The correlation study revealed significant positive correlation of grains/spike and harvest index with grain yield. These findings suggest the importance of grains/spike and harvest index for ultimate yield improvement of durum wheat.

Key words: *Triticum durum*; hard wheat; heritabilty; genetic variation; genotypes; yields; harvest index; grain; spikes; Bangladesh.

التباين وقابلية التوريث والتقدم الوراثي ودراسة الارتباط في بعض الصفات الكمية في القمح القاسي.

الملخص

تمت دراسة المعايير والارتباطات الوراثية في 21 طرازاً وراثياً / صنفاً من القمح القاسي (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) لتحديد التباين والتلازم الموجودين بين الغلة ومكوناتها. لوحظت فروقات معنوية في الطرز الوراثية بالنسبة لجميع الصفات المدروسة، إذ كان مُعامل التباين للطراز الوراثي، الأعلى بالنسبة للغلة الحبية تلاها دليل الحصاد وعدد الحبات في كل سنبلة. أظهرت تقديرات قابلية التوريث بالمعنى الواسع قيمة كبيرة لعدد الأيام حتى الإزهار، والغلة الحبية، ودليل الحصاد في حين كانت متوسطة القيمة بالنسبة لوزن الألف حبة والغلة البيولوجية. أشارت قابلية التوريث العالية والتقدم الوراثي المرغوب في مجالي الغلة الحبية ودليل الحصاد إلى تأثير هيمنة أي مورثة ذات أثر متجمع في التحكم بهذه الصفات. كشفت دراسة الارتباط عن وجود ارتباط إيجابي كبير بين الحبات/سنبلة ودليل الحصاد وبين الغلة الحبية. وتوحي هذه النتائج بأهمية الحبات/سنبلة ودليل الحصاد في تحسين غلة القمح القاسي في آخر الأمر.

Introduction

Genetic variation for economically important traits and the extent to which the desirable characters are heritable is an essential prerequisite for successful breeding of crop species.

This information on the nature and magnitude of variability and heritability in a population owing to genetic and non-genetic factors is one of the prerequisites in any breeding program for selecting genotypes with desirable characters (Dudley and Moll 1969). Hence, it is essential to divide the observed variability into its heritable and non-heritable components. The present investigation was, therefore, undertaken to estimate the genetic variability, heritability and genetic advance in durum wheat.

Materials and Methods

The trial consisted of 21 entries supplied from ICARDA. Stork and Cham 1 were used as checks. The experiment was conducted under irrigated conditions at the Wheat Research Centre, Nashipur, Dinajpur during the *rabi* (winter) season of 1989/90. The experiment was laid out in randomized complete block design and replicated thrice. Plot size was 4.5 m^2. Seeds were solid seeded in rows 30 cm apart at the rate of 130 kg/ha. Fertilizers were applied at the rate of 100, 60, 40 and 20 kg/ha – N, P, K and S respectively. Data were recorded for days to anthesis (50%), spikes/m^2, grains/spike, 1000-grain weight, grain yield, biological yield, harvest index and grain filling period. Grain yield and biological yield were recorded from 2.5 m of the middle 4 rows (3 m^2).

Mean values were used for statistical analysis. The co-efficients of variation, heritability and genetic advance were worked out using the formulae of Burton and De Vane (1953), Hanson et al. (1956) and Johnson et al. (1955), respectively.

Results and Discussion

Significant differences were observed in the genotypes of durum for all characters studied (Table 1). The genotypic co-efficient of variation was highest for grain yield, followed by harvest index and grains per spike (Table 2). Lowest genotypic co-efficient of variation was exhibited by days to anthesis, followed by spikes/m^2 and grain filling period. The rest of the characters showed moderate magnitude of genotypic co-efficient of variation. Those characters showing comparatively high genetic co-efficient of variation may respond favorably to selection (Debnath 1987). The phenotypic co-efficient of variation was highest for grains/spike and lowest for days to anthesis. Except grains/spike, characters showed little differences in genotypic and phenotypic co-efficient of variation indicating less environmental influence on them. Large differences for grains/spike indicate a large environmental influence.

Heritability estimates in broad sense (Table 2) showed high value for days to anthesis, grain yield and harvest index, indicating that these characters were predominantly controlled by genetic factors. Moderate heritability was shown by 1000-grain weight and biological yield. The heritability values were low for spikes/m^2, grains/spike and grain filling period. Although heritability estimates

Table 1. Analysis of variance for grain yield and some other traits in durum wheat.

Source of variation	df	Days to anthesis	Spikes/ m^2	Grains/ spike	1000-grain wt (g)	Grain yield (g/plot)	Biological yield (kg/plot)	Harvest index	Grain-filling period (days)
Replication	2	61.40**	1126.3 ns	17.50 ns	17.18*	833.33 ns	0.213**	0.004**	23.30**
Genotypes	20	70.82**	1863.7*	157.86**	72.44**	69,178.57**	0.354**	0.013**	33.68**
Error	40	2.75	828.9	56.54	8.10	3,864.58	0.045	0.001	11.34

* P = 0.05, ** P = 0.01.

Table 2. Estimates of genetic parameters for grain yield and some quantitative traits in durum wheat.

Characters	Range	Mean ± SE	Coefficient of variation		Heritability	Genetic advance (% over mean)
			Genotypic	Phenotypic		
Days to anthesis	75.33 – 95.00	82.02 ± 0.93	5.81	6.15	89.19	11.29
Spikes/m^2	267.67 –370.33	309.17 ± 16.23	6.00	11.06	29.39	6.70
Grains/spike	7.87 – 35.43	20.98 ± 4.23	27.69	45.29	37.39	34.38
1000-grain weight (g)	42.23 – 65.50	56.56 ± 1.60	8.19	9.61	72.58	14.38
Grain yield (g/plot)	116.67 –791.67	470.24 ± 35.03	31.38	34.05	84.93	59.57
Biological yield (kg/plot)	1.62 – 3.12	2.32 ± 0.12	13.81	16.56	69.59	23.45
Harvest index	0.05 – 0.32	0.21 ± 0.02	30.85	34.49	80.00	57.07
Grain-filling period (days)	35.67 – 48.67	42.56 ± 1.90	6.41	10.18	39.65	8.31

Table 3. Correlation coefficients among different characters of durum wheat.

	Spikes/ m²	Grains/ spike	1000-grain wt (g)	Grain yield (g/plot)	Biological yield (kg/plot)	Harvest index	Grain-filling period (days)
Days to anthesis	0.370	0.244	-0.628**	0.025	0.710**	-0.332	-0.640**
Spikes/m²		-0.332	-0.218	-0.299	0.324	-0.443*	0.049
Grains/spike			-0.561*	0.447*	0.086	0.332	0.539
1000-grain wt (g)				-0.411	-0.647**	-0.074	0.407
Grain yield (g/plot)					0.208	0.853**	-0.104
Biological yield (kg/plot)						-0.306	-0.128
Harvest index							-0.035

* = Significant at 0.05, ** = Significant at 0.01.

provide the basis for selection on phenotypic performance, Johnson et al. (1955) suggest that estimates of heritability and genetic advance should always be considered simultaneously because high heritability will not always associate with high genetic advance. Swarup and Chaugale (1962) also report that high heritability is not an indication of high genetic advance. According to Panse (1957), high heritability associated with equally high genetic advance is mainly due to the additive gene effect, but if the heritability is due to dominance and epistasis, the genetic gain would be low. The present study revealed that grain yield and harvest index were predominantly controlled by additive gene effect.

In correlation study (Table 3), grain yield was significantly and positively correlated with grains/spike (0.447*) and harvest index (0.853**). A similar association between harvest index and grain yield is reported by Sharma and Smith (1986) and Shamsuddin (1990) in durum wheat. Days to anthesis had significant positive correlation with biological yield (0.710**), but significant negative correlations with 1000-grain weight (-0.628**) and grain filling period (-0.640**). Number of spikes/m² had significant negative correlation with harvest index (-0.443*). The correlation of grains/spike was negative with 1000-grain weight (-0.561*), but positive with grain-filling period (0.539*). The results indicate that increase in grain number/spike reduced grain weight, while longer grain-filling period increased number of seeds per spike. Thousand-grain weight was negatively associated with biological yield (-0.647**).

The results of the present study suggest that substantial genetic variability was observed among the genotypes/varieties for the characters studied and selection is likely to be useful in improving characters like grains/spike and harvest index for improving grain yield.

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Seedling Characteristics as Selection Criteria for Salinity Tolerance in Wheat

Mossad Muhammad Mahmoud Abdel-Aleem, Sami Reda Saber Sabry and Nabil Soliman Hanna
Wheat Research Department
Field Crop Research Institute
ARC, Giza, EGYPT

Abstract

Breeders lack sufficient information on early selection criteria for salinity tolerance at the seedling stage in wheat (*Triticum aestivum* L. ssp. *aestivum*).The objective of this study was to assess and compare the effect of four salinity levels (control, 7, 14 and 21 mmhos/cm) on different seedling characteristics (germination percentage, root length, shoot length, coleoptile length and seedling leaf area). The experiment was conducted in the laboratory in pots. Germination percentage was studied on 26 bread wheat genotypes. Seven of these cultivars exhibited less than 50% germination at 21 mmhos/cm compared to the control and were eliminated due to poor performance under saline conditions. Thus, the remaining characteristics were studied for 19 genotypes. The results indicated significant differences among genotypes averaged over the four salinity levels. There were also significant differences among genotypes at the highest salinity level (21 mmhos/cm) for root length, shoot length, coleoptile length and seedling leaf area. Increasing salinity levels significantly decreased the studied characteristics averaged over all genotypes. Analysis of variance showed significant genotype × salinity level interaction. This indicates that genotypes responded differently across salinity levels.

Key words: *Triticum aestivum*; soft wheat; salt tolerance; seedlings; salinity control; germination; stems; roots; coleoptiles; leaf area; genotypes; genetic variation; Egypt.

خصائص البادرة كمعايير انتخاب لصفة تحمل الملوحة في القمح.

الملخص

يفتقر المربون إلى معلومات كافية عن معايير انتخاب مسبقة لصفة تحمل الملوحة في طور البادرة في القمح (*Triticum aestivum* L. spp. *aestivum*)وتهدف هذه الدراسة إلى تقييم ومقارنة تاثير أربعة مستويات من الملوحة (الشاهد، 7، 14، 21 مليموز/سم) على مختلف خصائص البادرة (النسبة المئوية للإنبات، طول الجذر، طول الفرع، طول الغمد، ومساحة ورقة البادرة). أجريت التجربة في أصص في مختبر ودرست النسبة المئوية للإنبات في26 طرازاً وراثياً من القمح الطري. استبعدت سبعة من هذه الأصناف التي كانت نسبة انباتها أقل من النسبة 50٪ عند 21 مليموز/سم مقارنة بالشاهد بسبب تدني كفاءتها تحت ظروف الملوحة. وهكذا درست باقي الخصائص في 19 طرازاً وراثياً. دلت النتائج على وجود فروق معنوية بين الطرز الوراثية عند كل مستوى من مستويات الملوحة الأربعة، كما كانت هناك فروقات معنوية بين الطرز الوراثية عند أعلى مستوى للملوحة (21 مليموز/سم) بالنسبة لطول الجذر، وطول الفرع، وطول الغمد ومساحة ورقة البادرة. لقد أدى تزايد مستويات الملوحة إلى تخفيض الخصائص المدروسة في جميع الطرز الوراثية. إلى حد كبير. وأظهر تحليل التباين تفاعلاً كبيراً بين الطراز الوراثي x مستوى الملوحة. وهذا يشير إلى أن الطرز الوراثية استجابت بصورة مختلفة ضمن كل مستوى من الملوحة.

Introduction

Increasing wheat production under abiotic stress conditions (drought, salinity and heat) has become important in recent years, since wheat production in areas with optimum growing conditions does not meet the needs of the increasing population. Soil and water salinity drastically affects wheat production. Kuruvadi (1988) and Alam et al. (1989) studied the effect of saline solutions on wheat seedlings and conclude that increasing salinity level reduces germination percentage, and shoot and root lengths. Allan et al. (1965), Chowdhry and Allan (1966), Roy et al. (1969) and Kuruvadi (1988) indicate that coleoptile length is important and could protect the apical meristem under stress conditions. Other investigators (Ansari et al. 1987; Tarrad et al. 1988) studied the response of wheat to different saline solutions in different soils. Ehsan et al. (1986) studied salt tolerance of three wheat cultivars and found that Lyallpur 73 gave higher average grain yield than Chenab 70 and V5444. The objective of this work was to assess and compare the range of variation of different seedling characteristics for future use as selection criteria in breeding wheat for tolerance to salinity.

Materials and Methods

Twenty-six bread wheat genotypes (Table 1) were grown in 12-cm diameter pots in the laboratory. Pots were filled with well-washed sandy soil, and sown with ten seeds. The pots were arranged in a split plot design in three replications with the genotypes in the main plots and salinity levels in the subplots. Plots were irrigated with four different saline solutions as follows:

(i) Control, Hogland solution (2.5 mmhos/cm);
(ii) 7 mmhos/cm solution, Hogland solution + saline solution to reach 7 mmhos/cm;
(iii) 14 mmhos/cm solution, Hogland solution + saline solution;
(iv) 21 m mohs/cm solution, Hogland solution + saline solution.

The saline solution added to the Hogland solution was composed of sodium chloride, calcium chloride and magnesium chloride in the ratio 1:1:1. Plants were irrigated every seven days to avoid other stress effects. After 15 days, germination percentage was calculated. Genotypes with less than 50% germination in 21 mmhos/cm (Table 2) were eliminated. Sand was washed from seedlings and root length, shoot length, coleoptile length and seedling leaf area measured. Roots were measured from the stem base to the maximum length. Shoots were measured from the base of shoot to the tip. Coleoptile length was measured from its base to its tip. Leaf area of seedling leaves was measured using a leaf area meter.

Analysis of variance of germination percentage was performed for each salinity level. In addition, other studied characteristics analysis of variance took genotypes and salinity level in consideration.

Table 1. List of bread wheat genotypes.

Entry No.	Genotype
1	Sakha 69
2	Giza 163
3	Giza 164
4	Sakha 8
5	Sakha 92
6	Gemmieza 1
7	Giza 156
8	Sinai 1
9	Giza 155
10	Giza 157
11	Giza 160
12	Sakha 61
13	Giza 155
14	Wrb "s" / Vee "s"
15	HD 2206 / Hork "s"
16	Vee "s" / Ckr "s"
17	HD 2172 / Pavon "s" // 1158.57 / Maya "s"
18	Vee "s" / Bow
19	Kauz "s"
20	Ures / Bow "s"
21	Au / Up 301 // G11 / Sx /3/ Pew "s" /4/ Mai "s" / Maya "s" // Pew "s"
22	Ttr "s" / Bow
23	Nac / Vee "s"
24	Giza 165 // Maya "s" / Saka
25	Giza 156 / Chukar "s"
26	Her / Sap "s" // Vee "s"

Entries 1 to 13 Egyptian commercial cultivars.
Entries 14, 17, 22, 24, 25 Egyptian breeding material.
Entries 15, 16, 18, 19, 29, 21, 23, 26 selected from CIMMYT material.

Results and Discussion

Genotypes 21, 22, 23 and 25 had the highest significant germination percentage (Table 2) averaged over the four salinity levels. Genotypes 21, 22 and 23 also recorded the highest germination under 21 mmhos/cm salinity. Genotypes 9, 10, 12, 14, 15, 16 and 17 were among the low germination-percentage group, they were also significantly ($P<0.05$) the poorest germinators under 21 mmhos/cm salinity. The low germination percentage of those seven genotypes could be attributed to their sensitivity to high salinity during germination. High salt concentration in the soil increases the osmotic potential of the soil solution and causes seeds to use more energy to absorb water from the soil and hence fail to germinate.

Table 2. Germination percentage of wheat genotypes under different salinity levels.

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
1	97.67	80.00 (82.76	56.67 58.62	53.33 55.17)†	71.67
2	80.00	73.33 (91.66	86.67 108.34	63.33 79.16)	75.83
3	80.00	73.33 (91.66	73.33 91.66	63.33 79.16)	72.50
4	100	96.67 (96.67	93.33 93.33	73.33 73.33)	90.83
5	83.33	90.00 (108.00	76.67 92.01	73.33 88.00)	80.83
6	96.67	90.00 (93.10	83.33 86.20	63.33 65.51)	83.33
7	83.33	76.67 (92.01	66.67 80.01	53.33 64.00)	70.00
8	96.67	96.67 (100	83.33 86.20	73.33 57.86)	87.50
9	96.67	93.33 (96.55	70.00 70.00	23.33 23.33)**	70.83
10	96.67	80.00 (82.76	66.67 68.97	6.67 6.90)**	62.50
11	83.33	96.67 (116.01	73.33 88.00	56.67 68.01)	77.50
12	100	80.00 (80.00	83.33 83.33	46.67 46.67)**	77.50
13	93.33	90.00 (96.43	93.33 100	70.00 75.00)	86.67

Table 2. Germination percentage of wheat genotypes under different salinity levels (cont.).

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
14	93.33	100	73.33	3.33	67.50
		(107.15	78.57	3.57)**	
15	100	100	90.00	20.00	77.50
		(100	90.00	20.00)**	
16	100	96.67	86.67	46.67	82.50
		(96.67	86.67	46.67)**	
17	100	96.67	90.00	26.67	78.33
		(96.67	90.00	26.67)**	
18	96.67	93.33	90.00	60.00	85.00
		(96.55	93.10	62.07)	
19	100	93.33	93.33	80.00	91.83
		(93.33	93.33	80.00)	
20	76.67	90.00	90.00	63.33	80.00
		(117.39	117.39	82.60)	
21	93.33	83.33	80.00	86.67	85.83
		(89.29	85.72	92.86)	
22	96.67	93.33	96.67	93.33	95.00
		(96.55	100	96.55)	
23	93.33	100	86.67	80.00	90.00
		(107.15	92.86	85.72)	
24	93.33	83.33	80.00	53.33	77.50
		(89.29	85.72	57.14)	
25	96.67	96.67	100	70.00	90.83
		(100	103.45	72.41)	
26	93.08	90.00	96.67	63.33	87.50
		(96.69	103.86	68.04)	
Mean	93.08	90.00	83.08	56.41	80.64
		(96.69	89.26	60.60)	
LSD 5%	12.15	14.40	21.80	27.96	9.79
LSD 5% for saline solutions (over all cultivars)					1.92

† Figures in parentheses show percentages of control.

** Cultivars with less than 50% germination, not used in later experiments.

Genotypes 18, 23, 24 and 25 had the longest roots averaged over the four salinity levels. Genotypes 18, 20, 22 and 25 had the longest roots under 21 mmhos/cm salinity (Table 3). Root length could indicate big root size. Long roots might increase seedling ability to absorb water from high salinity soils.

Table 3. Maximum root length (cm) of wheat genotypes as affected by salinity levels.

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
1	6.74	6.08	4.34	3.32	5.12
2	6.09	5.26	4.32	3.27	4.73
3	7.03	5.87	4.25	3.37	5.13
4	7.35	5.97	4.84	3.72	5.47
5	7.25	6.81	5.01	4.24	5.83
6	7.02	6.47	4.34	3.14	5.24
7	6.24	5.81	5.35	3.25	4.16
8	6.49	6.11	4.13	3.67	5.15
11	8.40	8.39	6.38	4.90	7.02
13	6.81	7.31	8.20	4.63	6.74
18	18.24	18.86	16.34	13.08	16.63
19	17.74	17.43	13.76	6.69	13.90
20	21.01	19.02	16.22	11.33	16.90
21	18.36	18.40	15.75	10.07	15.65
22	17.65	17.30	15.68	11.79	15.61
23	19.17	19.33	17.91	7.86	16.07
24	17.42	19.23	16.61	11.30	16.14
25	18.13	18.51	18.31	13.57	17.13
26	16.42	18.21	15.86	10.12	15.15
Mean	12.29	12.12	10.40	7.02	10.46
LSD 5%	Cultivars: 1.02		Salinity: 0.25		C × S: 1.09

Genotype 22 had long shoots and the largest seedling leaf area under 21 mmhos/cm salinity (Tables 4 and 5). Long shoots and large seedling leaf area indicate possible high photosynthesis rate under high salinity level.

Table 4. Shoot length (cm) of wheat genotypes as affected by salinity levels.

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
1	15.11	11.76	5.34	1.18	8.35
2	10.67	9.70	7.10	1.81	7.32
3	11.69	9.38	3.44	2.03	6.64
4	13.00	10.35	6.61	2.98	8.24
5	12.08	9.65	6.16	2.30	7.55
6	12.40	8.59	4.75	1.45	6.80
7	12.03	8.62	4.57	1.09	6.58
8	15.16	12.36	5.36	1.77	8.66
11	15.30	15.02	7.31	3.41	10.26
13	12.97	14.38	9.43	2.76	9.88
18	17.50	17.60	15.31	8.61	14.75
19	16.10	16.11	14.53	8.23	13.74
20	16.78	17.11	16.96	8.33	14.80
21	15.93	15.64	14.62	9.83	14.00
22	16.63	17.94	13.55	9.27	14.35
23	16.27	17.24	14.62	7.55	13.92
24	16.27	17.32	13.63	5.69	13.23
25	17.07	18.26	15.89	9.25	15.12
26	15.98	16.42	13.79	8.15	13.59
Mean	14.68	13.87	10.16	5.04	10.93
LSD 5%	Cultivars: 1.14		Salinity: 0.29		C × S: 1.24

Table 5. Seedling leaf area (cm^2) of wheat cultivars as affected by salinity levels.

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
1	33.38	15.45	4.78	0.40	13.50
2	18.13	11.34	10.76	1.31	10.38
3	22.02	12.72	3.00	1.61	9.84
4	32.06	17.79	10.08	2.54	15.62
5	18.12	19.47	7.43	1.40	11.61
6	24.47	13.95	6.63	1.52	11.64
7	20.84	12.81	5.15	1.10	9.98
8	22.25	15.26	6.34	1.74	11.40
11	37.49	34.71	10.16	1.90	21.06
13	25.97	26.04	16.88	2.80	17.92
18	37.61	34.93	22.37	7.87	25.70
19	36.99	29.90	23.69	10.76	25.34
20	31.42	30.13	25.37	10.79	24.43
21	33.15	29.52	23.83	15.14	25.41
22	42.54	38.13	26.66	23.50	32.71
23	45.20	37.55	23.45	10.49	29.18
24	31.82	32.42	24.76	6.87	23.97
25	47.60	36.16	29.59	11.96	31.33
26	33.61	38.62	30.38	8.03	27.66
Mean	31.30	25.63	16.38	6.41	19.93
LSD 5%	Cultivars: 4.62		Salinity: 0.97		C × S: 4.25

Genotypes 22 and 25 had significantly the longest coleoptiles, both overall and under 21 mmhos/cm salinity (Table 6). Genotypes 3, 5 and 6 had the shortest coleoptiles overall and under 21 mmhos/cm salinity. The long coleoptile could protect the apical meristem region from environmental hazards and could be an important characteristic in breeding for salinity tolerance.

