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EDITORIAL

Increasing world population and limited cultivable land have contributed to the concentration of efforts on raising productivity per unit of land. The available technology that has come about through extensive research and considerable experience has helped the world realize significant increases in food production, particularly during the past four decades. This so-called improved technology has produced its best results on large mechanized farms using high levels of production inputs under favorable climatic, edaphic, and socioeconomic conditions.

There is now a growing concern that the improved technology, if unchanged, may not succeed in supporting a sustainable agriculture in the future. The technology has proved inadequate in low-potential areas, is not within the easy reach of resource-poor farmers, and is leading to a depletion of natural resources and degradation of the environment. Physical resources (soil, water, and atmosphere) are threatened by such effects of the technology as soil erosion, desertification, waterlogging, salinization, and pollution with agrochemicals and industrial exhausts. Biological resources (plants and animals) have been managed in a way that has largely favored the expansion of a limited number of genotypes, resulting in reduced genetic variability and increased vulnerability. Yet, it is with this technology that today's farmers are "feeding the world."

For a sustainable future it is essential to reconcile the technological advancements that have brought about increased food production, with the efforts addressed to preserving and enhancing the natural resources on which tomorrow's agriculture will depend. One proposed approach has been to develop alternative technologies using little or no external inputs (primarily chemicals). This approach has been criticized as being incapable of keeping up with the perpetually increasing food demand. The task is complex and challenging and deserves to be handled as a global endeavor of a long-term investment in natural resources: choices made today will affect the earth and its inhabitants of tomorrow.

Research and Production

Barley Production and Improvement in Nepal

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Nepal is a landlocked country with a total area of 143 000 km². About 90% of the population depends on agriculture, and subsistence farming is usually predominant.

Barley is considered the fifth most important cereal in the country. It is important in the higher hills, especially over 2000 m above sea level. Of the total area and production of barley in Nepal, more than 85% lies in the higher hills. Naked barley predominates especially in areas located over 2500 m above sea level, whereas hulled barley is more popular at lower altitudes.

According to the Land Resources Mapping Project (LRMP), total area under barley is estimated at 75 000 ha with an annual production of 60 000 tonnes and an average yield of 857 kg/ha only. Among the various constraints to barley production in the higher hills are marginal land, inadequate irrigation, little access to advanced production technology, long time to mature, and the food habit of the people. Some of these constraints, however, could be removed by adopting improved varieties and management practices.

In the higher mountains, barley is consumed both as food and feed. It is used for making bread, porridge (known as 'Chhampa', made of roasted and ground kernels), and alcoholic beverages. As both the barley grain and straw are important for the animals, farmers prefer varieties with high straw recovery over those with high grain yield only.

Agro-ecological Zones

The country can be broadly divided into three zones from north to south, and into another three from east to west, with a total of nine agro-ecological zones.

From east to west, there is a progressive decline in temperature, while the temperature difference between north and south as a function of altitude variation is obvious. The other important factor is the rainfall gradient. Rainfall decreases from east to west. Areas stretching beyond the monsoon belt have an arid to semi-arid climate quite similar to the Mediterranean region. It is desirable that different varieties be introduced or developed for the various environments of the country.

Because of the negative precipitation gradient from east to west, the soils tend to be more acidic in the east and south. This variation in soil pH may have considerably affected the genetic makeup of adapted landraces. In a study where the reactions of landraces and exotic sources were compared, local sources were found to be acid tolerant, whereas many exotic sources showed sterility.

Cropping Pattern

Traditionally, farmers always prefer to grow two or more crops a year, which obviously limits them to growing short duration varieties. Altitude, by and large, determines the cropping pattern and the type of barley to be grown. At higher altitude, barley is the only crop that can be rotated with summer crops such as potato or buckwheat. In western mountains, because of high sunlight intensity, barley is usually rotated with rice. In mid-hills, wherever irrigation is limiting, barley may be rotated with maize, millet, or any other summer crops.

Biotic and Abiotic Stress

The most important disease in barley is yellow rust (Puccinia striiformis), followed by barley stripe (Helminthosporium gramineum), powdery mildew (Erysiphe graminis). and covered smut (Ustilago hordei). Yield loss due to yellow rust is estimated at 15-20%. Losses due to other diseases are yet to be determined. Until now, none of the local landraces has been found to be resistant to yellow rust although there is variation within populations. It is, however, remarkable that even the most heavily infested plants produce some grains. This indicates the tolerance present in local landraces.

Moisture stress, acidic and degraded soils with low nutrients content, dissected topography, frost damage, and hailstorm during grain ripening are some of the important abiotic factors that limit barley production. In some locations, sterility occurs, especially with introduced barley lines, and is suspected to be associated with soil acidity.

Institutional Development

Barley is one of the mandated crops of the National Hill Crops Improvement Program (NHCIP) of the National Agricultural Research and Services Center (NARSC). Both the Program and the Center have been recently established. The NHCIP has it headquarters located 165 km east of Kathmandu at 1750 m above sea level, and is responsible for:

- research in breeding, agronomy, crop protection, soil, and plant nutrition;
- outreach activities such as farmers' field trials, production verification trials, 'minikits' distribution, and information dissemination:
- breeder's and foundation seed production, and varietal maintenance (certified and improved seed are produced by the Agriculture Input Corporation); and
- training junior technical staff, farmers, and researchers, and holding technical meetings.

Accomplishments in Barley Breeding

Both exotic and local sources were tested during the 1970s. As a result, the barley varieties Bonus, Ketch, HBL-56, C11048, and Galt were released for general cultivation, but only Bonus has become popular to some extent. Since the establishment of NHCIP in 1987, six cultivars are being improved through head-to-row selection. These cultivars are considered to be widely adapted and possess considerable genetic variability.

The introduction of exotic sources has been a part of the varietal development process. Material introduced from the CIMMYT/ICARDA barley program, Mexico, has shown desirable traits such as adaptation to high-altitude environments, yellow rust resistance, and high grain yield. For instance, during 1987/88, entry 119 of the 14th IBON performed better than Bonus and the best landrace in Mustang. However, because of its short height, this line proved less appealing to the farmers. Short plant height appears to be the main shortcoming in many exotic sources.

