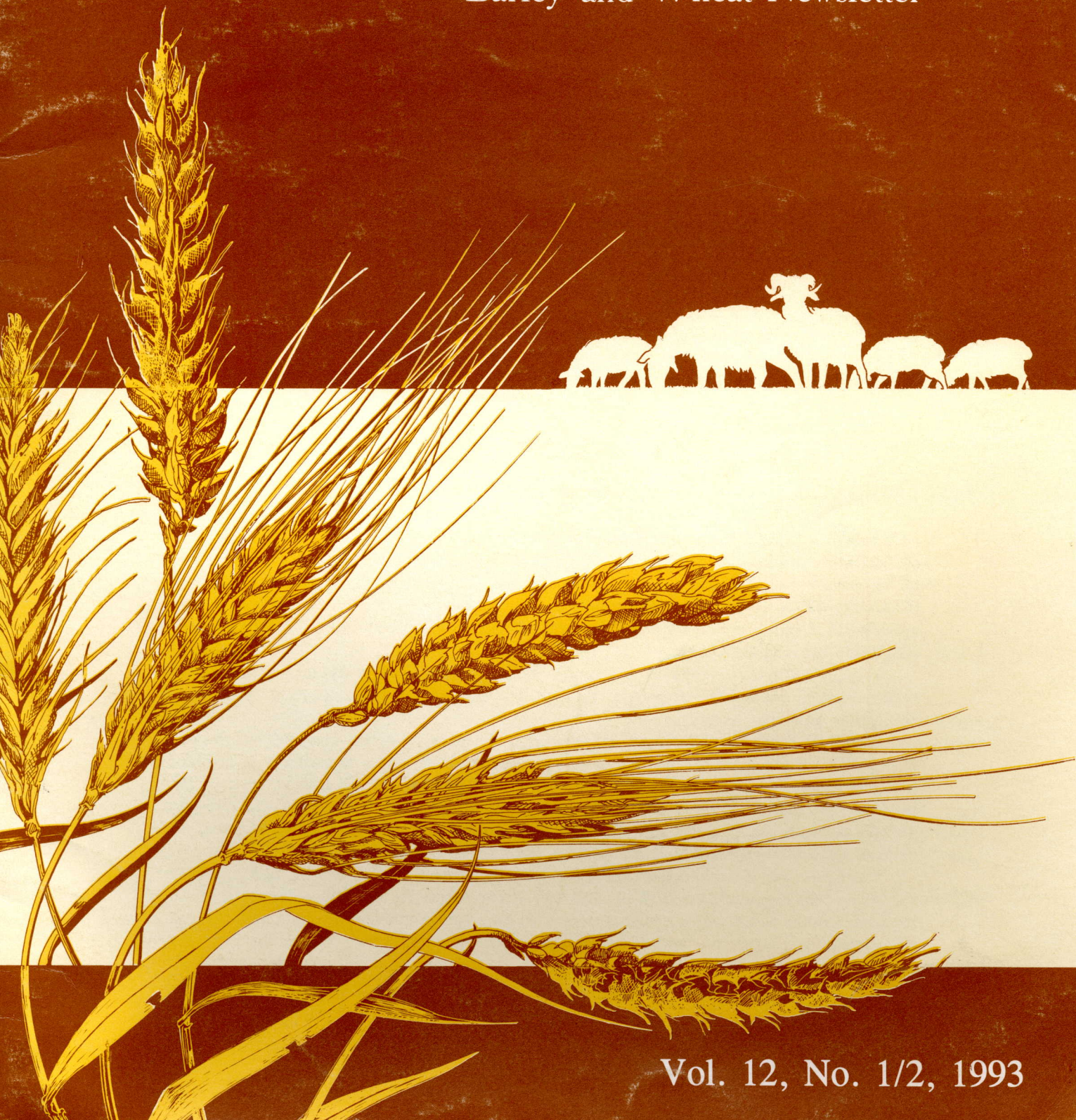
RACHIS

Barley and Wheat Newsletter



Vol. 12, No. 1/2, 1993

ISSN 0255 6421

ICARDA and CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 18 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA's mission is to meet the challenge posed by a harsh, stressful and variable environment in which the productivity of winter rain-fed agricultural systems must be increased to higher sustainable levels, in which soil degradation must be arrested and possibly reversed, and in which the quality of the environment needs to be assured. ICARDA meets this challenge through research, training and dissemination of information in a mature partnership with the national agricultural research and development systems.

The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility in West Asia and North Africa for the improvement of wheat, chickpea, forage and pasture – with emphasis on rangeland improvement and small ruminant management and nutrition – and of the farming systems associated with these crops.

ICARDA LIBRARY
Date 15 JAN 1997

RACHIS

Vol. 12, No. 1/2, 1993

Barley and Wheat Newsletter

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.

Cereal researchers and the libraries of institutions conducting research on barley and wheat in West Asia and North Africa may apply for a free subscription to: Rachis/CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria. Contributions to *Rachis* should be addressed to the Rachis Editor, CODIS.

Editorial Committee:

Dr Mohan Saxena
Dr Habib Ketata
Mr Guy Manners

Arabic abstracts:

Mr Khaled Al Jbaili
Mr Adel Abdel Khaliq

Typesetting:

Miss Rania Homsi

CONTENTS

RESEARCH AND PRODUCTION

3 Variation in virulence of net and spot forms of *Pyrenophora teres* (Died.) Drechsl. in barley
B.M. Baltazar and A.L. Scharen

8 Development of a new barley line by induced mutation methods
Jamal Bahaa El Den

11 Effect of fall growth and development on winter hardiness in barley
M. Sait Adak and Didar Eser

14 Environmental factors limiting barley yield in the high plateaux of eastern Algeria
H. Bouzerzour and A. Benmahamad

20 Relationship of growth vigor, leaf color and other agronomic characters with grain yield in winter and facultative barley in a low-rainfall environment
Yizhong Cai, M. Tahir and S.K. Yau

24 Production of antisera for sensitive detection of two cereal viruses by different ELISA variants
K.M. Makkouk and S.G. Kumari

28 Induction of a new Iraqi wheat cultivar by gamma rays
I.F. Ibrahim, K.K. Al-Janabi, E.M. Al-Maaroof, M.O. Al-Aubaidi, A.H. Mahmood, A.A. Al-Janabi, H.O. Haidar and A.H. Ali

36 Inheritance of dwarfism in wheat
S.K. Mishra and C.M. Kushwaha

38 Variability and correlation studies in durum wheat in Alem-Tena, Ethiopia
Getachew Belay, Tesfaye Tesemma and Demissie Mitiku

41 *Fusarium* spp. on wheat, with special reference to fusarium head blight (*F. graminearum* Schw.) PD
Slobodan Tomasović, Mladen Matijašević and Branko Sesar

43 Performance of bread wheat genotypes in northern Sudan BG
Abdalla Ibrahim Sheikh Mohamed

49 Effect of minimum tillage in wheat grown after rice AM
Indrajit Roy and A.K. Dey Sarkar

51 Optimizing fertilizer rate for wheat in calcareous dark gray floodplain soil of Bangladesh AM
U.K. Saha, A.F.M. Rahman, M.S. Islam and H.A. Haque

56 Improvement of hexaploid triticale for grain yield and its components BG
Mouhammad Siddique Sadiq

CEREAL NEWS

60 Network for integrated research on durum wheat improvement in the Mediterranean region
M.M. Nachit and M. Baum

63 Forthcoming events

63 Recent literature

67 Agricultural libraries receiving ICARDA publications

67 *Rachis* back issues

68 ICARDA publications and services

Contributors' style guide

Research and Production

Variation in Virulence of Net and Spot Forms of *Pyrenophora teres* (Died.) Drechsl. on Barley

B.M. Baltazar[1] and A.L. Scharen[2]

[1] *Department of Plant Pathology, Montana State University, Bozeman, MT 59717, USA*

[2] *US Department of Agriculture, Agricultural Research Service, Department of Plant Pathology, Montana State University, Bozeman, MT 59717, USA*

Abstract

Differences in levels of virulence of net and spot forms of *Pyrenophora teres* were detected. This suggests that different biotypes of *P. teres* exist. The importance of the high variation present in populations of net and spot isolates lies in the fact that a barley (*Hordeum vulgare* L. ssp. *vulgare*) cultivar resistant in one location may not be resistant in a different region due to the presence of different biotypes of the pathogen. Among the lines tested, CI 9776 was highly resistant, CI 5791 and CI 7584 were resistant, and CI 14023, CI 9819, CI 1197 and CI 5845 were moderately resistant to all of the isolates regardless of whether they were net or spot forms of *P. teres*. Future studies might attempt to understand the mode of inheritance of the genes determining resistance to the spot form of *P. teres*. Meanwhile, the cultivars detected as highly resistant to both forms of *P. teres* could possibly be used in breeding programs in crosses with high-yielding genotypes.

Key words: *Hordeum vulgare*; barley; *Pyrenophora*; disease resistance; pathogenicity; genetic inheritance; varieties; USA.

التباين في فوعة النمطين المرضيين البقعي والشبكي للفطر *Pyrenophora* teres (Died.) Drechsl. على الشعير.

الملخص

تم الكشف عن الفرق بين مستويات فوعة النمطين المرضيين البقعي والشبكي للفطر *Pyrenophora teres* ، مما يوحي بوجود طرز حيوية مختلفة منه. وتكمن أهمية التباين الشديد الموجود بين مجموعات عزلات النمطين المرضيين البقعي والشبكي في إمكانية أن يكون أحد أصناف الشعير مقاوماً في موقع ما وغير مقاوم في منطقة أخرى نتيجة لوجود طرز حيوية مختلفة من المسبب المرضي. ومن بين السلالات التي اختبرت كانت السلالة CI 9776 شديدة المقاومة والسلالتان CI 5791 و CI 7584 مقاومتين والسلالات CI 14023، CI 9819، CI 1197 و CI 5845 متوسطة المقاومة بالنسبة لجميع العزلات سواء كانت من النمط البقعي أو الشبكي للفطر *P. teres*. وقد تحاول الدراسات المستقبلية فهم أسلوب توريث المورثات التي تحدد المقاومة للنمط التبقعي للفطر *P. teres* . وحتى ذلك الوقت يمكن استخدام الأصناف التي وجد أنها شديدة المقاومة للنمطين البقعي والشبكي لذلك الفطر في برامج التربية بغية تهجينها بطرز وراثية مغلالة.

Introduction

Pyrenophora teres is one of the most devastating pathogens of barley. Yield losses as high as 40–60% have been reported in farmers' fields when susceptible barley cultivars are infected with highly virulent races of the pathogen (Smedegard-Petersen 1971; Tekauz and Buchanon 1977). Two forms of *P. teres* have been described: the net form, *P. teres* f.sp. *teres* Smedeg., that forms a characteristic net-like pattern and the spot form, *P. teres* f.sp. *maculata* Smedeg., which produces well-defined spot lesions on barley (Khan and Tekauz 1982; McDonald 1963, 1967; Smedegard-Petersen 1971). Resistance in barley to the net form of *P. teres* has not been associated with resistance to the spot form (Khan and Tekauz 1982; Smedegard-Petersen 1971; Tekauz and Buchanon 1977). Smedegard-Petersen (1971) tested 12 barley cultivars resistant to North American *P. teres* isolates and observed different reactions to net and spot forms of *P. teres* isolates from Denmark. Tekauz and Buchanon (1977) report that spot-form isolates gave milder symptoms than those of the net form based on lesion characteristics and extent of chlorosis and necrosis. Khan and Tekauz (1982) note that disease reactions with the Australian spot form of *P. teres* were different from those to Canadian isolates. Similarly, Bockelman et al. (1983) observed that isolates from Morocco, Tunisia and Turkey that produced the spot reaction, induced larger

individual lesions and different reactions than those from Montana (USA) spot-form isolates. More recently, Karki and Sharp (1986) demonstrated that spot-form isolates from Montana, Morocco, Tunisia and Turkey differed in their ability to infect a set of 20 barley cultivars. The objective of this study was to evaluate the virulence of 12 isolates of *P. teres* f.sp. *teres* and 8 isolates of *P. teres* f.sp. *maculata* from the USA, Mexico and Colombia using 32 barley lines.

Materials and Methods

Isolate selection and designation

Isolates collected in Mexico were from four locations used by the ICARDA breeder stationed at CIMMYT to select barley cultivars resistant to net blotch (Hugo Vivar, personal communication). Other isolates were collected in the USA and Colombia. Isolates were selected based on differential reactions on some specific cultivars previously investigated (Bjarko 1979; Karki and Sharp 1986). Subsequently, 12 isolates of net and 8 isolates of spot form of *P. teres* were selected for evaluation with the 32 lines. Isolates were named on the basis of state or country, collector and place of collection (Table 1).

Isolate maintenance and pathogen isolation

Leaf tissue showing characteristic symptoms of net or spot forms of *P. teres* were cut into pieces 10 mm long and surface-sterilized in 1% sodium hypochlorite solution (NaOCl) for about 1 min. Three or four leaf pieces of each sample were transferred to petri dishes containing 2% water agar and incubated at 16°C with alternating 12 h light and 12 h dark. Single conidia emerging from the leaf tissue were transferred to the centers of petri dishes containing V-8 juice agar. Maintenance of monoculture isolates in V-8 juice agar medium, subsequent subculture and inoculum preparation were conducted as per Karki and Sharp (1986).

Table 1. Net and spot forms of *P. teres* from the USA, Mexico and Colombia.

Isolate designation	State or country of origin	Name of collector	Type of reaction
Mex-2 (Anahuac-1)	Mexico	H. Vivar	net
Mex-3 (Anahuac-2)	Mexico	H. Vivar	net
Mex-4 (Cd. Sahagun)	Mexico	H. Vivar	net
Mex-5 (La Lagunilla)	Mexico	H. Vivar	net
Mex-6 (E. Zapata)	Mexico	H. Vivar	net
Calif-1 (Tulare County)	California	B. Steffenson	net
Calif-3 (Fresno County)	California	B. Steffenson	net
Calif-5 (Solano County)	California	B. Steffenson	net
Pt-R	Montana	M. Bjarko	net
Sco-B	Montana	M. Bjarko	net
86-Hfi	Montana	M. Bjarko	net
MN-1	Minnesota	B. Steffenson	net
Col-1 (Iraka County)	Colombia	H. Vivar	spot
Col-2 (Tundama County)	Colombia	H. Vivar	spot
Col-3 (Boyaca County)	Colombia	H. Vivar	spot
Pt 6-2	Wyoming	M. Bjarko	spot
Fc-1	Montana	M. Bjarko	spot
Con-S	Montana	M. Bjarko	spot
Hort Farm	Montana	B. Baltazar	spot
Post Farm	Montana	B. Baltazar	spot

Line selection

The 32 barley lines used are listed in Table 2. Selection was based on differential reaction to isolates of net and spot forms of *P. teres*. They included current commercial varieties grown in Montana and neighboring states.

Table 2. Barley cultivars used in determining pathogenic variation of net and spot forms of *P. teres*.

Cultivar	CI number
Klages	CI 15478
Moravian III	CI 15812
Hector	CI 15514
Gallatin	PI 491534
Beecher	CI 11292
Morex	CI 15773
Robust	PI 476976
Piroline	CI 9558
Clark	CI 15857
Harrison	CI 10667
Menuet	PI 428490
Bowman	PI 483237
Betzes	CI 6398
Freja	CI 11303
Tifang	CI 4407
Herta	CI 12325
Compana	CI 5438
Erbet	CI 13826
Manker	CI 15549
Summit	CI 1136
Vireo	CI 15555
	CI 7584
	CI 9776
	CI 5791
	CI 9819
	CI 2330
	CI 2750
	CI 1615
	CI 5845
	CI 12821
	CI 14023
	CI 1197

Inoculation

Ten-day-old barley seedlings were inoculated by spraying 100 ml of inoculum suspension containing 20,000 spores/ml with an atomizer driven by compressed air. Inoculated plants were incubated in a saturated dark dew chamber at 16°C for 24 h, then for 8 days at 21–24°C.

Considerable attention was devoted to the possibility that symptoms observed in barley plants might be produced by *Cochliobolus sativus* (Ito & Durib.) Drechsl. rather than by the spot form of *P. teres*. Microscopic observations confirmed the spot form of *P. teres* as the etiological agent.

Disease rating and statistical analysis

Disease ratings were made ten days after inoculation on a scale 1–10 as described by Tekauz (1985). Disease ratings were based on percentage of leaf area infected and lesion size. Cultivars rated lower than 4.3 were considered resistant and others were considered susceptible. This separation point for resistance and susceptible reaction has been described as the most appropriate based on a cluster analysis by taking the average disease ratings and adding the standard errors of the means (Tekauz and Buchanon 1977). The experimental arrangement corresponded to a single replication of two-factor factorial with 32 and 20 levels for variety and isolate, respectively. Statistical analysis for the main effects of line and isolate was the conventional calculation of the mean square for the interaction between the factors as the denominators for the F-ratios (and when developing the standard error for making LSD multiple comparisons). Such statistical tests are valid when factor levels are considered random, i.e. the lines and isolates studied represent a sample from a larger set of lines and isolates toward which statistical inference is directed. These statistical tests are conservative when inference is directed only toward the specific set of isolates and lines studied in this research. It is not possible by this analysis to consider interaction itself statistically (Snedecor and Cochran 1989, pages 319–324).

Results

Highly significant differences existed for virulence among the net and spot forms of *P. teres* (Table 3). The range of virulence was greater among the net-form isolates than the spot-form isolates (Table 4). However, when the mean disease ratings were compared, there were no differences in virulence between the two forms (Table 4). Isolates

from Mexico were the least virulent along with a Californian isolate designated Calif-1. Other isolates from the USA were the most virulent regardless of their net or spot phenotype. Pt-R, a Montana isolate, was not classified as highly virulent as previously described (Bockelman et al. 1983).

Table 3. Analysis of variance of disease ratings of 12 net and 8 spot *P. teres* isolates on 32 barley lines.

Source	df	Mean square
Line	31	32.618**
Isolate	19	80.661**
Line × Isolate	589	2.384

** Significant at P = 1%.

The barley lines also differed in their reactions to infection with net or spot forms of *P. teres* (Table 3). CI 9776 appeared to be highly resistant to most of the isolates, CI 5791 and CI 7584 were resistant and CI 14023, CI 9819, CI 1197 and CI 5845 had moderate resistance. Compana, Erbet, Harrison and Clark were the most susceptible, and Klages, Hector and Moravian III were moderately susceptible (Table 5). Tifang, a cultivar with at least one gene for resistnce (Bjarko 1979), was classified as moderately susceptible.

Discussion

Previous reports (Khan and Tekauz 1982; Tekauz and Buchanon 1977), along with the present study, suggest that different biotypes of *P. teres* exist. Most barley breeding programs aim to develop resistant cultivars; however, it now seems that a barley cultivar resistant in one location might not be resistant in another region due to the presence of different biotypes of the pathogen. Isolates of *P. teres* from Mexico were the least virulent. Isolates from Mexico were collected in four locations used by the ICARDA barley breeder located at CIMMYT to select resistant cultivars to the net form of *P. teres*. This preliminary selection is followed by a multilocation testing via international nurseries sent to several locations worldwide. Our data suggest that this approach is extremely important to expose future barley varieties to a large number of environments, and virulence biotypes of both forms of *P. teres*.

Genes for resistance to net blotch have been identified in some barley lines (Bjarko 1979; Tekauz and Buchanon 1977). The lines CI 9819 and CI 5791 have three genes, CI 1197, CI 9776 and CI 7584 have two genes each and Betzes has one gene. In our experiments some of these barley cultivars were found resistant to all of the isolates regardless of whether they were net or spot forms of P. teres (Table 5). These results suggest that genes determining resistance to both forms of *P. teres* in barley may be the same or at least very similar. Future studies might focus on understanding the mode of inheritance of the genes conferring resistance to the spot form of *P. teres*. Meanwhile, the lines detected as highly resistant to both forms could be used in breeding programs in crosses with high-yielding genotypes.

Table 4. Comparative mean virulence of net and spot forms of *P. teres* from the USA, Mexico and Colombia using a set of 32 barley lines.

Isolate designation	Virulence (means)†
Calif-1	2.469 a
Mex-6	2.813 a
Mex-4	2.875 a
Mex-2	3.656 b
Mex-3	4.250 cb
Pt-R	4.594 cd
Col-1	4.844 ced
Mex-5	4.875 ced
Calif-5	4.969 cedf
Col-2	5.000 cedf
Calif-3	5.188 edf
Post farm	5.594 ef
Col-3	5.719 fg
Con-s	6.469 gh
Fc-1	6.750 hi
Mn-1	7.031 hij
Pt 6-2	7.125 hij
Hort Farm	7.219 hij
Sco-B	7.313 ij
86-Hfi	7.563 j

† Isolates followed by the same letter were not significantly different at 1% as determined by the multiple mean comparisons based on LSD.

Table 5. Comparative mean resistance of 32 different lines to infection with 12 net-form and 8 spot-form *P. teres* isolates.

Line	Mean †	Disease reaction
CI 9776	2.55 a	HR
CI 5791	2.90 ab	R
CI 7584	3.05 abc	R
CI 14023	3.70 bcd	MR
CI 9819	3.80 bcd	MR
CI 1197	4.00 cd	MR
CI 5845	4.30 de	MR
Robust	4.55 def	MS
CI 1615	4.55 def	MS
Beecher	4.55 def	MS
CI 2750	5.00 efg	MS
CI 2330	5.00 efg	MS
Tifang	5.05 efgh	MS
CI 12821	5.20 efghi	MS
Vireo	5.20 efghi	MS
Simmit	5.45 fghi	MS
Menuet	5.55 ghij	MS
Freja	5.65 ghijk	MS
Morex	5.70 ghijk	MS
Manker	5.70 ghijk	MS
Bowman	6.00 hijkl	MS
Gallatin	6.05 ijkl	MS
Betzes	6.10 ijkl	MS
Herta	6.10 ijkl	MS
Piroline	6.15 ijkl	MS
Moravian III	6.50 jklm	S
Hector	6.50 jklm	S
Klages	6.55 klm	S
Clark	6.80 lm	VS
Harrison	6.85 lmn	VS
Erbet	7.25 mn	VS
Compana	7.80 n	VS

† Cultivars followed by the same letter are not significantly different at the 1% level as indicated by LSD mean comparison.

References

Bjarko, B.M. 1979. Sources of and genetic action of resistance in barley to different virulence types of *Pyrenophora teres*, the causal organism of net blotch. MS Thesis, Montana State University, USA.

Bockelman, H.E., E.L. Sharp and M. Bjarko. 1983. Isolates of *Pyrenophora teres* from Montana and the Mediterranean region that produce spot-type lesions on barley. *Plant Disease* 67: 696–697.

Karki, C.B. and E.L. Sharp. 1986. Pathogenic variation in some isolates of *Pyrenophora teres* f.sp. *maculata* on barley. *Plant Disease* 70: 684–687.

Khan, T.N. and A. Tekauz. 1982. Occurrence and pathogenitiey of *Drechslera teres* isolates causing spot-type symptoms on barley in Western Australia. *Plant Disease* 66: 423–425.

McDonald, W.C. 1963. Heterothallism in *Pyrenophora teres*. *Phytopathology* 53: 747–755.

McDonald, W.C. 1967. Variability and the inheritance of morphological mutants in *Pyrenophora teres*. *Phytopathology* 57: 747–755.

Smedegard-Petersen, V. 1971. *Pyrenoplhora teres* f. *maculata* f.nov. and *Pyrenophora teres* f. *teres* on barley in Denmark. Pages 124–144 *in* Royal Veterinary Agricultural University Yearbook 1971. Copenhagen, Denmark.

Snedecor, G.W. and W.G. Cochran. 1989. Statistical Methods. 8th Edn. Iowa State University Press, Ames, USA.

Tekauz, A. 1985. A numerical scale to classify reactions of barley to *Pyrenophora teres*. *Canadian Journal of Plant Pathology* 7: 181–183.

Tekauz, A. and K.W. Buchanon. 1977. Distribution of and sources of resistance to biotypes of *Pyrenophora teres* in Western Canada. *Canadian Journal of Plant Science* 57: 389–395.

Development of a New Barley Line by Induced Mutation

Jamal Bahaa El Den
Ministry of Agriculture and Agrarian Reform
Directorate of Agricultural Research
P.O. Box 113
Douma, Damascus
SYRIA

Abstract

Sodium azide was applied to induce mutations in barley (*Hordeum vulgare* L. ssp. *vulgare*) variety ER/APAM, with the objective of increasing plant height. The sodium azide induced chlorophyll mutations. Few chromosome aberrations were observed. A mutant line, E-3559, was compared with the original variety over three years (1987–1989) at Al-Moujarje Research Center, Hassakeh (annual rainfall 250 mm). The mutant line was consistently taller and produced more straw compared with the original variety, ER/APAM.

Key words: *Hordeum vulgare*; barley; induced mutation; height; varieties; barley straw; chlorophylls; sodium azide; chromosome aberrations; Syria.

Introduction

In variety development, barley breeders normally depend on traditional breeding methods which are generally time-consuming. However, varieties can be developed in a shorter time by artificial mutation techniques.

The barley variety ER/APAM is high yielding, drought tolerant and lodging resistant. However, its short stem hampers mechanical harvesting. The objective of this study was to increase plant height in ER/APAM by applying mutation techniques.

Materials and Methods

Barley var. ER/APAM was treated with sodium azide (0.003 –0.006*M*) by using the soaking method in 1982/83. Solutions were prepared using distilled water or buffer solutions, pH 4.2 and 11. The seeds were soaked in distilled water for 2.5 hours and then in sodium azide solutions for 25 hours. Some of the treated seeds were sown in petri dishes to check the germination percentage.

استنباط سلالة جديدة من الشعير باستحداث طفرة

الملخص

استخدم أزيد الصوديوم (0.003 M) في إحداث طفرات في الصنف ER/APAM من الشعير (*Hordeum vulgare* L. spp. *vulgare*) بهدف زيادة طول النبات. وقد أثبت أزيد الصوديوم فعاليته في إحداث طفرات يخضورية. وتم الحصول على عدد قليل من الانحرافات الصبغية ومعدلات معقولة من الطفرات المظهرية والفيزيولوجية. قورنت السلالة الطافرة E-3559 بالصنف الأصلي على مدى ثلاث سنوات (1986–1989) في مركز بحوث المجرجة في الحسكة (الأمطار السنوية 250 مم)، فتبين أن تلك السلالة الطافرة كانت أطول وأكثر إنتاجاً للتبن على نحو ثابت بالمقارنة مع الصنف الأصلي ER/APAM.

Root tips were fixed and stored in acetic acid/alcohol solution for cytology tests to check for chromosome aberrations.

The remaining seeds were planted at Karahta Research Station, Damascus, to produce the first mutant generation (M_1). At maturity, the main spike from each plant was selected.

In 1983/84, the seeds of each spike were planted in a row to produce the M_2 plants. Morphological variants were studied in this generation.

Three long-stemmed mutants were selected and yield tested in 1985/86 at the Al-Moujarge Research Station (Hassakeh) which represents Zone C (rainfall average *250* mm/year). The best mutant (E-3559) was selected.

After confirming that the plant height of E-3559 had been genetically fixed, we compared it with the original variety ER/APAM in a trial that consisted of four entries: (1) mutant line E-3559; (2) variety ER/APAM; (3) variety Arabi Aswad (common variety in farmers' fields in Hassakeh) as a check; (4) variety Arabi Abiad as a second check.

The study was conducted over three seasons 1986/87–1988/89. In the first season, the study comprised E-3559 and ER/APAM only. The trial was planted in randomized complete block design with four replications;

each entry was planted in six rows, 2.5 m long with 0.3 m between rows.