Increasing salinity level from control to 21 mmhos/cm significantly decreased all studied characteristics averaged over all cultivars. Analysis of variance showed significant genotype × salinity level interaction for all the characteristics which indicates that genotypes respond differently to increased salinity.

It appears from the results that there are significant differences among genotypes for germination percentage, root length, shoot length, coleoptile length and seedling leaf area. Genotypes could be grouped into two groups (high and low) for each of the mentioned characteristics. Also, there was a wide range of variation for each trait. The significant differences between genotypes under the four salinity levels, the wide range of variation within each salinity level, and the significant genotype × salinity level interaction are important signals for potential use of the studied characteristics as selection criteria for salinity tolerance at the seedling stage. This might save breeders time in the future as they can screen a large number of genotypes at the seedling stage.

Table 6. Coleoptile length (cm) of wheat genotypes as affected by salinity levels.

Entry No.	Salinity (mmhos/cm)				
	Control	7	14	21	Mean
1	3.51	3.75	3.41	2.09	3.19
2	2.93	2.84	2.65	2.12	2.64
3	2.92	3.10	2.34	1.89	2.56
4	3.07	3.20	3.17	2.33	2.94
5	3.07	3.24	3.06	1.71	2.77
6	2.59	3.22	2.65	1.65	2.53
7	4.14	3.68	3.74	1.59	3.29
8	4.44	4.02	3.43	2.82	3.63
11	3.37	3.49	3.35	2.45	3.17
13	3.08	3.13	3.04	2.33	2.89
18	2.84	2.86	2.91	2.47	2.77
19	2.64	2.89	3.98	2.51	3.01
20	2.74	3.05	3.23	3.26	3.07
21	2.40	2.85	2.84	2.57	2.67
22	3.76	3.72	3.69	3.31	3.62
23	2.71	2.99	2.91	2.87	2.87
24	3.28	3.59	3.47	2.67	3.26
25	3.62	3.43	3.69	3.20	3.49
26	2.74	3.01	3.61	2.53	2.98
Mean	3.14	3.27	3.22	2.44	3.02
LSD 5%	Cultivars: 0.36		Salinity: 0.07		C × S: 0.30

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Four New Durum Wheat Cultivars for Cyprus

C.M. Josephides
Agriculture Research Officer
Agricultural Research Institute
Nicosia, CYPRUS

Abstract

The registration of four new durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) cultivars, which originated from the National Hybridization Program and named Cyprus 1, Cyprus 2, Cyprus 3 and Cyprus 4, aims to provide durum breeders with high-yielding, early maturing, high carotene content and strong gluten alternative durum wheat cultivars to Karpasia, the most widely grown cultivar in the region at present. Foundation seed is available from the Agricultural Research Institute, Nicosia, Cyprus.

Key words: *Triticum durum*; hard wheat; yields; maturity; carotenoids; gluten; varieties; Cyprus.

أربعة أصناف جديدة من القمح القاسي لزراعتها في قبرص.

الملخص

يهدف تسجيل أربعة أصناف جديدة من القمح القاسي (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) قام باستنباطها برنامج التهجين الوطني تحت أسماء قبرص 1 وقبرص 2 وقبرص 3 وقبرص 4، إلى تزويد مربي القمح القاسي بأصناف من القمح القاسي مغلالة، ومبكرة النضج، وذات محتوى عالي من الكاروتين وغلوتن قوي كبديل للصنف كارباسيا الذي يزرع حالياً على نطاق واسع جداً في قبرص. ويتوفر حالياً البذار الأساس من هذه الأصناف في معهد البحوث الزراعية في نيقوسيا، بقبرص.

Introduction

Cyprus 1, 2, 3 and 4 are new durum wheat cultivars adapted to Cyprus conditions developed by the Agricultural Research Institute through its national hybridization program and breeding methodology. They are high yielding, early maturing, lodging resistant with good grain-quality characteristics and excellent carotene content and gluten strength.

Hybridization and selection

The cultivars Cyprus 1 and 2 are sister lines and originated from the cross of Lloyd (the currently grown cultivar at North Dakota, USA) with Karpasia[1] (the commercially grown cultivar in Cyprus). Cultivars Cyprus 3 and 4 are also sister lines and they originated from the cross of Edmore (another North Dakota cultivar) with Karpasia.

Both crosses were made at the Agricultural Research Institute in 1984 and the F_1 was propagated to F_2 seed at the ICARDA summer nursery. Each F_2 population was planted as a bulk in the fall of the same year and individual heads were selected the following spring. Seed from these heads was planted in head rows in the fall of 1985 in a fertile soil with supplementary irrigation. Selected lines were screened for grain-quality characteristics, carotene content and gluten strength. Selected lines were tested for yield in a simple lattice design trial in 1988. Five to ten heads from each F_4 line were picked before harvesting. Individual heads from selected lines were planted in head rows in the fall of 1987, and further selection was made in the spring of 1988. Selected lines were planted in a preliminary yield trial in the fall of 1988. In the last two growing seasons (1989/90–1990/91) they were evaluated, together with other cultivars, in the multi-environmental testing program of the Agricultural Research Institute (total of 13 environments).

The elite lines with the designations, Lloyd/KIA CYD 84-313-52D-OP-2M-OP, Lloyd/KIA CYD84-313-52D-OP 10M-OP, EDM/KIA CYD-84-330-29D-OP-3M-OP and EDM/KIA CYD-84-330-29D-OP-6M-OP were named Cyprus 1, Cyprus 2, Cyprus 3 and Cyprus 4, respectively.

[1] Karpasia = KIA = WAHA = CELTA = CTA = Cham 1 = PLC "S"/RUFF "S"//GTA "S"/D-6715 CM 17904-B-3M-1Y-1Y-OM.

Grain yield performance

The newly developed durum wheat cultivars exhibited consistently good grain yield, as indicated by their mean yield and their stability parameters (Table 1). Data from yield trials in 13 different environments during the last two growing seasons (1989/90–1990/91) showed that the grain yields of new cultivars Cyprus 1, 2, 3 and 4 were 100, 102, 105 and 102% that of the currently commercially grown cultivar, Karpasia. Furthermore, the average yield response of all new cultivars in the different environments was close to 1 (Table 1).

A desirable, widely adapted cultivar should have a regression coefficient (average yield response to several environments) close to or larger than 1. A regression coefficient larger than 1 may indicate either a better than average response to high-yield environments or a worse than average response to low-yield environments. Thus, inspection of the regression of the new cultivars with that of Karpasia shows that the cultivar Cyprus 1 had a slightly better response in low-yielding environments and worse in high-yielding environments than Karpasia (Fig. 1). Conversely, Cyprus 4 had a slightly worse response in low-yielding and better response in high-yielding environments than Karpasia (Fig. 2). Cyprus 2 had similar yield response in low-yield environments and better than Karpasia in the high-yielding environments (Fig. 1). Cyprus 3 had a better average response than Karpasia in all environments (Fig. 2).

Agronomic characteristics

Agronomic characteristics of the new cultivars relative to local durum wheat cultivars, Kyperounda, Aronas and Karpasia, are summarized in Table 2. The new cultivars are intermediate in plant height at maturity. Cyprus 1 and 2 are slightly taller and Cyprus 3 and 4 slightly shorter than Karpasia. Generally, all cultivars are resistant to lodging. The heading date of Cyprus 2 is similar to that for Karpasia, and 2–3 days later than Cyprus 1, 3 and 4. The tillering capacity of the new cultivars is slightly better than Karpasia: Cyprus 1, 2, 3 and 4 had 34, 32, 12 and 37 more tillers/m^2 than Karpasia, respectively. The kernel weights of Cyprus 1, 2, 3 and 4 were broadly comparable to that of Karpasia.

Table 1. Comparative mean and relative yield performance along with stability parameters of durum wheat cultivars grown at 13 Cyprus environments in 1989/90 and 1990/91.

Culivar	Mean yield (kg/ha)	Rel. performance (KIA=100)	Regression coefficient (b)	Mean square deviation from regression (kg/ha)
Kyperounda	2604	65	0.72	541
Aronas	3792	94	0.90	720
Karpasia (KIA)	4015	100	1.06	323
Cyprus 1	4012	100	0.92	449
Cyprus 2	4099	102	1.11	364
Cyprus 3	4207	105	1.09	562
Cyprus 4	4115	102	1.18	347

Table 2. Comparative agronomic characteristics of durum wheat cultivars grown at six Cyprus environments in 1989–91.

Culivar	Plant height (cm)	Days to heading (1 March=1)	No. tillers/ (m^2)	Kernel weight (mg)
Kyperounda	101	37	232	36
Aronas	91	21	244	45
Karpasia	82	25	250	39
Cyprus 1	84	23	284	40
Cyprus 2	86	25	282	42
Cyprus 3	80	23	262	37
Cyprus 4	80	22	287	38

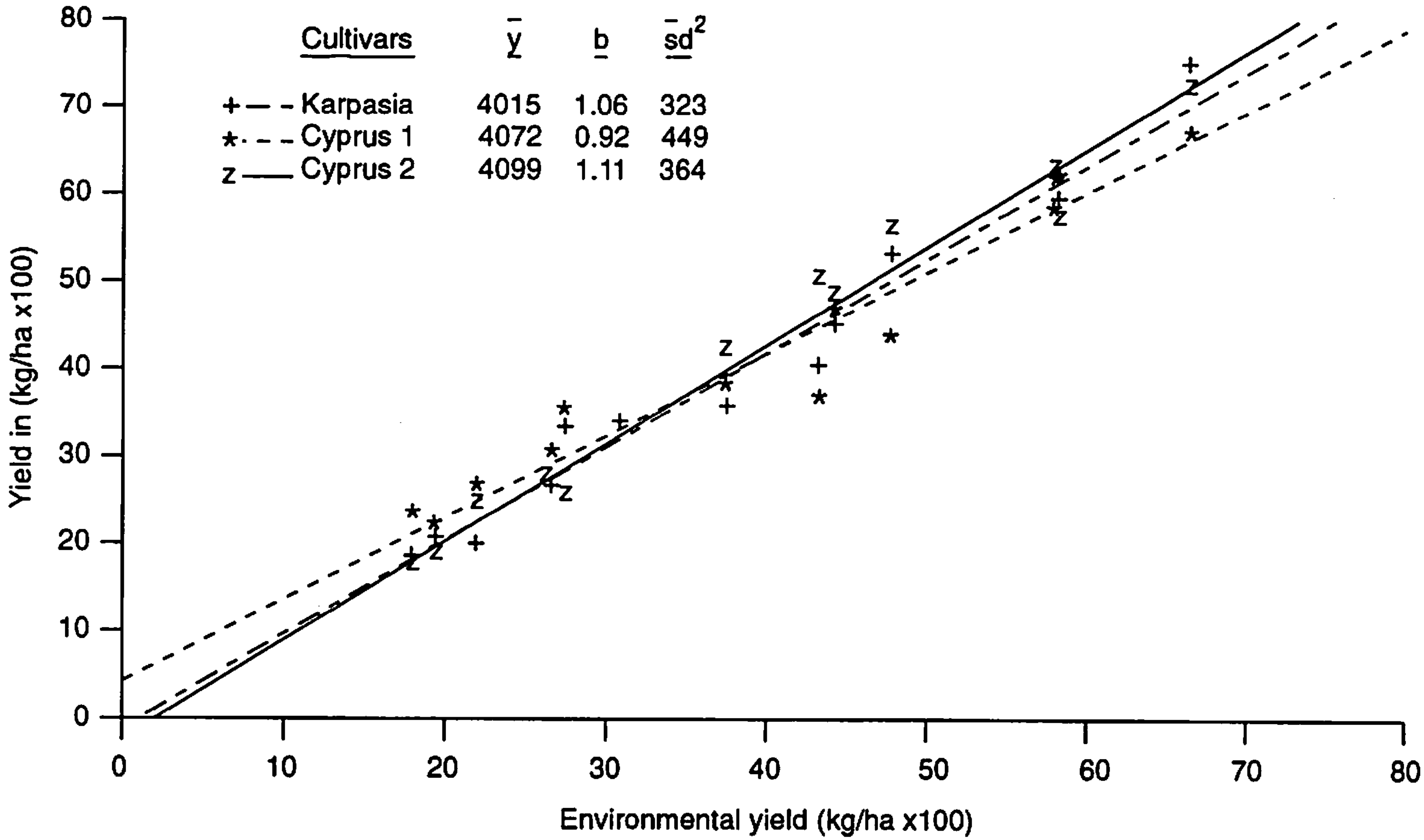

Figure 1. Average regression lines and individual observations for yield of the cultivars Karpasia, Cyprus 1 and Cyprus 2 grown at 13 environments.

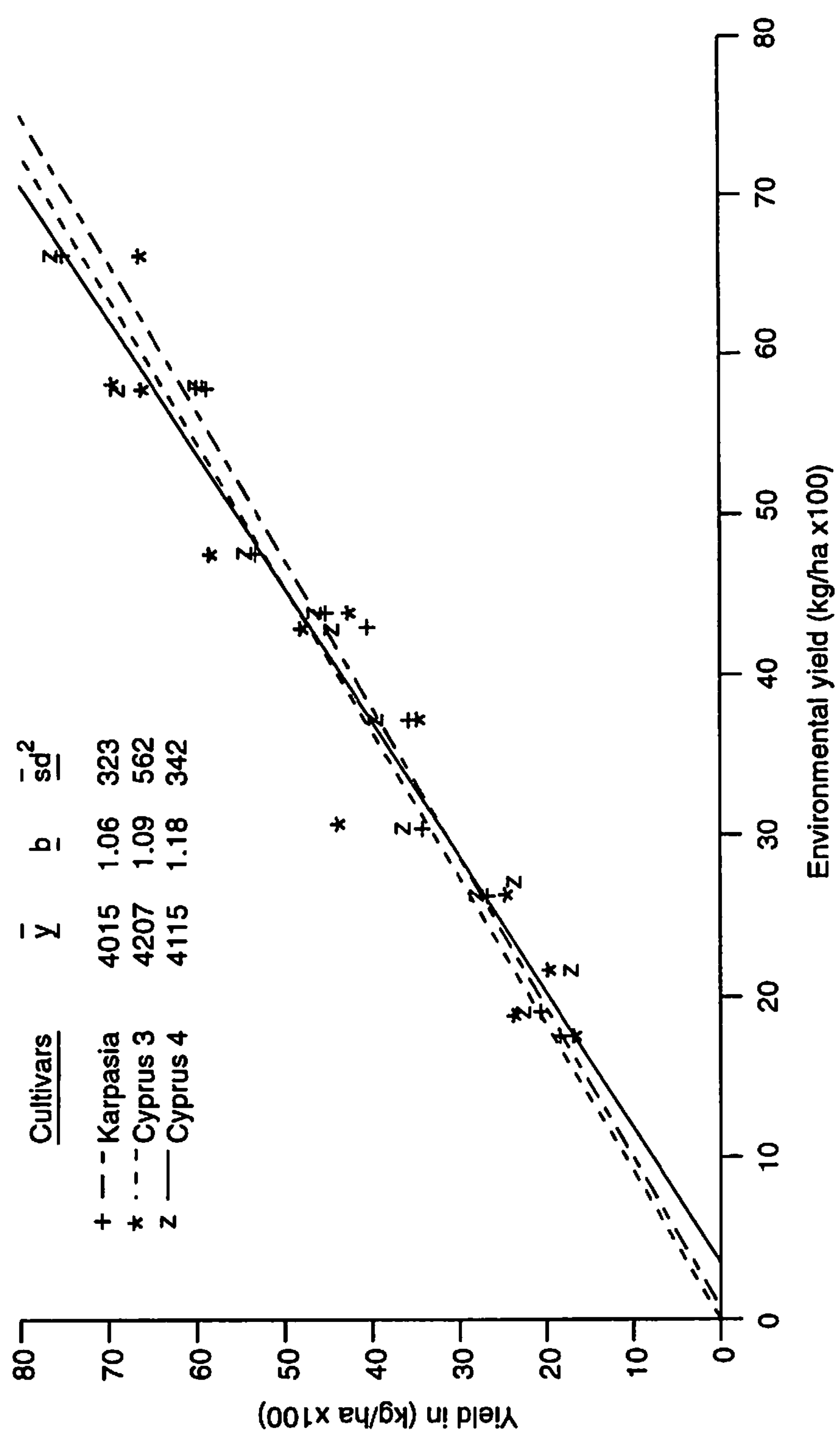

Figure 2. Average regression lines and individual observations for yield of the cultivars Karpasia, Cyprus 3 and Cyprus 4 grown at 13 environments.

Grain quality characteristics

Grain quality characteristics of Cyprus 1, 2, 3 and 4 relative to the Cyprus cultivars Kyperounda, Aronas and Karpasia and North Dakota cultivars Vic and Lloyd are summarized in Table 3. All new cultivars have amber-colored kernels with high vitreous percentage. The average vitreousness of the new cultivars ranged from 83 to 89% compared to 86% for Karpasia. Generally, all cultivars grown in the experiment had excellent volume weight values, ranging from 77 to 79 kg/hl. These values, along with the high percentage of amber vitreous kernels make all cultivars eligible for the grades of Canada Western and United States Amber Durum.

All four cultivars, but especially Cyprus 2, 3 and 4, have exhibited excellent grain carotene content compared to that of Karpasia (Table 3). Grain carotene content of Cyprus 2, 3 and 4 was also superior to that of Vic, but inferior to Lloyd. SDS-sedimentation values showed that the new cultivars are expected to have superior gluten strength to that of Karpasia (Table 3).

Flour characteristics

Within the limits of flour ash content, 0.95% permitted by the Cyprus standards, all cultivars tested had high flour yield, averaging over 76 per cent (Table 4). Flour protein levels, especially for Cyprus 2, 3 and 4, are satisfactory (13.4–15.2%) for good durum wheat quality. Strong gluten flours take a long time to reach peak resistance

Table 3. Comparative grain quality characteristics of durum wheat cultivars grown at five Cyprus environments in 1989/90.

Cultivar	Vitreous kernel (%)	Volume weight (kg/hl)	Carotene content (p.p.m.)	SDS height (mm)
Kyperounda	96	79	5.9	35
Aronas	78	79	3.1	42
Karpasia	86	79	6.1	23
VIC (USA)	91	79	7.2	36
Lloyd (USA)	90	77	8.2	41
Cyprus 1	89	79	6.8	40
Cyprus 2	88	79	7.4	40
Cyprus 3	89	77	7.8	32
Cyprus 4	83	77	7.7	32

Table 4. Comparative flour characteristics of durum wheat cultivars grown at three Cyprus environments in 1989/90.

Cultivar	Flour			Mixograph characteristics	
	Extraction (%)	Ash (%)	Protein (%)	Dough development time (min.)	Range of stability (min.)
Kyperounda	74	0.83	15.3	2.0	1.3
Aronas	78	0.84	12.3	4.6	2.7
Karpasia	75	0.84	14.4	2.0	1.7
VIC	76	0.88	17.0	2.4	1.5
Lloyd	74	0.89	15.3	2.5	1.9
Cyprus 1	75	0.80	12.6	3.4	2.3
Cyprus 2	77	0.77	13.9	2.8	2.3
Cyprus 3	75	0.89	13.4	3.5	2.2
Cyprus 4	76	0.92	15.3	3.1	2.4

during mixing (Dough Development Time, DVT) and thereafter tend to retain high resistance (Range of Stability, RS). These physicochemical changes in dough during mixing were measured at the Cereal Technology Laboratory by a 30 g bowl mixograph. Flours from the new durum cultivars exhibited excellent gluten strength for durum wheats as indicated by DVT and RS values, which ranged from 2.8 to 3.4 min. and 2.2 to 2.4 min., respectively. The DVT and RS values of the cultivar Karpasia were 2.0 min. and 1.7 min., respectively.

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The Effect of Outliers on Interpretation of Breeding Data on Heat Tolerance in Wheat

M. Singh and M. Tahir
ICARDA, P.O. Box 5466
Aleppo, SYRIA

Abstract

Examinations of influential observations in data from three experiments on heat tolerance in wheat (*Triticum aestivum* L. ssp. *aestivum*) have been conducted. One outlier in each of two experiments and a misrecording of an observation in the third experiment were detected using a statistical procedure. Outliers have considerable effects on estimates of genotypic means and their precision, influencing the selection of genetic material. Thus, their detection and elimination allows more accurate analysis and interpretation of data.

Key words: *Triticum aestivum*; heat; temperature resistance; data analysis; plant breeding; selection; genotypes.

تاثير القيم العزلاء على تفسير بيانات التربية لصفة تحمل الحرارة في القمح.

الملخص

تمت دراسة الملاحظات المؤثرة في البيانات من ثلاث تجارب على تحمل الحرارة في القمح (*Triticum aestivum* L. ssp. *aestivum*) وحددت قيمة عزلاء واحدة في كل من التجربتين، وحدث سوء تسجيل ملاحظة في التجربة الثالثة باستخدام الإجراءات الإحصائية.

إن للقيم العزلاء تاثيرات كبيرة على تقديرات متوسطات الطرز الوراثية ودقتها، وتؤثر على انتخاب المادة الوراثية. لذا، فإن عملية تحديدها وإزالتها تتيح إمكانية تحليل وتفسير للبيانات بدقة أكبر.

Introduction

An outlier in a set of data is an observation that appears inconsistent with the rest of the data (Barnett and Lewis 1984). Outliers may arise due to ignorance, measurement errors, incorrect labelling of treatment assigned to a plot, extremely high competition arising from vigorous or feeble genotypes, a rare unseen fertility patch, high or low plant stand in a plot.

Inferences may be seriously affected by the presence of outliers. However, it is very important to judge whether a suspected observation is an outlier. A method was presented by Tiku et al. (1986). In this paper, an examination of outliers is carried out on a set of experiments conducted to determine the heat tolerance of wheat varieties (Tahir 1989). The crucial effect of outliers is demonstrated by one figure which made a susceptible variety appear resistant.

Materials and Methods

Martineau et al. (1979), Tahir (1989) and Saadalla et al. (1990) describe a technique using plant tissues to evaluate tolerance to high temperature in terms of membrane thermostability. The degree of injury (measured as relative injury percentage, %RI) as a result of the temperature treatment is calculated as follows:

$$\%RI = 100 \{ 1-[1-(T_1/T_2)]/[1-(C_1/C_2)] \}$$

where variables T_1 and T_2 are initial and final conductances for the heat treatment and C_1 and C_2 the initial and final conductances for the control. We consider three experiments in this paper. In each experiment, there were three replications for each of the 24 genotypes evaluated. The variables considered for detecting outliers are T_2 in experiment 1, and C_1 in experiments 2 and 3. To economize on space, data on only few units (two units in the beginning and end of the data file and the units suspected as outliers) are listed in Table 1.

