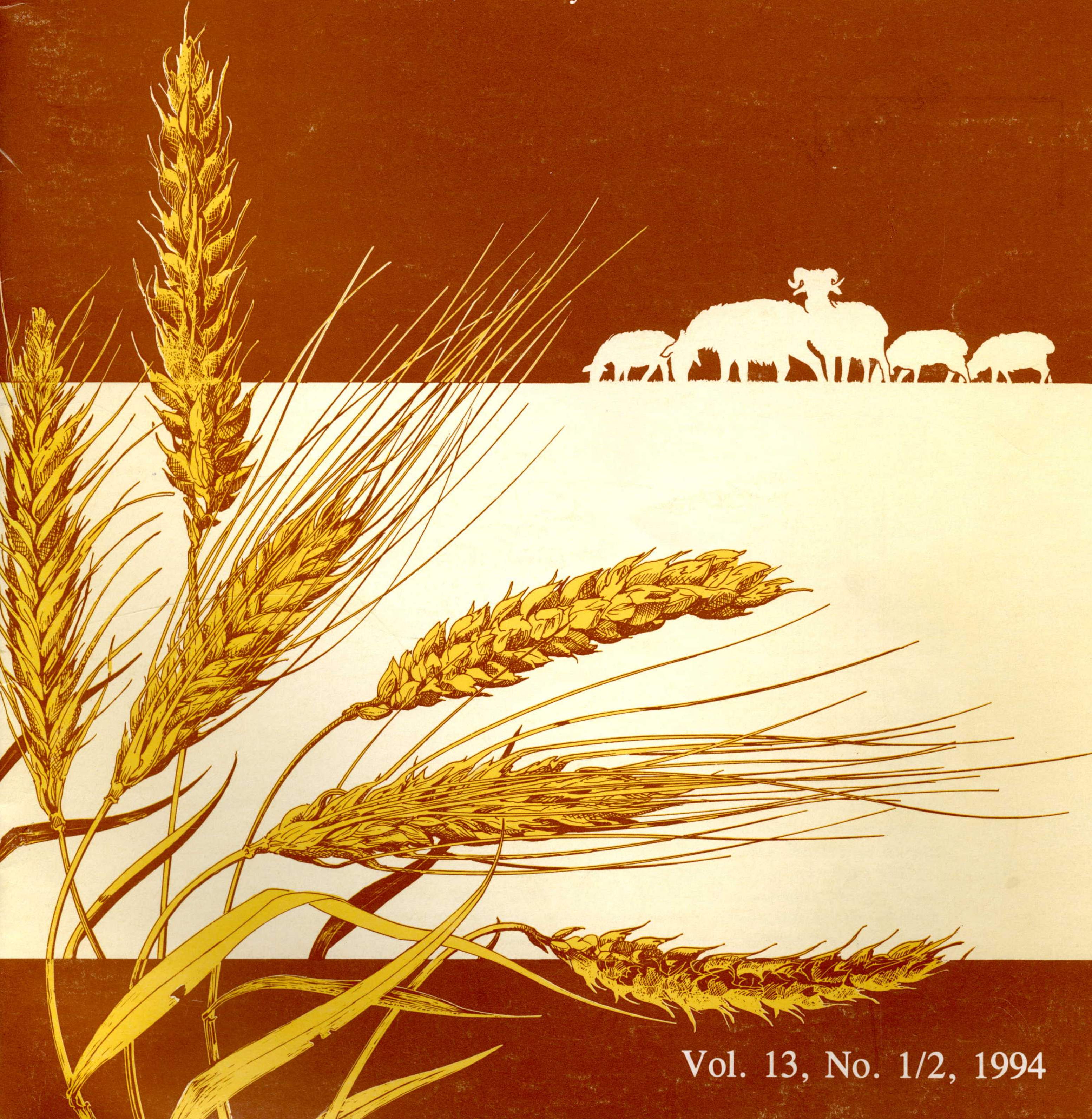
RACHIS

Barley and Wheat Newsletter



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Vol. 13, No. 1/2, 1994

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.

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Research and Production

Visual Evaluation of Barley Lines in Cyprus

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Abstract

Data on visual evaluation of varieties by the agronomic score (AS) and on grain yield from 114 variety trials with 10–25 varieties each, conducted in Cyprus during 1988–92, were used to evaluate the use of AS in assessing yield of barley (*Hordeum vulgare* L. ssp. *vulgare*) breeding material. AS was significantly correlated with grain yield in most trials in which unselected material was evaluated. AS provides useful information even for lines in the final stages of testing. Other studies in the WANA region on analytical selection procedures identified individual traits which could be used, along with visual selection, in breeding for consistency of performance under dryland conditions.

Key words: *Hordeum vulgare;* barley; genotypes; selection; evaluation; yields; agronomic characters; genetic correlation; grain; rain fed farming; Mediterranean climate; Cyprus.

تقييم بصري لسلالات شعير في قبرص

الملخص

استخدمت بيانات التقييم البصري للأصناف عن طريق تحديد الدرجة الزراعية (AS) وبيانات الغلة الحبية من 114 تجربة على الأصناف، كل منها مكون من 10–25 صنفاً، أجريت في قبرص خلال 1980–92، وذلك لتقييم استخدام AS في تحديد غلة مادة التربية للشعير (*Hordeum vulgare* L. ssp *vulgare*) . وقد ارتبطت AS بالغلة الحبية معنوياً في معظم التجارب التي تم فيها تقييم المادة غير المنتخبة. وتوفر AS معلومات مفيدة حتى للسلالات في مراحل الاختبار النهائية. وقد حددت دراسات أخرى في منطقة وانا، على إجراءات الانتخاب التحليلي، صفات محددة يمكن استخدامها في التربية إلى جانب التقييم البصري بغية التوصل إلى كفاءة موحدة تحت ظروف المناطق الجافة.

Introduction

Evaluation of new barley genotypes which originate either from a crossing program or introduction from other areas, passes through several stages. Different methods are employed during this selection process, the relative importance of which depends on the stage of testing (e.g. segregating population vs final large-plot variety trials), the experience of the breeder, the availability of funds, and other factors.

In segregating populations, single-plant selection is mainly based on visual evaluation and not on yield. A deep knowledge of the relationships of individual traits (e.g. earliness, plant height, disease resistance) with yield and consistency of performance is necessary for efficient selection. Results from research conducted in the dryland Mediterranean climates has provided useful data for breeding programs (Hadjichristodoulou 1987, 1992; Acevedo et al. 1991; Ceccarelli et al. 1991).

The second step of screening genotypes is normally done in unreplicated nurseries with 1–2 rows for each genotype, each row 1–2 m long. The comparison is based on checks, sown at fixed intervals in the nursery, e.g. every 20 entries. Visual selection plays an important role in genotype evaluation in nurseries, though grain yield may be also included as a selection criterion.

The final stage of evaluation uses biometric techniques for statistical evaluation of the performance of genotypes. Grain yield is the major selection criterion, but other traits are also recorded. Recording traits other than grain yield enables the breeder to eliminate the genotype × environment interaction caused by unpredictable environmental factors (Hadjichristodoulou 1987, 1992; Acevedo et al. 1991; Ceccarelli et al. 1991). The performance of genotypes in yield trials is also evaluated visually just before harvesting, in order to obtain information on the general value of genotypes.

The purpose of this paper is to discuss the value of visual evaluation of genotypes in yield trials, with special reference to barley.

Materials and Methods

The data for this study were obtained from variety trials conducted in Cyprus under rain-fed conditions during 1988–92. The series 35/1/A, B and BF consisted of 25 lines selected from the breeding program and were included for the first time in yield trials or, at most, after one year of testing (Table 1). The same was true for the International Trials, which consisted of material introduced from other countries and evaluated in Cyprus for the first time. Trials of series C, D and E consisted of 10 varieties each, but this material had been selected after 2–4 years in yield trials.

Visual scoring of varieties was expressed as Agronomic Score (AS), on a 1–9 scale, 1 given to the most desirable and 9 to the worst lines. The best available varieties, checks, were given score 4. The AS has been widely used by the International Center for Agricultural Research in the Dry Areas (ICARDA) and other international centers working on cereals. AS is based on the overall apperance of the plot just before harvesting, including measurable as well as non-measurable traits. Ear and grain shattering, lodging and losses from overmaturity are accounted for, in addition to traits like plant height, tillering capacity and disease resistance.

Grain yield was also recorded on a plot basis and correlation coefficients between grain yield and AS were computed from variety means to assess the association between the two recordings.

Results and Discussion

The data reported were obtained from a total of 114 trials. In most trials, there was a significant negative correlation between grain yield and AS. The best lines, having low AS, gave high grain yield. The significant correlation coefficients ranged from –0.41 to –0.91 (Table 1). In some trials, however, there was no significant correlation between AS and grain yield. Lines in the series C, D and E trials were selected from earlier yield trials. In only 48% of the 52 C, D and E trials, was the correlation significant. However, in the other trials, which included material not evaluated before for yield, the correlation was significant in 45 of the 62 trials.

The results show that AS can be used in assessing yield of lines, with more accuracy in unselected breeding material. In fact, at this stage of selection, AS is most needed to enable the breeder to reduce the number of lines entering costly yield trials. At the final stages of evaluation and for varieties close to release, major emphasis must be given to yield. However, even in this case, visual scoring is useful, as it can give an assessment of the performance of a line, considering all traits, including those not easily measured.

The AS is environment specific, as are yield and other traits. If a breeder is interested in selecting lines with consistently high performance over years and at other environments, including other years, he must use the analytical procedures described by Hadjichristodoulou (1987, 1992), Acevedo et al. (1991) and Ceccarelli et al. (1991). Among the traits recommended in selecting for consistency of performance (or stability) over a wide range of dryland conditions are optimum earliness for each location, profuse tillering and stability of number of

Table 1. Significant correlation coefficients between grain yield and AS (Agronomic score).

Trial	Number of varieties	Number of trials	Number of trials with significant correlation ($P \leq 0.005$)
35/1/A	25	24	18 (–0.41 to –0.78)
35/1/B	25	13	9 (–0.42 to –0.74)
35/1/BF	25	12	10 (–0.40 to –0.81)
International trials	24	13	11 (–0.45 to –0.80)
35/1/C	10	30	11 (–0.65 to –0.76)
35/1/D	10	7	4 (–0.63 to –0.80)
35/1/E	10	15	11 (–0.64 to –0.91)

tillers/m^2, height, high Harvest Index, long awns, disease resistance and early seedling vigor. AS is a subjective score and, therefore, not as accurate as other measurements. Practise and good understanding of the crop and environment are necessary in order to use AS efficiently.

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Stress Tolerance in Winter and Facultative Barley

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Abstract

Studies were carried out to evaluate ICARDA's winter barley germplasm (*Hordeum vulgare* L. ssp. *vulgare*) to identify lines/varieties with good tolerance of drought (DT), cold (CT) and boron (BT). The evaluation and screening of ICARDA nurseries for different stresses was done at five locations: Breda (Syria) for DT and BT, Tel Hadya (Syria) for DT, Haymana (Turkey) and Krasnodar (Russia) for CT and resistance to lodging, and Kazan (Turkey) for CT and BT. In dry areas with mild winters, local varieties appeared to be the highest yielding due to high DT. There were genotypes which showed multiple stress tolerance to drought, cold, boron and at the same time had good yield. Based on these studies the crossing block has been reconstituted, to include the following varieties and lines: Wysor, OK 84817, NE 89747, Acton, Obruk 86, Activ, Bastion, ICB 101332, ICB 105968, ICB 101294, ICB 101294, ICB 100111, ICB 100034, KS 87C37, ICB 101302, super-early chinese lines ICB 118167, ICB 118032, ZDM 8265. Local varieties Arabi Aswad, Tokak, Walfajer, Zarjou, Baluchistan and some of the elite lines possess very good BT.

إجهاد التحمل في الشعير الشتوي والاختياري

الملخص

نفذت دراسات لتقييم الأصول الوراثية للشعير الشتوي الموجودة في إيكاردا (*Hordeum vulgare* L. ssp. *vulgare*) بغية تحديد السلالات/الأصناف ذات التحمل الجيد للجفاف (DT) والبرودة (CT) والبورون (BT). وقد أجريت لمشاتل إيكاردا عمليات تقييم وغربلة لمختلف الإجهادات في خمسة مواقع : بريدة (سورية) لتحديد DT و BT، تل حديا (سورية) لتحديد DT، هيمانا (تركيا) وكراسندار (روسيا) لتحديد CT والمقاومة للرقاد، وقازان (تركيا) لتحديد CT وBT. أبدت الأصناف المحلية في المناطق الجافة ذات الشتاء المعتدل؛ أنها الأوفر غلة نظراً لارتفاع درجة تحملها للجفاف. وهناك طرز وراثية أظهرت تحملاً لإجهادات متعددة، الجفاف والبرودة والبورون وأعطت في نفس الوقت غلة جيدة. واعتماداً على هذه الدراسات أعيد تكوين قطاع التهجين ليشمل الأصناف والسلالات التالية :

Wysor, OK 84817, NE 89747, Acton, Obruk 86, Activ, Bastion, ICB 101332, ICB 105968, ICB 101294, ICB 101294, ICB 100111, ICB 100034, KS 87C37, ICB 101302, والسلالات الصينية الباكورية للغاية 118167, ICB 118032, ZDM 8265. وتتمتع الأصناف المحلية، عربي أسود، Tokak, Walfajer, Zarjou, Baluchistan، وبعض السلالات المتفوقة بمقدرة جيدة جداً على تحمل البورون.

Yield losses caused by boron toxicity in Breda and Kazan were assessed. In the stress-free location of Tel Hadya, four nearly identical lines from the cross Zarjou/80-5151 had similar yields with a maximum difference of 11% between them. Whereas in Kazan, the difference reached 62% among these sister lines, which is attributed to their reaction to boron toxicity.

Key words: *Hordeum vulgare*; barley; genotypes; germplasm; evaluation; drought resistance; cold; temperature resistance; boron; phytotoxicity; chemical resistance; yields; Russia; Syria; Turkey.

تم تقدير الخسائر في الغلة الناجمة عن سمية البورون في بريدة وقازان. وقد أعطت أربع سلالات متماثلة تقريباً من الهجين Zarjou/80-5151 في موقع تل حديا الذي لايتعرض للإجهادات، غلة مماثلة بفارق أقصاه 11٪ بين تلك السلالات، في حين بلغ الفارق 62٪ بين تلك السلالات الشقيقة في قازان، الأمر الذي يعزى إلى تفاعلها مع سمية البورون.

Introduction

The main constraints to winter and facultative barley production in the highlands of West Asia and North Africa (WANA) are biotic and abiotic stresses: diseases and insects, cold, heat, drought, problematic soils, salinity, and boron toxicity (ICARDA 1992a). Their interaction complicates the identification of the simple effect of each stress and hinders the acquisistion of information necessary for setting research priorities and developing appropriate methods and techniques for screening.

The complexity of these traits and the genotype × environment interactions force breeders to use various sources of germplasm to process a great volume of breeding material, and to test it in various soil–climate conditions or artificially "create provocative environments" (Sparrow 1992) for testing.

The goal of this study was to evaluate recently developed and introduced winter and facultative barley lines for stress tolerance in order to identify lines/cultivars possessing good plant architecture and other agronomic traits. with multiple resistance against drought, cold and boron.

Material and Methods

Due to low disease incidence and severity at ICARDA-Tel Hadya (Syria), the 1992/93 cropping season was suitable for assessment of barley germplasm for its tolerance to non-biotic stresses, which were: drought and boron toxicity in Breda (Syria), drought in Tel Hadya, cold and lodging in Haymana (Turkey) and Krasnodar (Russia), cold and boron toxicity in Kazan (Turkey).

The tested material included 24 entries from the International Winter and Facultative Barley Yield Trials (IWFBYT), a special set of 24 varieties from different countries selected from the International Winter and Facultative Barley Adaptation Yield Trials (IWFBAYT), 150 lines from the International Winter and Facultative Barley Crossing Block (IWFBCB), 150 lines of the International Winter and Facultative Barley Observation Nursery (IWFBON), and 2200 lines from the Winter and Facultative Barley Elite Lines (WFBEL).

All nurseries were drill-sown; IWFBYT and IWFBAYT with eight-row plots 2.5 m long, with 20 cm between rows and 30 cm between plots in randomized complete block design with three replications, whereas in IWFBON and IWFBCB augmented design with systematic checks was used. The WFBEL nursery was grown on plots 10 m long in one replication. All were harvested by experimental-plot combine.

The evaluation for cold tolerance (percentage survival) was carried out under controlled conditions by using low temperatures from -8°C to -11°C during 18–24 hours in growth chambers both at ICARDA and in Krasnodar with the application of modified methods described earlier (Tahir et al. 1987; Tahir and Banisadr 1991). Tested plants were 30–45 days old and in one experiment they were in the beginning of booting stage. Additional data on cold tolerance under field conditions in Turkey and Russia were also recorded as plant survival after overwintering.

To evaluate the nurseries for boron toxicity resistance, all the experiments were planted at Kazan Research Farm in a field with a severe boron toxicity problem and the data were recorded by using 1 (resistant – no necrotic spots) to 5 (susceptible – with severe necrotic spots) scale. Supplementary data on boron tolerance from laboratory studies were also used in the interpretation of results.

Results and Discussion

The yield data from Breda showed that in dry conditions with warm winters and restricted growth period, the genotypes targeted for cold climate could not compete with local spring-type checks. At Breda the rainfall is restricted to winter months with very little or no rain from early spring onwards. This limitation favors genotypes which are photoperiod insensitive with minimum or no vernalization requirement. Therefore, inspite of good drought tolerance the winter and facultative barley lines could not compete with spring-type check varieties for grain yield, because a much longer growth period was needed for the completion of their life cycle due to the presence of vernal gene(s) and photoperiod sensitivity. It is also well established that increased level of cold tolerance, which is generally associated with vernal gene(s) and photoperiodism, often influences many biological characteristics especially the rate and duration of growth (Hoshino and Tahir 1987; Tahir et al. 1987; ICARDA 1992b). The ability of a line/variety to have vigorous growth and form good biomass in a short period of time after seedling emergence is positively correlated with high yield potential in dry areas with short growth period. However, in Tel Hadya and Breda some entries such as CWB 117-5-9-5, Tokak, Walfajer, Victoria, and several promising lines from WFBEL had productivity close to that of the best drought-resistant check varieties Arabi Abiad, Arabi Aswad and Rihan-3 (Table 1).

Table 1. Performance of winter barley in advanced trials

Line	CT%[†]	Breda		Tel Hadya	Kazan		Haymana	
		DT[‡]	Yield (kg/ha)	Yield (kg/ha)	CT[§]	Yield (kg/ha)	CT[§]	Yield (kg/ha)
				IWFBYT				
Tokak	75.4	4.0	2411	3888	4.0	4510	4.5	5002
CWB117-...	82.7	4.5	2411	4344	3.2	2834	3.0	5559
Monolit	80.4	4.0	2000	3888	4.0	3873	4.5	7879
Plaisant	74.3	4.0	1722	4111	3.5	2734	3.0	4770
K-253	100	2.5	1655	3666	4.0	3583	4.5	7362
Salmas	46.4	5.0	2244	4111	1.7	1879	2.0	3789
A.Abiad	20.3	5.0	2788	4333	1.5	1540	1.7	2120
Rihan-3	5.6	5.0	2944	4111	1.0	1328	1.0	1540
$LSD_{0.05}$	11.8		536	663		720		844
				IWFBAYT				
Tokak	78.6	4.0	2544	3888	4.5	3853	4.5	5549
Bulbul	86.8	4.0	2655	4888	4.0	3666	4.5	6272
Walfajer	62.3	4.5	2555	5083	3.0	2807	3.0	4766
Zarjou	52.3	4.0	2177	4444	2.7	2320	2.5	3479
Baluchist	56.4	5.0	1777	4388	2.7	2369	3.0	2214
Victoria	80.4	4.5	2500	5083	3.5	2942	3.5	6414
Plaisant	74.3	4.0	1788	4666	3.0	2478	3.5	5285
Lignee527	98.4	4.0	1844	4250	4.5	3679	4.0	5679
Robur	70.6	3.0	1744	4555	3.2	2133	3.0	5224
Cyclon	98.6	2.5	1722	4166	3.0	2863	4.0	7913
Novator	90.6	1.0	1111	2000	4.0	2506	4.5	6594
A. Aswad	62.6	5.0	2500	4166	2.0	1844	2.5	3433
A. Abiad	20.3	5.0	2833	4777	0.7	499	0.5	834
Rihan-3	5.6	5.0	2933	4555	0.5	391	0.5	869
$LSD_{0.05}$	11.8		560	722		736		862

[†] CT% = Percentage of plants surviving after freezing.
[‡] DT = Drought tolerance as agronomic score: 1=very low, 3=medium, 5=very high.
[§] CT = Cold tolerance as agronomic score in the field: 1=very low, 3=medium, 5=high.

The agronomic score in Breda indicates the genotype reaction to drought and boron toxicity. The majority of the top-yielding lines in Breda also performed well in Tel Hadya, except lodging susceptible or super early lines, which could not make effective use of the late rains in May. The data demonstrate the possibility of combining important traits and identifying genotypes with acceptable balance of many desirable characters provided the volume of breeding material and selection pressure are sufficient.