During 1986/87, rainfall was low (203 mm, average 278 mm) and badly distributed, so yields were low. In 1987/88, rainfall was high (526 mm) and well distributed. While the 1988/89 season was below normal both in terms of quantity (184 mm) and distribution. Temperature extremes (frost to high temperatures) also affected plant growth and development.

Results and Discussion

Table 1 shows the toxic effect on ER/APAM of sodium azide at 0.003*M* in the acid buffer (pH 4.2) and at 0.006*M* sodium azide, both of which reduced germination drastically.

Chlorophill mutants

All 128 families treated with the sodium azide 0.003*M* in distilled water were studied in the M_2 generation. Eight families had chlorophill mutants. So sodium azide has an acceptable efficiency to induce chlorophill mutations in ER/APAM.

Chromosome aberrations

Sodium azide (0.003*M* in distilled water) caused few chromosome aberrations. It destroyed only 0.87% of the chromosomes. This low percentage indicates that the M_1 plants were practically not affected, thus showing the suitability of this mutagen for these studies.

Visible mutations

Of the 128 families of var. ER/APAM treated with sodium azide (0.003*M* in distilled water) studied in the M_2 generation, five families exhibited changes in morphological and physiological characters (3.9%). Thus, sodium azide has a moderate ability to induce visible mutations in the field, offering the possibility for selection of useful mutants in the M_2 generation.

During three years testing, the mutant E-3559 was taller and produced more straw than the original variety ER/APAM (Tables 2–4). It also compared well with the local landraces. In particular, the plant height of the mutant makes it suitable for mechanical harvesting.

Table 1. Seed germination (%) of ER/APAM treated with sodium azide.

Treatment	Solution	Germination			
		First day	Second day	Third day	Fourth day
Check	Distilled water	0	52	81	88
0.003*M*	Distilled water	0	26	28	28
0.003*M*	Buffer, pH 4.2	0	0	0	0
0.003*M*	Buffer, pH 11	10	66	68	68
0.006*M*	Distilled water	0	6	9	9

Table 2. Performance of E-3559 and ER/APAM at Al-Moujarje Research Station, Hassakeh, in 1986/87.

Variety	Days to maturity	Plant height (cm)**	Grain yield (kg/ha)	Straw yield (kg/ha)*
E-3559	135	57	1640	2917
ER/APAM	137	45	1529	2028

*,** Significant difference between values within column at 5% and 1%, respectively.

Table 3. Performance of the barley mutant E-3559 compared to the original variety, ER/APAM, and two check landraces at Al-Moujarje Research Station, Hassakeh, in 1987/88.

Variety	Days to		Plant height (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)
	Heading	Maturity			
E-3559	98	137	64	2303	2836
ER/APAM	95	137	47	2039	2411
Arabi Aswad	101	138	70	2031	2550
Arabi Abiad	101	139	58	2081	2531
LSD at 5%			9	584	317
1%			11.4	742	402
CV (%)			4.8	17	7.8

Table 4. Performance of the barley mutant E-3559 compared with the original variety, ER/APAM, and two checks at Al-Moujarje, Hassakeh, 1988/89.

Variety	Days to		Plant height (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)
	Heading	Maturity			
E-3559	113	143	53	993	3118
ER/APAM	108	143	45	993	2293
Arabi Aswad	108	141	50	1155	2249
Arabi Abiad	111	143	39	735	2347
LSD at 5%			5.9	NS	573
1%			7.5		727

NS Not significant at 5%.

Acknowledgement

I thank M. Fathallah Jagan, Head of Moujarjea Research Station of Hassakeh for his help in conducting the research. I also thank ICARDA for assistance with the translation and editing of the article.

Effect of Fall Growth and Development on Winter Hardiness in Barley

M. Sait Adak and Didar Eser
Department of Field Crops
Faculty of Agriculture
Ankara University
06110 Ankara, TURKEY

Abstract

Six released two-rowed barley (*Hordeum vulgare* L. ssp. *vulgare*) cultivars were grown under field conditions in 1988/89 and 1989/90. Observations were made on different traits including crown fresh weight, dry weight, water content, crown depth, root length, and number of roots, tillers and leaves. Years and cultivars had a significant influence on most of these variables. Positive and significant relations were found between cold hardiness and crown depth, root length, dry crown weight and number of tillers. Cold hardiness was negatively associated with seedling height and crown water content.

Key words: *Hordeum vulgare*; barley; resistance to injurious factors; winter hardiness; length; crown; varieties; Turkey.

Introduction

Barley is an important crop in Turkey where it is grown over 3.5 million ha. The grain production of 7.5 million tonnes is used in the feed and malt industries.

Turkey has various climatic regions where barley can be grown in winter and spring. Winter sowing is prefered to spring sowing in dry areas. In high-elevation areas, the temperature may become as low as –30°C and barley cannot be grown safely. These areas are dry during late spring and summer. So, cold hardiness and tolerance are important for these areas since they are mostly occupied by winter cereals.

Barley generally is not very resistant to cold. Most varieties suffer damage at about –10°C and will be killed at –15°C without snow cover (Tosun and Yurur 1982). Thus, cold resistance is one of the most important characters in barley, yet little research has been conducted in this area.

تأثر نمو وتطور الشعير في الخريف بقساوة الشتاء

الملخص

تمت زراعة ستة أصناف معتمدة من الشعير الثنائي الصف *(Hordeum vulgare* L. ssp. *vulgare)* تحت الظروف الحقلية في موسمي 89/1988 و 90/1989. وقد أخذت قراءات عن صفات مختلفة شملت وزن التاج الغض، الوزن الجاف، محتوى الماء، عمق التاج، طول الجذور، عدد الجذور، الاشطاءات والأوراق. وكان للسنوات والأصناف تأثير كبير على معظم هذه المتغيرات، وتبين أن هناك علاقات إيجابية ومعنوية بين قساوة الشتاء وعمق التاج، طول الجذور، وزن التاج الجاف وعدد الإشطاءات. وقد اقترنت برودة الشتاء الشديدة سلبياً بطول البادرة ومحتوى التاج من الماء.

The main objective of this study was to determine the relationship among some morphological and physiological characters measured during the fall, and the relationship between these characters and the cold hardiness of barley.

Materials and Methods

The research was carried out in the 1988/89 and 1989/90 growing seasons at the Department of Field Crops, Faculty of Agriculture, Ankara University. Six released two-rowed barley cultivars – Tokak 157/37, Cumhuriyet 50, Obruk 86, Anadolu 86, Terçil 147 and Ankara 86 – were planted, using normal seeding rate, in a randomized block design with three replicates, on 17 October 1988 and 13 October 1989.

In both years, samples of each variety from each replication were taken in mid-December, which is considered the beginning of the cold season for the Ankara region by Kun and Sehirali (1977).

The following measurements were made:

(1) crown depth: distance between the crown and the stem or leaf areas containing chlorophyll;
(2) seedling height: distance between the stem or leaf sheath area without chlorophyll and the tip of the longest leaf;
(3) number of tillers/plant;
(4) number of leaves/plant;
(5) number and length of roots;

Table 1. Means of several plant traits measured on six barley varieties for two consecutive years (1988/89 –1989/90).

Variety	Crown depth (cm)			Root length (cm)			Seedling height (cm)			No. of tillers/plant			No. of roots/plant		
	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean
Tokak 157/37	3.89	3.16	3.53	29.99	26.56	28.27 a*	8.19	11.03	9.61 b	3.00	3.73	3.37	5.60	7.33	6.47 ab
Cumhuriyet 50	3.57	3.19	3.38	30.21	26.45	28.33 a	8.31	11.63	9.97 b	3.00	3.87	3.43	5.80	6.73	6.27 b
Obruk 86	3.69	3.12	3.40	29.82	26.90	27.36 a	8.56	11.21	9.89 b	3.00	3.93	3.47	6.13	7.73	6.93 a
Anadolu 86	4.07	2.97	3.52	30.57	26.09	28.33 a	8.81	11.22	10.01 b	3.00	3.93	3.47	5.93	7.80	6.86 a
Yerçil 147	3.65	2.87	3.26	26.97	21.61	24.29 b	9.46	15.47	12.46 a	3.00	3.33	3.17	6.33	7.53	6.93 a
Ankara 86	4.20	2.82	3.51	30.97	28.05	29.51 a	8.33	10.63	9.48 b	3.00	3.60	3.30	5.33	6.93	6.23 b
Average	3.85	3.02		29.75	25.61		8.61	11.86		3.00	3.73		5.89	7.34	
LSD (0.05)			NS			2.49			0.88			NS			0.48

Variety	No. of leaves/plant			Crown fresh wt (g/5 plants)			Crown dry wt (g/5 plants)			Crown water content (%)			Field survival (%)		
	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean
Tokak 157/37	6.28	9.67	7.97 a	1.75	3.42	2.58 cd	0.19	0.42	0.31 b	88.81	87.72	88.26 bc	98.69	100.00	99.35a
Cumhuriyet 50	6.60	10.00	8.30 a	1.93	3.94	2.93 bc	0.22	0.44	0.33 b	88.73	88.71	88.72 bc	98.02	100.00	99.01a
Obruk 86	6.60	10.53	8.57 a	2.01	5.09	3.55 a	0.22	0.55	0.39 a	88.82	89.29	89.06 b	99.35	98.67	99.01a
Anadolu 86	6.47	10.47	8.47 a	1.93	4.24	3.08 ab	0.22	0.48	0.35 ab	87.95	88.66	88.30 bc	97.19	97.28	97.24a
Yerçil 147	5.40	8.13	6.77 b	1.22	3.15	2.18 d	0.12	0.29	0.21 c	89.76	90.99	90.38 a	8.79	0.00	4.40b
Ankara 86	6.47	10.00	8.23 a	1.70	3.33	2.51 cd	0.19	0.44	0.31 b	88.76	86.79	87.77 c	99.33	98.68	99.01a
Average	6.30	9.80		1.75	3.86		0.19	0.44		88.80	88.69		83.56	82.44	
LSD (0.05)			1.16			0.47			0.05			1.20			2.69

* Means followed by the same letter in each column are not significantly different at the 5% level.
NS = Not significant at the 5% level.

(6) fresh weight (g/5 plants) of plant parts 3 cm above and 5 cm below the crown tissue;
(7) dry weight (g/5 plants) of plant parts used for fresh weight determinations after oven-drying at 105°C for 2 h or longer as necessary;
(8) water content: 100 × (fresh weight − dry weight)/fresh weight;
(9) cold hardiness (field survival): determined by counting plants in fall and after winter in 0.2 m^2 for each variety.

Results and Discussion

Air temperatures were recorded throughout the growing season. There were 84 frost days in 1988/89 and 94 frost days in 1989/90. Minimum temperatures for the two seasons were −11.8°C and −15°C, respectively.

Differences due to years were significant for all variables except crown water content. Deeper crowns and longer roots were observed in the first season. Taller seedlings, more tillers, more leaves and roots per plant and greater fresh and dry weights were noted in 1989/90 (Table 1). These differences were due to climatic differences between the two years in the sowing-to-sampling period. The second year was milder and wetter during this period and plants showed better growth and development above ground and less underground.

Correlations among the measured traits are shown in Tables 2 and 3. There was a significant positive relationship between crown depth and field survival in the second year, but this was not significant in the first year. A positive and significant correlation existed between root length and cold hardiness in both years. A negative relation was found between number of roots and cold hardiness in the first year, but not in the second year. Seedling height showed a significant negative correlation with cold hardiness in both seasons. The number of tillers and leaves were positively correlated with cold hardiness. Cold hardiness correlated positively with crown dry weight and negatively with crown water content.

Table 2. Correlations among traits in 1988/89.

	Crown depth (1)	2	3	4	5	6	7	8
2. Root length	−0.115							
3. No. roots	−0.038	−0.350						
4. Seedling ht	0.300	−0.551*	0.733**					
5. No. leaves	0.142	0.369	−0.514*	−0.514*				
6. Crown fresh wt	−0.235	0.503*	−0.278	0.465	0.586*			
7. Crown dry wt	−0.102	0.481*	−0.297	−0.459	0.724**	0.949**		
8. Crown water cont	−0.469*	0.018	0.096	0.052	−0.628**	−0.152	−0.376	
9. Field survival	0.192	0.540*	−0.526*	−0.611**	0.758**	0.797**	0.883**	−0.462

Table 3. Correlations among traits in 1989/90.

	1†	2	3	4	5	No. tillers (10)	6	7	8
2	0.114								
3	−0.072	−0.207							
4	−0.228	−0.790**	−0.009						
5	0.080	0.520*	0.006	−0.503*					
10	0.124	0.370	0.281	−0.510*	0.817**				
6	0.366	0.027	0.042	−0.206	0.585*	0.466			
7	0.247	0.377	−0.110	−0.581*	0.659*	0.516*	0.855**		
8	0.162	−0.680**	0.314	0.746**	−0.169	−0.074	0.205	−0.326	
9	0.579*	0.720**	−0.174	−0.910**	0.547*	0.484*	0.377	0.690**	−0.663**

† See Table 2 for traits.

One of the varieties, Terçil 147, experienced severe (91%) frost damage at –11.8°C in 1988/89, and was completely killed at –15°C in 1989/90. A high survival rate was observed in all other varieties.

The results of this study indicate that fall growth and plant development of a cultivar varies from year to year. The effects of fall growth and development on winter hardiness in winter cereals have been investigated (e.g. Fowler and Gusta 1977). In our study, both varietal and environmental factors affected fall growth and development of barley grown in cold conditions. Cold hardiness seems to be more related to seedling height, root length and crown dry weight than to other traits. However, the phenomenon is complex and needs investigation over a longer period of time.

References

Fowler, D.B. and L.V. Gusta. 1977. Influence of fall growth and development on cold tolerance of rye and wheat. *Canadian Journal of Plant Science* 57: 751–755.

Kun, E. and S. Sehirali. 1977. Investigations on root development of wheat. TUBITAK Publication No. 36. Ankara, Turkey.

Tosun, O. and N. Yurur. 1982. Cool season cereals. Faculty of Agriculture, Ankara University Press, Publication No. 72.

Environmental Factors Limiting Barley Yield in the High Plateaux of Eastern Algeria

H. Bouzerzour and A. Benmahamad
Agricultural Research Station, ITGC
B.P. 03, Setif, 19000
ALGERIA

Abstract

Ten barley (*Hordeum vulgare* L. ssp. *vulgare*) lines of diverse origin were sown at three seeding dates in 1988/89, to determine the factors which limit grain yield (GY) in the high plateaux of Algeria. Data were collected on GY and yield components, days to heading, mean minimum and maximum temperatures. Significant differences existed between varieties within sowing date and between sowing dates for GY and yield components. Significant correlation coefficients were found between GY, kernels/head, days to heading, mean minimum temperature and the difference between mean maximum and minimum temperatures of the 15 days prior to heading for early material, and seeding dates. We deduce that low temperatures are the main limiting factor to high yield in this region. This suggests that the ongoing selection program should incorporate frost tolerance into future varieties and select material with slow primordia initiation and rapid primordia development.

[1] Present address: Ecole Normale Supérieure, Centre Universitaire de Oum El Bouaghi, 4000, ALGERIA.

العوامل البيئية المحدة لغلة الشعير في الهضاب المرتفعة من شرقي الجزائر

الملخص

زرعت عشر سلالات من الشعير (*Hordeum vulgare* L ssp. *vulgare*) متنوعة المنشأ في ثلاثة مواعيد زراعة في موسم 89/1988 لتحديد العوامل المحدة للغلة الحبية في الهضاب المرتفعة من الجزائر. جمعت البيانات المتعلقة بالغلة الحبية ومكونات الغلة، عدد الأيام حتى الإسبال، متوسط درجات الحرارة الدنيا والعظمى. وقد تبين أن هناك فروقاً كبيرة بين الأصناف ضمن موعد الزراعة الواحد وفيما بين مواعيد الزراعة الثلاثة بالنسبة للغلة الحبية ومكونات الغلة. ووجدت معاملات ارتباط معنوية بين الغلة الحبية، الحبات/السنبلة، عدد الأيام حتى الإسبال، متوسط درجات الحرارة الدنيا والفرق بين متوسط الحرارة العظمى والدنيا خلال الـ 15 يوماً التي تسبق الإسبال بالنسبة للمادة الباكورية ومواعيد الزراعة. نستنتج من ذلك أن درجات الحرارة المتدنية هي العامل الرئيسي المحد لارتفاع الغلة في تلك المنطقة، مما يوحي بضرورة قيام برنامج الانتخاب الحالي بإدخال صفة تحمل الصقيع في الأصناف المستقبلية وانتخاب مواد وراثية ذات بدايات تشكل نباتي بطيء وتطور نباتي سريع.

Key words: *Hordeum vulgare*; barley; environmental factors; varieties; yields; plateaux; cold; Algeria.

Introduction

Barley is becoming the most important field crop grown in Algeria. It accounted for 40% of the total area planted to small-grain cereals, which averaged 3.5 million hectares. Grain yield of barley is very low and unpredictable under the growing conditions of the high plateaux region where durum and bread wheats cannot give acceptable yield and where most of the barley area is located.

Barley time of anthesis is limited by late frost and maturity is greatly accelerated by water deficit and high temperature which are more frequent by mid-June. Breeding aims at high and stable yields of the economically important plant parts in such an environment.

The ideal genotype for a given environment will be one which will escape or tolerate all the stresses of that environment. However, this is seldom possible. In general yield is the result of the interaction between the climatic constraints and the biological characteristics of the variety. The gap between genetic potential yield and realized yield in the high plateaux of Algeria is primarily related to environmental stress factors. Large yield reductions are due to water deficit and frost damage.

This study was initiated to identify the primary environmental factors that limit barley yields in the high plateaux of eastern Algeria.

Materials and Methods

Ten barley varieties from diverse origins were seeded at the Agricultural Research Station, Setif, Algeria during the 1988/89 crop season. The experimental design was a split plot with four replications and three seeding dates: October (Oct), November (Nov) and December (Dec), which formed the main plots while varieties were allocated to subplots. The small plots were 6 rows × 10 m long with 18 cm inter-row spacing. Agronomic practices were as per the recommendations for the region. Data were recorded on number of spikes/m², number of kernels/spike, 1000-kernel weight (TKW), grain yield (GY), number of kernels/m² and days to heading (DHE), counted from 1 January to heading. Also calculated, for the 15-day period prior to heading, were mean minimum temperature (Tm), mean maximum temperature (Tx), their difference ($\Delta T = Tx - Tm$) and the sum of the daily mean minimum temperature minus 4°C, i.e. $\Sigma(Tm - 4)$. Data were analyzed using STATITCF computer program.

Results and Discussion

Grain yield, grain yield components, DHE, Tm, ΔT and $\Sigma(Tm - 4)$ of the ten tested lines are reported in Table 1. The analysis of variance for some traits is presented in Table 2. Highly significant differences were found among sowing dates and among barley lines for the characters analyzed. The significant interaction between sowing dates and lines indicates that the response of varieties differed with sowing date.

Table 2. Analysis of variance for barley yield and yield components.

Source of variation	df	Mean squares		
		Heads/m²	TKW	GY
Total	89	7091.30	14.26	80.90
Reps	2	433.19	0.41	0.46
Dates (D)	2	8133.06**	69.68**	969.18**
Error (1)	4	503.50	5.95	3.88
Varieties (V)	9	54887.10**	59.89**	470.66**
D × V	18	3991.66**	26.17**	52.61**
Error (2)	54	854.55	1.76	1.16

** Significant at 1% level.

By using different planting dates, the temperature regime, photoperiod, and exposure to cold and drought are changed and each group of plants is therefore subjected to different stresses. Early planting exposes material to frost damage at flowering, while late planting exposes the plants to heat and drought stresses during grain-filling (Nachit 1983). Mean grain yields were 1087, 1403 and 2191 kg/ha for Oct, Nov and Dec seedings averaged over varieties. Taking Dec sowing as 100%, Oct and Nov seeding represent 49.6 and 64%, suggesting that some limiting factors had affected GY of material sown in Oct and Nov.

Coefficients of correlation among GY, GY components, DHE, Tm, ΔT and $\Sigma(Tm - 4)$ were calculated for each seeding date to display the effect of sowing date on the relationship between these characters and for the three seeding dates as an overall effect. Number of heads/m² showed low and non-significant correlation with GY, indicating that differences in this character between

Table 1. Yield, yield components and climatic characteristics of the 15 days prior to heading for 10 barley lines sown at three seeding dates.

Sowing date	Variety	Heads/ m²	Kernels/ head	TKW† (g)	GY (t/ha)	Grains/ m²	DHE	Tm (°C)	Σ(Tm –4) (°C)	ΔT (°C)
5 Oct	Tichedret	279	15.7	42.5	1.86	4385	107	4.6	9	10.5
	ACSAD 176	235	6.0	31.6	0.45	1430	92	5.6	24	11.2
	Barberousse	267	8.2	37.8	0.83	2195	107	4.6	9	10.5
	WI 2391/WI 2192	446	3.4	43.9	0.66	1510	84	5.6	24	9.8
	Jaidor	325	3.1	39.6	0.34	1001	99	5.5	22	11.5
	Tatiana	268	28.9	36.7	2.85	7767	109	4.7	71	9.8
	Saida	321	4.1	38.4	0.51	1317	99	5.5	22	11.5
	Tina	362	15.7	35.3	2.01	5682	111	5.5	23	10.3
	Rihan	252	4.1	31.9	0.32	1022	93	5.3	20	16.8
	Thibault	308	8.1	38.5	0.96	2501	109	4.7	71	9.8
10 Nov	Tichedret	229	14.7	39.5	1.33	3367	113	5.7	26	10.3
	ACSAD 176	270	5.7	41.3	0.63	1542	99	4.5	22	11.5
	Barberousse	320	8.0	36.8	0.94	2561	111	5.0	23	10.3
	WI 2391/WI 2192	529	4.9	42.2	1.10	2608	86	5.6	24	10.3
	Jaidor	323	5.9	41.1	0.76	1901	103	4.6	9	10.3
	Tatiana	341	25.4	38.4	3.33	8672	114	7.4	71	9.8
	Saida	292	6.4	40.8	0.76	1855	103	4.7	71	9.7
	Tina	428	20.0	37.3	3.19	8552	114	7.5	26	10.3
	Rihane	292	5.5	41.6	0.76	1611	100	4.5	22	11.5
	Thibault	296	11.0	37.2	1.22	3268	114	5.7	26	10.3
7 Dec	Tichedret	284	16.1	39.9	1.94	4869	123	4.9	14	10.3
	ACSAD 176	248	17.1	41.5	1.76	4237	112	5.5	23	10.5
	Barberousse	244	29.9	31.5	2.29	7286	123	4.9	14	10.3
	WI 2391/WI 2192	566	10.1	44.4	2.54	5713	108	4.7	71	9.8
	Jaidor	303	17.1	35.5	1.84	5187	107	5.7	26	10.3
	Tatiana	287	30.5	31.5	2.76	8760	114	4.9	14	10.3
	Saida	310	17.1	36.1	1.91	5294	109	5.7	26	10.5
	Tina	422	20.0	34.6	2.92	8455	114	4.5	8.2	10.0
	Rihane	389	13.7	35.1	1.87	5314	100	5.7	26	10.3
	Thibault	308	19.2	35.0	2.07	5922	114	4.5	8.2	10.0

† See text for explanation of abbreviations and symbols used.

varieties within each date do not seem to influence final GY. Means per sowing date were 306, 302 and 337 heads/m², respectively for Oct, Nov and Dec sowing. Grains/m² presented a positive and highly significant correlation coefficient with GY at each sowing date. Mean grains/m² were 2881, 3594 and 6104 for Oct, Nov and Dec seeding date; values for Oct and Nov representing 47.2 and 58.8% of the number of grains/m² of Dec sowing.

Number of kernels/head showed a positive and highly significant correlation coefficient with kernels/m², indicating that these two yield components varied in the same way. As grains/m² is a resultant of heads/m² × kernels/head, then variation in growing conditions has affected GY via kernels/head for Oct and Nov planting. Kernels/head showed a positive and highly significant coefficient of correlation with GY for Oct and Nov sowing, and non-significant coefficient of correlation for Dec planting (Table 3). Mean kernels/head were 9.74, 10.75 and 19.08, respectively for Oct, Nov and Dec sowing dates. Reduction in kernels/head for Oct and Nov relative to Dec seeding date were 50 and 43.7%, respectively.

Thousand-kernel weight showed low and non-significant correlation coefficients with GY, heads/m², kernels/head and kernels/m². However, the correlation coefficients became negative and highly significant on Dec planting date for TKW with kernels/m² and kernels/head (Table 3). This indicates that increases in kernels/m² and kernels/head result in a reduction of TKW for late sowing. Days to heading was positively correlated with GY, kernels/head and grains/m², and negatively correlated with Tm in Oct and Nov seeding only. Considering the three seeding dates together, GY was positively correlated with kernels/head, grains/m² and DHE, and negatively correlated with Tm and ΔT. These results indicate that variation in DHE and ΔT can explain much of the variation in GY, kernels/head and grains/m².

Results of a stepwise regression analysis showing the importance of heads/m², kernels/head, grains/m² and TKW in predicting GY, and the importance of Tm, DHE, Σ(Tm –4) and ΔT in predicting kernels/head are presented in Table 4. For GY, the maximum step (highest R^2) is achieved with grains/m² and TKW for each seeding date. Considering the three seeeding dates together, kernels/head and heads/m² are the only traits entering the equation. In all cases, the first trait cited is the first variable to enter into the model; this stresses the importance of grains/m² and kernels/head in predicting GY under the growing conditions of the high plateaux. For kernels/head, only the experiments seeded in Oct and Nov showed that DHE was *the variable* which achieved a high coefficient of determination (R^2).

Table 4. Stepwise prediction equations for grain yield and kernels per head per sowing date and for the 3 seeding dates.

Prediction equations	R^2
October seeding	
GY = 3.68 grains/m² + 0.194 TKW – 7.42	0.998
Kernels/head = 0.589 DHE – 49.81	0.426
November seeding	
GY = 3.79 grains/m² + 0.306 TKW – 11.81	0.999
Kernels/head = 0.2013 DHE – 24.17	0.361
December seeding	
GY = 3.14 grains/m² + 0.43 TKW + 0.006 heads/m² – 15.35	0.999
3 seeding dates all together	
GY = 1.037 kernels/head + 0.044 heads/m² – 12.46	0.962
Kernels/head = 0.5912 DHE – 49.77	0.433

Slatyer (1969) states that three important growth stages in relation to drought stress should be considered. These are stages of floral initiation-inflorescence development, anthesis-fertilization and grain-filling. Drought at anthesis-fertilization stage will reduce kernels/head because of dehydration of pollen grain. Gate (1989) reports that minimum temperature as low as 4°C, under shelter, reduces pollen fertility at anthesis-fertilization stage. This stage occurred from 23 March to 3 May for the ten lines tested here.

Lateness, in terms of days from 1 January to heading, was the main character discriminating the material capable of high GY through high spike fertility within the early seeded experiments (Oct and Nov). We suspect that low temperature is responsible for the low spike fertility observed in early material; however, there was no evidence of significant correlation between kernels/head and Tm, or between kernels/head and ΔT in the early seeding. This may be explained by the fact that the tested materials have different degrees of tolerance to low temperatures and to the range between Tx and Tm.

When considering the range of low temperatures experienced by the material tested during the three seeding dates, there is evidence that the main environmental limiting factor to high barley grain yield is frost, because of the significant correlations of GY and kernels/head with DHE, Tm and ΔT. In the material used in this study, we found that the correlation coefficients of DHE, Tm and ΔT with GY were influenced by environmental conditions. In particular, the unfavorable environment created by October seeding and, to a lesser degree, November seeding, determined a yield disadvantage for the entries with a shorter period from 1 January to heading.