Table 1. Data of selected units in the three experiments.

Unit	Rep	Geno	C_1	T_1	C_2	T_2	%RI
Experiment 1							
1	1	1	13	36	109	143	15.04
2	1	2	3	71	119	137	50.58
5	1	5	3	67	137	122	53.91
38	2	5	4	97	150	1240	5.30
69	3	12	4	83	124	133	61.15
70	3	19	4	64	86	103	60.29
Experiment 2							
1	1	1	3	93	116	245	36.31
2	1	2	5	143	130	214	65.50
37	2	2	4	92	92	143	62.71
63	3	2	17	162	111	207	74.33
71	3	7	6	87	88	137	62.88
72	3	14	3	34	78	91	34.86
Experiment 3							
1	1	1	3	39	104	148	24.16
2	1	2	3	72	74	142	48.62
21	1	21	15	130	217	216	57.23
40	2	21	4	119	153	204	57.21
67	3	21	6	131	187	205	62.71
71	3	7	4	106	195	197	52.84
72	3	14	3	85	142	156	53.50

Rep = Replication no.; Geno = genotye no.

Detection of outliers

Let the response y_{ij} corresponding to the j-th observation in the i-th treatment (i=1... v; j=1... r_i) be modelled as:

$$y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

where μ is general mean, α_i is the effect of the i-th treatment and ε_{ij} are random variables assumed to be normally distributed with mean zero and constant variance σ^2. The unknowns μ and α_i can be estimated as:

$$\hat{\mu} = \bar{y}.., \text{ and}$$
$$\hat{\alpha}_i = \bar{y}_i - \bar{y}..,$$

where $\bar{y}..$ is the grand mean and $\bar{y}_i$ is the mean of observations with the i-th treatment. Residual R_{ij} at (i,j)-th unit is

$$R_{ij} = y_{ij} - (\hat{\mu} + \hat{\alpha}_i) = y_{ij} - \bar{y}_{i}.$$

Its variance is

$$\text{Var}(R_{ij}) = \sigma^2(1 - 1/r_i)$$

where σ^2 is estimated by $\hat{\sigma}^2$, the residual mean square

$$\hat{\sigma}^2 = \sum(y_{ij} - \bar{y}_i)^2/(n-v)$$

and r_i is the number of observations under the i-th treatment. The studentized residual is

$$R'_{ij} = R_{ij}/[\,\hat{\sigma}\,(1 - 1/r_i)^{1/2}\,].$$

Let the residual mean square in the presence of outlier be denoted by $\hat{\sigma}^2_o$ and without outlier be denoted by $\hat{\sigma}^2_w$. The ratio %E = 100 $\hat{\sigma}^2_o/\hat{\sigma}^2_w$ will serve as a measure of the efficiency of the estimate when the outlier is removed from the analysis.

Results and Discussion

Corresponding to the three experiments, the observed values, fitted values and studentized residuals on the associated variables were calculated.

Experiment 1

The graphs of residual versus fitted values for T_2 indicated that the Units 5 and 38 possessed large residuals and were suspected outliers:

Sr. No.	Observed	Fitted	Standardized residual
5	122	681.0	–6.3174 *
38	1240	681.0	+6.3174 *

when compared with the table values in Srikantan (1961) (see Barnett and Lewis 1984, pp. 419–420). A verification of the original record of observation showed that 1240 was mis-recorded in place of a value 124 for T_2 for Unit 38. The value 122 corresponding to Unit 5 appears reasonable. Since both values are related to the same genotypes, the fitted value appeared as the average of the two: (122+1240)/2 = 681. We consider the analysis of variance without Unit 38 in Table 2.

The marked drop in the magnitude of residual mean squares by deleting Unit 38 reflected the contribution of this influential observation. A more uniform spread of residuals was observed after dropping Unit 38. To test whether Unit 38 is an outlier, a test described by Tiku et al. (1986) was applied as follows.

Compute the change in residual sum of squares by dropping this unit, C = 642039 – 17077 = 624962 with p = 1 d.f. (p being number of units dropped). A stable estimate of σ^2 is obtained by residual mean square unaffected by the influential observations. Thus $\hat{\sigma}^2$ = 426.9. Therefore, a test of whether unit 38 is an influential observation is to compute F = $(C/p)/\hat{\sigma}^2$, which follows an F-distribution with p and q d.f. when the suspected unit is not an outlier, and q is the residual d.f. used in estimating σ^2. In this case F = 624962/426.9 = 1463.95 on 1 and 40 d.f., which indicates that Unit 38 is likely to be an outlier. We further notice that the residual mean square of 416.6, when replaced by the correct value, is close to the residual mean square of 426.6 when it is dropped.

Experiment 2

Genotype factor was fitted on original and log-transformed data on variable C_1. Log-transformation was chosen on the basis of residual versus fitted plots indicating an increase in residual dispersion with the fitted values. Unit 63 had a large residual and may therefore be a suspected outlier:

Trans-formation	Observed	Fitted value	Standardized residual
Original	17.0	8.67	4.564
Log	2.833	1.943	3.363

The deletion of Unit 63 led to a more unpatterned spread. The analysis of variance is given in Table 3.

Table 2. Analysis of variance of data in Experiment 1.

Source	With unit 38			Without unit 38			With correct value of unit 38		
	d.f.	SS	MS	d.f.	SS	MS	d.f.	SS	MS
Regression	23	59004	25655	23	18593	808.4	23	18775	816.3
Residual	41	642039	15659	40	17077	426.9	41	17079	416.6
Total	64	1232103	19253	63	35670	566.2	64	35854	560.0

d.f. = degrees of freedom; SS = sum of squares; MS = mean squares.

Table 3. Analysis of variance of data in Experiment 2.

Source	With unit 36			Without unit 36		
	d.f.	SS	MS	d.f.	SS	MS
			Original data			
Regression	23	335.1	14.57	23	290.5	12.63
Residual	48	240.0	5.00	47	135.8	2.89
Total	71	575.1	8.10	70	426.4	6.09
			Log-transformed data			
Regression	23	12.44	0.541	23	11.70	0.509
Residual	48	5.05	0.105	47	3.86	0.082
Total	71	17.48	0.246	70	15.56	0.222

The influence of Unit 63 is tested by computing the F-statistics:

	Untransformed	*Log-transformed*
Change C		
(240.0 − 135.8)	= 104.2	5.056 − 3.857 = 1.189
$\hat{\sigma}^2$	= 2.89	= 0.082
F	= 104.2/2.89	= 1.189/0.082
	= 36.05**	= 14.49**

Thus, Unit 63 is likely to be an outlier based on both original and transformed data. The log-transformation did not eliminate the influence of the unit as an outlier.

Experiment 3

Unit 21 had the largest residual for variable C_1. In this case: Observed-value = 15, fitted-value = 8.33, standardized-residual = 4.95. The analysis of variance is given in Table 4.

We have $\hat{\sigma}^2 = 1.362$ and $F = (130.7 - 64.00)/1.362 = 48.97$, a highly significant figure.

Influence on the Estimates of Parameters

The effect of the outliers on the mean values and error variance along with the efficiency of estimates by droping the outlier are given in Table 5.

Outliers can seriously influence the estimates of parameters, their precision and the resulting inferences to a great extent. Therefore, careful examination of data for the presence of outliers is essential. A number of robust procedures have been mentioned in the literature to deal with outliers (Tiku et al. 1986; Barnett and Lewis 1984;

Table 4. Analysis of variance of data in Experiment 3.

Source	With unit 21			Without unit 21		
	d.f.	SS	MS	d.f.	SS	MS
Regression	23	121.7	5.289	23	73.24	3.184
Residual	48	130.7	2.722	47	64.00	1.362
Total	71	252.3	3.554	70	137.24	1.961

Table 5. Effect of outliers on the mean of the affected genotype, error variance and efficiency.

Expt	Geno	Mean of genotype		Error variance		Efficiency (%E)
		With	Without	$\hat{\sigma}_o^2$	$\hat{\sigma}_w^2$	
1	5	29.6	53.9	15659	427	3667
2	2	66.8	64.10	5.00	2.89	173
3	21	59.0	60.0	2.72	1.36	200

Expt = experiment no.; Geno = genotype no.; with = with outlier; without = after excluding outlier.

Hampel et al. 1986). Having detected an outlier, one procedure would be to perform the intended analysis after dropping the outliers from the data set. In this paper, the procedure of deletion of the outlier has been examined. It gave rise to high efficiency of the estimates (Table 5). A high jump in the estimate of effect of genotype 5 in Experiment 1 can be quite critical in a screening process. A damage of 29.6% appears to be a distorted figure compared to 53.9% when the outlier was removed. In fact, with RI value of 29% the genotype would have been classified as resistant to heat stress, whereas the value of 53.9% without outlier, puts this genotype in the susceptible category. In Experiment 2, there is a difference of 3% in the estimate of the %RI for genotype 2. The precision of these estimates are considerably increased when the outlier is excluded from the analysis.

The presence of outliers in a set of data can greatly influence the inference; therefore, their detection, elimination or adjustment is a useful exercise to enable correct inferences to be drawn.

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An Active National Gene Bank for Cereals

Ardeshir B. Damania[1]
Genetic Resources Unit, ICARDA, P.O. Box 5466, Aleppo, SYRIA

Abstract

The conservation of genetic resources has become vital to modern agricultural research. International centers such as ICARDA maintain long-term stores of seeds of their mandate crops. National programs need not duplicate these storage conditions, but should endeavor to maintain medium-term stores for use by national breeders and other researchers. An area of 195 m² needs to be used to house a 40 m² cold-storage room and the other facilities required to maintain an active collection, including those for seed-drying, packaging and testing. The total cost is about US$ 800,000 at 1992 prices. The curators of such collections should also characterize and evaluate the germplasm. The gene bank may also serve to restock natural habitats for *in situ* conservation.

Key words: Research; seed storage; cold stores; seed testing; gene banks; germplasm conservation; cereals; Syria.

بنك وراثي وطني نشيط للحبوب

ملخص

اصبح حفظ الاصول الوراثية أمراً حيويا في البحوث الزراعية الحديثة. ويوجد في المراكز الدولية المشابهة لإيكاردا مستودعات لتخزين حبوب المحاصيل التي تجري ابحاثها عليها لمدة طويلة .ولايتعين على البرامج الوطنية تكرار ظروف التخزين هذه بل يجب ان تسعى للحفاظ على مخزونات متوسطة الاجل لكي يستخدمها المربون المحليون و الباحثون الآخرون . و يجب تخصيص مساحة 195 م² لبناء غرفة ذات تخزين بارد مساحتها 40 م² بالإضافة الى المرافق الأخرى اللازمة للإحتفاظ بمجموعة فعالة ، و التي تضم مرافق تجفيف البذور وتعبئتها و اختبارها . وتبلغ الكلفة الإجمالية حوالي 800.000 دولار امريكي باسعار عام 1992 . كما ينبغي على القيّمين على هذه المجموعات توصيف الأصول الوراثية وتقييمها. كما قد يقوم البنك الوراثي في إعادة تخزين بذور الموائل الطبيعية للحفظ في المواقع .

Introduction

When American poet Edgar A. Guest bought a packet of seed it flashed through his mind that he had purchased "a miracle of life" (Justice and Bass 1978).

> "The seeds were worth only a dime
> but possessed a power no man could create,
> a dime's worth of mystery, destiny, and fate."
> from poem *A Package of Seeds*

In working with seeds, whether it is harvesting, cleaning, handling, storing or transporting, it is essential to keep in mind at all times that inside the seed is a dormant miniature plant awaiting the opportunity to continue its life cycle.

The principal purpose of storing seeds of economically important plants in a gene bank is to preserve seed stocks for the current and future use of plant breeders, cytogeneticists, taxonomists, pathologists and other scientists. While an international center such as ICARDA preserves, on a long-term basis, the genetic resources of its mandate crops at considerable running costs, a national program need not duplicate the storage conditions available at an international center, but endeavor to develop its own active collection storage facility which can be of immediate benefit to national breeders. This short communication describes how this can be achieved economically, taking cereals as an example.

Gene Bank Operation

The operation of a gene bank is a complex activity which must be carried out in an orderly and efficient way to conserve adequately the genetic resources that it holds in

[1] Present address: Genetic Resources Conservation Program, University of California, Davis, CA 95616-8602, USA.

care. In view of the great responsibilities involved in curating these resources, the standard of day-to-day work must be careful and precise.

There are two major categories of gene bank collections.

1. **Base collections** are those which preserve accessions under adequate conditions for long-term storage. The germplasm contained therein is not used as a routine source for distribution or research, but as a security against loss. Seeds from the base collection are tested after long intervals to monitor viability, and to regenerate the seeds where necessary.

2. **Active collections**, on the other hand, store accessions from which seed samples are withdrawn for multiplication and evaluation for useful traits, and for distribution on request. Physical storage conditions are less stringent than those demanded of base collections because seeds are kept for a shorter period of time (medium-term storage).

There is also a third category, **working collections**, which are those that breeders normally maintain for their own research. Collections of this nature usually include the breeder's lines, advanced breeding lines, cultivars and previously released material. It is relatively simple to maintain such a collection. All that is needed is a secure room with air-tight windows and doors with good insulation, and two or three 3-tonne air-conditioners with built-in dehumidifiers. Under such conditions the room temperature can be brought down to 15°C or even less which is sufficient for maintaining viability of most cereals for at least 5 years. It is a highly recommended and cost-effective way for a national program to maintain its working collection considering the high costs involved in constructing regular medium- or long-term storage facilities (Table 1).

The base and active collections are closely linked and complimentary to one another. All accessions in the base collection must be available in one or more active collections. However, base and active collections need not be located at a single location, although they often are. Information about the accessions must flow freely between active and base collections.

In maintaining a collection the following tasks are essential (Hanson 1985):

1. sample registration
2. seed cleaning
3. seed moisture-content monitoring and drying
4. seed viability testing (prior to cold-storage)
5. seed packaging
6. seed storage
7. inventory
8. monitoring viability
9. distribution on request
10. regeneration of accessions whose viability has become low
11. evaluation and other genetic resources research. It is important to consider the number of accessions to be stored and the size of each sample when considering the overall dimensions of the cold room. An oversize store would mean unduly heavy initial investment and subsequent higher running costs as well. One should look for a facility with at least 40 m^2 of space. Besides the cold room, which could operate at a temperature of 5–7°C and a relative humidity of 15–20%, a seed-drying room, seed-germination room and a seed-packaging room are needed. Two medium-sized rooms could serve as offices for a curator and a technician. Other facilities for research available at crop-improvement programs could be used as and when required. Most of the evaluation work should be carried out in collaboration with breeders and scientists from other disciplines. The sequence of events in an active gene bank is given in Fig. 1. The facility could be created in existing buildings or a new one could be constructed, depending on the funds available (Table 1).

A computer terminal facility in the form of an adequately powerful personal computer (e.g. 486 processor, large RAM, 300 Mb hard disk) would be needed to maintain an on-line access to data and information.

In order to facilitate the use of genetic resources collections, breeders need to be informed of the desirable characteristics of the germplasm. This essentially calls for an elaborate and reliable characterization and evaluation program.

Characterization involves recording observations on traits which do not vary from one location to another, such as awned/awnless, seed color, growth habit, and winter or spring type. We need to characterize in order to obtain a phenotype profile of identification and preservation of the integrity of the collection. Information is also needed for seed multiplication, e.g. vernalization requirement. A geographic pattern of diversity and similarity can also be developed based upon characterization data. Evaluation, on the other hand, is a task which is essential to utilization. It needs to be carried

Table 1. Estimates of basic costs for a medium-term gene bank.†

Item	Floor area (m^2)	Cost (US$)
Capital		
Machinery for cold store operating at 0–5°C (incl. standby compressor and motor)		66,000
Shelving and containers for cold store		46,000
Machinery for seed-drying room		25,000
Laboratory/office equipment and furniture		75,000
Buildings		
Cold room with appropriate insulation	40	95,000
Machinery room (for above)	10	35,000
Seed-drying room	10	35,000
Seed-cleaning/packing room	20	70,000
Laboratory	40	95,000
Store room	15	50,000
Offices (2)	20	80,000
Toilet/services	10	30,000
Corridors, passages, etc. (20% of above)	30	90,000
Overheads (at 10%)		8,000
Total	195	800,000

† Deduced from estimates given in IBPGR (1985), taking into account inflation and currency fluctuations.

out to find genetic resources which can solve a particular problem in breeding. Evaluation data can also yield information which can be used in the study of crop evolution and collecting strategies.

A short-list of germplasm samples with desirable traits supplied by a gene bank will prevent breeders from being overwhelmed with a large number of lines. Breeders invariably want to look at a limited number of lines in their own experimental plots, glasshouse or laboratory before starting to use the material for crossing and other purposes.

Genetic Resources Related Research

A gene bank should not merely exist as a museum for samples and their exchange. Personnel need to also engage themselves in topics related to genetic resources conservation and utilization, and keep themselves up to date with research trends. For example, studies on genetic diversity in the collection could be undertaken based on agromorphological as well as biochemical data (e.g. electrophoretic analysis of storage proteins). Evaluation for resistance to certain diseases and/or pests of immediate interest to breeders is part of the knowledge needed prior to use of the germplasm. Similarly, screening for abiotic stresses such as salinity, frost and drought could be undertaken. And finally, variability in the germplasm sample from a collection needs to be eliminated in favor of stable pure lines for desirable traits which breeders can use without fear of going 'backwards' (i.e. incorporation of undesirable genes from parents) as far as the most recently developed germplasm is concerned. Hence, there is a need for pre-breeding and development of genetic stocks; endeavors in which the gene bank personnel could take part together with scientists from other disciplines. Conservation of biodiversity of wild progenitors of major cultivated crops, such as wheat and barley, *in situ* is another important avenue for research where national gene bank personnel can play an active role in developing methodology and providing avenues for reintroducing almost extinct wild species from a gene bank collection to their original habitats.

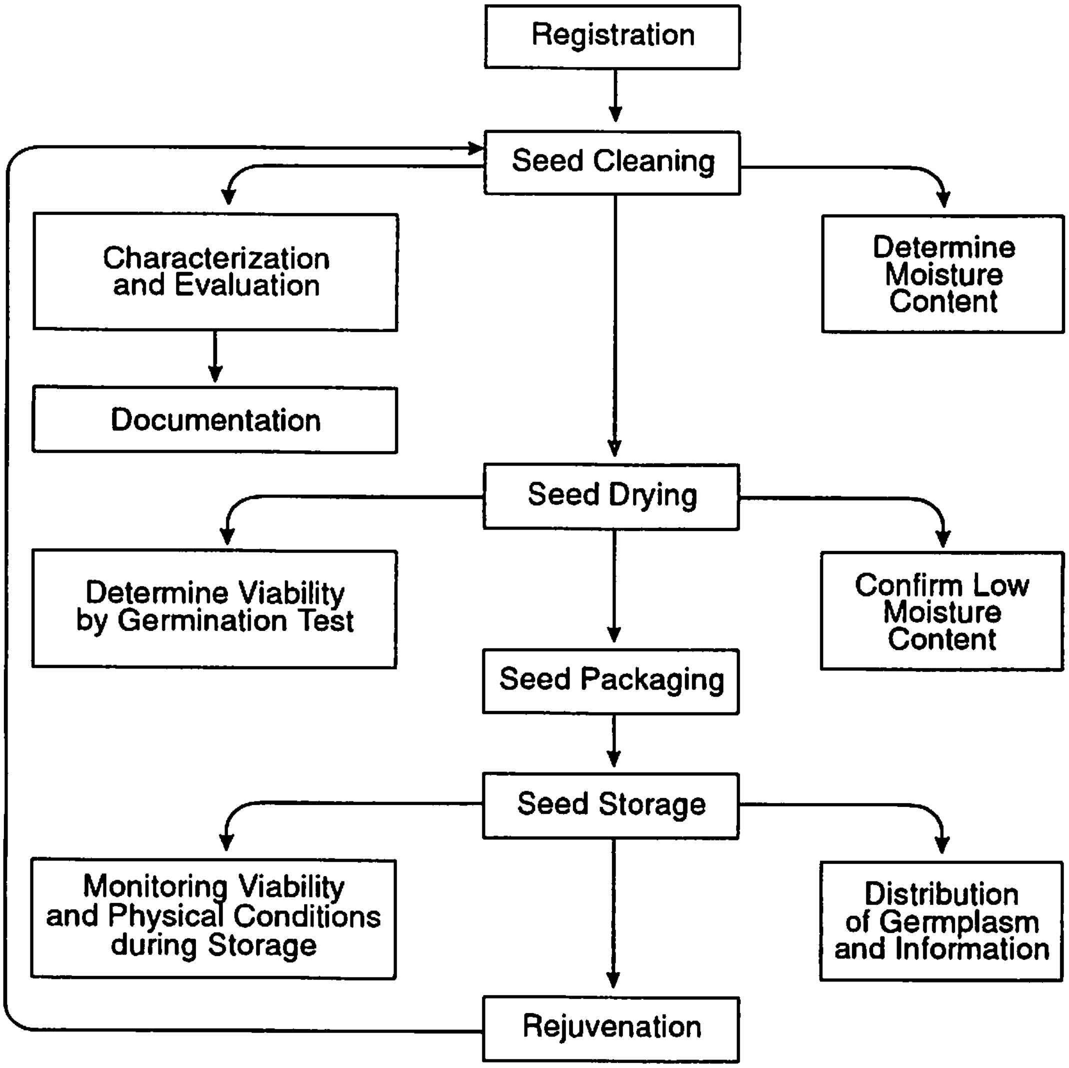

Fig. 1. Sequence of events in an active gene bank (modified from Hanson 1985).

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Grain Yield and Quality of Five Genotypes of Durum Wheat as Influenced by Nitrogen Fertilization

الغلة الحبية وجودتها في خمسة طرز وراثية للقمح القاسي وتأثرها بالتسميد الأزوتي.

R. Sayar[1], A. Gharbi[2] and H. Ghorbel[3]

[1] *Station du Kef, INRAT, Avenue de l'Independence, Ariana 2080, TUNISIA*

[2] *Ecole Supérieur d'Agriculture du Kef, TUNISIA*

[3] *Faculté des Sciences de Tunis, TUNISIA*

Abstract

Five genotypes of durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) currently grown in Tunisia were studied from the standpoint of their nitrogen use efficiency for fertilizer recommendation improvement purpose. Wheat cultivars were combined with five rates of ammonium nitrate application within a randomized complete block design. Grain yields and quality parameters were measured and statistical analyses were performed. Results showed that Chili and INRAT 69 cultivars could positively respond to incremental amounts of nitrogen up to 60 and 80 kg N/ha, respectively. Exceeding these rates decreased grain yield. Karim, Ben Bechir and Razzak could use higher rates of nitrogen, but grain yield decreased when nitrogen levels were higher than 100 kg/ha. Data revealed that Chili and INRAT 69 genotypes were richer in protein and more resistant to yellow berry than the others. However, in all genotypes protein content in the grain and resistance to yellow berry increased with increasing nitrogen.