In Tel Hadya, where there was no cold or frost damage even on spring-type varieties, 410 elite lines from different hybrid combinations were selected on the basis of high grain yield and good adaptability to dry conditions. The cold-tolerance scores in Kazan ranged from 2 to 5. A correlation coefficient between cold tolerance and yield in non-stressful environments was rather low (r=0.06), indicating the lack of biological barrier, in combining these traits without sacrificing yield. This theory is varified by cv. Lignee 527, which possesses very good cold tolerance and at the same time has other desirable agronomical characters, hence its good performance in several locations. It performed well even in mild environments where a high level of cold hardiness was not needed. In the Winter and Facultative Barley Project at ICARDA efforts are made to develop germplasm with different levels of cold tolerance, suitable for a number of locations. Selections, therefore, in the breeding nurseries of ICARDA's base-program are directed not only at identifying extremely tolerant genotypes but at achieving a gradient in cold tolerance. In the WFBEL nursery, the highest yield (7300 kg/ha) was obtained with moderately tolerant line Dier Alla 106/4/Cel/XY2240 (Table 2).

The data for resistance to abiotic stresses indicate that new winter barley germplasm is showing increased tolerance as a result using new resistant sources in hybridization and heavy selection pressure at appropriate testing sites of Kazan, Haymana, Kayseri and Ulas (Turkey). and under controlled environments at ICARDA and Krasnodar.

The importance of cold tolerance is sometimes underestimated, because many recent winters were rather warm and did not cause major damage to the crop. While average annual temperature may increase with global warming, even a very short cold spell can seriously damage all of a crop which has inadequate resistance to cold or frost. Yield data from Kazan and Haymana clearly demonstrate that cold-susceptible varieties – Rihan-3, Arabi Abiad, Salmas and others – could not recover after winter stress and gave no grain yield. Cold tolerance is a complex character and consists of many morpho-physiological components which can interact with environmental components individually or pleiotropically and, to a certain extent, can compensate any lack of physiological resistance. However, the varieties which cannot withstand temperatures of −10 to −11°C at tillering are extremely risky to cultivate in this area. Here the yield potential and especially yield stability are very closely linked with the degree of expression of this trait and its strong relationship with other economically important characters (Table 3).

Table 2. Performance of top-yielding winter barley lines at Tel Hadya.

Line/variety	CT†	GV†	HD‡	Yield (kg/ha)
Salmas	3	5	16.04	4964
Rihan-3	1	5	14.04	6175
Tokak	5	3	26.04	4400
Rihan-3/ICB 105932	5	5	9.04	6500
Roho/Mazurka//ICB 103020	5	5	16.04	6650
ICB 101669//Gaines/Ore'S'	3	5	19.04	6560
Chi Cm/AN 57//Albert/3/ICB 102379	4	5	16.04	6240
Kitchin/Mullers Heydla//Salmas	5	5	17.04	5600
Deir Alla 106/4/Cel/XY 2240...	3	5	14.04	7300
Zarjou/80-5151	5	4	20.04	6650
Rihan-3/Lignee 640//ICB 102854	3	5	18.04	6450
CWB 117-77-9-7/ICB 102893	5	5	16.04	6670
CWB 22-6-13/ICB 102893	5	4	20.04	6150
$LSD_{0.05}$				663

† CT, GV = Cold tolerance and growth vigor score, respectively: 1=very low, 3=medium, 5=high.
‡ HD = Heading date.

Table 3. Correlation coefficients between main determinants for selections in winter barley in Turkey.

Correlated characters	Kazan		Haymana	
	IWFBYT	IWFBAYT	IWFBYT	IWFBAYT
Cold tolerance - yield	0.82	0.92	0.70	0.86
Agronomic score - yield	0.72	0.92	0.57	0.90
Cold tolerance - agronomic score	0.86	0.93	0.57	0.80

The trials in Haymana revealed the yield potential of the tested entries. The list of top-yielding varieties included Monolit, K-253, Cyclon, Star, Novator and Victoria, which did not perform so well in Tel Hadya, Breda and Kazan because of insufficient drought tolerance, lateness, and boron susceptibility. Of course, in the field it is not easy to separate the pure effect of every factor, but by regular field observations and thorough analysis it is possible to do so, at least in part. In order to exclude the influence of the cold tolerance, which can foster barley yield in Kazan and hinder its performance in Breda, four varieties from IWFBYT and six from IWFBAYT have been chosen for comparison. The criteria for selecting these rather productive varieties was their similarity in cold tolerance and in maturity time. The data showed that, at the yield potential level of 4–5 t/ha as it was in Tel Hadya, the drought tolerance did not play as significant a role as in Breda (yield level of 2–3 t/ha).

Compared with Tokak, varieties Monolit, Plaisant and K-253 in Breda and Tel Hadya, showed yield decreases of 17.1, 28.6 and 31.4%, respectively (Table 4). These yield losses can be attributed to lower tolerance to drought and lower resistance to boron toxicity, as confirmed by agronomic scores and degree of leaf necrosis. At the same time the relative yield decline of these lines in Kazan of 16.2, 39.6 and 20.6%, respectively, can be related mostly to lower boron tolerance, because yield potential in Tel Hadya and Kazan was the same (4–5 t/ha), but in Kazan it was realized by local variety Tokak only, which is very resistant to boron toxicity, as has been shown in laboratory tests (Yau et al. in press).

Table 4. Relationship between Boron sensitivity and yield in winter barley.

Line	BS†	Breda		Tel Hadya		Kazan	
		(kg/ha)	% tolerant	(kg/ha)	% tolerant	(kg/ha)	% tolerant
				IWFBYT			
Tokak	1	2411	100	3888	100	4510	100
Monolit	3	2000	82.9	3888	100	3873	85.8
Plaisant	3	1722	71.4	4111	105.7	2734	60.4
K-253	4	1655	68.6	3666	94.3	3583	79.4
$LSD_{0.05}$		536		366		720	
				IWFBAYT			
Tokak	1	2544	100	3888	100	3853	100
Bulbul	1–2	2655	104.3	4888	125.7	3666	95.2
Plaisant	3	1788	70.3	4666	120.0	2478	64.3
Robur	4	1744	68.5	4555	117.1	2133	55.3
Cyclon	4	1722	67.7	4166	107.1	2863	74.3
Novator	5	1111	43.7	2000	51.4	2506	65.0
$LSD_{0.05}$		560		722		736	

† BS = Boron sensitivity as a leaf necrosis score: 1=very low, 3=medium, 5=very high.

The same approach in the analysis of the data in IWFBAYT gives additional evidence that in Kazan site the boron tolerance plays a significant role. In this nursery the comparison of rather flexible and cold-tolerant varieties Plaisant, Robur and Cyclon with Tokak shows that their yield losses – 37.7, 44.7 and 25.7%, respectively – were to a great extent related to poor boron tolerance. Only the very sensitive Novator failed in all three locations due to its lateness and insufficient drought tolerance.

Of course, the use of isogenic lines with different boron reaction could help to determine more precisely yield losses caused by high boron concentration in the soil. The examination of 1332 lines from WFBYT in Kazan revealed good tolerance in some. Four lines from the cross Zarjou/80-5151 were especially suitable for comparison due to their very close phenotypes. Two of them displayed a distinct spot necrosis on the leaves, while the other two did not have any symptoms. These lines harvested in Tel Hadya surpassed the nearest check Bulbul by 17–28%, with the maximal difference between them 11% (Table 5). In Kazan, this difference reached 62% and can be attributed to boron toxicity, because all of them have the same level of cold tolerance and are very similar in duration of vegetative period and other agronomic traits, which explains their similar yield in Tel Hadya, where this constraint was absent. For more detailed verification of genotypic reaction to boron toxicity thoroughly planned experiments will be carried out in the field and in the laboratory.

Table 5. Performance of winter barley lines with different reaction to excessive boron.

Line/Cross	Kazan				Tel Hadya Yield	
	Boron reaction	CT	Yield			
			(kg/ha)	% tolerant	(kg/ha)	% tolerant
Bulbul	Tolerant	5	4000	100	4420	100
1 Zarjou/80-5151	Tolerant	5	5800	145	5200	117
2 Zarjou/80-5151	Sensitive	5	3348	83	5250	118
3 Zarjou/80-5151	Sensitive	5	3556	89	5300	120
4 Zarjou/80-5151	Tolerant	5	5044	126	5700	128
$LSD_{0.05}$			728		663	

CT = Cold tolerance.

Conclusions

The results of the research have emphasized once more the importance of winter barley improvement for cold and drought tolerance as well as for resistance to boron toxicity.

The realization of available genetic polymorphism for boron tolerance through development of new varieties can have the same economic effect as achievements in breeding for cold and disease tolerance. Breda in Syria and Kazan in Turkey are suitable locations for evaluation and screening of breeding material for this character.

On the basis of complex assessment, a set of reliable sources for increased winter hardiness has been identified, including foreign varieties/lines Wysor, Perkins, OK 84817, NE 89747, Acton, Obruck 86, 4679/105//YEA 455, Activ and Radical, and ICARDA collection ICB 101332, ICB 105968, ICB 101294, ICB 100111, ICB 100037, KS 87C37 and ICB 101302, and super-early Chinese lines ZDM 8265 and ICB 118108.

Local varieties Tokak, Bulbul, Arabi Aswad, Walfajer, Zarjou and Baluchistan possess good drought tolerance and resistance to boron toxicity.

A very successful combination of cold tolerance, wide plasticity and good productivity is well expressed in varieties Tokak, Bulbul, CWB 117-5-9-5, Star, Lignee 527, Monolit, Victoria, and new promising ICARDA lines CWB 117-77-9-7/ICB 104073 Rihan/Lignee 640, and Robur/J-125//OWB 753343D/SL3.

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Bread Wheat Selection for Tolerance to Abiotic and Biotic Stresses in Highland Balochistan

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Abstract

Bread wheat (*Triticum aestivum* L. ssp. *aestivum*) lines were screened in multi-location trials in highland Balochistan, Pakistan from 1982 (F_2) to 1990 (fixed lines). The objective was to select and evaluate desirable genotypes for winter planting. Of 816 entries only four successfully passed through the observation nurseries and yield trials. After nine years of testing

انتخاب القمح الطري لصفة تحمل الإجهادات اللا أحيائية والأحيائية في المناطق المرتفعة من بالوخستان

الملخص

تمت غربلة سلالات قمح طري *(Triticum aestivum* L. ssp *aestivum)* في تجارب متعددة المواقع في المناطق المرتفعة من بالوخستان في الباكستان، من عام 1982 (F2) إلى عام 1990 (سلالات ثابتة). وكان الهدف منها القيام بغربلة وتقييم الأصول الوراثية المرغوبة للزراعة الشتوية. فمن أصل 816 مدخلاً، انتقل بنجاح أربعة مدخلات فقط إلى مشاتل المشاهدة وتجارب مقارنة الغلة. وبعد تسع سنوات من الاختبار، لم يتم سوى انتخاب طراز وراثي واحد (ICW81.1471) لاختبار الصفات الزراعية على نطاق واسع. ورغم أن الكفاءة الإنتاجية لهذا الطراز لم

only genotype ICW81.1471 was selected for wide-scale agronomic testing. Although the yield potential of this genotype was not significantly higher than that of the local check, it had the important advantage of possessing good resistance to yellow rust (*Puccinia striiformis* West). The results showed that exposure of a segregating population to the prevailing environmental stresses of cold and drought was an effective selection procedure for identifying genotypes which are resistant to such stresses. Effective selection can be made for other desirable attributes such as disease and pest resistance, plant height and time to maturity.

Key words: *Triticum aestivum*; soft wheat; genotypes; selection; disease resistance; pest resistance; cold; temperature resistance; drought resistance; arid climate; highland; Pakistan.

تكن أعلى معنوياً من الكفاءة الإنتاجية للشاهد المحلي، إلا أنه تفوق على الصنف المحلي بامتلاكه ميزة هامة تجلت في مقاومته الجيدة للصدأ الأصفر (*Puccinia striiformis* West). وقد أظهرت النتائج أن تعريض العشائر الانعزالية إلى الإجهادات البيئية السائدة من برودة وجفاف إجراء فعال في عملية الانتخاب لتحديد الطرز الوراثية المقاومة لهذه الإجهادات، كما يمكن القيام بانتخاب فعال للصفات المرغوبة الأخرى من قبيل مقاومة الأمراض والآفات، طول النبات والزمن حتى النضج.

Introduction

In Balochistan province, Pakistan most of the rain-fed wheat is grown in the highlands. Yields are low mainly because of moisture stress; however, other causes of low yield are cold winters, yellow rust epidemics in the few wet years, non-availability of improved genotypes, and poor cultural practices. Climatic conditions are severe. The most important factor is the rainfall which averages 240 mm, but varies greatly between and within seasons, and also spatially. Summers are hot and dry, and winters are cold and may be quite wet, with some snow. If adequate rainfall is received in late summer or fall, wheat is sown in October or November. If rainfall is scant in summer/fall, but some falls in winter, spring planting is done. Genotypes needed for winter planting differ from those for spring planting, but both need to have good drought tolerance, as the soil moisture reserves towards the end of the growing season are usually small and diminishing rapidly.

Another important environmental constraint is severe frost, which often occurs during the early vegetative growth of crops planted in October–November. However, many genotypes can recover from such cold damage and start growing again in the spring, to give reasonable yields. Breeding, evaluation and selection for desirable characters in this environment are difficult because cold and drought resistance are rarely found together in a single genotype. A very cold-resistant variety may not be high yielding if it is unable to escape terminal drought; a cold-susceptible variety may be the highest yielding in a warm winter, but in a cold winter the same line may be killed completely by low temperatures. Breeding and selection for yellow rust resistance is another important aspect, as this disease can have a major impact on wheat yields in the highlands of Balochistan (Ahmad et al. 1990; Mohammad 1989).

Since 1982, the Arid Zone Research Institute (AZRI) has been collaborating with the International Center for Agricultural Research in the Dry Areas (ICARDA) in a wheat-improvement program. It has established a multi-locational testing program in Balochistan to develop improved varieties for these difficult conditions, at sites ranging from 1500 to 2300 m elevation.

The objective of the study reported here was to select lines for winter sowing.

Materials and Methods

In the 1982/83 season, 816 entries of winter bread wheat F_2 populations were received from the ICARDA Cereal Improvement Program. The segregating populations (F_2–F_6) were planted at Quetta from 1982 to 1988 in order to generate homogeneous lines. In the F_2 populations, single-plant selection was used, but from the F_3 to the F_5 generations a modified bulk method was adopted. Each year, plants were inspected frequently to assess cold and drought tolerance and disease resistance. Lines contaminated with yellow rust and septoria tritici blotch (*Mycosphaerella graminicola* (Fuckel) Sand.), and lines showing poor stand under cold and drought conditions were eliminated from the following year's experiment. Yield recording was started from the F_6 generation when the selected lines were phenotypically homogeneous.

Each year the seeds were planted in early winter and a single pre-planting irrigation was applied where necessary to ensure uniform crop emergence and stand establishment. Unfortunately, in the 1985/86 season inadequate moisture at planting and soon after caused poor seed germination which resulted in total crop loss. The seed rate was 100 kg/ha, and fertilizer was applied at 60 kg P_2O_5 and 60 kg N per hectare in all years except 1985/86. The selected lines were tested in observation nurseries (BWON) at Quetta, Khuzdar and Kan Mehtarzai in the 1988/89 season, and in yield trials (BWYT) at Quetta and Loralai in the 1989/90 season. Characteristics of these locations are given in Table 1. The observation nurseries were planted in single rows of 5 m length with 25 cm between rows. For the analysis of variance each of the three sites was considered as a single replicate of a randomized complete block. The yield trials were laid out using a randomized complete block design with three replications per site. The row length was 5 m, the row width was 25 cm, and there were six rows in each plot, of which four central rows were harvested to determine total dry matter production and grain yield.

Table 1. Site details, total rainfall during the season and absolute minimum air temperature at different sites in Balochistan, 1985-90.

Site	Altitude (m)	Latitude (N)	Longitude (E)	Season	Total rainfall (mm)†	Absolute minimum air temperature (°C)
ARI, Quetta	1690	30° 07′	66° 58′	1985/86	208	-7
				1986/87	313	-16
				1987/88	173	-7
				1988/89	239	-8
				1989/90	301	-8
Khuzdar	1250	27° 46′	66° 39′	1988/89	219	-8
Kan Mehtarzai	2250	31° 00′	67° 45′	1988/89	222	-13
Loralai	1340	30° 24′	68° 36′	1989/90	**	**

† Excluding one supplemental irrigation applied before sowing.

** Data not available.

Results and Discussion

The 1986/87 season was extremely cold, while 1987/88 was very dry (Table 1), thus the two seasons applied high selection pressure for cold and drought tolerance, respectively. The selection history and pedigrees of the selected lines are presented in Tables 2 and 3. From 1982 to 1989, the number of selected entries was reduced from 374 to 4 through intensive selection for desirable parameters (Table 2). There was considerable variability for various traits across the selected lines, but the total dry matter and grain yields of the selected lines were similar ($P>0.05$) to the local check (Tables 4 and 5). The local landrace (Local White) was taller than the rest of the selected genotypes ($P<0.05$) and the selected lines had the same level of cold tolerance as the local check.

The main selection criteria applied to this segregating *population* were winter-hardiness and drought-resistance. Another major consideration was selection against yellow rust, which can be severe in years with high rainfall. Thus, screening for disease resistance in the field is likely to be most effective in wet years. A very severe outbreak was experienced in 1982/83, which was the wettest season ever recorded in Quetta. The selection pressure for yellow rust was intense and only 374 of 816 F_2 entries were selected. After the 1982/83 attack, yellow rust spore populations fell considerably in the following, much drier years and no further screening against this disease was possible until 1989/90 when another epidemic occurred. Then, the local wheat suffered severe infection which caused 50-75% yield reduction at most places in the highlands of Balochistan, while the selected lines showed very good resistance to yellow rust. The screening results also confirmed that genotypes with a prostrate growth habit were usually more cold tolerant than erect or intermediate genotypes.

Table 2. Selection in a segregating populations of winter bread wheat.

Year	Entries tested	Entries selected	Generation†
1982/83	816	374	F_2
1983/84	374	335	F_3
1984/85	335	159	F_4
1985/86	159	—	F_5
1986/87	159	35	F_5
1987/88	35	4	F_6
1988/89	4	4	BWON
1989/90	4	1	BWYT

† BWON = Bread wheat observation nurseries; BWYT = Bread wheat yield trials.

Table 3. Genetic background of the four selected lines of winter bread wheat.

Entry no.	Name, cross/pedigree
1	Bez//Tob/8156/4/On/3/6*Th/KF// 6*Lee/KF/5/Myna 's' ICW81.1471
2	Lomll/Son64/3/Pj 's'/Gb55//093/44/ Stw597949/4/Kirac ICW81.1504
3	FAO-K350/3/5-Mt//Gb/4/340/F2/5/2Rfn/Ofn 's'/ 6/Lom10/7/Martonvasar 6. ICW81.1656
4	Bez//Mnv 's' ICW81.1683
5	Check (Local White)

Table 4. Performance of winter bread wheat lines during 1988/89 averaged over three sites in highland Balochistan.

Entry no.	Cold resistance score	Plant height (cm)	Dry matter yield (kg/ha)	Grain yield (kg/ha)
1	1†	63	5572	801
2	1	68	4873	725
3	1	61	4498	706
4	1	66	4758	697
5‡	1	77	3469	600
CV (%)		16	16	24
SD		5	329	74

† Resistant.
‡ Local check.

Table 5. Dry matter and grain yields (kg/ha) of bread wheat lines during 1989/90 at two sites in highland Balochistan.

Entry no.	Dry matter yield		Grain yield	
	Quetta	Loralai	Quetta	Loralai
1	10,800	6,533	1,621	1,879
2	10,200	6,500	1,688	1,591
3	9,066	4,000	951	814
4	6,800	5,800	1,400	1,631
5†	12,000	6,000	1,766	1,836
CV (%)	25	30	21	34
SD	1,097	762	179	238

† Local check.

Selection for cold resistance in conjunction with all the other desirable characters was complicated. Although many entries were cold hardy during their vegetative stages, winter hardiness was not always linked with drought tolerance at later stages, or with yield. Effective evaluation and selection of winter-hardy plants necessitated early planting to allow selection of genotypes which had passed their vegetative period in winter and had started their reproductive phase after the winter. In highland Balochistan cold damage is not usually experienced later in the season during the reproductive stages, but in early May 1989 a late frost during grain-setting adversely affected grain production, causing sterility and shrivelled grains with reduced kernel weight. Fletcher (1984) and Single (1985) report that frost after ear emergence can reduce seed-set and may result in complete sterility.

Plant height is another important consideration in highland Balochistan. In this region, straw production is just as important as grain owing to the shortage of feed for livestock, and the price of straw often exceeds that of grain. Farmers in this area prefer tall varieties for good straw production. The common practice of grazing or cutting good crops of winter wheat provides additional valuable green forage and also minimizes cold and frost damage.

In conclusion, this type of research approach for the dry areas of highland Balochistan can provide breeders with desirable parental wheat material, obtained through the ICARDA cereal-improvement program, for crossing or for selecting germplasm resistant to environmental stresses. Desirable attributes such as cold, drought and disease tolerance or resistance, plant height and earliness can be effective selection criteria for the improvement of bread wheat in this environment.