Table 3. Correlation coefficients between grain yield, grain yield components, days to heading and climatic characteristics of the 15-day period prior to heading of ten barley lines grown at three sowing dates.

Traits	1	2	3	4	5	6	7	8	9
Grain yield	1.000	-0.046	0.975	0.994	0.111	-0.504	0.669	0.424	-0.467
	1.000	0.325	0.945	0.998	-0.530	-0.042	0.693	0.399	-0.460
	1.000	0.441	0.399	0.894	-0.248	-0.317	0.131	0.018	-0.590
Heads/ m^2	0.252	1.000	-0.222	-0.070	0.629	0.426	-0.295	-0.049	-0.377
		1.000	0.041	0.313	0.103	0.123	-0.500	-0.073	-0.236
		1.000	-0.590	0.078	0.473	-0.288	-0.430	0.736	-0.775
Kernels/ head	0.878	-0.156	1.000	0.979	-0.023	-0.542	0.653	0.448	-0.386
			1.000	0.947	-0.604	0.660	0.665	0.446	-0.488
			1.000	0.715	-0.793	-0.250	0.441	-0.606	0.256
Grains/ m^2	0.984	0.181	0.922	1.000	0.022	-0.458	0.674	0.449	-0.435
				1.000	-0.573	-0.033	0.633	0.389	-0.478
				1.000	-0.647	-0.565	0.174	-0.328	-0.307
TKW	-0.211	0.387	-0.450	-0.356	1.000	-0.208	-0.017	-0.070	-0.551
					1.000	-0.238	-0.094	-0.094	0.431
					1.000	0.028	-0.086	0.697	-0.235
Tm	-0.363	-0.054	-0.238	-0.316	-0.085	1.000	-0.672	-0.316	0.256
						1.000	-0.681	-0.529	0.371
						1.000	-0.530	0.112	0.748
DHE	0.588	-0.267	0.658	0.596	-0.218	-0.306	1.000	0.326	-0.364
							1.000	0.213	-0.440
							1.000	-0.422	0.014
Σ(Tm – 4)	0.200	0.197	0.065	0.125	0.239	-0.260	0.018	1.000	-0.311
								1.000	-0.599
								1.000	-0.391
Tx–Tm	-0.457	-0.284	-0.368	-0.422	-0.276	0.232	-0.392	-0.255	1.000

Above diagonal are correlation coefficients respectively for Oct, Nov and Dec seeding dates, r(5%) = 0.6319, r(1%) = 0.7646, n= 10.
Below diagonal are correlation coefficients for the 3 seeding dates all together; r(5%) = 0.361 and r(1%) = 0.463, n = 30.

Days to heading, which has been indicated as an important selection criterion for drought tolerance (Nachit and Jarrah 1986), appears here as a good selection criterion for frost tolerance (escape). Days to heading was characterized by its high correlation with GY and kernels/head in the unfavorable environments (Oct and Nov seeding), but it showed no relationship with GY and kernels/head in the favorable environment. Considering December planting as unstressed environment and October sowing as the stressed one, frost reduced barley yield on the average of all cultivars by:

$$D = 1 - \overline{Y}o/\overline{Y}p = 0.5,$$

where $\overline{Y}o$ is the mean GY of Oct sowing and $\overline{Y}p$ is the mean GY of Dec seeding.

A susceptibility index, S (Fisher and Wood 1979), was calculated for the ten barley lines tested, using data of October and December planting dates. It appears that cultivars like Tichedrett, a local 6-row variety, Tatiana and Tina possess some tolerance to low temperatures (low S value), while lines such as Jaidor and Rihane are sensitive as shown by their high S values (Table 5).

Due to late frost hazard, frost tolerance should be taken into account while selecting for specific environments such as the high plateaux of eastern Algeria. In general, in the high-elevation Mediterranean area, although little winter-hardiness is required for survival, substantial vernalization response for flowering is needed to develop barley varieties adapted to a wide range of sowing times and still have an optimum heading time to avoid frost.

Table 5. Susceptibility index for ten barley lines grown in relatively stressed and unstressed environment.

Line	S value
Tichedrett	0.08
ACSAD 176	1.47
Barberousse	1.27
WI/WI	1.47
Jaidor	1.56
Tatiana	0.00
Saida	1.46
Tina	0.62
Rihane	1.64
Thibault	1.06

References

Fisher, R.A. and J.T. Wood. 1979. Drought resistance in spring wheat cultivars. III. Yield association with morpho-physiological traits. *Australian Journal of Agricultural Research* 30: 1001–1020.

Gate, P. 1989. L'épi du blé à la floraison. *Perspective Agricole* 132: 18–30.

Nachit, M. 1983. Use of planting dates to select stress tolerant and yield stable triticale genotypes. Page 331 *in* Proceedings 10th Eucarpia, Netherlands.

Nachit, M. and M. Jarrah. 1986. Association of some morphological characters to grain yield in durum wheat under Mediterranean dryland conditions. *Rachis* 5: 33–34.

Slatyer, R. 1969. Drought injury and resistance. *In* Physiology of Dryland Farming. Wiley and Son, New York, USA.

Relationship of Growth Vigor, Leaf Color and Other Agronomic Characters with Grain Yield in Winter and Facultative Barley in a Low-rainfall Environment

Yizhong Cai[1], M. Tahir[2] and S.K. Yau[2]

[1] *Institute of Agricultural Modernization, Hubei Academy of Agricultural Science, Wuhan 430064, CHINA*

[2] *ICARDA, P.O. Box 5466, Aleppo, SYRIA*

Abstract

Genetic variation in growth vigor, leaf color and other agronomic characters, and their relationship with grain yield were studied in 243 winter/facultative barley (*Hordeum vulgare* L. ssp. *vulgare*) lines at Tel Hadya (long-term average annual rainfall of 328 mm) in northern Syria. Visual scores were taken on growth vigor and leaf color at four growth stages. Differences between entries were significant (P<0.01) for all traits measured. Heritabilities for growth vigor (40.0–47.5%) and leaf color (38.5–48.1%) were between those for days to heading and maturity, and grain yield. Growth vigor, but not leaf color, was positively correlated with plant height and grain yield (r = 0.50 to 0.69), except at the earliest growth stage in winter type. The study indicated that growth vigor would be a more valuable selection trait than leaf color for high yield in winter and facultative barley under semi-arid conditions in northern Syria.

Key words: *Hordeum vulgare*; barley; agronomic characters; grain; yields; heterosis; semiarid zones; leaves, colour; genetic variation; plant habit; heritability; Syria.

Introduction

Barley is an important winter crop in the drier, predominantly rain-fed areas in West Asia and North Africa (Srivastava 1987). Breeding high-yielding varieties of barley under the Mediterranean climatic conditions requires information on the effect of drought on grain yield and yield-related characters (Nachit and Jarrah 1986). Some studies have revealed that dark leaf color during winter and light leaf color in spring was correlated positively with grain and biological yield of wheat, and that vigorous seedling growth and good ground cover were important for high yield in two- and six-rowed spring barley genotypes in dry environments (ICARDA 1988, 1989, 1991).

The objectives of this study were: (1) to investigate the genetic variation in growth vigor, leaf color and other agronomic characters, and (2) to study their relationship with grain yield in winter and facultative barley in a moisture-stress environment.

Materials and Methods

Two hundred and forty three winter/facultative barley lines of the Preliminary Barley Screening Nursery were grown at Tel Hadya (ICARDA) in northern Syria (36.01°N, 36.56°E, 284 m) with a long-term average annual rainfall of 328 mm. The seeds were sown at the rate of 125 kg/ha on 11 November 1991. The check cultivars were Tokak,

علاقة قوة النمو، ولون الورقة، وصفات زراعية أخرى بالغلة الحبية في الشعير الشتوي والاختياري في بيئات متدنية الأمطار.

الملخص

تمت دراسة التباين الوراثي في قوة النمو ولون الورقة وصفات زراعية أخرى، وعلاقة ذلك بالغلة الحبية في 243 سلالة من الشعير الشتوي الاختياري في تل حديا (المتوسط العام للأمطار السنوية 328 مم) بشمالي سورية. قيست درجات قوة النمو ولون الورقة في أربعة أطوار للنمو بالمشاهدة العينية، وكانت الفروقات بين المدخلات معنوية (P< 0.01) بالنسبة لجميع الصفات التي تم قياسها. وكانت قابلية التوريث بالنسبة لقوة النمو (40.0-47.5%) ولون الورقة (38.5-48.1%) تتوسط قابلية التوريث لعدد الأيام حتى الإسبال أو النضج، والغلة الحبية. وقد ارتبطت قوة النمو إيجابياً، وليس لون الورقة، بطول النبات والغلة الحبية (معامل الارتباط = 0.50 إلى 0.69) عدا في بداية طور النمو في الطراز الشتوي. ولقد أشارت الدراسة إلى أن انتخاب صفة قوة النمو سيكون أكثر جدوى من انتخاب لون الورقة للحصول على غلة عالية في الشعير الشتوي والاختياري تحت الظروف شبه الجافة في شمالي سورية.

Salmas, Steptoe and Arabi Abiad. An α-lattice design with three replications was used. The plot size was 6 m^2 (four 5-m rows 0.3 m apart). The experiment received 40 kg N and 60 kg P_2O_5/ha before drilling. Weeds were controlled by Brominal (bromoxynil) on 17 March 1992.

Visual scores were taken on growth habit (score 1 to 5: spring type <2; facultative type 2 to 4; winter type >4), growth vigor (score 1 to 5: 1 = poor; 5 = excellent), and leaf color (score 1 to 5: 1 = very light green; 5 = very dark green). Growth vigor and leaf color scores were taken four times at about ten-day intervals from 26 March 1992. According to Feeke's Scale the first three recording dates corresponded to growth stages 3–6 (GS1), 7–9 (GS2) and 10.1–10.4 (GS3) of the four checks; the final record was made at stage 10.5 (flowering, GS4) for each of the 243 lines. Days to heading, days to maturity, plant height and row type were also recorded. Whole plots were harvested for grain yield at maturity.

Statistical analysis of all measured traits was carried out by the ALPHANAL program of the Scottish Agricultural Statistics Service, and adjusted means were used in computing simple correlations among traits. Heritability estimates in the broad sense were computed using the components of variance method (Gao Zhiren 1986).

Results and Discussion

The season was relatively dry and cold. Total rainfall was 277.8 mm, less than the long-term average. The monthly mean minimum temperatures (°C) from December to April were: 1.9 (2.7), –1.7 (1.7), –0.7 (2.1), 1.2 (4.6), and 5.6 (8.0), respectively (the figures within parenthesis are the 13-year average).

Differences between entries were significant (P<0.01) for all traits, indicating the presence of genetic variability (Table 1). Mean growth vigor of the four growth stages

Table 1. Means, ranges and heritability estimates (h^2) of growth vigor, leaf color and other agronomic characters for 243 barley lines.

Characters	Mean†			Range (all lines)	h^2 (%)
	F‡	W‡	All		
Growth habit	3.20	4.67	3.71	0.98–5.02**	66.2
Growth vigor 1‡	3.16	3.17	3.19	1.22–4.99**	44.0
Growth vigor 2	3.11	2.64	2.95	1.22–4.49**	47.5
Growth vigor 3	3.09	2.61	2.93	1.33–4.55**	42.1
Growth vigor 4	3.16	2.65	2.99	1.21–4.82**	40.0
Leaf color 1	2.63	3.17	2.82	0.98–4.37**	38.5
Leaf color 2	2.56	3.14	2.77	1.02–4.37**	47.9
Leaf color 3	2.41	2.92	2.59	1.02–3.97**	45.5
Leaf color 4	2.12	2.51	2.26	0.86–3.49**	48.1
Days to heading	152	158	154	144–167**	82.6
Days to maturity	187	191	189	180–197**	65.0
Plant height (cm)	65.5	64.2	65.0	38–99**	51.2
Grain yield (kg/ha)	3351	3029	3241	1619–4787**	29.7

** Differences between lines significant at the 1% level.

† Adjusted means by α-lattice analysis were used.

‡ F Facultative type (146 lines); W Winter type (97 lines)

were non-significantly different, but mean leaf color scores decreased as growth progressed, showing that leaves became lighter in color with growth.

Heritability estimates were highest for days to heading, growth habit and maturity, and lowest for grain yield (Table 1). Heritabilities were intermediate for growth vigor (40.0–47.5%) and leaf color (38.5–48.1%).

The 243 entries were divided into two groups: 97 winter type and 146 facultative type. Mean growth vigor at GS2, 3 and 4, and grain yield were higher for the facultative types than for the winter types, while the winter lines had darker leaves at all four stages, and took longer to head and mature. The ten highest yielding lines all came from the facultative group; only one line from the winter group was among the top 20.

The higher grain yield of the facultative types at Tel Hadya is expected. The winter there is not severe enough to kill facultative lines, and there is a short spring growing period and terminal moisture stress which favor the earlier heading and maturing facultative lines but not the later heading and maturing winter lines. This result provides further support to the Winter and Facultative Barley Project at ICARDA for using sites in the Anatolia Plateau of Turkey and north-western Iran to help develop cold-tolerant, high-yielding winter barley.

Growth vigor, except at GS1 in winter type, was positively correlated with grain yield and plant height (Table 2), but had negative correlations with days to heading and maturity. Partial correlations were calculated to remove the possible influence of days to heading on the correlation of growth vigor and grain yield (Table 3). The

Table 2. Correlation coefficients between agronomic characters in 146 facultative and 97 winter lines of barley.

	GV2[†]	GV3	GV4	LC1	LC2	LC3	LC4	DHE	DMA	PLH	YLD
GV1	0.73**[‡]	0.66**	0.68**	–0.12	–0.18*	–0.23**	–0.32**	–0.40**	–0.41**	0.47**	0.57**
	–0.11	–0.08	–0.21*	0.00	0.02	–0.06	–0.04	–0.17	–0.09	0.01	–0.02
GV2		0.85**	0.78**	–0.27**	–0.31**	–0.36**	–0.39**	–0.56**	–0.56**	0.53**	0.69**
		0.75**	0.79**	0.11	–0.01	–0.07	–0.16	–0.39**	–0.40**	0.55**	0.50**
GV3			0.74**	–0.19*	–0.22**	–0.28**	–0.35**	–0.53**	–0.52**	0.55**	0.68**
			0.75**	0.07	0.06	–0.01	–0.15	–0.43**	–0.42**	0.45**	0.52**
GV4				–0.15	–0.15	–0.22**	–0.28**	–0.44**	–0.40**	0.46**	0.64**
				0.21	0.11	0.03	–0.16	–0.46**	–0.49**	0.51**	0.66**
LC1					0.83**	0.78**	0.68**	0.43**	0.46**	0.17*	–0.10
					0.88**	0.70**	0.49**	0.15	0.10	0.28**	0.31**
LC2						0.85**	0.75**	0.44**	0.49**	0.05	–0.19*
						0.78**	0.60**	0.23*	0.16	0.18	0.23*
LC3							0.81**	0.43**	0.50**	–0.01	–0.17*
							0.59**	0.31**	0.27**	0.08	0.20*
LC4								0.33**	0.41**	–0.09	–0.18*
								0.31**	0.29**	0.04	–0.04
DHE									0.84**	–0.21*	–0.50**
									0.89**	–0.20	–0.42**
DMA										–0.08	–0.44**
										–0.16	–0.41**
PLH											0.40**
											0.47**

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

[†] GV1–4 and LC1–4 represent growth vigor and leaf color at the four growth stages, respectively; PLH plant height, YLD grain yield, DHE days to heading, DMA days to maturity.

[‡] Upper line: facultative type; lower line: winter type.

same relationship was obtained as shown by the simple correlations. Thus the earlier finding that vigorous seedling growth and good ground cover is important for high yield for spring barley (ICARDA 1988) is also true for facultative and winter types of barley in dry Mediterranean environments.

Table 3. Partial correlation coefficients between growth vigor and grain yield with days to heading held constant.

	GV1†	GV2	GV3	GV4
Faculative type	0.47**	0.57**	0.56**	0.55**
Winter type	-0.10	0.40**	0.42**	0.58**

† see Table 2 for explanation of abbreviations.

Leaf color had a low and negative correlation with grain yield for the facultative lines (r = -0.10 to -0.19). However, for the winter lines the correlation was positive, though low, for GS1 to GS3. The low correlations of leaf color with grain yield suggest that selection for leaf color may not be efficient in improving grain yield, though leaf color has a higher heritability than grain yield. The correlations of leaf color with days to heading and maturity were positive, suggesting that lines with darker leaves tend to be later in heading and maturity. This relationship was stronger in facultative types than in winter types.

Correlation coefficients between growth vigor and leaf color for the facultative lines were negative, though some were not significant (Table 2). This suggested that facultative lines with better growth vigor tend to have lighter leaves. There was no association between growth vigor and leaf color for the winter types.

There was a positive correlation between grain yield and plant height, but negative correlation between grain yield with days to heading and maturity (Table 2). This agrees with the results of Samarrai et al. (1987) and indicates that early ear emergence and maturity, and taller plants are important traits for high yield under semi-arid conditions in northern Syria.

In conclusion, results on heritability estimates and correlations with grain yield indicate that growth vigor would be a more valuable selection trait than leaf color for high yield in winter and facultative barley under semi-arid conditions in northern Syria.

References

Gao Zhiren. 1986. Quantitative Genetics. Sichuan University Press, Wuhan, China. [Chinese]

ICARDA. 1988. Cereal Improvement Program Annual Report for 1987. ICARDA, Aleppo, Syria.

ICARDA. 1989. Cereal Improvement Program Annual Report for 1988. ICARDA, Aleppo, Syria.

ICARDA, 1991. Cereal Improvement Program Annual Report for 1990. ICARDA, Aleppo, Syria.

Nachit, M.M. and M. Jarrah. 1986. Association of some morphological characters to grain yield in durum wheat under Mediterranean dryland conditions. *Rachis* 5(2): 33-34.

Samarrai, S.M., S.M. Seyam, H.R. Mian and A.A. Dafie. 1987. Growth periods, harvest index, and grain yield relationships in barley. *Rachis* 6(2): 21-24.

Srivastava, J.P. 1987. Wheat and barley improvement: An over-view of the Cereal Improvement Program of ICARDA. *Rachis* 6(2): 5-10.

Production of Antisera for Sensitive Detection of Two Cereal Viruses by Different ELISA Variants

K.M. Makkouk and S.G. Kumari
ICARDA, P.O. Box 5466, Aleppo, SYRIA

Abstract

Antisera for Syrian isolates of barley stripe mosaic virus (BSMV) and a PAV isolate of barley yellow dwarf virus (BYDV) were produced and used for the detection of these viruses using different ELISA variants. In comparison with the double antibody sandwich ELISA, the most sensitive procedure was ELISA with enzyme amplification (EA-ELISA), where BSMV and BYDV were detected in sap dilutions of 1:1,310,720 and 1:5,120, respectively. In purified virus preparations and by using EA-ELISA, BSMV and BYDV were detected at concentrations of 0.5 and 50 pg, respectively. Other ELISA variants, such as dot-blot ELISA and by using either chromogenic or chemiluminescent substrates, also proved suitable for sensitive detection of both viruses. Penicillinase-based ELISA was adequate for BSMV but not for BYDV detection.

Key words: *Hordeum vulgare*; barley; plant viruses; Syria.

Introduction

Since the first report of using ELISA for the detection of plant viruses (Clark and Adams 1977), a number of procedures employing different modifications have been reported. These modifications include the use of different enzymes or different materials for the solid phase. One recent variant is the use of chemiluminescent substrates instead of chromogenic substrates (Makkouk et al. 1993).

In this communication we are reporting the production of good quality antisera against two cereal viruses, barley stripe mosaic virus (BSMV) and barley yellow dwarf virus (BYDV), and the evaluation of the usefulness of these antisera for sensitive detection of these viruses using different ELISA variants.

إنتاج أمصال مضادة للكشف الدقيق عن فيروسين يصيبان الحبوب بواسطة اختبارات إليزا المختلفة

الملخص

أنتجت أمصال مضادة للعزلات السورية من فيروس الموزاييك المخطط للشعير (BSMV) ولعزلة PAV من فيروس إصفرار وتقزم الشعير (BYDV)، واستخدمت للكشف عن هذين الفيروسين باستخدام مختلف اختبارات إليزا وبالمقارنة مع The double antibody sandwich ELISA كانت أكثر طرائق الاختبار دقة اختبار إليزا ذي الانزيم المضخم (EA-ELISA) حيث تم اكتشاف BSMV و BYDV في محاليل نسغ مخففة : 1:1، 310، 720، و 5:1، 120 على التوالي. كما تم اكتشاف BSMV و BYDV في مستحضرات فيروسية معقمة باستخدام EA-ELISA في تراكيز 0.5 و 50 Pg، على التوالي. وقد أثبت أيضاً أن اختبارات أخرى من إليزا من قبيل dot-blot ELISA وباستخدام مواد خاضعة إما مولدة للون أو للتألق الكيميائي (Chemiluminescent)، ملائمة للكشف الدقيق عن كلا الفيروسين. إن اختبار إليزا المرتكز على البنسيلينيز مناسب للكشف عن BSMV ولكنه غير ملائم للكشف عن BYDV.

Materials and Methods

Virus purification

The BSMV isolate SB1-91 and the BYDV isolate SB18-89 used both originated from Syria. BSMV was purified essentially by the method described by Atabekov and Novikov (1971), but the virus preparation was further purified by sucrose density gradient centrifugation. The BYDV isolate, which has been identified earlier as a PAV isolate transmissible by the two aphid species *Rhopalosiphum padi* and *Sitobion avenae*, was purified by the procedure of D'Arcy et al. (1989).

Antiserum production

BSMV antiserum was produced by giving a New Zealand white rabbit six weekly intramuscular injections each

containing 1–2 mg virus. The purified virus was emulsified with an equal volume of Freund's complete adjuvant for the first injection and with incomplete Freund's adjuvant for subsequent injections. A similar approach was used for the production of BYDV antiserum, except that each injection contained only 200–500 µg of purified virus. Rabbits were bled ten times starting one week after the sixth injection.

ELISA procedures

Different ELISA variants were compared to the standard double antibody sandwich ELISA (DAS-ELISA) reported by Clark and Adams (1977). To amplify the reaction, a cocktail of enzymes were used as reported by Stanley et al. (1985) (enzyme-amplified ELISA, EA-ELISA). The indirect ELISA (I-ELISA) procedure followed was that of Lommel et al. (1982). Detection of the viruses on the nitrocellulose membrane by dot-blot ELISA was conducted by using either the chromogenic substrates nitro blue tetrazolium (NBT) and bromo-chloro-indoly phosphate (BCIP) (Hsu et al., 1990) or by using the chemiluminescent substrate AMPPD^R (Tropix Inc., undated). All these procedures were based on the enzyme alkaline phosphatase. One ELISA procedure based on penicillinase (PNC-ELISA) (Sudarshana and Reddy 1989) was also evaluated.

Results and Discussion

Virus purification and antiserum production

In 10–40% sucrose gradients, BSMV produced two sharp bands and a diffuse third band (Fig. 1A). The first band

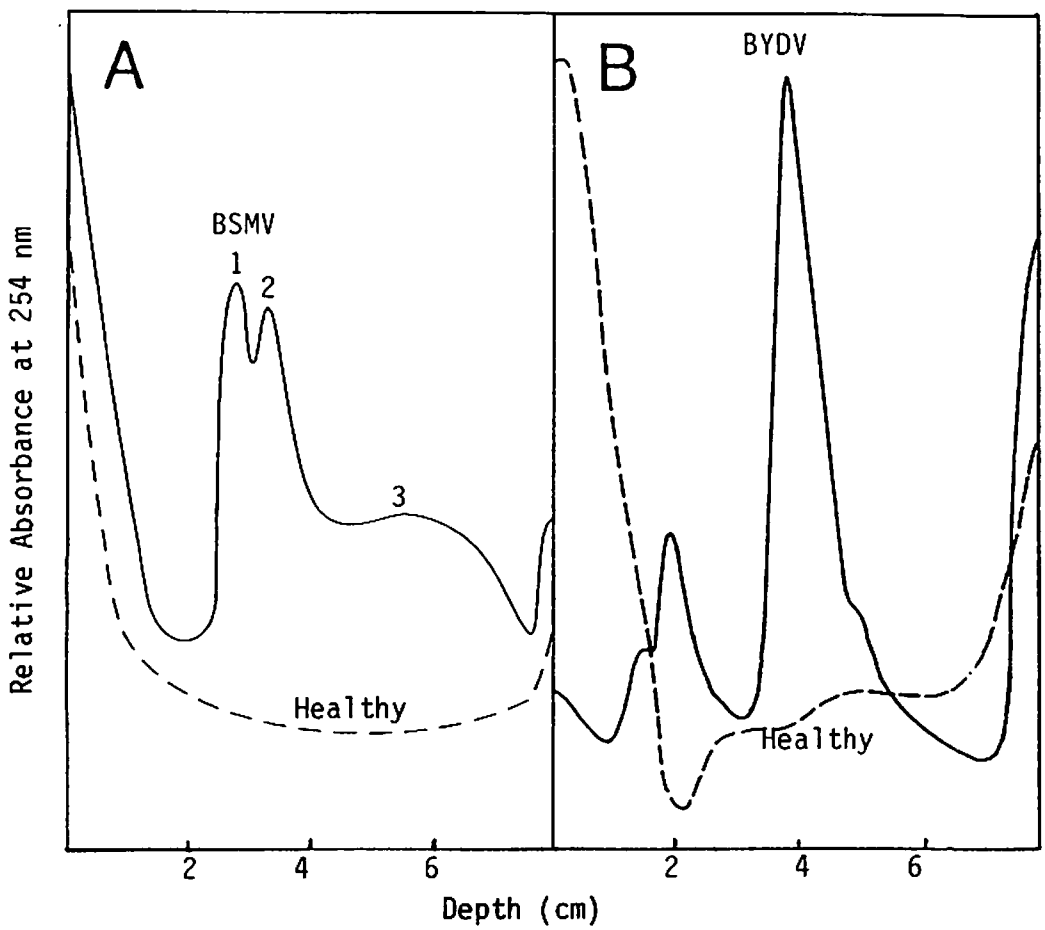


Fig. 1. Rate-zonal sucrose density gradient centrifugation analysis for partially purified preparations of barley stripe mosaic virus centrifuged for 1.5 h at 24,000 r.p.m. in a Beckman SW 28 rotor (A) and barley yellow dwarf virus centrifuged for 1.5 h at 38,000 r.p.m. in a Beckman SW 41 rotor (B). Tubes were scanned through an ISCO gradient fractionator with a UV monitor.

had a UV 260/280 ratio of 1.36 and the second band 1.71 (not corrected for light scattering). The presence of BSMV in both bands was confirmed by its reactivity to BSMV antiserum provided by Dr T. Carroll, Montana State University, USA. The possibility of having more than one band for BSMV has been reported earlier (Atabekov and Novikov 1971). The purified BSMV preparation having a higher 260/280 ratio than those previously reported (Atabekov and Novikov 1971) suggests that our preparation was contaminated with host nucleic acids. However, Carroll et al. (1979) report that purified virus preparations with 260/280 ratios as high as 1.86 had little effect on the quality of the antiserum produced; our findings agree with this. The BSMV antiserum produced by injecting virus particles from bands 1 and 2 produced a high-quality antiserum as indicated by the very low healthy background in DAS-ELISA (A 405 value of 0.00) and a high value (A 405 value of 2.84) for BSMV-infected tissue extract. When the BSMV antiserum produced was evaluated by indirect ELISA, it had a high titer of 1:4,096,000. There was no significant difference in titer among the antisera obtained from the different bleedings.