Key words: *Triticum durum*; *Triticum turgidum*; hard wheat; genotypes; nitrogen fertilizers; ammonium nitrate; statistical analysis; varieties; fertilizer application; yields; disease resistance; Tunisia.

الملخص

تمت دراسة خمسة طرز وراثية من القمح القاسي *Triticum trugidum* L. spp. *durum* (Desf.) Husn. تزرع حالياً في تونس من حيث كفاءة التسميد الأزوتي بهدف وضع توصيات لتحسين السماد. استخدمت في التجارب خمسة أصناف من القمح مع خمسة معدلات من نترات الأمونيوم في تصميم القطع العشوائية الكاملة. تم قياس الغلة الحبية ومعايير الجودة بالإضافة إلى إجراء تحليلات إحصائية. أظهرت النتائج أن الصنفين Chili و INRAT 69 قد يتجاوبان مع تزايد كمية الأزوت حتى 60 و80 كغ N/هـ على التوالي. وعند تجاوز هذه المعدلات، فإن الغلة الحبية تتناقص، ويمكن إضافة معدلات أعلى من الأزوت على الأصناف كريم وبن بشير ورزاق، إلا أن الغلة الحبية تناقصت عندما تتجاوز مستويات الأزوت 100 كغ/هـ. وكشفت البيانات أن الطرازين الوراثيين Chili و INRAT 69 أغنى بالبروتين ويتمتعان بمقاومة لمرض تقرح الحبوب أكبر من الأصناف الأخرى. إلا أن محتوى البروتين في الحب ومقاومة تقرح الحبوب ازدادت مع زيادة الأزوت في جميع الطرز الوراثية.

Introduction

Increasing crop yield through adequate nitrogen fertilization is a pertinent farm management tool. Literature dealing with the effect of nitrogen on wheat plant responses is replete, although a few conflicting results due to varietal behavior differences have been reported.

Dorsheimer and Isaac (1982) reported that the basic requirement for high wheat yield and quality is that plants receive optimum amounts of nitrogen throughout the growing season. Previous studies demonstrated that supplying cereals with optimum rates of nitrogen leads to higher yield as well as higher protein content of the grain (Johnson et al. 1973; Batey and Reynish 1976; Hass et al. 1976; Eppendorpher 1978).

Orphanos and Krentos (1980) showed that increasing rates of nitrogen supplied to cereals increases their nitrogen level in the grain and in the straw, and reduces yellow berry in durum wheat from 25% to 6%. Robinson et al. (1979) also report a linear decline of yellow berry with increasing rates of N fertilizer. Valdeyron and

Seguela (1958) observed a significant positive correlation between protein content of durum wheat and its yellow berry resistance.

More recent studies of Sanmaneechai et al. (1984) and of Gharbi and Boubakri (personal communication, 1988) report an increase of N in wheat leaves and in straw as well as a higher grain yield following the application of increasing amounts of nitrogen fertilizers. Gharbi (1989) found that nitrogen supply to durum wheat enhanced its N and K uptake and had no significant effect on P uptake.

This paper reports on the effect of N fertilizer rates on grain yield and quality of five genotypes of durum wheat grown in Tunisia.

Material and Methods

This study was carried out at an experimental station of the National Institute for Agricultural Research (INRAT) located in El Kef, Tunisia. The area is characterized by a semi-arid climate with an annual rainfall of about 460 mm, varying between 250 and 700 mm.

The test wheat cultivars were Chili and INRAT 69, which until recently were the standard durum wheats grown in Tunisia, and the high-yielding cultivars Karim, Ben Bechir and Razzak, newly released in the country.

The soil of the experimental site is a vertic xerochrept, fine textured (50% clay), calcareous (27–29% $CaCO_3$), alkaline (pH 8), high in bicarbonate-soluble P (13 mg/kg) and in exchangeable K (460 mg/kg), and low in organic matter (1%).

The fertilizer treatments were different rates of ammonium nitrate (0, 40, 60, 80, 100 and 120 kg N/ha) supplied at different stages of growth (emergence, tillering, booting and heading). The experimental design was a randomized complete block, replicated thrice; plots were 6.25 m^2. Durum wheat was sown using a seeding rate *of 1980* seeds/plot. Nitrogen fertilizer was side-dressed. The crop received a supplemental irrigation to overcome the water stress established after an unusual drought.

Beside the soil samples, grain and straw samples were collected at harvest. Straw and grains were analyzed for total nitrogen by the micro-Kjeldahl method. The protein content of the grain was derived according to the equation:

Protein (%) = N (%DM) × 5.83.

Other parameters such as 1000-grain weight and grain yield were also recorded.

In addition, the percentage of yellow berry of each genotype was determined. Entirely mealy grains were given score 1; 75% mealy grains were given score 0.75; 50% mealy grains were given score 0.5; 25% mealy grains were given score 0.25; and unaffected grains were given score 0. The weighted mean of the scores with respect to the number of grains falling in each score range gave the percentage of yellow berry.

Analysis of variance was performed and the means were compared according to the LSD procedure. Correlation studies were also conducted to measure the strength of the relationship between some plant parameters.

Results and Discussion

Nitrogen fertilizer prolonged the vegetative growing period of durum wheat and consequently delayed its date of heading. Such a delay was intensified as higher rates of N were applied. The addition of 120 kg N/ha delayed the formation of the first head of Chili, Razzak, Karim, INRAT 69 and Ben Bechir by 13, 11, 7, 6 and 5 days respectively over the control. These results are in agreement with previous findings (Tisdale and Nelson 1975).

Data in Table 1 revealed that grain yields of Ben Bechir, Karim and Razzak cultivars were significantly higher than those of INRAT 69 and Chili, regardless of the rate of N applied ($P<0.05$). The supply of increasing amounts of nitrogen enhanced grain yields of Karim, Ben Bechir and Razzak linearly. However, the addition of 120 kg N/ha led to lodging of the last two cultivars and, hence, to a decrease in production. Chili and INRAT 69, which showed initially a positive yield response to N fertilization suffered a significant decline in grain yield with applications exceeding 60 and 80 kg N/ha, respectively. Ben Bechir and Razzak gave maximum response with N-fertilizer level of 100 kg/ha. Karim responded positively up to 120 kg N/ha. These differences in amounts of nitrogen used by the various genotypes could be of paramount importance to future nitrogen-fertilizer recommendations for durum wheat.

Chili was shown to be superior in straw yield (Table 1) regardless of the amount of N applied. All cultivars increased their dry matter content with increasing rates of nitrogen up to a certain limit beyond which a subsequent decrease was observed. Such a decline occurred at rates of N higher than 100 kg/ha for Chili and Karim, and 80 kg/ha for Razzak, Ben Bechir and INRAT 69. Straw yield decline was most likely due to nutritional imbalances induced by higher rates of N.

Protein content of wheat grains increased with increasing rates of nitrogen ($P<0.05$). Table 2 shows that high-yielding cultivars (Karim, Razzak and Ben Bechir), which produced higher grain yields, had lower protein content in the grain than the low-yielding cultivars (INRAT 69 and Chili). The latter were then richer in protein. The effect of nitrogen on protein content of wheat grains is of paramount importance in the baking industry where the price of the flour is dependent on the protein content.

Table 1. Straw and grain yields (kg/ha) of durum wheat cultivars as influenced by N fertilization.

Cultivar	Applied nitrogen (kg/ha)					
	0	40	60	80	100	120
			Straw			
Chili	7920	8720	9000	10680	13640	9800
INRAT 69	7160	9360	9280	8960	8280	7760
Ben Bechir	5760	7640	9880	10200	8360	8120
Karim	6080	6720	7960	8000	9800	9080
Razzak	4880	5920	7240	7200	6360	6160
			Grain			
Chili	2007	3064	3488	2859	2847	2468
INRAT 69	4320	4807	5019	5632	5131	4202
Ben Bechir	4800	5810	6014	6925	7361	7229
Karim	5442	5528	5708	6022	6502	7331
Razzak	4728	4991	6558	6648	7118	6631

Table 2. Protein content in wheat grains (percentage of dry matter).

Cultivar	Applied nitrogen (kg/ha)					
	0	40	60	80	100	120
Chili	13.46	16.40	16.90	17.60	18.80	19.96
INRAT 69	14.06	14.46	14.90	15.70	16.10	16.76
Ben Bechir	11.46	12.26	12.93	13.10	13.73	14.30
Karim	11.73	12.23	13.30	13.23	13.70	14.63
Razzak	10.86	11.30	12.26	12.63	13.36	14.73

Data in Table 3 indicate that the percentage of yellow berry in the wheat grains declined as the amount of nitrogen in the fertilizer increased. Chili was the most resistant to yellow berry followed by INRAT 69. The new released high-yielding cultivars which gave the highest yellow berry percentage at low nitrogen levels, increased their resistance to yellow berry drastically and were most resistant at the highest level of nitrogen (120 kg/ha).

Figure 1 shows a negative and significant correlation (r=-0.846) between protein content of wheat grain and the percentage of yellow berry.

Data in Table 4 indicate that N fertilization affected 1000-grain weight. When the nitrogen level in the fertilizer was low the grain weight was maximum for all genotypes. Grain weight declined with increasing nitrogen except for Chili and Ben Bechir which showed subsequent increases at rates higher than 60 and 80 kg N/ha, respectively. The higher values of grain weight found at lower nitrogen rates could be due to carbohydrate migration rather than protein migration towards the heads. Such an interpretation is supported by the low protein content of the grains recorded when the nitrogen amounts added were low.

Table 3. Yellow berry percentage in wheat grains as affected by N rates.

Cultivar	Applied nitrogen (kg/ha)					
	0	40	60	80	100	120
Chili	5.2	0.0	0.0	0.0	0.0	0.0
INRAT 69	37.0	23.6	17.0	10.8	8.2	4.5
Ben Bechir	66.0	43.8	37.1	26.2	17.1	14.5
Karim	57.9	44.4	29.8	28.9	17.8	3.7
Razzak	63.7	49.8	42.6	29.6	16.1	9.7

Table 4. Weight of 1000 grains (g) as influenced by N fertilization.

Cultivar	Applied nitrogen (kg/ha)					
	0	40	60	80	100	120
Chili	50.83	44.83	37.83	40.56	40.10	44.05
INRAT 69	43.80	40.61	40.40	43.10	40.28	37.43
Ben Bechir	53.90	48.46	46.63	42.76	46.06	48.73
Karim	52.80	51.10	47.10	48.50	46.53	45.06
Razzak	54.00	51.56	50.93	48.70	48.86	46.20

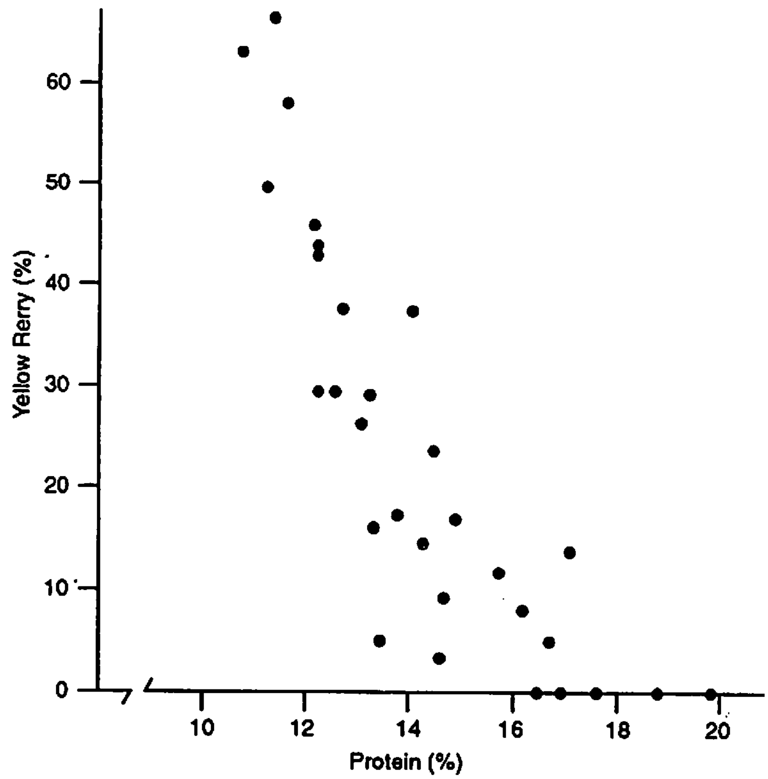

Fig. 1. Relationship between yellow berry and protein in durum wheat grains.

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Yield Performance of Seven Wheat Cultivars at Different Dates of Sowing

M.H. Chaudhry, A. Sattar and M. Ibrahim
Directorate of Wheat Research
Ayub Agricultural Research Institute
Faisalabad, PAKISTAN

Abstract

Seven wheat (*Triticum aestivum* L. ssp. *aestivum*) cultivars of different growth-duration groups were tested for grain yield at eight planting dates from 31 October to 10 January for the three years 1981/82 to 1983/84 at the Wheat Research Institute, Faisalabad, Pakistan. Average performance over three years across eight planting dates indicated that cultivars Punjab 81 and Pak 81 gave significantly greater yields than Barani 83, Chakwal 86, Blue Silver and Faisalabad 83. All wheat cultivars produced significantly higher yield when sown on 10 November compared to other planting dates. A significant decrease of 30 kg/ha/day in wheat yield occurred when planting was delayed after 10 November.

Key words: *Triticum aestivum*; soft wheat; varieties; sowing date; yields; Pakistan.

كفاءة غلة سبعة أصناف من القمح في مواعيد زراعة مختلفة

الملخص

تم اختبار سبعة أصناف من القمح (*Triticum aestivum* L. ssp. *aestivum*) تنتمي إلى مجموعات ذات فترات نمو مختلفة لتحديد الغلة الحبية، وذلك في ثمانية مواعيد للزراعة بدءاً من 31 تشرين الأول/أكتوبر وحتى 10 كانون الثاني/يناير على مدى السنوات الثلاث 1981/82-1983/84 في معهد بحوث القمح في فيصل آباد، باكستان. ويشير متوسط الكفاءة المحصولية على مدى ثلاث سنوات في ثمانية مواعيد للزراعة إلى أن الصنفين بنجاب 81 وباك 81 أعطيا غلة أعلى بكثير من الأصناف براني 83 وشاكوال 86، وبلو سيلفر وفيصل أباد 83. وأعطت جميع أصناف القمح غلة أعلى بكثير عندما زرعت في 10 تشرين الثاني/نوفمبر بالمقارنة مع مواعيد زراعة أخرى. وحصل نقص كبير بلغ 30 كغ/هـ/يوم في غلة القمح عندما تأخرت الزراعة حتى 10 تشرين الثاني/نوفمبر.

Introduction

The introduction of high-yield potential, semidwarf cultivars and improved crop-production technology has helped increase total wheat production in Pakistan. However, there is still great scope for further increase.

In the Pak Punjab, wheat is planted between the end of October and mid-January. Specific cultivars belonging to long-, medium- an short-duration groups are recommended for different planting times. Optimum planting time for a cultivar has often been reported to be one of the most crucial factors for enhancing wheat yield in the Punjab. The present study was undertaken to investigate the optimum planting time for newly developed cultivars for commercial production in the Punjab.

Review of literature

Several workers (Chaudhry and Khalid 1961; Ashraf 1968; Nazir et al. 1980) report a linear reduction in grain yield with delay in planting time. Bishnoi and Gill (1972) found a progressive decrease in yield from 4.14 to 1.8 t/ha with delay in sowing from 12 November to 11 January.

Sharma and Singh (1972) found that a long-duration cultivar, Kalyan Sona, gave the highest yield when planted in early November, while Sonalika (a medium-duration cultivar) performed the best in the mid-November planting; Hira (a short-duration wheat) proved top yielder in late November planting.

Mid-November planting was found optimum by other workers (Waraich et al. 1982; Bajwa et al. 1987).

Material and Methods

The study was conducted for three consecutive years from 1981/82 to 1983/84 under irrigated conditions at the Wheat Research Institute, Faisalabad. Seven wheat cultivars of different durations (details in Table 1) were planted on eight dates with 10-day intervals. For each date, cultivars were arranged in a randomized complete block design in three replications with a gross plot measuring 5.0 × 1.8 m. The crop was planted with a three-row planter using a seed rate of 100 kg/ha. A uniform fertilizer dose of 100–68 kg N–P/ha was applied at the time of seed-bed preparation before planting. At maturity, a net plot size of 3.35 × 1.2 m was harvested. The data on grain yield were recorded and analyzed statistically according to the procedure outlined by Leclerg et al. (1962). Response to different planting dates was estimated by regressing each cultivar's mean yield (over three years) on the eight sowing dates.

Results and Discussion

Year 1981/82

Highly significant yield differences were found among dates (D), cultivars (C) and dates × cultivars (D×C). Cultivar Pak 81 gave the highest mean yield (3410 kg/ha) followed by Punjab 81, Barani 83 and Faisalabad 83 with yields of 3241, 3175 and 3053 kg/ha, respectively (Table 2). Blue Silver gave significantly lower yield (2003 kg/ha) than all other cultivars.

Table 1. List of wheat cultivars included in the study.

Cultivar	Parentage/Pedigree	Characteristics
Pak 81	Kvx/Buho//Kal/Bb CM.33027-F-15M-500Y-OM	Long duration, general purpose for irrigated and rain-fed areas.
Punjab 81	Inia/3/Son64/P4160(E)//Son64 Pk.6841-2a-2a-1a-0a	Medium duration, for irrigated areas.
Kohinoor 83	Ore F1 158/FDL//MFO's'/2* Tiba/3/Coc CM.32987-1-1Y-5M-0Y	Medium duration, for irrigated areas.
Barani 83	Bb/Gallo/3/Gto/7C//BB/Cno CM.32347-3Y-1Y-1M-1Y-0M-3VSY	Long/medium duration, for rain-fed areas.
Chakwal 86	Fln/Acc//Ana SWM-4578-56M-3Y-3M-0Y	Long duration, for rain-fed areas.
Blue Silver	II.54-388/AN/3/YT54/NO10B// LR 64 II.18427-4R-1M	Short duration, for irrigated and rain-fed areas.
Faisalabad 83	Fury//Kal/Bb CM.37138-42Y-1M-5Y-1M-0Y	Short duration, for irrigated and rain-fed areas.

Table 2. Grain yield (kg/ha) of seven wheat cultivars sown at different dates during 1981/82.

Planting date	Varieties							
	Pak 81	Pb. 81	Kn. 83	Bar. 83	Chakwal 86	B. Sil.	Fsd. 83	Mean
31 Oct.	3955	2365	2202	4607	2609	1142	2160	2720 a
10 Nov.	4770	4770	3955	4770	3588	2813	4770	4205 a
20 Nov.	3996	4281	3303	4322	2528	3873	3425	3675 b
30 Nov.	3670	3262	3474	2650	2569	2079	2609	2901 cd
10 Dec.	3466	3629	3001	2895	3425	2079	3262	3108 c
20 Dec.	3588	2936	3058	2936	3180	1509	3751	2994 c
30 Dec.	1957	2609	2079	1590	1712	1264	2528	1962 e
10 Jan.	1876	2079	1753	1631	1346	1264	1916	1695 f
Mean	3410	3241	2853	3175	2620	2003	3053	
	a	ab	c	b	d	e	bc	

	Dates (D)	Cultivars (C)	D × C
LSD ($P \leq 0.05$)	214.22	200.39	565.36

Means followed by a common letter are not significantly different ($P \leq 0.05$).

The mean performance of the seven cultivars planted on 10 November was significantly higher (4205 kg/ha) than all other dates followed by 20 November (3675 kg/ha). After 10 November, a considerable reduction in grain yield of 40.5 kg/ha/day was observed. The mean performance of cultivars from 30 November to 20 December remained statistically level, but declined after 20 December. These results are in agreement with those of Bajwa et al. (1987).

The yield performance of the seven cultivars varied differently across dates of planting as shown by highly significant interaction between cultivars and dates. Cultivars Pak 81, Punjab 81, Kohinoor 83, Chakwal 86, Barani 83 and Faisalabad 83 gave their highest yields when planted on 10 November, whereas Blue Silver did so when planted on 20 November. These results are similar to those of Bajwa et al. (1987) and Nazir et al. (1980) who also report different varieties performing better at different dates. The variety Blue Silver was susceptible to rust which could explain the considerable yield reduction in December and January plantings.

1982/83

During 1982/83, dates and cultivars differed significantly ($P \leq 0.05$), and dates × cultivars interactions were highly significant (Table 3). Although the mean performance of cultivars was best when planted on 10 November, this date was statistically at par with 20 November and 30 November. Thus, the best planting time for wheat during 1982/83 was 10–30 November. After 30 November, significant reduction in yield was observed: 28.2, 35.1, 33.9 and 60.2% when planting was delayed for 10, 20, 30 and 41 days, respectively. During this year cultivars Pak 81, Kohinoor 83, Chakwal 86 and Faisalabad 83 gave their highest yields on 10 November, whereas Punjab 81 and Blue Silver were highest on 30 November, and Barani 83 was the highest on 31 October.

These results are slightly different from 1981/82. This may be due to differences in climatic conditions. During 1982/83 yields were higher than 1981/82. Although in December planting yields were significantly lower than November planting, Pb. 81 and Kohinoor 83 performed better than other cultivars.

1983/84

During 1983/84, date, cultivar and date × cultivar effects were significant (Table 4). Cultivars planted on 10 November yielded (3959 kg/ha) significantly higher than all other dates, followed by 31 October (3004 kg/ha). Three dates – 20 November, 30 November and 10 December – were statistically equal, whereas 20 December, 30 December and 10 January dates were significantly different from each other. After 10 November, an erratic reduction in grain yield occurred up to 43 kg/ha/day when planting was delayed until 10 January.

Table 3. Grain yield (kg/ha) of seven wheat cultivars sown at different dates during 1982/83.

Planting date	Varieties							
	Pak 81	Pb. 81	Kn. 83	Bar. 83	Chakwal 86	B. Sil.	Fsd. 83	Mean
31 Oct.	4673	4069	4779	4444	4754	3408	4355	4355 b
10 Nov.	4909	4534	5480	4403	5219	4436	4876	4837 a
20 Nov.	4501	5137	4542	4224	4689	4477	4452	4575 ab
30 Nov.	4403	5496	5040	3988	4485	5186	4599	4742 a
10 Dec.	3229	3254	4028	2813	3841	3425	3229	3403 c
20 Dec.	2642	3311	3311	2740	3784	3033	2715	3077 d
30 Dec.	3066	3621	3637	2805	2642	2601	3564	3134 d
10 Jan.	1778	1990	1876	1631	1802	1973	2169	1888 e
Mean	3650 b	3926 ab	4086 a	3381 d	3902 ab	3568 cd	3745 abc	

	Dates (D)	Cultivars (C)	D × C
LSD ($P \leq 0.05$)	295.35	276.27	779.44

Means followed by a common letter are not significantly different ($P \leq 0.05$).

