# RACHIS

## Barley and Wheat Newsletter

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# Research and Production

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### Abstract

**Though barley is the main cereal of Morocco's dryland zone, it is seldom fertilized despite potential yield increases from fertilization, especially with nitrogen. While recent effort has been made for adaptation of triticale in drier areas, its response to N has not been intensively studied. This study of an improved cultivar of barley and triticale involved N rates of 0, 30, 60, 90, 120, and 150 kg/ha at five sites that formed a rainfall gradient in Morocco's semiarid cereal zone. Because of drought, two sites at the lower rainfall areas produced negligible yields and were therefore discarded. Yields were satisfactory at the other sites and decreased with rainfall. Overall triticale yield was superior to that of barley, with no difference between them at the moderately dry Skour Rehamna site. Both cereals responded similarly to N, but differed with site; maximum increase ranged from 90 kg/ha at Khouribga and 150 kg/ha at Settat to only 30 kg/ha at Skour Rehamna. Thus, while triticale seems as good as barley in drier areas, it can be competitive with it in more favorable zones. The study clearly demonstrates the yield increases possible with appropriate N fertilization.**

## مقارنة استجابات التريتيكال والشعير للآزوت في المواقع المتباينة الأمطار في المناطق الجافة من المغرب

### الملخص

رغم أن الشعير يعتبر محصول الحبوب الرئيسي في المناطق الجافة من المغرب، إلا أنه نادراً مايسمد رغم زيادة الكفاءة الإنتاجية الناجمة عن التسميد وخاصة بالآزوت. وفي حين بذلت مؤخراً جهود لأقلمة التريتيكال في المناطق الأكثر جفافاً، فإن استجابته للآزوت لم تدرس دراسة وافية. وقد شملت هذه الدراسة عن صنف محسن من الشعير والتريتيكال معدلات آزوت 0، 30، 60، 90، 120 و150 كغ/هـ في خمسة مواقع تشكل مدرجاً للأمطار في مناطق الحبوب شبه القاحلة من المغرب. ونتيجة للجفاف، استُبعِد موقعان لتدني أمطارهما عن المواقع الأخرى وأعطائهما غلة متدنية لاتكاد تذكر. وكانت الغلال مقبولة في المواقع الأخرى وتناقصت بهطول الأمطار. وفاقت غلة التريتيكال الإجمالية غلة الشعير وإن لم يكن هناك فرق بينهما في موقع سكور رحمانا المعتدل الجاف. وقد استجاب كلا المحصولين للآزوت على نحو متشابه واختلفا بحسب المواقع. وقد تراوحت الزيادة القصوى من 90 كغ/هـ في خوريبكا و150 كغ/هـ في ستات إلى 30 كغ/هـ فقط في سكور رحمانا لذا ففي الوقت الذي يبدو فيه التريتيكال محصولاً لا يقل جودة عن الشعير في المناطق الأكثر جفافاً فهو ينافسه في المناطق الأكثر ملاءمة. وقد بينت الدراسة بوضوح زيادات الغلال الممكنة بالتسميد الآزوتي المناسب.

### Introduction

Rainfed agriculture impinges upon the lives of the vast majority of farmers in the semiarid Middle East–North Africa region. Applied research has shown that productivity of such low-input agriculture can be increased. The establishment of ICARDA (International Center for Agricultural Research in the Dry Areas) has spearheaded technology transfer efforts throughout the region. At the national level in Morocco, much hope is pinned on the newly-developed Aridoculture Center in Settat, with emphasis on the predominantly dryland (250–450 mm) cereal zone (Shroyer et al., 1990). In this zone, barley (*Hordeum vulgare* L.) occupies about half the area planted to cereals, with equal amounts of bread wheat (*Triticum aestivum* L.) and durum wheat (*T. turgidum*, var *durum* L.). The area devoted to corn (*Zea* *mays* L.) is small, while the novel cereal, triticale (X Triticosecale), is only now being grown in significant amounts.

While public policy has focused on producing wheat—the staple food for human consumption—barley continues to hold its own in terms of the area cultivated since it is less risky than wheat in the cereal-livestock systems of low-rainfall areas of the region (Cooper et al., 1987). Relative resistance to Hessian fly (*Mayetiola destructor* Say), which plagues wheat, is an additional feature to drought resistance for barley. While efforts were made to produce improved, higher-yielding, disease-resistant varieties, little emphasis was placed on fertilization. Previous trials on dryland barley fertilization, conducted on agricultural experimental stations, rarely showed a nitrogen or phosphorus response. A possible explanation may be that fertility levels at such stations are so high as to preclude a crop response (Ryan et al., 1990). Fertility levels in farmers' fields are generally much lower as indicated by a soil test survey of the Chaouia region (Abdel Monem et al., 1990d). In fact, on-farm trials with N fertilization of wheat consistently produced yield increases depending on soil type, season, location, and previous crop (Ryan et al., 1989; Abdel Monem et al., 1990a; 1990b). A recent crop assessment of nutrient deficiency in over 2000 cereal fields showed the overwhelming importance of N (Ryan et al., 1991). It could be deduced from such studies that on-farm N fertilization would also increase barley yields.

The drive to improve cereal output in Morocco has centered on developing new species as well as traditional ones, such as barley. Because of potential yield and drought resistance, triticale is being seriously considered (Mergoum et al., 1991). Several studies in the region suggest that it has a complementary role in cereal areas (Nachit, 1986; Genc et al., 1989). Though some studies have shown barley to be superior to triticale (Yau, 1987), no such comparisons have been made in Morocco. In view of our current emphasis on N, the relative response of both cereals is of considerable interest. Thus, in this study, we compared an improved barley and triticale cultivar under a range of N fertilizer rates at five sites with varying rainfall and moisture stress.

## Materials and Methods

Five on-farm sites were chosen to represent a diversity of environmental—mainly rainfall—conditions (Table 1). These ranged from sites in areas with normally good rainfall, i.e., Khouribga and Settat in the Chaouia region, to others in a lower rainfall area near Skour Rehamna, and then further south to the diverse sites of Sidi Othman and Chemaia in the more arid region; the latter areas are mainly pastoral with "good" rainfall occurring in about two of every five years. The soils were relatively similar, all being shallow (30–35 cm), and with low water-holding capacity. The sites were selected primarily through extension agents from the local Centres des Travaux. In each case, the cooperating farmer, or a family member, undertook to supervise the plots on a paid basis. Each site had been cropped the previous year to cereals, thus ensuring low N levels and increasing the provability of a crop response.

The sites were cultivated on November 22–28, 1989, with an offset disc harrow. Plots (4 × 5 m) were laid out in a split-plot design, with N treatment as the main plot and cereals as the subplot. Nitrogen was hand-broadcast as ammonium nitrate at 0, 30, 60, 90, 120, and 150 kg N/ha with a basal dressing of 40 kg P/ha as triple superphosphate. Seeds of Arig-8 barley and Juanillo triticale were hand-broadcast at 150 kg/ha at the same time. The plots were then disc-harrowed again to incorporate the seed and fertilizer. At the tillering stage, the plots were sprayed at 4 l/ha a.i. with "Certrol H." Observations were taken on growth throughout the season. In late May, 1990, the plots were hand-harvested, and biomass from entire plots was weighed on site. Subsamples were taken for threshing to estimate grain weight.

## Results

Because of extreme drought from December to February, which affected the lower rainfall areas of the dryland cereal zone, the two driest sites in the study, Sidi Othman and Chemaia, were devastated to the point that stands were too poor and erratic to warrant harvesting. Growth observations at Chemaia indicated some response to N, while at Sidi Othman, growth appeared depressed with N application rates above 30 kg/ha. At both sites, the triticale stands appeared to be better than barley, and had erect, though sparse, growth in contrast to wilted prostrate barley. A critical, though brief, drought period was experienced at Skour Rehamna, and to a lesser extent at Settat. Though the Khouribga area had no rain in February, it had 52 mm in December and 39 mm in January.

Analysis of biomass and grain yield showed significant effects of site, cereal type, and N treatment. In addition, interactions between site × N treatment were significant. Mean yield of the three sites in essence, followed the rainfall gradient from Khouribga to Skour Rehamna (Table 2). Triticale, on average, outyielded barley by 5% with biomass and 20% with grain yields (Table 3). There

Table 1. Rainfall and soil information of trial sites, Morocco.

| Site | Rainfall (mm) Mean | Rainfall (mm) Season | Soil type | Organic matter (%) | Available nutrients (ppm) N | P | K |
|---|---|---|---|---|---|---|---|
| Khouribga | 402 | 396 | Palexeroll | 1.6 | 6.8 | 12.0 | 390 |
| Settat | 386 | 370 | Palexeroll | 3.5 | 2.4 | 4.0 | 436 |
| Skour Rehamna | 280 | 270 | Xerocrept | 1.2 | 3.2 | 2.6 | 512 |
| Chemaia | 240 | 210 | Xerocrept | 1.4 | 3.9 | 1.8 | 361 |
| Sidi Othman | 215 | 180 | Xerocrept | 0.6 | 4.1 | 4.3 | 360 |

Table 2. Mean dry-matter and grain yields at each site where the experiment was harvested.

| Site | Dry matter (t/ha) | Grain (t/ha) |
|---|---|---|
| Khouribga | 4.63 | 2.56 |
| Settat | 3.97 | 1.98 |
| Skour Rehamna | 2.18 | 0.93 |
| LSD (5%) | 0.17 | 0.09 |

Table 3. Mean dry matter and grain yields of barley and triticale.

| Crop | Dry matter (t/ha) | Grain (t/ha) |
|---|---|---|
| Barley | 3.60 | 1.65 |
| Triticale | 3.79 | 1.98 |
| LSD (5%) | 0.04 | 0.07 |

were differences between the two cereals depending on the site (Table 4). At the two sites in the more favorable zone of Chaouia, i.e., Khouribga and Settat, triticale outyielded barley, but no difference was found between the two cereals at the drier Skour Rehamna site.

The overall yield response to N was significant up to 60 kg/ha; additional increments of N had nonsignificant impact on yield (Figure 1). As might be anticipated with such widely different sites, N response varied with the site (Figure 2). The pattern was similar for total dry matter and grain yield; therefore, only dry matter yield data are presented. At the higher yielding Khouribga site, responses were significant up to 90 kg N/ha, while at Settat, where unfertilized yields were considerably lower, responses continued up to 150 kg N/ha. However, for the drier Skour Rehamna site, there was no response beyond 30 kg N/ha.

Table 4. Mean dry matter and grain yields of barley and triticale at three sites where the experiments were harvested.

| Site | Crop | Dry matter (t/ha) | Grain (t/ha) |
|---|---|---|---|
| Khouribga | Barley | 4.30 | 2.31 |
| | Triticale | 4.95 | 2.76 |
| Skour Rehamna | Barley | 2.21 | 0.90 |
| | Triticale | 2.15 | 0.95 |
| Settat | Barley | 3.68 | 1.75 |
| | Triticale | 4.26 | 2.22 |
| LSD (5%) | | 0.28 | 0.19 |

## Discussion

Despite previous perceptions regarding the response of barley to N fertilization, this study showed that, with the exception of the extremely dry areas, N fertilization of farmers' fields in Morocco's semiarid zone can substantially and consistently increase straw and grain yield. Given the yield responses for wheat to applied N throughout the dryland zone (Shroyer et al., 1989), the responses for barley and triticale were hardly surprising. Based on recent economic analysis of wheat response to N (Abdel Monem et al., 1990c), the yield increases produced here are probably economically attractive; the increased grain sales would add to household income while the increased straw yield would enhance the farmer's livestock carrying capacity. Indeed, economic returns are more likely with N fertilization of barley and triticale than for wheat because of their relative drought resistance and tolerance to Hessian fly damage.

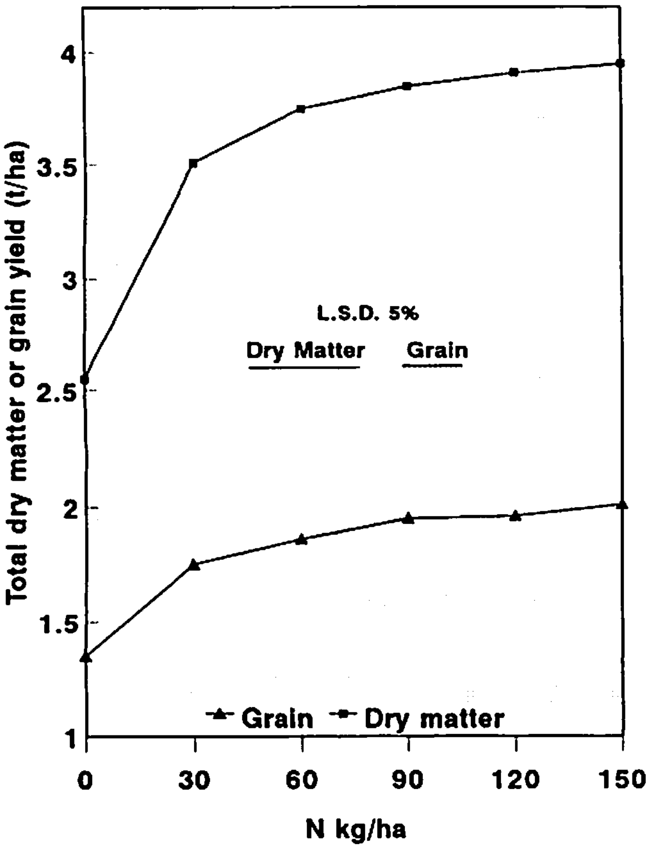

Figure 1. Overall yield response to N application rates.

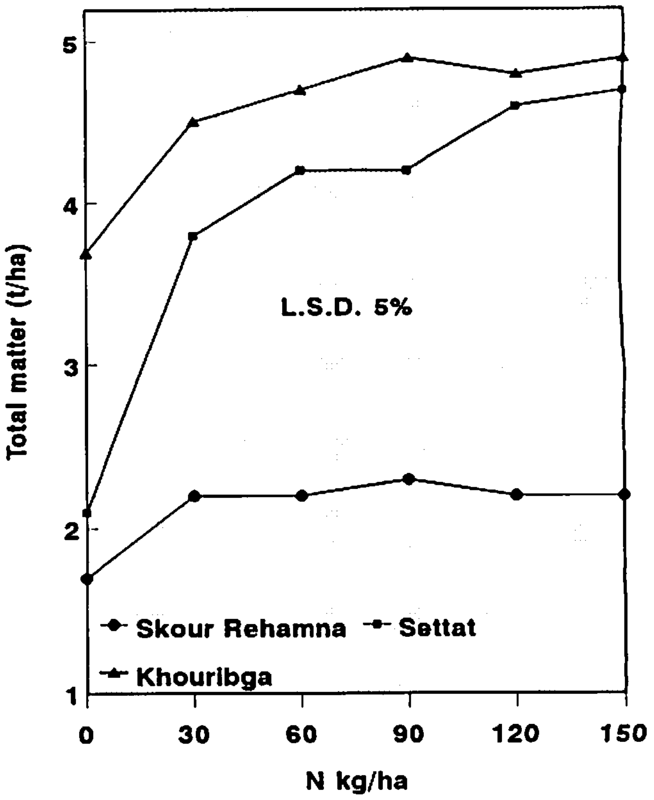

Figure 2. Mean dry matter yield with applied N at three sites.

The finding that cereal yields were related to rainfall was expected. However, the differential responses to applied N have important implications for fertilizer recommendations for farmers. Depending on the site and the initial soil N level, rates up to 90 kg N/ha could be reliably used in the favorable rainfall area, i.e., above 350 mm/year. With decreasing rainfall, these rates could be decreased as not to exceed 30 kg/ha in marginal rainfall areas, i.e., 250–350 mm/year. However, where rainfall is less than 250 mm/year, N fertilizer is unlikely to produce a response in most yields, and may even decrease the already meager stands in such areas.

An interesting result of the study was the overall superiority of triticale to barley in contrast to other trials in the Mediterranean region (Yau, 1987). Such comparisons would depend on the varieties used; the triticale cultivar (Juanillo) used here has a high-yield potential (Mergoum et al., 1991). While future efforts are needed to improve the nutritional quality of triticale straw and promote farmers' acceptance of this new cereal, the superior yields shown in this study suggest that triticale may make inroads to the barley and, indeed, wheat area cultivated in Morocco. Future applied research will focus on on-farm demonstrations to show the comparative advantage of triticale in relation to barley and wheat.

While research in all phases of cereal production is continuing at the Aridoculture Center in Settat, it is clear at this stage that introducing new high-yielding, disease-resistant cereals and fertilization, particularly with N, can have a major impact on cereal yields in Morocco. This simple technology can be easily incorporated into existing farming systems; just use a different bag of seeds and hand-spread fertilizer. While other factors impinge on fertilizer use—supply, costs, etc.—the first step is to convince farmers of the potential benefits of using fertilizers.

## References

Abdel Monem, M., A. Azzaoui, M. El Gharous, J. Ryan, and P. Soltanpour. 1990a. Demonstrating fertilizer response and Hessian fly resistance with wheat in Morocco. *Journal of Agronomy Education* 77–80.

Abdel Monem, M., A. Azzaoui, M. El Gharous, J. Ryan, and P. Soltanpour. 1990b. Response of dryland wheat to nitrogen and phosphorous in some Moroccan soils. Pages 52-66 In *Soil Test Calibration in West Asia and North Africa: Proceedings of the Third Regional Workshop* (J. Ryan and A. Matar, eds), 3–9 Sept 1988, Amman, Jordan. ICARDA, Aleppo, Syria.

Abdel Monem, M., J. Ryan, and A. Azzaoui. 1990c. Economic response of dryland wheat in Morocco: soil type, rotation and rainfall effects. *RACHIS* 9(1):32–35.

Abdel Monem, M., J. Ryan, and M. El Gharous. 1990d. Soil fertility assessment in the mapped area of Chaouia. *Al-Awamia* 72 (in press).

Cooper, P.J.M., P.J. Gregory, D. Tully, and H.C. Harris. 1987. Improving water use efficiency of annual crops in the rainfed farming systems of West Asia and North Africa. *Experimental Agriculture* 23:113–158.

Genc, I., A.C. Ulger, and T. Yagbasanlar. 1989. Screening for high yielding triticales to replace wheat in the Cukarova region of Turkey. *RACHIS* 8(1):25.

Mergoum, M., J. Ryan, and J.P. Shroyer. 1991. Triticale in Morocco: Potential for adoption in the semi-arid zone. *Journal of Agronomy Education* (in review).

Nachit, M. M. 1986. Use of planting dates to select stress tolerant and yield stable triticale genotypes for the rainfed Mediterranean environment. *RACHIS* 3(1):15–17.

Ryan, J., M. Abdel Monem, and K. El Mejahed. 1989. Timing of nitrogen application for Hessian fly-resistant "Saada" wheat in Morocco. *RACHIS* 8(2):23–26.

Ryan, J., M. Abdel Monem, and M. El Gharous. 1990. Soil fertility assessment at agricultural experiment stations in Chaouia, Abda, and Doukkala. *Al-Awamia* 72 (in press).

Ryan, J., M. Abdel Monem, and J. Shroyer. 1991. A profile of nutrient deficiency in cereal production fields, fertilizer needs, and economic implications in Morocco's rainfed region. *Journal of Agronomy Education* (in review).

Shroyer, J.P., M. Abdel Monem, J. Ryan, and A. Hamel. 1989. Comparative N response for Hessian fly-resistant wheat in Morocco. *Agronomy Abstracts* p. 12.

Shroyer, J.P., J. Ryan, M. Abdel Monem, and M. El Mourid. 1990. Production of fall-planted cereals in Morocco and technology for its improvement. *Journal of Agronomy Education* 19:32–40.

Yau, S. K. 1987. Comparison of triticale with barley as a dual-purpose crop. *RACHIS* 6(1):19–20.