Crosses have been made between local and exotic sources. Many of the local landraces are better adapted to the existing environment but generally susceptible to diseases, whereas the exotic sources are disease resistant, and have a high tillering capacity. The local sources are mainly NB 1003-37, NB 1003-11, Tukuche Local, NB 1003-103, LG 51/Acc. 7152, LG 11/Acc. 480, LG 100/Acc. 9017, and Jumla Local. The exotic sources are mainly PRO409, IBON-171, DD-21, DD-37, D-60, and Bonus.

Barley Breeding Strategy

Barley breeding in Nepal focuses on:

- Head-to-row or pure line selection of local landraces in the short term to exploit the significant genetic variability in the populations.
- Use of exotic sources. Introduced germplasm can be utilized in breeding for disease resistance, particularly yellow rust, and superior agronomic characters, particularly high tillering potential.
- Recombination of landraces and exotic sources to get best segregants.

The general breeding scheme that is being followed is presented in Fig. 1. The selection approaches and trial designs are mainly targeted, at present, at the following three ecological zones:

- High altitude areas. In these areas mainly naked varieties are needed for food.
- Hills and mid-mountain regions. The varieties needed are of the naked as well as the hulled types.
- Lower hills and *tarai*. Hulled types are used for feed and malting purposes. The development of malt barley varieties for the country's brewery industries is envisaged for the future.

Future Plans

Breeding

Varietal improvement will receive the first priority in the barley program. The following activities have been planned:

- 1. Varietal selection through the utilization of landraces and exotic sources will be carried out to meet the need of different agro-ecological zones.
- 2. Crossing of exotic sources with well adapted promising landraces.

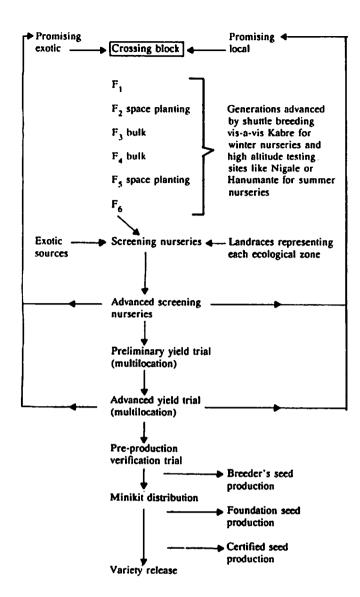


Fig. 1. The present barley breeding scheme in Nepal.

- 3. Further collection, characterization, and conservation of landraces to counterbalance genetic erosion.
- Systematic screening for disease resistance, especially to yellow rust and barley stripe. At the outset, screening techniques for these diseases should be developed, and resistant sources subsequently used.
- 5. Maintenance of barley varieties. Individual head selection of advanced lines to ensure maximum genetic purity is desirable.
- 6. Improving the research facilities at the testing sites in the hills, especially in the higher hills.

Agronomy, management, and nutrition

In the beginning, agronomy and management will be given less emphasis than varietal improvement. However, the NHCIP would make studies on seed rate, date of planting, fertilizer use, and soil amendment through the use of compost and bio-fertilizers.

Sterility has been observed in most of the exotic sources when grown under low pH (< 5.5). The cause of sterility may be environmental, nutritional, or genetic. However, it is highly suspected to be due to the low soil pH environment and its associated effects. Study on the influence of different soil amendments and nutrients, such as lime to raise pH, phosphorus to supplement P deficiency at low pH, or micro-nutrients e.g. Bo, Mn, and Mo should help to investigate the cause.

Testing barley varieties under actual farm conditions is desirable. Varieties developed under high fertility level often fail in farmers' fields. Since the use of farmyard manure is a common practice, parallel screening using chemical fertilizer and farmyard manure should help identify the best barley varieties.

Crop protection

Emphasis will be put on epidemiological and other studies of economically important diseases. Work on chemical protection will be confined to seed treatment by fungicide to control mainly seed-borne diseases. Limited attention will also be given to the epidemiology and biology of insects.

Outreach

The NHCIP works in collaboration with the extension agencies on technology dissemination. Identification and verification of improved agronomic practices and varieties in farmers' fields through on-farm trials, demonstration trials, and minikits will be part of NHCIP's activities.

Rapid rural appraisal

There is a need to recognize the importance of barley in the farming system in specific areas. Studies on people's perception of the cultivation and use of barley would be conducted in collaboration with the Socio-economic and Farming System Division. This should help recognize and address the needs of the farmers with regard to the variety type, management practices, and their attitude towards the adoption of improved technologies.

Training

The number of trained personnel for the barley program

is limited and should therefore be upgraded. Training should cover barley breeding, plant protection, and barley genetic resources.

Collaboration with international institutions

Recent developments in collaboration between the NHCIP and international institutions, such as ICARDA, or other national programs will help strengthen the barley program in Nepal.

Variability in a World Collection of Durum Wheat for Reaction to Yellow Rust and Common Bunt

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Landraces constitute the backbone of sustainability in agriculture. Their genetic structure comprises different genotypes that are in equilibrium with the environment as a result of an intensive natural and human selection over a long period of time. This structure endowed these populations with stability over diverse seasons against abiotic and biotic stresses.

The most valuable contribution of such less conventional genetic resources to modern plant breeding has been the incorporation of resistance to new diseases or new races of diseases into cultivated forms (Krull and Borlaug 1970). A necessary step before the utilization of landraces in breeding programs is the identification of sources of resistance that could be introduced into a suitable and already adapted genetic background.

Since its inception the International Center for Agricultural Research in the Dry Areas (ICARDA) assembled a large collection of durum wheat germplasm. The aim of the present study was to assess the various resistance levels present in the ICARDA's durum wheat collection to two major diseases occurring in West Asia and North Africa, namely, yellow rust (Puccinia striiformis West) and common bunt (Tilletia foetida (Wallr.) Liro. and Tilletia caries (DC) Tul.).