Table 4. Grain yield (kg/ha) of seven wheat cultivars sown at different dates during 1983/84.

Planting date	Varieties							
	Pak 81	Pb. 81	Kn. 83	Bar. 83	Chakwal 86	B. Sil.	Fsd. 83	Mean
30 Oct.	4689	2088	3588	3898	4461	285	2022	3004 b
10 Nov.	4750	4713	4220	3421	3612	2985	4012	3959 a
20 Nov.	2173	2642	2353	2222	2251	2948	2630	2460 c
30 Nov.	2226	2821	2601	2104	2707	2577	2552	2513 c
10 Dec.	2283	3596	2801	1888	2279	2442	2821	2587 c
20 Dec.	2283	3074	2234	1818	1606	2145	2088	2178 d
30 Dec.	1965	2079	1990	1296	1044	1834	1647	1694 e
10 Jan.	1386	1753	1549	1150	954	1043	1566	1343 f
Mean	2720	2846	2667	2225	2364	2033	2417	
	a	a	a	bc	b	c	b	

	Dates (D)	Cultivars (C)	D × C
LSD (P≤0.05)	243.63	227.90	642.96

Means followed by a common letter are not significantly different (P≤0.05).

For average yield performance, Pb. 81 (2846 kg/ha) was best, followed by Pak 81 (2720 kg/ha) and Kohinoor 83 (2667 kg/ha), although all three were statistically equivalent.

Blue Silver (2033 kg/ha) was significantly lower in yield than Faisalabad 83 (2417 kg/ha) and Chakwal 86 (2364 kg/ha), but at par with Barani 83. Five cultivars – Pak 81, Punjab 81, Kohinoor 83, Blue Silver and Faisalabad 83 – gave their highest yields when planted on 10 November, whereas Barani 83 and Chakwal 86 did so on 31 October. In the experiment sown on 20 November, severe lodging occurred in most of the cultivars which caused a drastic reduction in grain yield. Punjab 81 showed better yield than other varieties in December planting. In general, 1983/84 yields were low compared to the other two years due to dry weather and high temperature during March and April (Table 5).

Pooled data

Averages from the three seasons showed that cultivars performed differently across planting dates. In general, however, Pak 81 ranked first in early plantings (31 October and 10 November), but Pb 81 was top yielder thereafter. Regression analysis of the pooled yield data (Fig. 1) showed a slope of -299.86 kg/ha (P≤0.01) indicating an average reduction of about 30 kg per hectare/day when planting was delayed after 10 November. These findings are in agreement with those of Bajwa et al. (1987).

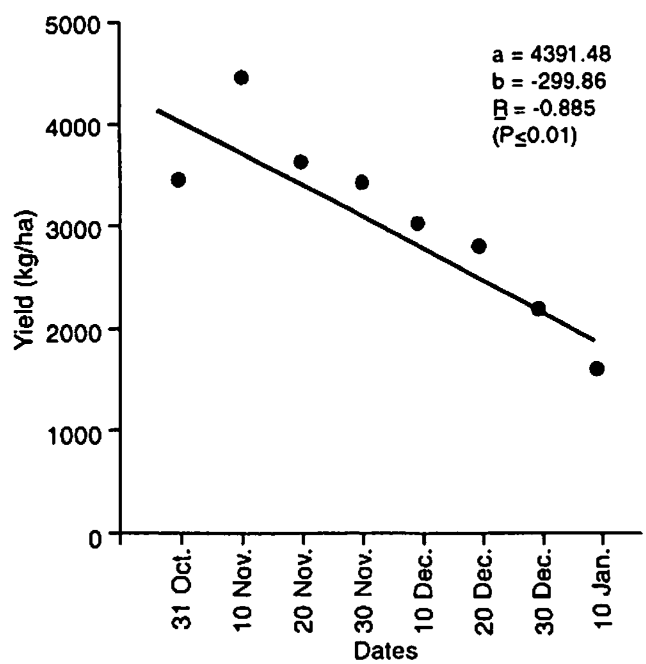

Fig. 1. Grain yield of eight wheat cultivars over three years as influenced by planting dates.

Table 5. Monthly temperature and rainfall at Faisalabad for three wheat crop seasons, 1981-1989.

Month	1981/82			1982/83			1983/84		
	Av. max. temp. (°C)	Av. min. temp. (°C)	Rainfall (mm)	Av. max. temp. (°C)	Av. min. temp. (°C)	Rainfall (mm)	Av. max. temp. (°C)	Av. min. temp. (°C)	Rainfall (mm)
October	32.4	16.1	3.3	32.0	17.2	Traces	31.8	16.8	Traces
November	25.7	9.6	Traces	26.0	9.9	10.7	26.5	9.4	Traces
December	22.0	3.6	0	18.9	4.7	27.5	20.8	5.6	Traces
January	17.9	3.3	15.0	17.1	2.8	0.8	17.2	2.3	1.8
February	18.3	5.1	17.0	19.4	5.5	37.1	18.8	4.5	33.8
March	20.8	9.8	57.9	23.7	9.2	6.6	28.6	12.8	5.3
April	31.7	16.1	42.7	27.9	14.8	88.5	32.7	18.9	18.7
Total rainfall			135.9			171.2			59.7

We conclude that, for maximum yield, wheat should be planted during the first two weeks of November. If wheat has to be planted after *kharif* crops, its planting should be finished before 20 December to obtain an economical yield. Beyond this date, other crops such as sugarcane, sunflower, mungbean and maize should be preferred.

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Performance of Spring Wheat Genotypes Grown in Mixtures

Muhammad Aslam Chowdhry, Khurshid Alam and Ihsan Khaliq
Department of Plant Breeding and Genetics
University of Agriculture
Faisalabad, PAKISTAN

Abstract

An experiment was conducted on inter-genotypic competition comprising five wheat (*Triticum aestivum* L. ssp. *aestivum*) genotypes to determine if over-compensation would be associated with some binary mixtures. The performance of ten blends each in a 1:1 genotypic ratio was compared with the performance of the component genotypes grown as pure cultures. Over-compensation was observed in some blends. Four of the ten blends were higher yielding than the average of their components giving yield advantage ranging from 2.35 to 12.55%. Two blends gave 2.01 and 5.60% higher yield than their higher-yielding components. The binary mixtures have potential to increase crop yield, but the identification of correct genotype combinations is essential.

Key words: *Triticum aestivum*; soft wheat; spring crops; genotypes; mixing; yields; Pakistan.

كفاءة طراز وراثية ربيعية من القمح مزروعة في أخلاط

الملخص

أجريت تجربة حول التنافس بين الطرز الوراثية ، بحيث شملت خمسة طرز وراثية من القمح لتحديد فيما إذا كان التعويض المفرط سيقترن ببعض الأخلاط الثنائية.

وتمت مقارنة كفاءة عشرة أخلاط، نسبة الطرز الوراثية في كل منها 1:1 مع اداء مكونات الطراز الوراثية المزروعة كمستنبتات نقية. ولوحظ التعويض المفرط في بعض الأخلاط، وكانت غلة أربعة أخلاط من أصل عشرة أعلى من متوسط مكوناتها، وأعطت زيادة في الغلة تراوحت بين 2.35 و 12.55٪. كما أعطت خلطتان غلة أعلى من مكوناتها الأعلى غلة بنسبة 2.01 و 5.60٪. ان الأخلاط الثنائية قادرة على زيادة غلة المحصول، بيد أن تحديد الأخلاط الصحيحة من الطرز الوراثية، أمر ضروري.

Introduction

Competition effects have been described by various terms, but they can be adequately summarized by using the following interpretation of the terminology of Schutz et al. (1968): neutral (neither genotype affected by competition); under-compensation (gain in one component is more than offset by loss in the other or a mutual disadvantage); complementation (gain in one component is offset by an equal loss in the other); over-compensation (cooperation to a mutual advantage or gain in one combination is not completely offset by a loss in the other).

The primary objective of the present study was to gather information on the performance of binary mixtures in spring wheat and to determine if over-compensation would be associated with some blends to increase yield.

Materials and Methods

An inter-genotypic competition experiment comprising five wheat varieties – LU26S, Pb. 81, Pak. 81, Kohinoor 83 and Pb. 85 – was conducted at the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during 1989/90. Five monocultures along with all possible pair combinations in 1:1 ratio were planted in the field using a randomized complete block design with four replicates on 14 November 1989. A plot of 3 m × 1m served as the experimental unit. Regularity of spacing and uniformity of sowing depth were maintained with the help of a template. Inter-plant and inter-row distances were 15 cm. Two seeds per hole were dibbled and thinned to one seedling after germination. All plots received normal cultural treatments.

At maturity, ten plants were selected from each plot, and grain yield per plant was measured. The land equivalent ratios (LER) were calculated using the concept of relative yield totals (RYT) of de Wit and van den Bergh (1965):

$$LER = \frac{1}{2}\left[\frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}\right]$$

where

Y_{aa} = pure stand yield of variety 'a',
Y_{bb} = pure stand yield of variety 'b',
Y_{ab} = yield of genotype 'a' in mixed culture with 'b',
Y_{ba} = yield of genotype 'b' in mixed culture with 'a'.

Results and Discussion

The analysis of variance showed highly significant differences ($P<0.01$) between treatment means for grain yield per plant (Table 1). The yield data (Table 2) revealed that genotypes LU26S, Kohinoor 83 and Pak. 81 showed yield advantages in some binary mixtures ranging from 0.89 to 29.63% over their monocultures. Pb. 81, the highest-yielding cultivar in pure culture, had decreased yield when grown in association with other genotypes of 1.31 to 15.14%. The other high-yielding cultivar, Pak. 81, yielded 5.10 and 0.89% more grain compared to its pure culture when planted in combination with Kohinoor and Pb. 81, respectively. However, it showed losses of 6.71% with LU26S and 9.84% with Pb. 85. Similarly, medium-yielding cultivar, Kohinoor 83, showed increased yields of 1.74% in association with LU26S and 6.28% with Pb. 81, but with Pak. 81 and Pb. 85, the yield decreased by 7.73 to 9.37%. On the other hand, the low-yielding cultivar in this experiment, LU26S, gave significantly increased yield when grown with other genotypes exhibiting yield advantage ranging from 13.15 to 29.63%. In contrast, another low-yielding genotype, Pb. 85, showed disadvantage of 3.25 to 9.34% when associated with other cultivars.

Table 1. Analysis of variance for grain yield per plant.

Source of variation	d.f.	SS	MS	FR
Replications	3	1.70	0.567	1.26ns
Treatments	24	76.63	3.193	7.09**
Error	72	32.37		

** = $P<0.01$; ns = not significant.
CV = 6.45%.

In this experiment, 4 of 10 blends gave more yield than the mean of their components. Of these, two combinations, LU26S–Pb. 81 and LU26S–Kohinoor 83, yielded higher than the high-yielding component and showed over-compensatory effects of competition. They produced 12.55 and 11.30% more grain per plant over the components and 2.01 and 5.60% over the superior components, respectively. Five blends showed under-compensatory effects and yielded lower than the components. One blend, Pb. 81–Kohinoor 83, yielded almost equal to expectations.

Table 2. Mean grain yield (g) per plant in pure stand and mixtures, and land equivalent ratios (LER) for different varietal associations of spring wheat.

Varietal association		Pure stand			Mixture			LER
Cv. 1	Cv. 2	Cv. 1	Cv. 2	Mean	Cv. 1	Cv. 2	Mean	
LU26S	Pb. 81	9.28	11.43	10.36	12.03	11.28	11.66	1.141
LU26S	Koh. 83	9.28	10.35	9.82	11.33	10.53	10.93	1.118
LU26S	Pak. 81	9.28	11.18	10.23	10.50	10.43	10.47	1.032
LU26S	Pb. 85	9.28	9.85	9.57	10.58	9.08	9.83	1.031
Pb. 81	Koh. 83	11.43	10.35	10.89	10.78	11.00	10.89	1.003
Pb. 81	Pak. 81	11.43	11.18	11.31	9.70	11.28	10.49	0.928
Pb. 81	Pb. 85	11.43	9.85	10.64	11.00	9.35	10.18	0.956
Koh. 83	Pak. 81	10.35	11.18	10.77	9.55	11.75	10.65	0.986
Koh. 83	Pb. 85	10.35	9.85	10.10	9.38	9.53	9.46	0.937
Pak. 81	Pb. 85	11.18	9.85	10.52	10.08	8.93	9.51	0.904

Over-compensatory effects suggest that genotypic behavior in a competitive situation may be a reliable criterion for predicting superior blends. In the present study, the blends exhibiting over-compensatory effects gave 2.72 to 12.55% yield advantage over their components and 2.01 to 5.60% over the high-yielding component. Over-compensation from blends have been reported by various workers in wheat (Jensen and Federer 1965; Allard and Adams 1969; Sage 1971; Baker 1977; Sharma and Prasad 1978; Prasad and Sharma 1980; Reddy and Prasad 1980; Rao and Prasad 1984; Cheema et al. 1988), barley (Allard and Adams 1969; Palvakul et al. 1973) and oats (Frey and Maldonado 1967). Over-compensation in most of these studies ranged from 1 to 7.6% greater than the average of the component lines under the particular environmental conditions of the experiment. Palvakul et al. (1973) reported a maximum yield advantage of 16% in favor of the mixture in barley. Rao and Prasad (1984) obtained 28.3% higher grain yield in some mixtures when compared to pure stands in wheat, while Cheema et al. (1988) reported 18.8% higher yield than the mean of the components and 17.5% over the high-yielding component in wheat. LER is a reliable criterion for comparing mixtures and monocultures. Rao and Prasad (1984) obtained a maximum LER of 1.14 in some mixed stands of wheat, whereas Cheema et al. (1988) reported that one out of ten blends gave an LER of 1.188. In the present investigation, 4 out of 10 associations gave LER values of 1.141, 1.118, 1.032 and 1.031 idicating that 14.10, 11.80, 3.20 and 3.10% higher yields by these blends compared to their respective monocultures.

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Pollen Production Studies in Common Bread Wheat

Muhammad Aslam Chowdhry, Naeem Mahmood and Ihsan Khaliq
Department of Plant Breeding and Genetics
University of Agriculture, Faisalabad, PAKISTAN

Abstract

Pollen production studies were conducted on ten varieties of common bread wheat (*Triticum aestivum* L. ssp. *aestivum*) to identify phenotypic differences in some reportedly important traits. We also studied the association between the anther and pollen grain morphology and physiology with six components of grain yield. Results show that selection for long anthers and high rate of anther extrusion should be effective in promoting natural cross-pollination.

Key words: *Triticum aestivum*; soft wheat; pollen; phenotypes; grain; yields; selection; cross pollination; varieties; Pakistan.

دراسات على إنتاج حبوب الطلع في القمح الطري الشائع.

الملخص

أجريت دراسات على انتاج حبوب الطلع على عشرة أصناف من القمح الطري الشائع (*Triticum aestivum* L.) لتحديد الاختلافات في الشكل الظاهري لبعض الصفات الهامة. كما درسنا العلاقة بين مورفولوجية وفيزيولوجية المئبر وحبوب الطلع مع ست مكونات من الغلة الحبية. وتظهر النتائج أن الانتخاب لصفة المئبر الطويل وظهور المئبر بمعدل مرتفع يجب أن يكون فعالاً في تشجيع التقليح الخلطي.

Introduction

Wheat is believed to have been one of the first plants to be domesticated by man possibly more than 1500 years ago and has existed since then as a self-pollinated crop. It is becoming important to use the available hybrid vigor in small-grain crops like wheat in commercial hybrid-seed production. However, this depends upon the floral characteristics and the amount of cross-pollination achieved. Wheat has a cliestogamous flower, i.e. the floral characteristics are such that the flower is not suitable for efficient cross-pollination. Therefore, it is an objective for breeders to improve the cross-pollination potential of wheat to use it in commercial hybrid-seed production. The important floral characteristics which affect pollen production and seed set should be considered to see whether they can be modified to enhance the amount of cross-pollination.

Differences have been observed in anther extrusion (Milohnic and Jost 1970), anther size (DeVries 1974; Milohnic and Jost 1970) and pollen grains per anther (Khan et al. 1973). Komaki and Tsunkewaki (1980) found variation in anther length from 3.0 mm to 5.1 mm. Significant positive correlation between anther extrusion and plant height is reported by Lucken et al. (1982). Razzaq et al. (1986) report that days to heading is positively correlated with yield. Anthesis date is negatively correlated with grain-filling period (Bruckner and Frohberg 1987).

Sufficient information about the floral characteristics of wheat and their relationship, as reviewed above, is now available to select the ideal combination of these floral characteristics or to improve their performance so that suitable wheat lines may be developed which could be used in commercial hybrid-seed production. However, less information is available about the mode of inheritance of these floral characteristics, which is needed for selection and evaluation programs. Results are presented here concerning differences and inter-relationships of several floral traits and some agronomic characters.

Materials and Methods

Ten varieties of common bread wheat were planted in November 1990 in a randomized complete block design with three replications. Five-row plots of 5 m length served as experimental units. In the spring of 1991 data on the following pollen traits were recorded.

1. Days taken to heading and anthesis were recorded from date of sowing to date of 50% heading and 50% anthesis, respectively.
2. Anther extrusion: Twenty spikes were collected from each plot one week after flowering, and mean extrusion

(percentage) was calculated by using the formula of Milohnic and Jost (1970):

$$\text{Extrusion (\%)} = 1 - \frac{\text{(Unextruded anthers per 20 heads)}}{3 * \text{(Fertile florets per 20 heads)}} * 100$$

3. Anther size: Length and width of 15 anthers from the central lateral florets of five randomly selected spikes per plot were measured in millimeters using a disecting scope and a 10-mm ocular micrometer.

4. Pollen grain size: Five spikes were selected at random from each plot and five pollen grains from each spike were measured using a 0.1-mm micrometer at 40× magnification.

5. Pollen viability was determined by staining pollen grains with 1% acetocarmine and counting the number of viable pollen grains per microscopic field at 10× magnification. Viable pollen stained darker while nonviable pollen either did not stain or stained a lighter color.

6. Pollen grains per anther: Number of pollen grains per anther was determined by the method described by Sapra and Hughes (1974). Fifty mature anthers from ten randomly selected spikes per plot were placed in vial with 2 ml of 1% acetocarmine and were shaken until pollen fully dehisced. A drop of this mixture was placed on a slide and the number of pollen grains was counted using a standard haemocytometer. Fifteen observations per plot were recorded and converted to number of pollen grains per anther.

Agronomic traits including plant height, filling period, seed-set percentage, grains per spike, 1000-grain weight and grain yield per plant, were also determined at maturity. Data were subjected to analysis of variance and simple correlation analysis.

Results and Discussions

All ten varieties differed significantly for all the traits studied (Table 1). Days to heading ranged from 96.67 (S-691) to 109.33 (LU60 and Pak. 81). Days to start anthesis ranged from 103 (S-691) to 114.33 (Pak. 81). Anther length was maximum (4.41 mm) in Faisalabad-83 and minimum (3.90 mm) in WL-711 and Yekora. Atashi-Rang and Lucken (1978) observed differences in anther length ranging from 3.45 to 5.09 mm in spring wheat cultivars. Anther width ranged from 0.77 mm (Punjab-85) to 0.90 mm (LU26S). Maximum anther extrusion of 82.78% was found in S-691 and minimum (19.44%) in LU60. Pollen size varied from 69.17 µm (Pak. 81) to 61.43 µm (S-691). Highest number of pollen grains per anther (1457.78) was found in Faisalabad-83 and lowest (1107.56) in Yekora. Khan et al. (1973) observed that number of pollen grains per anther ranged from 1300 to 1600 in twelve hard red winter wheats, while Singh and Sindhu (1974) observed a range of 975–2773 pollen grains per anther. Pollen viability ranged from 92.62 to 96.31%. A considerable range in mean values of yield components was also observed (Table 2).

Table 1. Mean values of pollen traits for ten bread wheat varieties.

Variety	Days to heading	Days to anthesis	Anther length (mm)	Anther width (mm)	Anther extrusion (%)	Pollen size (µm)	No. of pollen grains/ anther	Pollen viability (%)
WL-711	103.3	108.3	3.90	0.84	56	64.12	1240	94
Shalimar	99.0	105.7	4.01	0.85	68	64.88	1420	96
LU26S	97.3	103.3	4.09	0.90	79	63.65	1420	96
Faisalabad-83	97.7	105.7	4.41	0.89	56	65.28	1460	94
S-691	96.7	103.0	3.93	0.80	83	61.43	1270	93
Yekora	98.0	103.7	3.90	0.79	62	64.67	1110	94
LU31	109.0	112.0	3.99	0.78	21	63.25	1350	95
Punjab-85	103.7	108.7	4.00	0.77	77	65.65	1300	96
LU60	109.3	112.0	3.94	0.80	19	66.56	1320	95
Pak. 81	109.3	114.3	4.24	0.86	30	69.17	1440	95
LSD 0.05	1.6	1.0	0.186	0.062	7.6	2.513	116	2.4
LSD 0.01	2.2	1.4	0.255	0.085	10.4	3.443	158	3.3
CV %	0.9	0.5	2.7	4.4	8.0	2.3	5.1	1.5

Table 2. Mean values of agronomic traits for ten bread wheat varieties.

Variety	Grain-filling period (days)	Plant height (cm)	Seed set (%)	Grains per spike	1000-grain weight (g)	Grain yield per plant (g)
WL-711	42.7	102.6	68	65.4	38.89	34.22
Shalimar	46.7	109.2	75	73.3	42.16	35.97
LU26S	45.3	96.8	70	54.7	45.95	34.53
Faisalabad-83	46.3	104.1	76	73.3	42.45	40.66
S-691	46.3	93.2	67	47.5	47.53	30.30
Yekora	44.7	83.7	66	57.6	40.59	32.24
LU31	40.7	73.5	68	65.6	38.60	35.54
Punjab-85	42.3	105.5	71	64.7	37.98	36.93
LU60	40.3	78.8	68	62.2	36.51	33.50
Pak. 81	38.7	81.7	68	73.5	35.67	29.46
LSD 0.05	1.77	3.76	4.0	5.50	3.822	4.886
LSD 0.01	2.42	5.14	5.5	7.54	5.235	6.693
CV%	2.4	2.4	3.3	5.0	5.5	8.3

Simple correlation analysis (Table 3) indicated that days to heading and anthesis were significantly and positively correlated with pollen size and grains per spike. However, the relationship between days to heading and anthesis was also significant and positive, but they were negatively correlated with anther extrusion, grain-filling period (also reported by Razzaq et al. 1986; Bruckner and Frohberg 1987), plant height and 1000-grain weight. Anther length and width were positively correlated with number of pollen grains per anther. Similar results have been reported by DeVries (1974), Sapra and Hughes (1974), and Milohnic and Jost (1970). Anther length was also significantly associated with grains per spike. These results suggest that selection for longer anthers would improve pollen production for efficient cross-pollination. Anther extrusion was positively and significantly correlated with grain-filling period, plant height and 1000-grain weight, but negatively correlated with pollen-grain size and grains per spike. Lucken et al. (1982) found a significant positive relationship between anther extrusion and plant height. High anther extrusion before anthesis is a desirable character to enhance natural cross-pollination, so selection for anther extrusion may be effective (Sage and Isturiz 1974; Atashi-Rang and Lucken 1978). Pollen-grain size was positively correlated with grains per spike, but negatively correlated with grain-filling period and 1000-grain weight. Number of pollen grains per anther was positively and significantly correlated with seed set and grains per spike. Pollen viability showed positive correlation with grain yield per plant and negative association with grain-filling period. Welsh and Klatt (1971) also found positive correlation (r=0.87) between pollen viability and grains per spike.