BYDV produced a single sharp band in sucrose gradients (Fig. 1B). The collected virus band had a UV 260/280 ratio of 1.6–1.7, which is close to the reported value. The presence of BYDV in the band was confirmed by its reactivity with BYDV antiserum (PAV type from Bioreba). The purification procedure used yielded 1 mg/kg of infected oat and 0.7–0.8 mg/kg of infected barley tissue.

Comparison of detection methods

Table 1 summarizes the sensitivity of detection of both BSMV and BYDV by the procedures used in this study. The most sensitive procedure for BSMV was the EA-ELISA, where virus in tissue extract diluted up to 1:1,310,720 times was still detectable. The same method detected purified virus at 0.5 pg[1]/ml. However, we did not try dilutions of purified virus below 0.5 pg/ml, so the detection limit of BSMV by EA-ELISA could be below 0.5 pg/ml. The detection limits of BYDV by EA-ELISA in sap extracts and purified virus preparations were 1:5120 and 50 pg/ml, respectively.

Table 1. Detection limits of barley stripe mosaic and barley yellow dwarf viruses in leaf extracts and purified preparations when tested by different ELISA variants[†]. Assessment was made either visually or spectrophotometrically.

Method	Wavelength (nm)	Detection limit			
		BSMV		BYDV	
		Sap (diluted 1 in...)	Purified (pg)	Sap (diluted 1 in...)	Purified (pg)
Spectrophotometric					
DAS-ELISA	405	40,960	5	640	10,000
I-ELISA	405	163,840	1	NS[‡]	NS
EA-ELISA	492	1,310,720	0.5	5120	50
Visual					
PNC-ELISA	–	40,960	50	NS	NS
Dot-blot					
– chromogenic substrate	–	20,480	10	2560	100
– chemiluminescent substrate	–	163,840	1	5120	50

[†] DAS-ELISA = double antibody sandwich ELISA, I-ELISA = indirect ELISA, EA-ELISA = ELISA with enzyme amplification mixture, PNC-ELISA = penicillinase-based ELISA.

[‡] NS = test was not successful.

[1] pg = picograms.

By using visual readings of ELISA plates, PNC-ELISA was useful for the detection of BSMV in tissue extract up to a dilution of 1:40,960, which is similar to the results obtained with DAS-ELISA. However, PNC-ELISA was not adequate for BYDV detection. In addition to its suitability for sensitive detection of BSMV, PNC-ELISA is less costly than DAS-ELISA. Where resources are limiting, PNC-ELISA might prove to be the test of choice.

On the basis of visual evaluation of the test, dot-blot was also a very sensitive diagnostic tool for the detection of BSMV and BYDV. Both chromogenic and chemiluminescent substrates were adequate for this test, with the latter being slightly more sensitive; this is in agreement with recent findings on the detection of other viruses (Makkouk et al. 1993).

The quality of BSMV and BYDV antisera produced permits testing groups of 25 or 50 leaves (or seeds in the case of BSMV) with little reduction in test sensitivity. This is important for epidemiological studies or seed certification where a large number of samples need to be tested. Testing groups of 25 or 50 leaves (or seeds) as one sample reduces test cost and produces results quicker.

References

Atabekov, J.G. and V.K. Novikov. 1971. Barley stripe mosaic virus. *CMI/AAB Descriptions of Plant Viruses* No. 68.

Carroll, T.W., P.L. Gossel and D.L. Batchelor. 1979. Use of sodium dodecyl sulfate in serodiagnosis of barley stripe mosaic virus in embryos and leaves. *Phytopathology* 69: 12–14.

Clark, M.F. and A.N. Adams. 1977. Characteristics of the microplate method of enzyme-linked immunosorbent assay for the detection of plant viruses. *Journal of General Virology* 34: 475–483.

D'Arcy, C.J., R.R. Martin and S. Spiegel, S. 1989. A comparative Study of luteovirus purification methods. *Canadian Journal of Plant Pathology* 11: 251–255.

Hsu, H.T., H. Hibino and P.Q. Cabauatan. 1990. Development of serological procedures for rapid, sensitive and reliable detection of rice grassy stunt virus. *Plant Disease* 74: 695–698.

Lommel, S.A., A.H. McCain and T.J. Morris. 1982. Evaluation of indirect enzyme-linked immunosorbent assay for the detection of plant viruses. *Phytopathology* 71: 1018–1022.

Makkouk, K.M., H.T. Hsu and S.G. Kumari. 1993. Detection of three plant viruses by dot-blot and tissue blot immunoassays using chemiluminescent and chromogenic substrates. *Journal of Phytopathology* 139: 97–102.

Stanley, C.J., A. Johannsson and C.H. Self. 1985. Enzyme amplification can enhance both the speed and the sensitivity of immunoassays. *Journal of Immunological Methods* 83: 89–95.

Sudarshana, M.R. and D.V.R. Reddy. 1989. Penicillinase-based enzyme-linked immunosorbent assay for the detection of plant viruses. *Journal of Virological Methods* 26: 45–52.

Tropix, Inc. [undated]. Western-light chemiluminescent detection system: Procedure for the detection of membrane-bound protein with AMPPD substrate. Tropix, Inc., Bedford, Massachusetts, USA.

Induction of a New Iraqi Wheat Cultivar by Gamma Rays

I.F. Ibrahim[1], K.K. Al-Janabi[1], E.M. Al-Maaroof[1], M.O. Al-Aubaidi[1], A.H. Mahmood[1], A.A. Al-Janabi[1], H.O. Haidar[2] and A.H. Ali[2]

[1] *Department of Agric. Research, Nuclear Research Center, P.O. Box 765, Baghdad, IRAQ*
[2] *Station of Applied Agric. Research, Telafer, Ninava, IRAQ*

Abstract

Iratom-1 is a new Iraqi wheat (*Triticum aestivum* L. ssp. *aestivum*) cultivar induced by seed-treatment with 13 krad gamma rays and developed through 13 generations (M_1–M_{13}) of testing. Results revealed that Iratom-1 was moderately resistant to leaf rust (*Puccinia recondita* Rob. ex Desm.), yellow rust (*P. striiformis* West) and common bunt (*Tilletia* spp.), while the original cultivar was susceptible to these diseases. Iratom-1 was also moderately resistant to lodging. Iratom-1 surpassed its parent in kernel weight of 100 spikes, 1000-kernel weight, and in grain and protein yield per unit area. Isozyme and protein analysis (plants and grains) of Iratom-1 showed high genetic purity and stability. Chemical analysis of flour from the mutant cultivar indicated that it could be successfully used for bread-making.

Key words: *Triticum aestivum*; soft wheat; gamma radiation; yields; grain; protein content; disease resistance; *Puccinia recondita*; *Puccinia striiformis*; *Tilletia*; kernels; genetic stability; wheat flour; lodging; wind resistance; Iraq.

Introduction

Economically, wheat is the most important crop in both Iraq and the world. This crop was first cultivated in the Fertile Crescent more than 6500 years ago, from whence it spread to the rest of the world. Some regions in northern Iraq are still considered the main stock of wild species (Abu-Aless 1972a; Popov and Dimitrov 1979).

SaberBeg is a local genotype. Its cultivation predominated in Al Jazira and some of the northern provinces a long time ago. It is still popular with farmers for its good baking quality, high resistance to shattering, and tolerance, more than any other variety, to rain-fed conditions, particularly the areas where annual rainfall does not exceed 450 mm. However, it shows low productivity and is highly susceptible to common bunt (*Tilletia caries* (D.C.) Tul., *T. foetida* (Wallr.) Liro, and their hybrid) (Al-Hassan and Alwan 1973). During the high-rainfall seasons, especially spring, this variety is susceptible to lodging and to leaf and yellow rusts (*Puccinia recondita* and *P. striiformis*) which leads to low production (Abu-Aless 1972b).

Nuclear techniques have been used intensively since the early 1970s to obtain mutants with different reactions to the different pathogens, and to develop varieties resistant to economic diseases which are difficult to control by chemicals (such as rusts and powdery mildew) (Micke 1987).

Studies in this field have helped improve some of the desirable traits in different crops. By mid-1989, some 1300 varieties had been developed; 20% of these varieties were resistant to economic diseases and are grown widely (Micke 1987, 1989; Micke et al. 1985).

This paper gives a detailed account of the program of developing mutant variety Iratom-1 from the local cultivar

استحداث صنف قمح عراقي جديد بواسطة أشعة غاما

الملخص

يعتبر إراتوم -1صنف قمح عراقي جديد (*Triticum aestivum* L. ssp. *aestivum*) مستحدث بواسطة معالجة البذور بـ Kr13 من أشعة غاما ومستنبط من خلال 13 جيلاً (M1-M13). وقد بينت النتائج أن هذا الصنف كان متوسط المقاومة لصدأ الأوراق (*Puccinia recondita* Rob. ex Desm.) والصدأ الأصفر (*P. striiformis* West) والتفحم المغطى (*Tilletia* spp.)، في حين كان الصنف الأصلي حساساً لهذه الأمراض. كما كان إراتوم -1متوسط المقاومة للرقاد. وقد فاق إراتوم -1 أبويه في وزن الحب لمئة سنبلة ووزن الألف حبة، وفي الغلة الحبية والبروتينية في وحدة المساحة. وأظهر تحليل البروتين وتماثل الانزيم (النباتات والحب) أن للصنف إراتوم -1 نقاء واستقراراً وراثيين عاليين. وأشار التحليل الكيميائي لدقيق هذا الصنف الطافر إمكانية استخدامه بنجاح في صناعة الخبز.

SaberBeg by using gamma rays through a series of intensive studies from 1977 to 1990.

Materials and Methods

Kernels of wheat variety SaberBeg were irradiated with gamma rays transmitted from a cobalt-60 source, at a rate of 67.4 rad/s in 1977. Treatment doses were 7, 10, 13 and 16 krad, combined treatment of 7 krad gamma rays with the chemical mutagen ethyl methane sulfonate (EMS), and treatment with 1% EMS for three hours.

M_1 was obtained during the 1977/78 season. Seeds were sown 24 hours after irradiation, during the last week of January, at high seeding rate along the rows. Main stems of M_1 plants were isolated after emergence. At maturity, spikes of the main stems were collected to obtain the M_2 seeds. The screening and selection program started from this generation as described below.

Common bunt resistance

Seeds of the main stems (500 g) were artificially inoculated uniformly from spores of fungi *Tilletia caries*, *T. foetida* and their hybrid. The spores were from 20 regions of the country (Ibrahim et al. 1986). Experiments were carried out at the Applied Agricultural Research Station, Telafer during 1978–1980 to obtain M_2, M_3 and M_4 generations, during which artificial infection and selection of resistant forms were carried out.

In M_5, M_6 and M_7, artificial infection was repeated on 116, 41 and 20 selections, respectively. Irradiated seeds were grown at Tuwaitha following Enken's (1966) method on 2-m rows, with two rows per entry. To secure the high rate of infection under Baghdad conditions, contaminated seeds were grown on boards by the end of December at 7–9 cm depth. They were irrigated 3–4 days before cultivation. First irrigation was given at the appearance of the first true leaf. At the M_7 generation, mutants showing genetic stability for resistance and other characteristics in the previous three generations were selected and introduced into a yield trial to compare their resistance to common bunt under Telafar and Rabia conditions for four consecutive generations (M_8 to M_{11}) as reported previously (Ibrahim et al. 1984, 1985, 1986, 1989a).

Rust resistance

Evaluation for leaf rust resistance started from M_6. Mutants showing natural resistance to the disease at Tuwaitha were isolated. The study was repeated in M_7. In M_8, a mutant called Iratom-1 was tested along with other mutants and with the parent cultivar (SaberBeg) at Tuwaitha using a randomized complete block design with three replications. Each plot comprised four rows, 1.5 m long with 30 cm spacing. Seed rate was 5 g/row.

Artificial inoculation of plants was conducted by spraying spore suspension of *Puccinia recondita* at 6×10^4 spores/ml. Severity of infection was calculated at flowering and early maturity stages following Loegering's (1981) method as follows. Zero: no visible infection on plants; resistant (R): necrotic areas with or without minute uredia present; moderately resistant (MR): small uredia present surrounded by necrotic areas; moderately susceptible (MS): medium uredia with no necrosis, but possibly some distinct chlorosis; susceptible (S): large uredia with no necrosis and little or no chlorosis.

The experiment was repeated over four consecutive seasons M_8–M_{11} (Ibrahim et al. 1989b). In 1987/88, epidemic infection of yellow rust prevailed. Resistance of Iratom-1 to this disease was tested at Tuwaitha and Latifia also following Loegering (1981).

Agronomic characteristics

Seeds of Iratom-1 and other mutants were grown along with the parent at Tuwaitha Station for four consecutive generations. Cultivation was as per the rust experiment.

The following growth traits were evaluated: seedling emergence, heading, flowering and maturity. Resistance to lodging at flowering and maturity was evaluated following Scarasia-Mugnozza (1965) where zero = no lodging, and 5 = complete lodging. Other traits studied were plant height, spike length, kernel weight/100 spikes and 1000-kernel weight of plants artificially infected with leaf rust. The mutant Iratom-1 was also compared with the parent in a RCB yield trial conducted over three years (M11–M13) at Latifia using 3 m × 3 m plots. The objective of this trial was (1) to study the stability of resistance of Iratom-1 to rust, lodging and shattering, and (2) to estimate tillering capacity, the number of seeds and weight/spike, 1000-kernel weight, grain yield and protein content.

Grain quality

Preliminary moisture of 5 kg of seeds was measured by Rapid Moisture Tester. Moisture was amended before milling at Al Qazimia Milling Complex. Flour was stored in nylon bags in a fridge at 5°C. All tests were carried out

on the basis of a relative moisture of 14% of flour.

Chemical tests

Protein content of the flour was assessed using Microkjeldahl (AACC 1976, 46-10) by extracting nitrogen and multiplying N content by 5.7. The experiment was conducted in three replicates. Wet gluten was assessed by using 10-g samples in an Aglutomatic-2200 (three replicates). Enzyme and protein analysis was carried out for the mutant cultivar (at M_{13}) and for the parent (SaberBeg). The analysis was carried out on 20 four-week-old seedlings. Leucine amino-peptidase (LAP), glutamate oxaloacetate transaminase (GOT), esterase isozyme (EST) and acid phosphatase (ACP) were determined using three replicates. Variation among plants was studied by isozyme analysis using 20 separate seeds.

Physical tests

Farinograph of 300 g capacity was used to measure: water absorption, development time and stability time (AACC 1976, 54-12).

Pop loaf was made according to AACC (1976, 10-10) with the following rates: flour 100%, yeast 1.5%, salt 1.5%, sugar 2%, fat 3% and water in accordance with the absorption capacity of the farinograph. Ingredients were all mixed for 2 minutes, except the water and yeast. Active yeast was added to lukewarm water (35–37°C) and a little sugar, then mixed with the remaining water until the dough matured. The dough was then fermented for 30 minutes (at 30% relative moisture and 85°C). Then the dough was cut into 150-g pieces, balled and returned to the fermenter for a further 60 minutes. Dough pieces were then baked in an oven at 230°C for 17–20 minutes. Size and weight of pieces were recorded after cooling.

Results and Discussion

Common bunt resistance

Rate of infection with *Tilletia* was greater with higher irradiation in M_2 (Table 1). Significant reduction in infection occurred, particularly in the 10 krad dose. In M_3, the lowest rate of infection was observed with 7 krad. The high rate of infection with common bunt is in accord with that reported by Al-Shukri (1958), and Al-Hassan and Alwan (1973) who note that the rates of natural infection in the same site during 1955 and 1972 were 80% and 77%, respectively. We attribute the high rate of infection to the length of the germination period and the time to complete emergence of the real primary leaf, both of which depend on the rainfall and environmental conditions which in turn affect the race of the pathogen. At M_3, 244 resistant and moderately resistant plants were isolated from 22,920 lines.

Table 1. Rate of infection of M_2 and M_3 plants with common bunt and frequency of resistant plants in M_3.

Treatment	Infection rate (%)		Total no. of M_3 plants	Frequency of resistance (%)
	M_2	M_3		
Check[†]	80.03 a	93.39 a	2358	0
1% EMS	65.48 c	88.48 ab	4660	0.73
7 krad + 1% EMS	64.01 c	85.16 b	1517	1.05
7 krad	71.10 b	69.16 d	3710	1.32
10 krad	55.65 d	77.14 c	2699	2.14
13 krad	80.03 a	82.65 b	4216	1.25
16 krad	82.59 a	84.16 b	3770	0.82

[†] Untreated seeds.

There is no significant difference between the treatments with the same letter vertically per Duncan's test at 5%.

Twenty selections continued to resist the disease from M_5 to M_7 (Table 2). From these, Iratom-1 was selected; it was characterized by its resistance to the disease as well as its superiority in other agronomic traits. It was introduced into yield trials with the parent in subsequent generations.

Table 2. Number of resistant and moderatly resistant selections isolated in the M_5, M_6 and M_7 generations.[†]

Treatment	No. of R and MR selections		
	M_5	M_6	M_7
Check	0	0	0
7 krad	62	13	8
10 krad	33	12	9
13 krad	8	7	3
16 krad	13	9	0
Total selections	116	41	20

[†] Resistant (R): infection rate range 0–10%; Moderately Resistant (MR): infection rate range 11–40%.

Iratom-1 showed moderate resistance to the disease over four consecutive generations (M_8–M_{11}, Table 3) at Telafer and Rabia Stations with infection rates of 28 and 23%, respectively, compared with 80 and 68% for SaberBeg at the same sites.

Resistance to the pathogens causing this disease is genetic. There are eight genes in wheat for resistance to the different fungal races. There is only one gene (*Bt8*), however, which confers resistance to all races. Stability of the resistance of the isolated wheat selections to common bunt throughout the different generations is a natural phenomenon and agrees with the results obtained by other researchers (Nelson 1977).

Leaf rust resistance

The parent cultivar, SaberBeg, was moderately susceptible to *P. recondita* at heading and highly susceptible at maturity (Table 4). The same behavior was observed on the cultivar under natural infection in the field in 1981 (Ibrahim et al. 1989b). Iratom-1 showed consistent resistance to the fungus at heading and moderate resistance at maturity over six consecutive generations (M_8–M_{13}) under artificial infection. A reduction in the number and size of urediospores and delay in the development of the infection were also observed.

Inducing wheat resistance to leaf rust in this way is quite common. Some 20 cultivars resistant to this disease have been developed (Nelson 1977). This may be due to the high specificity of the pathogen of which more than 183 races are known.

Iratom-1 showed early heading, flowering and maturity (a 8–10 day advantage over SaberBeg). It was resistant to lodging at flowering and moderately resistant at full maturity, while the parent cultivar was susceptible (Table 4).

Table 3. Resistance of the induced mutant Iratom-1 to common bunt in M_8–M_{11} generations at Telafer and Rabia.[†]

Site	Generation (M_i)	Infection rate (%)		LSD at	
		SaberBeg	Iratom-1	0.05	0.01
Telafer	8	95.71	26.38	7.63	11.52
	9	76.93	41.98	15.11	22.90
	10	77.16	36.23	12.02	18.20
	11	68.82	8.89	9.23	12.94
	mean	79.65	28.37		
Rabia	8	–	–	–	–
	9	83.94	38.60	18.39	27.86
	10	76.50	24.80	14.12	21.38
	11	42.86	5.62	6.39	18.96
	mean	67.76	23.00		

[†] Each figure represents three replicates.

Table 4. Resistance of Iratom-1 to leaf rust and lodging over six consecutive generations (M_8–M_{13}) at Tuwaitha.

Genotype	Resistance†			
	Leaf rust		Lodging	
	Heading	Maturity	Heading	Maturity
SaberBeg	MS	S	MR	S
Iratom	R	MR	R	MR

† R= resistant; MR = moderatly resistant; MS = moderately susceptible; S = susceptible.

Agronomic traits

Under artificial infection with *P. recondita* for three consecutive generations at Tuwaitha, Iratom-1 was superior over SaberBeg in 1000-kernel weight (36.38 vs 25.8 g) and kernel weight/100 spikes (130.6 vs 54.6 g) (Table 5). No significant differences were observed between Iratom-1 and the parent in plant height or spike length. There was an increase in the thickness of the stem and in kernel size of the new variety over these seasons, along with a stability in the plant and spike morphology (Fig. 1). Resistance to leaf rust and lodging may have contributed to the better performance of Iratom-1 over SaberBeg.

Table 5. Some traits of Iratom-1 compared with SaberBeg.

Trait	Year	SaberBeg	Iratom-1	LSD at	
				0.05	0.01
Plant height (cm)	1985†	97.50	101.10	18.20	27.70
	1986†	93.47	96.92	7.19	10.91
	1987†	129.66	128.66	8.90	13.30
	mean‡	106.87	108.89	10.09	13.77
Spike length (cm)	1985	–	–	–	–
	1986	7.96	8.18	2.16	3.25
	1987	8.88	7.72	2.90	4.40
	mean	8.42	7.95	0.87	1.22
Kernel weight/100 spikes (g)	1985	49.20	116.00	29.90	45.50
	1986	37.12	121.32	29.75	42.77
	1987	77.50	154.70	41.10	62.16
	mean	54.60	130.67	26.01	37.40
1000-kernel weight (g)	1985	28.30	38.70	2.90	4.30
	1986	21.30	29.85	3.27	4.71
	1987	27.80	40.60	12.32	18.61
	mean	25.80	36.38	5.92	8.51

† Each figure represents three replicates.

‡ Each figure represents three replicates over three years M_8–M_{10} analyzed by a combined analysis of RCB.

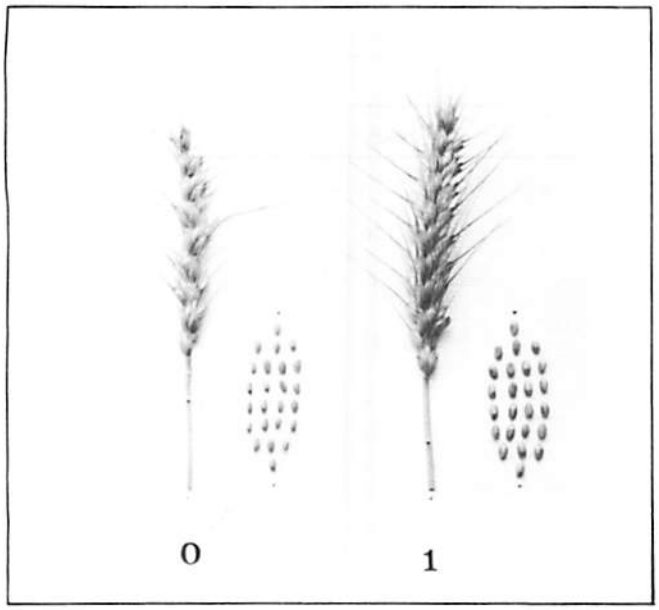


Fig. 1. Spike and grain of Iratom-1 (1) and SaberBeg (0) wheat cultivars.

Iratom-1 and SaberBeg were also compared at Latifia during M_{11}–M_{13}. Number of kernels/spike and number of spikes/meter were not different (Table 6). However, Iratom-1 had an 11.14-g advantage over SaberBeg in 1000-seed weight. Iratom-1 was also superior over SaberBeg in grain yield. The mean advantage during the last three generations was 1503.6 kg/ha. These results agree with those obtained by other researchers who have developed wheat varieties with good agronomic traits and resistance to diseases by using irradiation (Micke 1987, 1989; Micke et al. 1985; IAEA 1981–89).

Quality characteristics

Enzyme and protein analyses showed that Iratom-1 has a high genetic stability. Earlier, no differences were shown either at the level of studied enzyme systems or whole protein (Al-Jibouri et al. 1990) compared with SaberBeg. The rate of flour extraction was 74.80% (75.68% for SaberBeg) when samples were milled at the experimental mill (Table 7). This rate is acceptable. The mutant cultivar was slightly superior over SaberBeg in farinograph analysis at maturity stage (Table 7); it also showed high

Table 6. Some agronomic traits of Iratom-1 and SaberBeg at Latifia for three consecutive generations, M_{11}–M_{13}.

Trait	Year	SaberBeg	Iratom-1	LSD at	
				0.05	0.01
Kernels/spike	1988	36.2	40.4	9.00	10.80
	1989	35.8	33.4	10.5	14.0
	1990	21.7	29.6	10.9	14.6
	mean	31.23	31.13		
No. of spikes/m	1988	142.2	117.3	36.7	43.9
	1989	142.5	144.7	30.8	41.0
	1990	155.0	106.7	12.5	16.7
	mean	146.56	122.9		
1000-kernel weight (g)	1988	32.2	42.3	4.50	5.40
	1989	30.8	44.0	5.7	7.6
	1990	33.8	43.9	2.6	3.5
	mean	32.26	43.4		
Grain yield (kg/ha)	1988	5689	8822	1030	1567
	1989	5122	6589	1040	1576
	1990	4603	6818	951	1441
	mean	5140	7411		

Table 7. Some physical and chemical characteristics of Iratom-1 compared with SaberBeg.[†]

Trait	SaberBeg	Iratom-1	LSD	
			0.05	0.01
Flour yield (%)	75.68	74.80		
Wet gluten (%)[‡]	40.68	34.44	1.196	0.790
Protein[§]				
(kg/ha)	748.6	979.2		
(%)	13.16	11.10	0.947	0.625
Water absorption (%)	75.0	73.30		
Arrival time (min)	2.50	2.80		
Development time (min)	4	4.50		
Stability time (min)	4.60	5		
Mixing tolerance[¶]	80	80		
Specific size of bread	0.49	0.47	0.011	0.008

[†] Each figure represents three replicates.

[‡] Results taken on the basis of moisture rate of 14%.

[§] Protein = Nitrogen × 5.7.

[¶] Brabender units.

stability time (Fig. 2). Mixing tolerance of the dough of Iratom-1 was equal to that of the parent. Despite the superiority of SaberBeg over the developed cultivar in protein content and wet gluten, Iratom-1 was superior in the quality of protein and protein yield per unit area. This increase in protein yield of Iratom-1 was due to the high grain yield compared with the parent (Table 6). Specific size of baking in Iratom-1 was close to that of SaberBeg (Fig. 3).

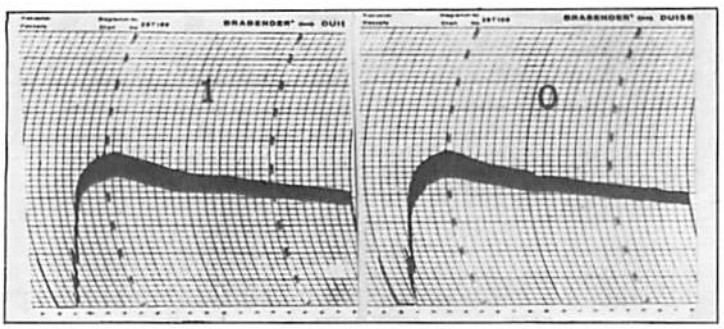


Fig. 2. Farinograph curves for Iratom-1 (1) and SaberBeg (0) wheat cultivars.

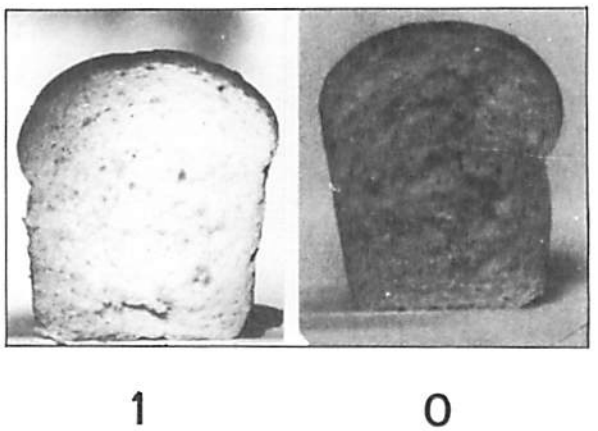


Fig. 3. Transverse section of bread loaf for Iratom-1 (1) and SaberBeg (0) wheat cultivars.