Materials and Methods

A total of 6936 accessions of known geographical origin were evaluated at ICARDA's principal station at Tel

Hadya, Syria (36°01'N, 36°56'E, 284 m above mean sea level, 348 mm long term average annual rainfall) in 1985/86, 1986/87, and 1987/88. About one-third of the accessions was evaluated in each season under the same experimental design and management. The plot size was a single 30-cm row sown with 25-30 seeds. Check varieties Sham I, Stork, Haurani, and Gezira 17 for yellow rust, and Sebou and Haurani for common bunt were planted every twenty test plots to assess the level and the homogeneity of infection.

An artificial epiphytotic of yellow rust was created after plant establishment by using a bulk of spores comprising two predominant races in Syria and neighboring countries, namely, 6E16 and 82E16. For common bunt, seeds were mixed with a composite sample of spores collected from different sites in Syria and adjusted to a *T. foetida*: *T. caries* ratio of 1:1.

Data on yellow rust were recorded during stem elongation and, on common bunt, at full maturity. Diseases were scored for each accession on a plot basis according to the 1-9 scale below:

	Score	Yellow rust (%leaf covered with pustules)	Common bunt (%infected heads)
Resistant	1	0-10	0
Moderately			
resistant	3	11-20	6-10
Moderately			
susceptible	5	21-30	21-30
Susceptible	7	31-50	46-60
Highly			
susceptible	9	> 50	> 7.5

The accessions were grouped into ten regions on the basis of their geographic occurrence (Pecetti et al. 1989). The ten most represented countries in the collection (Turkey, Jordan, Syria, Morocco, Tunisia, Ethiopia, the USSR, Greece, Italy, and Portugal) were also studied separately. East Africa was represented only by Ethiopia which was, thus, included in both groups. This was accepted because a large number of accessions in the collection came from Ethiopia, and also because of Ethiopia's importance as a center of diversity for durum wheat.

Results and Discussion

Fig. 1 shows the accessions distribution following their response to yellow rust and common bunt on a whole-collection basis. The proportion of fully resistant accessions to yellow rust was very low, whereas a high percentage was moderately susceptible and susceptible. In screening for common bunt, many

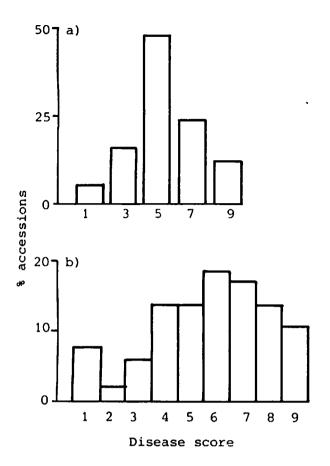


Fig. 1. Variability in a world collection of 6936 accessions in response to (a) yellow rust and (b) common bunt.

accessions (463) proved resistant, but the percentage of susceptible types was also high. The accessions that showed disease resistance in this study will be further tested to understand whether they are indeed resistant to the pathogen or have just escaped the infection.

Germplasm from different geographic origins showed specific frequency patterns in response to the two diseases. Central Europe, Southern Europe, Southwestern Europe, and South America had a relatively high frequency of resistant and moderately resistant types to yellow rust, whereas South Asia, North Africa. Eastern Europe, and North America had a high frequency of moderately susceptible and susceptible accessions (Fig. 2). With regard to common bunt (Fig. 3), the highest frequency of resistant to moderately resistant types was found in collections from Southwest Asia, Southwestern Europe, Central Europe, Southern Europe, and South America. Germplasm from South Asia, Ethiopia, Eastern Europe, and North America had a high frequency of highly susceptible accessions.

Among countries, Greece, Italy, and Portugal had the highest percentage of yellow rust resistant accessions; Jordan and Syria, a high number of moderately resistant accessions; and Turkey, Morocco, and the USSR, the highest percentage of susceptible accessions (Fig. 4). Turkey, Syria, Tunisia, Italy, and Portugal had the highest frequency of common bunt resistant accessions, whereas Moroccan and Ethiopian germplam was mostly susceptible (Fig. 5).

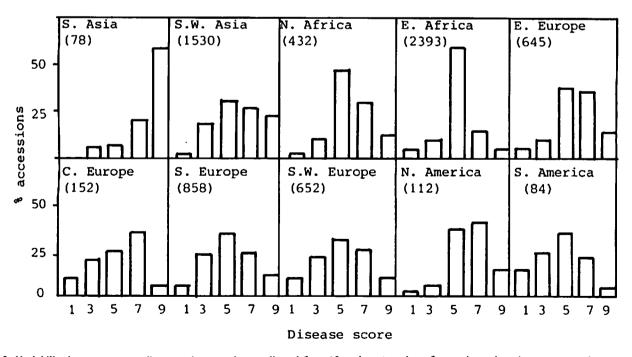


Fig. 2. Variability in response to yellow rust in germplasm collected from 10 regions (number of accessions given between parentheses).

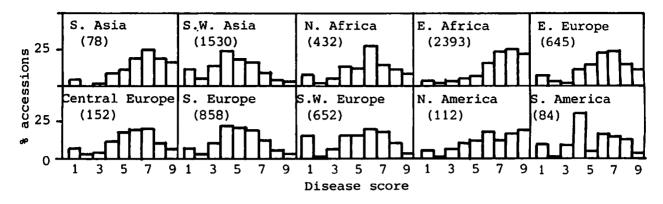


Fig. 3. Variability in response to common bunt in germplasm collected from 10 regions (number of accessions given between parentheses).