These results suggest that selection for anther size would be effective to increase pollen production for effective cross-pollination; however, anther extrusion at anthesis should also be considered. As early varieties, such as S-691, Punjab-85 and LU26S, showed more anther-extrusion percentage, they may be used in a hybridization programs for natural cross-pollination provided a suitable parent is available to receive air-blown pollen.

Table 3. Correlation coefficients for several pollen traits and agronomic characters.[†]

	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Days to heading	0.966**	-0.023	-0.257	-0.839**	0.489**	0.068	0.185	-0.921**	-0.599**	-0.191	0.369*	-0.786**	-0.219
2. Days to anthesis		0.124	-0.152	-0.833**	0.550**	0.200	0.208	-0.906**	-0.507**	-0.094	0.493**	-0.782**	-0.151
3. Anther length			0.312	-0.105	0.313	0.410*	-0.113	-0.028	0.138	0.345	0.375*	-0.000	0.112
4. Anther width				0.132	0.124	0.382*	0.026	0.193	0.261	0.417*	0.282	0.292	0.187
5. Anther extrusion					-0.431*	-0.119	-0.116	0.735**	0.718**	0.113	-0.406*	0.648**	0.079
6. Pollen size						0.197	0.331	-0.497**	-0.144	0.107	0.577**	-0.598**	0.026
7. No. of pollen grains/anther							0.335	0.059	0.209	0.417*	0.438*	-0.052	0.261
8. Pollen viability								-0.376*	0.172	0.286	0.345	-0.151	0.427*
9. Grain-filling period									0.607**	0.329	-0.224	0.722**	0.316
10. Plant height										0.547**	0.154	0.338	0.417*
11. Seed-set percentage											0.603**	0.035	0.578**
12. Grains/spike												-0.530**	0.328
13. 1000-grain wt													0.087
14. Grain yield/plant													1.000

[†] n = 30.
* = Significant at 0.05 level; ** = Significant at 0.01 level.

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Influence of Bread Wheat Kernel Color on Flour and Arabic Two-layered Flat Breads

F. Jaby El-Haramein[1], G. Ortiz-Ferrara[1] and P. Williams[2]

[1] *International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, SYRIA*

[2] *Canadian Grain Commission, Grain Research Laboratory, 1404-303 St., Winnipeg, Manitoba, R3C 3G8, CANADA*

Abstract

Bread wheat cultivars (*Triticum aestivum* L. ssp. *aestivum*) with white/amber seeds are preferred by farmers in most countries of West Asia and North Africa (WANA). This preference often leads to the rejection of promising lines due to their having red bran. This study was conducted to determine whether differences in two-layered flat bread baking, and other quality parameters, existed among wheats of red and white bran color. Twenty-six bread wheat lines with red or white/amber bran were planted in three contrasting environments and tested against a wide

تأثير لون حبة القمح الطري على الدقيق والخبز العربي المرقد ذي الطبقتين.

الملخص

يفضل المزارعون في معظم بلدان غربي آسيا وشمالي إفريقيا (وانا) أصناف القمح الطري .*Triticum aestivum* L) (spp. *aestivum* ذات الحبات البيضاء/الكهرمانية. ويؤدي هذا التفضيل في غالب الأحيان إلى رفض السلالات المبشرة بسبب نخالتها الحمراء. اجريت هذه الدراسة لتحديد فيما إذا كانت توجد اختلافات بين أقماح ذات نخالة حمراء وبيضاء اللون، في خبيز الخبز المرقد ذي الطبقتين، بالإضافة إلى معايير جودة أخرى. تم زرع 26 سلالة قمح طري ذات نخالة حمراء اللون أو بيضاء/كهرمانية في ثلاث بيئات متباينة، وتم اختبارها إزاء طائفة واسعة من معايير الجودة. لوحظت اختلافات طفيفة بين الدقيق الأحمر والأبيض فيما يتعلق برماد الدقيق، ومعايير الفارينوغراف، إلا أنه لم تكن توجد فروقات معنوية في لون فتات الخبز المخبوز من أقماح حمراء وبيضاء. وتوحي هذه النتائج بأن سلالات القمح

range of quality parameters. Minor differences were observed between red and white flours in terms of flour ash and farinograph parameters, but there were no significant differences in the crumb color of breads baked from red and white wheats. These results suggest that promising, high-yielding bread wheat lines with red bran have equal quality potential to white/amber cultivars. This justifies their use in bread wheat breeding programs aimed at improving production in the rain-fed areas of WANA region.

Key words: *Triticum aestivum*; soft wheat; seeds; breadmaking; quality; flours; varieties; rain fed farming; North Africa; Western Asia; Canada.

Introduction

Hexaploid common (bread) wheats can be separated into eight classes, representing all possible combinations of spring and winter habit, hard and soft kernel texture and red and white bran color. Due mainly to climatic factors, the most extensive wheat-growing areas of the world are dominated by red-bran varieties of the Hard Red Spring (HRS), Hard Red Winter (HRW) and Soft Red Winter (SRW) classes. When wheat is milled into flour commercially, the amount of flour extracted varies between 75 and 77%.

While the bran layers may be different colors, the interior of the kernel, or endosperm, is white, and flour milled from both red and white wheats under these conditions has the same degree of "whiteness".

In order to obtain the maximum amount of bakery flour from wheat, some importing countries, including those in the West Asia/North Africa (WANA) region, mill to higher extraction rates of 80–87%. This leads to concern that the inclusion of a greater proportion of the bran layers may cause the flours milled from red wheats to be darker than those milled from white wheats, with corresponding changes in interior crumb color in the breads. As a result, national wheat-breeding programs in WANA and other countries tend to favor germplasm with white to amber bran. In pursuing this policy, germplasm with high yield potential but red bran color may be overlooked.

The bread wheat breeding program at the International Center for Agricultural Research in the Dry Areas (ICARDA) uses germplasm with both red and white bran. The purpose of this article is to illustrate the effect of bran color on functionality parameters, including both flour and bread crumb color, of flours from both types of wheat for the baking of Arabic two-layered flat (2LF) bread.

الطري المبشرة المقلالة ذات النخالة الحمراء تتمتع بجودة متساوية مع الأصناف البيضاء/الكهرمانية. وهذا يسوغ استخدامها في برامج تربية القمح الطري الهادفة إلى تحسين الإنتاج في المناطق البعلية من منطقة وانا.

Materials and Methods

Based on the highest average yields from advanced yield trials grown under three regimes during the 1988/89 campaign, ten red- and ten white-bran lines were selected. Three red and three white standard cultivars were also included. The wheats were planted under the same three conditions in the 1989/90 growing season. The conditions were Tel Hadya rain-fed (RF), where precipitation was 233 mm during the growing period, Tel Hadya with supplementary irrigation to 400 mm (IRR) and Breda, where precipitation was 179 mm. The wheats were planted in duplicate plots of four rows, 2.5 m long. Yield from both replicates was combined to give enough wheat for milling and baking. The trial at Breda was replicated three times to ensure sufficient grain at harvest.

Wheats were freed of foreign material using a Carter Dockage tester. Test weight, 1000-kernel weight, kernel hardness (Particle Size Index), protein content, flour milling, Farinograph testing and 2LF-bread-baking were all carried out according to Williams et al. (1988a). Flour color was determined using a Kent-Jones Color Grader – the lower the figure, the brighter the color.

In order to simulate as closely as possible the higher extraction of commercial flour mills in the WANA region the Buhler Model MLU 202 laboratory flour mill was modified as follows: break roll gaps were reduced to 16, 3 and 2/1000 inch, and clothing of the reduction section was replaced with 8 XX, 8 XX and 9 XX clothing (Buhler mill soft wheat clothings).

Results

The wheat quality factors are summarized in Table 1. The white wheats were slightly harder and less variable in kernel texture than the red wheats. Average kernel size of the white wheat series was greater, as were test weight and flour yield. Protein content of the white wheats was

Table 1. Grain characteristics of red and white wheats grown under three different conditions.

Site/regime	Class		TW (kg/hl)	TKW (g)	Protein (%)	PSI (%)	FY (%)
RF	Red	Mean	75.1	26.8	15.0	49.3	73.7
		SD	1.9	2.7	0.9	5.8	1.6
	White	Mean	76.1	27.4	14.9	46.1	74.1
		SD	2.5	2.8	0.4	3.2	1.4
IRR	Red	Mean	76.4	30.0	13.2	46.7	75.0
		SD	1.8	2.9	0.4	3.4	0.9
	White	Mean	77.4	32.8	13.3	45.0	75.6
		SD	2.4	4.2	0.4	2.4	1.0
Breda	Red	Mean	75.0	23.6	15.6	47.5	73.5
		SD	2.2	3.4	0.6	4.0	0.7
	White	Mean	75.5	25.2	15.2	46.8	74.5
		SD	2.5	2.2	1.1	2.6	1.2
Overall	Red	Mean	75.5	26.5	14.6	47.8	74.0
		SD	2.0	4.0	1.2	4.5	1.3
	White	Mean	76.3	28.5	14.4	46.0	74.7
		SD	2.5	4.5	1.1	2.8	1.3

FY = Flour yield; IRR = Tel Hadya, irrigated; PSI = Particle Size Index; RF = Tel Hadya, rain-fed; SD = Standard deviation; TKW = 1000-kernel weight; TW = Test weight.

slightly lower. These differences were apparent under all three growing conditions, but were not significant. In the case of the red wheats there was no correlation between flour yield and test weight, 1000-kernel weight or kernel hardness (PSI) at any of the growing locations. Flour yield was significantly related to kernel weight in wheat grown under the Tel Hadya rain-fed conditions (r = 0.63), but this relationship was not noticeable under either of the other two field conditions.

Flour functionality, including physico-chemical properties as measured by the Brabender Farinograph and 2LF-baking performance, is summarized in Table 2. Only minor differences were observed between red and white flours in terms of flour ash and Farinograph parameters across the three environments. Farinograph development times of the white-wheat flours were slightly higher than those of the red-wheat flours, but this apparent superiority in strength was counterbalanced by slight superiority of the red-wheat flours in Farinograph stability and mixing tolerance. Earlier work at ICARDA (Williams et al. 1988b) involved the development of a laboratory-scale 2LF-bread-baking sequence, and the determination of the precision of the baking method. The LSDs between means (n = 6) for dough-handling properties at the dividing and sheeting stages, crumb color and total score were 0.6, 0.2, 0.5 and 1.9 units, respectively. The 2LF-bread-baking results in the present study (where n = 10) indicated that the average total score of the bread baked from flours milled from the white wheats was significantly superior to those milled from red wheats in the three environments. These results are summarized in Table 3. Bread parameters which did not differ significantly as a result of statistical analysis are not included.

Table 2. Flour properties of red and white wheats grown under three growing conditions.

Site/regime	Class		FA[†]	FC	FAB	FDT	FST	FMT	BCC	BSC
RF	Red	Mean	0.67	1.53	63.1	5.53	5.35	82.5	4.15	36.8
		SD	0.03	0.84	2.5	0.59	2.77	40.9	0.34	2.3
	White	Mean	0.66	0.40	63.6	6.37	5.07	96.0	4.50	38.8
		SD	0.05	0.42	1.4	1.55	2.74	46.9	0.24	1.9
IRR	Red	Mean	0.64	1.26	62.2	5.26	4.82	99.0	3.95	36.4
		SD	0.03	1.03	2.0	1.10	1.73	43.5	0.28	2.1
	White	Mean	0.66	0.36	63.4	5.83	4.16	105.0	4.20	37.6
		SD	0.05	0.66	0.8	1.05	1.38	34.0	0.35	1.3
Breda	Red	Mean	0.57	1.84	61.6	5.82	6.89	64.0	4.38	37.4
		SD	0.06	1.30	2.2	1.17	3.40	34.5	0.23	2.5
	White	Mean	0.60	0.85	61.6	7.13	7.25	62.6	4.79	40.4
		SD	0.05	0.72	1.4	2.67	3.78	31.4	0.27	1.1
Overall	Red	Mean	0.63	1.54	62.3	5.69	5.68	81.8	4.14	36.8
		SD	0.06	1.06	2.2	2.77	2.78	41.1	0.33	2.3
	White	Mean	0.64	0.54	62.8	6.44	5.49	97.9	4.46	38.8
		SD	0.06	0.63	1.4	1.90	3.01	41.1	0.36	1.8

[†] BCC = Bread crumb color (scale 1–5); BSC = Bread score (1–5); FA = Flour ash (%); FC = Flour color (Kent–Jones units); FAB = Farinograph (water) absorption (%); FDT = Farinograph development time (min); FMT = Farinograph mixing tolerance (Brabender units); FST = Farinograph stability (min); IRR = Tel Hadya, irrigated; RF = Tel Hadya, rain-fed.

Table 3. Two-layered flat bread baking details for red and white wheat flours.

Site/regime	Type	DHD	DHS	BCC	BSC
RF	Red	3.90	3.95	4.15	36.75
	White	4.20	4.25	4.50	38.80
IRR	Red	3.90	3.90	3.90	36.40
	White	4.30	4.05	4.20	37.65
Breda	Red	3.75	3.69	4.38	37.38
	White	4.33	4.22	4.79	40.36
Overall	Red	3.85	3.83	4.14	36.79
	White	4.33	4.22	4.50	38.78
Mean difference		0.48	0.39	0.36	1.99
LSD (0.05)		0.60	0.20	0.50	1.90

BCC = Bread crumb color (scale 1–5); BSC = Baking score (1–45); DHD = Dough-handling at dividing (1–5); DHS = Dough-handling at sheeting (1–5); IRR = Tel Hadya, irrigated; RF = Tel Hadya, rain-fed.

Discussion

Wheat-importing countries in the WANA region tend to prefer wheats with white/amber bran color. In many instances this is a question of tradition, rather than observed differences in performance. This preference often leads to the rejection of promising high-yielding lines with red bran. This study was implemented to determine whether differences in 2LF-bread-baking, and other quality parameters, existed among wheats of red and white bran color.

The same trends in the quality factors of the 2LF breads were apparent in flours milled from both red and white wheats. The most important feature was that, despite differences in the color of the flours, there were no significant differences in the crumb color of breads baked from red and white wheats grown under the three environments.

Jordan, Lebanon and Syria periodically import HRS, HRW or SRW wheats from the USA or Canada, and other red-kerneled wheats from Europe. Thus, millers and bakers are familiar with the milling characteristics of all these wheats. Specifications for commercial bakery flours in these countries include maximum flour color strictures ranging from 6.0 to 8.0 Kent–Jones units. Although the present study represented wheats differing widely in protein content, test weight, kernel size and other parameters, none of the flours milled from them exceeded these guidelines for flour color.

Ideally, in order to conduct a true evaluation of the influence of wheat bran color on flour color, it would be necessary to develop near-isogenic lines, which differed in bran color only. The development of this type of genetic material is very time-consuming, and during the time it would take to develop enough material for a comprehensive study, large numbers of red-bran genotypes with high-yield potential could be discarded. The chief conclusion drawn from the work described is that bread wheat lines with high-yield potential, but red bran can justifiably be included in bread wheat breeding programs aimed at improving production in the West Asia/North Africa region.

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Responses of Rain-fed Triticale Cultivars to Nitrogen and Phosphorus in Morocco

استجابات أصناف التريتيكال البعلية إزاء الأزوت والفوسفور في المغرب.

J. Ryan[1], M. Mergoum and N. Nsarellah
INRA/MIAC, Aridoculture Center
P.O. Box 290, Settat, MOROCCO
(USAID Project no. 608-0136)

Abstract

Considerable emphasis is being placed on adapting and developing triticale (× *Triticosecale* Wittm. ex A. Camus) in the dryland farming systems of North Africa. In this effort, it is vital to assess how triticale cultivars respond to fertilization. This on-farm trial, conducted on a shallow soil (Petrocalcic Palexeroll, 300 mm) which was deficient in both nitrogen and phosphorus, evaluated responses of five triticale cultivars (Drira Outcross, Juanillo, Delfin 205, Rhinos and Beagle) to N and P. While the application of N and P individually increased yields, combining the two more than doubled yields. Fertilization has little effect on grain N percentage or kernel weight. Similarly, there were few differences between cultivars. The study emphasized the importance of N and P fertilization for triticale.

Key words: Triticales; nitrogen fertilizers; phosphate fertilizers; fertilizer application; yields; rain fed farming; Morocco.

الملخص

ثمة تركيز على أقلمة واستنباط (x *Triticosecale* Wittm. ex A. Camus) في النظم الزراعية في الأراضي الجافة من شمالي إفريقيا. وفي هذا المسعى، من الهام تقييم كيفية استجابة أصناف التريتيكال إلى التسميد. وقد اجريت هذه التجربة في حقول المزارعين، على تربة سطحية (Petrocalcic Palexeroll, 300m) يعوزها الأزوت والفوسفور، بهدف تقييم استجابات خمسة أصناف من التريتيكال (Drira outcross، Juanillo، Delfin 205، Rhinos و Beagle) للأزوت والفوسفور. وفي حين أدت إضافة الأزوت والفوسفور، كل على حدة، إلى زيادة الغلة، أعطت إضافتهما معاً إلى زيادة الغلة إلى أكثر من الضعف. إن للتسميد تأثيراً طفيفاً على نسبة الأزوت الحبة أو وزن البذرة. كما كانت توجد فروقات قليلة بين الأصناف. وقد ركزت الدراسة على أهمية التسميد الأزوتي والفوسفوري للترتيكال.

Introduction

In the past decade or so, much research effort has focused on increasing the output of rain-fed cereals in the West Asia–North Africa (WANA) region. While barley (*Hordeum vulgare* L.), bread wheat (*Triticum aestivum* L. ssp. *aestivum*) and durum wheat (*T. turgidum* L. ssp. *durum* (Desf.) Husn.) are the dominant cereals, attention has centered on triticale, a crop deemed to have considerable potential in commercial agriculture (Skovmand et al. 1984). In Syria and Turkey, studies have dealt with agronomic comparisons of triticale with barley, and environmental adaptation (Genc et al. 1989; Nachit, 1982, 1983, 1984; Nachit and Malik 1983; Yau 1987). In the North African zone, research efforts with triticale have been minimal.

In Morocco, this newly-introduced cereal is seen as having a complementary role to the major cereals, especially in the semiarid zone (Mergoum et al. 1992). Given the importance of nitrogen for increasing cereal output in Morocco (Abdel Monem et al. 1990; Shroyer et al. 1990), one of the few triticale trials which have been conducted compared a high-yielding triticale variety, Juanillo, with a barley variety (Arig 8) in relation to N fertilization, at locations with different rainfall (Ryan et al. 1991b). Triticale generally outyielded barley and responded well to N, i.e. up to 30 kg N/ha at the drier locations (270 mm) and 90-150 kg N/ha at the wetter areas (>370 mm).

These encouraging results suggested a comparison of both N and P fertilization of the commonly used triticale cultivars under insufficient levels of both elements in on-farm conditions. The foregoing trial on a representative shallow soil in the Chaouia region was both diagnostic and demonstrational.

[1] Present address: Farm Resource Management Program, ICARDA, P.O. Box 5466, Aleppo, SYRIA.

Materials and Methods

The site of this on-farm trial was near Settat in Morocco's semiarid zone, i.e. a mean annual rainfall of 386 mm with large inter-annual fluctuations. While rainfall for the cropping year was 277 mm, it was erratically distributed, i.e. virtually no rain in November or January, heavy rains fell in early December and again in February and March, resulting in satisfactory yields.

The soil was a Petrocalcic Palexeroll with insufficient levels of both N (2 p.p.m. NO_3-N) and P (3.2 p.p.m. $NaHCO_3$-P), but with adequate available K (270 p.p.m.).

The previous crop was barley; however, a fallow-cereal-legume rotation is commonly practiced in the area. The site was prepared with an offset disc.

The broadcast fertilizer treatments were: (1) N as ammonium nitrate at 150 kg/ha, (2) P as triple superphosphate at 40 kg/ha, (3) N and P combined at these rates, and (4) an unfertilized control. The triticale cultivars were Juanillo, Drira Outcross, Rhinos, Delfin 205 and Beagle; all were hand-broadcast at 160 kg seed/ha. Characteristics of the cultivars are shown in Table 1. Both fertilizer and seed were then disced in to a depth of about 10 cm on 3 December 1990.

Table 1. Characteristics of five triticale cultivars.

Cultivar	Pedigree	Origin	Registered	Yield potential
Drira Outcross	DR44/3/INIA/RYE//ARM "S"	CIMMYT	1988	Very high
Juanillo	DRIRA//KISS/ARM "S"	CIMMYT	1988	Very high
Delfin 205	MZA/BGL "S"	CIMMYT	1988	Very high
Rhinos "S"	GRIZZLY "S"//AI FONG 43/DOVE	CIMMYT	1988	Very high
Beagle	UM "S"/TCL BULK	CIMMYT/INRA	"	High

Treatments were arranged according to a split plot design where varieties were allocated to main plots and fertilizer treatments to subplots. Varieties were randomized following a radomized complete block design. Subplots were 5 x 4 m. Treatments were in three replicates. On 12 June 1991 the plots were hand-harvested by sickle. Full-plot biomass was weighed and samples were threshed for harvest index. Plant dry matter was analyzed for total N and 1000-seed measurement taken from each treatment.

Results

The overall mean effect of individual triticale cultivars varied with the measurement in question (Table 2). While significant biomass yield differences occurred among cultivars, the range was narrow, i.e. 6.94 t/ha for Drira Outcross to 6.38 t/ha for Beagle. Predictably, grain yield followed a similar pattern with a range of 1.46 to 1.82 t/ha. In terms of N content of the grain, values for Beagle (1.28%) were significantly lower than for the other four cultivars. For kernel weight, the pattern changed among cultivars, with highest values (38.9 g) being for Juanillo (38.9 g) and the lowest (31.9 g) for Delfin 205.

Table 2. Cultivar influences on triticale yield and quality parameters.