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Chemical Composition and Nutritive Value of Three Barley Cultivars Grown Under the Semi-arid Conditions of Northwestern Tunisia

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Abstract

Three barley (*Hordeum vulgare* L. ssp. *vulgare*) cultivars (two-row Ceres and Esperance, and six-row Martin) were grown under rain-fed conditions at Le Kef, northwestern Tunisia, to determine the effect of cutting stage on chemical composition and nutritive

التركيب الكيميائي والقيمة الغذائية لثلاثة أصناف من الشعير مزروعة تحت ظروف شبه جافة في الشمال الغربي من تونس

الملخص

زرعت ثلاثة أصناف من الشعير (*Hordeum vulgare* L. ssp. *vulgare*)، وهي سيريس وإسبرانس الثنانيا الصف ومارتين السداسي الصف، تحت الظروف البعلية في الكيف الواقعة في شمال غربي تونس، وذلك لتحديد مدى تأثير فترة القطع (الحش) على التركيب الكيميائي والقيمة الغذائية. أظهرت الأصناف الثلاثة أنماطاً متشابهة من التركيب الكيميائي خلال دورة حياتها. وازداد محتوى المادة الجافة بدءاً من الاشطاء وحتى الطور العجيني الصلب، وفيما بعد تناقص بشكل طفيف في الصنفين الثنائيي الصف، إلا أنه ازداد بشكل طفيف في الصنف مارتين. أما محتوى الرماد، فقد تناقص بين

value. The three cultivars showed similar patterns of chemical composition through their life cycles. Dry matter content increased from tillering to hard dough stage; thereafter it decreased slightly for the two-row cultivars, but increased slightly in Martin. Ash content decreased from early stage to late dough stage, thereafter remaining unchanged. Crude fiber content increased to milky stage, then decreased to hard dough stage. Crude protein content was very high at early leaf stage, decreased sharply to flowering, decreased more slowly to milky stage, then stabilized or increased slightly. Overall digestibility generally decreased to pre-bloom stage, then increased steadily to hard dough stage. Organic matter digestibility decreased rapidly to milky stage, then stabilized to hard dough stage, then increased slightly. Digestible protein content followed crude protein content. Esperance showed a rapid decrease in digestibility after the early vegetative stage, suggesting suitability for early mob grazing. Martin maintained relatively constant digestibility, making it suitable for continuous grazing.

Key words: *Hordeum vulgare*; barley; rain fed farming; chemical composition; nutritive value; plant developmental stages; digestibility; grazing; sheep; Tunisia.

بداية الطور العجيني ونهاتيه، ثم بقي ثابتاً فيما بعد. ازداد محتوى الألياف الخام حتى الطور الحليبي ومن ثم بدأ بالتناقص حتى الطور العجيني الصلب. وكان محتوى البروتين الخام عالياً جداً في بداية طور التوريق ثم تناقص بحدة حتى طور الإزهار، ثم تناقص ببطء أكثر حتى الطور الحليبي، وعندها استقر أو ازداد بصورة طفيفة. وبشكل عام تناقصت قابليته الكلية للهضم حتى الطور السابق على الإزهار، وبعدها ازدادت على نحو ثابت حتى الطور العجيني الصلب، ومن ثم تزايدت على نحو طفيف. وقد تلا محتوى البروتين القابل للهضم محتوى البروتين الخام. وقد أظهر إسبرانس تناقصاً سريعاً في قابلية الهضم بعد بداية الطور الخضري مما يوحي بأنه ملائم للرعي المبكر الكثيف والقصير المدة (mob grazing)، في حين حافظ مارتين على قابلية هضم ثابتة نسبياً مما يجعله مواتياً للرعي المستمر.

Introduction

Under Mediterranean climatic conditions and agricultural systems, barley can be an important feed for sheep. It can be used in different ways: sown pasture for continuous grazing, freshly cut forage for silage, and straw plus grain (Amara et al. 1985). Barley is generally more drought and cold tolerant than other cereals. Thus, it can be an important forage source in semi-arid areas because of its reliability and versatility (Bronzi 1978; Droushiotis 1984, 1989; Hadjichristodoulou 1984; Khaldoun 1989).

This study was conducted to determine the effect of cutting stage of barley on the chemical composition and nutritive value of the crop.

Material and Methods

Three barley cultivars – Ceres, Esperance and Martin – were tested under rain-fed conditions at El Kef station of ESAK (Ecole Supérieure d'Agriculture du Kef), Tunisia. The soil of the experimental field was loam and clay loam, representative of the cereal-growing areas of El Kef region. The climate is Mediterranean continental type with daily maximum and minimum temperatures of 25°C and 6°C, respectively. There was a peak of rainfall in December and a low in February (Fig. 1). Seeds were drilled in rows 20 cm apart, at a rate of 100 kg/ha. Seeding was done during October and fertilizers were applied at 100 kg P_2O_5 and 33.5 kg N (ammonium nitrate) per hectare. The trial was arranged in a randomized complete block design. Plants were cut at five stages of development: early vegetative, pre-bloom, milky, dough and late dough.

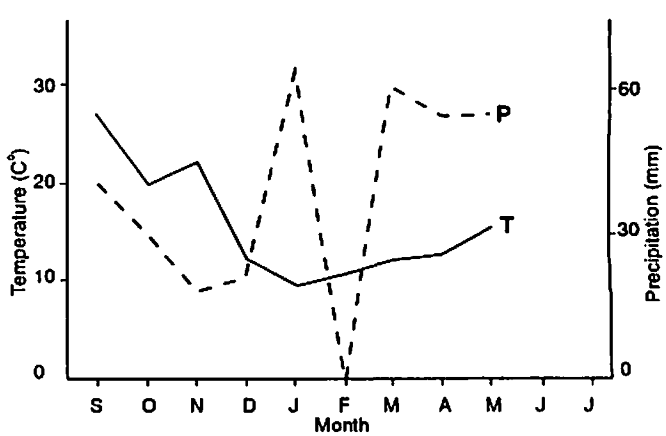

Figure 1. Monthly rainfall and temperature at El Kef research station for the year of the study.

Chemical analysis

All samples were analyzed for dry matter (DM), ash, crude protein (CP) and crude fiber (CF) (Howitz 1975).

Digestibility and nutritive value

Organic matter digestibility was calculated according to the following equation developed by Adjroudi and Lawrence (1981): $Y = -1.096CF + 97.817$
(Y = organic matter digestibility; CF = crude fiber). Nutritive values were determined using the prediction equations developed by Andrieu et al. (1981) and Demarquilly et al. (1980).

Results and Discussion

Chemical composition

The chemical composition of the varieties showed similar patterns, although some slight differences were observed at certain stages of cutting (Table 1). This conforms with the findings of Edwards et al. (1968). Differences in chemical composition at different stages of cutting were significant for all constituents.

Dry matter content
The dry matter (DM) content increased from tillering to hard dough stage for all three cultivars, from an average of 15% at tillering to an average of 50% at hard dough stage (Table 1). However, a slight decrease was observed between milky and dough stage for the two-row cultivars Esperance and Ceres, while the six-row cultivar maintained an increase in content.

Ash content
Ash content decreased from the early stage to the late dough stage for all three cultivars, after which it remained relatively unchanged. High ash content at the early stage (14.4, 14.7 and 14.6% for Martin, Ceres and Esperance, respectively) can be attributed to soil contamination which confirms the previous findings of Edwards et al. (1981), Demarquilly (1970), Hadjipanayiotou and Economides (1983), Droushiotis (1984, 1989) and Majdoub (pers. comm., 1990).

Crude fiber content
The crude fiber (CF) content in the three barley varieties varied with the different cutting stages. Crude fiber content of barley develops differently from that in forage grasses (Smith 1960; Hopkins 1968; Demarquilly 1970; CIHEAM 1990; Majdoub, pers. comm., 1990). Crude fiber *increased* up to the pre-bloom or milky stage then decreased steadily until the hard dough stage (Table 1). However, slight differences appeared in the intensity of CF variation among the three cultivars. Although the proportion of CF increased with the cutting stage in the vegetative parts of the plant, the ear (which is generally poor in CF) grew at the same time which may have led to an overall decrease in CF for the whole plant.

These results agree with findings of Hopkins (1968), Polan et al. (1968) and Cherney et al. (1983).

Crude protein content
The crude protein content ($CP = N \times 6.25$) was very high at the early leaf stage (33.10, 25.83 and 28.72% for Martin, Ceres and Esperance, respectively). However, it dropped at the flowering stage (12.5% for the six-row cultivar, and 10.67 and 8.10% for Ceres and Esperance). For the three cultivars, CP decreased with advancing cutting stage but more slowly until the milky stage, then it stabilized or increased slightly to the dough stage (Table 1). In general Ceres maintained a higher CP than the other cultivars (Table 1).

Digestibility

Martin showed the highest digestibility. Ceres and Esperance showed no significant differences at the early stage. Digestibility for the three varieties varied similarly with advancing stage: it generally decreased to the pre-bloom stage, then increased regularly until the hard dough stage. This could be attributed to variation in CF content which was low at the early vegetative stage, maximum at pre-bloom stage, and gradully lower thereafter. Edwards et al. (1968) note an increase in the *in vitro* digestibility of barley when CF content declines. On the other hand, the organic matter digestibility decreased rapidly until the milky stage, at which point it was 65, 64 and 60% for Martin, Ceres and Esperance, respectively. It then remained relatively constant until the dough stage, where it slightly increased. This is due to the increase in the proportion of grain in the whole plant, which has a high digestibility and makes up for the decrease in digestibility of all the other parts of the plant. This confirms previous reports by Cannel and Jobson (1968), Demarquilly (1970), Mowat and Slumskie (1971) and Corrall et al. (1977). The six-row cultivar, Martin, had an overall higher DM digestibility than the other varieties (68.4 versus 65.0 and 64.6). Organic matter digestibility followed the same trend (66.0 versus 65.0 and 63.0). The rapid decrease in digestibility for Esperance confirms its good adaptation to early mob grazing, while the relatively constant digestibility of Martin makes it a good source for continuous grazing.

Table 1. Effect of the cutting stage on the chemical composition of three barley cultivars.

Cultivar	Cutting stage	DM (%)	CP	Ash	OM	CF	CP	CF
			as % of DM				as % of OM	
Martin	Early vegetative	14.40	33.10	14.4	85.6	15.54	38.66	18.15
	Pre-bloom	26.90	12.50	8.3	91.7	23.07	15.70	25.16
	Milky	32.90	9.10	6.0	94.0	23.34	9.68	24.83
	Dough	34.05	9.60	6.4	93.6	23.00	10.25	24.57
	Late dough	46.2	8.10	5.1	94.9	22.50	8.53	23.71
Ceres	Early vegetative	17.11	25.83	14.7	85.3	18.58	30.88	21.78
	Pre-bloom	26.62	10.64	7.8	92.2	26.40	11.57	23.63
	Milky	33.96	10.16	7.8	92.2	25.86	11.02	28.04
	Dough	28.23	9.13	7.6	92.4	25.22	10.60	27.30
	Late dough	57.70	8.65	7.1	92.9	23.45	8.99	25.24
Esperance	Early vegetative	15.81	28.72	14.6	85.4	19.01	33.64	22.26
	Pre-bloom	24.34	8.10	8.4	91.6	28.67	8.84	31.30
	Milky	31.59	7.17	7.4	92.6	27.01	7.74	29.17
	Dough	26.75	7.93	7.5	92.5	24.98	8.57	27.00
	Late dough	54.06	5.54	6.4	93.6	22.41	5.92	23.94

DM = dry matter, OM = organic matter, CP = crude protein, CF = crude fiber.

Nutritive value

The energy value expressed as Lactation Forage Units (LFU) changed according to the value of digestibility from which it was derived. At all stages, average values showed a similar trend to that of digestibility value (0.78 for the six-row cultivar versus 0.76 and 0.73 for the two-row cultivars). Esperance had the lowest average values (Table 2). The digestible protein content (DP) varied in the same way as CP: it was high in the early vegetative stage (27.3, 23.0 and 23.3% for Martin, Ceres and Esperance, respectively); it decreased rapidly until the milky stage, then increased and stabilized thereafter (Table 2).

Table 2. Effect of cutting stage on digestibility and nutritive values of three barley varieties.

Cultivar	Cutting stage	dDM (g/kg)	LFU/ kg DM	LFU/ kg OM	DP (g/kg DM)	IDPE (g/kg DM)	IDPN (g/kg DM)
Martin	Early vegetative	691	0.81	0.95	273	186	224
	Pre-bloom	664	0.84	0.92	103	100	98
	Milky	679	0.76	0.81	56	80	62
	Dough	679	0.77	0.82	60	82	65
	Late dough	708	0.75	0.79	46	76	55
Ceres	Early vegetative	606	0.87	1.02	230	150	175
	Pre-bloom	635	0.74	0.81	70	85	72
	Milky	640	0.74	0.88	65	83	69
	Dough	649	0.74	0.88	62	82	68
	Late dough	667	0.73	0.79	49	76	57
Esperance	Early vegetative	657	0.85	0.99	233	164	195
	Pre-bloom	608	0.70	0.76	48	75	55
	Milky	632	0.70	0.75	38	72	49
	Dough	651	0.70	0.76	46	74	54
	Late dough	685	0.68	0.73	45	66	38

dDM = dry matter digestibility; LFU = Lactation forage unit; OM = organic matter content; DM = dry matter content; DP = digestible protein content; IDPE = intestinal digestible protein content (energy level); IDPN = intestinal digestible protein content (N level).

The six-row variety Martin had the highest average digestible protein content (12.3% versus 10.7 and 9.1% for Ceres and Esperance, respectively). Intestinal Digestible Proteins allowed by the nitrogen level (IDPN) content was higher than that of the Intestinal Digestible Proteins allowed by the energy level (IDPE) at the first cutting stage for all three varieties. Both IDPN and IDPE followed the same decreasing trend as DP. These observations agree with those previously reported (Cannel and Jobson 1968; Hadjichristodoulou 1976; Droushiotis 1984).

Conclusion

Observations of chemical and nutritional changes in three barley cultivars prior to the pre-bloom stage, showed that the protein content remained above 15% and the crude fiber of the plant was below 20%. These figures indicate a forage of high quality, suitable for intensive grazing and usually associated with high lamb production. Thus, adapted cultivars of barley, such as Martin and Esperance, offer one of the most economical sources of nutritious feed during the winter and early spring. Finally, it appears that there are greater differences in protein content within each cultivar with increasing plant age, than there are among the three barley cultivars themselves.

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Phenotypic Variation in Boron Toxicity Tolerance in Barley, Durum and Bread Wheat

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Abstract

Symptoms of boron (B) toxicity on crops have been identified in many dryland areas of West Asia and North Africa. This study investigated variation in B toxicity tolerance in some of the ICARDA barley (*Hordeum vulgare* L. ssp. *vulgare*) and CIMMYT/ICARDA durum (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.) and bread wheat (*T. aestivum* L. ssp. *aestivum*) international nurseries. Seedlings were grown in soils treated with 50 mg B/kg soil, and foliar symptom scores were taken about four weeks after sowing. Shoot B concentrations for entries with least symptom development were also measured. Significant variation in symptom scores occurred between entries within each crop. The largest variation was found in barley, while durum wheat had the least. Shoot B concentrations varied widely for the entries with lowest symptom scores in all crop species. Data on barley suggest that B toxicity may be widespread in West Asia, and breeders in this region should not neglect this trait when developing new cultivars.

Key words: *Hordeum vulgare*; *Triticum aestivum*; *Triticum durum*; barley; hard wheat; soft wheat; phenotypes; genetic variation; boron; phytotoxicity; chemical resistance.

تباين النمط المظهري في تحمل سمية البورون في الشعير والقمحين القاسي والطري

الملخص

حُددت أعراض سمية البورون (B) على المحاصيل في مناطق جافة عديدة من غربي آسيا وشمالي إفريقيا. وتقوم هذه الدراسة بتحديد التباين في تحمل سمية البورون في بعض أصناف إيكاردا من الشعير *(Hordeum vulgare* L. ssp. *vulgare)* وبعض أصناف إيكاردا/سيميت من القمح القاسي *(Triticum turgidum* L. ssp *durum* (Desf.) Husn.)، وبعض المشاتل الدولية للقمح الطري *(Triticum aestivum* L. ssp. *aestivum)*. زرعت بادرات في ترب معاملة بـ 50 مغ B/كغ تربة وأُخذِت درجات الأعراض الورقية بعد حوالي أربعة أسابيع من الزراعة، كما تم قياس تركيزات البورون في فروع المدخلات التي أظهرت أدنى تطور للأعراض. وقد حدث تباين كبير في درجات الأعراض بين المدخلات ضمن كل محصول، كما وجد أكبر تباين في الشعير بينما كان أقله في القمح القاسي. وقد تباينت بشدة تركيزات البورون في فروع مدخلات جميع أنواع المحاصيل التي حصلت على أقل درجات الأعراض. وتوحي البيانات المأخوذة من الشعير باحتمال أن تكون سمية البورون منتشرة في غربي آسيا، لذا من الضرورة بمكان أن لايهمل المربون في هذه المنطقة هذه الصفة عند استنباطهم لأصناف جديدة.

Introduction

Boron (B) is an essential element needed in trace amounts for crop growth. As with other micronutrients, imbalances in B nutrition are widespread. Indeed, B is unique in that the range between deficient and toxic levels is narrow. While deficiency, generally indicated by less than 0.5 p.p.m. hot-water-soluble B in the soil, is the more common problem globally, the limited soil and plant analysis data suggest that deficiency may not be common in West Asia and North Africa (WANA) (Khan et al. 1979; Sillanpaa and Vlek 1985). However, excess B is increasingly being considered as a problem in many soils. Soil B concentrations of just a few p.p.m., whether naturally occurring in the soil or added in irrigated water, can cause B toxicity to the plant (Ryan et al. 1977).

High soil B concentrations occur in arid and semi-arid areas. Boron toxicity has been recognized as a serious and widespread problem in the drylands of South Australia with a Mediterranean climate (Cartwright 1986). Toxicity may also be a widespread problem in dryland areas of WANA. In a survey of tropical and subtropical countries, the Mediterranean region had the highest B concentration in the topsoil, especially in Iraq (Sillanpaa and Vlek 1985). So far, B-toxicity symptoms in winter cereal crops

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and/or high soil B have been found near Aleppo, Syria, near Eskisehir and Konya, Turkey, and on the northwest coast of Egypt. Wallace (1980) recorded excess B in barley and alfalfa in the Tauorga Project in Libya. In the same country, B-toxicity symptoms are widespread in barley, but have been incorrectly identified as a foliar disease (M.S. Mekni, pers. comm.). Toxicity symptoms in barley have also been observed near Mosul in northern Iraq (A.A. Al-Dhahir, pers. comm.). Analysis of B concentrations in barley grain samples collected throughout Jordan and Morocco also suggest that B toxicity may be a problem in many dry areas of the two countries (S.K. Yau, unpublished data).

Boron toxicity can cause substantial reduction in grain and straw yield (Cartwright et al. 1984; Moody et al. 1993). Since treating the soil to remove or reduce the effect of B, e.g. by leaching, is not economically feasible and is technically difficult, selecting or breeding crop cultivars with high tolerance/resistance to B toxicity is the most promising approach.

The variability of B distribution in the soil, both vertically and horizontally, makes reliable field screening of large numbers of breeding lines difficult. Besides, performance in such trials may not be due only to different responses to soil B. A simple, fast and effective way to screen for B tolerance is to grow seedlings in the greenhouse in soil in which a known quantity of boric acid has been evenly mixed (A.J. Rathjen, pers. comm.).

The objective of this study was to use this technique to investigate variation in B-toxicity tolerance among advanced lines in some of the ICARDA and CIMMYT/ICARDA international nurseries.

Materials and Methods

Preliminary experiments were conducted on barley using 24 random entries, 2 replicates and 5 rates of B. Adding boric acid at the rate of 50 mg B/kg soil-mix (equal parts of soil and sand), which gave a hot-water extract of 27 p.p.m. B, provided the best symptom discrimination between entries. At this level, non-tolerant entries started to show foliar toxicity symptoms two weeks after sowing. However, symptom scores taken four weeks after sowing had a much lower coefficient of variation than those taken at 2 and 3 weeks after sowing. Thus, the main experiments were conducted at this level of soil B, and foliar symptom scores recorded about 4 weeks after sowing.

Advanced lines, mainly from the 1992/93 ICARDA barley international nurseries and the CIMMYT/ICARDA regional wheat nurseries (Table 1), were screened under natural light in a plastic house with temperatures controlled to vary from 15 to 25°C. Halberd, the most tolerant Australian bread wheat and classified as moderately tolerant to B toxicity (Paull et al. 1991), was used as the tolerant check. The Australian barley cultivar, Galleon, was used as the tolerant barley check.

Table 1. Materials used for screening in each experiment.