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# A Progress Report on the Effects of Humidity on Expression of Partial Resistance to Mildew

# تقرير حول تأثيرات الرطوبة على ظهور مقاومة جزئية لمرض البياض الدقيقي

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## Abstract

**Seedling leaves of five barley accessions, four of which express partial resistance, were inoculated with mildew and enclosed in an apparatus that enables accurate control of humidity, air speed, and temperature. At high humidity (> 95%) infection frequency was always greater than at low humidity (40%–50%). Cultivar 9855 (South American 2.79) showed less reduction in infection frequency under low humidity than other cultivars. The potential for exploiting such differences in breeding is discussed.**

## الملخص

تم إعداء (تلقيح) أوراق بادرات من خمسة مدخلات من الشعير- أربعة منها تبدي مقاومة جزئية- بمرض البياض الدقيقي ثم وضعت في جهاز يُمكن فيه التحكم بالرطوبة وسرعة الهواء ودرجات الحرارة بدقة. تبين أن تكرار العدوى كان أكثر حدوثاً تحت درجات الرطوبة العالية (أكبر من ٪95 ) منه تحت درجات الرطوبة المتدنية ( ٪40-٪50 ). وقد أبدى الصنف 9855 (أمريكي جنوبي 2.79 ) تكراراً أقل بالعدوى من الأصناف الأخرى تحت الرطوبة المتدنية. ويتم بحث إمكانيات استغلال فروق كهذه في التربية.

## Introduction

Much interest has been expressed in using partial resistance as a source of potentially durable resistance against mildew in cereals. However, partial resistance has a high environmental component in its expressions and has many components that may individually or pleiotropically interact with environmental components. Controlled infection of seedling leaves under highly controlled environmental conditions can provide more detailed information on infection frequency and colony biomass, and thereby both overall mildew damage and spore production for epidemic development, which may be significant to final yielding ability (Newton 1989a). Colony biomass can be assessed using an antibody to mildew in an enzyme-linked immunosorbent assay (ELISA) (Newton and McGurk 1991) in conjunction with infection frequency data. The objective of this study was to investigate the effects of humidity on mildew infection frequency and colony biomass, and the differential responses of barley accessions with or without partial resistance to mildew.

## Materials and Methods

**Seedlings:** Five barley accessions, four of which express partial resistance to mildew [7204 (Cornutum), 7526 (Abed 894), 9319 (Ethiopian), and 9855 (South American 2.79)] and a susceptible control (Golden Promise) were sown in propagators in a spore-proof glass house at 20 °C. When the second leaf was partially extended (GS 12), seedlings were cut at soil level and the second leaves removed. Immediately the cut end was slotted through an angled hole in a sheet of perspex to allow it to dip into a reservoir.

**Environmental control:** Leaves of three accessions were arranged in sequence across a row of 23 holes and held down with a glass rod so that they lay horizontally. The perspex sheet was then sealed into a waterproof perspex box through which air of specified humidity could be passed at controlled rates. The whole apparatus was submerged in a controlled temperature water bath and illuminated from above with a Thorn '2D' 16-W light source. The air flow rate through the leaf chambers was regulated at 1500 ml per minute. The leaf chamber water bath was maintained at 15 °C ± 0.5 °C, and humidity levels of 100% and 45% were set by conditioning water baths at 35 °C ± 3 °C and 3.9 °C ± 0.2 °C. The apparatus was similar to that described by Harrison and Lowe (1989) except that two leaf chambers were alongside each other in the same water bath and extra water traps were fitted in the leaf chamber water bath before and after the conditioning coil for high humidity.

**Pathogen inoculation:** A mixture of at least four isolates of mildew were produced on leaves of Golden Promise as previously described (Newton 1989a). Both leaf chambers were inoculated together by blowing the mixture of spores into a 1-m tall inoculating tower aimed at achieving an infection frequency of approximately 10 colonies per cm on leaves of accession 9319 at high humidity.

**Sporulation assessments:** Infection frequency was assessed after nine days by counting colonies on 7 cm of each leaf from the basal end, excluding the first 1 cm. Spores were then blown off the colonies. Leaves were left to dry for 24 hours at 37 °C, then stored frozen. Colony biomass was assessed by grinding leaf segments in liquid nitrogen using a mortar and pestle, and then weighed. The total mildew biomass was assessed in proportion to this weight using an ELISA method described previously (Newton and McGurk 1991).

**Experiments:** Eleven experiments were carried out, with 10 having accession 9319 in common. With only three cultivars in each experiment, each of the other cultivars occurred six times in total. Modifications to the experimental apparatus were made through the course of these experiments, hence the humidity levels achieved claim only ± 5% accuracy.

Infection frequency differences between the cultivars and humidity treatments in these experiments were highly significant ($P = 0.001$), indicating large effects of both genotype and humidity on pathogen development. The interaction component, however, was less significant.

All accessions gave reduced infection frequencies under low humidity compared with high humidity (Table 1), with 7204 and 7526 giving greater reductions than Golden Promise, 9319, or 9855. However, only the comparison of 7204 and 9855 approached a reasonable level of significance ($P = 0.1$, treating each leaf as a separate observation as not all cultivars were included in all experiments). Inter-experimental variation was large due to factors such as differences in the condition of glasshouse-grown leaves, differences in the metabolic state and density of inocula, and variation in the performance of components of the experimental apparatus.

Three of the five accessions, Golden Promise, 7526, and 9319, gave greater biomass per colony under low humidity compared with high humidity, and two, 7204 and 9855, gave less. Estimations of inter-experimental variation could not be obtained. This was because the apparatus did not allow complete comparisons of the accessions in each experiment. In ELISA determinations the developmental stage of colonies at which leaves were assayed varied between experiments. These data indicate some differences between cultivars in colony biomass response to humidity.

**Table 1. Effect of humidity on infection frequency and colony biomass on barley cultivars expressing partial resistance.**

| Cultivar | Biomass/ colony (%) | Infection frequency (%) |
|---|---|---|
| Golden Promise | 159[†] | 69.5[†] |
| 7204 (Cornutum) | 78 | 57.6 |
| 7526 (Abed 894) | 128 | 59.5 |
| 9319 (Ethiopian) | 133 | 73.1 |
| 9855 (South American 2.79) | 77 | 79.1 |
|  |  | SED = 10.7-15.1% |

[†] Data recorded for low humidity environment divided by that recorded for the high humidity environment.

Leaves frequently showed uneven infection from the basal portion to the leaf tip. In the low humidity treatment, the area sheltered by the glass rod had markedly enhanced infection. The basal section, which tended to face the incoming air, was always least infected. However, such distribution effects were observed on all cultivars and did not affect overall results.

## Discussion

These data clearly demonstrate that humidity affects resistance to mildew differentially in various barley accessions. The effects appear to be not only on establishment of infection but also on colony development, which will also affect epidemic development. Accession 7204 has reduced colony size as one of its components of partial resistance, a characteristic environmentally dependent for its expression (Newton 1989a, 1989b). However, because of inter-experimental variation problems and difficulties in achieving even humidity control at the leaf surface, the results should only be taken as an indication that there may be genotype-humidity interactions that can be exploited in breeding.

One explanation for the greater reduction in infection frequency in cultivars 7204 and 7526 under low humidity is that they provide greater resistance to primary germ tube penetration. Under arid conditions, failure of attaching of the short nonappressorial primary germ tube to the host surface has been shown to result in quick shrivelling and dying of the germinating spores (Carver and Bushnell, 1983). Such resistance should be race nonspecific. In the agronomically adapted cultivar Golden Promise, which lacks any recognized partial resistance expression, such a characteristic was not as well-expressed. Similarly, accession 9855, selected for its expression of adult plant resistance rather than partial resistance at the seedling stage (Asher, 1981), showed less reduction in infection frequency under low humidity conditions than those selected as expressing seedling partial resistance. Thus there is potential for selecting sources of resistance from primitive sources for particular environments.

A constant air speed along the leaves is critical for reproducibility since the gradient of humidity from 100% within the substomatal cavity to that of the supplied air is a function of air speed. Leaf curling resulted in obvious areas of enhanced sporulation under the low humidity treatment, as did the zone around the glass rod, presumably indicative of pockets of sheltered high humidity. Conversely, greater exposure to the incoming air increased the humidity gradient, resulting in less favorable environment for colony establishment. Air speed was thought to be insufficient to dislodge spores as it would equate to no more than a very light breeze in the field. After nine days even leaves which were very lightly infected began to senesce, especially under low humidity. This was probably due to poor supply of water and lack of nutrients through the cut leaves compared with that which could be supplied by roots. Attempts to use the antisenescent benzimidazole were unsuccessful as the transpiration rates caused accumulation of toxic substances and may affect resistance expression. Leaving roots attached resulted in too much second-leaf expansion and leaf twisting.

Experiments on the germination potential of spores on glass showed that it is lower under arid conditions than under humid conditions, and thus varies independently of the host (Manners and Hossain, 1963). Conidia are able to take up water from the atmosphere (Somers and Horsfall, 1966), but below 98% R.H. only short primary germ tubes are produced on glass (Manners and Hossain, 1963). Spores produced under high humidity have higher germination potential than those produced at low humidity or after storage at low humidity (Somers and Horsfall, 1966; Ward and Manners, 1974). Thus, differences between cultivars may be enhanced if spores stored under dry conditions or produced under arid conditions are used. It is therefore important to use air at 100% R.H. to achieve maximum germination potential irrespective of the inoculum or cultivar resistance differences. In this work inoculum was produced under high humidity conditions. Saturation of the leaf testing chamber atmosphere was always achieved as indicated from the condensation on both the chamber lid and in the conditioning coil.

These studies are continuing using leaf and mildew material produced under more highly controlled environments and modified leaf chamber conditions suited to the characteristics of these barley leaves.

*N.B. The author would like to receive barley genotypes which are thought to be particularly resistant to mildew infection under arid conditions.*

## References

Asher, M.J.C. 1981. The expression of partial resistance to powdery mildew in barley seedlings. Pages 466–471 In *Barley Genetics IV: Proceedings of the Fourth International Barley Genetics Symposium*, Edinburgh, UK.

Carver, T.L.W. and W.R. Bushnell. 1983. The probable role of primary germ tubes in water uptake before infection by *Erysiphe graminis*. *Physiological Plant Pathology* 23:229–240.

Harrison, J.G. and R. Lowe. 1989. Effects of humidity and air speed on sporulation of *Phytophthora infestans* on potato leaves. *Plant Pathology* 38:585–591.

Manners, J.G. and S.M. Hossain. 1963. The effect of temperature and humidity on conidial germination of *Erysiphe graminis*. *Phytopathology* 53:1378–1380.

Newton, A.C. 1989a. Genetic adaptation of *Erysiphe graminis* f.sp. *hordei* to barley with partial resistance. *Journal of Phytopathology* 126:133–148.

Newton, A.C. 1989b. Measuring cell wall sterol of mildew (*Erysiphe graminis* f.sp. *hordei*) as a means of assessing partial resistance. *Plant Pathology* 38:534–540.

Newton, A.C. and L. McGurk. 1991. Recurrent selection for adaptation to partial resistance in barley by *Erysiphe graminis* f. sp. *hordei*. *Plant Pathology* (in press).

Somers, E. and J.G. Horsfall. 1966. The water content of powdery mildew conidia. *Phytopathology* 56:1031–1035.

Ward, S.V. and J.G. Manners. 1974. Environmental effects on the quality of viable conidia produced by *Erysiphe graminis*. Transactions of the British Mycological Society 62:119–128.

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# Resistance of Barley Lines to Greenbug (*Schizaphis graminum* Rondani)

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## Abstract

**Greenbug, *Schizaphis graminum* (Rondani), is an important aphid species attacking barley. As the use of resistant varieties is an effective tool of management against it, 81 barley lines were tested in the laboratory to explore new sources of resistance. Greenbug culture was established on a susceptible wheat cultivar at a regime of 27 ± 2°C, 60% RH, and 16:8 hour day:night. The seedlings of test lines were grown in metal trays. Of the test material, 8 germplasm lines [PAK 30095, PAK 30101, PAK 30104, PAK 30128, PAK 30133, BA-1 2, BYT (MRA) 9, and BYT (MRA) 11] had high levels of resistance (damage rating ≤ 3 on a scale of 0–9). The lines found resistant or moderately resistant may be used in breeding programs.**

# مقاومة سلالات من الشعير لمنّ الحبوب (*Schizaphis graminum* Rondani)

## الملخص

يعتبر من الحبوب من حشرات المنّ الهامة التي تصيب الشعير. ولما كان استخدام الأصناف المقاومة أحد الوسائل الناجعة لمقاومته تم اختبار 81 سلالة من الشعير في المختبر بحثاً عن مصادر جديدة للمقاومة. وجرى استزراع ذلك النوع على صنف قمح حساس تحت ظروف 27±2 درجة مئوية، 60٪ RH و 8:16 ساعة يوم/ليل. وزُرعت بادرات السلالات المختبرة في أطباق معدنية، فتبين أنه كان من بين السلالات المختبرة 8 أصول وراثية (PAK 30104, PAK PAK 30095, PbAK 30101 9MRA011O ،30128,PAK 301m33, BA-1 2, BYT) تتمتع بمستوى عالٍ من المقاومة (درجة الضرر أقل من 3 على مقياس مدرج من صفر إلى 9). وقد تستعمل السلالات التي أظهرت مقاومة متوسطة في برامج التربية.

## Introduction

Barley (*Hordeum vulgare* L.) is attacked by a number of aphid species. In Southeast Asia, Das (1918) reported corn leaf aphid, *Rhopalosiphum maidis* (Fitch), *Melanaphis sacchari* (Zehntner), grain aphid, *Sitobion avanae* (Fabricius), and greenbug, *Schizaphis graminum* (Rondani) attacking barley. Hamid (1983) surveyed Pakistan and reported greenbug, grain aphid, and *Sipha maydis* Passerini as the damaging pests of barley in the northern hills. Recently, a survey has been conducted in Pakistan and 45 species of aphids attacking shoots and roots of germinaceous plants have been recorded (K. Etienne-Neumann, 1990, Personal Communication).

Greenbug is a cosmopolitan pest of small grains and sorghum, attacking in about 46 countries (Inayatullah, 1985). It is one of the major vectors of the global disease, barley yellow dwarf mosaic virus (Plumb, 1983). Kieckhefer and Kantack (1986; 1988) calculated the yield losses in barley and wheat due to the attack of cereal aphids. Greatest losses in yield were caused by aphids feeding during the seedling (2-3 leaf) stage; mean densities of 25–30 aphids per stem resulted in losses of about 50% in some yield components at this stage.

As greenbug has been a constant threat to small grains and sorghum, it is desirable to develop resistant varieties against it. However, the occurrence of virulent biotypes in this pest has posed severe hindrances in breeding programs (Starks et al., 1983). At present, six biotypes of the greenbug are occurring in the USA (Inayatullah et al., 1987; Kindler and Spomer, 1986). In addition to the greenbug, biotypes have been reported in 11 other aphid species, including cereal pests, i.e., corn leaf aphid, grain aphid, and bird cherry-oat aphid (Webster and Inayatullah, 1985). Therefore, efforts are being made continuously to explore new sources of resistance, so as to utilize them in resistance breeding programs. In this paper, we report new sources of resistance to the greenbug biotype PK-1 in barley.

## Materials and Methods

The greenbugs were collected from Charsadda (North Western Frontier Province), attacking wheat, in November 1988. Its culture was established on susceptible wheat cultivar 'Faisalabad-83' as reported by Inayatullah and Nahid (1990).

A seedling test was conducted in the laboratory at 27 ± 2°C, 60% RH, and 16:8 hour photophase, to evaluate the resistance in 81 barley lines against greenbug. One row of each test entry was sown in a metal tray measuring 51 × 35 × 9 cm. There were nine rows in a tray, and about 20 seedlings per row. Position of a germplasm line in the tray was determined at random. There were five replications in this test. Six lines failed to germinate. When the seedlings were about 5 cm high, greenbugs were released on them at the rate of about 10 greenbugs per seedling. The greenbugs were allowed to develop. The plants were observed daily, and if the infestation level declined, more greenbugs were added. After 10 days of infestation, the damage occurred to each entry was visually recorded on a 0–9 damage scale (0, healthy; 9, dead or dying plant). The entries were classified as highly resistant (damage rating 0–3), moderately resistant (damage rating 4–6), or susceptible (damage rating > 6).

## Results and Discussion

Of the 81 barley lines tested, eight had high levels of resistance with damage ratings of 2–3 (Table 1). These lines were retested and were again found to be resistant. Twenty-one lines were found to be moderately resistant to greenbug with damage ratings of 4–6. Fifty-two germplasm lines were found to be susceptible to greenbug.

**Table 1. Barley lines found resistant or moderately resistant against greenbug in seedling test.**

| Germplasm | Damage Rating |
|---|---|
| PAK 30101 | 2 |
| PAK 30095 | 3 |
| PAK 30104 | 3 |
| PAK 30128 | 3 |
| PAK 30133 | 3 |
| BA-1 2 | 3 |
| BYT (MRA) 9 | 3 |
| BYT (MRA) 11 | 3 |
| PAK 30055 | 4 |
| PAK 30093 | 4 |
| PAK 30115 | 4 |
| PAK 30121 | 4 |
| PAK 30125 | 4 |
| PAK 30130 | 4 |
| PAK 30260 | 4 |
| PAK 30262 | 4 |
| BYT (MRA) 2 | 4 |
| PAK 30094 | 5 |
| PAK 30097 | 5 |
| PAK 30141 | 5 |
| BYT-4 | 5 |
| PAK 30099 | 6 |
| PAK 30159 | 6 |
| PAK 30183 | 6 |
| PAK 30259 | 6 |
| PAK 30261 | 6 |
| BYT (MRA) 12 | 6 |
| BYT (MRA) 13 | 6 |
| BYT (MRA) 14 | 6 |

These lines have not been tested before, therefore, the results cannot be compared. However, barley resistance to the greenbug has been reported by many workers, e.g., Starks et al. (1983), El-Serwiy et al. (1985), Montllor and Gildow (1986), and Tsumuki et al. (1987).

Considerable work has also been conducted to determine the mechanism of resistance against greenbug. Its feeding mechanisms differ from host to host plant. In barley, the feeding path of biotype A is intercellular, ending in phloem, whereas that of biotype B is intra- and inter-cellular, ending in the mesophyll parenchyma. El-Serwiy et al. (1985) reported that barley strains with thin layers of sclerenchyma cells and larger numbers of vascular bundles are highly preferred by the greenbug. Tsumuki et al. (1987) reported that the degree of resistance in barley is positively correlated with surface wax, whereas susceptibility increased with increasing contents of sugars and free amino acids in the leaves.

The lines found resistant may be utilized in breeding programs. Studies on the inheritance of resistance in the resistant and moderately resistant lines are warranted. This may lead to the discovery of new gene(s) conferring resistance to the greenbug, which will have an immense value.

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## References

Das, B. 1918. The Aphididae of Lahore. *Mem. Indian Museum* 6:138–274.

El-Serwiy, S.A., H.S. El-Haidari, I.A. Razoki, and A.S. Ragab. 1985. Susceptibility of different barley strains and varieties to aphids in the middle of Iraq. *Journal of Agriculture and Water Resources Research* 4:59–71. (In Arabic with English summary.)

Hamid, S. 1983. Natural balance of graminicolous aphids in Pakistan: survey of populations. *Agronomie* 3:665–673.

Inayatullah, C. 1985. Greenbug biotypes in relation to host plant resistance. *Pest Management Technical Report No. 1*, USDA-ARS and Oklahoma State University, Stillwater. 290 pp.

Inayatullah, C. and M. Nahid. 1990. Evaluation of wheat, barley, and sorghum germplasm for resistance to the greenbug, *Schizaphis graminum* (Rondani). *Annual Technical Report*, USAID Project 7.137, Islamabad. 90 pp.

Inayatullah, C., W.S. Fargo, and J.A. Webster. 1986. Use of multivariate models in differentiating greenbug (Homoptera: Aphididae) biotypes. *Environmental Entomology* 16:839–846.