As a result, we conclude the possibility of registering and adopting Iratom-1 as a variety for both rain-fed and irrigated farming at Al Jazira and in northern Iraq, since it possesses desirable traits while maintaining the good specific qualities of SaberBeg, particularly the baking quality.

References

AACC. 1976. *Approved Methods of the American Association of Cereal Chemists.* [10th Edn.] AACC, St Paul, Minnesota, USA.

Abu-Aless, R.M. 1972a. Wheat. *Iraqi Ministry of Agriculture Report* No. 53.

Abu-Aless, R.M. 1972b. Wheat cultivars in Iraq. *Iraqi Ministry of Agriculture Report* No. 52.

Al-Hassan, K.K. and A.H. Alwan. 1973. Maj. *Al-Zira Al-Iraqiya* 29: 5.

Al-Jibouri, A.M., I.F. Ibrahim and A.A. Mahdy. 1990. Isozyme and protein analysis of induced rust resistant wheat mutants. *In* 8th Congress of the Mediterranean Phytopathology Society.

Al-Shukry, M.M. 1958. Covered smut of wheat. *Majallat Alziraa ALOIraqi*, Baghdad 2,3: 210–217.

Enken, V.B. 1966. Manifestations in experimental mutagenesis of Vavilovs law on homologous rows in hereditary variability. *In* Induced Mutations and Their Utilization, Proceedings of the Symposium Erwin-Bauer-Gadach. iv, Gatersleben, Akademie-Verlag, Berlin, Germany.

IAEA (International Atomic Energy Agency). 1981–89. *Mutation Breeding Newsletter* Nos 18–34. IAEA, Vienna.

Ibrahim, I.F., F.A. Kadhem, A.H. Mahmood and H.O. Hoidar. 1984. Induced resistance to common bunt disease and the improvemet of some agronomic characters in wheat by gamma radiation. Page 27 *in* 1st Scientific Conference on Applied Agicultural Research, 24–27 November, Baghdad, Iraq.

Ibrahim, I.F., F.A. Kadhem, A.H. Mahmood and H.O. Hoidar. 1985. Induced resistant mutation to common bunt by gamma rays and ethyl methane sulfonate. *Indian Phytopathology* 38(1): 158–160.

Ibrahim, I.F., K.M. Tamimi, H.A. Hadwan, A.H. Mahmood and H.O. Haidar. 1986. Response of cultivated wheats to local collections of common bunt fungi in Iraq. *Indian phytopathology* 38(3): 569–571.

Ibrahim, I.F., E.M. Al-Maaroof, A.H. Mahmood, A.A. Al-Janabi and Al-Aubaidi. 1989a. Response of three wheat mutants to common bunt in Iraq. *Indian Phytopathology* 42(3).

Ibrahim, I.F., K.K. Al-Janabi, E.M. Al-Maaroof, M.O. Al-Aubaidi, A.H. Mahmood, A.A. Al-Janabi and H.O. Haider. 1989b. Development of new Iraqi wheat varieties through induced mutations. Pages 48–49 *in* 2nd Scientific Conference of the Iraqi Atomic Energy Commission, 21–23 November, Baghdad, Iraq.

Loegering, W.Q. 1981. Method for recording cereal rust data. Pages 1–9 *in* 9th Preliminary Observation Nursery Bred Wheat. USDA.

Micke, A., M. Maluszynski and B. Donon. 1985. Plant cultivars drived from mutation induction or the use of induced mutants in cross breeding. *Mutation Breeding Review* 3: 1–92.

Micke, A. 1987. Achievements of mutation breeding. Pages 3–12 *in* 2nd International Symposium on Experimental Mutagenesis in Plants, Plovdiv, 26–30 October.

Micke, A. 1989. 25 years Plant Breeding and Genetics Section of the Joint FAO/IAEA Division, Vienna. *Mutation Breeding Newsletter* (1989): 2–3.

Nelson, R.R. 1977. Breeding Plants for Disease Resistance. The Pennsylvania State University Press, USA. (Page 401.)

Popov, P. and D. Dimitrov. 1979. Wheat in Bulgaria. Zimizdat, Sofia, Bulgaria.

Scarasia-Mugnozza, G.T. 1965. Induced mutations in breeding for lodging resistance. Pages 537–558 *in* The Use of Induced Mutations in Plant Breeding. Report of the FAO/IAEA Technical Meeting, Rome, 1964. Pergamon Press, Oxford, UK.

Rachis 12(1/2) 1993

Inheritance of Dwarfism in Wheat

S.K. Mishra and C.M. Kushwaha
Division of Genetics, IARI
New Delhi 110012, INDIA

Abstract

The inheritance of dwarfism was studied using F_1 and F_2 populations of 40 wheat (*Triticum aestivum* L. ssp. *aestivum*) crosses involving ten indigenous tall varieties and four sources of dwarfism. The study revealed that dwarfism caused by *Rht1* was partially recessive and that of *Rht2* was dominant. Additive gene action was found to control plant height in crosses involving *Rht3* and *Rht8* dwarfing sources. *Rht8* can be successfully exploited in wheat breeding.

Key words: *Triticum aestivum*; soft wheat; dwarfism; genetic inheritance; varieties; India.

توريث صفة التقزم في القمح

الملخص

تمت دراسة توريث صفة التقزم باستخدام عشائر الجيل الأول والثاني F1 و F2 لـ 40 هجيناً من القمح *(Triticum aestivum* L. ssp.*aestivum)* شملت على 10 أصناف طويلة محلية و4 مصادر للتقزم. وقد بينت الدراسة أن صفة التقزم التي يسببها Rht 1 كانت متنحية جزئياً أما التي يسببها Rht 2 فكانت سائدة. كما وجد أن تأثير المورثة التجميعي يتحكم في طول النبات في الهجن التي تحتوي على مصدري التقزم Rht 3 و Rht 8. ويمكن استغلال Rht 8 في تربية القمح بصورة ناجحة.

Introduction

A quantum jump in wheat yield has been linked to the development of semidwarf varieties utilizing the Norin-10 dwarfing genes (*Rht1*, *Rht2*). Most present-day cultivars possess these gene(s), which are introduced either directly from Norin-10 or from its derivatives. The stabilizing of yield in wheat shows that the high yielding potential of Norin genes has been fully exploited. There are discouraging reports on the use of another dwarfing gene, *Rht3* as it reduces plant height drastically (Flintham and Gale 1983) and causes poor yield in wheat (Gale and Youssefian 1985; Sastry 1985). Other sources of dwarfism may provide a tool to increase further the yield of wheat. The present experiment was conducted to study the inheritance of dwarfism using a Chinese variety 'Chuan Mai 18' (possessing the *Rht8* gene) in combination with three other sources (*Rht1*, *Rht2* and *Rht3*), and ten tall indigenous wheat varieties.

Materials and Methods

During the *rabi* (winter) season of 1988/89, forty crosses were made using ten tall varieties (K 65, K 68, Hybrid 65, NI 5439, C 306, C 591, NP 710, NP 824, NP 846 and NP 875, all used as females) with four dwarf sources – HD 2122 (*Rht1*), HD 1981 (*Rht2*), Tom Thumb (*Rht3*) and Chuan Mai 18 (*Rht8*) – in a line × tester design. The F_1s were raised during the off-season at Lahaul Spiti, Himachal Pradesh. The F_2 populations and respective F_1s and parents were grown in randomized block design with two replications during *rabi* 1989/90. Parents and F_1s were grown in single rows, while F_2s were in six rows. The rows were 3 m long, 22.5 cm apart with 20 cm between plants within a row. Data on plant height were recorded for ten random plants in each F_1 and parent, and for all the plants in each F_2 of both replications.

Results and Discussion

Data for average plant height of parents and F_1s are given in Table 1. Mean plant height for tall parents ranged from 94 cm (NI 5439) to 126 cm (NP 846), and for dwarf parents from 50 cm (Tom Thumb, *Rht3*) to 83 cm (HD 1981, *Rht2*). The plant height of Chuan Mai 18 (*Rht8*) was equal to that of HD 2122 (*Rht1*) with slight deviation.

The data for plant height of the F_1 crosses involving HD 2122 (*Rht1*) indicated that dwarfism was partially recessive: the mean plant height value of each cross exceeded the respective mid-parental values. Similar results were reported for the *Rht1* dwarfing gene by Gale and Marshall (1976). Conversely, in most of the crosses involving HD 1981 (*Rht2*) the F_1 plants were shorter than the mid-parental values, except in crosses with K 68, NI 5439 and NP 846. This indicated dominant behavior of the *Rht2* dwarfing gene. This varied behavior of the possible major gene in specific crosses may be attributed to the presence of some modifier minor genes. Similar results were reported by Gale and Law (1977), and Nelson et al. (1980). The F_1 plants of crosses involving Tom

Thumb were closer in height to the mid-parental values, indicating that *Rht3* was not dominant, and that plant height in this case is controlled by additive gene action. This is in agreement with the findings of Sastry and Singh (1988). Most of the F_1s involving Chuan Mai 18 (*Rht8*) also showed plant height to be mainly controlled by additive gene action. However, varied behavior in combinations such as K 68, C 591, NP 710 and NP 824, where dominance behavior was shown, may be explained by the presence of certain modifier genes as described earlier.

Values of plant height variation in the F_2 populations for different crosses (Table 2) indicated that the magnitudes of coefficients of variability were relatively higher in the cross combinations with Chuan Mai 18 (*Rht8*). This showed the possibility of deriving semidwarf genotypes from these crosses. The interbreeding of F_2 plants belonging to these crosses may lead to better segregates. It was also observed that Chuan Mai 18 was of similar height to HD 2122, suggesting that the *Rht8* dwarfing source could successfully be utilized in wheat breeding programs.

Table 1. Mean plant height (cm) of F_1s of 40 tall × dwarf crosses.

Female parent	Male parent			
	HD2122 (76)†	HD1981 (83)	Tom Thumb (50)	Chuan Mai 18 (74)
K 65 (102)†	99	84	75	82
Hybrid 65 (105)	95	85	75	90
K 68 (107)	96	92	77	88
NI5439 (94)	91	93	74	81
C 306 (111)	109	95	79	92
C 591 (103)	100	96	85	91
NP710 (111)	102	92	79	87
NP824 (101)	98	93	80	81
NP846 (126)	104	101	80	94
NP875 (113)	91	92	76	87

† Values in parentheses are mean plant heights (cm) of respective parents.

Table 2. Range of plant height (cm) in F_2 populations of tall × dwarf wheat crosses.

Female parent	Male parent			
	HD2122	HD1981	Tom Thumb	Chuan Mai 18
K 65	76-108 (10.2)†	79-106 (11.3)	43-82 (13.4)	68-108 (12.6)
Hybrid 65	73-102 (13.7)	76-110 (17.8)	48-92 (18.7)	43-110 (36.5)
K 68	74-112 (11.4)	68-97 (9.8)	53-90 (12.4)	54-116 (29.6)
NI 5439	68-93 (9.7)	73-98 (7.6)	57-92 (8.8)	74-96 (13.2)
C 306	46-116 (21.4)	63-112 (18.2)	42-101 (24.6)	36-118 (28.8)
C 591	65-107 (17.3)	71-106 (14.3)	44-97 (17.8)	78-104 (13.7)
NP 710	78-115 (14.7)	68-112 (15.6)	38-91 (14.2)	75-115 (24.2)
NP 824	69-110 (20.2)	81-113 (11.8)	41-94 (19.6)	40-110 (32.3)
NP 846	87-116 (11.3)	73-114 (13.6)	46-103 (21.2)	57-135 (27.4)
NP 875	70-110 (12.7)	66-115 (18.8)	56-88 (16.4)	70-121 (22.3)

† Values given between parentheses are coefficients of genotypic variability (%) for the respective F_2 population.

References

Flintham, J.E. and M.D. Gale. 1983. The Tom Thumb dwarfing gene *Rht-3* in wheat. *Theoretical and Applied Genetics* 66: 249–256.

Gale, M.D. and C.N. Law. 1977. The identification and exploitation of Norin 10 semidwarf genes. Pages 21–35 *in* 1976 Annual Report of Plant Breeding Institute, Cambridge.

Gale, M.D. and G.A. Marshall. 1976. The chromosomal location of *Gai 1* and genes for gibberellin insensitivity and semidwarfism in a derivative of Norin 10 wheat. *Heredity* 37: 283–289.

Gale, M.D. and S. Youssefian. 1985. Dwarfing genes in wheat. Pages 1–35 *in* Progress in Plant Breeding – 1 (G.E. Russell, ed.). Butterworths, London, UK.

Nelson, W., H.J. Dubin and S. Rajaram. 1980. Norin 10 dwarfing genes present in lines used in the CIMMYT bread wheat programme. *Cereal Research Communications* 8: 573–574.

Sastry, E.D.V., G.S. Sharma and J.R. Mathur. 1985. Dwarfism in wheat: Effect of *Gai/Rht* dwarfing genes on the correlation of yield and yield traits. Pages 345–351 *in* Proceedings of the 3rd National Seminar on Genetics and Wheat Improvement, 8–10 May, Shimla, India.

Sastry, E.D.V. and R.M. Singh. 1988. Effect of dwarfing genes on grain yield in tall × dwarf crosses of wheat. *Cereal Research Communications* 16(3–4): 273–275.

Variability and Correlation Studies in Durum Wheat in Alem-Tena, Ethiopia

Getachew Belay, Tesfaye Tesemma and Demissie Mitiku

Alemaya University of Agriculture
Debre Zeit Agricultural Research Center
P.O. Box 32, Debre Zeit
ETHIOPIA

Abstract

Variability and correlation studies were carried out on seed yield and nine component characters of 70 durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) genotypes in Alem-Tena, Ethiopia. Seed yield showed the highest variation indicating the wide opportunity for direct selection. The lowest variation was shown by days-to-heading. Higher variations were also observed for number of tillers and kernels/spike. Seed yield exhibited a strong positive association with all characters except days-to-heading and harvest index. Besides seed yield itself, plant height and 1000-kernel weight may be considered good indirect selection criteria under Alem-Tena conditions.

Key words: *Triticum durum*; hard wheat; genetic variation; genetic correlation, genotypes; yield components; Ethiopia.

دراسات التباين والارتباط في القمح القاسي في ألم - تينا بإثيوبيا

الملخص

أجريت دراسات التباين والارتباط على الغلة الحبية وتسع خواص أساسية أخرى لـ70 طرازاً وراثياً من القمح القاسي (*Triticum durum turgidum* (Desf.) Husn.) . L. ssp في ألم-تينا بإثيوبيا. أظهرت الغلة الحبية أعلى التباين مما يشير إلى توفر إمكانية كبيرة للانتخاب المباشر، في حين أظهر عدد الأيام حتى الإسبال أدنى التباين. كما لوحظ وجود تباينات أعلى فيما بين عدد الاشطاءات والحب/السنبلة. وقد أظهرت الغلة الحبية ارتباطاً إيجابياً قوياً بجميع الخواص ما عدا عدد الأيام حتى الإسبال ودليل الحصاد، فضلاً عن ذلك، قد تُعتبر الغلة الحبية نفسها، وطول النبات، ووزن الألف حبة معايير جيدة للانتخاب غير المباشر في الظروف السائدة في ألم-تينا.

Introduction

Wheat (*Triticum* spp.) is one of the most important cereals cultivated in Ethiopia. Both tetraploid (mainly *T. turgidum* ssp. *durum*) and hexaploid (*Triticum aestivum* L. ssp. *aestivum*) species are grown. The former occupy more than two-thirds of the total wheat area (approx. 700,000 ha) and are mostly grown by the small-holder peasant

sector in the highland cool wet areas at altitudes of 1800–2500 m (Tesfaye and Getachew 1991). Since recently, however, farmers at lower altitudes have started showing interest in growing wheat. One of these new places is Alem-Tena, in Southern Shewa administrative region located at an elevation of 1600 m.

As national coordinator of durum wheat research in the country, the Debre Zeit Agricultural Research Center has started a research program at this location with the ultimate goal of developing suitable durum wheat cultivars for the region. In the present study, we evaluated some of our germplasm to investigate its gross variability for different agronomic characters and to determine the correlation coefficients between pairs of characters for effective selection.

Materials and Methods

The trial was carried out in 1991 growing season in Alem-Tena, Ethiopia, on sandy loam soil. One hundred durum wheat genotypes were each grown in non-replicated single-row plots 2.5 m long. Spacing was 40 cm between rows and 10 cm between plants. All the genotypes were formerly grown for sufficient number of generations to become pure lines. Planting was done on 18 July. Fertilizer was applied at the rate of 64 kg N/ha and 20.3 kg P/ha. Weeds were controlled manually.

From each plot, five plants were used to record: number of tillers, spike length, number of spikelets, number of kernels/spike, plant height, biological yield, seed yield/plant and harvest index. Number of days to heading was recorded on plot basis and 1000-kernel weight was determined from 1000 seeds randomly counted from the bulk of the five plants. In all cases average values of the five plants were used for analysis. Range, mean, coefficient of variation, standard error values and simple correlation coefficient between the various characters were calculated.

Results and Discussion

Of the 100 genotypes originally planted, 30 were excluded from the analysis because of their extreme susceptibility to stem rust (*Puccinia graminis* Pers. f.sp. *tritici* Eriks & Henn.) beyond acceptable level and failure to reach physiological maturity and set seeds. Among these, the local landraces and the two released cultivars, Cocorit 71 and Gerardo, were the most conspicuous. Therefore, in an attempt to develop cultivars for Alem-Tena area, stem rust resistance should be given a very serious consideration. Of the 70 lines analyzed, 48 were found to be clean and the rest scored between trace and 10 MS.

Range, mean, standard error and coefficient of variation values of the ten characters are given in Table 1. Greater variation was observed for seed yield, number of tillers and kernels/spike; whereas, days-to-heading exhibited minimum variation. The remaining characters showed low to intermediate variation. The highest variation was obtained for seed yield (34.3%) indicating wide opportunity of direct selection for yield among the genotypes.

Table 1. Range, mean, standard error (SE) and coefficient of variation (CV) for ten characters of 70 durum wheat gentoypes tested at Alem-Tena, Ethiopia, 1992.

Character	Range	Mean	SE	CV (%)
Days to heading	50-77	63.1	0.62	8.1
No. of tillers	3-12	6.6	0.23	29.1
Spike length (cm)	5.1-9.6	6.9	0.10	12.0
No. of spikelets/spike	14.4-23.0	18.9	0.23	10.2
No. of kernels/spike	25.3-42.0	32.1	0.50	23.7
Biological yield (g)	7.6-45.0	22.0	0.90	13.3
Plant height (cm)	55-100	75.6	1.19	13.1
1000-kernel wt (g)	24-50	35.9	0.68	15.8
Seed yield/plant (g)	3.3-16.1	7.8	0.32	34.3
Harvest index	0.24-0.51	0.36	0.01	14.4

Table 2. Simple correlation coefficents among different characters of 70 durum wheat genotypes grown at Alem-Tena, Ethiopia.

	2	3	4	5	6	7	8	9	HI†
1. Days to heading	0.095	0.097	0.412**	0.171	0.263*	–0.059	–0.249*	0.047	–0.492***
2. No. of tillers		0.503***	0.393***	–0.051	0.827***	0.223	0.095	0.782***	–0.188
3. Spike length			0.637***	0.068	0.471***	0.050	–0.100	0.410***	–0.140
4. No. of spikelets/spike				0.252	0.505**	0.070	–0.128	0.338**	–0.331***
5. No. of kernels/spike					0.284*	0.299*	–0.052	0.315***	0.093
6. Biological yield						0.405***	0.089	0.880***	–0.253*
7. Plant height							0.226	0.404***	0.014
8. 1000-kernel weight								0.266*	0.434***
9. Seed yield/plant									0.162

*,**,*** Significant at 0.05, 0.01 and 0.001 levels of probability, respectively. † HI = harvest index.

Simple correlation coefficients among the different characters are presented in Table 2. Seed yield showed a strong and positive correlation with all characters except days-to-heading and harvest index. The absence of significant association between seed yield and days-to-heading is in agreement with Ehdaie and Waines (1989) and Bekele (1990), although the latter found a positive but non-significant association between seed yield and harvest index. The correlations of seed yield with plant height and with number of tillers are in accordance with Nachit and Jarrah (1986). Significant positive associations between seed yield and 1000-kernel weight are also reported by Knott and Talukdar (1971) and Bekele (1990).

There was a significant negative association between days-to-heading and 1000-kernel weight (r = –0.249), and days-to-heading and harvest index (r = –0.429). This suggests that indirect selection for earliness alone may not be beneficial to realize an optimum yield and seed quality under Alem-Tena conditions.

Although it was not significant, plant height showed a positive association (r = 0.226) with 1000-kernel weight which is in disagreement with both Ehdaie and Waines (1989) and Bekele (1990), but in agreement with Nachit and Jarrah (1986). Number of kernels/spike was significantly and positively associated with plant height, while it showed a weak negative association with 1000-kernel weight (r = –0.052). Harvest index showed a significant positive association only with 1000-kernel weight which was similar to that reported by Bekele (1990).

There are no universally applied selection criteria, besides yield itself, to obtain high-yielding cultivars. Under dryland farming conditions, the situation is further complicated by the variability of the environment requiring a stable selection criterion. Nalitolela et al. (1989) note that 1000-kernel weight alone may not be a reliable indicator for high yield in wheat. The instability of 1000-kernel weight was also reported by Bekele (1990). However, in the present study, besides direct selection for seed yield, plant height and 1000-kernel weight may be considered as practical selection criteria under Alem-Tena conditions. Selection for one of these characters did not seem to significantly affect the other.

Acknowledgement

We thank the technical staff of the wheat section of the Debre Zeit Agricultural Research Center for their assistance in this study.

References

Bekele Geleta. 1990. Stability of yield and harvest index in improved varieties of bread wheat and barley. MSc Thesis. Alemaya University of Agriculture, Ethiopia.

Ehdaie, B. and J.G. Waines. 1989. Genetic variation, heritability and path analysis in landraces of bread wheat from southwestern Iran. *Euphytica* 41: 183–190.

Knott, D.R. and B. Talukdar. 1971. Increasing seed weight and its effects on yield, yield components and quality. *Crop Science* 11: 280–283.

Nachit, M.M. and M. Jarrah. 1986. Association of some morphological characters to grain yield in durum wheat under Mediterranean dryland conditions. *Rachis* 5(2): 33–34.

Nalitolela, A.J., E. Morris and Z.Y. Maimu. 1989. Reliability of kernel weight and test weight as components determining yield potential in wheat. Pages 181–190 *in* Sixth Regional Wheat Workshop for Eastern, Central and Southern Africa (D.G. Tanner, M. van Ginkel and W. Mwangi, eds). CIMMYT, Mexico.

Tesfaye Tesemma and Getachew Belay. 1991. Aspects of Ethiopian tetraploid wheats with emphasis on durum wheat genetics and breeding research. Pages 47–71 *in* Wheat Research in Ethiopia: A Historical Perspective (Hailu Gebre Mariam, D.G. Tanner and Mengistu Hulluka, eds). IAR/CIMMYT.

Fusarium spp. on Wheat with Special Reference to Fusarium Head Blight (*F. graminearum* Schw.)

Slobodan Tomasović, Mladen Matijašević and Branko Sesar

Department of Small Grain Cereal Crops, Botinec
Institute for Breeding and Production of Field Crops
Marulićev trg 5/I, 41.000 Zagreb
CROATIA

Abstract

Gibberella zeae **(Schw.) Petch., i.e. *Fusarium graminearum* Schw. in condial stage, is the most widespread cause of head blight of wheat (*Triticum* spp.) in the former Yugoslavia (fusarium head blight). The fungus invades wheat spikes in the heading stage; attack is most dangerous at anthesis. The occurrence of *Fusarium* spp. is favored by high temperatures (25–30°C) and high relative humidity (above 85%). There are several measures of controlling *Fusarium* spp., such as crop rotation and seed treatment. However, the development of wheat cultivars resistant to or tolerant of head blight represents the principal method of controlling the disease that has become increasingly evident over several years.**

Key words: *Triticum*; *Fusarium*; disease control; Croatia.

Introduction

Considerable achievements have been made in wheat breeding, i.e. cultivars with high genetic yielding potential and good adaptability have been developed. However, full genetic yield potential is not achieved because of some adverse factors affecting yield, grain and flour quality. One of these factors is fusarium head blight (also known as scab), most frequently caused by *Fusarium graminearum*.

فطر الفيوزاريوم *Fusarium* spp. على القمح مع التنوية بشكل خاص إلى لفحة السنابل الفيوزاريومية (*F. graminearum* Schw.)

الملخص

يُعتبر *Gibberella zeae* (Schw.) Petch. أي *Fusarium graminearum* Schw المسبب الأكثر انتشاراً لمرض لفحة السنابل على القمح (*Triticum* spp.) في يوغسلافيا سابقاً. ويغزو هذا الفطر سنابل القمح خلال طور الاسبال، وتشتد خطورة الإصابة به عند طور الإزهار. إن درجات الحرارة المرتفعة (25-30°م) والرطوبة النسبية العالية (أعلى من 85٪) تشكل ظروفاً مواتية للإصابة بهذا الفطر، علماً أن هناك اجراءات عديدة لمكافحته، من قبيل الدورة الزراعية ومعاملة البذار. إلا أن استنباط أصناف قمح مقاومة أو متحملة للفحة السنابل يمثل الطريقة الرئيسية لمكافحة المرض الآخذ بالتزايد خلال سنوات عديدة.

Strong or weak *F. graminearum* attack in wheat has been known in former Yugoslavia for many years. During recent years the occurrence of this disease has been reported on a large scale in farmers' fields, increasingly affecting wheat heads, especially when high temperatures are accompanied with high relative humidity during anthesis. Fusarium head blight attacks high-yielding wheat genotypes when intensive cultural practices are applied.

Strains of *Fusarium*

Wheat head blight is known to be caused by several *Fusarium* species. *Gibberella zeae* is the most widespread cause of head blight in wheat, as shown in our previous investigations (Milatović et al. 1982). Similar findings have been reported by other authors (Purss 1966, 1969; McKnight and Hart 1966; Wildermuth and Purss 1971), whose investigations were focused more on studying stem-base area and plant foot. Apart from *F. graminearum*,

wheat spikes are also infected by the following *Fusarium* species: *F. culmorum* (W.G.Sm.) Sacc., *F. avenaceum* (Corda ex Fr.) Sacc., *F. nivale* (Fr.) Ces. ex Berl. & Vogl. (Čizmić 1986) and, to a lesser extent, *F. poae* (Peck) Wollenweber. Several other *Fusarium* species attack spikes, but insignificantly: *F. moniliforme* Sheld., *F. solani* (Mart.) Sacc. em. Snyder & Hansen p.p., *F. equiseti* (Corda) Sacc., *F. oxysporum* Schlecht em. Snyder & Hansen and *F. acuminatum* Ellis & Everhart (Mesterhazy 1974).

These species exist in conidial and perithecial stages, but largely persist in conidial stage which is the imperfect stage of fungus development. Conidia initiate and spread the infection. *Fusarium culmorum* and *F. poae* survive solely in conidial (*Fusarium*) generation – in these species, a perithecial stage (sexual) is not known.