Cultivar	Yield (t/ha)		N content (%)	1000-seed weight (g)
	Dry matter	Grain		
Drira Outcross	6.94a[†]	1.82a	1.45a	37.31ab
Juanillo	6.77ab	1.76a	1.34ab	38.9 a
Delfin 205	6.69ab	1.72ab	1.45a	31.9 c
Rhinos "S"	6.66ab	1.61b	1.42a	33.4 bc
Beagle	6.38b	1.46c	1.28b	35.6 abc

[†] Means with different letters are significantly different at $P<0.05$.

The mean effect of fertilization was pronounced and consistent (Table 3), irrespective of cultivar. The addition of P alone (30 kg P/ha) increased dry biomass yields by an average of 15%, while addition of N (140 kg/ha) alone increased yields by 2.85 t/ha or 66%. When both N and P were added, yields were then doubled to 10.2 t/ha (136%). Thus, combining N and P doubled the effect of N alone. Grain yield followed a similar pattern with the NP treatment producing 2.6 t/ha compared with the control at

1.1 t/ha. However, fertilization had no significant effect on either N content, and therefore crude protein, or kernel weight.

Table 3. Mean influence of fertilization on triticale yield and quality indicators.

Treatment	Yield (t/ha)		N content (%)	1000-seed weight (g)
	Dry matter	Grain		
Control	4.3a[†]	1.1a	1.40a	35.2a
P	5.0b	1.2b	1.42a	35.9a
N	7.2c	1.8c	1.37a	35.1a
NP	10.2d	2.6d	1.33a	35.4a

[†] Means with different letters are significantly different at $P<0.05$.

Discussion

The trial showed that, for yield and protein content, all cultivars performed similarly, except for Beagle, which was poorer. However, the mean grain protein content of 8.7% was considerably lower than the ranges cited for other triticales by Skovmand et al. (1984). Nevertheless, a more evident effect was that of fertilization. The yield increases reflected the dramatic effect of adequate fertilization; as commonly observed in our cereal fertilization program (Abdel Monem et al. 1990; Ryan et al. 1991a), N had the most pronounced effect, while P responses were of a lower order of magnitude (Ryan et al. 1992).

This trial demonstrated clearly the need for both N and P when soil is deficient in these elements. Our efforts in the WANA region are to promote soil testing as a basis for rational fertilizer use. All the cultivars tested responded in a similar manner, with only small differences in yield potential between them. This obviates the need for extension testing of N fertilizer responses for individual triticale cultivars.

Several local farmers and researchers visited the site. Striking visual differences between plots served to underline the importance of adequate fertilization. The tall, erect stands of relatively disease-free triticale contrasted visually with barley and wheat in adjacent experimental plots. Triticale may therefore have a role in this area, traditionally dominated by barley and, to a lesser extent, wheat.

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Short Communications

Barley Collection and Characterization in North Yemen

Hassan M. Amer and K.L. Mehra[1]
Agricultural Research Authority
P.O. Box 87148
Dhamar, YEMEN

Barley is an important crop in the inter-moutane plains and high altitude (above 1000 m) regions in the Central and Northern Highlands and in the eastern slopes of North Yemen, Republic of Yemen, where the annual rainfall is less than 450 mm. The crop is cultivated/harvested twice in the Central Highland but only once in the eastern slopes. With the estimated area and production of barley at 48,000 ha and 42,000 tonnes grain yield, only the local demands are fulfilled, of which about 10% is used as animal feed. Its cultivation in irrigated or in regions of moderate rainfall is diminishing due to the rapid spread of improved, dwarf wheat (*Triticum aestivum* L. ssp. *aestivum*) cultivars. However, barley cultivation is presently spreading in dryland areas, where wheat almost fails to grow. Work on collection and conservation of local barley genetic resources was undertaken and the results of two seasons' program is reported in this short note.

Collection

The unique topography of North Yemen affects its rainfall and cropping seasons. Barley is grown under diverse agro-climatic conditions. In the highlands of North Yemen, most of the terraced fields alternate with rocky mountains and are spread out along the windward slopes, where the rainfall can support vegetation. Sampling strategy comprised stops at regular intervals of 10–15 km, along the travel route, among the inter-montane plains. Random population samples were collected, avoiding the redundancy of samples as far as possible. Collection site data were recorded, using ICARDA standard sheets. Collections were made in November–December 1989 from the Central Highland region, January 1990 from the Mareb region, and in February 1990 from Utma area in the Central Highlands.

Twenty-nine collections (17 in 1989 and 12 in 1990) were made from 18 sites differing in one or more eco-geographic descriptors, namely altitude (1780–2980 m); longitude (43.34–45.26°E); latitude (14.13–15.43°N); rainfall (200–800 mm/year); and geological soil formations (basalt flows and dikes, river-terrace deposits, alluvial fans, loess deposits, Yemen volcanic series, predominantly granite). Most of the collections were of 2-row, hulled types, but 6-row types were also collected. In Utma area, 2- and 6-row types were grown as mixtures. Common landraces are named Aswad, Baladi, Mardai, Saglah and Safeh. Landraces Bekur and Shair, collected from the Mareb area, had very long seeds. A dark green, naked barley landrace, Habeeb, was collected from a few isolated areas.

Characterization

Seventeen collections made in 1989 were sown in spring 1990 for characterization, using IBPGR (now IPGRI) descriptor lists. All collections were spring types. Phenotypic diversity between collections was observd in plant height (40–70 cm), days to flowering (58–94), row number/lateral florets (six rowed, two rowed with larger or small sterile lateral florets or two rowed with rudimentary sterile laterial florets), spike density (lax, intermediate or dense), spikelet groups/spike (12–23), awnleted or awned spikelets, degree of awned roughness, naked or covered grains (lemma and palea adhering to the caryopsis), pericarp color (white, black, greenish black or green) and 1000-grain weight (55–100 g).

Conclusions

Two Arabic manuscripts written by Rasulid Sultans – al-Isharah fil-imarah by al-Malik al-Mujahid Ali b. Dawad (AD 1363) and Bughyet-al-Fallahin by al-Malik al-Afdal al-Abbas b. Ali (AD 1370) – refer to landraces Sult and Habeeb of the naked-grain types. Sult could not be located in any farmer's field, but Habeeb has been collected. Barley genetic resources from other areas, especially the Southern Uplands, Northern Highlands and south Yemen need to be collected before they are replaced by modern varieties of barley and other crops.

[1] Present address: 38 Munrika Enclave, New Delhi – 110 067, INDIA.

Resistance of Barley Genotypes with the *Yd2* Gene to the Movement of Barley Yellow Dwarf Virus

K.M. Makkouk and W. Ghulam
Genetic Resources Unit, ICARDA
P.O. Box 5466, Aleppo, SYRIA

Barley yellow dwarf virus (BYDV) is known to cause serious economic losses to cereals worldwide (Plumb 1983). Resistance or tolerance to BYDV infection has been reported in cereals. In barley (*Hordeum vulgare* L.), a single incompletely dominant gene (*Yd2*) has been identified, whereas BYDV tolerance in wheat is believed to be controlled by more than one gene, but these have not been identified. The mechanism of BYDV resistance in small-grain cereals has not yet been elucidated.

The restriction of virus movement in resistant as compared to susceptible cultivars has been reported for cucumber mosaic virus (CMV) in pepper (Dufour et al. 1989; Nono-Womdim et al. 1991) and maize dwarf mosaic virus (MDMV-A) in maize (Law et al. 1989). In this study we investigated BYDV movement in resistant and susceptible barley genotypes.

Materials and Methods

Four resistant barley genotypes (+*Yd2*) (Corris, BQCB-10, BKL85-237 and Atlas 68), and two susceptible genotypes (-*yd2*) (Atlas 57 and Harmal) were used. Twelve plants of each genotype were grown in pots under greenhouse conditions at 15–25°C. At the 5–6-leaf stage, each plant was inoculated with a PAV isolate of BYDV through the aphid vector *Rhopalosiphum padi* L. A small plastic cage was placed on the tip of the second youngest leaf, and 10–15 viruliferous aphids were introduced to each cage. The aphids were allowed to feed on the plants for 48 hours to inoculate the virus, after which they were killed with insecticide (Pirimor).

At 3, 6, 9, 12, 18, 24, 30 and 40 days after inoculation with the virus, plants were harvested and divided into different parts: inoculated leaf, root and apex. Virus concentration was determined in each part by using ELISA (Clark and Adams 1977). Sample extraction buffer for ELISA (0.2 *M* phosphate, pH 6.0) was used at the rate of 10 ml per gram of tissue. Plant parts from every three plants were pooled together for extraction and were considered as one sample.

Results and Discussion

Six days after inoculation, virus was not detectable in either roots or apex of any of the genotypes tested except in one of four samples of the susceptible cultivar Atlas 57. Nine days after inoculation, virus was detected in the roots of three out of four (3/4) and 1/4 groups of the susceptible genotypes Harmal and Atlas 57, respectively, but was not detected in roots of the resistant genotypes. Twelve days after inoculation, virus was detected in roots of 3/4 and 4/4 groups of Harmal and Atlas 57, respectively, but again was not detectable in roots of the resistant genotypes. BYDV was only detected 18 days after inoculation in the roots of the resistant genotype Atlas 68 and 24 days after inoculation in the other resistant genotypes. It seems that virus movement to the roots was not at the same speed in the four resistant genotypes, suggesting that the *Yd2* gene, when present in different backgrounds, has different effect on BYDV movement. The period required for the virus to reach the root system of the different genotypes tested is illustrated in Figure 1. Jensen (1973) reports that BYDV can move out of the inoculated leaf more readily in susceptible than in resistant cereals; however, he did not measure the time required for the virus to move from the inoculated leaf to the root system.

In the susceptible genotypes, BYDV was detected simultaneously in the roots and the apex of inoculated plants, whereas in the resistant genotypes virus was detected in the roots one week before its detection in the apex. This suggests that resistant genotypes reduce both downward virus movement to the roots and upward movement to the growing point.

In this preliminary study, it was clear that BYDV movement from the inoculated leaf to the root was much slower in resistant than in susceptible genotypes, which is in agreement with findings with some other viruses (Dufour et al. 1989; Law et al. 1989; Nono-Womdin et al. 1991).

These results suggest that retardation of virus movement inside the plant is one of the factors that contribute to the BYDV-resistance mechanism in barley. It would be interesting to find out if such a factor is also functional in other small-grain cereals such as wheat, rye, oats and triticale, where genotypes with tolerance to BYDV have been identified (Qualset 1992).

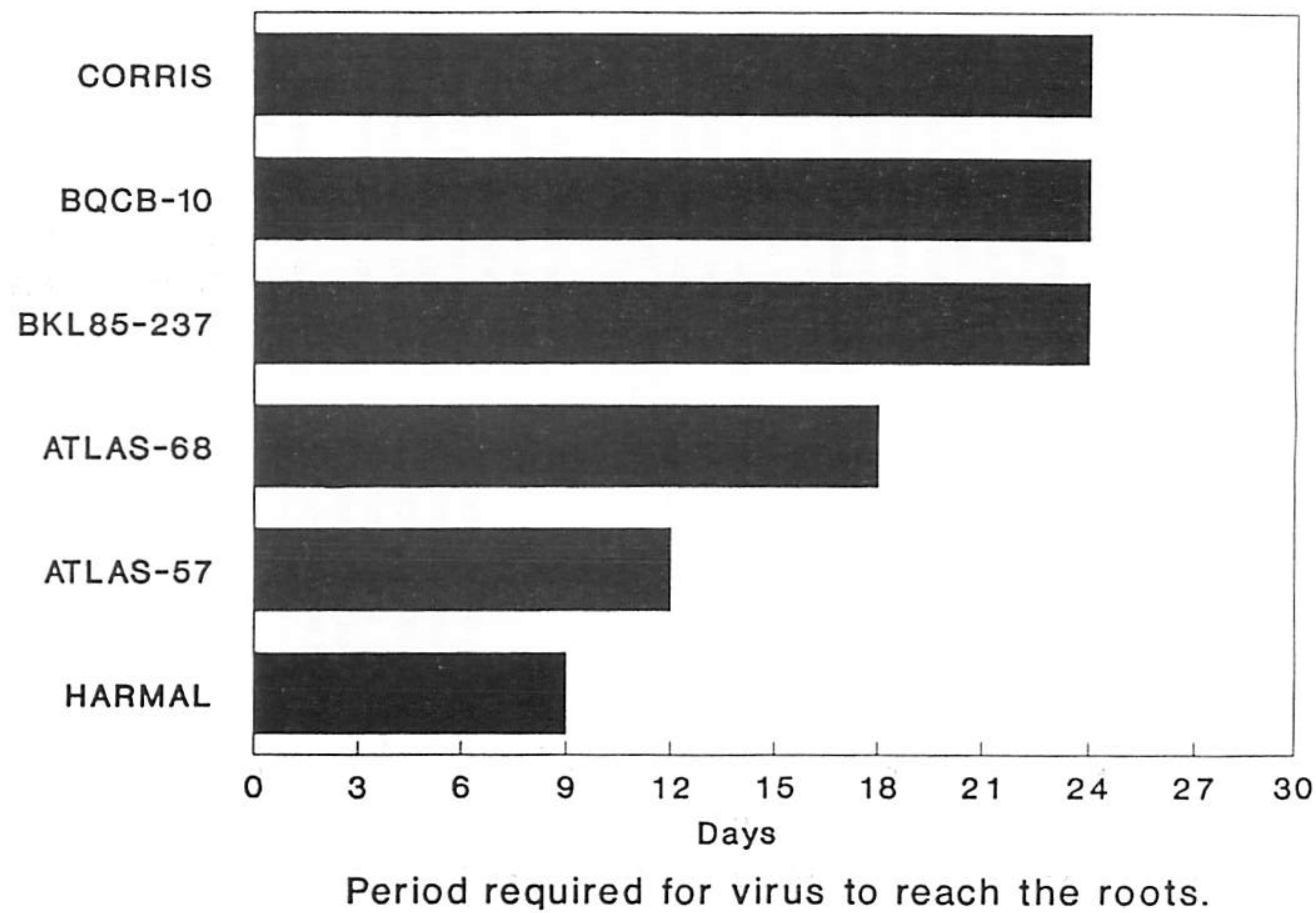

Figure 1. Time after inoculation (days) required for barley yellow dwarf virus to reach the roots of resistant (Corris, BQCB-10, BKL 85-237 and Atlas 68) and susceptible (Atlas 57 and Harmal) barley genotypes.

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Performance of 24 Bread Wheat Entries Under Irrigation in the Libyan Desert

Abdel Rahman A. El-Mahdi and Farag A. El-Majbari

Sarir Production Project, Research Station
P.O. Box 2649
Benghazi
LIBYA

Introduction

Bread wheat (*Triticum aestivum* L. ssp. *aestivum*) is the most important crop at Sarir Production Project, Libya. The Sarir project is situated about 600 km south of Benghazi at an altitude of 150–200 m, latitude 26–28°N and longitude 22–23°E in the Libyan desert. The soil is coarse sandy with poor nutrients, low organic matter content and pH 8.5–9. The climate is that of subtropical desert. Khalifa (1980) reported that sand storms (*Gibli*) frequently blow during the first three weeks of March and have adverse effects on the crop and enhance seed shattering. Therefore, wheat varieties resistant to drought and shattering are desirable.

The purpose of this study was to assess the performance of Regional Bread Wheat Yield Trial (RWYT) entries provided by the International Center for Agricultural Research in the Dry Areas (ICARDA) under irrigation in the Libyan desert.

Materials and Methods

The experiment was conducted in 1990/91 season at Sarir Research Station. The trial consisted of 24 bread wheat entries: 23 provided by ICARDA and one local check variety (Anza). The experiment was arranged in a randomized complete block design with three blocks. Each block was divided into two sub-blocks. Plots consisted of seven rows, 4 m long and 15 cm apart. Sowing was on 9 November 1990. The crop was regularly irrigated using a central pivot system. All cultural practices were carried out according to Sarir Research Station procedure including a fertilizer application of 200 kg N, 150 kg P_2O_5 and 75 kg K_2O/ha. A mixture of micronutrients (12% Mn, 12.6% Cu, 2.3% Zn and 1.4% Fe) was sprayed at 16 kg/ha split into two equal doses at tillering and elongation stages.

Data were recorded for number of days to 50% heading, plant height, 1000-kernel weight and grain yield.

Results and Discussion

Mean, range, standard deviation and coefficient of variation of grain yield and other traits are given in Table 1. Significant differences among entries were detected for each of grain yield, days to 50% heading, plant height and 1000-kernel weight. The highest (3249 kg/ha) and the lowest (1625 kg/ha) grain yield were obtained for Gh"S"/Anza and Cham 1, respectively. Gh"S"/Anza outyielded the local commercial variety (Anza) by 11% and was 3 days earlier. Cham 1 (a durum wheat) had short stature, whereas NS 732/Her was the tallest entry. The extreme values of 1000-kernel weight (32 and 42 g) were

Table 1. Mean, range, standard deviation and coefficients of variation of grain yield and other parameters of 24 bread wheat entries grown under irrigation at Sarir Research Station, Libya, 1990/91.

Parameter	Mean	Range	Standard deviation	Coefficient of variation (%)
Grain yield (kg/ha)	2283.68	1625–3249**	464.36	20.33
Days to 50% heading	102.52	92–124 **	2.81	2.74
Plant height (cm)	64.31	51–86 **	4.28	2.74
1000-kernel wt (g)	36.85	32–42 **	2.98	8.09

** Differences among entries significant at 1% level.

recorded for Goman and Nai60/Hn7//Sx, respectively. The earliest entry (KVZ/4/cc/India/.../ Iwp22) was about 32 days earlier than the latest (Vee"s"/Nao).

Grain yield was positively associated with 1000-kernel weight and negatively with days to heading (Table 2). These results agree with results obtained by Hadjichristodoulou (1987) and Nachit and Jarrah (1986). Thousand-kernel weight was positively associated with plant height and negatively with days to heading. These results show the importance of earliness and plant height as selection criteria of irrigated wheat grown under Libyan desert conditions which are generally conducive to seed shrivelling and shattering towards the end of the season.

Table 2. Coefficients of correlation between grain yield and other traits of 24 bread wheat entries grown under irrigation at Sarir Research Station, Libya, 1990/91.

Parameter	Grain yield	1000-kernel wt	Plant height
1000-kernel wt	0.2902		
Plant height	0.1050	0.875	
Days to 50% heading	–0.4417	–0.2457	0.498

Acknowledgement

We thank Dr S.K. Yau of ICARDA for the statistical analysis of the data; and all members of Sarir Research Station for their help and assistance during the study.

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Wheat Collection and Characterization in North Yemen

Hassan M. Amer and K.L. Mehra[1]
Agricultural Research Authority
P.O. Box 87148
Dhamar, YEMEN

Introduction

Wheat (*Triticum* spp.) is gradually becoming the most important staple food after sorghum (*Sorghum bicolor* (L.) Moench) in Yemen. Its area and production was estimated around 68,000 ha and 103,000 tonnes in 1988 in North Yemen. In the past, cultivation was mostly of *Triticum turgidum* L. ssp. *durum* (Desf.) Husn. (durum wheat) and to some extent *T. turgidum* L. ssp. *dicoccon* (Shrank) Thell. (emmer wheat) and *T. aestivum* L. ssp. *aestivum* (bread wheat), but in recent years the cultivation of high-yielding, dwarf bread wheat has been rapidly replacing that of the tetraploid wheats. Emmer wheat is favored for bread-making, but its cultivation and processing are labor intensive and uneconomical. Plant exploration and collection trips were undertaken in North Yemen to collect the local landraces of wheat.

Collection

Three collection trips were undertaken in parts of the Southern Uplands, Central Highlands, Northern Uplands and Marib Governorate. In the highlands of North Yemen, most of the terraced fields alternate with rocky mountains and are spread out along the windward slopes. Sampling strategy comprised stops at regular intervals of 10–15 km, along the travel route, among the inter-montane plains. Random population samples were collected, avoiding the redundancy of samples as far as possible. Collection site data were recorded, using ICARDA standard sheets. Collections were made in the Highland areas in October–November 1989 and in the Marib region in January 1990.

Thirty-three collections (16 in 1989 and 17 in 1990) of wheat were made from 27 sites differing in one or more eco-geographic descriptors, i.e. altitude (1780–2800 m), latitude (43.34–45.30°E), latitude (14.13–15.44°N), rainfall (200–1000 mm/year), and geological soil formations (basalt flows and dikes, loess deposits with calcareous matter, alluvial soils, predominantly granite and Yemen volcanics). Twenty-four collections belonged to durum wheat landraces Arabi, Baladi, Bouni, Dhamari, Khashabi, Maisaani and Samra, while two collections were of landrace Alas of emmer wheat, which had scented seeds. Seven collections of bread wheat belonged to races Masri and Hargadi, the later adapted to areas with warmer climate, and Masri especially suited to colder areas.

Characterization

Fifteen samples of durum wheat collected in 1989 were sown in spring 1990 for characterization, using IBPGR descriptor lists. All collections were spring types. Wide variation was observed between collections in several descriptors, namely plant height (55–70 cm), days to flowering (early to late), spike length (7.4–12.0 cm), spike density (lax to dense), spikelets/spike (13–20), seeds/spike (2.0–2.2), seed size (small to very large), soft to vitreous seeds, degree of seed shrivelling, lower glume elongate or elongate-ovate, beak length (small, medium or long) and grain shape (elongate or elongate-ovate).

Local collections of wheat from North Yemen were made by Ms Elly Aalders-Dubois in 1987 and she made 220 ear-to-row selections (180 durum, 6 emmer and 34 bread). These selections were sown in 1989 for characterization, using IBPGR (now IPGRI) descriptor list. The selections 180, 6 and 34 belonged to landraces Baladi, Maisaani and Masri of durum, Alas of emmer wheat and non-descript types of bread wheat, respectively. Selections within and between these races exhibited diversity in several descriptors, of which six are presented in Table 1. A catalog based on 20 descriptors was prepared.

Conclusions

An Arabic manuscript written by Rasulid Sultan al-Isharah fil-imarah al-Malik al-Mujahid Ali b. Dawud (AD 1363) refers to landraces Arabi, Halba, Wasni, Habashii, Bauni, Dhamari and Maisaani of durum wheat, and landrace Alas of emmer wheat. It further mentions that Alas has two sub-types: one with white husk, maturing in 90 days and one with red husk, maturing in 105–120 days. Only the former landrace could be collected; the latter seems to have become extinct. Similarly, the durum wheat races Halba, Wasni and Habashii could not be collected. Perhaps these have also become extinct. Since the cultivation of high-yielding, dwarf bread wheat is spreading rapidly, further collection work needs to be taken up in areas not covered during the earlier trips.

[1] Present address: 38 Munrika Enclave, New Delhi – 110 067, INDIA.

Table 1. Variation in wheat germplasm collected in North Yemen, 1989 and 1990.