Kieckhefer, R.W. and B.H. Kantack. 1986. Yield losses in spring barley caused by cereal aphids (Homoptera: Aphididae) in South Dakota. *Journal of Economic Entomology* 79: 749–752.

Kieckhefer, R.W. and B.H. Kantack. 1988. Yield losses in winter grains caused by cereal aphids (Homoptera: Aphididae) in South Dakota. *Journal of Economic Entomology* 81:317–321.

Kindler, S.D. and S.M. Spomer. 1986. Biotype status of six greenbug (Homoptera: Aphididae) isolates. *Environmental Entomology* 15:567–572.

Montllor, C.B. and F.E. Gildow. 1986. Feeding responses of two grain aphids to barley yellow dwarf virus-infected oats. *Entomologia Experimentalis et Applicata* 42:63–69.

Plumb, R. T. 1983. Barley yellow dwarf virus--a global problem. Pages 185–198 In *Plant Virus Epidemiology: the Spread and Control of Insect-born Viruses* (R.T. Plumb and J.M. Thresh, eds.). Blackwell Science Publishers, Oxford, UK.

Starks, K.J., R.L. Buron, and O.G. Merkle. 1983. Greenbugs (Homoptera: Aphididae) plant resistance in small grains and sorghum to biotype E. *Journal of Economic Entomology* 76:877–880.

Tsumuki, H., K. Kanehisa, T. Shiraga, and K. Kawada. 1987. Characteristics of barley resistance to cereal aphids. 2. Nutritional differences among barley stains. *Nogaku Kenkyu* 61:149–159. (In Japanese.)

Webster, J.A. and C. Inayatullah. 1985. Aphid biotypes in relation to plant resistance: a selected bibliography. *Southwestern Entomology* 10:116–125.

# Response of Irrigated Barley to Nitrogen Fertilization and Seeding Rates at Al-Hassa, Saudi Arabia

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## Abstract

**Nitrogen fertilizer applications of 0, 50, 100, 150, 200 and 250 kg N/ha and two seeding rates (100 and 130 kg/ha) were tested in a field experiment on sandy loam soil in Al-Hassa, Saudi Arabia, in 1988–89. The results indicated that the effects of seeding rate, nitrogen level, and nitrogen x seeding rate interactions were significant for grain and straw yield, and harvest index. The higher seeding rate produced higher yields of barley. At low seed rate (100 kg/ha), grain yield, biomass yield, harvest index, and economic returns increased gradually and consistently with increased rate of nitrogen application. Nitrogen application up to 200 kg N/ha resulted in significant increases in the measured traits under the 130 kg/ha seeding rate. Grain yield of barley responded better to nitrogen fertilizer with the higher seeding rate.**

# استجابة الشعير المروي للسماد الآزوتي ومعدلات البذار في منطقة الإحساء بالمملكة العربية السعودية

## الملخص

تم اختبار معدلات التسميد الآزوتي 0، 50، 100، 150، 200، 250 كغ آزوت/هـ ومعدلي بذار (100 و 130 كغ/هـ) في تجربة حقلية نفذت على تربة رملية طَفَالية في الإحساء بالسعودية في موسم 1988-89. وتشير النتائج إلى أن تأثيرات معدل البذار ومستوى الآزوت المضاف والتفاعل بين الآزوت ومعدل البذار كانت كبيرة بالنسبة لغلة الحب والتبن ودليل الحصاد. فكلما زاد معدل البذار ارتفعت غلة الشعير. وعند استخدام معدل بذار منخفض (100 كغ/هـ) ارتفعت الغلة الحبية وغلة الكتلة الحيوية ودليل الحصاد والعوائد الإقتصادية بشكل تدريجي ومستمر مع تزايد معدل التسميد الآزوتي. وقد أسفر التسميد الآزوتي حتى معدل 200 كغ آزوت/هـ عن زيادات معنوية في الصفات المقاسة تحت معدل بذار 130 كغ/هـ. لذا فإن استجابة غلة الشعير الحبية للتسميد الآزوتي ترتفع عند استخدام معدل البذار الأعلى.

## Introduction

Barley (*Hordeum vulgare* L.) is important in the economic crop production systems in Saudi Arabia. It is more tolerant to drought than wheat (Ceccarelli et al., 1987; Khaled, 1987). Barley grain and straw are mainly used for animal feed.

Factors such as cultivar, cultural practices, and climate determine barley yield. Cultivar and cultural practices are factors that can be controlled by growers. Studies investigating the effects of cultural practices on barley are very limited in the kingdom.

Fertilizer application, date of sowing, row spacing, and seeding rate are cultural practices that affect barley grain yield and quality. Nitrogen fertilizer increased yield and grain-nitrogen concentration. Alessi and Power (1973) and Baghott et al. (1968), reported similar response to nitrogen fertilizer.

In a plant density study, Kirby (1967) found that grain yield was high at higher densities. Other researchers studied seeding rate effects on barley and showed that final spike number/m$^2$, and hence yield, increased as plant population density increased. Differences in response to nitrogen and seeding rates might be expected because of the wide range of varietal differences and the strong mutual compensation between the yield components in response to changes in plant density (Darwinkel, 1978).

Agronomic studies try to maximize yields without due consideration of economic aspects of production. However, the main objective of growers is to increase their returns from the money invested in cropping. They are interested in maximizing profits.

The objective of this study was to determine the effects of applying nitrogen and high seeding rate on barley grain, biomass yield, and harvest index as well as on the economic returns from barley grown in the eastern region of Saudi Arabia.

## Materials and Methods

Field experiments were conducted on light salt-affected, sandy loam soil of the Experimental Station of King Faisal University which is located in Al-Hassa Oasis in the eastern region of Saudi Arabia.

Experimental treatments (Table 1) included two seed rates (100 and 130 kg/ha) and six nitrogen treatments (0, 50, 100, 150, 200, and 250 kg N/ha) given in the form of urea (46%) about two weeks after sowing. The fertilizer was broadcast between the rows and watered-in by immediate irrigation.

**Table 1. Mean grain yield, biomass yield, and harvest index of barley as affected by seed rate and nitrogen fertilization, Al-Hassa Oasis, Saudi Arabia.**

| Fertilizer level (kg N/ha) | Grain yield | Biomass yield | Harvest index |
|---|---|---|---|
| | ------ (kg/ha) ------ | | (%) |
| | Seed rate (100 kg/ha) | | |
| 0 | 2790 | 7322 | 38.1 |
| 50 | 3114 | 7595 | 41.0 |
| 100 | 3322 | 7966 | 41.7 |
| 150 | 3455 | 8148 | 42.4 |
| 200 | 3545 | 8168 | 43.4 |
| 250 | 3846 | 8681 | 44.3 |
| Mean | 3345 | 7980 | 41.8 |
| | Seed rate (130 kg/ha) | | |
| 0 | 3152 | 8102 | 38.9 |
| 50 | 3910 | 10025 | 39.0 |
| 100 | 4286 | 10796 | 39.7 |
| 150 | 5087 | 11802 | 43.1 |
| 200 | 5638 | 12473 | 45.2 |
| 250 | 5019 | 11921 | 42.1 |
| Mean | 4515 | 10853 | 41.3 |
| LSD (5%) | 172 | 168 | 2.9 |

The experiment was conducted in a split plot design, with seed rates as the main plots and fertilizer levels as the subplots, and planted in a randomized complete block arrangement with three replications. Each subplot was planted as six 3 m long rows at 0.2 m row spacing.

Planting was carried out in the first week of November each season. 'Gesto', one of the widely grown commercial cultivars in the region, was drilled by hand. Resowing of missing parts was done within the first week after planting. The cultural practices were as per recommendations for a good crop production.

At maturity, the central two rows of each subplot were cut at ground level and taken to the laboratory for measuring the whole plant weight. All the plants were then threshed, their grain yields recorded, and harvest index calculated.

Relative profitability of the different treatments included in the experiment were compared. Net returns per unit area were defined as the income from the sale of the barley grain minus costs of fertilizer, seed, planting, fertilizer application, and harvesting. No allowances were made for costs of barley establishment, annual land maintenance, or overhead costs. The support prices paid by the grain silos and flour mills organization for barley grain were used.

The data were analyzed as a split plot using a fixed effect model. As nitrogen x seed rate interaction was significant, the least significant difference (LSD) was computed using error b (Steel and Torrie, 1960), and was used to compare seed rate–nitrogen treatments.

## Results and Discussion

The combined analysis of variance for grain yield, biomass yield, and harvest index showed significant seeding rate and nitrogen effects on all three traits. Because harvest index is the ratio of grain yield to biomass yield, it is expected to be more consistent than either grain yield or biomass yield at different seeding rates and nitrogen levels. However, significant seeding rate × nitrogen level interactions were found for all three traits.

Grain yield of all levels of nitrogen was lower for the low seeding rate than for the high seeding rate (Table 1). The high and low seeding rates had the highest grain yields at the 200 and 250 kg N/ha levels, respectively. The zero-nitrogen levels had the lowest grain yields at both seeding rates. Barley yield response to nitrogen was similar at both seeding rates up to the 200 kg N/ha level. Treatments including N produced significantly higher grain yields than those with no N application.

Biomass yield of all nitrogen levels was lower at the low seeding rate than at the high seeding rate (Table 1). The average biomass yields for the low and high seed rates were 7980 and 10,850 kg/ha, respectively. There were significant seed rates x N fertilizer interactions. The average biomass yields were similar to those obtained for barley in previous studies (Stickler and Pauli, 1964; Singh et al., 1971).

The harvest index ranged from 38.1% to 44.3% at the low seeding rate and from 38.9% to 45.2% at the high seeding rate (Table 1). The averaged harvest index did not differ significantly over seeding rates (41.8% at the low seeding rate and 41.3% at the high seeding rate). Thus, the higher grain yield at the 130 kg/ha seeding rate was largely associated with changes in biological yield over the two rates.

Net returns for the different treatments ranged from 4512 SR/ha to 9182 SR/ha, with an overall mean of 6250 SR/ha (Figure 1). The levels of net return were markedly influenced by seeding rate and fertilizer level. In low seeding rate, net return was highest for the highest nitrogen level; while in high seeding rate, net return was greatest for the 200 kg N/ha level. The economic returns for applying nitrogen were higher than those without N application, especially when 130 kg/ha seed rate was used.

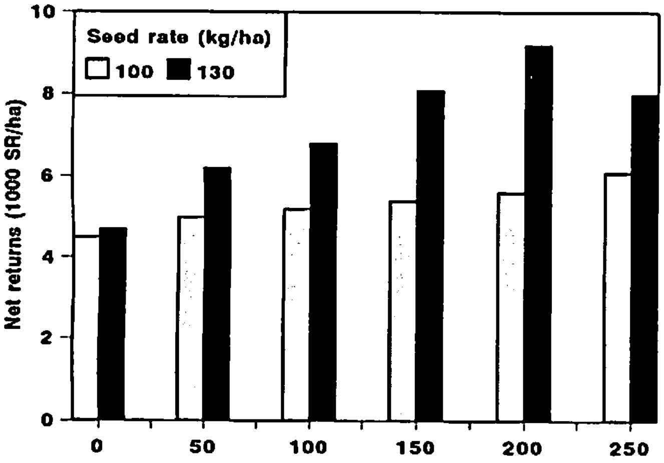

**Figure 1. Mean net returns for various nitrogen and seed rate treatments.**

In summary, applications of nitrogen fertilizer and high seeding rate increased barley grain yield, straw yield, and harvest index. Grain yield and net returns from grain sale were highest for 130 kg/ha seed rate and 200 kg N/ha fertilizer treatment, and lowest for the control. This quantitative information provides necessary planning data for farmers. Accurate planning data are essential for making profitable production decisions.

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## References

Alessi, J. and J.F. Power. 1973. Effect of source and rate of nitrogen on N uptake and fertilizer efficiency by spring wheat and barley. *Agronomy Journal* 65:53–55.

Baghott, K.G., C.W. Schaller, and A.D. Miller. 1968. Response of six barley varieties to selected cultural practices. *California Agriculture* 22(7):10–12.

Ceccarelli, S., S. Grando, and J.A.G. Van Leur. 1987. Genetic diversity in barley landraces from Syria and Jordan. *Euphytica* 36:389–405.

Darwinkel, A. 1978. Patterns of tillering and grain production of winter wheat at a wide range of plant densities. *Netherlands Journal of Agricultural Science* 26:383–398.

Khaled, D. 1987. Effect of soil water deficit on leaf water content of four barley (*Hordeum vulgare* L.) varieties in Algeria. *Rachis* 6(1):47–49.

Kirby, E.J.M. 1967. The effect of plant density upon the growth and yield of barley. *Journal of Agricultural Science, Cambridge* 68:317–324.

Singh, R.P., P. Mahabir, and S.K. Karshik. 1971. Effect of different levels of N and P on the yield of barley. *Indian Journal of Agronomy* 16:123–125.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics: A biometrical approach. 2nd edition. McGraw-Hill Book Company, New York, USA.

Stickler, F.C. and A.W. Pauli. 1964. Yield and winter survival of winter barley varieties as affected by date and rate of planting. *Crop Science* 4:487–488.

# Growth, Productivity, and Milling Qualities of Commercial Cultivars and Advanced Lines of Wheat (*Triticum aestivum* L.) Grown at Different Sites in Saudi Arabia

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## Abstract

**Six Saudi commercial wheat cultivars and four advanced lines were compared for agronomic and milling performances. The genotypes were grown at four locations in three growing seasons. KFU 183, one of the lines developed at King Faisal University, was the earliest in breeding and maturity, and had the highest grain yield besides good milling characteristics. KFU 183 and KFU 483 had higher flour yield than both Westbred and Yecora Rojo, the currently most commonly grown commercial cultivars in the kingdom.**

# نمو وإنتاجية وخواص الطحين لأصناف تجارية وسلالات متقدمة من القمح مزروعة في مناطق مختلفة من المملكة العربية السعودية

## الملخص

تمت مقارنة ستة أصناف قمح تجارية سعودية وأربع سلالات متقدمة من حيث الكفاءة الإنتاجية وصفات الطحين. وقد زرعت الطرز الوراثية في أربعة مواقع على مدى ثلاثة مواسم زراعية. وكانت السلالة KFU 183 المستنبطة في جامعة الملك فيصل الأبكر في التربية والنضج وقد تمتعت بأعلى غلة حبية وبخواص طحين جيدة. كما تمتعت السلالتان KFU183 و KFU 483 بغلة طحين أعلى من الصنفين Westbred وYecora Rojo اللذين يعتبران في مقدمة الأصناف التجارية التي تزرع حالياً في المملكة.

## Introduction

A breeding program for wheat was initiated at the College of Agricultural and Food Sciences, King Faisal University, in the late seventies. Hundreds of local and foreign collections were gathered to form a nucleus for breeding work. Crosses were made between local and introduced genotypes with the main objective of developing cultivars well adapted to environmental stresses prevailing in Saudi Arabia.

Four KFU advanced lines have been developed from this breeding program as a result of the cross between the indigenous wheat variety Madina and the commercially introduced cultivar Probred. In this study, the performance of the four advanced lines was compared with that of the six bread wheat cultivars commonly grown in the Kingdom of Saudi Arabia. Comparisons were made for growth, yields, and milling qualities.

## Materials and Methods

Ten wheat genotypes were included in this study, i.e., (commercial cultivars) Westbred, Yecora Rojo, Super X, Maxipak, Probred, and Cajame 71; and (advanced lines developed from crosses at King Faisal University) KFU 183, KFU 283, KFU 383, and KFU 483. The genotypes were grown at four sites: Al-Hassa, Dairab, Onaiza, and Hail, in the 1985–86, 1986–87, and 1987–88 growing seasons.

The field plot design was a randomized complete block with four replications. All plots were of six rows, 4 m long and 20 cm apart. The genotypes were planted at a seed rate of 130 kg/ha. All sowings were applied around the optimum seeding period for each site, which ranges between mid-November (in the eastern and central regions) to mid-December (in the northern parts of the country). Before sowing, 160 kg N/ha and 80 kg $P_2O_4$/ha were added to the soil in the form of urea and superphosphate, respectively. Cultural practices were as per recommendations for a good crop production at each site.

Heading date was recorded when 50% of the spikes in a plot had emerged fully. Plant height (cm) was measured from the soil surface to the top of the spikes. The central two rows of each plot were harvested by hand. The harvested bundles were threshed with a stationary thresher. Grains were then weighed to obtain grain yield.

Equal amounts of grain from each site were combined to form a composite sample of 5 kg for each genotype. Each composite sample was milled to evaluate its potential in commercial milling operations. Standard American Association of Cereal Chemists (AACC, 1984) methods were applied to determine test weight, grain protein, flour yield, flour protein loss, and ash percentage. Loss of protein was calculated as the difference in protein percentage between the grain and the milled flour.

## Results and Discussion

Grain yield, plant height, and days to heading and maturity of the genotypes averaged over sites and seasons are presented in Table 1. Significant differences in all four characters were found among the genotypes.

Comparison of the genotypes reflected the increase in yields that has been achieved through the breeding program in King Faisal University. KFU 183 ranked first in yield of all the genotypes, followed by the other three KFU lines. Westbred was the only commercial cultivar whose yield was not significantly different from that of KFU 183. Cajame 71, Maxipak, and Probred were among the oldest cultivars grown in the kingdom. They ranked at the bottom of the yield trials.

KFU 383 and KFU 183 were significantly taller than all other entries, except KFU 483 which was a little shorter (Table 1). The more recent commercial cultivars, Westbred and Yecora Rojo, had a reduced plant height. This result is expected as one of the parents of KFU lines was Madina, which is a native cultivar characterized by its tallness, while the commercial cultivars are Mexican dwarf wheat derivatives.

KFU 183 registered significantly earlier flowering than all other entries (Table 1), followed by KFU 283, and Westbred was the latest to flower. KFU 183 was also the earliest to mature (109.2 days after sowing).

Thousand-grain weight was significantly affected by the genotype (Table 2). KFU 183 produced significantly higher 1000-grain weight than all other genotypes, followed by Probred, Yecora Rojo, and Cajame 71, respectively.

Average grain protein percentages for the genotypes are presented in Table 2. Relative to grain yield, differences in protein content among the genotypes were small. When yield and protein content were considered simultaneously, the genotypes could be divided into four groups. KFU 183, KFU 483, KFU 383, and KFU 283 had high protein levels and good yields. Super X, Cajame 71, and Maxipak had medium-to-high protein levels with generally low yields. Westbred and Yecora Rojo had low protein levels with high yield, while Probred had both low protein and low yield.

The suitability of a wheat cultivar for milling into flour is dependent on a complex array of characteristics (Kent, 1983). The most reliable indicators of milling quality are test weight, 1000-grain weight, protein loss, and percent ash content, with percent flour yield being the most accurate indicator of whether ash content is acceptable or not.

**Table 1. Agronomic performance of the 10 wheat genotypes averaged over four sites and three seaso†,1985-88..**

| | | | Days to: | |
|---|---|---|---|---|
| Genotype | Grain yield (t/ha) | Plant height (cm) | 50% flowering | Maturity |
| KFU 183 | 7.8 a | 93.2 a | 65.6 e | 109.2 c |
| Super X | 6.4 bc | 87.3 bc | 76.4 c | 120.6 ab |
| KFU 483 | 7.0 ab | 91.1 ab | 75.4 c | 122.0 ab |
| Cajame 71 | 5.6 c | 80.3 cd | 82.8 a | 123.0 a |
| Maxipak | 5.6 c | 86.6 bc | 77.2 b | 119.0 b |
| KFU 283 | 7.6 a | 76.3 d | 72.2 d | 119.0 b |
| Westbred | 7.0 ab | 75.1 d | 84.4 a | 123.0 a |
| Probred | 5.9 c | 75.2 d | 78.6 b | 121.6 ab |
| Yecora Rojo | 6.9 b | 77.2 d | 75.6 c | 122.2 ab |
| KFU 383 | 7.2 a | 98.9 a | 81.8 a | 124.2 a |

† Means within a column followed by the same letter are not significantly different (P = 0.05) using Duncan's Multiple Range Test.