Reasons for increased fusarium incidence

Disease and damage severity vary between years, locations and cultivars. Intensive disease attacks result from narrow crop rotations (e.g. maize –wheat), and intensive fertilizer application, especially nitrogen (dosages of 200 kg/ha in our conditions are required to obtain high yields). The problem of *Fusarium* spp., especially *F. graminearum* and *F. culmorum*, is gaining importance in modern wheat production. Therefore, these diseases have the synonym of so-called modern diseases, i.e. "the disease of plants of high standard". New farming systems brought about an array of "new" diseases, including wheat fusaria, that depress grain production. These were, in fact, known much earlier, but now cause greater losses (Kišpatić 1980). *Fusarium* head blight causes considerable yield reductions (often 50% and up to 80%) depending on environmental factors and the genotypes. Dimitrijević et al. (1985) investigated the intensity of *F. graminearum* attack in wheat, expressed as percentage of infected spikes, percentage of infected kernels and infection severity. Percentage of infected spikes was high in most cultivars. In commercial production, it was 5–30% and in experimental fields it varied between 20 and 72%. Infection severity varied between weak and severe. Laboratory tests proved that seeds of cultivars Lonja and Mačvanka were not infected; the lowest infection (2%) was found in Super Zlatna, whereas the highest degree of infection was found in Yugoslavia (11%) and ZG IPK 18-82 (14%).

Severe onset of the disease is associated with the spread of new wheat cultivars lacking resistance to it. The parasite is always present in the soil and its feeding requirements are small. By its nature it is both parasitic and saprophytic, meaning that it can survive both on living and dead organic matter. This characteristic makes it more difficult to develop resistant cultivars.

Measures of control

The measures of eliminating losses and controlling diseases caused by fungi from *Fusarium* are as follows.

1. Deep plowing under of crop debris to ensure a good separation of the inoculum from the plant roots.
2. Use of long rotations as an important measure of control.
3. Seeding should be performed at optimal times, high densities avoided, and excessive N dosages avoided. These are measures commonly applied in agricultural practice elsewhere.
4. Use of healthy and treated seeds with high germination rate.
5. Use of resistant and tolerant wheat genotypes. Because of increasing damages due to yield losses caused by fusaria, the Institute for Breeding and Production of Field Crops in Zagreb has initiated work on resolving this problem by developing cultivars resistant to this disease.
6. Chemical control of wheat fusaria. Under high moisture and high temperatures, when severe outbreaks of fusaria are expected, foliar fungicides should be applied at heading and particularly at anthesis when the attack is most dangerous. During recent years, the incidence of fusarium diseases on wheat has increased on crops throughout the country. Possibilities of chemical control of the pathogen have not been fully exploited.

Conclusion

At the present time, wheat fusaria diseases, especially spike fusaria, constitute a major problem in agricultural wheat production. Resolving the problem of wheat fusaria, i.e. controlling the parasite, requires an integrated approach. There are three basic measures of controlling the development of the parasite and hence, the disease: (a) management practices; (b) breeding for resistance and the use of resistant cultivars; and (c) chemical control. Today, reductions of yield losses are attributed mostly to management practices (crop rotation, seeding, fertilizer application, etc.). In future, in wide agricultural practice, the best solutions are expected from breeding work and the use of resistant cultivars, as well as from chemical measures of control (fungicide application).

The most economical and efficient means of disease control is by using resistant cultivars. Zagreb Institute for Breeding and Production of Field Crops has approached this problem seriously and has initiated work on finding sources of resistance, testing them under artificial conditions, and incorporating improved sources of resistance into the existing high-yielding genotypes susceptible to this harmful disease.

Acknowledgment

We thank Prof. Jasenka Skoblar for translating this paper into English and for her technical assistance.

References

Čizmić, I. 1986. Fuzarioze pšenice i njihovo suzbijanje. *Bilten "Poljodobra"*, Br. 3, Zagreb.

Dimitrijević, M., D. Jurković and Dj. Kondić. 1985. *Fusarium* spp. na pšenici područja Baranje. *Agronomski glasnik*, Br. 5-6, Zagreb.

Kišpatić, J. 1980. Bolesti biljaka visokog standarda. *Bilten "Poljodobra"*, Br. 1, Zagreb.

McKnight, T. and J. Hart. 1966. Some field observation on crown rot disease of wheat caused by *Fusarium graminearum*. *Queensland Journal of Agriculture and Animal Science* 23: 373–378.

Mesterhazy, A. 1974. Fusarium diseases of wheat and tricticale in south-east Hungary. *Cereal Research Communications* 2(3): 167–173.

Milatović, I., V. Vlahović and S. Tomasović. 1982. Otpornost klasova pšenice prema *Fusarium graminearum* Schw. *Zaštita bilja* 35(4), Br. 162, Beograd.

Purss, G.S. 1966. Studies of varietal resistance to crown root of wheat caused by *Fusarium graminearum* Schw. *Queensland Journal of Agriculture and Animal Science* 23: 415–498.

Purss, G.S. 1969. The relationship between strains of *Fusarium* Schwabe causing crown rot of various *graminearum* hosts and stalk rot of maize in Queenland. *Australian Journal Agricultural Research* 20: 251–264.

Wildermuth, G.B. and G.S. Purss. 1971. Further sources of field resistance to crown rot (*Gibberella zeae*) of cereals in Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 11: 455–459.

Performance of Bread Wheat Genotypes in Northern Sudan

Abdalla Ibrahim Sheikh Mohamed
Hudeiba Research Station
P.O. Box 31, El-Damer
SUDAN

Abstract

Introduced bread wheat (*Triticum aestivum* L. ssp. *aestivum*) genotypes were evaluated in the period 1984/85–1989/90 at Hudeiba, northern Sudan. Heading of the genotypes was within 48–89 days, while maturity was within 80–131 days with significant differences among the genotypes. Grain yield also varied significantly with a highest yield of 5.6 t/ha and lowest of 0.5 t/ha. In general, the medium-maturity genotypes appear to yield better than early and late ones under the conditions of northern Sudan. Temperature during February and March seems to have a major affect on grain yield.

Key words: *Triticum aestivum*; soft wheat; genotypes; evaluation; maturity; yields; grain; temperature; Sudan.

كفاءة طرز وراثية من القمح الطري في شمالي السودان

الملخص

تم تقييم طرز وراثية مدخلة من القمح الطري (*Triticum aestivum* L. ssp. *aestivum*) في الحديبة بشمالي السودان خلال الفترة 1984/85-1989/90. وكان عدد الأيام حتى إسبال تلك الطرز ما بين 48-89 يوماً في حين كان عدد الأيام حتى النضج ما بين 80-131 يوماً مع وجود فروق هامة فيما بينها، كما تباينت الغلة الحبية بشكل كبير إذ بلغت أعلاها 5.6 طن/هـ وأدناها 0.5 طن/هـ وبشكل عام، يتبين أن الطرز الوراثية التي تنضج في فترة متوسطة تتفوق في الغلة على تلك الطرز الباكورية أو المتأخرة تحت ظروف شمالي السودان. إذ يبدو أن لدرجات الحرارة خلال شهري شباط/فبراير وآذار/مارس التأثير الرئيسي على الغلة الحبية.

Introduction

In Sudan, bread wheat is grown in the Northern, Central and Eastern states, with highest yields obtained in the Northern region, where the winter is relatively longer and cooler (Gorashi 1988; Ishag and Ageeb 1991; Mohamedali 1987).

The objective of this research was to study the performance and adaptability of introduced bread wheat genotypes under conditions of northern Sudan.

Materials and Methods

Bread wheat genotypes introduced from ICARDA were evaluated at Hudeiba (17°N, 33°E) in northern Sudan, with Mexicani and Wad Elnil as check cultivars. The design used was a randomized complete block with four replicates. Plot size was 2.5 × 1.8 m, and net harvested area was 3 m^2. Sowing was in mid-November in each season. Plots were on flat ground, and seeds were hand-drilled in rows 30 cm apart at a rate of 120 kg/ha. Irrigation was applied at two-week intervals throughout the season till maturity. Nitrogen fertilizer was applied at 86 kg N/ha, as urea in two equal doses at the second irrigation and at heading. Weeds and insect pests were kept to a minimum. The characters evaluated were days to heading, days to maturity, kernel weight and grain yield. Monthly minimum and maximum temperatures and relative humidity are given for each season in Table 1.

Table 1. Meterological date during the growing season at Hudeiba, 1984/85-1989/90.

Month		1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Oct.	min.	29	24	25	25	25	24
	max.	40	40	39	39	39	39
	R.H.	31	33	37	34	37	31
Nov.	min.	19	20	19	20	19	21
	max.	34	35	34	36	34	36
	R.H.	37	38	42	41	43	40
Dec.	min.	16	11	13	16	17	14
	max.	31	31	28	31	33	30
	R.H.	48	47	40	47	50	45
Jan.	min.	17	14	14	14	11	14
	max.	33	30	31	30	27	30
	R.H.	47	42	46	50	45	48
Feb.	min.	13	15	16	14	12	13
	max.	29	33	33	31	29	28
	R.H.	34	34	37	37	37	32
Mar.	min.	20	20	17	19	17	16
	max.	38	38	35	37	34	33
	R.H.	31	30	27	28	27	26
Apr.	min.	22	23	22	21	21	22
	max.	39	40	39	40	40	40
	R.H.	24	23	17	20	28	28

Min. : Mean minimum temeperature (°C).

Max. : Mean maximum temepature (°C).

R.H. : Relative humidity (%) at 0800 h.

Results and Discussion

The performance of the genotypes evaluated in each season is presented in Tables 2–7. There were significant differences among the genotypes in all characters.

Season 1984/85

In 1984/85, the genotypes reached heading within 48–69 days and maturity within 80–104 days, with the earliest entries being nos 6 and 20 and latest nos 10 and 23 (Table 2). Thousand-kernel weight (TKW) was 29–43 g. Grain yield varied from 0.5 to 1.8 t. None of the lines exceeded the check (Mexicani) in grain yield.

Season 1985/86

The genotypes evaluated in 1985/86 varied in grain yield from 0.9 to 2.7 t/ha, with the highest yielding entry being no. 11 and lowest no. 13. Heading and maturity were within 56–72 and 88–104 days, respectively, with the earliest entry no. 13 and latest line no. 7. TKW was 23–37 g. In this season, entry nos 11 and 16 exceeded the check (Mexicani) in grain yield by about 30% (Table 3).

Table 2. Performance of 24 wheat (or triticale) genotypes in northern Sudan, 1984/85.

No.	Name/cross	Days to heading*	Days to maturity*	1000-kernel weight (g)**	Grain yield (kg/ha)*
1	Mexipak 65	54	84	31	664
2	HD 2206/Hork(S)	52	87	34	1057
3	Vee (S)	55	90	29	557
4	Inia/__/KPK	50	85	29	698
5	GV/Ald (S)	61	95	34	1216
6	Bjy (S)	49	80	35	578
7	Bjy (S)/TRM	53	85	33	589
8	Bb/__/Kal*3	54	88	34	646
9	Gll/__/Cal	56	90	42	1016
10	Snb (S)	64	104	33	1414
11	7C/Pvn (S)	52	87	35	891
12	Cham-1	55	88	43	1695
13	Ald (S)/WW 15	54	91	35	1216
14	Kvz/__/Sn64	54	85	41	568
15	W3918A/Jup	56	90	33	1346
16	Nkt (S)	52	91	35	872
17	TAST/Mo/Nac	61	99	35	1363
18	CMH/__//FLR(S)	53	87	31	1151
19	Ana/Mon (S)	49	85	37	726
20	Sakha 18/__/Napo	48	82	40	505
21	Sakha 69	51	90	33	588
22	S. 84	53	87	39	966
23	"Triticale"	69	106	37	1393
24	Mexicani	54	89	32	1838
	Mean	54	89	35	982
	SE (±)	1.0	1.0	1.3	212

*,** Significant differences among the lines at P≤0.05 and P≤0.01, respectively.

Table 3. Performance of 24 wheat genotypes in northern Sudan, 1985/86.

No.	Name/cross	Days to heading*	Days to maturity**	1000-kernel weight (g)**	Grain yield (kg/ha)*
1	Mexipak 65	58	88	29	1058
2	K6290.9/__/Sx	64	97	27	1300
3	P106.19/__/Jt3(1)	58	92	34	1767
4	P106.19/__/Jt3(2)	6	93	28	1300
5	Kvz/__/Sn64	58	92	37	992
6	Kvz/Cgn (1)	71	103	24	1883
7	Kvz/Cgn (2)	72	103	28	2000
8	Ymh/Tob//Ron	70	104	23	1258
9	Bb/__/Kal*5	58	90	29	1792
10	SD 648.511/__/Zbz	63	97	28	2183
11	Vee (S)	63	97	31	2650
12	Cham-1	58	93	37	1617
13	Yd (S)/Pci(S)	56	93	36	958
14	Condor(S)/Ald (S)	65	101	31	2275
15	Maya 74/Cli	66	101	24	1683
16	Kal//__/Kal*3	61	96	32	2517
17	Hoopoe (S)	63	97	32	1233
18	Jup (S)/__/Lfn	57	95	33	1525
19	Bch(S)/__/7C	66	103	27	1367
20	WA 476/__/Ana(1)	61	97	30	1758
21	WA 476/__/Ana(2)	61	96	33	1950
22	Cham-2	61	98	27	1908
23	Mexicani	60	101	30	1592
	Mean	62	97	30	1678
	SE (±)	0.6	1	1	408

* Significant differences among the lines at P≤0.05 and P≤0.01, respectively.

Season 1986/87

In 1986/87, the genotypes reached heading within 54–66 days and maturity within 88–102, with entry no. 18 being earliest and entry no. 10 latest. TKW was 28–40 g. Grain yield varied from 1.1 to 2.2 t/ha and the highest yield was obtained by entry no. 10 (Table 4). Entry nos 2, 3, 10, 12 and 23 exceeded the check (no. 24) by more than 30% in grain yield.

Season 1987/88

In 1987/88, the genotypes varied in grain yield from 1.8 to 3.9 t/ha with none of the lines exceeding the check Wad Elnil (3.9 t/ha). The earliest line in heading and maturity was entry no. 10 which is Cham 4 (50 and 94 days, respectively) and the latest was no. 8, i.e. Tsi/Vee(S) (75 and 113 days, respectively) with acceptable yield. TKW was in the range 31–43 g.

Table 4. Performance of 24 wheat genotypes in northern Sudan, 1986/87.

No.	Name/cross	Days to heading**	Days to maturity**	1000-kernel weight (g)**	Grain yield (kg/ha)*
1	Mexipak 65	59	94	31	1453
2	W3918A/Jup	59	98	33	2023
3	Bow (S)	62	96	31	2090
4	Klpe/__/Huac (S)	61	93	29	1897
5	Chr/__/Hork	62	93	33	1887
6	P106.19/Soty//Jt*3	63	99	34	1603
7	Kal/Cndr (S)	63	96	28	1783
8	Gv/__ /Chr	66	100	35	1593
9	Sannine/Ald (S)	65	97	39	1843
10	Pco/Golan	66	102	40	2210
11	Kvz/__/Tob	65	100	35	1950
12	Cham-2	51	93	31	2117
13	Kvz/Cgn	64	97	34	1850
14	Pato/__/Napo	57	93	31	1637
15	Skh 8/__/Bon	55	96	34	1220
16	Ahgaf//Mxc/Tob	57	92	36	1123
17	Tzpp/__/Mn72131	56	93	35	1357
18	Trm//Kal/Bb	54	88	32	1453
19	Anza/Tob//Ald(S)	56	90	39	1720
20	G11/__/On	58	94	34	1490
21	Wa 4767/__//Ana	57	94	35	1897
22	Zp (S)/__/Pvn(S)	58	93	36	1590
23	Cham-1	55	90	40	2073
24	Mexicani	58	93	33	1520
	Mean	60	95	34	1723
	SE (±)	0.7	1.7	0.6	263

* Significant differences among the lines at P≤0.05 and P≤0.01, respectively.

Season 1988/89

The 1988/89 season was characterized by a longer and cooler winter (Table 1) where the genotypes generally gave high yields with an average greater than 4 t/ha, exceeding the best yield in any of the earlier seasons (Table 5).

Entry nos 14, 16 and 19 exceeded the check (no. 24) in grain yield by about 22%. The lines took longer to reach heading and maturity (55–89 and 113–131 days, respectively), due to low temperature during the season. This was reflected in higher grain yield and higher kernel weight. However, the very late lines in this season (e.g. entry nos 10 and 17) had low grain yield.

Table 5. Performance of 24 wheat genotypes in northern Sudan, 1988/89.

No.	Name/cross	Days to heading**	Days to maturity**	1000-kernel weight (g)**	Grain yield (kg/ha)*
1	Mexipak 65	64	113	36	4880
2	Ttr(S)/Jun(S)	73	120	38	4310
3	Tr 380-16-3A614/Chat(S)	69	118	42	4897
4	Tsi/Vee(S) (1)	65	118	40	4113
5	Tsi/Vee (S) (2)	65	123	39	4230
6	Kvz/__/Iwp22 (1)	68	126	39	2863
7	Kvz/__/Iwp22 (2)	64	125	42	3533
8	Bch (S)/__/23584	82	126	33	4903
9	Maya74(S)/___/Chat(S)	68	122	38	3030
10	KL-H636F2 600/__/Bun(S)	69	128	35	3636
11	Golden Valley/BulBul(S)	72	124	31	3563
12	Cham-4	71	123	35	5513
13	4777//__/Pvn(S)	65	114	41	4390
14	Rsk/__/An64	79	121	32	5537
15	Bow(S)/Baya(S)	74	116	31	4157
16	55-1744/__/Crow(S)	65	123	37	4563
17	Rbs/__/Bow(S)	89	131	32	2960
18	Bb/__/Bow(S)	86	124	36	2410
19	Dove(S)/Buc(S) (1)	71	125	36	5620
20	Dove(S)Buc(S) (2)	68	119	36	4980
21	Tsi/Vee (S)	55	114	40	3853
22	4777(2)//__/Pvn(S)	80	124	41	3540
23	Cham-1	69	114	42	4150
24	Wadi Elnil	76	127	40	5443
	Mean	71	121	37	4197
	SE (±)	1.6	2.8	1.2	169

*,** Significant differences among the lines at P≤0.05 and P≤0.01, respectively.

Season 1989/90

In 1989/90, the genotypes reached heading and maturity within 51–66 and 93–112 days, respectively. The best line (Rbs/Anza//__/4/Bow(S)) yielded 5.1 t/ha, while the lowest gave 1.8 t/ha. TKW was generally high with a range of 35–51 g.

Conclusion

The higher yields recorded during 1988/89 and 1989/90 may be due to lower temperatures during February and March compared with the other seasons.

Generally the genotypes which headed very early or very late gave lower yields, indicating that wheat genotypes with medium maturity were more adapted to the conditions of northern Sudan.

Acknowledgements

We thank the plant breeding staff at Hudeiba for technical assistance. The funds made available for this study from ICARDA/ARC Nile Valley Regional Program and ARC/IFAD/NFAR project are appreciated.

References

Gorachi, A.M. 1988. The response of wheat to sowing date and irrigation in eastern Sudan. *Rachis* 7(1/2): 46–49.

Ishag, H.M. and O.A.A. Ageeb. 1991. The physiology of grain yield in wheat in an irrigated tropical environment. *Experimental Agriculture* 27: 71–77.

Mohamedali, G.H. 1987. Wadi Elnil, a new bread wheat variety for northern Sudan. *Rachis* 6(2): 39–41.

Effect of Minimum Tillage in Wheat Grown after Rice

Indrajit Roy[1] and A.K. Dey Sarkar[2]

[1] *Bangladesh Agricultural Research Council, Farmgate, Dhaka 1215, BANGLADESH*

[2] *Wheat Research Center, Regional Agricultural Research Station, Jamalpur, BANGLADESH*

Abstract

The study was conducted to investigate the effect of minimum tillage on yield and yield characters of wheat (*Triticum aestivum* L. ssp. *aestivum*) grown after rice (*Oryza sativa* L.). A field experiment with wheat variety Kanchan was conducted in the 1989/90 growing season at Jamalpur, Bangladesh. Three tillage treatments – minimum (opening furrow), reduced (one plowing and one laddering) and conventional (five plowings and five ladderings) – were compared under irrigated and rain-fed conditions. Grain yield with minimum or reduced tillage was not different from yield obtained with conventional tillage. However, plant emergence in mimimum and reduced tillage treatments was significantly less, although each plant produced more spikelets and grains per spike.

Key words: *Triticum aestivum*; soft wheat; zero tillage; rice; yields; sequential cropping; Bangladesh.

Introduction

Wheat is generally grown in Bangladesh after wet-season rice, the major cereal crop of the country. Rice–wheat cropping systems account for 85% of the total area under wheat (CIMMYT 1985). Because of uncertainty of the monsoon rains and late floods, planting of the rice crop is frequently delayed which in turn causes the sowing time of wheat to shift from the optimum – exposing the wheat to unfavorable soil moisture and temperature regimes. Yields are reduced about 1% for each day that planting is delayed after the end of November (Butler 1985).

This cropping system related constraint is aggravated by farmers' preference for intensive tillage to obtain the

تأثير الحراثة الخفيفة على القمح المزروع بعد الأرز

الملخص

أجريت الدراسة لبحث تأثير الحراثة الخفيفة على غلة القمح (*Triticum aestivum* L. ssp. *aestivum*) وخواص غلة القمح المزروع بعد الأرز (*Oryza sativa* L.). نفذت تجربة حقلية باستخدام صنف القمح كانشان في الموسم الزراعي 90/1989 في جامالبور في بنغلاديش. تمت مقارنة ثلاث معاملات للحراثة- حراثة خفيفة جداً (أثلام مفتوحة)، حراثة خفيفة وخمس حراثات تقليدية تحت ظروف الري والظروف البعلية. لم تختلف الغلة الحبية في حالة الحراثة الخفيفة جداً والخفيفة عن الغلة في حالة الحراثة التقليدية. إلا أن تكشف البادرات في معاملتي الحراثة الخفيفة جداً والخفيفة كان أقل بكثير على الرغم من أن كل نبات أنتج سنيبلات وحبات أكثر في كل سنبلة.

required soil tilth. An average of six plowings followed by six passes of ladder are done to prepare the seedbed for sowing wheat (Wall et al. 1991). This repeated tillage takes up time and depletes much of the soil moisture making the wheat crop vulnerable to water stress at early growth stages. Minimum tillage, besides being cost-effective and energy-sparing, offers the opportunity for timely planting of wheat thus reducing the risk of drought stress (Mondal 1986).

The present study investigated the effect of minimum tillage on grain yield and yield characters of wheat grown in rotation with rice under rain-fed and irrigated conditions of Bangladesh.

Materials and Methods

The field study was conducted in 1989/90 at the Wheat Research Centre, Regional Agricultural Research Station, Jamalpur, Bangladesh. The soil was sandy loam. Three tillage treatments were compared under irrigated and rain-fed conditions: minimum tillage (opening furrow), reduced tillage (one plowing and one laddering) and conventional tillage (five plowings and five ladderings). The treatments were established on plots 3 × 5 m arranged in a split-plot design and replicated four times. Subplot treatments were tillage methods and main plot treatments were application of irrigation water. Wheat variety Kanchan was sown at 130 kg/ha in the third week of November each year immediately after the harvest of the wet-season rice crop. Fertilizers were broadcast at sowing at the rate of 100 kg N/ha, 60 kg P_2O_5/ha and 40 kg K_2O/ha. The irrigated plots received water at crown-root initiation and at head-emergence.

Results and Discussion

Tillage effects on grain yield averaged over irrigated and rain-fed conditions were not statistically significant, although minimum and reduced tillage treatments gave higher yields than conventional tillage under irrigated conditions (Table 1). These results tend to conform to those of Verma et al. (1989) in which zero tillage for growing wheat after rice gave grain yields similar to those obtained with conventional tillage. Plant emergence in minimum-tillage irrigated plots was statistically similar to that in conventional tillage. When results of irrigated and rain-fed conditions were combined, number of plants emerged/m^2 was significantly less in both minimum and reduced tillage treatments. This may be due to unfavorable conditions for seed germination caused by the presence of rice stubble left in the field. The number of spikes/m^2 was statistically equal for minimum tillage and higher for reduced tillage compared to conventional tillage; this partly offset the impact of lower plant stand (Table 2). Majid et al. (1988) also observed more spikes/m^2 in wheat

Table 1. Tillage effects on grain yield and emerged plants/m^2 of wheat, 1989/90.

Tillage method	Yield (kg/ha)			Emerged plants/m^2		
	Irrigated	Rain-fed	Mean	Irrigated	Rain-fed	Mean
Minimum	3531	3125	3328	114	103	108
Reduced	3656	3031	3343	99	131	115
Conventional	3000	3093	3046	123	136	129
LSD (0.05)	568.2	568.2	401.8	14.3	14.3	10.1

Table 2. Tillage effects on spikes/m^2, spikelets/spike and grains/spike of wheat, 1989/90.

Tillage method	Spikes/m^2			Spikelets/spike			Grains/spike		
	Irrigated	Rain-fed	Mean	Irrigated	Rain-fed	Mean	Irrigated	Rain-fed	Mean
Minimum	217	244	230	16	18	17	36	38	37
Reduced	300	241	270	17	18	17.5	35	40	37.5
Conventional	244	231	237	15	17	16	31	33	32
LSD (0.05)	27.2	27.2	19.1	0.9	0.9	0.6	4.0	4.0	2.9

grown with zero tillage. Minimum as well as reduced tillage treatments produced more spikelets/spike and more grains/spike under both irrigated and rain-fed conditions. Therefore, in rice–wheat cropping systems, minimum tillage practices may permit timely planting of wheat without reduction in yield, as well as reducing land-preparation costs.

References

Butler, L. 1985. Wheat varietal development strategy in Bangladesh. Pages 132–134 *in* Wheat for More Tropical Environments: Proceedings of the International Symposium (R.L. Villareal and A.R. Klatt, eds), 24–28 September 1984, Mexico. CIMMYT, Mexico.

CIMMYT. 1985. Report three: A discussion of selected wheat marketing and pricing issues in developing countries. Pages 29–30 *in* World Wheat Facts and Trends, 1985. CIMMYT, Mexico.

Majid, A., M. Aslam and N.I. Hashmi. 1988. Potential useof minimum tillage in wheat after rice. Pages 63–71 *in* Wheat Production Constraints in Tropical Environments: Proceedings of the International Conference (A.R. Klatt, ed.), 19–23 January 1987, Chiang Mai, Thailand. CIMMYT, Mexico, D.F.

Mondal, M.H. 1986. Minimum tillage and potential of the practices in Bangladesh. Pages 29–33 *in* Proceedings of the International Symposium on Minimum Tillage, 26–27 February 1986. Bangladesh Agricultural Research Council, Dhaka, Bangladesh.

Verma, U.N., V.C. Srivastava and R.B. Prasad. 1989. Effect of zero tillage on wheat (*Triticum aestivum*) with rice (*Oryza sativa*) – Stubble mulching. *Indian Journal of Agricultural Sciences* 59(10): 669–671.

Wall, P.C., P.R. Hobbs, D.A. Saunders, K.D. Sayre and D.G. Tanner. 1991. Wheat crop management in the warmer areas: a review of issues and advances. Pages 225–241 *in* Wheat for the Nontraditional Warm Areas: Proceedings of the International Conference (D.A. Saunders, ed.), 29 July to 3 August 1990, Foz do Iguacu, Brazil. CIMMYT, Mexico, D.F.