Species/race name	Range of variation in descriptors†					
	1	2	3	4	5	6
Triticum turgidum ssp. *durum*						
Baladi	40–90	3–9	46–94	1–7	9–17	1.1–2.2
Maisaani	40–80	5–9	55–70	5–7	9–17	2.0
Masri	35–80	5–9	52–80	1–5	10–16	2.0–2.4
T. turgidum ssp. *dicoccon*						
Alas	40–50	5	50–55	5	8–11	2.0
T. a. ssp. *aestivum*	40–83	5–9	50–88	3–7	8–24	1.0–3.0

† Descriptors 1 to 6 denote: 1. Plant height (cm); 2. Days to flowering (1 very early to 9 very late); 3. Spike length (mm); 4. Spike density (1 very lax to 9 very dense); 5. Spikelets/spike; 6. Seeds/spike.

Optimal Sowing Dates for Wheat in the Arid Tropics of Northern Sudan[1]

Gaafar H. Mohamedali[2]
Hudeiba Research Station
P.O. Box 31, Ed-Damer
SUDAN

Wheat (*Triticum aestivum* L. ssp. *aestivum*) has become a basic food crop in Sudan. A total area of about 150,000 ha is grown annually throughout the country during the winter period, October to March, under irrigation. The relatively short winter and high temperature play a crucial role in determining grain yields and consequently manipulation of sowing date is expected to have the major effect on crop establishment and grain yields.

Considerable work has been undertaken in Sudan by several investigators to determinate the optimum sowing dates in different wheat-growing regions in the country. Nevertheless more information is needed as new varieties of wheat of different maturities, high temperature tolerance and drought tolerance are being developed and introduced to replace those traditionally grown.

The present study was undertaken to investigate the yield performance of six varieties at different sowing dates in the arid tropics of northern Sudan.

[1] This work was partially supported by the ICARDA/OPEC Wheat Improvement Project, Sudan.

[2] Present address: National Center for Seed Multiplication, P.O. Box 9088, Seiyun, Hadramout Governorate, YEMEN.

The experiments were conducted at Hudeiba Research Station (17°34'N, 33°56'E, and 350 m above sea level) during the period 1983/84 to 1985/86. Four new varieties introduced from Egypt of various maturities – Wadi El Neel (103 days), Sakha 61 (94 days), Sakha 69 (94 days) and Sakha 80 (113 days) – in addition to Mexicani (102 days) and the standard variety Giza 155 (105 days) were used. The experiments were planted on six sowing dates, at 15-day intervals, beginning 1 October. A randomized complete block design of four replications was used in the first season, and a split-plot design of four replications was used in the second and third seasons (sowing dates were main plots and varieties were sub-plots). The experimental unit measured 16 m^2. Planting was done by hand in rows spaced 20 cm apart at a seeding rate of 167 kg/ha. Nitrogen (total 143 kg/ha) was split in three equal doses applied at planting, three and six weeks later. The plots were irrigated at intervals of 7–10 days, and were kept free of weeds. Only one chemical spray against aphids was necessary in each season and no disease incidence was reported. A random sample of 1 m^2 per treatment was taken prior to harvest to determine the number of heads, seeds per head and 1000-seed weight.

Mean grain yields of the different varieties at each of the six sowing dates are shown in Table 1. Averaged over varieties, the optimum sowing date was mid-November, confirming previous studies at the same location with different varieties.

Table 1. Average grain yields (kg/ha) over three seasons (1983/84 to 1985/86) of wheat varieties at six sowing dates.

Variety	Sowing date							
	1 Oct.	15 Oct.	1 Nov.	15 Nov.	1 Dec.	15 Dec.	Mean	SE
Wadi El Neel	1557	2390	3066	2798	2817	2456	2514	254.8*
Sakha 61	790	1297	2400	3059	2344	2632	2087	378.6*
Sakha 69	870	1508	2375	3119	2403	2672	2158	318.3**
Sakha 80	2012	2787	3050	3179	2601	2079	2618	302.2
Mexicani	1606	2489	3354	3411	2860	2327	2675	125.2**
Giza 155	1203	2063	2427	2222	2304	2432	2109	257.8
Mean	1340	2089	2779	2964	2555	2433		

*, ** Significant at P = 0.05 and 0.01, respectively.

There was significant variety × sowing date interaction in each of the three seasons. Averaged over the 3 seasons, Wadi El Neel had the optimal sowing date on 1 November, the optimal sowing date for Sakha 61 and Sakha 69 (sister lines) was 15 November. November sowing appeared to be optimum for Sakha 80 and Mexicani. Giza 155 gave its best yields in November and December sowings.

Differences among sowing dates in heads per m^2, number of seeds per head and 1000-seed weight were significant (Table 2). All three yield components were reduced in the October sowings. Late sowing in December resulted in reduced 1000-seed weight.

The varieties differed significantly (P = 0.01) in number of heads per m^2 and seeds per head. Some varieties gave high yields primarily as a large number of heads per m^2 were produced (e.g. Mexicani), while others gave high yield primarily as a large number of seeds per head were produced (e.g. Sakha 80).

Table 2. Average values for yield components of wheat by sowing date and variety (1983/84 to 1985/86).

	Heads/ m^2	Seeds/ head	1000-seed wt (g)
Sowing date			
1 Oct	421	28	32.1
15 Oct	440	32	34.1
1 Nov	449	35	37.9
15 Nov	472	35	38.3
1 Dec	486	34	35.2
15 Dec	473	36	31.9
SE	13.7*	1.2**	0.69**
Variety			
Wadi El Neel	436	35	36.4
Sakha 61	414	30	34.6
Sakha 69	427	31	35.8
Sakha 80	458	41	34.7
Mexicani	510	33	33.3
Giza 155	496	30	34.7
SE	13.7**	1.2**	0.69

*, ** Significant at P = 0.05 and 0.01, respectively.

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Induction of Dedifferentiation in Triticale

N.C. Sharma and Priti Shrivastva
Department of Genetics
Barkatullah University, Bhopal 462 026, INDIA

Triticale (× *Triticosecale* Wittm. ex A. Camus) was the first man-made cereal, derived by hybridization of wheat (*Triticum aestivum* L. ssp. *aestivum*) and rye (*Secale cereale* L.) with subsequent induction of amphidiploidy. It holds much promise as a commercial crop due to its high protein and lysine contents, its ability to perform well under marginal farming conditions, and its resistance to diseases. In the past, it suffered from certain drawbacks such as partial sterility, seed shrivelling, poor baking-quality, and pre-harvest sprouting. Over the last few years, improvements have been achieved and a number of varieties have been released in several countries. A key factor for the success of breeding programs is the existence of genetic variability for desirable traits. Induction of somaclonal variation by applying tissue culture techniques can be usefully exploited to create genetic variation (Skirvin 1978; Larkin and Scowcroft 1981). However, it has had very little effect on triticale improvement so far (Gustafson 1986). The tissue culture cycle essentially involves dedifferentiation leading to formation of callus, its proliferation and regeneration. Induction of dedifferentiation is, thus, the first step towards realizing genetic variability.

Various explants such as immature embryos, inflorescence, anthers, seedling root, seedling leaf and shoot base have been used for induction of callus and regeneration (Ono and Larter 1976; Bernard 1977, 1980; Sharma et al. 1978, 1981; Nakamura and Keller 1982; Reddy and Reddy 1983). The objective of the present investigation was to assess the suitability of different explants and cultural conditions for establishing cell cultures.

Material and Methods

Seeds of seven strains of triticale, namely JNK 6T 142, JNK 6T 231, JNK 6T 392, UC 15, UC 43, UC 63 and Coorong, were obtained through the courtesy of Department of Agricultural Botany, Meerut University, Meerut, India for use in the present study. Seed, seedling root, seedling leaf and shoot base were used as explants. These were surface sterilized with 0.1% solution of mercuric chloride and then repeatedly washed with sterile distilled water. Afterwards these were inoculated onto Murashige and Skoog (MS) medium supplemented with 2,4-D (2 mg/L) or Linsmaier and Skoog (LS) medium without vitamins but with 2,4-D (2 mg/L). The cultures were maintained under aseptic conditions with a photoperiod of 16 h light and 8 h dark. The light was approximately 4000 lux obtained from fluorescent tubes. The relative humidity was maintained between 65 and 70% at a temperature of 27 ± 2°C.

Results

The explants did not respond to dedifferentiation in the majority of cases but callus could be induced in UC 15 when seed was used as explant on MS medium supplemented with 2,4-D. No dedifferentiation or callusing could be obtained when seedling root, seedling shoot or shoot base were used as explants. These results suggest that both genotype and experimental media have an effect of dedifferentiation and callus induction. This capability has also been attributed to the physiological status and the extent of differentiation of the constituent cells of the explants (Murashige 1974). In the present study, it was the mature embryo within the seed that underwent dedifferentiation and produced callus. This may be due to a lower level of differentiation in comparison to the other explants used. Immature embryos have been widely used for callusing in a number of cereals in the past. The present study demonstrates that the mature embryo within the seed can also be a good explant. Moreover, it has the advantage that it can be easily stored, transported and used over a longer period of time.

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Cereal News

Forthcoming Events

1994

***22nd International Nematology Symposium*, Gent, Belgium, 7-12 August.** Contact: Dr A. Coomans, University of Gent, Zoology Institute, K.L. Ledegankstraat 35, B-9000 Gent, Belgium.

***5th International Mycological Congress*, Vancouver, Canada, 14-21 August.** Contact: Dr Anthony Griffiths, IMC-5 Secretariat, c/o Vunue West, #645-375. Water Street, Vancouver, BC, V6B 5C6, Canada [Fax 1-604-681-2503].

***3rd EFPP Conference "Environmental Biotic Factors in Integrated Disease Control"*, Poznan, Poland, 5-9 September.** Contact: Prof. Z. Weber, Department of Plant Pathology, University of Agriculture, 60-594 Poznan, Uldabrowskiego 159, Poland.

***5th Arab Congress of Plant Protection*, Morocco, 27 November-2 December.** Contact: Prof. Dr M. Besri, General Secretary, ANAPPAV, Institute Agronomique et Vétérinaire Hassan II, B.P. 6202, Rabat - Instituts, Morocco [Tel. 212-7-778364; Fax 212-7-778110/778364; Telex AGROVET 36873/36089 M].

1995

***24th International Seed Testing Association (ISTA) Congress*, Copenhagen, Denmark, 7-16 June 1995.** Contact: Dr Hans Arne Jensen, ISTA Congress Coordinator, Plante Directorate, Skovbrynet 20, DK-2800 Lyngby, Denmark [Tel. 45-42-88-33-66; Fax 45-45-93-33-66].

***International Symposium on Preharvest Sprouting in Cereals*, Abashiri, Hokkaido, Japan, 2-7 July 1995.** Contact: Kaz Noda [Tel. (045) 741-5082].

***13th International Plant Protection Congress*, The Hague, The Netherlands, 2-7 July 1995.** Contact: J. Zadoks, Department of Phytopathology, P.O. Box 8025, 6700 EE Wageningen, The Netherlands.

Changes at ICARDA

Dr John Hamblin has left ICARDA to become Director of CLIMA in Western Australia, where he previously worked for the Department of Agriculture. John came to ICARDA in 1991 to head the then Cereal Improvement Program. We wish John and his new colleagues every success in this venture.

The Centre for Legumes in Mediterranean Agriculture (CLIMA) was established by the Australian Government in July 1992, as the national Co-operative Research Centre for Legumes in Mediterranean Agriculture. The cooperating organizations are the Western Australia Department of Agriculture, The University of Western Australia, Murdoch University and CSIRO. CLIMA's objectives are (i) to develop more productive pasture and grain legumes, (ii) to enhance the benefits of legumes in increasing soil fertility while minimizing soil degradation, and (iii) to achieve better adoption of appropriate new technology resulting from research. There are obvious links between the work of CLIMA and that of ICARDA, and there is now an official collaboration agreement between the two institutions.

Cereal Program has been merged with Legume Program and is now known as Germplasm Program. The new program is headed by Dr Mohan C. Saxena (see next item).

Heading the new Germplasm Program: Dr Mohan C. Saxena

Dr Saxena joined ICARDA in 1977 as Agronomist/Crop Physiologist in the Food Legume Improvement Program. He was appointed Head of that same program in 1981. Before coming to ICARDA, Dr Saxena spent 10 years at the Agricultural University, Pantnagar, India, for the last year of which he was Director of Research. Mohan is well placed to take on the challenge of the new program, since he earned a Dr. Agr. degree for his work on the effect of moisture stress on P and N nutrition of barley and wheat at Hohenheim, Germany in the 1960s.

Recent literature

Books

CIMMYT. 1993. *1992/93 CIMMYT world wheat facts and trends. The wheat breeding industry in developing countries: an analysis of investments and impacts.* CIMMYT, Singapore. 52 pp. ISSN 0257-8743. ISBN 968-6127-91-7.

This report presents information on the level of investment in wheat-breeding research in developing countries and the impact of that research, and discusses issues related to assessing returns to wheat-improvement research and improving research efficiency. In 1990, the total estimated investment in wheat-improvement research in developing countries was US$ 96 million. Expressed another way, developing countries spent about US$ 0.40 per tonne of wheat on improvement research (US$ 0.95 in WANA), or about 0.3% of the value of production. This research has had considerable impact in the developing world. Modern varieties of wheat cover 70% of the developing country wheat area, and many farmers have replaced older improved varieties with newer ones. Research on improved spring bread wheat varieties alone has contributed an additional US$ 3 billion in benefits in developing countries in the past decade. However, results of this study suggest that national agricultural research programs have considerable scope to utilize research resources more efficiently, by rationalizing the number and size of wheat-research programs and by examining opportunities to import technology or collaborate with countries sharing similar production environments.

Specific data for WANA include the fact that the region received about 2.3 million tonnes of wheat as food aid in 1989 and that total wheat production for the region was 39 million tonnes in 1990. Three pages are devoted to country-specific figures for WANA.

Diekmann, M. 1993. *Seed-bourne diseases in seed production.* ICARDA, Syria. 81 pp. ISBN 92-9127-012-1.

This publication is based on material used in numerous seed technology and seed health training courses. In addition to general background information on the importance of seed-borne diseases in seed production, it contains methods relevant for seed health testing in the context of seed certification, on seed treatment and on other pertinent topics. A list of relevant literature is also given.

Skovmand, B., G. Varughese and G.P. Hettel. 1992. *Wheat genetic resources at CIMMYT: Their preservation, enrichment, and distribution.* CIMMYT, Mexico. 19 pp. ISBN 968-6127-66-6.

Colorful introduction to the management of wheat genetic resources at CIMMYT.

Proceedings

Bushuk, W. and R. Tkachuk (eds). 1991. *Gluten proteins 1990.* American Association of Cereal Chemists, St Paul, Minnesota, USA. 794 pp. ISBN 0-913250-71-6.

This publication is based on presentations at the 4th International Workshop on Gluten Proteins, Winnipeg, Canada, 27–29 June 1990. Papers are divided into four sections: Functionality and Technology; Chemistry and Structure; Genetics and Agronomy; and "Wrap-up". The final section includes short papers on nomenclature, gluten structure and genetics.

Christiansen, S., L. Materon, M. Falcinelli and P. Cocks (eds). 1993. *Introducing ley farming to the Mediterranean basin. Proceedings of an international workshop, 26–30 June 1989, Perugia, Italy.* ICARDA, Syria. 299 pp. ISBN 92-9127-004-0.

The objectives of this workshop were to: (i) discuss research and progress on the ley farming system in the WANA region and elsewhere.; (ii) formulate a strategy to implement and develop annual medic/ceral rotation systems in the Mediterranean region.; and, (iii) define guidelines for the establishment of a network to collect and conserve genetic resources of annual *Medicago*. The papers are presented in four sections: Ley farming around the region; Ley farming in progress; Annual legumes research and genetic resources conservation; and Strategies for more efficient work. The book closes with 12 recommendations.

Damania, A.B. (ed.). 1993. *Biodiversity and wheat improvement.* John Wiley & Sons and Sayce Publishing, for ICARDA. 434 pp. ISBN 0-471-94137-9.

Papers presented at the international workshop on 'Evaluation and Utilization of Biodiversity in Wild Relatives and Primitive Forms for Wheat Improvement' held at ICARDA in October 1992. The book is divided into eight parts: Cytogenetics of the Triticeae; Taxonomy of the Triticeae; Wide-crossing and hybridization; Resistance to diseases; Abiotic stress tolerance; Evaluation of biodiversity; Utilization of biodiversity; and, Research by national programmes. The book is concluded with a 33-point summary and recommendations, and there is a comprehensive index. A full review will appear in a later issue of *Rachis*.

Jones, M., G. Mathys and D. Rijks (eds). 1993. *The agrometeorology of rainfed barley-based farming systems. Proceedings of an international symposium, 6-10 March 1989, Tunis.* ICARDA. 368 pp. ISBN 92-9127-002-4.

The aims of this joint World Meteorological Organization/ICARDA-sponsored symposium were: (i) to place the barley crop and barley-based farming systems in their environmental context, meteorologically and socio-economically, with particular reference to dry, rain-fed farming areas of Mediterranean climate; (ii) to seek ways to relate the production of barley and associated crops to agrometeorological parameters, facilitating the integration of current knowledge and the transfer of expertise and experience within the region; and (iii) to bring together meteorological and agricultural scientists of different countries, to improve mutual understanding, to identify common purposes and, where appropriate, to forge linkages for future research cooperation. The papers (some in French) are presented under five headings: The global distribution of barley; The ecophysiology and agrometeorology of barley; Barley-based farming systems; Research in barley-based farming systems; and, Agrometeorology and barley modelling.

Theses

Elings, A. 1992. *Evaluation methods for large germplasm collections; distribution, variation and evaluation of Syrian durum wheat landraces.* Doctoral thesis. Wageningen Agricultural University, The Netherlands. 183 pp. ISBN 90-9005443-X.

Landrace populations of Syrian durum wheat were collected. Regions of collection and landrace groups were described with respect to environmental and plant characteristics, respectively. Phenotypic variation patterns were studied, and agronomic performance under various environmental conditions, frost tolerance and host resistance to three fungal diseases were evaluated. Evaluation methods were formulated that allow the utilization of single-evaluation results in forecasting growth and development under different environmental conditions. Use is made of knowledge on the environment of origin, analysis of variance and simulation models. Herewith, the qualitative and quantitative limitations related to the evaluation of large germplasm can be reduced.

Mayer, M. 1992. *Breeding experiments with doubled haploid lines and F_2-bulks towards the improvement of barley in the dry areas of north Syria.* Doctoral thesis. Universität Hohenheim, Germany. 96 pp.

The utility of doubled haploid lines (DHL) and conventional F_2 plant-derived bulks (F_2B) in improving barley in stress environments is compared. Double crosses were made, DHL were developed by anther culture from double-cross F_1 plants and F_2B were produced by bulking the offspring of F_2 plants. Field tests were conducted in three drought-stressed environments in Syria and at Hohenheim. No major differences were observed in the mean performance of DHL and F_2B. For most traits both the genotypic and the genotype × location interaction variances were higher in the DHL group whereas heritabilities were similar. Higher gains from selection were predicted for the DHL group. Regression analysis of yield stability indicated a lower predictability of the DHL performance. Although DHL may not represent the desired varietal structure for adverse and fluctuating environments, the haploid technique can improve breeding populations from which varieties with stable yields can be developed. The costs involved were determined by the DHL production rate, which needs to be improved in many developing countries.

The traits awn appearance, peduncle length and number of fertile tillers are suggested as indirect selection traits for grain yield preselection in early generations. For total biological yield, the number of fertile tillers was predicted to be the most efficient indirect selection trait.

For grain yield, a strong and negative relationship between yield potential and yield under stress occurred. This is explained by the fact that earliness enables entries to escape from terminal drought but prevents them from taking advantage of long vegetation periods in favorable environments. For total biological yield, yield potential and yield under stress were weakly and positively correlated. The importance of a high grain yield potential for varieties grown in North Syria is questioned. However, a high total biological yield potential is advantageous under terminal drought stress. Relationships between drought resistance (measured as drought response index) and grain and total biological yield under stress existed, while no correlations of drought resistance to the respective yield potentials were observed.

Despite the low heritability of total biological yield, a significant gain in this trait was achieved from one cycle of selection. The selected entries produced higher total biological yields under stress and stress-free conditions. The improvement was mainly a result of increased straw yields.

van Oosterom, E. 1993. ***Adaptation of barley to harsh Mediterranean environments.*** Doctoral thesis. Agricultural University of Wageningen, The Netherlands. 141 pp. ISBN 90-5485-059-0.

A collection of six research papers variously in press, accepted or submitted for publication in research journals, and one at a pre-submission stage. The book is held together by a general introduction, a general discussion and an overall summary. Development pattern of the apex was identified as the adaptation criterion of barley to the Mediterranean environment. Within 36 genotypes, four patterns were observed of which two are suitable for the Mediterranean. Early heading spring-types with no vernalization requirement were cold sensitive but avoided terminal drought stress. This pattern is adapted to mild winters with terminal drought, e.g. Jordan and North Africa. Medium-early heading winter-types with mild vernalization requirement and very rapid spring development are adapted to cold winters and terminal drought, e.g. north Syria. The first pattern was strongly associated with prostrate growth habit, dark color and cold tolerance; the second with early heading. The first ideotype had positive effect in low-yielding environments, but weakly negative effect in high-yielding environments. For low-yielding environments, early heading winter-types had highest yield. Selection in early generations (F_3-F_4) can be for low-yielding ideotype but conducted in a high-yielding environment. Later generations can be tested in low-yielding environment and other desirable traits selected thereafter. This complementation of ideotype breeding with empirical yield selection combines low risk of loss of adapted germplasm in early generations with effective empirical selection later. This method can be used for many crops and types of stress. The essential prerequisite is to identify the ideotype - preadapted landraces may be useful in this procedure.

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All articles must have an abstract (maximum 250 words) and usually the following sections: Introduction, Materials and Methods, Results, Discussion, Conclusions and References. Articles will be edited to maintain uniform style, but substantial editing will be referred to the author(s) for approval. Papers requiring extensive revision will be returned to the author(s) for correction. Authors can refer to a recent issue of *Rachis* for format. The following guidelines should be followed.

Include the authority name at the first mention of scientific names.

Present measurements in metric units, e.g. t/ha, kg, g, m, km, ml, L. Where other units are used (e.g. quintal), the metric equivalent should be provided in parentheses.

Define in footnotes or legends any unusual abbreviations or symbols used in the text, tables or figures.

Provide the full name of journals and book titles. Use the following formats for references.

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

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 – 6 May 1982, ICARDA/the Government of the Netherlands, ICARDA, Aleppo, Syria.

Book: Evans, L.T. and W.J. Peacock (eds). 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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International Center for Agricultural Research in the Dry Areas
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P.O.Box 5466, Aleppo, Syria