**Table 2. Quality characteristics of the 10 wheat genotypes averaged over three growing seasons 1985-88.[†]**

| Genotype | 1000-grain weight (g) | Grain protein (%) | Flour yield (%) | Test wt. (lb/Pu) | Flour ash (%) | Flour protein loss (%) |
|---|---|---|---|---|---|---|
| KFU 183 | 49.9 a | 13.2 a | 70.64 ab | 68.8 a | 0.409 c | 0.94 b |
| Super X | 40.0 d | 12.19 b | 66.10 bc | 63.8 c | 0.522 ab | 0.54 c |
| KFU 483 | 40.3 d | 12.23 ab | 76.02 a | 67.4 a | 0.500 ab | 0.98 b |
| Cajame 71 | 45.1 b | 12.10 b | 66.52 bc | 64.9 b | 0.493 b | 0.54 c |
| Maxipak | 42.1 c | 12.19 b | 62.87 c | 64.4 c | 0.480 bc | 0.59 c |
| KFU 283 | 43.4 c | 12.07 b | 65.300 bc | 65.0 bc | 0.501 ab | 1.25 a |
| Westbred | 43.7 c | 11.35 b | 65.35 bc | 63.9 c | 0.581 a | 0.32 d |
| Probred | 46.0 b | 11.51 b | 64.92 bc | 64.4 c | 0.486 bc | 0.59 c |
| Yecora Rojo | 45.2 b | 11.69 b | 63.87 c | 62.0 d | 0.490 bc | 0.85 b |
| KFU 383 | 43.4 c | 12.23 ab | 66.29 bc | 64.1 c | 0.497 b | 0.76 bc |

[†] Means within a column followed by the same letter are not significantly different (P = 0.05) using Duncan's Multiple Range Test.

The genotypes' milling qualities are summarized in Table 2. KFU 483 and KFU 184 had a higher flour yield than both Westbred and Yecora Rojo, which are considered to be the quality standard in the Kingdom of Saudi Arabia. Normally low ash content and high percent loss of protein indicate a low flour yield. KFU 183 and KFU 483 had high flour protein loss, and KFU 183 also had low ash content, but their flour yield was high. Their high test weight appeared to be responsible for this advantage. Super X, Cajame 71, KFU 283, Westbred, Probred, and KFU 383 all had acceptable flour yields. Westbred displayed the highest ash content. Yecora Rojo and Maxipak both had low flour yields. The low flour yield of Yecora Rojo appeared to be related to its exceptionally low test weight.

In conclusion, KFU advanced lines in this trial, especially KFU 183, had top yields and good-quality characteristics. They appeared to be superior to the local commercial cultivars, thus exhibiting high potential potential of being released.

## References

American Association of Cereal Chemists. 1984. Approved methods of the AACC. AACC, St. Paul, Minnesota, USA.

Kent, N. L. 1983. Technology of cereals. Third edition. Pergamon Press. Willowdale, Ontario. p. 133–144.

# Plant-Water Relations in Rainfed Wheat as Influenced by Antitranspirants

# تأثير مضادات النتح على العلاقة بين النبات والماء في القمح البعلي

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## Abstract

**The influence of antitranspirants (AT) on leaf water potential and relative leaf water content (RWC) was investigated in wheat grown under dryland conditions during the winter season of 1980–81. PMA (60 g/ha), Alachlor (10 g/ha), and Kaolinite (60 kg/ha) were applied at midtillering and boot stages. Alachlor and Kaolinite showed 4% and 2.7% higher RWC, respectively; whereas PMA reduced it by 9.5% compared with the control. Leaf water potential under all the three ATs was higher than the control. Correlation study involving untreated control plants at the flowering stage showed that a significantly negative relationship exists between RWC and leaf water potential.**

## الملخص

تمت دراسة تأثير مضادات النتح على كفاءة ماء الورقة ومحتواها النسبي من الماء في قمح مزروع تحت ظروف الأراضي الجافة خلال موسم شتاء 1980-81. وقد أضيفت المواد PMA (60 غ/هـ) و Alachlor (10 غ/هـ) و Kaolinite (60 غ/هـ) عند منتصف طور الإشطاء والحبل. وأظهر Alchlor وKaolinite نسبة أعلى من محتوى الورقة النسبي من الماء تقدر بـ 4٪ و 2.7٪ على التوالي، في حين أنقصته PMA بنسبة 9.5٪ بالمقارنة مع الشاهد. وكانت كفاءة ماء الورقة تحت مجموع مضادات النتح الثلاثة أعلى منها في الشاهد وقد أظهرت دراسة الارتباط التي شملت نباتات الشاهد غير المعاملة في طور الإزهار وجود علاقة سلبية معنوية بين محتوى الورقة النسبي من الماء وكفاءة ماء الورقة.

## Introduction

The main aim of using any antitranspirant (AT) is to cut down the transpiration. In studies of any AT, it is important to establish a relationship between the leaf water potential and relative water content (RWC) and their trend. Davenport et al. (1979) reported that ATs caused an improvement in plant water status of several bars, which was not obviously correlated with changes in environmental conditions. In fact the mechanism involved in AT action is the restriction of water diffusion through leaf stomata through their partial or complete closure.

Earlier results showed that an increase in resistance to water-vapor diffusion as a result of antitranspirant treatment ultimately caused an increase of up to 26.2% in water potential of peach leaves (Davenport et al., 1971) and citrus leaves (Davenport et al., 1972). Under rainfed conditions, the utility of AT is more beneficial; where even a simple departure from the critical plant water condition might favorably affect plant survival. Under these circumstances, as much as 29.8% and 62.8% increase in leaf water potential over control was reported in Alachlor- and PMA-treated maize, respectively (Santakumari et al., 1977). This phenomenon is obviously of a high importance in osmotic adjustment against drought, particularly in drought-prone areas.

The concept of RWC as an index of the water status of the plant tissue by expressing water content of plant as a percentage of the completely saturated tissue was developed by Weatherley (1950). In wheat leaves, RWC was used to estimate the water status of the plant. Increase of moisture stress is more or less associated with a decrease in leaf water content, which subsequently gives a good indication of assessing the internal severity of drought (Todd et al., 1962; Salim et al., 1969).

## Materials and Methods

The object of this study was to investigate the effectiveness of three antitranspirants on increasing wheat leaf water potential and relative water content.

In the winter of 1980–81, a field investigation under dryland conditions of a research farm, Punjab Agricultural University, Ludhiana, was carried out on three ATs: PMA, Alachlor, and Kaolinite. PMA 60 g/ha, Alachlor 10 g/ha, and Kaolinite 60 kg/ha, were all applied twice (at midtillering and at boot stage) to wheat crop, cv. WL-711, grown on loamy sand soil, broadly classified as Typic Ustochrpt (Rhizosphere 180 cm, field capacity 20 cm, permanent wilting point 6.8 cm, and available water content 13.2 cm/m, pH 8.4, organic carbon 0.24%). As much as 230 mm rain was received during the cropping season.

Leaf water potential of the flag leaves was determined, just before the determination of RWC, from 100-day old plants at 1130 hours, using a pressure chamber apparatus (Pressure Chamber Instrument Company, Corvallis, Oregon, USA).

RWC was calculated as per the method adopted by Weatherley (1950), by taking 25 discs (1 cm diameter) from the flag leaves replicated twice:

$$RWC \quad \frac{(FW - DW)}{(TW - DW)} \times 100$$

where, FW denotes fresh weight of leaf discs; TW denotes full-turgor weight after the discs were floated on distilled water for 8 hours, and then dried to remove excess of water drops by blotting; and DW denotes oven-dry weight of discs dried at 65°C ± 2°C.

## Results and Discussion

Figure 1 shows the TWC of flag leaf three days after the second application of the antitranspirants. RWC values were below 76% in all the treatments. Alachlor and Kaolinite showed 4.0% and 2.7% increase in RWC over the control, respectively. Agrawal and De (1976) also observed higher RWC in Kaolinite-treated barley than in the control. However, PMA caused 9.5% decline in RWC over the control. Davenport (1972) reported similar decline of 5.5 and 6.5% in RWC of stressed and unstressed oleander plant treated with two ATs, respectively. The reduction in RWC due to PMA could probably have resulted from sort of disruption of cell tissue of the leaf which impairs cell permeability.

The corresponding leaf water potential (Figure 1) under PMA, Alachlor, and Kaolinite treatments were -20, -20, and -23 bars, respectively; whereas the lowest leaf water potential was observed under the control (-28 bars). The data thus showed that the plants under the ATs' treatments tended to maintain higher water potential than those of the control. The improvement in leaf water potential due to ATs had been widely reported (Davenport et al., 1971; Santakumari et al., 1977; Davenport et al., 1979).

The results indicated that the crop experienced severe moisture stress, though the RWC values were not as depressed as those of the leaf water potential. Obviously, the RWC was not that well related to leaf water potential. However, Singh (1981) showed that crops do suffer severe stress and reduction in yields whenever RWC is less than 80%.

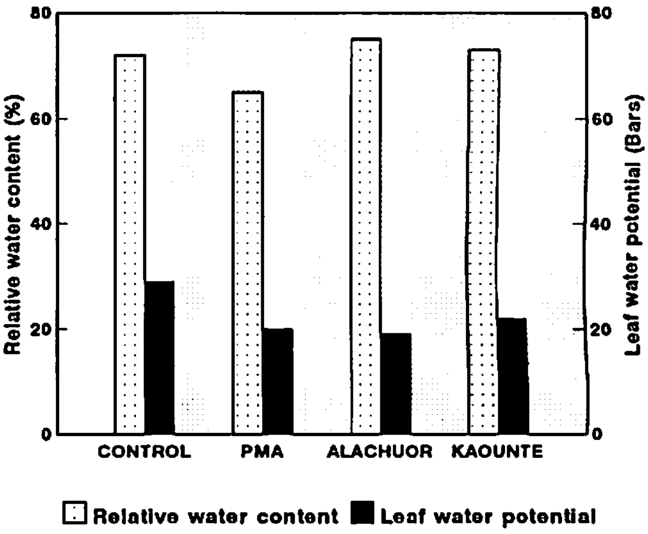

**Figure 1. Relative water content and water potential of wheat leaf after treatment with three different antitranspirants.**

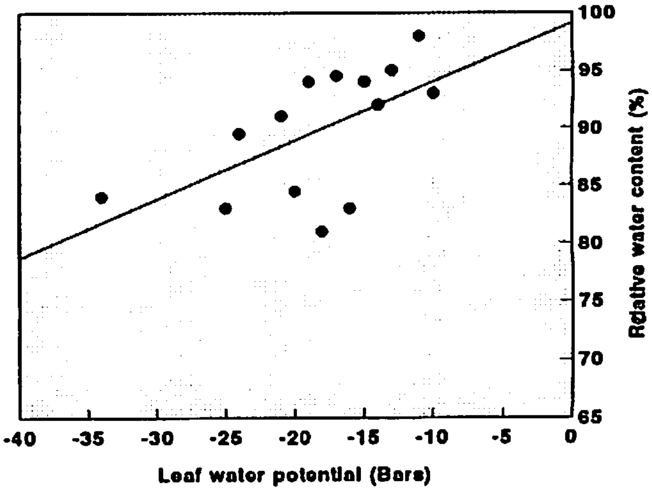

**Figure 2. Relationship between the relative leaf water content and leaf water potential of wheat flag leaf without antitranspirant treatment.**

To investigate the relationship between RWC and leaf water potential of wheat crop under field conditions, a study was conducted on 90-day old plants (flowering stage) in the control plots only. A negative and significant (at the 5% level) correlation was found between the RWC and the leaf water potential, with r = -0.55 (Figure 2). A linear regression of $Y = 100.60 - 0.65 X$ fitted the data, where Y = relative water content and X = leaf water potential.

From these studies, it seems that leaf water potential is closely related to water stress and hence likely to be a more sensitive criterion of indexing the moisture stress in plants than RWC which loses its sensitivity below 80%.

## References

Agrawal, S.K. and Rajat, De. 1976. Effect of straw mulch and antitranspirants on soil and leaf temperature, relative leaf water content and canopy reflectivity of barley. *Plant Physiology* 14(1):169–175.

Davenport, D.C. 1972. Relative water content of leaves; under estimation caused by antitranspirant film. *Journal of Experimental Botany* 13(76):651–654.

Davenport, D.C., J.E. Anderson, L.W. Gay, B.E. Kynard, E.X. Bonde, and R.M. Hagan. 1979. Phreatophyte evapotranspiration and its potential reduction without eradication. *Water Resources Bulletin* 15(5):1293–1300.

Davenport, D.C, M.A. Fisher, and R.M. Hagan. 1971. Some counteractive effects of antitranspirants. *Plant Physiology* 49:722–724.

Davenport, D.C., P.E. Martin, and R.M. Hagan. 1972. Antitranspirants for conservation of leaf water potential of transplanted citrus trees. *Hortscience* 7(5):511–512.

Salim, M.H., G.W. Todd, and C.A. Stutte. 1969. Evaluation of techniques for measuring drought avoidance in cereal seedlings.

Santakumari, M., C.S. Reddy, and V.S. Rama Das. 1977. Alachlor; a new potent antitranspirant on maize plants. *Proceedings of the Indian Academy of Sciences* 86(3):143–150.

Singh, Kirpal. 1981. Relationship between physiological age and season to the induced soil moisture stress and variable post stress irrigation in 2- and 3-gene dwarf wheat. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.

Todd, G.W., F.W. Ingram, and C.A. Stutte. 1962. Relative turgidity as an indicator of drought stress in cereal plants. *Proceedings of Oklahoma Academy of Sciences* 24:55–60.

Weatherley, P.E. 1950. Studies in the winter, relation of the cotton plant. L. The field measurement of water deficit in leaves. *New Phytologist* 49:81–93.

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

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## Abstract

**A field experiment was conducted on calcareous dark grey floodplain soil at Ishurdi for two consecutive *rabi* (winter) seasons to study yield response, nutrient uptake, and fertilizer economics of wheat as influenced by N, P, K, S, and Zn fertilization. The highest grain yield and nutrient uptake were recorded with the treatment involving N 150, P 60, K 60, S 20, and Zn 5 kg/ha. Yield responses of wheat were more pronounced with N, S, and Zn fertilization, producing 261, 54, and 33% increase in grain yield over the controls due to application of N 150, S 40, and Zn 5 kg/ha, respectively. Economic evaluation suggested that application of N 120, P 60, K 30, S 20, and Zn 5 kg/ha gave the highest and the second highest average rates of return.**

# المعدل الأمثل لتسميد القمح في الترب الطمية الكلسية الرمادية الغامقة في بنغلاديش

## الملخص

**نفذت تجربة حقلية في تربة طمية كلسبة رمادية غامقة في إشوردي في موسمين زراعيين متتالبين (rabi) وذلك لدراسة استجابة الغلة وامتصاص العناصر المغذية واقتصاديات تسمبد القمح بالأسمدة الآزوتية N والفوسفورية P و البوتاسية K و الكبريتية S والزنكية Zn. سُجلت أعلى غلة حبية وامتصاص العناصر المغذية في المعاملة التي تشمل N150، P60، K60، S20، Zn5 كغ/هـ. وكانت استجابات غلة القمح أكثر وضوحاً عند التسميد بـ N، S، وZn معطية 261٪ و54٪ و33٪ زيادة في الغلة الحبية على الأصناف الشاهدة وذلك نتيجة إضافة N:150 و S40 وZn5 كغ/هـ على التوالي. وقد أوحى التقييم الإقتصادي بأن إضافة N:120، P:60، K:30، S:20، Zn:5 كغ/هـ قد أعطت أعلى المتوسطات وما دونها من العوائد.**

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## Introduction

Wheat is the second major cereal crop of Bangladesh. Recently, its cultivation has dramatically been expanded throughout the country. But the yield level so far achieved is much below those recorded in some other wheat-growing countries.

Balanced fertilization is essential for increasing the yield of modern varieties. A number of fertilizer trials conducted in different soils of the country revealed positive yield responses of wheat to various fertilizer nutrients (Islam et al., 1986; Ali et al., 1987; 1988; 1990). Significant yield responses of wheat to N, P, K, and S fertilization have also been reported from India (Sinha and Sharma, 1976; Meelu and Rana, 1978; Meelu et al. 1982; Malik, 1981; Kumar, 1985).

Fertilizer recommendation solely based on crop response data may not be economically viable. In this context, Elias and Karim (1984) suggested that response data should be coupled with economic evaluation for judicious fertilizer recommendation. The objective of this study was to investigate the effects of N, P, K, S, and Zn fertilization on yield, nutrient uptake, and economics of fertilizer application of wheat in a calcareous dark grey floodplain soil of Bangladesh.

## Materials and Methods

The experiment was conducted during the *rabi* (winter) seasons of 1987–88 and 1988–89 at the Regional Agricultural Research Station, Ishurdi. The experimental soil, a calcareous dark grey floodplain loam developed in the Ganges river alluvium, is classified as "Calcaric Fulvisol." Some important properties of the soil are given in Table 1.

**Table 1. Properties of initial soil samples of the experimental area.**

| Soil properties | |
|---|---|
| Soil pH | 7.8 |
| Organic matter (%) | 1.67 |
| K (meq %) | 0.45 |
| Ca (meq %) | 15.8 |
| Mg (meq %) | 3.8 |
| $NH^4$-N (ppm) | 18.0 |
| P (ppm) | 12.0 |
| S (ppm) | 14.0 |
| Zn (ppm) | 2.0 |

The experiment involved 14 different treatment combinations (Table 2). These were five levels of N (0, 60, 90, 120, and 150 kg N/ha), four levels of P (0, 30, 60, and 90 kg $P_2O_5$/ha), three levels of K (0, 30, and 60 kg $K_2O$/ha), three levels of S (0, 20, and 40 kg S/ha), and two levels of Zn (0 and 5 kg Zn/ha). Urea, triple superphosphate, muriate of potassium, gypsum, and zinc oxide were used as the sources of N, P, K, S, and Zn, respectively.

The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 6 × 5 m. Wheat cv. Kanchan was taken as the test crop. In both seasons, seeds were sown and the crop was harvested during mid-November and mid-March, respectively. All P, K, S, and Zn, and one-third of N were applied as basal. The remaining N was applied in two equal splits; half on the 30th and the rest on the 50th days after sowing. The crop received three irrigations on the 30th, 50th, and 70th days after sowing.

Plant samples were collected during harvest, dried in an oven at 65 °C, and then taken for chemical analysis. The total nitrogen content of grain and straw was measured by the micro Kjeldahl method, and phosphorus by the Olsen method. Potassium and sulphur were analyzed by digesting the samples in nitric perchloric acid and determined by using atomic absorption spectrophotometer, respectively.

Economic evaluation was done by partial budgeting and dominance analysis, followed by marginal analysis of undominated treatments as suggested by Elias and Karim (1984). Return was derived from average yields of two years, and only fertilizer costs were considered for economic study.

## Results and Discussion

### Grain and straw yields

Yield performance of wheat under the 14 *different* fertilizer treatments is shown in Table 2. Both grain and straw yields of wheat were significantly different among treatments. The treatment $T_6$ (N:150, P 60, K 60, S 20, Zn 5 kg/ha) recorded the highest grain (4.53 and 4.12 t/ha) and straw (7.06 and 6.67 t/ha) yields in 1987–88 and 1988–89, respectively. The lowest yields in both years were obtained under the control ($T_1$) treatment.