Optimizing Fertilizer Rate for Wheat in Calcareous Dark Grey Floodplain Soil of Bangladesh

U.K. Saha, A.F.M. Rahman, M.S. Islam and M.A. Haque

Division of Soil Science
Bangladesh Agricultural Research Institute
Gazipur 1701, BANGLADESH

Abstract

A field experiment was conducted on Calcareous Dark Grey Floodplain Soil of Ishurdi, Bangladesh, for two consecutive *rabi* (winter) seasons (1987/88 and 1988/89) to observe yield response, nutrient uptake and fertilizer economy of wheat (*Triticum aestivum* L. ssp. *aestivum*) as influenced by N–P–K–S–Zn fertilization. The highest grain yield and nutrient uptake were recorded with the treatment 150–60–60–20–5 kg/ha. Yield responses of wheat were most pronounced with N, S and Zn fertilization producing 261, 54 and 33% increased grain yield over control due to application of 150 kg N/ha, 40 kg S/ha and 5 kg Zn/ha, respectively. Economic evaluation suggested that application of 120–60–30–20–5 kg/ha might be sufficient for optimum wheat yield (about 4 t/ha) giving a marginal rate of return as high as 758%.

رفع معدل الأسمدة إلى الحد الأمثل للقمح المزروع في السهول الفضارية الطمية الرمادية الغامقة في بنغلاديش

الملخص

نفذت تجربة حقلية في السهول الفضارية الطمية الرمادية الغامقة في اشوردي ببنغلاديش على مدى موسمين شتويين متعاقبين (88/1987 و 89/1988)، لتحديد استجابة الغلة وامتصاص العناصر المغذية واقتصادية تسميد القمح (*Triticum aestivum* L. ssp *aestivum*) بعد إضافة السماد الآزوتي والفوسفوري والبوتاسي والكبريتي والزنك (N-P-K-S-Zn)، سجلت أعلى غلة حبية وكذلك أعلى امتصاص للعناصر المغذية في المعاملة 150-60-60-25-5 كغ/هـ . وقد تجلت أكثر استجابات الغلة وضوحاً في المعاملة المسمدة بـ N,S و Zn ، مما أدى إلى تفوق الغلة الحبية بنسبة 261، 54 و 33٪ على الشاهد نتيجة لإضافة 150 كغ N/هـ 40 كغ S/هـ و 5 كغ Zn/هـ على التوالي. ويوحي التقييم الإقتصادي بأن إضافة 120، 60، 30، 20، 5 كغ/هـ قد يكون كافياً للحصول على أفضل غلة حبية (حوالي 4 طن/هـ) ومعدل حدي للعائد يصل حتى 758٪.

Key words: *Triticum aestivum*; soft wheat; fertilizer application; application rates; yields; calcareous soils; flood plains; Bangladesh.

Introduction

Wheat is the second major cereal crop of Bangladesh. Recently its cultivation has been expanded dramatically throughout the country. However, the yield level so far achieved is well below those recorded in some other wheat-growing countries. Balanced fertilization is essential for increasing the yield of modern varieties. A number of fertilizer trials conducted in different soils of the country gave positive yield responses of wheat to various fertilizer nutrients (Islam et al. 1986; Ali et al. 1987, 1988, 1990). Significant yield responses of wheat to N, P, K and S fertilization have also been reported from India (Sinha and Sharma 1976; Meelu and Rana 1978; Meelu et al. 1982; Malik 1981; Kumar 1985). Fertilizer recommendations based solely on crop response data may not be economically viable. In this context, Elias and Karim (1984) suggest that response data should be coupled with economic evaluation for judicious fertilizer recommendation. This paper reports the work on the effects of N–P–K–S–Zn fertilization on yield, nutrient uptake and fertilizer economy of wheat in Calcareous Dark Grey Floodplain Soil of Bangladesh.

Material and Methods

The experiment was conducted during *rabi* (winter) seasons of 1987/88 and 1988/89 at the Regional Agricultural Research Station, Ishurdi. The experimental soil, a Calcareous Dark Grey Floodplain loam developed in the Ganges river alluvium, is classified as Calcaric Fulvisol. Some important properties of the soil are given in Table 1. There were 14 different treatment combinations in the experiment composed of five levels of N (0, 60, 90, 120 and 150 kg N/ha), four levels of P (0, 30, 60 and 90 kg P_2O_5/ha), three levels of K (0, 30 and 60 kg K_2O/ha), three levels of S (0, 20 and 40 kg S/ha) and two levels of Zn (0 and 5 kg Zn/ha). Urea, triple superphosphate, muriate of potash, gypsum and zinc oxide were used as the sources of N, P, K, S and Zn, respectively. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 6 m × 5 m. Wheat cv. 'Kanchan' was taken as the test crop. In both the seasons, the seeds were sown during mid-November and the crop was harvested in mid-March. All P–K–S–Zn and one-third of the N were applied basally. The remaining N was applied in two equal splits: half 30 and half 50 days after sowing. The crop received three irrigations at 30, 50 and 70 days after sowing. Plant samples were collected during harvest and dried in an oven at 65°C before chemical analysis. The total nitrogen content of grain and straw was estimated by the micro Kjeldahl method and phosphorus by the Olsen method. Potassium and sulfur were analyzed by digesting the samples in nitric perchloric acid and determined by using atomic absorption spectrophotometer and spectrophotometer, respectively. Economic evaluation was done by partial budgetting and dominance analysis followed by marginal analysis of undominated treatments as suggested by Elias and Karim (1984). Return from average yields of two years and only fertilizer costs were considered for the economic study.

Table 1. Properties of initial soil sample of the experimental area.

Soil properties	Values
Soil pH	7.8
Organic matter (%)	1.67
K (meq. %)	0.45
Ca (meq. %)	15.8
Mg (meq. %)	3.8
NH_4-N (p.p.m.)	18.0
P (p.p.m.)	12.0
S (p.p.m.)	14.0
Zn (p.p.m.)	2.0

Results and Discussion

Grain and straw yields

Grain and straw yields under the 14 fertilizer treatments are shown in Table 2. Both grain and straw yields of wheat were significantly influenced by treatment. Treatment T_6 (150–60–60–20–5 kg N–P–K–S–Zn/ha) recorded the highest grain (4.53 and 4.12 t/ha in 1987/88 and 1988/89, respectively) and straw (7.06 and 6.67 t/ha) yields. The lowest yields in both years were registered in the absolute control treatment (T_1).

The effect of nitrogen was distinct. Yields increased progressively with increasing rates of applied nitrogen up to 150 kg/ha. However, there was no significant yield difference between 120 and 150 kg N/ha. Application of

Table 2. Grain and straw yield of wheat as influenced by various fertilizer treatments.

Treatment	Nutrients added (kg/ha)					Grain yield (t/ha)[1]			Straw yield (t/ha)[1]		
	N	P_2O_5	K_2O	S	Zn	1987/88	1988/89	Mean	1987/88	1988/89	Mean
T_1	0	0	0	0	0	0.82 f	0.88 f	0.85	1.52 g	1.55 e	1.54
T_2	0	60	60	20	5	1.18 ef	1.22 f	1.20	2.32 g	2.20 e	2.26
T_3	60	60	60	20	5	2.06 de	2.08 e	2.07	3.58 f	3.62 cd	3.60
T_4	90	60	60	20	5	3.02 bc	2.98 d	3.00	4.22 ef	3.95 cd	4.09
T_5	120	60	60	20	5	4.41 a	3.96 ab	4.19	6.98 a	6.22 ab	6.60
T_6	150	60	60	20	5	4.53 a	4.12 a	4.33	7.06 a	6.67 a	6.87
T_7	120	0	60	20	5	3.57 ab	3.02 cd	3.30	5.73 bcd	5.48 ab	5.61
T_8	120	30	60	20	5	3.95 ab	3.40 bcd	3.68	6.08 abc	5.86 ab	5.97
T_9	120	90	60	20	5	4.44 a	3.92 ab	4.18	6.97 a	6.04 ab	6.51
T_{10}	120	60	0	20	5	3.65 ab	3.38 bcd	3.52	5.95 abcd	5.65 ab	5.80
T_{11}	120	60	30	20	5	3.97 ab	3.72 abc	3.85	6.42 ab	6.09 ab	6.26
T_{12}	120	60	60	0	5	2.60 cd	2.88 d	2.74	4.82 de	5.04 bc	4.93
T_{13}	120	60	60	40	5	4.48 a	3.98 ab	4.23	6.98 a	6.56 a	6.77
T_{14}	120	60	60	20	0	2.99 bcd	3.29 bcd	3.14	5.07 cde	5.60 ab	5.34
SE (±)						0.22	0.16	-	0.27	0.29	-
CV (%)						12.04	9.28	-	8.96	10.02	-

[1] Figures in a column followed by different letter(s) are significantly different from each other at the 1% level of significance by DMRT.

60, 90, 120 and 150 kg N/ha increased grain yield by 73, 150, 249 and 261% and straw yield by 59, 81, 192 and 204%, respectively over the N control treatment. Thus, application of 120 kg N/ha might be sufficient for optimum wheat yield. The present findings are in agreement with those of Ali et al. (1990).

Application of P at 30, 60 and 90 kg P_2O_5/ha increased grain yield by 12, 27 and 27% and straw yield by 6, 18 and 16% over control, respectively. This implies that use of 60 kg P_2O_5/ha is the most appropriate dose for optimum yield.

Potassium application at 30 and 60 kg K_2O/ha resulted in 9 and 19% increased grain yield and 8 and 14% increased straw yield over control, respectively. Although yield increase due to K application was not remarkable, 30 kg K_2O/ha may be applied to avoid deficiency.

Grain and straw yields were increased by 53 and 34% over control, respectively due to application of 20 kg S/ha. Application of 40 kg S/ha showed only a slight yield increase over 20 kg. Hence, use of 20 kg S/ha might be sufficient for optimum yield.

Zinc application at 5 kg/ha gave a 33% increase in grain yield and 24% increase in straw yield over control. This indicated that 5 kg Zn/ha is necessary for optimum yield.

Nutrient uptake

The average uptake of N, P, K and S by the crop as influenced by different treatments is shown in Table 3. The highest uptake of different nutrients was observed in treatment T_6 (150–60–60–20–5 kg N–P–K–S–Zn/ha and lowest in the control (T_1). N application increased its uptake and favored higher uptake of other nutrients. The same was also true for P, K and S application. The uptake of N, P, K and S was also improved by the addition of Zn. Thus, balanced fertilization ensured a balanced uptake of different nutrients which ultimately led to high yields. Ali et al. (1990) note similar observations.

Economic evaluation

The gross margin curve shown in Figure 1 shows that treatments T_2, T_3, T_4, T_9, T_{12} and T_{13} are cost dominated; hence, these should not be recommended (Elias and Karim 1984). Marginal analysis of the cost-undominated treatments is presented in Table 4. The maximum marginal rate of return (MRR) of 758% was obtained with treatment T_{11} (120–60–30–20–5 kg N–P–K–S–Zn), followed by T_5 (120–60–60–20–5 kg N–P–K–S–Zn/ha) with an MRR of 731%. The average rate of return (ARR) was highest in T_5 (393%) and second highest in T_{11} (371%), but the costs involved in T_5 were higher than those in T_{11}. Hence, application of 120–60–30–20–5 kg N–P–K–S–Zn/ha might be considered the most judicious for wheat cultivation in the soil under study. However, a rich farmer may use 120–60–60–20–5 kg N–P–K–S–Zn/ha to achieve a higher gross margin.

Table 3. Uptake of N, P, K and S by wheat under various fertilizer treatments.

Treatment	Nutrient uptake (kg/ha)[†]			
	N	P	K	S
T_1	18.39	5.91	25.68	1.84
T_2	26.81	9.11	39.92	3.35
T_3	51.98	17.68	66.91	6.89
T_4	75.32	24.38	80.12	8.70
T_5	112.89	35.09	127.64	13.96
T_6	120.83	35.88	132.99	14.05
T_7	90.68	23.96	98.37	9.90
T_8	97.72	28.93	110.33	11.72
T_9	108.03	34.10	122.65	13.43
T_{10}	90.17	29.50	110.11	10.60
T_{11}	97.37	30.27	121.11	12.90
T_{12}	67.78	22.25	90.50	7.45
T_{13}	107.11	34.43	131.16	14.47
T_{14}	80.05	23.43	101.31	9.96

[†] Average results of two years are shown.

Table 4. Marginal analysis of cost-undominated fertilizer treatments.

Treatment	Gross margin (Tk/ha)	Variable cost (Tk/ha)	Marginal gross margin (Tk/ha)	Marginal variable cost (Tk/ha)	Marginal rate of return, MRR (%)	Average rate of return, ARR (%)
T_6	19754	4061	437	333	131	371
T_5	19317	3728	1645	225	731	393
T_{11}	17672	3503	826	109	758	371
T_8	16846	3394	764	116	659	359
T_{10}	16082	3278	993	217	458	348
T_7	15089	3061	547	333	164	340
T_{14}	14542	2728	9867	2728	362	362
T_1	4675	0	–	–	–	–

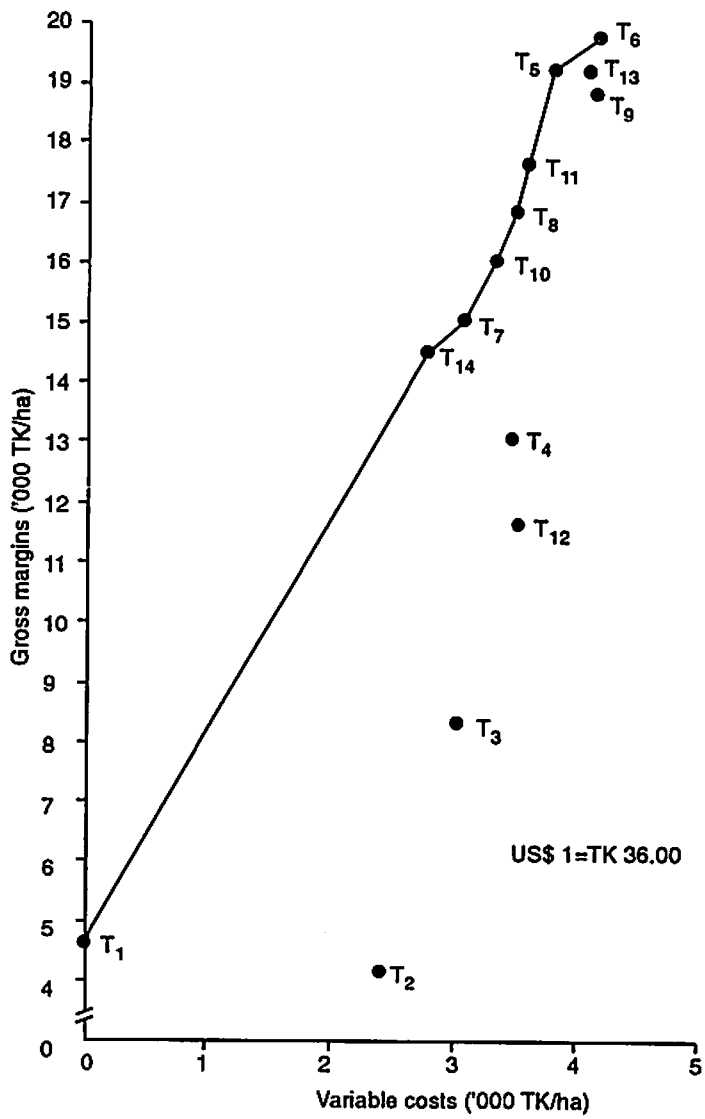


Fig. 1. Gross margin curve for different fertilizer treatments on wheat in floodplain soil of Bangladesh.

References

Ali, M.I., M.A. Islam and M.A.R. Khan. 1987. The growth and yield of wheat as affected by N, P and S fertilizers. *Bangladesh Journal of Agricultural Science* 14(1): 115–120.

Ali, M.I., M.M. Ali, M.C. Chanda and B.K. Topder. 1988. On going contract research project report up to June 1988. BINA/Soil Sci./48. pp. 10-12.

Ali, M.M., M.I. Ali and M.K. Khan. 1990. Effect of fertilization on the growth and yield of wheat in Red Brown Terrace Soils of Bangladesh. *Bangladesh Journal of Soil Science* 21(1): 13–17.

Elias, S.M. and R. Karim. 1984. Application of partial budget technique in cropping system research at Chittagong. AERR No. 10. Division of Agricultural Economics. BARI, Joydebpur, Bangladesh.

Islam, M.S., K.M. Hossain, N.I. Sarkar, S. Altamash and J.U. Sarker. 1986. Experimental methodology and responses of principal crops to sulphur fertilization in Bangladesh. *In* Proceedings of the International Symposium on Sulphur in Agricultural Soils. BARC, Dhaka. 20–22 April 1986.

Kumar, A. 1985. Response of wheat cultivars to nitrogen fertilization under late sown condition. *Indian Journal of Agronomy* 30(4): 464–467.

Malik, C.V.S. 1981. Response of wheat varieties to different levels of nitrogen. *Indian Journal of Agronomy* 26(1): 93–94.

Meelu, O.P., K.R. Kulkarni and A.L. Bhandari. 1982. Crop response to nutrients under irrigated conditions. Pages 426–444 *in* Review of Soil Research in India. Part I.

Meelu, O.P. and D.S. Rana. 1978. National Symposium on Land and Water Management in Indus Basin I. 492 (Review of Soil Research in India Part I. 1982).

Sinha, G.C.P. and N.N. Sharma. 1976. Response of dwarf wheat varieties to different levels of nitrogen fertilization and dates of sowing. *Indian Journal of Agronomy* 21(3): 282–288.

Improvement of Hexaploid Triticale for Grain Yield and its Components

Mouhammad Siddique Sadiq
Plant Genetics Division
Atomic Energy Agricultural Research Centre
Tandojam, Sind, PAKISTAN

Abstract

Segregating lines of triticale (× *Triticosecale* Wittm. ex A.Camus) produced by hybridization at the Atomic Energy Agricultural Research Centre, Tandojam, Pakistan, were screened in yield trials in 1985/86 and 1986/87. Advanced line NIAB-T-598 gave highest grain yield (4500 kg/ha) in the first year, significantly higher than the wheats (*Triticum* spp.) and barley (*Hordeum vulgare* L. ssp. *vulgare*) cultivars included in the trial. In the second season, this line again out-yielded the bread wheat controls and also gave the highest 1000-kernel weight. NIAB-T-598 also showed increased kernel hardness over earlier triticale lines, to an acceptable level.

Key words: Triticales; *Triticum*; *Hordeum vulgare*; barley; *Triticum aestivum*; soft wheat; hexaploidy; grain; yields; yield components; Pakistan.

تحسين الغلة الحبية للتريتيكال السداسي التضاعف ومكوناتها

الملخص

تمت غربلة السلالات الانعزالية من التريتيكال (X *Triticosecale* Wittm A. Camus) - الناتجة عن عمليات تهجين نفذت في مركز الطاقة الذرية للبحوث الزراعية في تاندوجام في الباكستان - في تجارب مقارنة الغلة في موسمي 86/1985 و 87/1986. وقد أعطت السلالة المتقدمة NIAB -T- 598 أعلى غلة حبية (4500 كغ/هـ) في السنة الأولى، وهي أعلى بكثير مما أعطته أصناف القمح (*Triticum* spp.) و الشعير (*Hordeum vulgare* L ssp. *vulgare*). التي شملتها التجربة. وفي الموسم التالي تفوقت هذه السلالة ذاتها مرة أخرى على أصناف الشاهد من القمح الطري من حيث الغلة كما أعطت أعلى وزن للألف حبة. وأظهرت NIAB -T- 598 أيضاً تفوقاً في صلابة الحبة على سلالات التريتيكال إلى حد مقبول.

Introduction

Research work on triticale (6x) at the Atomic Energy Agricultural Research Centre (AEARC), Tandojam, Pakistan, is closely related to the research efforts on wheat (*Triticum aestivum* L. ssp. *aestivum*) coordinated by the Pakistan Agricultural Research Council, Islamabad and is focused mainly on improving spring-type hexaploid triticale for high productivity coupled with desirable quality.

For this purpose, base material was received from the International Wheat and Maize Improvement Center (CIMMYT), Mexico. The genetic variability in this germplasm was further broadened through the synthesis of primary triticales (Kaltsikes 1974) utilizing locally adapted bread wheat and Behrain rye (*Secale cereale* L.) collected from the northern parts of the country.

We used a breeding approach that involved the crossing of synthesized octoploids with hexaploid triticale, and the intercrossing of bread wheat with hexaploid triticale (Hsam and Larter 1974). Visual selection was carried out in the advanced segregating generations. Significant improvement has been achieved through the use of octoploids (8x) in improving hexaploid triticale (Zillinsky 1974; Skovmand et al. 1984). The results are summarized here.

The improvement of grain yield and yield components

1985/86

The yield performance of advanced lines of triticale was evaluated in comparison with durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.), bread wheat and barley in a randomized complete block design under irrigated conditions at the National Institute of Agricultural Botany, Faisalabad, Pakistan. Data for grain yield and other characteristics are presented in Table 1.

There were significant differences among lines for grain yield and tiller survival. NIAB-T-598 significantly outyielded bread wheat, durum wheat and barley varieties, but did not differ significantly from NIAB-T-183. Non-significant differences for tiller survival were found between barley and triticale lines.

Table 1. Grain yield and other characteristics of various varieties/advanced lines of durum wheat, bread wheat, barley and triticale.

Variety/ advanced line	Tiller survival (%)	Grain yield (kg/ha)	1000-grain weight (g)
Barley			
Barley-83	49.5	3345	37.0
Durum wheat			
Wadanak-83	39.7	3650	40.0
Bread wheat			
Pak-81	40.0	4100	38.0
Lu 26S	41.5	4248	44.6
Pb-85	41.0	4050	39.0
Triticale			
NIAB-T-183 (Triticale × triticale)	48.5	4450	42.9
NIAB-T-273 (Bread wheat × triticale)	50.0	4380	34.1
NIAB-T-306 (Bread wheat × triticale)	47.8	3990	36.0
NIAB-T-598 (Octoploid × triticale-6x)	49.0	4500	44.5
LSD 5%	5.5	198	
1%	7.4	235	

1986/87

The performance of advanced lines of triticale in comparison with standard bread wheat varieties was confirmed in a randomized complete block experiment with four replications under normal growing conditions at AEARC, Tandojam. Data for grain yield and other morphological characteristics are presented in Table 2.

There were significant differences among entries for grain yield. Triticale line NIAB-T-598-8 yielded (5739 kg/ha) significantly higher than the bread wheats used as controls. The same line showed highest 1000-grain weight. The spike fertility of triticale selections was comparable to that of bread wheat.

Table 2. Mean grain yield and other characteristics of advanced lines/varieties of triticale and bread wheat.

Advanced line/ variety	Grain yield (kg/ha)	Plant height (cm)	Spike fertility (%)	1000-grain weight (g)
Triticale				
NIAB-T-598-1	4733	140	93.06	39.90
NIAB-T-598-2	4334	123	92.70	40.12
NIAB-T-598-3	4668	135	94.56	42.08
NIAB-T-598-4	5127	130	89.28	42.25
NIAB-T-598-5	4557	128	94.38	38.45
NIAB-T-598-6	4650	135	95.87	41.25
NIAB-T-598-7	4906	135	92.64	42.15
NIAB-T-598-8	5739	130	93.18	42.80
NIAB-T-598-9	5553	135	91.75	40.90
NIAB-T-598-10	5502	132	93.92	41.38
NIAB-T-598-11	5063	138	94.36	37.58
NIAB-T-598-12	5579	141	95.32	42.18
Bread wheat				
Pavon	3944	94	90.23	38.59
Sind-81	5257	112	90.29	40.24
Sonalika	3771	100	83.78	42.08
LSD 5%	202			
1%	270			

The high-yielding ability of this strain was further tested in National Uniform Triticale Yield Trials during 1987/88 at various locations under different ecological zones throughout the country.

Quality characteristics

The quality attributes of triticale lines in comparison with barley, durum wheat and bread wheat are shown in Table 3.

Soft kernels and low test weight have been persistent characteristics of triticale. As a result of intensive selection, improvement has been made in these traits so that triticale compared well with the existing commercial bread wheat varieties in our tests. Triticale line NIAB-T-598 possesses desirable grain hardness as well as test weight, and seems to be the most promising triticale strain. Similar results with other genotypes have been reported regarding triticale characteristics at CIMMYT, Mexico (Amaya et al. 1986).

Table 3. Quality characteristics of triticale in comparison with barley, durum wheat and bread wheat.

Variety/line	Grain color	Moisture content (%)	Hardness (%)	Test weight (kg/hl)
Barley				
Barley-83	White, dull	10.4	70.2	56.4
Durum wheat				
Waddnak-83	Amber	9.8	62.3	74.3
Bread wheat				
Lu 26-S	Amber	9.5	68.3	74.3
Pak-81	Amber	10.2	62.3	73.3
Barani-83	Amber	10.8	73.2	76.8
Triticale				
NIAB-T-183	Amberish	9.8	57.5	69.6
NIAB-T-256	Amberish-red	10.8	61.3	70.5
NIAB-T-273	Amberish	10.2	57.5	68.8
NIAB-T-598	Amberish	11.3	65.8	72.0

Acknowledgements

I thank Dr K.A. Siddiqui, Head of Plant Genetics Division, and Dr A.R. Azmi, Director, AEARC, Tandojam, for critically reviewing the manuscript.

References

Amaya, A., R.J. Pena and G. Varughese. 1986. Influence of grain hardness on the milling and baking properties of recently developed triticale. Pages 511–524 *in* Proceedings of the International Triticale Symposium, Sydney, Australia. *Institute of Agricultural Science Occasional Publication* 24.

Hsam, S.L.K. and E.N. Larter. 1974. Influence of source of wheat cytoplasm on the synthesis and plant characteristics of hexaploid Triticale. *Canadian Journal of Genetics and Cytology* 16: 333–340.

Kaltsikes, P.J. 1974. Methods for triticale production. *Zeitschrift für Pflanzenzüchtung* 71: 264–286.

Skovmand, B., P.N. Fox and R.L. Villareal. 1984. Triticale in commercial agriculture: Progress and promise. *Advances in Agronomy* 37: 1–45.

Zillinsky, F.J. 1974. The development of triticale. *Advances in Agronomy* 26: 351–348.

Cereal News

Network for Integrated Research on Durum Wheat Improvement in the Mediterranean Region

M.M. Nachit and M. Baum
Germplasm Program
ICARDA
P.O. Box 5466
Aleppo
SYRIA

Introduction

Eighty five per cent of the total durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) prodution area in the world is located in the Mediterranean region. The growing conditions are ideal for producing adequate grain quality for the various endproducts (pasta, *couscous* and *burghul*), which provide the main food in the Mediterranean basin. Also the manufacturing technology and the market of durum endproducts are mainly concentrated in this region. It is, therefore, not surprising that research on durum wheat is also mainly conducted in the Mediterranean countries.

Drought, cold and terminal heat stress are the major abiotic factors which limit durum yields in the region. Selection for resistance to these stresses is difficult because of the complex nature of the traits, and also the specific regional adaptation requires different genes in different sites and years. Additionally, biotic stresses (nematodes, viruses, root rot and Hessian fly) and micro-nutrient imbalances (boron toxicity and zinc deficiency) can be severe limitations and are known to occur widely in this region. Until recently, several research programs addressing these problems were working independently.

Realizing that the effectiveness of research efforts could be improved if these programs worked together, a collaborative program was initiated in 1983 by the international durum breeding program at ICARDA, Aleppo, Syria involving all the major durum breeding programs in West Asia and North Africa. In order to include the expertise of European universties, the program was extended to Southern Europe in 1986: Tuscia University-Viterbo (Italy), ENSA/INRA-Montpellier (France), University of Paris Sud (France) and Barcelona University (Spain). Thus, durum joint research encompasses the activities in South Europe, West Asia and North Africa (SEWANA). In 1991, the network was further expanded to include collaborators from North America: Cornell University, Ithaca, USA, and Laval University, Quebec, Canada. The role of each participant is spelled out in Figure 1.