Crop	Total no. of entries	Name and abbreviation of nurseries
Spring barley (Expt. 1)	427	Barley Observation Nursery for - Low Rainfall Areas, Mild Winters (BON-LRA-C) - Low Rainfall Areas, Cool Winters (BON-LRA-M) - Moderate Rainfall Areas (BON-MRA) Barley Crossing Block (BCB) On-farm Trial (OFT)
Winter/facultative barley (Expt. 2)	344	International Winter and Facultative Barley - Observation Nursery (IWFBON) - Crossing Block (IWFBCB) - Yield Trial (IWFBYT) Barley High Elevation Adaptation Yield Trial (BHEAYT)
Durum wheat (Expt. 3)	250	Durum Observation Nursery[†] for - Semi-arid Areas (DON-SA) - Favorable Areas (DON-FA)
Bread wheat	140	Bread Wheat Crossing Block (WCB)

[†] only CIMMYT/ICARDA entries were screened

Other tolerant and non-tolerant checks were also included. Spring/facultative barley entries were screened first (Experiment 1), followed by winter/facultative barley (Experiment 2), and durum and bread wheat (Experiment 3). The whole screening ran from December 1992 to May 1993.

Seedlings were grown in trays 200 × 75 × 20 cm. Each plot consisted of a row of ten seeds sown at a between-plant distance of 2 cm and a between-row distance of 5 cm. There were two replicates. The trays were watered 2–3 times a week after sowing. Severity of B-toxicity symptoms on leaves was scored visually on a scale of 0 to 5 (0 = no symptoms, 5 = very severe symptoms). Entries with least symptom development were harvested and their shoot B concentrations measured.

Results and Discussion

Barley tended to show earlier and heavier B-toxicity symptoms than wheat. Symptoms first developed on the tips of the first leaves, with successively younger leaves being affected to a lesser extent. In barley, there was a diversity in symptoms. Chlorosis (whitish), grayish mottles, brown spots or blotches, or necrosis soon developed at leaf edges and spread down to leaf bases. In wheat, necrosis of the leaf tip gradually developed down the leaf. Three of the Bread Wheat Crossing Block entries were very sensitive to B toxicity, displaying 'mid-leaf necrosis' (Paull et al. 1991).

Significant ($P<0.001$) variation in symptom scores occurred between entries within each crop. The largest coefficient of variation (CV) occurred in barley, while durum wheat had the smallest variation (Table 2). No published data are available on variation in B-toxicity tolerance in durum wheat. Little variation in tolerance to B toxicity in durum wheat was found in Australia (A.J. Rathjen, pers. comm.). One explanation for the low variation in durum wheat in this study is that the CIMMYT/ICARDA durum wheat project has been evaluating its material at Breda and Bouider, two Syrian sites which have high soil B, so sensitive lines might have been discarded. This explanation does not, however, account for the higher variation in barley, which had also been evaluated at Breda and Bouider.

The largest variation in symptom scores occurred between entries in the Barley High Elevation Adaptation Yield Trial, which contained winter/facultative barley lines of different origin (Table 2). The Barley Crossing Block, which contained lines having specific expression of particular traits, also had a large variation.

Table 3 shows that there was a large variation in shoot B concentrations for those entries with the lowest symptom scores in all crop species. This indicates that some of these entries with low symptom scores took up less B from the soil and had lower shoot B concentrations, while others had better tolerance to high shoot B concentrations and did not display the same symptoms as non-tolerant entries. It follows that if symptom expression was the sole selection criterion, entries with tolerance to high shoot B concentrations would not be distinguished from those which took up less B from the soil.

Table 2. Phenotypic variation in boron-toxicity symptom scores (0 to 5) for all entries. (Note: comparison of means only valid within experiments.)

Crop/nursery	Mean	Range	S.D.	CV	Means of checks
Spring barley (Expt. 1)	2.7	1.25–5.0	0.67	25	1.4 (Galleon), 2.4 (Stirling), 1.3 (Halberd)
BON-LRA-C	2.6	1.5–4.8	0.58	22	
BON-LRA-M	2.6	1.5–4.0	0.47	19	
BOM	2.7	1.25–4.8	0.72	26	
BCB	2.8	1.25–5.0	0.79	28	
Winter/facultative barley (Expt. 2)	3.4	1.25–5.0	0.88	26	0.9 (Halberd), 2.0 (Tokak), 4.0 (Stirling)
IWFBON	3.3	1.5–5.0	0.84	26	
IWFBCB	3.5	1.25–5.0	0.90	26	
IWFBYT	3.9	1.75–5.0	0.67	17	
BHEAYT	3.1	1.25–4.5	0.98	32	
Durum wheat (Expt. 3)	2.9	2.0–3.5	0.29	10	2.1 (Halberd), 2.6 (Schomburgk)
Bread wheat (Expt. 3)	3.1	2.0–5.0	0.56	18	2.3 (Halberd), 2.8 (Schomburgk)

Table 3. Phenotypic variation in shoot boron concentrations (p.p.m.) for entries with low symptom scores. (Note: comparison of means only valid within experiments.)

Crop	No. of entries	Mean	Range	Means of checks
Spring barley (Expt. 1)	31	670	486–994	556 (Galleon), 461 (Halberd), 1196 (Onslow)
Winter/facultative barley (Expt. 2)	37	838	398–1172	336 (Halberd), 767 (Stirling) 874 (Tokak)
Durum wheat (Expt. 3)	40	751	576–1286	477 (Halberd), 734 (Schomburgk)
Bread wheat (Expt. 3)	32	687	272–1231	447 (Halberd)

Tables 4 and 5 give the nursery abbreviations, entry numbers, shoot B concentrations and names/crosses of the most tolerant entries. A number of barley entries had few B toxicity symptoms and B concentrations slightly lower than or comparable to that of Galleon, but none of them had a lower shoot B concentration than Halberd (Table 4).

Table 4. Barley lines with least boron toxicity symptoms and shoot concentrations. (Note: comparison of means only valid within experiments.)

Nursery & entry no.	B conc. (p.p.m.)	Name/cross
(a) Spring barley (Expt. 1)		
BON-LRA-M41	536	H. spont. 20-4/Arar 28/3/OP/Zy//Alger/Union
BON-MRA 31	639	Bco.Mr/Avt//Cel/3/Line 257-14/4/Rihane'S'-5
BON-MRA 43		Deir Alla 106//Api/EB8B-8-2-15-4/4/Lth/3/Nopal//Pro/11012-2
BON-MRA 74	665	Sawsan/Badia//Arar
BON-MRA 76	539	Lignee 527/NK1272
BCB 59	552	9Cr.279-07/Roho
BCB 79		As68
OFT	529	Zanbaka
OFT	486	SLB 5-95
Tolerant checks	556	Galleon
	461	Halberd (bread wheat)
Sensitive checks		
BCB 48	1196	Onslow
BCB 89	833	Pirate
(b) Winter/facultative barley (Expt. 2)		
IWFBON 87	540	ZDM 314 (=ICB 116365)
IWFBON 103	488	ZDM 939 (=ICB 117474)
IWFBCB 7	581	Local B. Kan Mehterzai
IWFBCB 8	612	Baluchistan
IWFBCB 127	626	ZDM 477 (=ICB 116472)
IWFBCB 129	484	ZDM 3485 (=ICB 117093)
IWFBCB 136	581	Viringa 'S'
IWFBCB 145	586	Viringa 'S'
BHEAYT 9	398	ICB 104041
BHEAYT 10	573	Baluchistan
Tolerant check	336	Halberd (bread wheat)
Sensitive checks	767	Stirling
IWFBON	938	Kamiak/Belts67-875//WA1094-67

Table 5. Durum and bread wheat lines with least boron toxicity symptoms and shoot concentrations.

Nursery & entry no.	B conc. (p.p.m.)	Name/cross
(a) Durum		
DON-SA 72	613	T.A73-74/D.Coll-01.1Y/3/Pg/Chap//21563/4/Crosby
DON-SA 287	610	Deraa2/Bicre
DON-FA 66	580	Ru/Mrb15
DON-FA 69	595	Awl 2/Bit
DON-FA 120	618	Awl 2/Bit
DON-FA 145	576	Awl 2/Bit
DON-FA 167	633	Zud2/Kbr3
DON-FA 168	599	Bicre/Kbr3
DON-FA 200	625	Awl 1//Memo/Goo
Tolerant checks	477	Halberd (bread wheat)
Sensitive checks	734	Schomburgk (bread wheat)
DON-SA 49	937	Khb1/4/Rabi/3/Gs/AA//Plc
(b) Bread wheat		
WCB 33	280	Shi#4414/Crow'S'
WCB 37	416	Shi#4414/Crow'S'
WCB 47	411	C182.24/C168.3/3/Cno*2/7C//Cc/Tob
WCB 64	308	T.aest. Ast/Sprw'S'//Ca8055
WCB 105	295	NS.12.5.3/Atfn
DON-FA 145	576	Awl 2/Bit
WCB 134	272	Shi#4414/Crow'S'
Tolerant check:	447	Halberd
Sensitive checks:		
WCB 4	878	Zidane 89

Barley entries SLB 5-95, Zanbaka, SLB 39-60 and Tadmor, which are selections from Syrian landraces, had high tolerance. In the Barley High Elevation Adaptation Yield Trial, cultivars from Europe and Russia (Robur, Novator, Lignee 527, Plaisant, Victoria and Cyclone) were non-tolerant, while the landrace varieties from West Asia (ICB 104042 from Afghanistan, Baluchistan from the high plateau of Pakistan, Walfajr and Zarjou from Iran, Tokak from Turkey, and Tadmor from Syria) were tolerant. This suggests that B toxicity may be widespread in West Asia and that breeders in this region should not neglect this trait when developing new cultivars.

The best durum entries had symptom scores as low as Halberd, but none of them had B concentrations lower than or comparable to that of Halberd (Table 5). Durum may be more tolerant than bread wheat, or at least Halberd, to higher shoot B concentrations. Six bread wheat entries had symptom scores as low as, and B concentrations lower than, Halberd. The durum wheat cross Awl 2/Bit and the bread wheat cross Shi#4414/Crow'S' appear three times in Table 3, indicating that they may carry gene(s) for B-toxicity tolerance. Boron tolerance has been reported to be under the control of major genes in bread wheat (Paull et al. 1991; Moody et al. 1993) and barley (Jenkin and Lance 1991). Investigation is needed to confirm if this is also true for durum wheat.

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Distribution and Importance of Wheat and Barley Diseases in Tunisia, 1989 to 1991

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Abstract

Surveys of wheat (*Triticum* spp.) and barley (*Hordeum vulgare* L. ssp. *vulgare*) diseases were conduced in 1989, 1990 and 1991 in most of the cereal-growing areas of Tunisia. Disease incidence was in general highest in 1990 and lowest in 1989. Barley fields were more infected than wheat fields. Net blotch, powdery mildew, barley stripe and covered smut were the most frequent barley diseases. Whereas net blotch and powdery mildew were found in almost all the governorates,

توزع أمراض القمح والشعير وأهميتها في تونس من 1989 إلى 1991

الملخص

أجريت دراسات حصرية لأمراض القمح *(Triticum* ssp.) والشعير *(Hordeum vulgare* L. ssp.*vulgare)* في 1989، 1990 و1991 في معظم مناطق زراعة القمح في تونس. وكانت الإصابة بالأمراض عموماً الأعلى في 1990 والأدنى في 1989. وقد أصيبت حقول الشعير على نحو أكبر من حقول القمح، وكانت أكثر أمراض الشعير تكراراً التبقع الشبكي، البياض الدقيقي، تخطط الشعير والتفحم المغطى. ففي حين وجد التبقع الشبكي والبياض الدقيقي في جميع المحافظات تقريباً، كان التفحم المغطى أكثر تكراراً في الوسط والجنوب، كما وجد تخطط الشعير في بعض النواحي فقط. ويبدو أن مرض السفحة غير منتظم أبداً، وقد وجد في محافظات كثيرة من

covered smut was more frequentin the center and south, and barley stripe was found only in some districts. Scald seems very irregular, but was found in many governorates of the country. For wheat, the most frequent diseases were: leaf rust, powdery mildew, free-state streak, barley yellow dwarf, septoria leaf blotch and root rot. All of these diseases were mainly found in the north and center of the country. Diseases such as free-state streak, Hessian fly and tan spot which were not important in the past have become more frequent.

Key words: *Hordeum vulgare*; *Triticum aestivum*; *Triticum durum*; barley; soft wheat; hard wheat; surveys; plant diseases; blotches; mildews; smuts; *Mayetiola destructor*; Tunisia.

البلد. أما بالنسبة للقمح، فلقد كانت أكثر الأمراض تردداً : صدأ الأوراق، البياض الدقيقي، التخطط free-state streak، تقزم واصفرار الشعير، التبقع السيبتوري وتعفن الجذور. وقد وجدت كل هذه الأمراض في شمالي ووسط البلد بشكل رئيسي. وأصبحت الأمراض من قبيل التخطط free-state streak، وذبابة هس وتبقع الأوراق الأصفر أكثر تردداً بعد أن كانت غير هامة في الماضي.

Introduction

Cereals form the most important sector of Tunisian agriculture. During 1989, 1990 and 1991, the areas sown to durum wheat (*Triticum turgidum* L. ssp. *durum* (Desf.) Husn.), bread wheat (*T. aestivum* L. ssp. *aestivum*) and barley were 478,000 ha, 128,000 ha and 227,000 ha in the north, and 321,000 ha, 44,000 ha and 450,000 ha in the center and south, respectively (Anonymous 1990). Cereal production is usually influenced by biotic and abiotic constraints. Losses due to combined fungal diseases have been estimated by one of us at 17% of the 1990 national production.

Kamel et al. (1987) studied the importance and the distribution of wheat and barley diseases in the different governorates of Tunisia. In the period 1985–90, rusts, root rot, smut diseases and septoria leaf blotch were the most important diseases of wheat. Barley was especially infected by net blotch, scald, powdery mildew and leaf rust (Anonymous 1990).

The objective of this study was to determine the importance of wheat and barley diseases in different governorates of Tunisia during 1989, 1990 and 1991.

Methods

Surveys of durum wheat, bread wheat and barley diseases were conduced in April in 1989, 1990 and 1991. The majority of cereal-growing areas in the north, center and south were visited. The fields visited were 10–20 km apart. In 1989, a total of 86 fields (34 fields of durum wheat, 24 fields of bread wheat and 28 fields of barley) were surveyed. In 1990, 110 fields (44 of durum wheat, 24 of bread wheat and 42 of barley) were inspected. In 1991, 91 fields were examined (29 of durum wheat, 13 of bread wheat and 49 of barley). Disease diagnosis was based on visual symptoms. Isolation of fungi was done in the laboratory when the disease diagnosis seemed insufficient. Disease incidence (the number of infected fields over the total number fields assessed) was calculated for each disease.

Results

In 1989, there were more disease-free fields than in 1990 or 1991. Among the 58, 68 and 41 fields of wheat inspected in 1989, 1990 and 1991, no diseases were detected in 21, 4 and 8, respectively. Barley fields visited during the three successive years were more infected than the wheat fields since only one field in 1989 and two fields in 1991 were disease free (Table 1).

Table 1. Number of surveyed and disease-free fields of durum wheat, bread wheat and barley visited in 1989, 1990 and 1991.

Crop	No. of surveyed fields			No. of disease-free fields		
	1989	1990	1991	1989	1990	1991
Durum wheat	34	44	28	7	0	6
Bread wheat	24	24	13	14	4	2
Barley	28	42	49	1	0	2

Disease incidence found during the three years of surveys is shown by frequency histograms (Fig. 1 and 2).

Tables 2 to 5 show disease distributions of barley and wheat in the different governorates in 1990 and 1991.

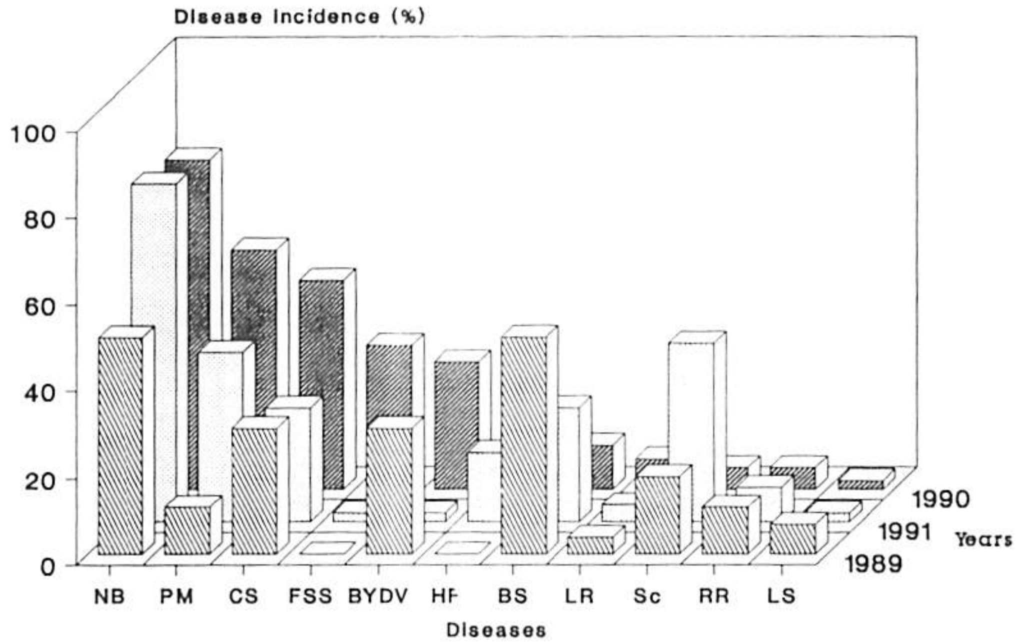

Figure 1. Incidence of barley diseases in Tunisia during 1989, 1990 and 1991.

NB = Net blotch, PM = Powdery mildew, CS = Covered smut, FSS = Free-state streak, BYDV = Barley yellow dwarf virus, HF = Hessian fly, BS = Barley stripe, LR = Leaf rust, Sc = Scald, RR = Root rot, LS = Loose smut.

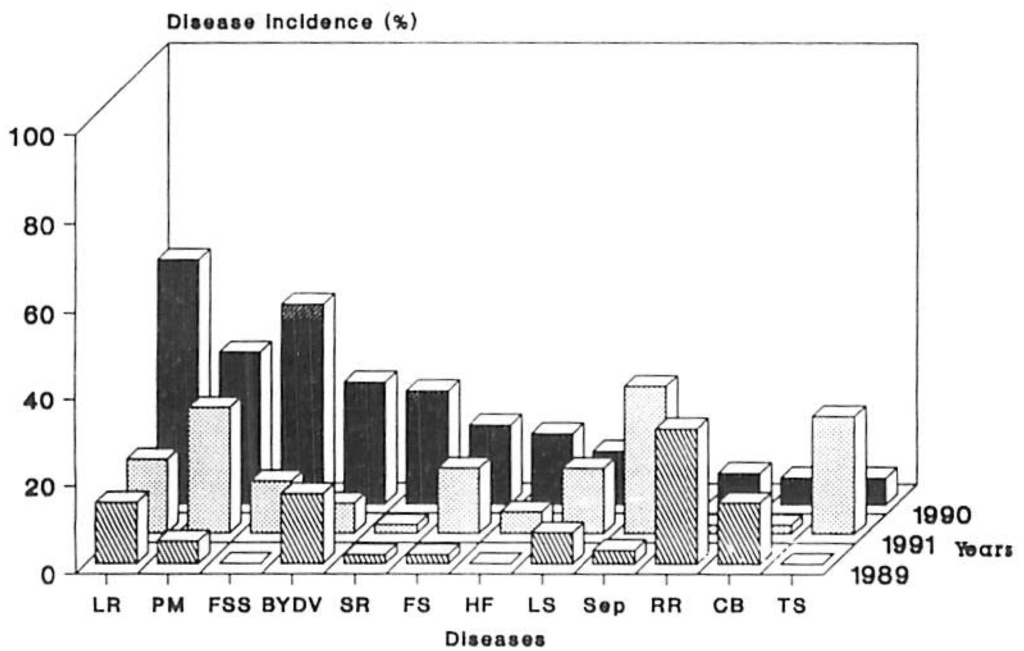

Figure 2. Incidence of wheat diseases in Tunisia during 1989, 1990 and 1991.

LR = Leaf rust, FSS = Free-state streak, PM = Powdery mildew, BYDV = Barley yellow dwarf virus, SR = Stripe rust, FS = *Flag smut*, HF = Hessian fly, LS = Loose smut, Se = Septoria, RR = Root rot, CB = Common bunt, TS = Tan spot.

Table 2. Barley diseases and pests in governorates of Tunisia in 1990.

Governorate	NF	Disease/pest																					
		Net blotch		Powdery mildew		Covered sumt		Free-state streak		BYDV		Hessian fly		Barley stripe		Leaf rust		Scald		Root rot		Loose smut	
		N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I
Northern Zone																							
Ariana	1	1	100	1	100					1	100												
Bizerte	2	2	100																				
Tunis	1	1	100	1	50																		
Ben Arous	1	1	100																				
Nabeul	1	1	100	1	100							1	100			1	100						
Zaghouan	1	1	100			1	100																
Beja	3	3	100	1	33																	1	50
Kef	2	1	50	2	100	2	100	2	100	1	50	1	50										
Siliana	8	6	75	6	75	3	43	5	63	4	50			3	43								
Central Zone																							
Kairouan	4	4	100			4	100					3	75			1	25	2	50	2	50		
Sousse	3	3	100			2	67					1	33										
Sfax	3	3	100	1	33	2	67			2	67			1	33	1	33						
Kasserine	4	2	50	3	75	1	25	4	100	3	75												
Southern Zone																							
Gabes	4	3	75	3	75	4	100					1	25										
Gafsa	4			4	100	1	25	3	75	1	25												
Disease incidence (%)		67		55		48		33		29		17		10		7		5		5		2	

I = incidence (%), N = no. infected fields, NF = no. fields surveyed.