The effect of nitrogen was apparent. In the presence of 60, 60, 20, and 5 kg/ha of P, K, S, and Zn, respectively, yields increased progressively with increasing rates of applied nitrogen up to 150 kg/ha. Application of 60, 90,

**Table 2. Grain and straw yield of wheat under various fertilizer treatments.**

| Treatment | Nutrients added (kg/ha) |  |  |  |  | Grain yield (t/ha)† |  |  | Straw yield (t/ha)† |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  | N | $P_2O_5$ | $K_2O$ | S | Zn | 1987-88 | 1988-89 | Average | 1987-88 | 1988-89 | Average |
| $T_1$ | 0 | 0 | 0 | 0 | 0 | 0.82f | 0.88f | 0.85 | 1.52g | 1.55e | 1.54 |
| $T_2$ | 0 | 60 | 60 | 20 | 5 | 1.18ef | 1.22f | 1.20 | 2.32g | 2.20e | 2.26 |
| $T_3$ | 60 | 60 | 60 | 20 | 5 | 2.06de | 2.08e | 2.07 | 3.58f | 3.62cd | 3.60 |
| $T_4$ | 90 | 60 | 60 | 20 | 5 | 3.02bc | 2.98d | 3.00 | 4.22ef | 3.95cd | 4.09 |
| $T_5$ | 120 | 60 | 60 | 20 | 5 | 4.41a | 3.96ab | 4.19 | 6.98a | 6.22ab | 6.60 |
| $T_6$ | 150 | 60 | 60 | 20 | 5 | 4.53a | 4.12a | 4.33 | 7.06a | 6.67a | 6.87 |
| $T_7$ | 120 | 0 | 60 | 20 | 5 | 3.57ab | 3.02cd | 3.30 | 5.73bcd | 5.48ab | 5.61 |
| $T_8$ | 120 | 30 | 60 | 20 | 5 | 3.95ab | 3.40bcd | 6.68 | 6.08abc | 5.86ab | 5.97 |
| $T_9$ | 120 | 90 | 60 | 20 | 5 | 4.44a | 3.92ab | 4.18 | 6.97a | 6.04ab | 6.51 |
| $T_{10}$ | 120 | 60 | 0 | 20 | 5 | 3.65ab | 3.38bcd | 3.52 | 5.95abcd | 6.56ab | 5.80 |
| $T_{11}$ | 120 | 60 | 30 | 20 | 5 | 3.97ab | 3.72abc | 3.85 | 6.42ab | 6.09ab | 6.26 |
| $T_{12}$ | 120 | 60 | 60 | 0 | 5 | 2.60cd | 2.88d | 2.74 | 4.82de | 5.04bc | 4.93 |
| $T_{13}$ | 120 | 60 | 60 | 40 | 5 | 4.48a | 3.98ab | 4.23 | 6.98a | 6.56a | 6.77 |
| $T_{14}$ | 120 | 60 | 60 | 20 | 0 | 2.99bcd | 3.29bcd | 3.14 | 5.07cde | 5.60ab | 5.34 |
| SE ± ($P < 0.01$) |  |  |  |  |  | 0.22 | 0.16 | - | 0.27 | 0.29 | - |
| CV (%) |  |  |  |  |  | 12.04 | 9.28 | - | 8.96 | 10.02 | - |

† Figures in a column followed by different letter(s) are significantly different from each other at the 1% level by Duncan's Multiple Range Test.

120, and 150 kg N/ha increased grain yield by 73%, 150%, 249%, and 261%; and straw yield by 59, 81, 192, and 204%, respectively, over the N control treatment. However, there were no significant yield differences between 120 and 150 kg N/ha. Thus, it appears that application of 120 kg N/ha might be sufficient for optimum wheat yield. The present findings are in agreement with those of Ali et al. (1990).

In the presence of 120, 60, 20, and 5 kg/ha of N, K, S, and Zn, respectively, application of 30, 60, and 90 kg $P_2O_5$/ha increased grain yield by 12, 27, and 27%; and straw yield by 6, 18, and 16% over the control, respectively. This implies that 60 kg $P_2O_5$/ha is the most appropriate dose for optimum yield.

In the presence of 120, 60, 20, and 5 kg/ha of N, P, S, and Zn, respectively, potassium application at 30 and 60 kg $K_2O$/ha resulted in 9 and 19% increase in grain yield, and 8 and 14% increase in straw yield over the control, respectively. Although yield increase due to K application was not remarkable, 30 kg $K_2O$/ha may be applied as maintenance dose for sustainable yield.

In the presence of 120, 60, 60, and 5 kg/ha of N, P, K, and Zn, respectively, grain and straw yields increased by 53 and 34% over the control, respectively, due to application of 20 kg S/ha. Application of 40 kg S/ha showed only a slight yield increase over 20 kg. Hence, use of 20 kg S/ha might be sufficient for optimum yield.

In the presence of 120, 60, 60, and 20 kg/ha of N, P, K, and S, respectively, zinc application at 5 kg Zn/ha offered 33% increase in grain yield and 24% increase in straw yield over the control. This indicated that 5 kg Zn/ha is necessary for optimum yield.

### Nutrient uptake

The average uptake of N, P, K, and S by the crop as influenced by different treatments is shown in Table 3. The highest uptake of different nutrients was observed in the $T_6$ treatment (N 150, P 60, K 60, S 20, and Zn 5 kg/ha) and lowest in the absolute control treatment ($T_1$).

Table 3. Average uptake (kg/ha) of N, P, K, and S by wheat over two seasons under various fertilizer treatments.

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

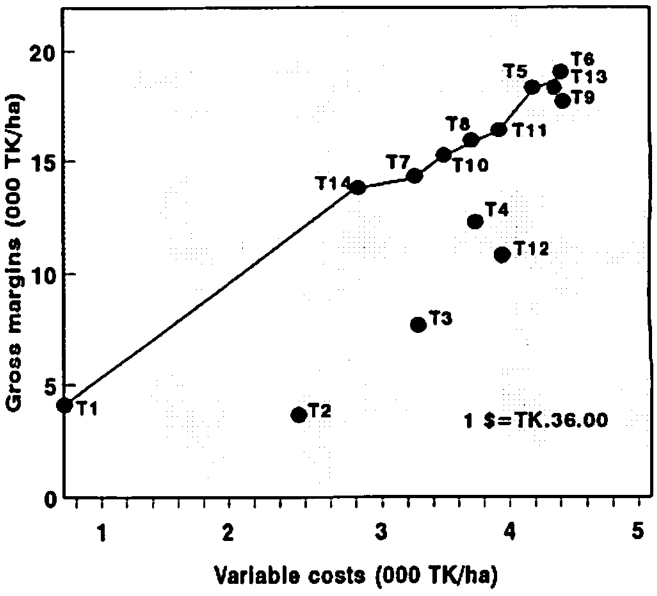

Figure 1. Gross margin curve for different fertilizer treatments.

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

| Treatment | Gross margin (Tk†/ha) | Variable cost (Tk/ha) | Marginal gross margin (Tk/ha) | Marginal variable cost (Tk/ha) | Marginal rate of return (%) | Average rate of return (%) |
|---|---|---|---|---|---|---|
| $T_6$ | 19754 | 4061 | 437 | 333 | 131 | 391 |
| $T_5$ | 19317 | 3728 | 1645 | 225 | 731 | 393 |
| $T_{11}$ | 17672 | 3503 | 826 | 109 | 758 | 371 |
| $T_8$ | 16846 | 3394 | 764 | 116 | 659 | 359 |
| $T_{10}$ | 16082 | 3278 | 993 | 217 | 458 | 348 |
| $T_7$ | 15089 | 3061 | 547 | 333 | 164 | 340 |
| $T_{14}$ | 14542 | 2728 | 9867 | 2728 | 362 | 362 |
| $T_1$ | 4675 | 0 | — | — | — | — |

† US $1 = 30.8 Taka, 1986.

N application increased its own uptake as well as the uptake of other nutrients. The same was also true for P, K, and S application. The uptake of N, P, K, and S was also favored by the addition of Zn. Thus, balanced fertilization ensured balanced uptake of different nutrients which ultimately led to higher yields. Ali et al. (1990) also noted similar observations.

## Economic evaluation

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

## References

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

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

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

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

Islam, M.S., K.M. Hossain, N.I. Sarkar, S. Altamash, and J.U. Sarkar. 1986. Experimental methodology and responses of principal crops to sulphur fertilization in Bangladesh. In *Proceedings of International Symposium on Sulphur in Agricultural Soils*, 20-22 Apr 1986, BARC, Dhaka. 184 pp.

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

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

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

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

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

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# Medics (*Medicago* spp.) in a Semi-Arid Area of Morocco : Cultivar and Seeding Rate Effects on Biomass and a Subsequent Wheat Crop

# النفل (Medicago spp.) في إحدى المناطق شبه القاحلة من المغرب : تأثيرات الصنف ومعدل البذار على الكتلة الحيوية ومحصول القمح اللاحق

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## Abstract

**Currently there is considerable interest in examining the potential of medics in Morocco's dryland zone. This 2-year study evaluated seeding rates of two medic cultivars (Serena and Snail) and considered their impact on residual soil N and the subsequent wheat crop. While optimum seed rate varied with the cultivar, there was, however, no discernible effect on the following year's wheat crop or on residual soil nitrate.**

## الملخص

ثمة اهتمام كبير حالياً بدراسة إمكانيات زراعة النفل في المناطق الجافة من المغرب. وقد قيمت هذه الدراسة التي دامت سنتين معدلات البذار لصنفين من النفل (سيرينا وسنيل) ودرست تأثيرهما على آزوت التربة المتبقي وعلى محصول القمح اللاحق. ففي حين تباين معدل البذار الأمثل وفق الصنف إلا أنه لم يكن هناك تأثير ملحوظ على محصول القمح في السنة التالية أو على نيترات التربة المتبقية.

## Introduction

Several aspects of medic cultivation have recently been addressed in Morocco. Derkaoui (1988) considered genotype-environment interactions for several species. Subsequently, responses of three cultivars in the field and eight accessions in the greenhouse to applied P were evaluated (Ryan et al. 1991). However, applied aspects such as optimum seeding rate and its relationship to residual soil N and cereal yields were not yet considered.

Optimal seed rates of 10 (Bakhtri, 1983) to 50 kg/ha (Cocks, 1984) were reported. While N-fixing bacteria for annual medics are well distributed in soils, differences do exist between species in the actual amounts of N fixed. For instance, *M. truncatula* was found to fix more N than *M. polymorpha* (Smith and Baltensperger, 1983). As much as 300 kg/ha/yr of N was fixed by medics under field conditions in Syria (Cocks, 1984). But the amount of residual N depends on crop management (Cocks et al., 1980).

The objectives of this study were to identify the optimum seeding rate for two common medic cultivars in Morocco and assess their contribution to residual soil N and effects on subsequent wheat yield.

## Materials and Methods

The site chosen for the study was adjacent to Settat (mean annual rainfall 386 mm) and representative of the cereal-growing area of the Chaouia plateau. Barley was the previous crop and was unfertilized. The soil was a shallow (<35 cm) Petrocalcic Palexeroll. Rainfall during the initial medic year (1987-88) was exceptionally high at 470 mm, while the following cereal year (1988-89) was below normal at 355 mm. Initial cultivation was with a disc harrow. As the soil was low in available P, superphosphate was broadcasted at 18 kg P/ha and disced in. Available K was adequate and therefore no K was applied.

The plots were 2 m wide x 10 m long. Two medic cultivars were used, i.e., Snail and Serena (*M. polymorpha*) at seeding rates of 55, 110, 200, 440, and 880 seeds/m$^2$ (equivalent to 10, 20, 40, 80, and 160 kg/ha for Snail, and 2.5, 5, 10, 20, and 40 kg/ha for Serena). The control for both was the natural weedy fallow. The design was a randomized complete block with four replications. The experiment was sown on 6 Nov. 1987. After germination, emergence counts were made. Subsequently, half of each plot was reserved for forage only, while the remaining half was for harvest after seed formation. For the forage part, a sample of 1m$^2$ was harvested on 12 Feb. 1988, and another sample of 4 m$^2$ on 16 April. In Oct. 1988, all plots were sampled to 30 cm for soil nitrate, which was extracted by KCl and analyzed following the chromotrophic acid procedure.

During the following cropping year, the site was planted to wheat (*Triticum aestivum* L.) using a Hessian fly (*Mayetiola destructor* Say)-resistant cultivar, "Saada". The same cultural operations were used to prepare the site. Seed was drilled at 80 kg/ha together with a basal dressing of 9 kg P/ha. Weed control was achieved with 2,4-D. At harvest time, two inner rows from each plot were hand-harvested at maturity.

## Results

The number of medic seedlings emerged in Dec. 87 increased with increasing seeding rate (Table 1), but the percentage emergence for both species decreased with seed rate above 110-120 seed/m$^2$. The initial sampling showed that biomass increased with seeding rate for both cultivars. The optimum seeding rate was 930 and 440 seeds/m$^2$ for Serena and Snail, respectively. The second harvest about two months later revealed the same general trend, except that there were no increases in biomass of the cultivar Snail beyond the third seeding rate (220/m$^2$). The optimum seeding rate decreased to 465 and 220 seeds/m$^2$ for Serena and Snail, respectively. For both cultivars, the biomass yields produced by the lower two or three seeding rates were not significantly greater than the control, i.e., natural vegetation.

**Table 1. Biomass of two cultivars under five seed rates at two harvest dates.**

| | Seed rate | Plants emerged | | Green matter (t/ha) | |
|---|---|---|---|---|---|
| Cultivar | (Seed/m$^2$) | (No./m$^2$) | % | 12 Feb. 88 | 16 Apr. 88 |
| Serena | 60 | 43 | 72 | 2.50 | 6.73 |
| | 120 | 110 | 92 | 2.80 | 7.60 |
| | 230 | 170 | 73 | 8.20 | 8.53 |
| | 465 | 239 | 50 | 11.00 | 14.25 |
| | 930 | 367 | 39 | 25.00 | 16.13 |
| Snail | 55 | 34 | 62 | 6.30 | 6.30 |
| | 110 | 86 | 78 | 7.00 | 9.00 |
| | 220 | 106 | 48 | 18.50 | 18.33 |
| | 440 | 184 | 41 | 22.80 | 18.10 |
| | 880 | 247 | 27 | 24.50 | 18.35 |
| Control[1] | - | - | | 2.90 | 6.73 |
| LSD (5%) | | 60 | | 5.50 | 2.23 |

[1] Naturally germinated weeds.

Grain N%, 1000-seed weight, and grain yield for the following year's wheat crop were not significantly influenced by previous year's medic seeding rate (Table 2). Mean wheat grain yields and grain N content following medics tended to be higher than the control, i.e., 2.10 t/ha after Serena and 1.97 t/ha after Snail vs 1.85 t/ha for the control, and 1.30% N after Serena and 1.39% after Snail vs 1.11% for the control.

**Table 2. Effect of medic seeding rate and cultivar on grain nitrogen, seed weight, and grain yield of the following year's wheat.**

| Seed rate (no./m²) | | Grain N (%) | | 1000-seed wt (g) | | Grain yield (t/ha) | |
|---|---|---|---|---|---|---|---|
| Serena | Snail | Serena | Snail | Serena | Snail | Serena | Snail |
| 0 | 0 | 1.11 | 1.11 | 35.0 | 35.0 | 1.85 | 1.85 |
| 60 | 55 | 1.44 | 1.59 | 35.0 | 34.0 | 2.46 | 1.71 |
| 120 | 110 | 1.41 | 1.36 | 35.5 | 34.0 | 2.46 | 1.71 |
| 230 | 220 | 1.33 | 1.34 | 33.0 | 34.5 | 2.10 | 2.03 |
| 465 | 440 | 1.34 | 1.34 | 32.5 | 34.0 | 1.98 | 2.05 |
| 930 | 880 | 1.42 | 1.32 | 35.3 | 32.0 | 1.91 | 2.17 |
| LSD (5%) | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

Wheat grain yields after medics were similar whether the medic was for forage or for seed production (Table 3). Similarly, measurement of residual $NO_3$ after medics showed no relationship with cultivars or seeding rate. Indeed, the plots were extremely variable. For instance, $NO_3$ values for the control ranged from 9 to 28 ppm. There is no clear difference in $NO_3$ values after medics for forage or seed, although mean soil $NO_3$ values on plots left to seed (18.6 ppm N) were higher than those taken for forage (15.2 ppm N). Nitrate levels after either medic cultivar were similarly variable.

**Table 3. Grain yield of wheat (t/ha) after two medic cultivars cut for forage or left for seed production.**

| Seed rate (seed/m²) | Serena | | Snail | |
|---|---|---|---|---|
| | Forage | Seed | Forage | Seed |
| 0 | 1.8 | 1.9 | 1.8 | 1.9 |
| 55 | 2.1 | 2.1 | 1.7 | 2.1 |
| 110 | 2.6 | 2.5 | 1.7 | 1.7 |
| 220 | 2.4 | 1.9 | 2.1 | 2.0 |
| 440 | 2.0 | 2.0 | 2.1 | 2.0 |
| 880 | 2.1 | 1.9 | 2.3 | 2.0 |
| Mean | 2.1 | 2.1 | 2.0 | 2.0 |

## Discussion

While it was predictable that forage yield of medics would be related to seeding rate (Bakhtri, 1983; Cocks, 1984), this study showed that the optimum rate varies with the species. In this case, the cultivar Snail required half the seed rate required by Serena in terms of seeds/m², but twice the rate in terms of kg/ha. In view of the difficulties in obtaining medic seed because of limited supplies, this finding is of importance to farmers. The optimum rates found here fall within the range reported elsewhere.

Wheat grain N and yield after medics were non-significantly higher than the control. It was likely that real differences were obscured because of background soil $NO_3$ variability as well as mineralization. For the same area, Abdel Monem et al. (1989) showed wide spatial variability even over distances as small as 20 m. Factors which contribute to this include uneven topsoil depth, animal droppings, and erratic fertilizer distribution by hand. The relatively high organic matter content (around 4%) probably contributed to residual N through mineralization (El Gharous et al., 1990) and masked the residual contribution from the medics. In other soils with lower N mineralization potentials, the impact of medics on soil N and cereal growth would probably be more evident. As mineralization takes time, a later sampling might have detected differences due to the medics. Thus, while medics may not always impact on the following cereal phase, the N presumed to be fixed would add to the pool of total soil N and would benefit future crops. The issue of medics and soil N calls for further research in Mediterranean areas, where the potential of medics in agriculture is greatest.

## References

Abdel Monem, M., J. Ryan, and A. Arif. 1989. Spatial variability of nutrients in a Rendoll in the semi-arid area of Morocco. *Agronomy Abstracts*. p. 231.

Bakhtri, M.N.1983. La rotation céréale-luzerne annuelle en Afrique du Nord et au Proche Orient. Food and Agriculture Organization, Rome, Italy.

Cocks, P.S. 1984. Annual pastures to replace fallow. Pages 269-283 In *ICARDA Annual Report for 1983*. ICARDA, Aleppo, Syria.

Cocks, P.S., M.J. Mathison, and E.J. Crawford. 1980. From wild plants to pasture cultivars: annual medics and subterranean clover in southern Australia. Pages 569-596 In *Advanced Legume Science* (R. J. Summerfield and A. H. Bunting, eds). Richmond, UK.

Derkaoui, M. 1988. The role of genotype x environment interaction in annual *Medicago* spp. Ph.D. Dissertation, Oklahoma State University, Stillwater, Oklahoma, USA.

El Gharous, M., R.L. Westerman, and P. N. Soltanpour. 1990. Nitrogen mineralization of arid and semi-arid soils of Morocco. *Soil Science Society of America Journal* 54:438-443.

Ryan, J., M. Derkaoui, and M. Abdel Monem. 1991. Significance of phosphorus fertilizer for medics (*Medicago* spp) in semi-arid Morocco. *Al-Awamia* (in press).

Smith, M.A. and A.A. Baltensperger. 1983. Agronomic and acetylene reduction evaluation of three annual medics. *Journal of Range Management* 36:55-57.