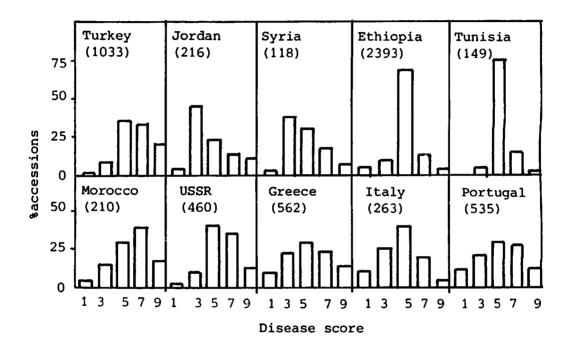


Fig. 4. Variability in response to yellow rust in germplasm collected from 10 countries (number of accessions given between parentheses).

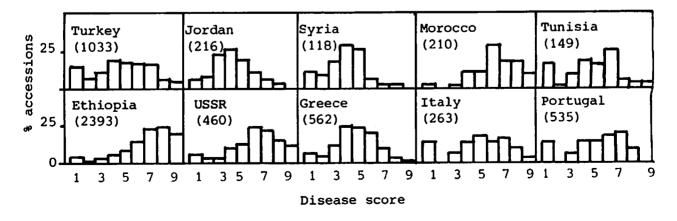


Fig. 5. Variability in response to common bunt in germplasm collected from 10 countries (number of accessions given between parentheses).

It is evident from these results that there are geographic areas in the regions, as well as countries, considered in this study in which disease resistances occur more frequently than in others. It is interesting that resistance to both diseases is included in the material coming from Jordan, Syria, Greece, Italy, and Portugal. A chi-square test revealed that Portugal, Spain, Italy, and Greece had a higher frequency of yellow rust resistant accessions than expected, whereas the frequency of accessions selected from Turkey and the USSR was lower. Portugal, Spain, Italy, Tunisia, and Iran showed a higher frequency, while Ethiopia and Morocco showed a lower frequency of common bunt resistant accessions than expected.

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Control of Leaf Rust of Wheat with Seed-treatment Fungicides

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Leaf rust (Puccinia recondita) of wheat is an important disease in most of the wheat-growing areas of Punjab, the major wheat-producing province of Pakistan. The intensity of infection of the disease varies from year to year depending upon the duration of the favorable weather conditions. Severe epidemics of leaf rust reported in 1948 and 1954 reduced wheat yield by 30 to 50% in certain areas. In 1978, a 10% yield loss primarily attributed to leaf and stripe rust compelled the country to import large quantities of wheat (Hassan 1979).

The cultivation of resistant wheat varieties is the cheapest and, so far, the best known method for the control of rust. However, due to sudden changes in the rust races pattern, commercial wheat varieties may become susceptible to rust attacks resulting in considerable losses in grain yield. According to Rowell (1968), the frequent failure of resistant wheat varieties has revived the interest in the chemical control of rust.

Foliar-spray fungicides against wheat rusts have been known for many years. Most of them are protectants and, therefore, must be applied several times to ensure good disease control, which increases the cost of production. Baytan, Bayleton, Plantvax, Benlate, etc. are systemic fungicides that have recently shown promise when applied as foliar sprays against cereal rusts (Buchenauer 1976; Rakotondradona and Line 1984). An alternative and less expensive chemical control would be the use of systemic fungicides applied as a seed-treatment only, or both as a seed treatment and foliar spray. Such treatments may also be used to complement various types of resistance to rusts.

Some encouraging results on the efficacy of seed-treatment fungicides against stripe and leaf rusts of wheat have been published. Rowell (1976) showed that leaf rust of wheat could be controlled to some extent by treating the seed with Butrizol. Among four tested fungicides, namely, RH-124, Triarimol, Oxycarboxin, and Benomyl, he recommended RH-124 as a systemic protectant against wheat leaf rust for foliar, soil, and seed applications. Hagburg (1970) observed that the systemic fungicide Plantvax (Oxycarboxin) increased wheat yield significantly by controlling leaf and stem rusts. Line (1976) evaluated the performance of several fungicides applied as seed treatments against stripe and leaf rusts of wheat. Rakotondradona and Line (1984) tested six fungicides against leaf and stripe rusts of wheat and reported that seed treatment with Bayleton 25 WP controlled both deseases from seedling to boot stage whereas Butrizole was effective against leaf rust only.

The objective of this study was to determine the effectiveness of nine systemic seed-treatment fungicides against leaf rust of wheat.

Materials and Methods

Nine fungicides (Table 1) in the form of wettable powder were separately mixed with water and applied as slurries to the seed of WL 711, a wheat variety highly susceptible to leaf rust. Treated as well as non-treated (control) seeds were planted on 3/12/1985 and 9/12/1986 at the Wheat Research Institute, Faisalabad. As leaf rust appears late in the region

Table 1. Names and doses (g/kg seed) of the nine tested fungicides

Trade name	Chemical name	Dose	
Baytan 25 WS	Triadimenol	2.5	
Bayleton 25 WP	Triadimefon	2.5	
Plantavax 75 WP	Oxycarboxin	2.5	
Daconil 75 WP	Chlorothlonil	2.5	
Sicarol 60 WP	Pyrocarbolid	2.5	
Tecto 60 WP	Thiabendazole	2.5	
Topsin-M 70 WP	Thiophanate Methyl	2.5	
Benlate 50 WP	Benomyi	2.0	
Vitavax-200	Carboxin	3.0	

where the experiment was conducted, sowing was delayed to ensure a heavy infection of the experimental plots at the early growth stages. A randomized complete block design with three replications and a plot size of 3x12 m was used.

A rust epidemic was induced at early growth stage by planting spreader rows of a mixture of susceptible wheat varieties around the experimental plots. The spreader rows were inoculated with a mixture of leaf rust inoculum consisting of prevalent virulent races in the country collected from various localities and the inoculum received from the Crops Diseases Research Institute, Sunny Bank, Murree. The rust percentages were estimated periodically by using the modified Cobb Scale Method. At maturity, a plot of 1 m² was harvested for yield estimation and samples of grains were drawn for measuring 1000-kernel weight.