Table 3. Barley diseases and pests in governorates of Tunisia in 1991.

Governorate	NF	Disease/pest																					
		Net blotch		Powdery mildew		Covered sumt		Free-state streak		BYDV		Hessian fly		Barley stripe		Leaf rust		Scald		Root rot		Loose smut	
		N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I
Northern Zone																							
Ariana	1	1	100															1	100				
Bizerte	4	4	100													1	25	1	25	1	25		
Tunis	1	1	100	1	100	1	100					1	100					1	100				
Ben Arous	2	2	100																				
Zaghouan	6	6	100	4	67	3	50					3	50	3	50			3	50				
Beja	2	2	100																				
Jendouba	1	1	100																				
Kef	5	4	80	2	40	2	40					1	20	1	20			5	100			1	20
Siliana	3	2	67	2	67	1	33					2	67					2	67	1	33		
Central Zone																							
Kairouan	8	6	50	5	63	2	25	1	13			1	13	4	50			3	37				
Sousse	2	1	50	2	100	1	50			1	50			1	50								
Sfax	3	3	100	1	33	1	33							1	33			1	33	1	33		
Sidi Bouzid	2	1	50	1	50													1	50				
Southern Zone																							
Gabes	5	3	60	1	20	4	20							2	40			2	40	1	20		
Tozeur	4	1	25			1	25							1	25	2	50						
Disease incidence (%)		78		39		26		2		2		16		26		4		41		8		2	

I = incidence (%), N = no. infected fields, NF = no. fields surveyed.

Table 4. Wheat diseases and pests in governorates of Tunisia (1990).

Governorate	NF	Disease/pest																							
		Leaf rust		Free state streak		Powdery mildew		BYDV		Stripe rust		Flag smut		Hessian fly		Loose smut		Septoria		Root rot		Common bunt		Tan spot	
		N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I
Northern Zone																									
Ariana	2	1	50							1	13			1	50					1	50				
Bizerte	7	4	57					2	29	1	50	1	13											3	43
Tunis	1													2	29			3	43			1	50		
Ben Arous	1																	1	50					1	12
Nabeul	1	1	100							1	100							1	100	1	100				
Zaghouan	3	2	67	2	67	3	100	2	67	2	67														
Beja	8	4	50			5	63	3	38	3	25			2	25	2	25	1	13			1	13		
Jendouba	2	2	100			2	100	2	100	1	50			1	50	1	50								
Kef	2			1	50	1	50	1	50					1	50										
Siliana	17	8	75	14	82	9	53	2	12	5	29	6	35	3	18	2	12			1	50				
Central Zone																									
Kairouan	5	5	100	2	40									1	20	2	40			1	20				
Sousse	3	3	100			1	33	3	100	1	33					1	33	1	20	1	33				
Sfax	2	2	100	1	50			1	50	2	25														
Kasserine	8	3	38	7	88	3	38	1	13			5	63									2	25		
Southern Zone																									
Gabes	1	1	100							1	100														
Gafsa	5	2	40	4	80			2	40	1	20														
Disease incidence (%)		56		46		35		28		26		18		16		12		10		7		6		6	

I = incidence (%), N = no. infected fields, NF = no. fields surveyed.

Table 5. Wheat diseases and pests in governorates of Tunisia (1991).

Governorate		Disease/pest																							
		Leaf rust		Free-state streak		Powdery mildew		BYDV		Stripe rust		Flag smut		Hessian fly		Loose smut		Septoria		Root rot		Common bunt		Tan spot	
		N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I	N	I
Northern Zone																									
Ariana	1																	1	100						
Bizerte	7	3	43			2	29									1	13	3	43					3	43
Zaghouan	6			1	17	2	33	1	17							2	33	3	50			1	17	2	33
Beja	3	2	67													2	66	3	100					1	33
Jendouba	2	1	50															2	100						
Kef	3			2	67	2	67	1	33	1	33			1	33										
Siliana	4					2	50	1	26			1	25			1	25	1	25					1	25
Central Zone																									
Kairouan	9	1	11	1	11	4	44					3	33					1	11					3	33
Sousse	1													1	100										
Sfax	1																			1	100			1	100
Kasserine	1																								
Southern Zone																									
Gafsa	3			1	33							2	67												
Disease incidence		17		12		29		7		2		15		5		15		34		2		2		27	

I = incidence (%), N = no. infected fields, NF = no. fields surveyed.

Although disease incidence was highly influenced by the year of investigation, net blotch, powdery mildew, barley stripe and covered smut were the most frequent barley diseases.

Net blotch caused by *Pyrenophora teres* Drechs. was the most common disease of barley during the three years. In 1990 and 1991, incidence was higher than 75%. The disease was frequent in almost all the governorates visited. The severity of the disease was mostly between 10 and 40%. It varied especially with the variety being grown, fields situated in the same region differing in disease severity between trace and 80%. High levels of disease severity (70–80%) were observed in the governorates of Sousse and Kairouan in 1990, and Sousse and Bizerte in 1991. In the southern governorates of Sfax, Gabes and Gafsa, attacks were very low owing to the semi-arid conditions.

Powdery mildew caused by *Erysiphe graminis* DC. ex Mérat f.sp. *hordei* Em.Marchal seemed to be the second barley disease in distribution. The disease was frequent in 1990 and 1991 in almost all districts of the country; however, its severity was difficult to estimate since the prospection period was not the optimal period of the disease development.

Covered smut incited by *Ustilago hordei* (Pers.) Lagerh was more frequent in the center and south of the country. Disease incidence reached 45% in 1990. However the severity of infection never exceeded 5%.

Contrary to the other diseases, barley stripe and scald were more important in 1989 and 1991.

Barley stripe caused by *Pyrenophora graminea* S.Ito & Kuribay is systemic in mature plants. It was found in some districts of the country, and although the disease incidence reached 50% in 1989, severity of infection never exceeded 10%.

Scald caused by *Rhynchosporium secalis* (Oud.) J.J. Davis was found in 1991 in many governorates of the north, center and south. The more severe infections were in the northern governorates (Bizerte and Kef) which are cool and humid.

Viral diseases, barley yellow dwarf and free-state streak, were more frequent in 1990 than in 1991. Their incidence was about 30% in 1990. In 1989, no diagnosis was made for free-state streak.

Hessian fly (*Mayetiola destructor* (Say)) was identified in some areas in 1990 and 1991. Its incidence was about 16–17%. Leaf rust, root rot and loose smut were very scarce.

For wheat, disease incidence was more important in 1990 than in 1989, except for root rot and common bunt (*Tilletia* spp.). Incidence in 1991 was lower than in 1990 except for loose smut (*Ustilago tritici* (Pers.) Rostr.), septoria leaf blotch and tan spot (Fig. 2). Leaf rust, powdery mildew, free-state streak, barley yellow dwarf, septoria leaf blotch and root rot seemed to be the most frequent diseases in the country (Fig. 2).

Leaf rust caused by *Puccinia recondita* Rob. ex Desm. f.sp. *tritici* Eriks. was generally the dominant disease on wheat during the three years of prospection. Highest disease incidence was recorded in 1990. The disease was identified in 52% of the inspected fields (62% of durum wheat and 37% of bread wheat). During this year, the disease occurred in almost all the governorates. However in 1991, it occurred only in some sites in the north. Leaf rust infections were generally not serious. On bread wheat, infections did not go beyond traces. On durum wheat, disease severity as high as 60% was found in 1990 at Kairouan. In 1991, all infections had non-significant impact on bread and durum wheat.

Figures 1 and 2 show that powdery mildew (caused by *Erysiphe graminis* DC. ex Mérat f.sp. *tritici* E.Marchal) was more frequent on barley than on wheat. On wheat, powdery mildew was detected in 35% and 29% of the inspected fields in 1990 and 1991, respectively. The disease was more common in the north.

Viral diseases, free-state streak and barley yellow dwarf, were as important as fungal diseases. In 1990, these two diseases were observed in almost all the cereal-growing areas. In 1991, the diseases were found mainly in the north. Free-state streak, which is transmitted by Russian aphid was more prevalent on wheat than barley (Fig. 1 and 2). The disease was identified in 46% of the fields inspected in 1990. Free-state streak was the most frequent and most serious disease in the governorate of Siliana (Table 4). Damage of about 50–80% was frequent on durum wheat. No diagnosis of free-state streak was made in 1989. Barley yellow dwarf was as frequent on barley as on wheat (Fig. 1 and 2). Incidence of this disease was 16% in 1989 and 28% in 1990.

Septoria leaf blotch caused by *Mycosphaerella graminicola* (Fuckel) Schroeter was found only in northern Tunisia (Tables 4 and 5). The disease was frequent only in 1991, with an incidence of 34%. Severity of infection was generally higher on durum wheat than on bread wheat.

Tan spot caused by *Pyrenophora tritici-repentis* (Died.) Drechs. seemed to become more important over the years. In 1989, no diagnosis was made for this disease. In 1990, its incidence was 6% and in 1991, it reached 27% leaf coverage. The disease was identified in the governorates of the north and center. The highest disease severity (70%) was observed in Bizerte (Utique) on durum wheat.

Root rot caused by the complex *Fusarium gramineum*, *F. culmorum* (W.G.Sm.) Sacc. and *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. was identified in 1989 with an incidence of 31%. In 1990 the disease was found only in the north and the center of the country.

The incidence of stripe rust caused by *Puccinia striiformis* West. was 26% in 1990. In 1989 and 1991 the disease was very scarce. It was detected everywhere in 1990 and only in the governorate of Kef in 1991.

The incidence of smut diseases (flag smut, loose smut and common bunt) never reached 20%. The disease severity (percentage of infected plants) was in general lower than 5%. However, some serious attacks were noted, for example, common bunt in the area of Fahs (governorate of Zaghouan) which reached 70–80% in 1991.

Hessian fly was found especially in the northern governorates (Tables 4 and 5). It was identified in 16% of the fields visited in 1991. Some fields were seriously infected. Many generations of Hessian fly were found in the same plant.

Discussion

The 1990 season was characterized by high precipitation especially in the center and south of the country, and moderate temperatures. The 1989 season was dry, while the 1991 season was rainy and cool. These observations can explain the general variation in disease incidence in 1990 and in 1989.

A greater proportion of barley fields were infected than wheat fields, with infestation levels also generally higher in barley than in wheat. The same observation was made by Kamel et al. (1987). The sensitivity of cultivated varieties and the presence of virulent pathogens which oversummer on straw or in the soil can explain the high infection level of barley.

In 1989, a relatively dry year, net blotch, barley stripe, covered smut and barley yellow dwarf were the most frequent barley diseases.

In 1990 and 1991, relatively wet years, net blotch was the most important disease. This disease was found wherever barley was grown. The higher attacks were confined to the north and center. Other attacks were found in more arid areas of the south. The disease seemed to be favored by the absence of resistant varieties, management practices employed and the intensification of barley cultivation in the same areas. Powdery mildew and covered smut were also frequent in 1990 and 1991, whereas scald was frequent only in 1991. The fungus causing powdery mildew seems adapted to Tunisian conditions with milder winter. Conidia germinate over a wide temperature range (1–30°C) and without free moisture. At the end of its cycle, the fungus produces cleistothecia which serve as primary inoculum for the next culture (Mathre 1982). Scald, which is one of the most important barley diseases in Tunisia, was very irregular during these three years. The disease was almost nonexistent in 1990, but reached 41% incidence in 1991 with serious attacks in the north. Although scald needs free water to sporulate and infect new leaves, its ability to develop at relatively low temperatures and the presence of initial inoculum on seed or stubble, enables epidemic development during winter rainy periods even in drier regions (van Leur 1989).

For wheat, the root rot was the most frequent disease in 1989. It was favored by the dry conditions probably because of lower competitive activity of other soil organisms (van Leur 1989).

In 1990, leaf rust, powdery mildew, free-state streak, barley yellow dwarf and stripe rust were frequent in the majority of the areas visited.

In 1991, septoria leaf blotch, powdery mildew and tan spot were the most important diseases, particularly in the northern humid regions.

Some diseases and pests such as free-state streak, Hessian fly and tan spot, which were not important in the past (Kamel et al. 1987), have become more serious. However, they are usually under-estimated.

Hessian fly infestations were in general more serious in barley than in wheat and they were favored by wetness. In a previous study, Miller et al. (1989) found that younger wheat and barley were more frequently and more heavily infested than more mature plants.

Seed-borne diseases such as smuts and bunts were not very serious; however, the incidence of infested fields reached 45% for covered smut of barley in 1990. Infection occurs either from soil or, in the case of loose smut, from untreated seed saved by farmers for the following season.

Stem rust caused by *Puccinia graminis* was declared as an important disease in Tunisia in 1973 (Anonymous 1973). The first locus of stem rust appeared in the south and the inoculum progressed to the north. Kamel et al. (1987) did not note the presence of this disease. In this study, no trace of stem rust was detected. It seems that the use of early varieties is efficient for the pathogen which is relatively tolerant of heat.

In Tunisia foliar treatment with fungicide is rarely done even when there is a serious epidemic. Losses due to attacks by one or many diseases can be significant especially in some regions where conditions are ideal for epidemic development with the presence of susceptible varieties.

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Inheritance of Grain Protein Content in Two High-protein Lines of Wheat

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Abstract

To study the inheritance of protein content, two high-yielding wheat (*Triticum aestivum* L. ssp. *aestivum*) lines (PH 132 and PH 133) were crossed with the widely grown Indian cv. WL 711 (grain protein <10%). Progeny were studied in the F_2, BC_1F_1 and F_3 seed (F_1, BC_1, and F_2 generations, respectively). Both groups of crosses produced ratios of 1:14:1, low : medium : high protein content in the F_2, and 1:3:0 in the BC_1. These figures indicate that two partially dominant genes, which have an additive effect, control grain protein content in these wheat genotypes. The degree of dominance was 0.89 in the cross WL 711 × PH 132. A backcrossing program is now being used to transfer high protein content (from PH 132 and PH 133) into an agronomically superior background (WL 711 and HD 2329).

Key words: *Triticum aestivum*; soft wheat; progeny; hybrids; genetic inheritance; protein content; varieties; India.

توريث محتوى الحب من البروتين الموجود في سلالتين من القمح عاليتي البروتين

الملخص

لدراسة توريث محتوى البروتين، تم تهجين سلالتين مغلالتين (PH 132 و PH 133) من القمح (Triticum aestivum L. ssp. aestivum) بصنف هندي WL 711 يزرع على نطاق واسع (بروتين الحب أقل من 10٪). دُرست الأنسال في بذور الجيل الثاني F2 و BC1 الجيل الأول والجيل الثالث F3 (أجيال F1، BC1 و F2 على التوالي). وقد أعطت كلتا المجموعتين من الهجن النِسَب 1 : 14 : 1، منخفض ومتوسط وعالٍ من محتوى البروتين في الجيل الثاني و 1 : 3 : 0 في الـ BC1. وتشير هذه الأرقام إلى أن هناك مورثتين سائدتين جزئياً ذات أثر متجمع، تتحكمان في محتوى الحب من البروتين في هذه الطرز الوراثية من القمح. وكانت درجة السيادة 0.89 في الهجين PH 132 X WL 711. ويستخدم حالياً برنامج للتهجين الرجعي لنقل محتوى البروتين العالي (من PH 132 و PH 133) إلى مجموعة من السلالات متفوقة زراعياً.

Introduction

Previous reports on the genetics of grain protein content in wheat have indicated that this trait is highly heritable and is determined by several genes (Johnson et al. 1968). However, in some cases protein content has been found to be controlled by one or two genes (Haunold et al. 1962; Cowley and Wells 1980). In general, genes for low grain protein content show weak dominance over those for high protein (Chapman and McNeal 1970; Halloran 1981), though in some cases the direction of dominance is the opposite (Cowley and Wells 1980). In this note, we report the results of a study on inheritance of protein content in two high-protein lines, PH 132 and PH 133, derived from a cross (Fnd-Cno 67^2 × Ron No.2-Fnd) involving high-protein line Frondoso, from the International Maize and Wheat Improvement Center (CIMMYT), Mexico.

Material and Methods

PH 132 and PH 133 were crossed with WL 711, a widely grown Indian spring wheat cultivar having grain protein below 10% on dry weight basis. Segregating generations from these crosses were used to study the inheritance of protein content in the two lines. F_2, BC_1F_2 and F_3 seed (harvested from single F_1, BC_1 and F_2 plants, respectively) were used to study protein content in F_1, BC_1 and F_2 generations, respectively. Protein content in seed harvested from each plant was determined on dry weight basis by estimating nitrogen content in each grain sample by using a Technicon auto analyser (Warner and Jones 1970) and the following formula:

$$\text{Protein content (\%)} = \text{Nitrogen content (\%)} \times 5.7$$

Results and Discussion

The mean grain protein contents of PH 132 (12.8%) and PH 133 (13.7%) were significantly higher than that of WH 711 (8.3%, t = 11.308 and 10.268, respectively). The percentage frequencies of plants for protein content in parents, F_1 and F_2 generations of the crosses WL 711 × PH 132 and WL 711 × PH 133 are shown in Figures 1 and 2, respectively. The F_2 distribution for protein content of the two crosses was similar. In both cases, there was discontinuity in F_2 distribution at 15% grain protein. Similarly, in both cases, there is a point of low frequency at 9%, which is lower than lowest of PH 132 (10%) and PH 133 (9.5%) as well as F_1s of WL 711 × PH 132 (10.5%) and WL 711 × PH 133 (12%). If these two points (15% and 9%) in the F_2 distribution for protein content are used to separate segregants having high protein (>15%) and low protein (9% or less) from the segregants having medium protein (9 to 15%), the number of plants in high, medium and low protein categories do not differ significantly from a 1:14:1 ratio in both the crosses (Table 1). This suggests that the difference in grain protein content of the two high-protein lines from that of WL 711 is under the control of two partially dominant genes with additive effect. This is further supported by the fact that the number of plants with low protein (9% or less) and medium protein (9 to 15%) did not differ significantly from 1:3 ratio (Table 1) in the BC_1 of the cross WL 711 × PH 132. Moreover, there is a clear discontinuity in the frequency distribution of BC_1 generation separating the plants with low protein content from those with medium protein content. The degree of dominance for the cross WL 711 × PH 132 was 0.89. In the cross WL 711 × PH 133, because of small sample size of F_1 generation studied, the mean protein percentage of F_1 was not used to estimate degree of dominance. However, the range of protein percentage in F_1 indicates partial dominance in this case as well.

The control of high protein content in PH 132 and PH 133 by two partially dominant genes suggests that this desirable trait can be transferred to an agronomically superior background by backcrossing. A program to transfer high protein percentage from these high-protein lines into two high-yielding widely adapted Indian spring wheat cultivars, WL 711 and HD 2329, has been initiated at the Punjab Agricultural University.

Table 1. Numbers of plants in low (7 to 9%), medium (>9 to 15%), and high (>15%) protein content categories in the segregating generations of crosses WL 711 × PH 132 and WL 711 × PH 133.

Cross	Generation	Protein content (%)			Total	Ratio	χ^2	P
		7–9	>9–15	>15				
Wl 711 × PH 132	F_2	10	72	5	87	1:14:1	4.087	0.10–0.20
	BC_1	2	11	–	13	1:3	0.641	0.30–0.50
Wl 711 × PH 133	F_2	5	62	7	74	1:14:1	1.367	0.50–0.70

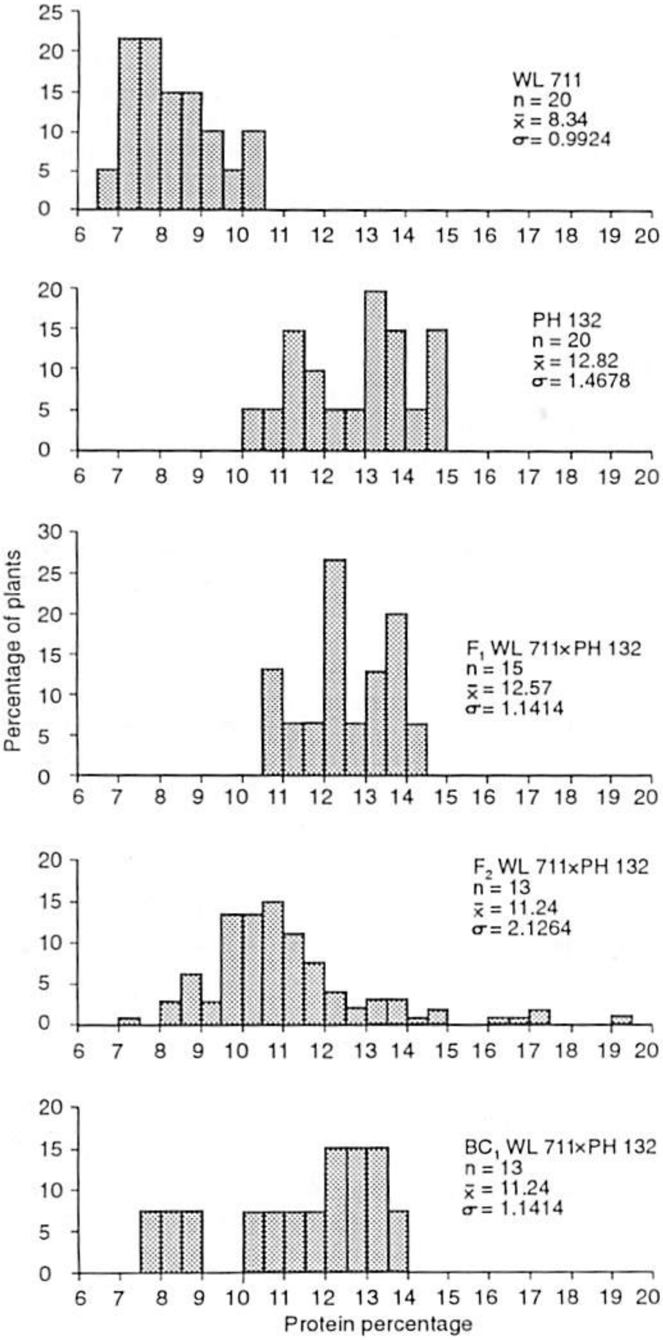

Fig. 1. Percentage frequencies for grain protein content in parents, F_1, BC_1 and F_2 generations of the cross WL 711 × PH 132.