The objectives of the durum network in the Mediterranean region are: (1) to develop productive durum genetic material combining high grain quality with resistance to the main abiotic and biotic stresses encountered in the Mediterranean region; (2) to use the available genetic variation found in durum local landraces and wild relatives; and, (3) to incorporate the use of DNA-molecular markers in durum breeding and selection activities.

Durum landraces as well as wild relatives possessing novel traits are evaluated and used to improve durum varieties in Aleppo and other SEWANA durum breeding programs. Conventional crosses, *in vitro* culture techniques, stress-resistance tools, and molecular markers are used to develop durum germplasm that can be used immediately by the durum scientists. Techniques which produce double haploids are used to hasten the development of populations for mapping of qualitative and quantitative trait loci for important agronomic traits.

Methodology

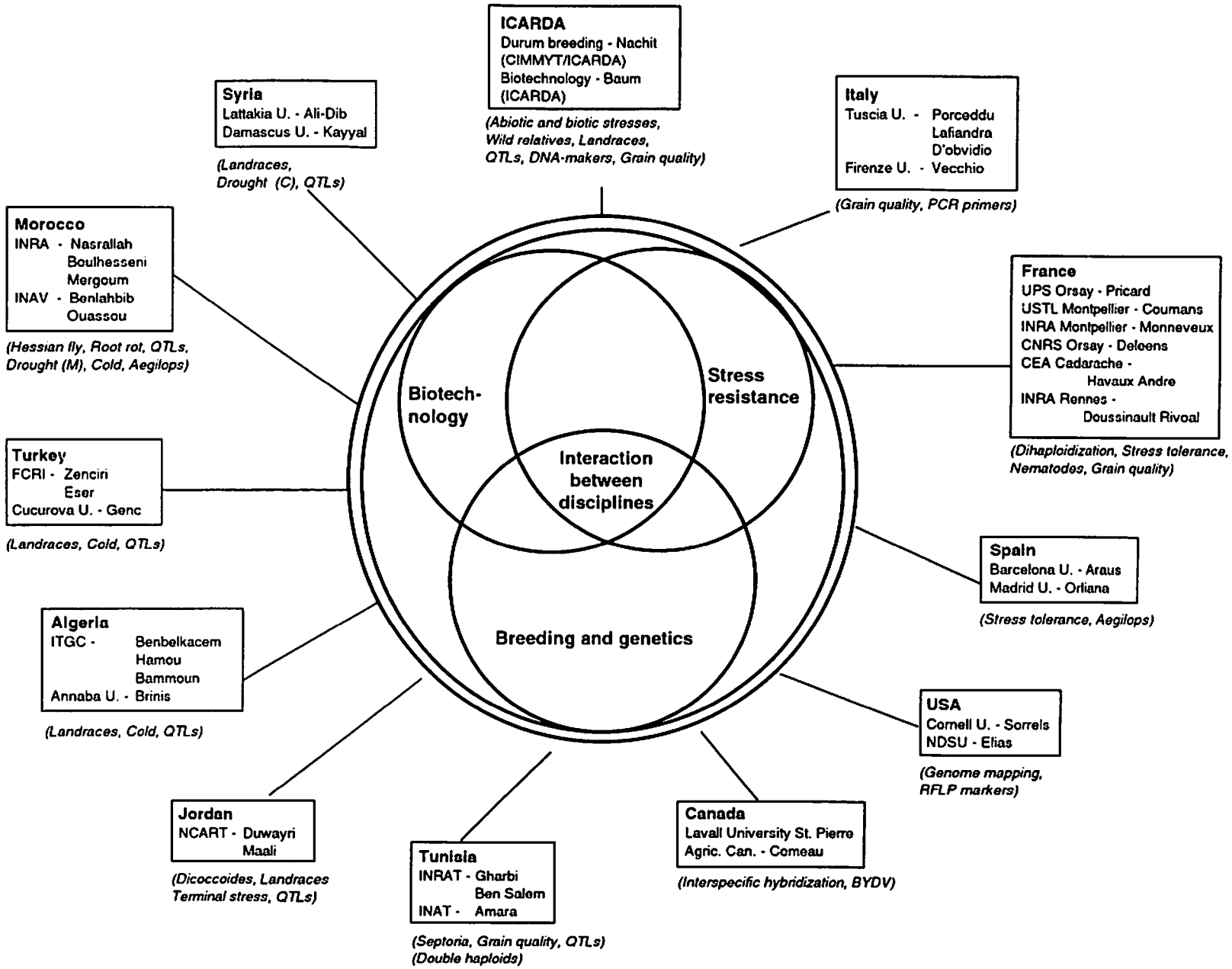
The major research activities of the durum network are as follows.

1. Analysis of stress resistance in durum and recombinant lines from crosses with wild relatives

Abiotic stresses:

- Relative water content
- Osmotic adjustment
- 12C/13C discrimination
- Canopy temperature
- Chlorophyll fluorescence
- Chlorophyll a, Chlorophyll b, and total chlorophyll contents
- Osmotic adjustment (soluble sugars, proline, etc.)

Integrated durum research network



- Root parameters (volume, weight, depth, number)
- Leaf anatomy and morphology
- Boron toxicity
- Zinc deficiency
- Cold at vegetative stage
- Cold at reproductive stage
- Heat at vegetative stage
- Heat at reproductive stage.

Biotic stresses:

- Rusts (yellow, leaf and stem)
- Septoria leaf blotch
- Tan spot
- Powdery mildew
- BYDV
- Hessian fly
- Wheat stem saw fly
- Russian wheat aphid.

2. Improvement of quality in durum and recombinants from crosses with wild relatives

- Protein content
- Vitreousness
- Gluten strength (sedimentation test)
- Farinograph traits (development, stability, mixing tolerance)
- Yellow pigments (carotene, xanthophyll, lutein)
- Ash content
- Kernel size and hectoliter weight
- Black point
- Gliadin and glutenin components.

3 Molecular mapping of tolerance and resistance to abiotic and biotic stresses

(1) The durum populations Jennah Khetifa × Cham 1, and the backcross populations Omrabi 5 × *T. dicoccoides*[1] and Korifla × *T. dicoccoides* are used for mapping desirable traits in the Mediterranean region. Linkage analysis, in particular for quantitative trait loci (QTL), is performed using RFLP markers at ICARDA, Tuscia University and Cornell University.

(2) Wild relatives conferring resistance to abiotic (drought, cold, heat) and biotic (Hessian fly, Russian wheat aphid (RWA), cereal cyst nematodes (CCN)) stresses are crossed with adapted durum genotypes and recombinant lines are being developed and evaluated. Introgression of alien chromatin into *durum* is monitored. For this purpose, repetitive species-specific probes are generated for the relevant *Aegilops* species. All advanced populations are tested in the laboratory and in the field in the SEWANA region. Information on field performance, resistance, and physiological and morpho-physiological traits is used for the QTL analysis.

(3) Markers related to resistance to drought and temperature extremes, and grain quality, are developed. Sequences such as the dehydrin, gliadin and glutenin genes are used to screen for abiotic stresses and grain quality. Identified sequences are applied to the mapping population to determine their location and relationship to other DNA-markers.

(4) A selection of landraces and improved genotypes, showing a wide range of response to abiotic and biotic stresses and grain quality parameters, are being analyzed at ICARDA and Cornell University, using DNA markers from cDNA or genomic libraries and cDNA libraries specific for some abiotic and biotic stress responses. By using multivariate analyses (correspondence analysis, canonic correlation, discriminating analysis), possible associations between quantitative trait polymorphism and molecular markers are estimated. True linkages will subsequently be confirmed in the mapping population.

4. Use of double haploids

The development of haplomethods is a useful step for several biotechnological applications. Genetic map construction is facilitated by the rapid development of completely homozygous lines. Several methods for developing double haploids are investigated:

- Anther culture
- Microspore culture
- Induced gynogenesis through intergeneric crosses
- *In vitro* selection.

5. Funding of collaborative research

As independent research programs each program was independently financed. Some of the durum research activities of the durum breeding program at ICARDA received funds from the Italian and French governments. Since the development of an international network on durum wheat in 1992/93, funds have been given specifically to support collaborative research within the durum network.

[1] = *T. turgidum* L. ssp. *dicoccoides* (Körn ex Asch. & Graebn.) Thell.

Conclusion

A network on durum wheat was established and joint research activities are conducted to improve abiotic and biotic stress resistance, and grain quality, using molecular marker techniques for durum breeding. The collaborating research programs complement each other through division of research activities. The joint ICARDA/CIMMYT international durum breeding program at Aleppo plays an important role in breeding, in testing, in developing and adopting tools and skills, in training, and by integrating the joint research activities of the durum network in the Mediterranean region. Germplasm and related information are available from the Germplasm Program, ICARDA, Aleppo, Syria, upon request.

Forthcoming Events

1995

***24th International Seed Testing Association (ISTA) Congress*, Copenhagen, Denmark, 7–16 June.** 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].

***7th International Symposium on Preharvest Sprouting in Cereals*, Abashiri, Hokkaido, Japan, 2–7 July.** Contact: Secretariat, 7th International Symposium on Preharvest Sprouting in Cereals, Kitami Agricultural Experiment Station, Kunneppu, Hokkaido 099-14, Japan [tel. 0157-47-2146; fax 0157-47-2774]; or, M.K. Walker-Simmons, USDA-ARS, 209 Johnson Hall, Washington State University, Pullman, WA 99164-6420, USA [tel. +1-509-335-8696; fax +1-509-335-8674; E-mail simmons@wsuvml.edu].

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

***10th biennial Australasian Plant Pathology Society Conference*, Lincoln University, Christchurch, New Zealand, 28–30 August.** Contact: Secretariat, 10th Biennial APPS Conference, Centre for Continuing Education, P.O. Box 84, Lincoln University, New Zealand [Tel. 64-3-325-3819; Fax 64-3-325-3840; E-mail crabbd@lincoln.ac.nz].

1996

***5th International Oat Conference and 7th International Barley Genetics Symposium*, University of Saskatchewan, Saskatoon, Canada, 30 July–8 August 1996.** Contact: 5th IOC and 7th IBGS (1996), Crop Development Centre, University of Saskatchewan, Saskatoon, S7N 0W0, Canada [fax +1-306-966-5015].

Recent literature

Books

DeRosa, D.A. 1994. *International trade, regional integration and food security in the Middle East.* Working paper 9406. Economic Research Forum for the Arab Countries, Iran & Turkey, Cairo, Egypt. 40 pp.

Against the background of increasing interest in closer economic relations in the Middle East, the contribution that greater integration of markets might make to improving food security in the region is investigated, using a quantitative framework for guaging the reduction in market supply instability for cereal, meat and dairy commodities under regional cooperation schemes versus more general policies to increase the integration of Middle East markets with markets in Western Europe and the world at large. Nondiscriminatory trade liberalization yields the greatest improvements in food security, but expansion of intra-regional trade relations also results in increased stability of market supplies, except in the case of wheat and other cereals because of already extensive Middle East imports of these commodities commercially and under bilateral and multilateral food aid programs.

Evans, K., D.L. Trudgill and J.M. Webster (eds). 1993. ***Plant parasitic nematodes in temperate agriculture.*** CAB International, Wallingford, UK. 648 pp. ISBN 0-85198-808-3.

This book not only deals with nematodes of specific crop-types (cereals in one chapter), but extraction, identification and control, population dynamics and yield losses, and quarantine.

Hudgens, R.E. 1992. ***Selecting technologies for sustainable agriculture.*** **Development Studies Paper Series.** Winrock International Institute for Agricultural Development. 38 pp. ISBN 0-933595-70-0.

Sustainable rural development is intended to increase food supply and improve living standards while maintaining the quality of the environment. However, there is conflict between the stability of an input-output balance and the rising world population requiring food. Thus, the central focus is agricultural productivity. The green revolution created false optimism and had little impact on crops other than wheat and rice. Rain-fed cropping systems were particularly unaffected. Modern hopes have shifted to biotechnology, but this is unlikely to have great impact without large inputs (particularly financial ones). Increased production in the short term needs to come from adapting existing technologies in areas of high or intermediate potential. This is necessary to relieve pressure on marginal lands. Non-government organizations will be increasingly involved in technology transfer to farmers. However, institutional reform and inter-institutional collaboration are essential.

Priority research areas include: maximizing biological processes and interactions of ecosystems for nutrient recycling and pest control; non-persistent, target-specific pesticides; biological pest control, and stress-tolerant germplasm. Extension should focus on problem-solving in the context of the whole farm, not one-off packages for single crops.

Long-term sustainability will depend on governments pursuing policy-driven development. Emphasis needs to be on bottom-up participatory research, i.e. involvement of farmers at an early stage. Incentives need to be environmentally sensitive

International Fund for Agricultural Research. 1994. ***Agriculture in India: The Role of the International Agricultural Research Centers.*** **Country Report # 14.** IFAR, Arlington, Virginia, USA. ISBN 1-56988-013-1.

International Fund for Agricultural Research. 1994. ***Agriculture in Pakistan: The Role of the International Agricultural Research Centers.*** **Country Report # 9.** ISBN 1-56988-008-5.

International Fund for Agricultural Research. 1994. ***Agriculture in Saudi Arabia: The Role of the International Agricultural Research Centers.*** **Country Report # 8.** ISBN 1-56988-007-7.

International Fund for Agricultural Research. 1993. ***Agriculture in Syria: The Role of the International Agricultural Research Centers.*** **Country Report # 4.** ISBN 1-56988-003-4.

Each of the booklets in this series (ISSN 1021-6324) provides data and information of the aggregate contributions of International Agricultural Research Centers (IARCs) and their developing country partners. Some 22 IARCs are covered including the 18 centers of the Consultative Group on International Agricultural Research (CGIAR). Wheat is the most important crop in terms of production in all of these Asian countries except India, where it comes second to rice. The value of past and ongoing research collaboration between the IARCs and national programs is highlighted. The specific role of ICARDA is evident in the Saudi Arabia and Syria booklets.

Iyama, S-y., K. Tsunewaki and Y. Tateno. 1993. ***Catalogue of wheat experimental strains maintained in the universities and institutes in Japan.*** National Institute of Genetics, Mishima, Japan. 150 pp.

A total of 2547 strains are catalogued as: artificial polyploids (225); aneuploids (689); chromosome substitution lines (341); mutant lines (133); isogeneic lines (43), and cytoplasm substitution lines (1116). Various data are presented for each strain/line, including (parent) species and location (where held).

Jaradat, A.A. and N.I. Haddad. 1994. ***Analysis and interpretation of Mashreq Project [increased productivity of barley, pasture and sheep] findings.*** **ICARDA Special Report.** (Mashreq Document No. 018.) ICARDA/UNDP/AFESD, Amman, Jordan. 133 pp.

A combined analysis of project results over years (1989/90 1991/92) and locations (Iraq, Jordan and Syria). The region has average rainfall of 250–350 mm/year. Fertilizer application increased barley grain and straw yields in Syria, whereas herbicide use alone decreased yields. No one cultivar proved suitable for all regions of Syria. Seeding rate accounted for 74.4% of grain yield variability

in Syria, optimum rate being 100 kg/ha. A full package of agronomic practices (plowing, planting date, seeding rate, cultivar, N + P fertilization, weed control and harvesting) produced 25–30% more grain than traditional methods in Jordan. Improved cultivars with N + P fertilizers outyielded unfertilized improved cultivars and landraces (with or without fertilizer) in Jordan. Dual-purpose barley in Iraq showed no reduction in grain yield after a single (fodder) clipping, but grain yield was significantly reduced after two clippings; however, grazing always reduced grain yield. Cultivar Gizerah 1 outyielded the local Iraqi variety, with and without fertilizers.

Tahir, M., W.K. Anderson, B. Bayaa and G.K. Walker. 1992. ***A review of dryland agricultural research in high elevation areas of north-western Iran: Achievements and suggestions for the future.*** ICARDA, 33 pp.

A review of dryland agricultural research in Iran was conducted in April 1992. Various suggestions are made for the improvement of agricultural research, farm management and extension. The need for collaboration among disciplines is noted; for example, breeders and pathologists working together on breeding for disease resistance, and cereal, legume and forage agronomists working together on crop rotations. Breeding programs need to use meteorological, soil and crop phenology data to characterize target environments. Details of information which could be presented as an extension package for wheat and barley production in cool, dry areas of north-western Iran are presented.

UNIFEM. 1993. ***Storage.*** **Food Cycle Technology Source Book 8.** The United Nations Development Fund for Women (UNIFEM), New York, 46 pp.

Storage is an essential element in food security. Without it, increased agricultural production occurs as seasonal gluts which reduce prices. Storage wards off the fear of starvation in the pre-harvest period. This practical manual covers traditional and improved storage techniques for unprocessed commodities, as well as basic principles and socio-economic aspects.

Proceedings

CIHEAM. 1994. ***Food and agricultural policies in the Middle East and North Africa: Egypt, Lebanon, Morocco, Sudan, Tunisia, Turkey. Proceedings of meetings held in Tunis, 5–7 July 1993.*** **Cahiers OPTIONS Méditerranéennes vol. 7.** 294 pp.

These proceedings are divided in two sections: country reports and the Agricultural and Food Policy Workshop. The country reports which make up the bulk of the book are the result of studies by an informal network established in 1989 by the Ford Foundation. The result of the workshop was the establishment of a Food Policy Network for the Middle East and North Africa and a proposal to establish the Centre for Agriculture and Food Policy Analysis (CAFPA) in North Africa and the Middle East.

CIHEAM–Instituto Agronomico Mediterraneo. 1992. ***International conference on "Supplementary irrigation and drought water management", Valenzano, Bari, Italy, 27 September – 2 October 1992.*** Vol. 1, 2 and 3, sectional pagination.

This is an immense proceedings, each volume running to over 200 pages! The objectives of this conference were (broadly) to open communication channels among experts in various topics and to encourage a multidisciplinary approach to drought and water management. Papers are presented in sessions: Supplementary irrigation in arid and semi arid regions; Socio economic aspects in supplementary irrigation; Planning and managing water resources in arid and semi arid environment; Modelling and drought irrigation management; Plant water relations under water stress conditions, and Unconventional water resources recycling and management under water scarcity and drought environments.

Gowda, C.L.L. and A. Ramakrishna (eds). 1993. ***Cereals and legumes: An Asian perspective. Summary proceedings of the CLAN Country Coordinators' Consultative Meeting, 29 Sep to 1 Oct 1993, ICRISAT Center, India.*** International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India. 160 pp. ISBN 92-9066-280-8.

The Cereals and Legumes Asia Network (CLAN) activities during 1991-93 are reviewed; collaborative research projects in the member countries are described, and future priorities suggested. The role of ICRISAT's research and research-support programs in the network is discussed. Papers from three international research institutes and a major funding agency are also included, outlining their possible contributions to future CLAN activities.

Recommendations are made for future research activities aimed at alleviating the major constraints to the production of CLAN priority crops: sorghum, millets, chickpea, pigeonpea and groundnut.

Molina-Cano, J.L. and J. Brufau (eds). 1991. ***New trends in barley quality for malting and feeding. Proceedings of the Barcelona/Spain seminar, 15–16 November 1990.*** **Options méditerranéennes, série A: Seminaires méditerranéens No. 20.** CHIEAM/IRTA, Bari, Spain. 93 pp.

Some eight papers are presented on the quality of barley grain. The important conclusion of this seminar was a unified concept of barley quality, for feed and brewing. This is in contrast to the old divide between these two uses and should help farmers produce barley of higher intrinsic value.

Saunders, D.A. and G.P. Hettel (eds). 1994. ***Wheat in heat-stressed environments: Irrigated, dry areas and rice-wheat farming systems. Proceedings of the international conferences: "Wheat in hot, dry, irrigated environments", Wad Medani, Sudan, 1-4 February 1993, and "Wheat in warm areas, rice-wheat farming systems", Dinajpur, Bangladesh, 13-15 February 1993.*** CIMMYT, Mexico, DF. 402 pp. ISBN 968-6127-87-9.

Both these conferences were sponsored by UNDP and organized by the Agricultural Research Corporation of Sudan, the Wheat Research Centre of the Bangladesh Agricultural Research Institute, and CIMMYT. The emphasis is on increasing and stabilizing wheat production in hot, dry environments, and also on crop, disease and pest management, which can reduce the effects of very high temperature on yield. Over 70 papers and posters are presented in this compact book.

Somani, L.L. (ed.). 1993. ***Recent advances in dryland agriculture. Proceedings of a national symposium held at CRIDA, Hyderabad, 13-16 September 1988.*** Part I, 252 pp. Part 2, 728 pp. Scientific Publishers, Jodhpur, India. ISBNs 81-7233-057-X, 81-7233-058-8, 81-7233-059-6 (set).

The National Symposium on Recent Advances in Dryland Agriculture was organized by the Indian Society of Dryland Agriculture, the Central Research Institute for Dryland Agriculture (CRIDA) and the Indian Council for Agricultural Research (ICAR). The papers are presented in 10 technical sessions and there is a report on the final plenary session.

Tekinel, O., Y. Bek and S. Çetiner. 1993. ***Agricultural education in Turkey*** **(Country Paper). FAO Regional expert consultation on strengthening the agricultural extension systems in the Near East countries, 6–10 November 1993, Ankara, Turkey. No. 95.** 34 pp.

Base information on agricultural education in Turkey, including curricula of departments of the Agricultural Faculties in Turkey, is presented, along with recommendations from the consultation.

Tekinel, O., Y. Bek and S. Çetiner. 1993. ***An overview of current status and prospects of collaboration between institutions of higher agricultural education and agricultural research institutes in Türkiye. FAO regional expert meeting on promoting the role of universities in national agricultural research system of selected Near East countries, Cairo, Egypt, 12–13 December 1993.*** 26 pp.

A brief overview of agricultural education at universities is presented. The state of agricultural research is given, with emphasis on the Ministry of Agriculture and Rural Affaris (MARA). A proposal for coordination between universities and MARA for training, research and extension is presented.

Thesis

Alamee, J. 1991. ***Use of*** **Hordeum spontaneum** ***in barley breeding under stress conditions.*** Thesis, Diploma in Agricultural Engineering, Lebanese University Faculty of Agricultural Sciences. Mimeograph, 61 pp. + references + appendices.

The objective of this study was to select plants with desirable traits, e.g. earliness, tall plants, long peduncle, many ears/m^2, very many kernels/ear and high grain yield. Seventy-five F_5 lines from crosses of *H. vulgare* [ssp. *vulgare*] and *H.* [*vulgare* ssp.] *spontaneum* were tested in simple lattice design experiments, at ICARDA, Syria. Some five lines showed outstanding performance compared with their parents and with improved checks. Coefficients of correlation and variation suggest that selection should be based on heading date.

Agricultural Libraries Receiving ICARDA Publications

ICARDA publications are deposited in agricultural libraries throughout the world to make them available to other users under normal interlibrary loan and photocopy procedures. These depository libraries are located in the countries listed. Readers requiring information on the library nearest to them should address inquiries to: Library, ICARDA, P.O. Box 5466, Aleppo, Syria.

Algeria
Bahamas
Bahrain
Bangladesh
Benin
Belgium
Bhutan
Botswana
Brazil
Canada
Chile
China
Costa Rica
Cyprus
Djibouti
Ecuador
Ethiopia
Fiji
Finland
France
Ghana
Guatemala
Guyana
India
Iran
Italy
Kenya
Korea (Republic)
Lesotho
Malawi
Malaysia
Mali
Mauritania
Mexico
Myanmar
Netherlands
Nepal
Nigeria
Norway
Papua New Guinea
Philippines
Saint Lucia
Saudi Arabia
Senegal
Somalia
Spain
Sri Lanka
Sudan
Swaziland
Syria
Taiwan
Tanzania
Thailand
Tunisia
United Kingdom
United Arab Emirates
USA
Yemen
Zambia
Zimbabwe

RACHIS BACK ISSUES

Here is your opportunity to make your set of *Rachis* complete! ICARDA Distribution Office needs to make space, so we are going to dispose of all pre-1990 stocks of our three crop-oriented newsletters and bibliographies. We are therefore offering to dispatch near-complete sets and odd back issues to cereal researchers and libraries who have missing copies, or who only recently began to subscribe to the newsletter. Hurry! Do not delay! Stocks will not last and some issues are very rare. Write *today* to: Rachis, CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria.

ICARDA Publications and Services

ICARDA Publications
Request a list of all currently available publications from the Communication, Documentation and Information Services (CODIS).

FABIS Newsletter
FABIS Newsletter is produced biannually by the Faba Bean Information Service. It publishes short scientific papers on the latest research results and news items related to faba bean and other legumes in the genera *Vicia* and *Lathyrus*. For further information or to receive a sample copy, write to: FABIS/CODIS.

LENS Newsletter
The newsletter of the Lentil Experimental News Service is produced twice a year at ICARDA in cooperation with the University of Saskatchewan, Canada. Short research articles provide rapid information exchange, and comprehensive reviews are invited regularly on specific areas of lentil research. The newsletter is available free to lentil researchers. An annual supplement to the newsletter contains lentil 'references, previously issued in *Lentil in AGRIS*. For further information or to subscribe, write to: LENS/CODIS.

Opportunities for Training and Post-graduate Research at ICARDA
ICARDA has active training courses on the development and improvement of food legumes, cereals, and forages with ICARDA's research scientists, trained instructors, and proven programs. For a complete brochure of the training opportunities at ICARDA, write to: Training Coordination Unit.

Graduate Research Training Awards, Opportunities for Field Research at ICARDA
The Graduate Research Training Program (GRTP) is intended primarily to assist Master of Science and PhD candidates who are enrolled at national universities within the ICARDA region. Men and women who are selected for the program will have an opportunity to conduct their thesis research work at ICARDA research sites under the co-supervision of university and center scientists. For further information on terms of award, nomination procedure, selection criteria, appointment conditions, the university's responsibilities, and the student's responsibilities, write to: GRT Program, Training Coordination Unit.

Library Services
The ICARDA library maintains bibliographic databases for the use of researchers at the center and elsewhere. Literature searches will be conducted for research workers by the library staff, upon request, and results downloaded to diskette or hard copy. Photocopies of articles identified in a literature search can be provided to users, if available. Researchers can request a literature search by letter or telex to: Library.

To obtain further information on these services, please write to the program indicated and state that you saw the advertisement in *Rachis*: ICARDA, P.O. Box 5466, Aleppo, Syria.

Contributors' Style Guide

Rachis publishes the results of recent research on barley and wheat, in English with Arabic abstracts. (Letters written in Arabic or French will be accepted for publication.) Articles should be brief, confined to a single subject and be of primary interest to researchers, extension workers, producers, administrators and policy makers in the field of barley or wheat research. Articles submitted to *Rachis* should not be published or submitted to other journals or newsletters.

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

Manuscript

Contributions should be sent to: RACHIS/CODIS, ICARDA, P.O. Box 5466, Aleppo, Syria. The name, address, and telex or fax number of the corresponding author should be included in the covering letter. One good-quality original of the text should be submitted, typed double-spaced on one side of the paper only. Figures should be original drawings, good-quality computer print-outs or black-and-white photographs of good quality. Photographs and figures should be suitable for reduction to a printed size of 8.5 or 17.4 cm wide. Photocopies are not acceptable for publication.

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.

ICARDA-005/2000/February 1995



International Center for Agricultural Research in the Dry Areas

(ICARDA)

P. O. Box 5466, Aleppo, Syria