Results and Discussion

The artificial inoculation, coupled with the favorable weather conditions, i.e. a temperature of 15-22°C and sufficient moisture, caused an infection of 70-100 S in all plots, except in those treated with Baytan and Bayleton (Table 2). In general, Baytan proved more effective than Bayleton when used at the same rate. In 1985/86 when the leaf rust infection was less severe, both these fungicides provided nearly complete control until the grain-filling stage. However, in 1986/87, when temperature and humidity were more favorable for the development of rust during the early growth stage of the crop, the disease could be controlled until flowering only, with Baytan being more effective.

Plantvax could delay the disease until the end of Feb in 1985/86, thus only providing a slight control. Daconil, Sicarol, Tetco, Topsin-M, Benlate, and Vitavax did not control the leaf rust after Jan. Rowell (1976)

Table 2. Effects of nine seed-treatment fungicides on the extent and type of leaf rust development at weekly intervals in Mar and Apr on the wheat cultivar WL 711.

F	*/		M	Ap	ril		
Fungicide	Year	ī	II	III	IV	Ī	II
Baytan	85-86	0	0	0	0	TS	5S
·	86-87	0	0	0	TS	20S	20 S
Bayleton	85-86	0	0	0	0	TS	5 S
	86-87	0	0	TS	5S	20S	258
Plantvax	85-86	TS	5 S	25 S	405	50S	70S
	86-87	5S	20S	40S	60S	100S	1005
Daconil	85-86	TS	108	25S	40S	60S	80S
	86-87	5 S	20S	60S	80S	80S	100S
Sicarol	85-86	5 S	20S	40S	60S	70S	90S
	86-87	5S	30S	60S	80S	100S	100S
Tecto	85-86	5S	108	25 S	408	60S	90S
	86-87	5 S	30S	60S	100S	100S	1005
Topsin-M	85-86	5 S	20S	40S	60S	80S	90S
·	86-87	5 S	30S	60S	1008	1005	1005
Benlate	85-86	5 S	20S	40\$	60S	80S	90S
	86-87	5\$	30S	60S	1005	1008	1008
Vitavax-200	85-86	5 S	20S	40S	60S	80S	100S
	86-87	5 S	30S	60S	1005	100S	100S
Control	85-86	5S	25S	40S	60S	80S	1005
	86-87	5 S	40S	80S	1005	1008	1005

indicated that Plantvax applied as a seed-treatment was promising for controlling leaf rust, but recommended larger doses (16 g/kg seed) for a long-lasting effectiveness. Such rates are too high for practical use.

Table 3 shows that the highest grain yield was obtained with the use of Baytan, followed by Bayleton. Averaged over the two seasons, the increases in grain yields due to the use of Baytan and Bayleton were 2643 and 2390 kg/ha, respectively, over the control, which shows their relative effectiveness in controlling leaf rust.

The differences in average 1000-kernel weight were also significantly higher for Baytan (41.3 g) and

Table 3. The effect of nine seed-treatment fungicides on the yield (kg/ha) and 1000-kernel weight (g) of the wheat cultivar WL 711.

Fungicide	Year	Yield	1000-kernel weight
Baytan	85-86	5028	39.8
•	86-87	3360	42.8
Bayleton	85-86	4749	39.1
	86-87	3143	41.0
Plantvax	85-86	3588	34.0
	86-87	2680	38.3
Daconil	85-86	2734	28.5
	86-87	1987	32.7
Sicarol	85-86	2567	26.7
	86-87	1287	31.6
Tecto	85-86	2528	25.9
	86-87	1193	25.4
Topsin-M	85-86	2502	25.9
·	86-87	1140	23.8
Benlate	85-86	2414	24.4
	86-87	990	21.2
Vitavax-200	85-86	2421	24.6
	86-87	1140	22.3
Control	85-86	2399	23.3
	86-87	720	19.1
LSD	85-86 86-87	336	2.0
	40-94	208	2.1

Bayleton (40.1 g) as compared to the rest of the fungicides and the control (21.2 g) (Table 3). Significant correlations of 0.98 and 0.73 were observed between the 1000-kernel weight and grain yield during 1985/86 and 1986/87, respectively. The results are in conformity with the findings of Aujla *et al.* (1975) that leaf rust caused yield losses by reducing the kernel weight.

Since leaf rust in most of the Punjab Province of Pakistan is usually severe early in the season, the most effective control strategy may be the use of Baytan as a seed-treatment before wheat sowing at the rate of 2.5 g/kg seed. In years of late, severe outbreaks, a foliar fungicide application at a late growth stage of the crop may be necessary. The seed

treatment may also provide protection against other seed-borne diseases such as loose smut (*Ustilago tritici*) and seed-borne inoculum of Karnal bunt (*Neovossia indica*) at a cost that could be compensated by yield increases (Singh *et al.* 1984).

Although some workers consider the chemical control of rust as uneconomical (Forysth and Peterson 1958; Dickson 1959), results of the present study justified the use of Baytan as a seed treatment, and indicated that in years when temperature and humidity are favorable for the development of rust epidemics, its use can reduce yield losses, hence save millions of rupees.

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Cytological and Developmental Effects of Four Herbicides on Barley

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With the accumulation of evidence indicating that some pesticides can induce chromosome aberrations in treated plants, extensive studies were conducted during the last two decades to determine which of the hundreds of registered pesticides can be safely used for crop protection. While some pesticides were found to have no detectable cytological effect (Wuu and Grant 1966; Tomkins and Grant 1972), others proved to be as effective as x-ray (Unrau and Larter 1952; Wuu and Grant

The present study was carried out to elucidate the effects of four herbicides, namely. bromoxynil. methabenzthiazuron, metribuzin, and terbutryn, on mitotic division and on germination and seedling growth of two barley cultivars.