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# Cluster Analysis of Bread Wheat Growing Sites in West Asia and North Africa

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## Abstract

**This study compared the association of two sites, the main autumn-sown station of Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) at Ciano, Sonora, northern Mexico, and the main station of the CIMMYT/ICARDA (International Center for Agricultural Research in the Dry Areas) bread wheat program at Tel Hadya, Aleppo, northern Syria, with the wheat-growing environments in West Asia and North Africa (WANA). Three years' data of the CIMMYT/ICARDA regional bread wheat yield trial were analyzed. Cluster analyses on the mean yield of each entry at individual trials were conducted, using the correlation coefficient as distance measure and the average linkage as the clustering strategy. In each year, Ciano was included in a cluster consisting mainly of irrigated sites below 32 °N, while Tel Hadya was included in another cluster consisting mainly of rainfed sites above 32 °N. The finding confirmed the authors' subjective feeling that the environment of Ciano is closer to mild, irrigated, high-rainfall environments in WANA; and that of Tel Hadya is closer to cool, rainfed, low-rainfall environments. Results were further discussed with respect to the distribution of international nurseries.**

# التحليل العنقودي لمواقع زراعة القمح الطري في غربي آسيا وشمالي إفريقيا

## الملخص

قارنت هذه الدراسة العلاقة بين موقعين هما: المحطة الرئيسية لسيميت في سيانو، سونورا بشمالي المكسيك حيث يُزرع القمح في الخريف، والمحطة الرئيسية لبرنامج القمح الطري المشترك بين سيميت وإيكاردا في تل حديا قرب حلب بشمالي سورية حيث تسود بيئات زراعة القمح في غربي آسيا وشمالي إفريقيا. وتم تحليل البيانات المأخوذة على مدى ثلاث سنوات من تجربة إقليمية مشتركة بين سيميت وإيكاردا حول مقارنة غلة القمح الطري. أجريت تحليلات عنقودية على متوسط غلة كل مدخل في التجارب الإفرادية باستخدام معامل الارتباط كمقياس للمسافة ومتوسط العلاقة كوسيلة للتعنقد. وفي كل عام كانت سيانو تُدخل في عنقود يتكون بصورة رئيسية من مواقع مروية واقعة تحت خط شمال 32 درجة، في حين أُدخلت تل حديا في عنقود آخر يضم بصورة رئيسية المواقع البعلية الواقعة فوق خط شمال 32 درجة. وتؤكد النتيجة المشاعر الشخصية للمؤلفين التي تنطلق من أن البيئة في سيانو أقرب إلى البيئات المروية الغزيرة الأمطار في منطقة وانا وأن بيئة تل حديا أقرب إلى البيئات الباردة البعلية القليلة الأمطار. وتم التوسع في بحث هذه النتائج فيما يتعلق بتوزيع المشاتل الدولية.

## Introduction

In West Asia and North Africa (WANA), bread wheat (*Triticum aestivum* L.) occupies an area of 17 million ha. Approximately, 77% of the area is rainfed, of which 7.3 million ha receive less than 400 mm annual rainfall (ICARDA 1989a). These rainfed environments are highly variable in terms of rainfall (amount and distribution), temperature, abiotic and biotic stresses, soil type, and crop management. Yau et al. (1991) showed that there is a large and significant genotype × site interaction in the region, which implies that breeding for wide adaptability for this region would be difficult. They also illustrated the differences between the irrigated, high-rainfall sites and the rainfed, low-rainfall sites using a cluster analysis on the yield responses of some wheat lines.

The International Center for Agricultural Research in the Dry Areas (ICARDA) has the regional mandate for wheat improvement in WANA, whereas the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) has the world mandate. To complement the research carried out at CIMMYT, Mexico, the CIMMYT/ICARDA bread wheat improvement program has concentrated its work on wheat improvement for the drier and more variable rainfed environments in WANA.

It is known that the environment under which germplasm are selected has an important influence on the adaptation of the germplasm. The main station of the CIMMYT/ICARDA bread wheat program is located at Tel Hadya (annual rainfall about 330 mm), near Aleppo, Syria, in an autumn-sown, rainfed wheat area with cool winters. The main autumn-sown station of CIMMYT is at Ciano, Sonora, northern Mexico, in an irrigated wheat area characterized by relatively mild winters. The objective of this study was to compare the association of these two contrasting sites with the wheat-growing environments of WANA.

## Materials and Methods

Data from the 1987-88 CIMMYT/ICARDA regional bread wheat yield trial (RWYT) were analyzed in detail. To gain information on more than one season, cluster analyses of the data from the 1983-84 and 1985-86 RWYTs as used by Yau et al. (1991) were also conducted, with the Ciano site in Mexico included. The trials were of a randomized complete block design, generally grown by national programs in a plot size of 4.5 $m^2$ with six 2.5 m long rows, spaced 30 cm apart, and four replications. There were 24 entries mainly of spring type but also with a few facultative ones. Test entries in the 1987-88 RWYT were promoted from the 1985-86 CIMMYT/ICARDA Regional Bread Wheat Observation Nursery. Thirty-three trials in WANA (including Sudan) and one trial in Mexico, all with a CV of less than 29%, were analyzed. A detailed description of the trial sites, entries, and data is given in ICARDA (1989b).

Cluster analyses were carried out using the mean yield of each entry, excluding the local check, at each trial. A hierarchical, agglomerative, and polythetic clustering program (Hartigan, 1985), with the correlation coefficient as distance measure and the average linkage (often called unweighted pair group method using arithmetic averages) as the clustering strategy, was employed. The average linkage strategy is nearly independent of group size, and, unlike the centroid strategy, does not suffer from inversion (Williams, 1976). Simulation studies also showed that average linkage has good overall performance.

ANOVAs were carried out on grain yield of 1987-88 assuming a random effect model. Following Yau et al. (1991), the ratio of entry × trial variance to entry variance was used as an indicator of the relative size of the interaction effect. Since some trials were grown with fewer replications, data of the first two replicates only were used in the ANOVAs.

## Results

The dendrogram resulting from the cluster analysis of the 1987-88 data is shown in Figure 1. Three clusters were considered. Cluster I was the largest (16 trials), but it was formed earliest in the amalgamation process. Cluster III was formed latest, although it was the smallest (6 trials).

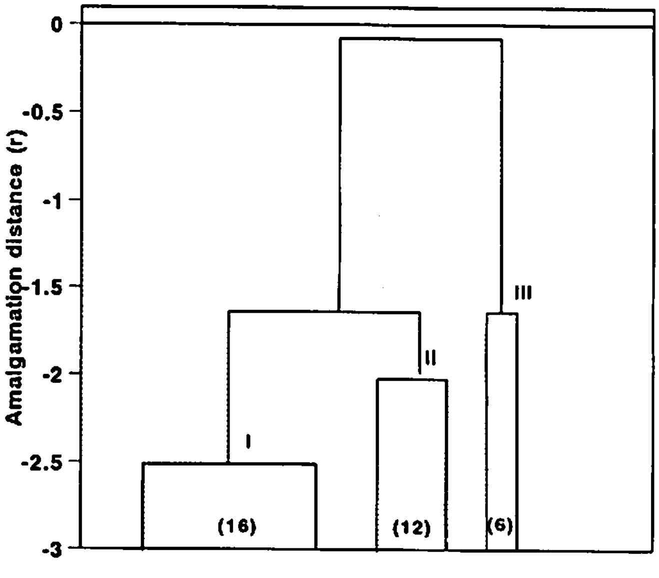

Figure 1. Simplified dendrogram produced from the cluster analysis of 34 trials conducted in West Asia and North Africa. (No. of trials in each cluster given within parenthesis).

Tel Hadya, the main testing site for the CIMMYT/ICARDA bread wheat project, was included within cluster II, while Ciano, the autumn planting site for CIMMYT, was included in cluster I (Table 1). Trials in cluster I were irrigated, possibly with the exception of one Jordanian site, and were all located at or below 32°N. Sites in cluster II were located at or above 32°N, and were rainfed or had supplementary irrigation, except the Egyptian site Sakha. The higher latitudes and more frost days in some of these sites in cluster II suggested that they had lower winter temperatures than those in cluster I. Cluster III also consisted of sites located above 32°N and were rainfed, with the exception of the Egyptian site Mallawy.

**Table 1. Information on the trial sites and the clusters they belong to.**

| Country | Location | Latitude | Elevation (m) | Rainfall (mm) | Irrigation No. | Irrigation (mm) | Frost days | Yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| Cluster I | | | | | | | | |
| Iran | Darab | 28.50 N | 1100 | 222 L[$] | 6 | #[$] | 7 | 6239 |
| Egypt | Gemmeiza | 30.43 N | 9 | NA[$] L | 6 | 600 | 0 | 5137 |
| Iran | Ahwaz (Khuzestan) | 31.20 N | 20 | 311 H | 4 | 400 | 0 | 5383 |
| Saudi Arabia | Gassim, Onaizah | 26.04 N | 724 | 73 L | 62 | 744 | 0 | 5019 |
| U.A. Emirates | Seh El Miah (Al Ain) | 22.00 N | NA | 110 H | 45 | 450 | 0 | 1495 |
| Yemen | Seiyun, Hadramout Govern. | 16.00 N | 600 | NA | 10 | 500 | NA | 4227 |
| Mexico | Ciano (Sonora) | 27.29 N | 40 | NA | 6 | # | 0 | 5929 |
| Sudan | Hudeiba | 17.34 N | 350 | NA | 11 | # | 0 | 2956 |
| Sudan | Gezira Stn (Wad Medani) | 14.24 N | 411 | NA L | 8 | # | 0 | 1466 |
| Egypt | Alexandria | 30.22 N | 3 | 200 N | 2 | # | NA | 2531 |
| Egypt | Sids | 29.04 N | 30 | NA | 2 | 300 | 0 | 6710 |
| Saudi Arabia | Tabuk (TADCO) | 28.22 N | 777 | 28 | # | # | 4 | 7223 |
| Saudi Arabia | Hail (HADCO) | 27.22 N | 700 | <100 L | # | 656 | 2 | 8582 |
| Egypt | Shandaweel | 26.26 N | 60 | NA | 3 | # | NA | 8208 |
| Saudi Arabia | Riyadh (college) | 24.41 N | 600 | NA | 16 | 800 | 0 | 2597 |
| Jordan | Taibeh (west of Irbid) | 32.32 N | 750 | NA H | NA | NA | NA | 2894 |
| Cluster II | | | | | | | | |
| Iraq | Erbil | 26.11 N | 414 | 703 H | 0 | 0 | 2 | 784 |
| Syria | Tel Hadya, early planting | 36.01 N | 282 | 504 H | 1 | 30 | 21 | 6234 |
| Iran | Araghee Mahaleh (Gorgan) | 36.53 N | 12 | 278 | 1 | 35 | 10 | 4036 |
| Tunisia | Beja | 37.00 N | 165 | 383 L | 0 | 0 | NA | 2278 |
| Lebanon | Terbol Station (Bekaa) | 33.52 N | 890 | 710 H | 1 | 30 | 53 | 3566 |
| Algeria | Dahmouni (Tiaret | 34.36 N | 980 | 412 | 0 | 0 | 32 | 1845 |
| Syria | Karahta | 33.25 N | 617 | NA H | # | # | NA | 3091 |
| Syria | El Ghab | 35.30 N | 170 | NA H | 0 | 0 | NA | 4115 |
| Libya | El-Marj | 32.28 N | 310 | 357 L | 0 | 0 | NA | 3255 |
| Syria | Tel Hadya, normal planting | 36.01 N | 282 | 504 H | 0 | 0 | 21 | 5406 |
| Syria | Homs | 34.45 N | 508 | NA H | 0 | 0 | NA | 4066 |
| Egypt | Sakha | 31.07 N | 6 | 78 H | 5 | # | 0 | 6545 |
| Cluster III | | | | | | | | |
| Jordan | Jubeiha | 32.01 N | 980 | 645 | 0 | 0 | 0 | 1859 |
| Lebanon | Tel Amara | 33.55 N | 950 | NA | 0 | 0 | NA | 2102 |
| Turkey | Diyarbakir | 37.55 N | 660 | 755 H | 0 | 0 | 45 | 1179 |
| Egypt | Mallawy | 27.42 N | 39 | NA | # | # | NA | 5450 |
| Turkey | Izmir | 38.35 N | 10 | NA | 0 | 0 | NA | 8847 |
| Syria | Breda | 35.56 N | 300 | 415 H | 0 | 0 | 24 | 3889 |

$ L = Low; N = normal; H = high.
NA = not available; # = amount not recorded;

The dendrograms and composition of the groups for 1983–84 and 1985–86 are not presented here, as there were no major changes to those presented in our previous research (Yau et al., 1991). A new piece of information was that Ciano, an additional site analyzed in this study, was included in the cluster consisting mainly of irrigated sites below 32°N in both seasons. The grouping of Tel Hadya in a cluster consisting mainly of rainfed sites above 32°N remained unchanged.

For 1987–88, entry, trial, and entry × trial effects were highly significant when all trials were analyzed together (Table 2). When the trials were classified into three clusters, the entry × cluster was significant, and so was the entry × trial within cluster. There were nonsignificant differences among the clusters, which indicates that clustering was not based on the mean yield of the trials but on the differential responses of the genotypes among trials. The entry mean yield ranged from 3020 to 4720 kg/ha, while the trial mean yield and CV ranged from 780 to 8850 kg/ha and from 5% to 28%, respectively.

**Table 2. Analysis of variance for grain yield of 23 wheat entries grown at 34 trials.**

| Source | df | MS ($\times 10^{-3}$) |
|---|---|---|
| Entry (E) | 22 | $8309^{***}$ |
| Trial (T) | 33 | $214028^{***}$ |
| Cluster (C) | 2 | 138370 ns |
| Within C | 31 | $218909^{***}$ |
| E × T | 726 | $951^{***}$ |
| E × C | 44 | $3174^{***}$ |
| E × T within C | 682 | $808^{***}$ |
| Error | 748 | 392 |

ns = nonsignificant at $P = 0.05$; and *** = significant at $P = 0.001$.

When trials were not classified into clusters, the variance component for the entry × trial interaction was 1.5 times larger than the entry component (Table 3). The relative size of the entry × trial interaction variance was smaller in clusters I and II, although the entry × trial interaction was still significant in each cluster. For cluster I, the largest group, the entry variance was larger than the interaction variance. For cluster III, the smallest group, the interaction variance was nearly five times larger than the entry variance, indicating that it was a nonconforming group. When further divided into two clusters, the relative size of the interaction variance decreased within each cluster.

**Table 3. Ratios of the entry × trial variance to the entry variance in grain yield. (no. of trials given within parentheses.)**

| | |
|---|---|
| Overall trials | 2.59 (34) |
| Cluster I | 0.74 (16) |
| Cluster II | 1.72 (12) |
| Cluster III | 5.82 (6) |
| IIIa | 1.99 (4) |
| IIIb | 2.58 (2) |

## Discussion

Our results showed that Tel Hadya, the main station of the CIMMYT/ICARDA bread wheat improvement program, and Ciano, the main autumn-sown station for the CIMMYT bread wheat program, were allocated into two different clusters of locations from WANA. Tel Hadya was in the cluster consisting mainly of rainfed sites above 32°N, while Ciano was in the cluster consisting mainly of irrigated sites below 32°N. This finding was in agreement with other findings by us and with some other wheat breeders' subjective experience that the environment of Tel Hadya is closer to cool, rainfed environments, and that of Ciano is closer to mild, irrigated environments of WANA. This is also in agreement with the results of Gallagher and Soliman (1988) on barley. They conducted a cluster analysis on heading days obtained from an international barley trial, and found that three autumn-sown trials in northern Mexico were all grouped in one cluster consisting of warm-winter sites (below 32°N, with one exception), while the two trials at Tel Hadya, Aleppo, Syria, were included in another cluster consisting of cool- to cold-winter sites (above 32°N) mainly of the Mediterranean region.

Within WANA, there is a large year-to-year variation in climatic conditions, so one-year data may not be reliable. However, results of the three seasons were unanimous in showing that Ciano was in the mild-winter, irrigated, high-rainfall cluster, and Tel Hadya in the cool-winter, rainfed, low-rainfall cluster. The chance of misclassification using three years' data is expected to be small.

As the selection condition influences the adaptation of the selected lines, results of the study suggest that lines developed through the two programs have different optimal environments of adaptation. Wheat lines selected in Mexico may be more adapted to mild-winter environments with high inputs, while lines from Syria may be more suited to cool-winter, rainfed areas.

Undoubtedly, materials from both sources are needed for the diverse WANA region. The critical consideration is that the materials supplied to national programs upon their requests should be suitable for their environments. The recent agreement signed by CIMMYT and ICARDA concerning international spring wheat nurseries is expected to make a significant contribution towards this goal. In brief, under the new agreement, international wheat screening nurseries will not be sent directly from CIMMYT, Mexico, to the WANA national programs. Instead, advanced lines for WANA will be sent to the CIMMYT/ICARDA program for seed increase, and the best lines subsequently distributed to WANA through the joint CIMMYT/ICARDA regional nurseries.

In this study, irrigated sites were found to be more cohesive than rainfed sites, a finding also reported by Yau et al. (1991). The irrigated cluster was formed earlier in the clustering process, although it was the largest group. Besides, the entry × trial variance was smaller than the entry variance in the irrigated cluster, but not in the rainfed clusters. This indicates that breeding for rainfed areas would be more difficult than for irrigated areas.

We believe that Tel Hadya is a suitable site for developing cold-tolerant spring wheat lines. Top-yielding lines at the site usually possess good cold tolerance and have certain degree of vernalization requirement. As a matter of fact, the local barley landraces are mostly cold tolerant and require vernalization (ICARDA 1989a). As such, Dr Byrd Curtis (personal communication) suggested that Tel Hadya would also be suitable for breeding facultative wheat. Besides cold-tolerance screening, there is mounting evidence that this site is also useful for screening terminal drought and heat stress.

## Acknowledgement

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## References

Gallagher, L.W. and K.M. Soliman. 1988. Classification of global environments and cultivars of spring barley based on heading time interactions. *Plant Breeding* 100:124–36.

Hartigan, J. 1985. Cluster analysis of variables. Pages 448-455 in *BMDP Statistical Software Manual* (W.J. Dixon, ed.). University of California Press, Berkeley, USA.

ICARDA, 1989a. Cereal Improvement Program Annual Report for 1988. International Center for Agricultural Research in the Dry Areas (ICARDA). ICARDA, Aleppo, Syria.

ICARDA, 1989b. Annual Report for the Regional Bread Wheat Nurseries, 1987–88. Cereal Improvement Program, International Center for Agricultural Research in the Dry Areas (ICARDA). ICARDA, Aleppo, Syria.

Williams, W.T. 1976. Hierarchical agglomerative strategies. Pages 84-90 in *Pattern Analysis in Agricultural Science* (W.T. Williams, ed.). CSIRO & Elsevier Scientific Publishing Co., Melbourne, Australia.

Yau, S.K., G. Ortiz-Ferrara, and J.P. Srivastava. 1991. Classification of diverse bread wheat growing environments based on differential yield responses. *Crop Science* 31 (in press).

# Short Communications

## Effect of Preceding Crops and N-P Fertilizer on Barley Yield in Northeastern Ethiopia

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In the highlands of North Shewa Administrative Region, northeastern Ethiopia, barley is the major source of food. However, its production and yield is limited by many factors, of which poor soil fertility and waterlogging are the most important. Farmers practice stubble burning to improve soil fertility and reduce waterlogging problems. But, stubble burning is destructive to the soil and is associated with long periods of fallowing, hence it is unproductive. Great effort is being made to replace stubble burning and long-term fallowing by using improved surface drainage methods and legume-cereal crop rotation system together with added fertilizer. Research results elsewhere indicated that in the highlands of Ethiopia, vetches (*Vicia* spp) can play a great role in crop rotation schemes and in replacing fallow (FNE, 1983). In systems with minimal fertilizer inputs, legumes can contribute to the crop phase by reducing the rate of soil fertility decline or even enhancing crop yield, as well as reducing the length of the fertility regenerating fallow period (Tothill, 1986).