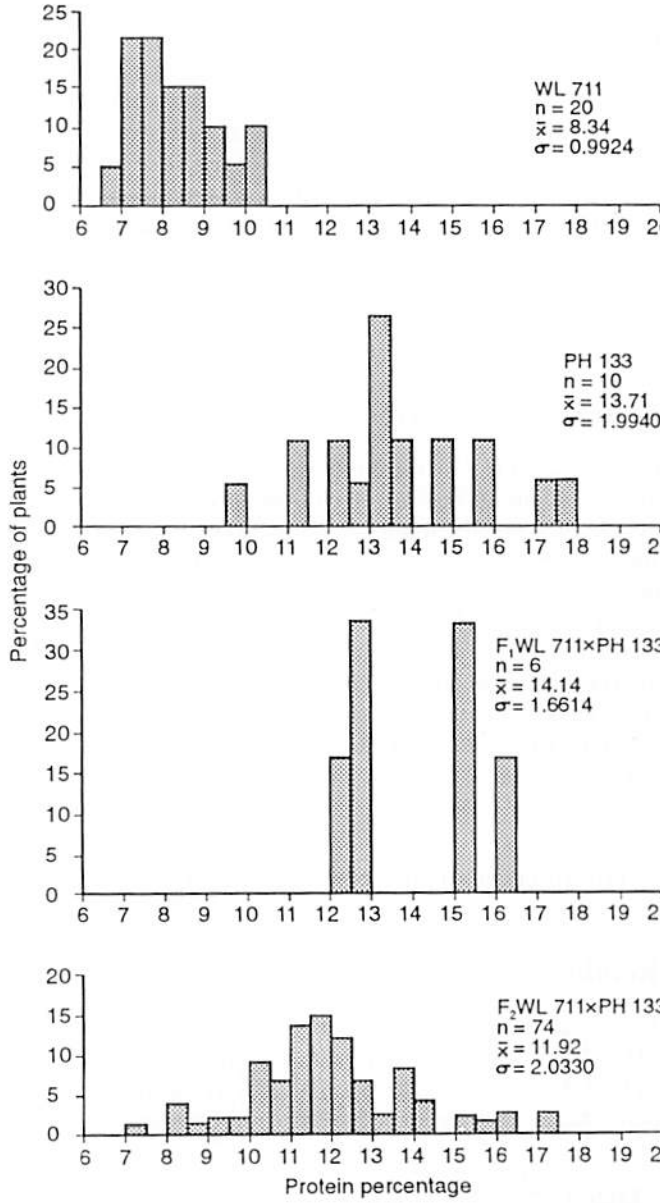

Fig. 2. Percentage frequencies for grain protein content in parents, F_1 and F_2 generations of the cross WL 711 × PH 133.

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New Wheat Cultivars Induced by Fast Neutrons in Iraq

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Abstract

Wheat (*Triticum aestivum* L. ssp. *aestivum*) seeds from the cultivar Mexipak and F_2 of the cross SaberBeg/Mexipak and SaberBeg//Mexipak/Abu-Ghraib-4 were irradiated with fast neutrons and screened for resistance to leaf rust (*Puccinia recondita* Rob. ex Desm.) during three generations. Thirty-eight and 226 variants showing resistant and moderately resistant reactions, respectively, were selected. Of these variants three mutants showing genetic purity and stability were studied for yield components for four successive generations. Analyses of proteins and isozymes along with chemical and physical properties were conducted on these mutants and their parents. Data on disease incidence, lodging, shattering and yield components indicated that all the mutants significantly surpassed the cultivars Mexipak, SaberBeg and Abu-Ghraib-4. Both mutants Tamuz-1 and Tamuz-2 surpassed Mexipak in bread-making quality, while the mutant Tamuz-3 had a higher tendency for better bread-making quality than Mexipak or SaberBeg.

إيجاد أصناف جديدة من القمح بواسطة النيوترونات السريعة في العراق

الملخص

عُرِّضَت بذور القمح (*Triticum aestivum* L. ssp. *aestivum*) من الصنف مكسيباك والجيل الثاني F2 من الهجين صابربك/مكسيباك وصابربك/مكسيباك/أبو غريّب 4 لأشعة ذات نيوترونات سريعة، ثم غربلت لمقاومة صدأ الأوراق (*Puccinia recondita* Rob. ex. Desm.) خلال ثلاثة أجيال. وقد تم انتخاب 38 صنفاً مقاوماً و 226 صنفاً متوسط المقاومة. ومن تلك الأصناف درست ثلاث طافرات، ذات نقاء واستقرار وراثي من حيث مكونات الغلة، خلال أربعة أجيال متعاقبة. وأجريت تحاليل للبروتين وتماثل الأنزيمات (isozymes) لهذه الطافرات وآبائها، فضلاً عن خواصها الكيميائية والفيزيائية. وقد أشارت بيانات الإصابة بالأمراض والرقاد والانفراط ومكونات الغلة إلى تفوق جميع هذه الطافرات بشكل كبير على الأصناف مكسيباك، صابربك وأبو غريّب 4، إذ تفوقت كلتا الطافرتين تموز -1 وتموز -2 على مكسيباك في جودة صناعة الخبز، بينما تمتعت الطافرة تموز -3 بميل أكبر من مكسيباك وصابربك نحو جودة أفضل لصناعة الخبز.

Key words: *Triticum aestivum*; soft wheat; seed treatment; *Puccinia recondita*; disease resistance; genetic variation; mutants; isoenzymes; breadmaking; quality; Iraq.

Introduction

Wheat is one of the most important crops in terms of cultivated area and economic importance in Iraq (Raja 1973). Several diseases, particularly leaf rust, badly affect its productivity and quality. Severity of incidence varies from year to year depending on the climatic conditions. Application of pesticides to control this disease is difficult and costly (Al-Baldawi 1981; Nelson 1977).

Mexipak has been the main wheat variety grown in both the irrigated and rain-fed areas of Iraq since 1967. It is a high-yielding variety with good response to fertilizer and moderate resistance to major diseases. Recently, a change in its response to rusts and bunts has been noted. It has shown the same behavior in other countries which resulted in its cultivation being stopped in countries such as Pakistan where this variety was selected under its prevailing conditions. Pakistani researchers developed variety Jauhar-76 by fast neutrons (dose: 600 rad), which gave yields 10% and 25% higher than Pakistan 70 and Mexipak, respectively; it was released in 1979 (Siddiqui et al. 1981). Nuclear techniques have been widely used over the past 20 years to induce mutants resistant to different pathogens and to develop resistant varieties, particularly those into which improved traits have been introduced (IAEA 1981–89; Micke et al. 1985; Ibrahim et al. 1990). Data on wheat mutation indicate the importance of hybrid irradiation in the early generations as an additional source to create variations which are difficult to obtain through hybridization or irradiation separately. Fast neutrons are the most important radiation source creating such variations due to their ability to infiltrate and diffuse inside the irradiated biological material, react with its nucleus, forming new isotopes and protons with high energy. This causes many chromosomal breakages (Brock 1970).

The International Atomic Energy Agency (1981–89) reports that the number of wheat varieties developed or improved by using irradiation techniques and chemical mutagens was more than 100 up to mid-1989, and that 20% of such varieties are disease resistant, and are grown over wide areas (Micke et al. 1985; Ibrahim et al. 1990; Brock 1970; Micke 1987, 1989).

This study reports the program of developing three mutants of Mexipak and some of its hybrids induced by fast neutrons during 1983–1991.

Materials and Methods

Six hundred seeds of wheat cultivars Mexipak and SaberBeg (local) and F_2 of the crosses Mexipak/SaberBeg and Mexipak//Saberbeg/Abu-Ghraib-4 were irradiated by fast neutrons in India, at the rates of 0, 400, 800 and 1200 rad. The experiment was conducted 43 days after irradiation.

The effect of irradiation on M_1 was evaluated on the basis of rate of germination, length of the first leaf, plant height at four-leaf stage and at maturity, spike weight and number of seeds per spike. At full maturity, all spikes of primary stems on M_1 plants were collected, and then multiplied as spike-rows in M_2. Through the different stages of growth observations were made on all plants, and mutants were selected based on their divergence from the parents for the following traits: earliness (flowering, maturity), rust resistance, stem thickness, reduction in plant height, spike compaction and shattering resistance.

At heading, all plants in the rows were artificially infected with a uredispore suspension of *P. recondita* at a concentration of 6.3×10^4 spores/ml. Three weeks later, the degree of infection was calculated following Loegering (1981).

Three mutants (to be named Tamuz-1, Tamuz-2 and Tamuz-3) that showed genetic stability, were yield tested for four consecutive generations in RCB experiments with three replications and 3×3 m plots. In addition to grain yield, the following traits were assessed: lodging resistance, shattering, yield components (number of spikes/m of row, spike weight and 1000-kernel weight), and resistance to leaf rust.

Chemical and physical characteristics of the three mutants were studied using generally accepted methods (AACC 1983). Clotomatic 2200 apparatus was used to assess the wet gluten. Weight of dry gluten was assessed after drying the wet gluten balls by using heater Clotork 2020 for two minutes.

Baking was assessed using the one-stage method of Jaddou (1988) with and without the addition of bread improvers. Size of loaf was measured by removing (Saljam) after leaving the bread to cool. Flour color was assessed by using Kent-Jones (Martin) apparatus.

The three mutants along with Mexipak and SaberBeg were studied for enzymes and proteins in M_7. The following systems were studied: Leucine amino peptidase (LAP), Glutamate oxaloacetate transaminase (GOT), esterase isozyme (EST) and Acid phosphatase (ACP) (Al-Jibouri et al. 1990). Protein was also determined for the various lines.

Results and Discussion

Morpho-physiological traits

The effect of irradiation by fast neutrons was significant on most characteristics of M_1 plants of Mexipak and SaberBeg when the dose of irradiation was 1200 rad, and to a lesser extent when it was 800 rad (Table 1). Different morphological variations were observed such as branching, compaction and distortion. Such variations are radiomorphoses that happen usually as a result of the physiological influence of radiation. Most variations in the plants of this generation are not genetic, but variation in M_1 is evidence of the potential to produce useful mutants, as seen by many researchers (Micke et al. 1985). The significant reduction in the number of seeds per spike of the two original varieties may be due to the sterility resulting from the biological effect of fast neutrons. This is a good indication for selecting mutants, since useful mutants appear usually in the spikes where sterility is around 24–74% (Brock 1970).

Resistance to leaf rust

The cross SaberBeg//Mexipak/Abu-Ghraib-4 yielded 31% plants that were resistant to leaf rust; whereas the best mutants derived from Mexipak or SaberBeg/Mexipak were only moderately resistant (Table 2). The mutant Tamuz-3, derived from SaberBeg//Mexipak/Abu-Ghraib-4, combined its good reaction to leaf rust with resistance to lodging and shattering. The other mutants, Tamuz-1 and Tamuz-2, also compared well with Mexipak, SaberBeg and Abu-Ghraib-4 for these traits (Table 3).

Yield

Over three years of testing, corresponding to the M_5–M_8 generations, the three mutants out-yielded Mexipak (Table 4). Superiority of the mutants continued up to M_9 (Table 5) in spite of the unfavorable conditions that took place after the Gulf War and their effect on fertilizer availability, irradiation, and cultivation. The good performance of the mutants over four years of testing implies genetic stability and consistently better yield in comparison to Mexipak, which warrants their adoption as new cultivars for irrigated and rain-fed wheat areas of Iraq.

Table 1. Effect of fast-neutron irradiation on some traits in M_1 mutants of Mexipak and SaberBeg.

Variety	Dose (rad)	Germination (%)	Length of 1st leaf (cm)	Plant height at 4-leaf stage (cm)	Plant height at maturity (cm)	Spike length (cm)	Spike weight (g)	Grains/ spike
Mexipak	Check	78.6	6.2	10.4	38.5	5.9	1.0	26.8
	400	69.6	5.4	10.7	43.0*	5.8	1.0	22.4**
	800	70.0	4.1**	8.6**	31.0**	4.3	0.3**	2.7**
	1200	34.1**	0.5**	5.4**	23.6**	4.2	0.3**	2.9**
	$LSD_{0.05}$	21.25	1.07	1.85	3.73	2.44	0.04	4.09
	$LSD_{0.01}$	32.22	1.62	2.15	5.66	2.70	0.07	6.21
SaberBeg	Check	69.9	6.7	8.7	59.3	6.8	0.9	21.6
	400	67.5	6.0	7.0	49.5	5.8	0.6*	13.9
	800	65.3	5.6*	7.3	45.9*	5.6*	0.5**	11.9**
	1200	38.8*	3.5**	6.2	39.9**	4.1**	0.3**	4.4**
	$LSD_{0.05}$	23.13	0.79	1.75	9.85	1.10	0.09	4.04
	$LSD_{0.01}$	35.07	1.18	2.66	14.94	1.66	0.16	6.10

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

Table 2. Resistance of selections of Mexipak and its hybrids in M_3 and M_4 to leaf rust under artificial infection.

Genotype	Dose (rad)	Total selections	Selections[†]			
			R	MR	MS	S
Mexipak (M)	0	20	0	0	16	4
	400	367	0	57	234	74
	800	142	0	2	83	59
	1200	259	0	2	123	134
SaberBeg (S)/M (F_5)	0	47	0	1	24	22
	400	426	0	41	221	164
	800	453	0	33	174	246
	1200	511	0	26	168	317
S//M/Abu-Ghraib-4 (F_5)	0	24	0	5	14	5
	400	61	23	25	5	8
	800	39	6	19	8	6
	1200	24	9	15	0	0

[†] R = resistant; MR = moderately resistant; MS = moderately susceptible; S = susceptible.

Table 3. Resistance of wheat cultivars and derived mutants in four generations (M_5–M_8) to leaf rust, lodging and shattering.

Genotype	Origin	Dose (rad)	Resistance		
			Leaf rust	Lodging	Shattering
Mexipak (M)	Imported	0	MS	R	MS
SaberBeg (S)	Local	0	S	S	R
Abu-Ghraib-4	Local selection	0	MR	R	MR
Tamuz-1	Mexipak	400	MS–MR	R	R
Tamuz-2	M/S	800	MR	MR–R	R
Tamuz-3	S//M/Abu-Ghraib-4	400	R	R	R

Table 4. Yield performance of mutant cultivars in comparison with Mexipak, 1988–90.

Genotype	Yield (kg/ha)				1000-seed wt† (g)	Seeds/ spike†	Spike wt/ seed†	No. spikes/ m†
	1988	1989	1990	Av.				
Mexipak	2191	2615	2226	2344	40.5	63.3	1.9	131.5
Tamuz-1	2678	3804	2988	3157	39.1	70.7	2.2	155.1
Tamuz-2	2332	2990	3622	2981	40.0	68.4	2.3	154.8
Tamuz-3	2200	3614	2603	2806	40.7	68.5	2.2	171.7
$LSD_{0.05}$	331	324	298					

† Averages shown only.

Table 5. Yield performance of wheat mutants at the M_9 generation (1991).

Genotype	Grain yield (kg/ha)	1000-seed wt (g)	Grains/ spike	Seed wt/ spike (g)	Spikes/ m
Mexipak	1283	31.2	50.5	1.7	75.5
Tamuz-1	1477	32.1	54.3	1.8	79.7
Tamuz-2	1537	32.8	54.1	1.8	87.0
Tamuz-3	1626	34.0	55.3	1.8	81.7
$LSD_{0.05}$	105	1.1	1.9	0.1	5.3

Physical and Chemical traits

Table 6 shows the quantity of extracted flour, 1000-seed weight, flour color, ash content and wet and dry gluten in the original varieties and the mutants. Flour extraction ranged between 68% and 75.8%, and 1000-seed weight 31.3–42.9 g. This test is used as evidence of grain filling, as large seeds with high density generally give higher extraction rate. This applies to most tested samples that have high 1000-seed weight accompanied by a reduction in protein and gluten, and consequently, a lower specific size of the produced bread from the tested flour. This might be due to the accumulative increase in starch at the expense of protein in the endosperm.

Color intensity ranged between 1.4 and 6.2. SaberBeg was superior to the other lines, followed by mutant Tamuz-3. Protein content of the flour ranged between 7.4 and 11.6%; SaberBeg had the highest protein content, followed by Tamuz-3.

Ash content was between 0.56% and 0.83%. The highest value of dry gluten was scored by SaberBeg (26.5).

Table 7 shows the dough characteristics of the tested genotypes. A significant rise in water absorption was noted in the farinograph of all tested samples, this might be due to the drop in protein content and the damage increase in the starch (Preston and Matsuo 1986). Differences in arrival time and stability time values reflect the difference in the composition of the tested samples. Most genotypes showed a relatively high extensibility/resistance ratio that corresponded to a color rating of 70. Values of falling number ranged between 380 and 510 seconds, the most desirable genotype being Tamuz-2 (380 seconds).

Table 6. Specific traits of developed mutant wheat varieties and parents.

Genotype	Flour extraction (%)	1000-seed wt (g)	Color	Protein (%)†	Ash (%)†	Wet gluten (%)	Dry gluten (%)
SaberBeg	71.8	31.3	6.2	11.6	0.83	26.5	9.4
Mexipak	70.0	41.3	2.3	9.5	0.64	16.0	5.7
Tamuz-1	70.3	40.5	2.0	7.4	0.65	17.0	6.0
Tamuz-2	68.0	41.9	1.4	8.0	0.56	16.0	5.7
Tamuz-3	75.8	42.9	2.5	11.0	0.69	19.7	6.8

† Calculated on the basis of dry weight of flour.

Table 7. Physical traits of dough of developed wheat mutant varieties and parents.†

Genotype	Farinograph readings			Extensograph readings			Falling no. (sec)
	Absorption	Arrival time (min)	Stability (min)	Extensibility	Resistance (Bu)	Rate	
SaberBeg	71.5	2.8	2.4	70.0	96.6	1.38	402
Mexipak	73.0	2.4	2.0	35.0	24.2	0.69	440
Tamuz 1	61.9	1.8	1.6	39.0	None	None	480
Tamuz 2	62.0	2.0	1.6	47.0	None	None	380
Tamuz 3	67.0	2.4	3.2	73.0	218	2.99	510

† Results calculated on the basis of 14–15% moisture in the flour.
Bu = Brahender units.

Table 8 shows the baking quality of the genotypes tested with and without bread improvers. Mutant Tamuz-3 gave the highest color ratings when no improvers were added (56), while SaberBeg gave 44. SaberBeg showed a high response to the improver, with superior color rating compared to the other genotypes. Results by Ali-Jibouri et al. (1990) on enzyme and protein analysis showed that mutants Tamuz-1, Tamuz-2 and Tamuz-3 have high genetic stability, and did not show any differences either at the level of studied enzymes or at the level of total protein.

Table 8. Specifications of bread made from the flour of mutant lines and parents.

Genotype	Without improver			With improver		
	Loaf size (cm)	Specific size of loaf	Color rating	Loaf size (cm)	Specific size of loaf	Color rating
SaberBeg	230	18	44	325	24	78
Mexipak	185	13	35	230	18	62
Tamuz-1	165	12	50	260	19	70
Tamuz-2	155	12	54	260	20	65
Tamuz-3	185	13	56	250	19	70

We conclude from the different studies conducted on the three mutants that they have the potential for registration and release as new varieties (Tamuz-1, Tamuz-2 and Tamuz-3 varieties), suitable for the irrigated and rain-fed areas due to their increased resistance to leaf rust and good combination of other desirable and genetically stable characteristics.

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Short Communications

New Hull-less Barley Germplasm for High-altitude Areas

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There is increased interest all over the world in barley (*Hordeum vulgare* L. ssp. *vulgare*) for use as human food. Historically, people living in highlands grow barley as a food crop for human consumption, probably due to its better performance under harsh environments as compared to other crops (ICARDA 1993, pp. 56–66). In the mountainous region of the Tibetan Plateau, hull-less barley is a main staple crop occupying 55% of the total cultivated land (Tashi 1993). The local people have established many unique ways of food perparatoin from barley grain.