Materials and Methods

Seeds of the barley cultivars Sahrawi 100 and Bonus were immersed for 6 hr at 20°C in a fresh acqueous preparation of each of four different concentrations (Table 1) of the tested herbicides, i.e. Brominal 24% e.c. (bromoxynil: 3,5-dibromo-4-hydroxybenzonitrile). Tribunil 70% w.p. (methabenzthiazuron: 1,3-dimethyl-3-(2-benzothiazolyl) urea), Sencor 70% w.p. (metribuzin: 4-amino-6-tert-butyl-3-(methylthio)-as-triazine-5(4 H)one), and Igran 80% w.p. (terbutryn:2-(tert-butylami-

Table 1. Effect of herbicides brownwynil, methabenzthiazuron, metribuzin and terbutryn on mitotic indices and induction of chromosome anomalies in root-tip cells of the barley cvs. Sahrawi 100 and Bomus.

			No. of cells with:					No	o£						
Concentration (ppm)	Mitotic index (%)		refress and tetras telephones and tetras telephones and tetras telephones and tetras and				cel			% aberrant cells					
	s ¹	в ¹	o Greetapas	o Polyploidy	S Bo nelei	7	a polar telo	stagged 8	serickiness	s Chromstid	s Others	s	В	S	В
Control	12.2 <u>+</u> 0.7	11.6 <u>+</u> 0.7	0 0	0 0	0	0	0 0	0 0	0 0	0 0	0 0	315	282	0	0
Bromoxynil															
312	11.4+0.7	10.6+0.8	0 0	0 1	1	1 (0 1	10	12	0 0	00	200	230	1.5+0.9	2.2+1
625	10.3+0.8	10.1 ± 0.7	23	1 2	0	1 (0 0	0 0	1 1	0 0	00	228	216	2.2+1.0	3.2+1
1250.	8.9+0.9**	9.0+0.8**	5 6	3 2	1	2 (0 1	0 1	0 2	1 1	0 0	195	204	5.1∓1.6	7.4+1.
2500 ^{&}	4.8+0.8**	4.9+0.7**	58	4 6	2	2	2 1	1 2	3 4	0 1	0 2	167	235	10.2+2.3	$11.1\overline{\pm}2.$
Methabenzthiazu	ron														
468	12.1+0.7	11.0+0.7	0 1	0 0	0	0 (0 0	1 0	10	0 0	0 1	212	245	0.9 <u>+</u> 0.7	0.8+0
937	9.6+0.8*	9.8+0.7*	1 1	10	1	0 (0 0	0 1	22	0 0	00	195	182	2.6+1.1	2.2+1
1875	9.8+0.7**	9.0+0.6**	12	22			0 1	21	11	0 1	00	158	166	4.4+1.6	5.4∓1
3750 ^{&}	6.4+0.6**	6.0+0.8**	3 4	5 4	2	2	1 2	1 3	2 3	1 0	0 0	170	182	8.8 ± 2.2	8.9 <u>∓</u> 2.
Metribuzin															
312	12.1+1.0	11.4+0.7	4 3	0 0	0		0 0	0 1	11	0 0	00	142	195	3.5 <u>+</u> 1.5	2.5+1
625	11.0+1.0	$11.0\overline{+}1.1$	4 7	1 3			10	11	21	0 1	02	156	205	$5.8\overline{+}1.9$	7.8 <u>+</u> 1.
1250,	9.9∓0.9	8.2+1.0**	56	24			0 1	20	1 3	1 1	02	198	154	6.0+1.7	12.4+2.
2500 ^{&}	6.5 <u>∓</u> 0.9**	6.0 <u>+</u> 0.8**	4 7	3 5	1	3	1 2	0 3	4 6	0 1	1 0	120	166	$11.7\overline{+2.9}$	16.3 <u>∓</u> 2.
Terbutryn															
625	11.8+1.0	10.5+0.7	0 1	00	•	-	10	0 1	22	00	00	210	195	1.4+0.8	1.5+0
1250	9.4+1.0*	9.0+0.7**	1 2	1 1	1	1	01	0 0	12	1 0	0 0	165	200	$3.0\overline{\pm}1.3$	3.5 <u>+</u> 1.
2500	8.1+1.0**	7.3+0.8**	0 4	22		2	0 0	1 1	1 1	0 1	01	110	189	4.5∓2.0	6.4 <u>+</u> 1.
5000 ^{&}	5.4+0.9**	4.5+0.8**	3 6	2 4	3	4	2 2	2 1	35	1 1	00	170	210	7.4+2.0	10.9+2

S = Sahrawi 100, B = Bonus. Others = Unequal segregation of chromosomes and disturbed cells.

Concentration of the field rate.

^{**} Significantly different from the control at the 0.05 and 0.01 levels, respectively.

no)-4-(ethylamino)-6-(methylthio)-s-triazine). Control seeds were soaked in distilled water for the same period. After treatment, the seeds were washed thoroughly with distilled water and allowed to germinate in petri-dishes on filter paper moistened with distilled water. When the roots reached 0.5-1.0 cm in length they were collected and fixed for 24 hours in Carnoy's fluid (3:1 ethanol:acetic acid). The fixed roots were stored in 70% ethanol at 4°C.

For cytological examination, preparations were made following the acetocarmine squash method (Darlington and La Cour 1962). For each treatment, at least five preparations were examined for types of aberrations and mitotic index. Measurements on germination and root and shoot growth were taken two weeks after the treatment.

Results and Discussion

Bromoxynil was more active than the other three herbicides in reducing mitotic index in Sahrawi 100, while terbutryn was the most effective on Bonus (Table 1).

All these herbicides acted as antimitotic agents, since they could significantly reduce the mitotic index in the root tips of the plant. These effects are similar to those obtained with various herbicides on different plant materials (Hakeem and Shehab 1973a,b; Hargitay et al. 1978; Badr and Ibrahim 1987).

All the tested herbicides induced different types of aberrations in both cultivars as shown in Table 1. The number of abnormalities induced in Bonus was generally higher than that induced in Sahrawi 100. In general, metribuzin was more active in inducing aberrations than the other herbicides in both cultivars, while methabenzthiazuron was the least effective one. The most frequent abnormalities observed were Cmetaphase, polyploidy, binucleate cells, stickiness of chromosomes, and unequal tripolar telophase (Fig. 1). Other kinds of aberrations, such as unequal segregation of chromosomes, chromatid bridges, lagging of chromosomes, and cells with giant nuclei (Fig. 1) were found in low frequencies. The formation of tetraploid cells confirms that the tested herbicides did not inhibit chromosome replication, but did inhibit spindle formation.