In the area considered in this study, the farmer uses little or no fertilizer for barley production. Therefore, identification and introduction of suitable preceding crops, such as legumes in rotation, may help obtain sustained and high crop yields with minimum N fertilizer input. Hence, an experiment was initiated with the objective of identifying suitable preceding crops for barley production.

The experiment was conducted at the Sheno Research Subcenter in the highland (2800 m above sea level) on a Pellic Vertisol soil. The site receives 818 mm rainfall annually (averaged over seven years). The soil of the experimental site had been characterized (Kamara et al., 1989) and its properties are presented in Table 1.

**Table 1. Surface soil characteristics of Sheno Research Subcenter.**

| Characteristic | Value |
|---|---|
| pH | 5.44 |
| Organic matter (%) | 4.23 |
| Total N (%) | 0.26 |
| Available P (ppm) | 3.46 |
| **Exchangeable cations** | |
| Na meq/100 g soil | 0.07–0.47 |
| K meq/100 g soil | 0.41–72 |
| Ca meq/100 g soil | 22.24 |
| Mg meq/100 g soil | 6.74 |
| Clay content (%) | 39 |
| Texture | Clay loam to clay |
| Bulk density | 1.06 cm |
| Drainage class | Poorly drained |

In 1986, the experiment was laid out using a split-plot design of three replications. The preceding crops (linseed, potatoes, oats, vetch, faba bean, wheat, and barley) were planted in the main plots. Subplot treatments were two fertilizer rates (0–0 and 18–20 kg/ha of N-P).

In 1987, barley was planted in rows spaced 20 cm apart as a test crop without fertilizer. The seed rate was 100 kg/ha. The variety used was Sheno Local. In the two cropping seasons (1986 and 1987), 5 m wide camber beds (= surface drainage method) were used to drain out the excess soil moisture. Grain and straw yield, and some other agronomic characters were measured.

Main effects of preceding crops and N-P fertilizer were not significant for days to heading, plant height at heading, days to physiological maturity, 1000-grain weight, and test weight of barley. The effect of preceding crops on yield of barley was significant (Table 2). The best grain yield (1.8 t/ha) was obtained from barley following vetch and faba bean. Grain yield of barley was lowest (1.3 t/ha) following potatoes and oats. The highest straw yield was obtained from barley following vetch and faba bean; and the lowest from barley following barley. Results of this study indicated that vetch and faba bean are suitable preceding crops for barley production.

**Table 2. Effects of preceding crops on grain and straw yield of barley, Sheno, 1987.**

| Preceding crop | Grain yield† (t/ha) | | | Straw yield† (t/ha) | | |
|---|---|---|---|---|---|---|
| Vetch | 1.8 | A | | 2.8 | A | |
| Faba bean | 1.8 | A | | 2.6 | A | |
| Wheat | 1.5 | A | B | 1.6 | | B |
| Linseed | 1.4 | A | B | 1.9 | | B |
| Barley | 1.4 | A | B | 1.5 | | B |
| Oats | 1.4 | | B | 1.9 | | B |
| Potatoes | 1.3 | | B | 1.6 | | B |

† Mean separation by DMRT at the 5% level.

## References

FNE. 1983. *Forage Network in Ethiopia Newsletter* 2:8–9. International Livestock Center for Africa, Addis Ababa, Ethiopia.

Kamara, C.S., I. Haque, and Desta Beyene. 1989. Characteristics of soils at the IAR Research Subcenters at Sheno and Gincho. ILCA, Addis Ababa, Ethiopia/IAR, Addis Ababa, Ethiopia.

Tothill, J. C. 1986. The role of legumes in farming systems. In *Proceedings on Potentials of Forage Legumes in sub-Saharan Africa.* An ILCA Workshop, Addis Ababa, Ethiopia.

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# Proline--an Ammonia Neutralizing Agent under Water-Stress Conditions

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Free proline is present in small amount in cereals and grasses, i.e., rice, sorghum, wheat, barley, and *Agropyron* species. Upon imposition of stress, seedlings of these plants accumulate proline to many folds higher. At water potential below -10 bars there are inter- and intra-specific variation in the extent of accumulation (Fischer et al., 1977; Singh et al., 1973). Four reasons have been suggested for the accumulation of proline under stress: (a) stimulation in synthesis, (b) reduction in export via phloem, (c) inhibition in oxidation, and (d) impaired incorporation in protein. In the leaves of field-grown plants under water stress, accumulation of proline has been reported, but upon re-hydration it decreases rapidly to pre-stress level (Singh et al., 1973). The accumulation of proline under water stress has been speculated to constitute an attribute of drought resistance. One of the hypothesis based on the possible role of proline in drought resistance is that it neutralizes free toxic ammonia produced in water-stressed leaves (Frota, 1972).

An experiment was conducted to test the role of proline as an ammonia neutralizing agent in water-stressed leaves of two wheat varieties (DS-4 and DS-17) which are resistant and susceptible to drought, respectively, (Ashraf and Khan, 1990).

Ten seeds of each variety were grown separately in plastic pots measuring 22 cm in diameter and 35 cm in depth, and filled with 4 kg of sandy loamy soil having 22% field capacity. A soaking dose of water was given for seed germination and emergence. After emergence, seedlings were thinned to 4 plants/pot, and watered at two-day intervals for 10 days. Subsequently, water was withheld from half of the pots for another 10 days, and then allowed. Second fully-expanded leaf samples were taken at 10, 20, (before rewatered), and 21 days after emergence.

The leaf water potential was determined by the pressure chamber technique. Proline and ammonia concentrations were determined according to Storey and Wyn Jones (1977) and Hecht and Mohr (1990), respectively.

The leaf water potential dropped to -15 bars and -11 bars in DS-4 and DS-17, respectively (Table 1), 10 days after water was withheld, but free ammonia concentration did not increase appreciably. Much higher amount of proline was accumulated in DS-4, the drought resistant variety. One day after rehydration proline concentration decreased, but ammonia concentration increased

**Table 1. Accumulation of proline and ammonia in two wheat cultivars under water stress and stress-relieved conditions.**

| | 10 DAE (irrigated) | | | 20 DAE (stressed) | | | 21 DAE (stress relieved) | | |
|---|---|---|---|---|---|---|---|---|---|
| Cultivar | Leaf water potential (bars) | Proline content u mol/g f.wt | Ammonia content (ppm) | Leaf water potential (bars) | Proline content u mol/g f.wt | Ammonia content (ppm) | Leaf water potential (bars) | Proline content u mol/g f.wt | Ammonia content (ppm) |
| DS-4 | -2.90 | 3.80 | 89 | -15 | 19.58 | 100 | -8.26 | 6.12 | 815 |
| DS-17 | -1.56 | 2.60 | 36 | -10 | 11.00 | 48 | -5.61 | 4.00 | 250 |

DAE = days after emergence.

considerably. It appears that accumulation of free ammonia is associated with the disappearance of proline. We tentatively suggest that proline's role is not for neutralization of ammonia under water-stress.

## References

Ashraf, M.Y. and A.H. Khan. 1990. Effect of drought on wheat varieties during vegetative stage. *Sci. Int.* (Lahore) 2(4):325-327.

Fischer R.A., N.C. Turner, and E.H. Everson. 1977. Evaluation of free proline accumulation as an index of drought resistance using two contrasting barley cultivars. *Crop Science* 17:720-726.

Frota J.N.E. 1972. Nitrogen metabolism in red kidney bean (*Phaseolus vulgaris* L). *Dissertation Abstracts International B* 33(2):523.

Hecht U. and H. Mohr. 1990. Factors controlling nitrate and ammonium accumulation in mustard (*Sinapis alba*) seedlings. *Physiologia Plantarum* 78:379-387.

Singh T.N., L.G. Paleg, and D. Aspinall. 1973. Stress metabolism III. Variation in response to water deficit in barley plant. *Australian Journal of Biological Sciences* 26:65-76.

Story R. and R.G. Wyn Jones. 1977. Quaternary ammonium compound in plants in relation to salt resistance. *Phytochemistry* 16:447-453.

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# Correlation and Regression Studies of Barley in Eastern Algeria

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Breeding high-yield varieties of barley under the semiarid conditions of eastern Algeria's upland requires information on the relationships between yield and yield components. The relationships can best be studied by the use of multiple regression and correlation. Such techniques can reveal vital information regarding the relative contribution of several independent variables to the dependent one. The plant breeder then has information available that will enable him to decide which component to select for maximum gain from selected material. This study investigated the association between yield and yield-related characters in barley.

Ten barley lines of different origins were planted the first week of October, November, and December, at three locations, namely Sersour, Setif, and Dahal, on the high plateau of eastern Algeria during the 1989–90 cropping season. The trials were conducted in a randomized complete block design with three replications. The plots consisted of 10 × 6 m rows with an interrow spacing of 18 cm. The crop was raised with the recommended package of practices under rainfed conditions. Data on grain yield per plot (GY), grain number per $m^2$ (GN), grain number per spike (GNS), 1000-kernel weight (TKW), number of spikes per $m^2$ (SN), and plant height (PH) were recorded.

Analysis of variance was carried out for each character using the STATITCF package. Each seeding date was considered as a separate environment. Simple correlation coefficients were calculated for each pair of characters per environment and pooled over environments. Partial and multiple regression coefficients with grain yield as dependent variable and the other characters as independent variables were worked out using the stepwise regression procedure.

Differences among lines were significant for all characters measured and in all environments tested. GY ranged from 10.87 to 33.33 q/ha; SN from 183 to 335; TKW from 34.4 to 39.5; GN from 2612 to 8773; GNS from 9.3 to 44.8; and PH from 53 to 87 cm. Pooled correlation coefficients over environments are shown in Table 1. Positive and highly significant coefficients of correlation existed between GY and GN, GY and GNS, and GN and GNS. SN was negatively correlated to GNS. All other correlation coefficients were nonsignificant.

**Table 1. Phenotypic coefficients of correlation among grain yield, yield components, and plant height in barley (average of nine environments).**

| Character | GN | GNS | SN | TKW | PH |
|---|---|---|---|---|---|
| GY (grain yield) | $0.98^{***}$ | $0.91^{***}$ | -0.36 | 0.16 | -0.20 |
| GN (grain no./$m^2$) | | $0.91^{***}$ | -0.37 | 0.00 | -0.24 |
| GNS (grain no./spike) | | | $-0.63^{**}$ | 0.03 | -0.24 |
| SN (spike no./$m^2$) | | | | 0.15 | 0.04 |
| TKW (1000-kernel weight) | | | | | 0.20 |

*, *** significant at the 5 and 0.1% levels, respectively.

Results of the stepwise regression analysis are shown in Table 2. The final regression consisted of three independent variables, namely GN, TKW, and SN. GNS does not appear in the equation because of its high coefficients of correlation with GN and GY.

GN was consistently the most important yield predictor. The addition of TKW and SN in the regression resulted only in slight improvement of the $r^2$.

**Table 2. Stepwise prediction equations for grain yield of barley grown in the upland of eastern Algeria.**

| Order | Equation | $R^2$ |
|---|---|---|
| 1 | GY = 0.0038 GN - 0.2871 | 0.9698 |
| 2 | GY = 0.0038 GN + 0.5135 TKW - 19.4038 | 0.9937 |
| 3 | GY = 0.0038 GN + 0.5135 TKW - 0.0027 SN - 18.9372 | 0.9940 |

The findings indicate that genetic advancement in grain number per unit area through increased spike fertility combined with higher TKW can be considered a promising selection criteria to improve barley grain yield in the highland of eastern Algeria.

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# Outbreak of Barley Yellow Dwarf Disease in Garhwal Hills, Uttar Pradesh, India

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Barley yellow dwarf virus (BYDV), called the "Yellow Plague" of cereals (Duffus, 1977), is a worldwide disease that infects practically all members of the Graminae, including all the important cereals and grasses. In india, BYDV was first reported on wheat and barley in the North Himalayan region (Nagaich and Vashisth, 1963). Though the disease has not been found to assume any serious proportion so far (Tandon et al., 1990), it can cause 60-80% yield reduction in naturally infected conditions (Gill, 1980).

A BYDV-like disease was observed in wheat crops grown during the post-rainy (October-June) 1990-91 season at the experimental blocks of Hill Campus, situated at 2000 m above sea level in the Garhwal hills of Uttar Pradesh in Central Himalaya. Though sporadic occurrence of a few yellow and dwarf plants had been recorded in the experimental blocks since 1988-89, the disease assumed a serious proportion in 1990-91. It was also observed in farmers' fields in nearby areas. The diseased plants showed bright yellow leaf chlorosis starting from the tip and developing toward the base. In some cases only flag leaves were chlorotic, probably because infection occurred late. Under early infection, plants showed a variety of discolorations, excessive tillering, and a rosette of stiff leaves, and in some cases white sterile spikes. Discoloration was often, but not always, accompanied by stunting, and in extreme cases plants were killed. The distribution of diseased plants was characteristics of BYDV.

Infection usually started from the border rows and spread in a roughly circular manner indicating the possible spread by a slow moving vector. Among the insects that were present in the diseased patch were leaf hoppers, aphids, and thrips. However, in no case was there a significantly high insect population.

The aforementioned symptoms closely resembled those of BYDV, and the virus was later confirmed to be an MAV isolate of BYDV using the DASELISA diagnostic test (Khetarpal et al., 1991).

The incidence of BYDV was recorded in six wheat experiments, i.e., zonal Standard Varietal Trials (SVT) for early sowing (ES) and for normal sowing (NS), national Advanced Varietal Trials (AVT) for ES, NS, and HAA (High-Altitude Areas), and in varietal demonstration plots. Diseased plants were counted, and expressed as a percentage of the total number of plants.

Disease incidence of individual experiments is presented in Table 1. The incidence was higher in the two early-sown (before 15 October) experiments as compared with the four normal-sown (up to 15 November) experiments. But it should be noted that the entries for all experiments were different. Cultivars showed varied susceptibility ranging from 5% to as high as 48% disease incidence. In the early-sown experiments, VL 616 showed the highest incidence (47.5%) followed by PRW 9001 (37.5%) and HS 321 (35%). In the normal-sown experiments, the triticale cultivar DT 18, the local cultivar Lalmisri, and PBW 154 showed the least incidence (5%). None of the cultivars was free from the disease.

**Table 1. Incidence of barley yellow dwarf virus in different wheat experiments during 1990-91, Uttar Pradesh, India.**

| Experiment+ | Entry | Disease incidence (%)* |
|---|---|---|
| SVT(ES)' | VL 682 | 13.7 |
| | VL 695 | 15.0 |
| | PRW 9001 | 37.5 |
| | PRW 9002 | 7.5 |
| | PRW 9003 | 7.5 |
| | VL 707 | 26.2 |
| | VL 616 | 47.5 |
| | ***Mean*** | ***22.1*** |
| AVT(ES) | HPW 68 | 20.2 |
| | HS 334 | 26.6 |
| | HS 333 | 18.3 |
| | HPW 69 | 20.0 |
| | HS 321 | 35.0 |
| | HPW 57 | 8.3 |
| | VL 712 | 20.2 |
| | HS 335 | 9.0 |
| | UP 2336 | 20.0 |
| | HS 277 | 21.7 |
| | VL 713 | 11.7 |
| | VL 616 | 33.3 |
| | HS 322 | 6.7 |
| | HPW 49 | 21.9 |
| | HPW 70 | 13.3 |
| | VL 707 | 10.0 |
| | ***Mean*** | ***18.5*** |
| AVT(NS) | HS 326 | 35.0 |
| | VL 703 | 11.7 |
| | Sonalika | 18.3 |
| | VL 704 | 16.7 |
| | HD 2380 | 15.0 |
| | HS 316 | 28.3 |
| | HPW 63 | 16.7 |
| | HS 240 | 11.7 |
| | HS 319 | 15.0 |
| | HS 317 | 16.7 |
| | VL 705 | 13.3 |
| | VL 702 | 28.3 |
| | DT 18 (Triticale) | 5.0 |
| | ***Mean*** | ***17.8*** |
| AVT-HAA(NS) | HS 284 | 11.7 |
| | HPW 42 | 8.3 |
| | HPW 72 | 8.3 |
| | VL 717 | 15.0 |
| | HS 297 | 8.3 |
| | VL 711 | 6.7 |
| | Sonalika | 7.3 |
| | VL 718 | 8.3 |
| | HS 223 | 18.3 |
| | RL 6-3-2 | 8.3 |
| | ***Mean*** | ***10.1*** |

Cont'd

Table 1. Continued.

| Experiment[+] | Entry | Disease incidence (%)[*] |
|---|---|---|
| SVT(NS) | VL 678 | 11.0 |
| | VL 687 | 25.0 |
| | PRW 9004 | 18.3 |
| | PRW 9005 | 31.7 |
| | HS 240 | 9.7 |
| | VL 702 | 15.0 |
| | VL 703 | 18.3 |
| | HD 2380 | 10.0 |
| | ***Mean*** | ***17.4*** |
| Demonstration (NS) | VL 421 | 20.0 |
| | CPAN 3004 | 30.0 |
| | Lalmisri (local) | 5.0 |
| | PBW 154 | 5.0 |
| | VL 616 | 40.0 |
| | ***Mean*** | ***20.0*** |

[*] Date of sowing, SVT(ES): 10.10.90; SVT(NS): 10.11.90; AVT(ES): 12.10.90; AVT(NS): 5.11.90; AVT-HAA(NS): 6.11.90. All sowings done under high fertility rainfed conditions.

[*] Average of three replications except for SVT(ES) where four-replication data were used.

[+] SVT = Standard Varietal Trial; AVT = Advanced Varietal Trial; ES = Early Sown; NS = Normal Sown; HAA = High-Altitude Areas.

## References

Duffus, J.E. 1977. Aphids, viruses and the yellow plague. Pages 361-383 In *Aphids as Virus Vectors* (K.F. Harrisand K. Maramorosh, eds.). Academic Press, New York, USA.

Gill, C.C. 1980. Assessment of losses on spring wheat naturally infected with barley yellow dwarf virus. *Plant Disease* 64:197-203.

Khetarpal, R.K., J. Kumar, M. Beure, and D.B. Parakh. 1991. Detection of barley yellow dwarf luteovirus 'isolate MAV' on wheat in India by using monoclonal antibodies. *Annual Meeting of Indian Phytopathological Society*, 30 Dec. 1991 - 2 Jan. 1992, Bhavnagar University, Gujarat, India.

Nagaich, B.B. and K.S. Vashisth. 1963. Barley yellow dwarf: A new viral disease for India. *Indian Phytopathology* 16:318-319.

Tandon, J.P., Shoran, J. and Pant, S.K. 1990. Status of barley yellow dwarf virus research in Asia with special emphasis on India. Pages 81-84 In *World Perspective on Barley Yellow Dwarf*. CIMMYT, Mexico, D.F., Mexico.

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# Bifurcated Inflorescence in *Agropyron spicatum*

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Naturally occurring as well as induced abnormal inflorescence have been reported in Gramineae (Ahloowalia and Sherington, 1985; Larsson, 1981; Pennell and Halloran, 1984; Sharman, 1967; 1978). Inflorescence abnormalities of common occurrence in Gramineae include heads with leaf primordium, twin spikelets, or branched heads. Of rarest occurrence is probably bifurcated spike.

Seeds of *Agropyron spicatum* (bluebunch wheatgrass, genome formula = SS) were germinated on a moistened filter paper in a petri dish like those of other *Agropyron* species. *A. spicatum* was the only S-genome species used. The seedlings were transplanted in pots in common greenhouse soil, vernalized, and raised under standard greenhouse conditions for wide crosses with wheat (Sharma et al., 1989).

Among four *A. spicatum* plants, and several plants of other *Agropyron* species and *Triticum* species, one *A. spicatum* plant produced one out of four spikes as bifurcated (Fig.1). Both members of the Y-forked spike were equal in length. The forked spike had a single spikelet at the lowermost node. The second node, i.e., the node at the point of bifurcation had twin spikelets at the same level. Thus, there appeared to be a true bifurcation of the axis. The twin spikes were quite normal, and not smaller than the single spikes born by the same plant or other plants of this species. The soil or plants were not treated with any chemical like 2,4-D. Furthermore, abnormal spikes caused by 2,4-D are recognizably different from the Y-shaped spikes (Sharman, 1978). Thus the abnormality observed here was not the result of apical damage but of morphogenetic disturbance during the ontogeny. The plant was self-sterile, and no seed could be obtained for further study.