In high-elevation areas of some Latin American countries, barley is a major constituent of the diet (ICARDA 1993, pp. 18–26). The interest in barley as human food also stems from high dietary value that could lead to a rediscovery of barley as a food crop in the western countries (Bhatty 1992). Recent studies have shown that barley surpassed other cereal crops in the content of β-glucan, total dietary fiber and soluable fiber, beneficial in treating hypercholesterolemia (Anderson et al. 1990; Berglund et al. 1993), and contains inhibitors to cholesterol synthesis. Its bran and bran-oil can cosiderably reduce serum cholesterol level (Weber et al. 1991). Therefore, waxy hull-less barley has acquired new importance due to its benefits in human health and absence of husk – it does not require pearling (Newman 1992; Newman et al. 1992; Bhatty and Rossnagel 1993). Higher-fiber food products of increased dietic quality can be obtained when waxy hull-less barley is substituted for wheat, rice and oats in amounts ranging from 25 to 100% with no loss of consumer acceptability (Berglund et al. 1992). There is now a trend to expand barley grain application as a blend in bread-making, because mixing it with wheat flour does not spoil the bread quality.

The hull-less genes have been reported not to affect visible morphological and genetic characteristics; they also do not decrease yield exept for the loss of hulls at harvest (Heen et al. 1991).

In accordance with its mandate, ICARDA initiated research on winter barley germplasm development for high-elevation areas, including enhancement of genetic material of hull-less barley. The major production constraints to barley production in mountaineous areas are: low cold tolerance and susceptibility to many diseases, which hamper yield potential and yield stability.

The objectives of this research were to study hull-less barley collections at ICARDA testing sites for various agronomic characters, identify sources of resistance to the above-mentioned constraints, and transfer desirable gene(s), through hybridization, to improved hull-less barley germplasm.

Materials and Methods

A set of 109 entries of hull-less barley, comprising 42 entries from ICARDA collection, 51 Viringa"S" lines, and 16 newly developed hybrid lines, were tested to determine (i) yield potential in comparatively favorable conditions at Tel Hadya (Syria), (ii) drought tolerance in Breda (Syria), and (iii) cold tolerance under natural conditions in Kazan (Turkey).

The yield trial in Tel Hadya was sown by drilling machine in eight-row plots, 10 m long, with 20 cm between rows and 30 cm between plots. In Kazan and in Breda, plots were 2.5 m long.

The evaluation for vernalization requirenment was done by planting all tested lines on 20 June 1993 in a special summer nursery under irrigation.

The best 47 lines, selected after complex evaluation at in all testing sites, were studied for cold tolerance under controlled conditions in growth chambers according to methods described earlier (Tahir et al. 1991).

Results and Discussions

An enormous amount of genetic diversity was observed for all the traits. The diversity comprised different morphological types, including two- and six-row lines; lax and dense heads; long and short, smooth and rough awns;

narrow and wide leaves of different length and color. Many types of grain were observed ranging from very small to rather large, long and round and various colors (yellow, green, brown and black).

Plant height ranged from 45 to 70 cm, time to heading ranged from 7 to 20 days (Table 1). The tested material differed considerably in growth habit which was recorded on a scale of 1 (erect – spring type) to 5 (prostrate – winter type), five lines were completely prostrate.

Of 48 lines tested in the summer nursery for vernalization requirement only four headed – others were thermosentitive. The best lines are listed in Table 1 along with the check cultivars; only ICB 102590 is facultative, others were winter types.

Hull-less barley in general is less drought tolerant than local checks, but some of the lines (e.g. Viringa "S", ICB 102607, ICB 118305, DZ-40-67, Abn/Cori//Abn) possessed fast initial growth and good drought tolerance in trials carried out at Breda (moisture-stress site) and had high agronomic score.

Four highly cold-tolerant lines (ICB 101354, ICB 100811, ICB 100819 and DZ-40-66) were identified which had 100% survival at Kazan, where check varieties Rihan-3 and Salmas were completely killed. In general, hull-less barley possessing high protein content has a very poor winter hardiness. However, these lines were evaluated under controlled conditions in growth chambers during two cycles of freezing test at –9°C for 18 h and –10°C for 18 h, and showed consistently good cold tolerance, comparable to the best check Tokak (Table 2). Some of the best selected lines differed greatly in agronomic traits.

Table 1. Characteristics of hull-less winter barley lines, 1993/94.

Line	Head type	GH†	GV	CT	DT	DH	PLH (cm)	YLD (kg/ha)	PC (%)	TKW (gr)
Viringa "S"	2	3	5	L	5	16	55	4250	15.1	39.0
Viringa "S"	2	3	5	L	5	18	55	4200	13.9	45.0
ICB 102607	2	2	5	L	5	17	70	3550	17.2	37.0
ICB 101354	2	4	3	H	5	20	60	3650	13.7	33.0
ICB 102590	2	2	5	L	4	19	55	3750	16.4	39.0
ICB 102282	2	5	4	M	5	18	55	3050	16.9	42.5
ICB 100811	6	3	5	H	4	15	60	4600	15.0	30.5
ICB 100819	6	4	4	H	4	18	60	4350	15.1	30.0
ICB 118305	6	3	5	L-M	5	19	65	4500	15.1	29.0
ICB 105960	6	2	4	H-M	4	8	45	4050	13.3	28.5
DZ-40-67	6	4	5	H	5	9	60	3200	13.7	29.0
Abn/Cari//Abn.	2	3	5	L	5	11	50	5000	15.4	43.0
Rmro"S"	2	4	5	L	4	11	55	4890	16.0	41.5
Cita"S"/3/Boy.	2	3	5	L	5	12	60	4900	14.5	43.5
Rihan-3	6	2	5	L	5	14	55	5100	12.7	39.0
Salmas	2	2	5	M	5	16	60	4964	13.1	42.0
Tokak	2	5	3	H	4	23	50	4300	13.6	47.0
LSD 0.05								680	0.5	2.7

† GH = growth habit (1=erect, 3=medium, 5=prostrate), GV = growth vigor, DT = drought tolerance (1=low, 3=medium, 5=high), CT = cold tolerance (L=low, M=moderate, H=high), DH = days to heading, PLH = plant height, YLD = grain yield, PC = protein content, TKW = thousand kernel weight.

Table 2. Cold tolerance of hull-less barley lines, 1993/94.

Line	Cold tolerance in Kazan†	ICARDA survival (%)	
		-9°C	-10°C
ICB 101354	5	100	76.5
ICB 100811	5	100	70.4
ICB 100819	5	100	69.3
DZ-40-66	5	100	100
IBC 102282	3	76.4	40.3
ICB 105960	3.5	80.4	58.8
Tokak	5	100	70.4
Salmas	2	40.3	0
Rihan-3	1	0	0
LSD 0.05		10.4	11.8

† Cold tolerance score: 1 = very low, 3 = moderate, 5 = high.

ICB 101354 a two-row line with prostrate plant habit, was very late and has long small grain which is green.

ICB 100811 six-row type, with good growth vigor and yielding capacity; small grains, and 15% protein content.

ICB 100819 six-row, smooth-awned type, with prostrate growth habit and good yield.

DZ-40-66 early six-row, winter type, with good growth vigor and drought tolerance; grains small and green.

ICB 102282 two-row, moderately cold-tolerant line of winter type with very good straw, large, colored grains and 16.9% protein content.

ICB 105960 early six-row, moderately cold-tolerant line with small, round grains.

Among the most productive material with yield potential of 4–5 t/ha were Viringa "S" lines (developed by the ICARDA-Mexico Latin America Program), as well as newly developed hybrid lines Abn/Cori//Abn..., Cita"S"/3/Boy..., and Rmro "S". These all possess stiff straw, and plump grains of high quality.

For grain-quality improvement, line ICB 102607 could be very useful in crosses. This two-row line with good agronomic score in hash environment (Breda) possesses rather tall straw and very high protein content; it also has grains identical to those of the best bread wheat types: *plump, oval and* red.

The identified new sources of resistance to cold and drought in hull-less barley germplasm are very valuable for development of germplasm suitable for high-elevation areas. These lines will be used to increase cold tolerance in the locally adapted germplasm, to increase yield potential and stability in production under severe cold conditions; in addition, they will play a vital role in improving the grain quality in hull-less barley for human consumption.

The seeds of these lines and some hybrid populations of hull-less barley are available to national programs upon request to ICARDA.

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Response of Semidwarf Barley and Wheat Lines from Libya to Exogenously Applied Gibberellic Acid

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To overcome the problems of lodging, semidwarf mutants have been exploited in many cereal-breeding programs. These can be classified into two groups based on their response to exogenous gibberellic acid (GA_3). One group comprises sensitive mutants, which can reach normal height by the application of gibberellins (GAs), whereas the dwarfs of the second group show a low reaction or complete insensitivity to added GA. The seedling response to exogenously applied GA_3 of the insensitive genotypes is widely used as a maker for final plant height in genetic studies and in breeding practice, especially in wheat (Gale and Youssefian 1985; Börner 1988).

Materials and Methods

The screening included 95 semidwarf barley lines developed at the Tajoura Nuclear Research Centre, Libya, and was carried out in 1991. All lines were obtained after gamma-ray irradiation of the locally adapted barley (*Hordeum vulgare* L. ssp. *vulgare*) cv. California Mariout (Ben Amer 1990). In addition, 28 Libyan wheat accessions from the Gatersleben gene bank (Germany) were examined. Two lines of the hexaploid wheat (*T. aestivum* L. ssp. *aestivum*) variety Bersee, isogenic for *rht* (GA sensitive) and *Rht1* (GA insensitive), supplied by the Cambridge Laboratory, Norwich (UK) were used for comparative purposes.

The modified GA_3 seedling tests described by Börner et al. (1987) was applied as follows: the seedlings were grown in plastic boxes, containing trays with single-grain fasteners. A standardized nutrient solution supplemented by GA_3 at 10 p.p.m. was used. After 21 days, the distance between the stem base and the upper end of the second leaf sheath was measured. From each genotype, 15 GA_3-treated seedlings were scored along with 15 control seedlings (grown under the same conditions but without GA_3). For the statistical analysis the *t* test was applied.

Results and Discussion

Results of screenings for GA response have been published by several authors for wheat (Börner et al. 1987, 1990; Gale et al. 1981; Worland 1986; Yamada 1990), rye (Börner and Melz 1988; Börner 1990) and barley (Favret et al. 1975; Hentrich et al. 1985). For wheat, in the absence of lodging, there is a yield advantage of the GA-insensitive semidwarfs over tall cultivars, mainly due to a positive effect on the number of grains/spike (Gale and Youssefian 1985; Börner 1988). This effect is unknown in rye and barley. Only Favret et al. (1975) describe a GA-insensitive mutant in barley, which was also less sensitive to temperature. It was considered that this mutant had a higher adaptability to different environments.

Among the 95 barley mutants tested in this experiment no genotype was found with any provable insensitivity to GA_3. All the treated seedlings were significantly taller ($P<0.01$) than their untreated equivalents.

In contrast, one hexaploid and four tetraploid (*T. turgidum* L. ssp. *durum* (Desf.) Husn.) wheats of the 28 tested accessions were GA_3 insensitive (Table 1). The durums were collected in 1981 from cultivated areas in Libya, in which various wheats from CIMMYT and ICARDA were extensively grown. Thus, it seems unlikely that they contain any different genes for GA insensitivity from the widespread Norin 10 or Tom Thumb alleles.

Of particular interest as a new source for GA-insensitive dwarfing genes is the hexaploid wheat line TRI 6964, which was collected in 1955 from an isolated area, called Al-Kufra oasis. This line will be further studied to determine the semidwarfing gene(s) involved.

Table 1. Morphological characterization and GA_3 response of the insensitive wheat lines.

Catalog number (Gatersleben)	Morphological group	Seedling length (mm)	
		Untreated	GA_3 treated
	Triticum turgidum ssp. *durum*		
TRI 13900	var. *africanum* Körn	75.0	86.8
TRI 13901	var. *leucurum* Alef.	70.6	76.6
TRI 13914	var. *valenciae* Körn.	62.3	67.0
TRI 13984	var. *leucurum* Alef.	68.8	73.6
	Triticum aestivum		
TRI 6964	var. *transcaspicum* (Vav.) Mansf.	49.1	57.9
Controls			
Bersee (*rht*)		102.9	169.0***
Bersee isogenic for *Rht1*		86.6	97.7*

*, *** Significant at 5% and 0.1% levels, respectively.

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Incidence of Barley Yellow Dwarf Virus in Barley and Wheat in Northern Gezira

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Barley yellow dwarf is the most economically important virus disease of cereals worldwide (Plumb 1983). The disease is caused by a range of luteoviruses that are grouped into strains on the basis of their transmissibility by over 20 aphid species in a circulative manner. These strains include MAV transmitted by *Sitobion avenae* F., RPV (*Rhopalosiphum padi* L.), RMV (*R. maidis* Fitch.), SGV (*Schizaphis graminum* Rond.) and PAV transmitted by *R. padi* (Rochow 1970).

The disease was reported to affect wheat, barley and other graminaceous plants in many countries neighbouring Sudan, including Egypt (Abdel Hak and Ghobrial 1984), Ethiopia (Yusuf et al. 1992) and Kenya (Wangai 1987). In Sudan, although symptoms suggestive of the disease have been observed by many scientists (Y. El-Daoudi, pers. comm.), no precise diagnosis was made to confirm the presence of BYDV in the country.

The present work was intended to investigate the relevance of BYDV on small-grain cereals in Sudan using DAS-ELISA.

Materials and Methods

Field surveys were made during winter 1993/94, at the testing site of the ARC in Turabi. Surveyed areas comprised 30 feddans of the experimental plot of the Cereal Breeding Section in which a number of varieties, accessions and breeding lines of barley (*Hordeum vulgare* L. ssp. *vulgare*), bread (*Triticum aestivum* L. ssp. *aestivum*) and durum wheat (*T. turgidum* L. ssp. *durum* (Husn.) Desf.) were grown. Volunteer sorghum (*Sorghum*) plants were abundant along irrigation ditches within the experimental plot.

Leaf samples from barley, wheat and sorghum plants with symptoms suggestive of BYDN infection (yellowing, stunting, reddening) were collected in polythene bags and taken to the laboratory at the University of Gezira, Wad Medani. Another set of samples was collected from visually healthy wheat plants grown in the vicinity of barley plots with severe BYDV-like symptoms. A total of 137 samples was collected during two successive visits. Juice was extracted from each of these samples and tested by DAS-ELISA using a rabbit anti-BYDV-PAV antiserum provided by the Virology Laboratory of ICARDA, Aleppo, Syria. Positive and negative controls (BYDV-diseased and healthy) comprised of freeze-dried plant material were also used.

Results

Symptoms observed in naturally diseased barley plants (L.ACSAD 1420) consisted of bright yellowing of young leaves and reddening of older ones. These reddening symptoms were not common to all barley lines. Other symptoms, such as severe stunting and small heads, were more prevalent in other barley lines, e.g. ACSAD 1394 and 1426. In durum wheat (ACSAD 1107), typical symptoms of flag-leaf yellowing were observed. Affected plants of the commercial bread wheat variety Debeira, exhibited mild leaf yellowing. Naturally diseased volunteer sorghum plants produced two types of symptoms: one characterized by leaf yellowing, reddening and necrosis, and the other consisted of bronzing of leaf margins.

Results of ELISA tests and estimated disease incidence are presented in Table 1. About 30% of the samples gave positive reaction for BYDV. The highest proportions of positive tests were obtained from barley lines ACSAD 1394 and 1420, sorghum with leaf reddening, and durum wheat ACSAD 1107. Disease incidence estimated on the basis of visual symptoms ranged between 1 and 5% in wheat and 5 and 35% in barley. Comparison between final ELISA values of some of leaf materials tested, with those of positive and negative controls, is presented in Figure 1. All samples tested gave ELISA values similar to the positive control prepared from plants inoculated with BYDV under controlled conditions, and significantly higher than the value of negative control. Furthermore, the increase in ELISA values obtained in five successive readings at different time intervals was consistently high as illustrated in Figure 2.

Discussion

The results obtained in this investigation confirm the association of BYDV with the yellowing, reddening and stunting symptoms observed in barley and other graminaceous plants grown in Northern Gezira. The virus was more prevalent in barley where it caused severe symptoms and seemed to affect its ability to produce grains significantly. In commercial wheat cultivars such as Debeira, the disease was sporadic and symptoms were mild. However, the virus was detected in a sample prepared from symptomless plants of this variety.

Barley yellow dwarf is becoming increasingly important in North and East Africa causing substantial yield losses in barley and other cereals (Makkouk et al. 1992). Its occurrence in Sudan presents a new challenge to cereal virologists and breeders, and calls for more intensive surveys. The occurrence of naturally infected sorghum plants together with the abundance of *Schizaphis graminum*, as a potential vector of BYDV (Rochow 1970), suggest that the virus may have been introduced to Sudan a long time ago. This explains the sudden epidemic outbreak of the disease in barley which was grown for the first season in that area. Further investigations are needed to determine the nature of this virus disease, the magnitude of its spread in the country, its survival and carry-over, and various factors affecting its spread.

Table 1. ELISA test of leaf samples of wheat, barley and sorghum from Turabi, Sudan.

Host plant	Positive tests/total	Estimated incidence level (%)	Symptoms†
Wheat			
Condor × Baladi	2/14	<1	Y
F5L 1534	3/15	<1	Y
Dibeira	2/21	—	Y+Symptomless
Durum ACSAD 1107	4/ 7	3–5	Y+S
Bread L. ACSAD 789	1/12	<1	Y
Bread L. ACSAD 805	3/ 9	<1	Y
Barley			
ACSAD 1394	9/17	20–30	Y+R+S
ACSAD 1420	8/13	25–35	Y+R+S
ACSAD 1426	2/ 9	<5	Y
ACSAD 1444	2/ 9	<5	Y
Sorghum sp.	3/ 5	—	R+necrosis
Sorghum sp.	2/ 6	—	Bronzing

† Y = yellowing, S = stunting, R = reddening.

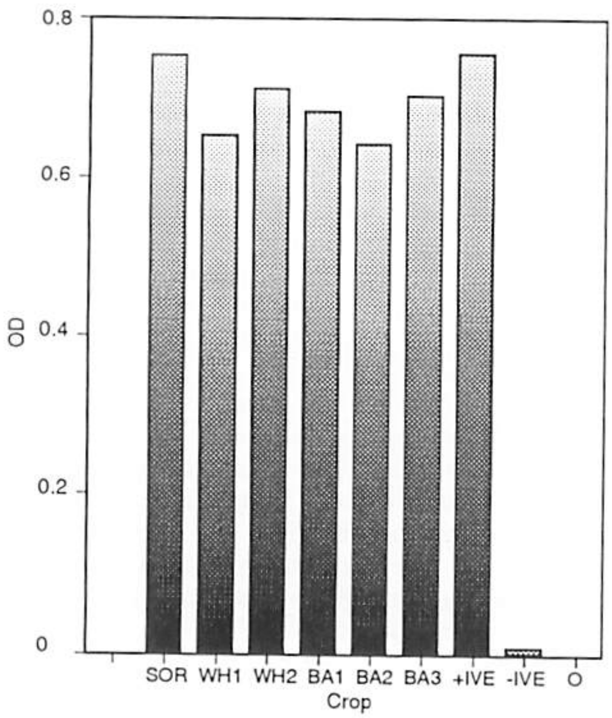

Fig. 1. ELISA test of naturally diseased plants in northern Gezira, 1993/94.

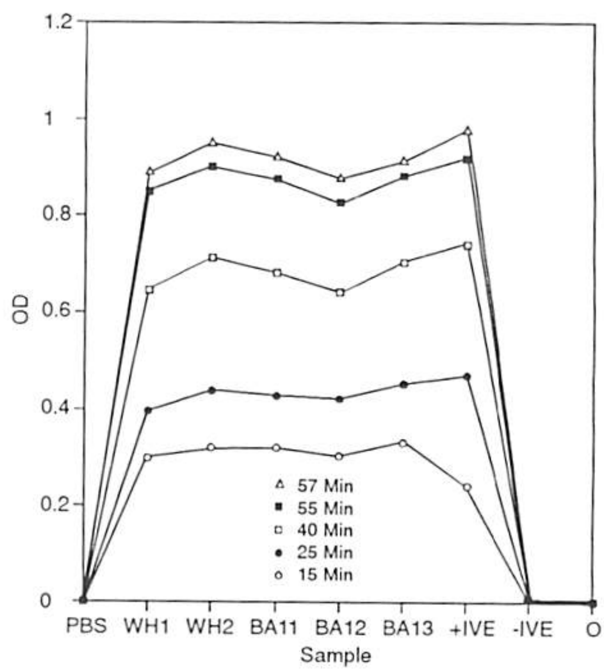

Fig. 2. ELISA test of wheat and barley in Turabi: Increase in OD values over time.