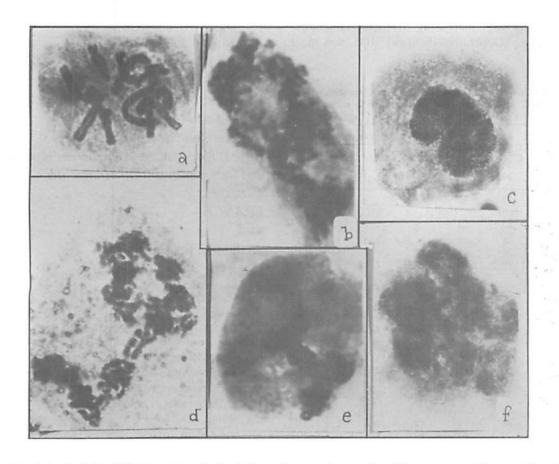


Fig. 1. C-metaphase (a); polyploid cell (b); binucleate cell with stickiness (c); unequal segregation of chromosomes with laggards (d) and with stickiness (e); and giant nucleus (f) in the herbicide treated seeds of barley cultivars Sahrawi 100 and Bonus.

The production of binucleate cells increased with increasing the concentration of each of the four herbicides (Table 1). The production of this abnormal type of cells is probably due to the inhibition of cytokinesis after normal mitosis. The occurrence of tripolar telophase and unequal segregation of chromosomes may result from a disturbance in spindle formation. Chromatid bridges and lagging of chromosomes were observed in some treatments. The chromatid bridge is probably due to the effect of these herbicides in producing terminal breaks in the chromosomes before their replications. The replication of such terminal deficient chromosome yields two sister chromatids, each with raw end. The fusion of these raw ends gives a dicentric chromatid bridge during the anaphase stage (Garber 1972). The results obtained are in accordance with that reported by Tobgy et al. (1969) who found that the herbicide MCPB caused tripolar anaphase and chromatid bridge in the root tips of Allium cepa and Vicia faba, and with Badr and Ibrahim's (1987) findings that the herbicide Glean was effective in inducing different types of chromosomal aberrations in the root tip cells of A. cepa.

Each of the four tested herbicides decreased the germination percentage and seedling growth. This effect increased steadily with increasing herbicide concentration (Table 2). Generally, Sahrawi 100 was more

Table 2. Effect of bromoxynil, methabenzthiazuron, metribuzin, and terbutryn on seed germination and seedling growth of the barley cultivars Sahrawi 100 and Bonus.

Concentration	% se	ed	See	dling gro	wth (cm))
(ppm)	germin	ation	Sahra	wi 100	Bon	us
	Sahrawi 100	Bonus	Shoot height	Root length	Shoot height	Root length
Control	87	93	16	11	13	12
Bromoxynii						
312	80	80	14	11	12	10
625	50	70	13	12	13	13
1250	30	67	11	10	11	11
2500 ^{&}	10	30	4	2	7	9
Methabenzthiazu	iron					
468	77	90	13	. 13	13	9
937	67	83	10	10	11	9
1875	40	83	10	8	11	11
3750 ^{&}	43	47	9	8	8	9
Metribuzin						
312	73	83	13	13	14	10
625	63	67	13	12	12	11
1250	60	63	12	10	12	9
2500 ^{&}	50	47	9	7	10	10
Terbutryn						
625	80	77	12	10	12	11
1250	37	63	10	8	10	10
2500	30	60	9	7	8	8
5000 ^{&}	17	43	4	3	6	6

[&]amp; Concentration of the field rate.

affected than Bonus in both its germination and seedling growth. With the exception of the treatment with the highest bromoxynil concentration, terbutryn was the most active herbicide in reducing germination and seedling growth of both varieties.

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Chlorophyll Fluorescence as a Predictive Test for Salt Tolerance in Cereals: Preliminary Results on Durum Wheat

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Chlorophyll fluorescence is very sensitive to abiotic stresses and can be considered as a reliable indicator of photosynthesis reduction or inhibition due to various constraints such as water deficit, temperature extremes, and high salt concentrations (Krause and Weis 1984; Schreiber and Bilger 1985). Fluorescence inhibition induced by water stress has been investigated in many species (Keck and Boyer 1974; Govindjee et al. 1981; Hetherington et al. 1982; Vertucci et al. 1985) including cereals (Havaux and Lannoye 1985; Pastore et al. 1989), and has been

recently proposed to measure drought tolerance in durum wheat (Havaux et al. 1988) and bread wheat (Martiniello and Blum 1989) based on the (P-S)/S ratio (for the different parameters, please refer to the figure in the appendix).

Smillie and Nott (1982), while studying the fluorescence signals emitted by three crop plants (sugar beet, sunflower, and bean) grown in pots and watered with nutrient solution containing 100 mM NaCl, observed a decrease of the (P-I)/I ratio both in the salt sensitive (bean) and the moderately tolerant (sunflower) species, and an increase of the same ratio in sugarbeet (salt tolerant). Dowton and Millhouse (1983) found that the expected fluorescence rise from I to P was reduced in grapevine with an increase in salinity.

Salinity is one of the major constraints to increasing cereal production, particularly in the Mediterranean region. It is desirable fluorescence technique be developed into a predictive test for selecting salt tolerant genotypes among a large number of landraces and segregating lines. The objectives of this study were to show that there are marked differences in the (P-I)/I ratio between salt tolerant and salt sensitive durum wheat lines, and to compare the simpler and faster 'stressed leaves' (SL) method with the 'stressed plants' (SP) method. Durum wheat (Triticum durum Desf.) has been chosen as a model because some information about the variability of salt tolerance has been already obtained on this crop by ICARDA and ENSA-INRA at Montpellier.