The bifurcation pattern observed in *A. spicatum* here mimicked that of *A. repens* (Sharman, 1947). Even though *A. repens* (genome formula = $S_1S_1S_2S_2XX$) and *A. spicatum* differ in pattern of spike disarticulation (Sharma and Gill, 1982), morphologically they are quite close, and S genome of *A. repens* has been derived from *A. spicatum* (Dewey, 1984). If the bifurcation behavior is attributed to the S genome, it may be anticipated in other species of super genus *Agropyron* that contain this genome.

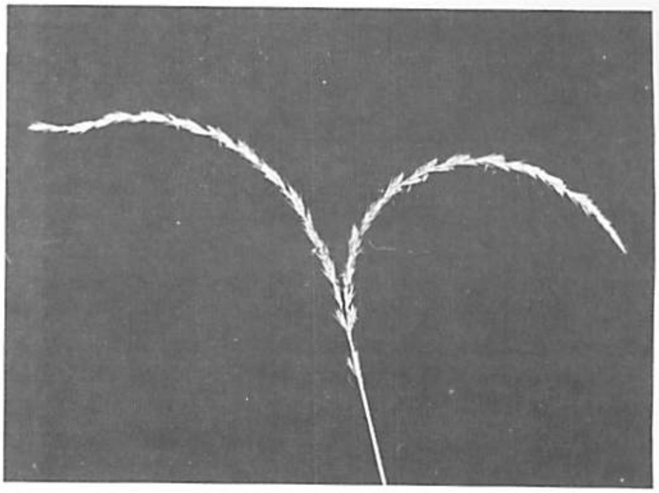

**Figure 1.** **Y-shaped forked spike of *Agropyron spicatum*.**

## References

Ahloowalia, B.S. and J. Sherington. 1985. Transmission of somaclonal variation in wheat. *Euphytica* 34:525-537.

Dewey, D.R. 1984. The genomic system of classification as a guide to intergeneric hybridization with the perennial Triticeae. *Stadler Genetic Symposium* 16:209–279.

Larsson, H.E.B. 1981. Branching spike mutants from two loci in two-row barley. *Barley Genetic Newsletter* 11:25-28.

Pennell, A. and G.M. Halloran. 1984. Influence of vernalization and photoperiod on supernumerary spikelet expression in wheat. *Annals of Botany* 53:821-831.

Sharma, H.C. and B.S. Gill. 1982. Variability in spikelet disarticulation in *Agropyron* species. *Canadian Journal of Botany* 60:1771-1775.

Sharma, H.C., H.W. Ohm, R.M. Lister, J.E. Foster, and R.H. Shukle. 1989. Response of wheatgrasses and wheat × wheatgrass hybrids to barley yellow dwarf virus. *Theoretical Applied Genetics* 77:369-374.

Sharman, B.C. 1947. The biology and developmental morphology of the shoot apex in the Gramineae. *New Phytologist* 46:20-34.

Sharman, B.C. 1967. Interpretation of the morphology of various naturally occurring abnormalities of the inflorescence of wheat (*Triticum*). *Canadian Journal of Botany* 45:2073-2080.

Sharman, B.C. 1978. Morphogenesis of 2,4-D induced abnormalities of the inflorescence of bread wheat (*Triticum aestivum* L.). *Annals of Botany* 42:145-153.

# Forthcoming Events

1992

*South Asian Regional Workshop on Groundwater Farmer-Managed Irrigation Systems and Sustainable Groundwater Management, 18–21 May 1992.* Contact: Dr Shaul Manor, FMIS Network Coordinator, IIMI, P.O. Box 2075, Colombo, SRI LANKA.

*PPI Conference on the Roots of Plant Nutrition, Chancellor Hotel, Champaign, IL, USA, 8-10 July 1992.* Contact: Dr Harold Reetz, 217/762-2074.

*International Soil Management Workshop, Oregon, California, Nevada, USA, 11-24 July 1992.* Contact: Dewayne Mayes, 402/437-5423.

*International Crop Science Congress, Iowa State University, Ames, Iowa, USA, 14-22 July 1992.* Contact: Travel and Transport, Inc., 103 Welch Ave., Ames, Ia 50010, USA, Tel:(515) 292-8182 OR Toll Free US 1-800-747-8182; Fax (515) 292-9100.

*International Conference on Mechanization of Field Experiments, Soest, GERMANY, 19-23 1992.* Contact: Egil Oyjord, 47-9-94-87 56.

*International Symposium on Preharvest Sprouting in Cereals, Coeur d-Alene, ID, USA, 25-29 July 1992.* Contact: 208/885-6486.

*International Symposium on Agricultural Techniques in Cold Climates, University of Alberta, Edmonton, USA, 4-7 August 1992.* Contact: Dr D.S. Chanasyk, 403/492-6538.

*International Symposium on Adaptation of Vegetables and Other Food Crops to Temperature and Water Stress, Taipei and Tainan, TAIWAN, 13-18 August 1992.* Contact: George Kuo, 8866-6-583-7801.

*International Congress on Photosynthesis, Nagoya, JAPAN, 30 August-4 September 1992.* Contact: Norio Murata, Fax 81-546-54-4866.

*EUROSOL: Conference on Integrated Research for Soil and Sediment Protection, Maastricht, NETHERLANDS, 6–12 September 1992.* Contact: Dr H. Eijsackers, (0)8370-84170.

*IMPHOS Conference on Phosphorus, University Town, Louvain-La-Neuve, BELGIUM, 8–11 September 1992.* Contact: M. Debbi, 33(1)47.23.72.53.

*International Conference on Organic Substances in Soil and Water, Lancaster University, UK, 14-17 September 1992.* Contact: Dr K.C. Jones, 0524 65201, ext. 4350.

*International Soil Conservation Organization Conference, Convention Centre, Sydney, AUSTRALIA, 28-30 September 1992.* Contact: G.M. Cunningham, (02) 413 5555.

*International Congress on Soilless Culture, Hunters Rest Centre, Rustenburg, SOUTH AFRICA, 2-9 October 1992.* Contact: Abram A. Steiner, 31(0)8370-13809.

*International Congress on Agroecosystem Modelling, Technical University, Braunschweig, GERMANY, 5-9 October 1992.* Contact: Dr O. Richter (0531) 391-3591.

*International Oat Conference, Adelaide, AUSTRALIA, 19-23 October 1992.* Contact:(08) 363-1307.

*10th Latin American Weed Science Society Congress, Santiago, CHILE, November 1992.* Contact: M. Kogan, Universidad Catolica del Cjile, Vicuna Mackenna, 4860.

*Haldane Centenary Congress on Evolution, Phase I: 5–7 November, Phase II: 28–30 December 1992.* Select a tentative title of a plenary lecture (50 minutes) or an invited oral presentation (30 minutes) and contact: H. K. Goswami, Department of Genetics, Society of Bionaturalists, The University Campus, Bhopal 462 026, INDIA. Tel. 91-755-552362; Fax: c/o Maegabyte, 91-755-555751
Bhopal.

1993

*Workshop on Engineering Plants against Pest and Pathogens, Madrid, SPAIN, 11-13 January 1993.* Contact: Instituto Juan March, Castello 77, 28006.

*International Grassland Congress, Palmerston, Nz, and*

*Queensland, AUSTRALIA, 8-21 February 1993.* Contact: 64 63 69099.

*Conference on Agricultural Research to Protect Water Quality, Radisson South, Minneapolis, USA, 21-24 February 1993.* Contact: 800/843-7645, 515/289-2331.

*Tenth Australian Plant Breeding Conference "Focused Plant Improvement: Towards Responsible and Sustainable Agriculture," Gold Coast, Queensland, AUSTRALIA, 19-23 April 1993.* The conference will provide a stimulating program to challenge plant breeders and others to contribute, innovate, and interact in the development of plant breeding into the 21st century. The program will consist of a scientific session centered around recent developments in key areas reviewed by eminent scientists, selected contributed research papers, and poster papers and objective reviews of them. Distinguished Australian and international scientists will be invited to participate and contribute to the program. Contact: Australian Convention and Travel Services Pty Ltd, GPO Box 2200, Canberra ACT 2601, Australia, Tel: 06-2573299; Fax: 06-2573256.

*International Symposium on the Biology of Adventitious Root Formation, Texas A&M University Research Center, Dallas, USA, 19-22 April 1993.* Contact: Edith Franson, 715/362-1112.

*7th International Symposium on Iron Nutrition and Interactions in Plants, Zaragoza, SPAIN, 27 June-2 July 1993.* Contact: Sr D. Jesus Gascon, Aula Dei Experimental Station, CSIC Apdo 202, 50080.

*Eighth International Wheat Genetics Symposium, Beijing, CHINA, 20–25 July 1993.* Contact: Prof. Chen Shouyi, Secretary-General, 8th IWGS, Institute of Genetics, Chinese Academy of Sciences, Beijing, 100101, CHINA. Telephone: 861-4231551, 86-1-4919944 (Ext. 553); Fax: 86-1-4231551; Telex: 222337 ICCST CN.

*Sixth International Congress of Plant Pathology, Montreal, Quebec, CANADA, 28 July-6 August 1993.* Contact: Mrs Doris Ruest, National Research Council Canada, Ottawa, Ontario, Canada K1A 0R6, Tel: (613) 993-9228; Telex: 053-3145; Fax: (613) 957-9828.

*International Symposium on Soil Testing and Plant Analysis, Evergreen State College, Olympia, Washington, USA, 14-20 August 1993.* Contact: Dr C. Owen Plank, 404/542-9072.

*International Commission on Irrigation and Drainage Congress, The Hague, THE NETHERLANDS, 30 August-12 September 1993.* Contact: R.S. Varshney, 011 91 11 301 6837.

*XII International Plant Nutrition Colloquium/Symposium--Zinc in Soils and Plants, Perth, WESTERN AUSTRALIA, 21-28 September 1993.* Contact: Plant Nutrition Secretariat, The Conference Office, University of Western Australia, Nedlands, WA 6009.

# Recent Publications

## Books

**Fabriani, G. and Lintas, C. (eds). 1988.** ***Durum Wheat: Chemistry and Technology*****. American Association of Cereal Chemists, Inc., St. Paul, Minnesota, USA. 332 pp. ISBN 0-913250-50-3.**

This volume provides a series of reviews on the chemistry and technology of durum wheat and derived products, as well as an extensive and updated bibliography. The multiauthored work presented in the book deals with the origin, distribution, genetics, breeding, and diseases of durum wheat. It also deals with the chemistry of durum wheat components and the technological processes such as milling and pasta manufacturing. Furthermore, the book covers topics such as durum wheat products and the nutritional characteristics of pasta, in addition to marketing and perspectives in the utilization of durum wheat and its products.

**Huntley Lodge (ed.). 1991.** ***Biotic Stress of Barley*****. Department of Plant Pathology, Montana State University, Bozeman, Montana, USA, and the International Center for Agricultural Research in the Dry Areas, Aleppo, SYRIA. 181 pp.**

This book cosists of reports presented at the international symposium on biotic stress of barley in arid and semi-arid environments, held in Bozeman, Montana, USA, during 30 July-2 August 1990. The symposium was a result of a cooperative agreement that linked USAID, ICARDA, and Montana State University. The agreement was signed with the objective to further the exchange of ideas and information among research workers. And the symposium addressed the role of biotic stresses in barley and methods of prevention.

**Munck, L. (ed.). 1991.** ***Barley Genetics VI, Volume I, Short Papers*****. Munksgaard International Publishers Ltd, Copenhagen K, DENMARK. 652 pp. ISBN 87-16-19658-9.**

This volume is based on the short papers presented at the Sixth International Barley Genetics Symposium held at Helsingborg, SWEDEN, 22-27 July 1991. The volume was distributed at the symposium in 1991 in the form of short papers to make participants have access to the ongoing research projects in order to improve the discussions of the poster sessions. It is classified into 10 sessions according to subject.

**Munck, L. (ed.). 1991.** ***Barley Genetics VI, Volume II, Barley Research Reviews 1986-91, Session and Workshop Summaries*****. Munksgaard International Publishers Ltd, Copenhagen K, DENMARK. 1175 pp. ISBN 87-16-19601-5.**

This volume provides a profound review of the current development within specific areas of barley research since the last barley genetics symposium held in 1986 in Okayama, Japan. In addition to the opening and closing sessions, the volume contains 10 sessions on different subject of barley genetics. Results from the discussions that were held during the symposium are provided separately. Lists of symposium sponsors and participants and an author index for both volumes are provided in the closing session.

**Gebre-Mariam, G., Tanner, D.G., and Hulluka, M. (eds). 1991.** ***Wheat Research in Ethiopia--A Historical Perspective*****. IAR/CIMMYT, Addis Ababa, ETHIOPIA. 392 pp. ISBN 968-6127-57-7.**

This volume provides essential information on wheat research in Ethiopia. It reports thorough reviews of the results generated by the various disciplines involved in wheat research. Its publication came as a result of the recognition of the *status quo* of wheat production in Ethiopia which is very low in spite of the fact that the country is endowed with a wealth of genetic diversity, particularly for tetraploid wheats.

The volume covers 16 disciplinary topics, each treated as a chapter. It is recommended for planners, researchers, extension workers, producers, and others.

**James Cook, R. and Veseth, R.J. (eds). 1991.** ***Wheat Health Management*****. American Phytopathological Society, St. Paul, Minnesota 55121, USA. 152 pp.**

The book evolved as a result of a collaborative effort among scientists from universities and the Agricultural

Research Service of the U.S. Department of Agriculture in the western region of the United States to foster new and innovative approaches to the management of pests and diseases on major crops.

The main purpose of the book is to guide wheat health managers (farmers, agribusiness fieldmen, farm advisers, and others) to an understanding of the basic concepts and approaches to wheat health management. Another purpose of the book is that it can serve as a useful tool in teaching agronomy, plant pathology, entomology, and weed science. The book can also serve as a conceptual framework for the next generation of computer models and decision support systems for wheat health management. Furthermore it lays the groundwork for the introduction of biotechnology into wheat farming--an advance in the time line of wheat development and management.

This book is recommended not only to farmers and farm advisers in North America but also to those in Europe, where wheat management is most intense, and in Australia, South America, and other wheat-growing regions.

**Sauer, D.B. (ed.) 1992. *Storage of Cereal Grains and Their Products.(Fourth Edition).* American Association of Cereal Chemists, Inc., St. Paul, Minnesota, USA. 615 pp. ISBN 0-913250-74-0.**

This is an updated edition of the book which was published for the first time in 1954 and revised twice afterwards. The book contains updated material and deals with new topics and subjects that were not presented in earlier editions. A wealth of scientific and technical information on storage of grains and grain products is reported in the book which includes about 1800 literature citations.

Among the new topics covered in the book are the physical structure and properties of grains, and the history of grain storage techniques, in addition to discussions on such topics as the economic costs and benefits of grain storage and future markets and the role of government policies in grain storage.

Much of the material previously covered under separate chapters has been updated and combined in new chapters.

**Peter R. Shewry (ed.). 1992. *Barley: Genetics, Biochemistry, Molecular Biology and Biotechnology.* CAB International, Wallingford, Oxon OX10 8DE, UK. 610 pp. ISBN 0-85198-725-7.**

The book provides an up-to-date view of different aspects of barley research. It is a mixture of detailed review articles and short specific topics that provide interesting and stimulating reading for young researchers as well as experienced barley workers. It is made into six sections, each dealing with a specific subject: section I deals with origin, evolution, and wild relatives of barley; section II with genetics; section III with analysis of metabolism and development; section IV with seed development, composition, germination, and utilization; section V with pathogen resistance; section VI on biotechnology.

**Moss, J.P. (ed.). 1992. *Biotechnology and Crop Improvement in Asia.* International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh 502 324, INDIA. 396 pp. ISBN 92-9066-198-4.**

This book is based on presentations made by representatives of Asian countries and scientific leaders in the various fields of biotechnology in a workshop held at ICRISAT, 3-7 December 1990, and sponsored by the Asian Development Bank (ADB). The book is made into several chapters: the introductory chapter outlines the role of the ADB in strengthening biotechnology research in Asia, a chapter on industry and public sector corporation highlights the advantages and disadvantages of private companies becoming involved in biotechnology research. Other chapters in the book review the major disciplines in biotechnology, and report on research relevant to Asian agriculture. The reviews cover cell and tissue culture, with emphasis on legumes, cereals, and haploids.

An appendix of the workshop recommendations is included separately, and it focuses mainly on the future development of biotechnology. Another appendix provides a list of the workshop participants. The book also contains a glossary of selected biotechnology terms and an index.

## Other releases

**Sposito, G. and Reginato, R.J. (eds). 1992. *Opportunities in Basic Soil Science Research.* Soil Science Society of America (SSSA), 677 South Segoe Road, Madison WI, USA. 109 pp. Softcover. ISBN 0-89118-799-5. $14.00.**

Soil, according to this report, is a complex system which is very difficult to understand. It is described as highly variable as it contains an infinite number and variety of chemical and biological phenomena which ensure that the system is never static. The study of soil is perceived as a very complicated one and if soils are to be understood, they must be studied at the atomic, human, and global scales.

***Glossary of Crop Science Terms. 1992.*** **Crop Science Society of America (CSSA), 677 South Segoe Road, Madison WI, USA. 88 pp. Softcover. ISBN 0-89118-535-6. $7.00 each for 1 to 9 copies and $6.50 each for 10 or more copies.**

The Glossary contains three sections with 1750 entries that are amply cross-referenced with many usage notes, synonyms, and abbreviations. There are 622 main entries in the nomenclature lists including 144 genera, 478 species, and more than 550 common names.

The three sections of the Glossary are 1) a general glossary, compiled from submissions from ad hoc committees of all Society divisions except Cell Biology and Molecular Genetics (C-7); 2) a glossary of terms pertinent primarily to Cell Biology and Molecular Genetics, compiled from submissions from a similar ad hoc committee from C-7; and 3) a glossary of crop scientific nomenclature, compiled by a Society-wide ad hoc committee.

The forage and grazing terminology glossary includes about 50 terms that were not in the CSSA Glossary, but were added to complete the Glossary with respect to grazing terms.

# CONTRIBUTORS' STYLE GUIDE

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

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

## Editing

Articles will be edited to preserve uniform style but substantial editing will be referred to the author for his/her approval. Occasionally, papers amy be returned for revision. Rejected papers will not be returned, but the author/s will be informed.

## Manuscript

Articles should be typed double spaced. The original and two other legible copies should be submitted. The name, title, full address, and telex or fax number should be included in the covering letter of the corresponding author. Photographs, figures, tables, etc. should be original, good-quality prints, and suitable for reduction to a printed size of 8.5 or 17.5 cm wide. Photocopies are not acceptable for publication in RACHIS.

All long articles must have an abstract and usually the following sections: Introduction, Materials and Methods, Results and Discussion, Conclusions, and References.

**The following guidelines should be followed:**

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

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

Use the metric system in presenting measurements, e.g., t/ha, kg, g, m, km, ml (=milliliter), $m^2$. Where other units are used (e.g., quintal), the metric equivalent should be provided in parentheses.

Express the numbers one to nine as words except in combination with units of measure; use numerals for all other numbers, e.g., nine plants, 10 leaves, 9 g, ninth, 10th, 0700hr.

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

**Book:** Evans, L.T. and W.J. Peacock (eds). 1981. *Wheat science-today and tomorrow.* Cambridge University Press, Cambridge, UK. 290 pp.

**Thesis:** Haitham Sayed, Mahmoud. 1990. Ecological study of important wild genetic resources of wheat and barley. Thesis. University of Aleppo, Aleppo, Syria. 235 pp.

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