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Genetic Potential and Nutritional Requirements of Newly Developed Wheat Lines

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Wheat is the staple food in Pakistan and accounts for almost 70% of the total cereal intake. The national average yield is about 1700 kg/ha which is low compared with other wheat-growing countries. The reasons for poor production may be many but improper and inadequate fertilization is the chief cause of low yield. High-yielding varieties of wheat tend to deplete soil fertility. Under low fertility conditions, a high-yielding variety cannot develop its full yield potential unless the soil is supplemented with appropriate nutrients. It has been reported earlier that nitrogen fertilization increases the grain yield of wheat (Sharma et al. 1966). Berg and Hamid (1976) report that the best combination of nitrogen and phosphorus for wheat is 134–90 kg/ha. In another study, combined application of nitrogen and phosphorus at 180 kg N/ha and 65 kg P/ha gave the highest grain yield (Gandapore and Bhatti 1983). Khan (1985) studied the effect of different levels of nitrogen and phosphorus on different parameters of wheat and concludes that increasing the rate of nitrogen increases straw yield. Information on optimal levels of fertilizer application needed to obtain high yield from advanced wheat lines is essential. The present work was undertaken to study the genetic potential of two new advanced wheat lines and their response to application of nitrogen alone and in various combinations with phosphorus.

Materials and Methods

A field experiment was conducted at the Nuclear Institute for Food and Agriculture (NIFA) during the year 1990/91 to determine the nitrogen and phosphorus requirements of two advanced wheat lines. The lines, coded WS 38 and WS 56, are genetically stable and have been included in the National Uniform Yield Trials for final testing. The experiment was a factorial combination of these two lines and seven fertilizer levels replicated four times in a split-plot design with wheat lines as the main plots and fertilizer levels as the sub-plots. The fertilizer treatments comprised: control, 65–0, 130–0, 195–0, 65–35, 130–70, 195–100 kg of N–P/ha. The nitrogen and phosphorus were applied in the form of urea and single superphosphate. All the phosphorus and half of the nitrogen were applied at sowing and the remaining nitrogen was applied at tillering. The crop was planted with a single row drill using a seed rate of 100 kg/ha. Each sub-plot was 3 m × 4 m and consisted of 10 rows, each 4 m long and 30 cm apart. The experiment was maintained by recommended cultural practices and harvested at grain maturity.

Results and Discussion

Biological and grain yield data are presented in Table 1.

Table 1. Effect of different nitrogen and phosphorus doses on the biological and grain yields of two advanced wheat lines.

Treatment (kg N–P/ha)	Yield (kg/12 m²)					
	Biological			Grain		
	WS 38	WS 56	Mean	WS 38	WS 56	Mean
0–0	14.23	12.57	13.40 b	2.85	3.05	2.95 c
65–0	16.25	14.65	15.45 a	3.53	3.70	3.61 b
130–0	17.52	15.20	16.36 a	3.72	4.18	3.95 b
195–0	17.02	14.57	15.80 a	3.55	3.72	3.64 b
65–35	16.55	14.63	15.59 a	3.83	3.97	3.90 b
130–70	18.30	14.77	16.54 a	4.28	4.75	4.51 a
195–100	16.98	15.10	16.04 a	3.72	3.88	3.80 b
Mean	16.69 a	14.50 b		3.64 a	3.89 a	

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

The results show that different fertilizer levels had a pronounced effect on yield of the two lines. Application of N up to 65 kg/ha increased biological yield. Higher doses of N or application of P had no significant effect on biological yield. Similar results are reported by others (Khan 1985; Tahir 1983; Mohammed et al. 1988). The grain yield increased with increasing levels of nitrogen up to 130 kg/ha, the yield decreasing with 195 kg N/ha (though not significantly). Similar observations have been reported by Gandapore and Bhatti (1983).

When phosphorus was combined with nitrogen it increased the grain yield over nitrogen alone, significantly 80 at the 130 kg N/ha level (Table 1). The reason why phosphorus increased grain yield but had no effect on biological yield may be due to its greater role in the reproduction processes. Wheat line WS 38 outyielded WS 56 in biological yield, but the grain yield difference between the two lines was not significant.

The above results indicate that a proper combination of nitrogen and phosphorus is necessary for profitable wheat production. Here the optimum fertilizer combination was 130–70 kg N–P/ha which gave the highest grain yield in both lines. These results agree with those reported by Mohammad et al. (1988) and Berg and Hamid (1976). There seems to be an interaction between lines and fertilizer levels for biological yield. While maximum biological yield was obtained with 130–70 from WS 38, WS 56 gave maximum yield with 130–0. Both lines, however, behaved similarly in increasing grain yield with fertilizer application. The economics of N–P fertilization (Table 2) revealed that the highest net profit (Rs. 4621) was obtained from the treatment 130–70 kg N–P/ha on WS 38, while for WS 56 highest net profit (Rs. 3954.50) was obtained from the treatment 130–0 kg N–P/ha, followed by 130–70 kg N–P/ha (Rs. 3096). Malik et al. (1988) report that combined application of 134 kg N/ha and 67 kg P_2O_5/ha gave a net return of Rs. 3100 in wheat. Similarly, Khattak et al. (1989) estimate a net profit of Rs. 3159/ha from combined application of N–P–K at 120–60–60 kg/ha. Our findings are in conformity with the results obtained in these other studies.

Table 2. Cost and profit of fertilizer used on two advanced wheat lines.

Treatment (kg N-P/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Total cost of fertilizer (Rupees)†	Net total value of Grain + Straw (Rupees)‡	Profit (Rupees)
WS 38					
0–0	2166.6	9691.7	—	16191.5	—
65–0	2941.6	10600.0	522.8	18902.0	2710.5
130–0	3275.0	11333.3	1045.6	20112.7	3921.2
195–0	2916.6	11275.1	1568.4	18456.5	2265.0
65–35	3191.6	10541.7	784.8	19331.7	3140.2
130–70	3566.6	11683.4	1570.6	20812.6	4621.1
195–100	3108.3	11041.7	2316.4	18048.2	1856.7
WS 56					
0–0	2541.6	7941.6	—	15566.6	—
65–0	3083.3	9125.0	522.8	17852.2	2285.6
130–0	3500.0	9166.7	1045.6	19521.1	3954.5
195–0	3083.3	9066.7	1568.4	16748.3	1181.7
65–35	3316.7	8875.0	784.8	18040.2	2473.6
130–70	3958.3	8358.4	1570.6	18662.8	3096.2
195–100	3233.3	9350.0	2318.4	16731.0	1164.4

† Prices: N = Rs. 8.08/kg; P = Rs. 8.33/kg.
‡ Values: wheat grain = Rs. 3/kg; wheat straw (busa) = Rs. 1/kg.
24 Rupees = US$ 1.

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Characteristics and Performance of Newly Released Winter Wheat Varieties in Croatia

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Breeding work for improving (*Triticum aestivum* L. ssp. *aestivum*) wheat varieties in the Zagreb Institute is part of the program of wheat- production advancement in Croatia, which has been ongoing for 30 years. In this and other institutes of the country, varieties with high yielding capacity have been developed. However, there are still certain improvements that can be made, though further progress will be slower if efforts are made to develop varieties that combine genes for high yield, quality, resistance to diseases and to different climatic stresses.

The principal objective of our breeding program is to develop high-yielding cultivars with good disease resistance and improved kernel and flour quality. Varieties Marija, Sana and Marina are examples of such cultivars; they represent a significant progress in overcoming the "antagonism" existing between yield and quality. Because of their high yielding ability and good flour and bread quality, Sana and Marija have been accepted both in Croatia and abroad for several years. Moreover, their adoption is spreading. These varieties also have wide adaptability and great biological plasticity. For instance, in 1990, on 7609 ha in the regions of Slavonia and Baranja, cv. Sana produced a mean grain yield of 8.44 t/ha. In the Bjelovar region, on 444 ha its average yield was 7.15 t/ha. Because of this high yielding capacity and good results achieved on a larger scale of production, Sana was chosen by the Committee for Varietal Registration as a check variety for high yield in 1991. Likewise, cv. Marija produced a mean yield of 7.79 t/ha in the regions of Slavonia and Baranja on 10,306 ha. On 2271 ha in the Bjelovar region, it produced an average yield of 6.41 t/ha.

This paper gives the most important traits of these newly registered winter wheat varieties that are currently being introduced into production.

Marina (ZG 3021/84)

The winter wheat cultivar Marina represents a model of intensive wheat with moderately high straw and a large number of spikes per unit area. It is a good-quality bread wheat. It was developed from crossing the high-yielding semi-dwarf line ZG 2468/74 and a source of resistance to *Septoria* spp., P-3030, whose distant ancestors were American cv. Arthur and Brazilian material IAS-20. It was tested by the Registration Committee in 1986–88 and released in 1989.

Spikes are pale yellow and glabrous; at full maturity they are mostly erect, somewhat dense and tapering. There are 18–20 spikelets per spike with 3–5 kernels in each.

The kernel has extended form, semi-hard consistency and is dark red. Thousand-kernel weight is 41–43 g and hectoliter weight 78–80 kg.

At the juvenile stage, leaves are bluish green, long and narrow with unexpressed nervature. The variety produces many tillers and semi-prostate plant types. The stem is strong and elastic, 83–85 cm high, with very good resistance to lodging. Marina is a mid-early wheat, three days later than Super Zlatna. It expresses resistance to shattering, and so tolerates later planting dates.

It has good resistance to stresses such as low temperatures (–17°C without snow), drought and high temperatures in the grain-filling stage. It possesses high resistance to leaf and spike *Septoria* and rust. Its resistance to powdery mildew and scab is satisfactory. Grain and flour quality are very good. By its protein content (13.0–13.5%) and sedimentation value (35–40 ml) it belongs to quality class I(II). Its farinographic quality number is 56.6–62.8, thus it belongs to the subgroup B_1. It gives high yield of flour and good bread quality.

Prior to registration, it was included in numerous small- and large-scale trials throughout the former Yugoslavia. According to long-term data, it expressed high productivity and stability. Yields of over 9 t/ha were recorded at certain locations. This variety is well adapted to different soil types, which explains its increasing area of production. Optimal planting date is 10–25 October, with a planting rate of 650–700 viable kernels/m^2. Under favorable conditions it can produce 700–800 fertile spikes/m^2.

Biljana (ZG 343/80)

The winter wheat cultivar Biljana was developed from crossing lines ZG 5994/66 and TP 114/1965 A. It was tested by the Varietal Committee in 1985–1987 and released in 1988. The spikes of this cultivar are cylindrical, with 18–20 spikelets and 3–4 kernels in each. Kernels are semi-transparent and light brown. Thousand-kernel weight is about 40 g, and hectoliter weight is 79–81 kg. It belongs to quality subgroups B_1–B_2.

The stem is about 80 cm high and has very good resistance to lodging. Leaves are mid-long and mid-wide, spirally attached, and intensely green.

Biljana is mid-early, about two days later than Super Zlatna. It possesses very good winter hardiness. It is resistant to powdery mildew, leaf and stem rust, and shows tolerance to *Septoria* spp. and fusarium head blight. Biljana is a very productive variety with genetic yield potential above 10 t/ha. It exhibits great adaptability to different agro-ecological conditions. Its spread in production is increasing.

The optimal seeding date is 10–25 October, with a recommended seeding rate of 650–700 viable kernels/m^2.

Alena (ZG 241/84)

Winter wheat cultivar Alena is high yielding, white and awnless. In trials conducted by the Varietal Committee in 1987–1989, it gave appreciably higher yields than the standards in all growing regions. It was released in 1990. Morphologically, the spikes are cylindrical, with 20 spikelets on average and 3–4 kernels in each. At full maturity spikes are mostly erect. Kernels are semi-transparent and light brown. Thousand-kernel weight is about 43 g, and hectoliter weight 80–82 kg.

The stem is about 85 cm high with good resistance to lodging. Leaves are mid-long and mid-wide with more horizontal growth habit, dark green, later developing a waxy coating. Alena is a mid-early wheat, 1–2 days later than Super Zlatna. It possesses very good resistance to leaf and stem rust, and good resistance to powdery mildew and *Septoria* spp. At some locations in small- and large-scale trials, it gave yields exceeding 9.5 t/ha. Its yielding ability is somewhat higher than that of Sana. Its kernel and flour quality are satisfactory, and it belongs to quality class II, subgroup B_1–B_2.

Thus, this is a variety that can assure substantial profits per unit area. The optimal planting date is 15–25 October, with a recommended seeding rate of 600 viable kernels/m^2. It shows great biological plasticity and adaptability to diverse agro-ecological conditions, but its production is still limited because of its recent release.

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Foliar Vanadium Stimulates Wheat Crop on Vertisol

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Various stimulatory compounds, or phytohormones, e.g. phenylphosphonic acid and kinetin, are being used to promote plant growth and to improve grain quality. Arnon and Wessel (1953) considered vanadium (V) an essential element for green plants and micro-organisms. Likewise, Peterburgskiya et al. (1977) report beneficial effect of vanadium in boosting N content in plants, particularly legumes. The present investigation was undertaken to test the efficacy of vanadium as foliar spray on wheat grown on vertisol at Akola, India.

Materials and Methods

Field experiments were conducted at the Central Research Station, P.K.V., Akola, India during 1983/84 and 1986/87 on vertisol (total N= 0.0449%, pH= 7.6). The following treatments were applied wheat var. HD2/89: (i) control (no nitrogen or vanadium, N_0V_0), (ii) 75 kg N/ha ($N_{75}V_0$), (iii) 100 kg N/ha ($N_{100}V_0$), (iv) 75 kg N/ha + 50 p.p.m. V ($N_{75}V_{50}$), (v) 75 kg N/ha + 100 p.p.m. V ($N_{75}V_{100}$), (vi) 100 kg N/ha + 50 p.p.m. V ($N_{100}V_{50}$), (vii) 100 kg N/ha + 100 p.p.m. V ($N_{100}V_{100}$). The seven treatments were alloted to plots according to an RCB design with four replications.

Nitrogen, in the form of urea, was applied in two installments. A common basal dose of 50 kg P_2O_5/ha and 50 kg K_2O/ha was also applied to all the plots in the form of single superphosphate and muriate of potash, respectively. The vanadium was applied as a foliar spray of ammonium vanadate solution. The extra N applied through ammonium vanadate was taken into account when calculating the quantity of urea required for each treatment. The sprays were given at 15 and 21 days after sowing. At harvest, grain and straw yields were recorded. Similarly, N content in the grain and straw was determined using the Kjeldahl's method (Jackson 1973).

Results and Discussion

Grain yield

The data (Table 1) revealed consistent significant increase in wheat grain yield with increasing N levels. However, the response to N reduced with increasing N levels. The response to foliar V along with N over N alone was marked in grain yield. Foliar application of V at lower concentration (50 p.p.m.) was more effective than the higher concentration (100 p.p.m.) at both N levels. The combination $N_{100}V_{50}$ gave the highest grain yields (2.567 and 2.533 t/ha in 1983/84 and 1986/87, respectively). Likewise, consistent and significantly higher grain yields (2.506 and 2.365 t/ha) were achieved with $N_{75}V_{50}$ versus $N_{75}V_0$. The $N_{75}V_{50}$ treatment also produced higher (2.6 and 2.7%) grain yield than $N_{100}V_0$, indicating the possibility of reducing the N dose by 25 kg/ha against vanadium supplementation. The combination $N_{100}V_{50}$ was significantly superior to $N_{100}V_0$ in the second trial. Pooled data exhibited a significant effect of N levels and N-V combinations over control. The vanadium supplementation resulted in boosting grain yield.

These results are in conformity with the findings of Peterburgskiya et al. (1977), who report increases in grain yield of various crops with V supplementation.

Straw yield

Nitrogen application consistently and significantly enhanced straw yield over the control but N levels did not differ among themselves. Vanadium applied with N resulted in increased straw yield over the respective N level. However, the V advantage was only significant at N_{75} in the second trial. Among the combinations, $N_{100}V_{50}$ consistently gave the highest yield. Although the pooled results were not significant, V_{50} tended to be superior over the V_{100} level.

Nitrogen content of the grain

The data revealed that increasing N level resulted in corresponding increase in N content in the wheat grain. The $N_{75}V_{50}$ treatment significantly and consistently enhanced N content over $N_{75}V_0$. In contrast, V_{100} level registered significant rise in N content in the second trial only. Highest N content was recorded with $N_{100}V_{50}$ in both trials. However, supplementation of V at lower concentration (V_{50}) exhibited comparatively greater response at both N levels. Pooled data revealed significant differences between the control and remaining treatments. Vanadium spray distinctly improved grain quality, i.e. protein content, by enhancing N content. Peterburgskiya et al. (1977) report similar observations.

Table 1. Influence of nitrogen and vanadium on yield and N content of wheat.

Treatments	Yield (kg/ha)						N content (%)					
	Grain			Straw			Grain			Straw		
	1983/84	1986/87	Pooled	1983/84	1986/87	Pooled	1983/84	1986/87	Pooled	1983/84	1986/87	Pooled
N_0V_0	1839	1667	1753	3608	3655	3631	1.91	1.89	1.90	0.39	0.38	0.39
$N_{75}V_0$	2266	2053	2160	4190	4580	4384	2.08	2.17	2.13	0.42	0.49	0.46
$N_{100}V_0$	2443	2303	2373	4435	4850	4643	2.23	2.26	2.25	0.43	0.51	0.47
$N_{75}V_{50}$	2506	2365	2435	4413	5260	4836	2.21	2.35	2.29	0.45	0.54	0.50
$N_{75}V_{100}$	2393	2213	2303	4280	4600	4440	2.17	2.35	2.26	0.43	0.53	0.48
$N_{100}V_{50}$	2567	2533	2550	4540	5460	5000	2.29	2.38	2.34	0.49	0.53	0.51
$N_{100}V_{100}$	2483	2434	2450	4463	5090	4776	2.26	2.35	2.31	0.46	0.53	0.50
SEm (±)	53	063	133	107	214	380	0.03	0.03	0.09	0.05	0.01	0.07
LSD (0.05)	162	195	380	329	660	ns	0.09	0.08	0.19	ns	0.03	ns

ns = not significantly at P=0.05.

Nitrogen content of the straw

Vanadium along with N boosted N content in wheat straw, but differences were significant in the second trial only. In that experiment, the combinations $N_{75}V_{50}$ and $N_{75}V_{100}$ exhibited significant rise in N content over $N_{75}V_0$ combination.

Nitrogen uptake

Nitrogen yield per unit area (grain and/or straw yield × N percentage) is a reflection of nitrogen uptake by the plants. This was calculated separately for the grain and the straw, and total nitrogen yield obtained as the sum of these two compoments (Table 2).

Table 2. Influence of nitrogen and vanadium on N uptake by wheat.

Treatments	N uptake (kg/ha)								
	Grain			Straw			Total (grain + straw)		
	1983/84	1986/87	Mean†	1983/84	1986/87	Mean†	1983/84	1986/87	Pooled
N_0V_0	35.11	31.58	33.35	14.12	13.90	14.01	49.23	45.48	47.36
$N_{75}V_0$	47.24	44.58	45.91	18.01	23.03	20.52	65.25	67.60	66.43
$N_{100}V_0$	54.48	52.09	53.29	19.17	24.62	21.90	73.64	76.71	75.18
$N_{75}V_{50}$	55.57	55.61	55.59	19.90	29.41	24.66	75.47	85.02	80.25
$N_{75}V_{100}$	51.99	51.92	51.96	18.10	25.01	21.55	70.09	76.92	73.51
$N_{100}V_{50}$	58.77	60.09	59.43	22.26	29.32	25.79	81.03	89.41	85.22
$N_{100}V_{100}$	55.97	57.23	56.60	20.32	26.30	23.31	76.29	83.53	79.91
SEm (±)	1.37	1.54	—	0.54	1.28	—	1.47	1.89	4.10
LSD (0.05)	4.07	4.56	—	1.60	3.79	—	4.35	5.59	11.36

† No pooled analysis was done.

The results were similar for the three cases (grain, straw, and grain plus straw). All treatments led to significantly higher nitrogen yield (or uptake) in comparison with the check that received no N or V. The application of N alone increased N uptake. The simultaneous addition of V enhanced N uptake but this depended on the levels of both V and N. There is evidence of an N–V interaction, the best combination for nitrogen yield or uptake being $N_{100}V_{50}$, closely followed by $N_{75}V_{50}$. The results of the present investigation are in conformity with the findings of Peterburgskiya et al. (1977) who report the stimulatory effect of V on the N metabolism in plants.

Conclusion

From the above results it may be concluded that vanadium may be used as a supplement in conjunction with N to enhance grain and straw yields, and N content and uptake in wheat. Foliar application of vanadium at a lower concentration (50 p.p.m.) was beneficial and more effective than at a higher concentration.

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***10th International Cereal and Bread Congress "The Source and the Future of Civilization"*, Porto Carras, Chalkidiki, Greece, 9–12 June 1996.** Contact: Mr G. Bakayiannis, Ministry of Agriculture, 5 Acharnon Street, Athens 10176, Greece [tel. +30-1-5244851; fax +30-1-5248584].

***5th International Oat Conference and 7th International Barley Genetics Symposium*, University of Saskatchewan, Saskatoon, Canada, 30 July to 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].

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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. 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, experienced 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 to assist MSc 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 may also 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 in, 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 should 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 (ed.). 1981. Wheat Science – Today and Tomorrow. Cambridge University Press, Cambridge, UK.

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

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