Materials and Methods

In the SP method, seedlings of various genotypes are grown in pots watered with mineral nutrient solutions containing different NaCl concentrations (0, 50, 100, and 150 mM). Experiments are conducted in glasshouse (22°C day/15°C night temperature; relative humidity 70%) and observations on fluorescence are recorded at the 4-leaf stage.

In the SL method, leaves of different genotypes are cut from plants growing in nutrient solution without NaCl. The basal tips of these leaves are immersed in deionized water or in pure NaCl solution (100 mM) for 1/2, 1, 2, and 4 hr before measuring fluorescence.

Fluorescence is measured with the SF 30 Fluorimeter (Richard Brancker Ltd. Ottawa, Canada) in both methods after 1/2 hr incubation in the dark. Before the measurement is taken, the central portion of the adaxial surface of the leaf is illuminated for 30 seconds by a red light (670 nm, $15 \mu E/m^2/s$). The

(P-I)/I ratio was adopted in this study as the sensitivity index since it was found in a preliminary study to give the most accurate indication of the effect of salinity on the leaves or plants.

In the SP method, seven durum wheat (Triticum durum) lines/cultivars were studied (Table 1). ACSAD 65 was found to be salt tolerant and Clairdoc was salt sensitive. ADYT 523, DCB 113, and DCB 44 have been identified as highly tolerant to salinity in a saline field at Hegla, northern Syria (ICARDA 1987). Sham 1 (=Waha) has been released in Algeria, Jordan, and Syria. 2777 was selected in Morocco from the Cypriot landrace Kyperounda, which is considered as very susceptible to salt (El Mekkaoui, unpublished data). Four genotypes already tested by the SP method, namely, ACSAD 65, Sham 1, ADYT 523, and 2777 were tested by the SL method.

Table 1. (P-I)/I value at 150 mM NaCl concentration (expressed as % of the 0mM NaCl control) for seven durum wheat genotypes, based on the 'stressed plant' method.

Genotype name	$\frac{P-I}{I}$
DCB 44 (=ICARDA 14789)	88.6
ACSAD 65	85.0
Sham I (=Waha)	81.3
ADYT 523 (=ICARDA 15596)	72.4
DCB 113 (=Quweig)	64.7
2777	58.2
Clairdoc	53.1

Results and Discussion

In the SP method, (P-I)/I ratio decreased with an increase in salinity (Fig. 1), as reported by other authors (Smillie and Nott 1982; Downton and Millhouse 1983). However, the (P-I)/I ratio is much more reduced by salt in Clairdoc (salt sensitive) than in ACSAD 65 (salt tolerant). For example the (P-I)/I ratio expressed as a percentage of the 0 mM NaCl control is 85.0 for ACSAD 65 and 53.1 for Clairdoc at the 150 mM NaCl concentration.

Table 1 summarizes the relative (P-I)/I values obtained at 150 mM NaCl concentration from all genotypes tested. Results indicated great genotypic differences in the effect of salinity on (P-I)/I values, with 2777 and Clairdoc being the most affected, and DCB 44 and ACSAD 65 being the least affected.

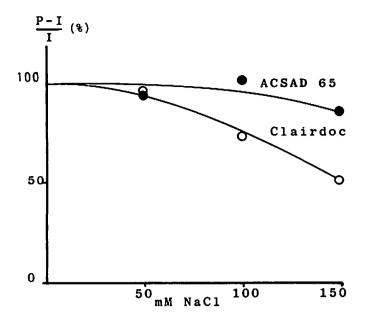
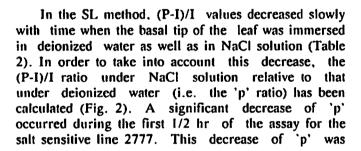


Fig.1. Variation of (P-1)/I ratio (expressed as % of the 0 mM NaCl control) with NaCl concentration of the medium (ACSAD 65, salt tolerant; Clairdoc, salt sensitive).



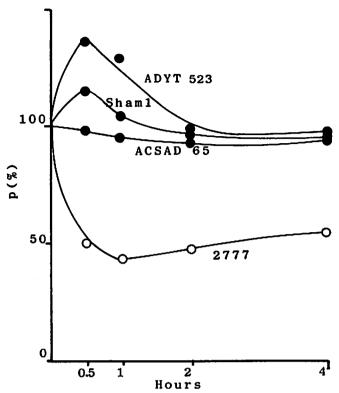


Fig. 2. Variation of p ((P-I)/I ratio in NaCl solution expressed as % of the 0 mM NaCl control) with time of immersion, using the 'stressed leaves' method.

slow for ACSAD 65, but an increase of 'p' was observed in the first 1/2 hr of the assay in ADYT 523 and Sham 1. Based on the variation of 'p' with time, the genotypes could be ranked in the following order:

Table 2. (P-I)/I values obtained after different immersion durations in deionized water or 100 mM NaCl, based on the 'stressed leaves' method.

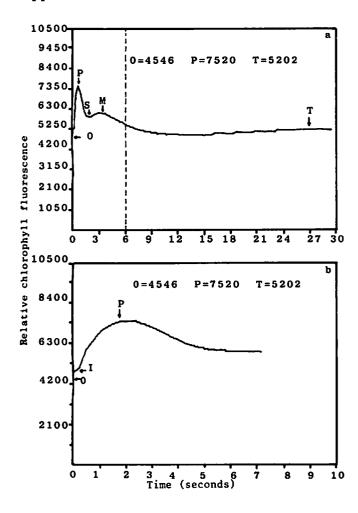
Genotypes		Deioni	zed water		100 mM NaCl					
	1/2 hr	1 hr	2 hrs	4 hrs	1/2 hr	1 hr	2 hrs	4 hrs		
ACSAD 65	0.85	0.95	0.80	0.78	0.84	0.80	0.76	0.76		
	(0.087*)	(0.031)	(0.061)	(0.050)	(0.081)	(0.085)	(0.075)	(0.085)		
Sham 1	0.91	0.91	0.89	0.88	1.05	0.95	0.87	0.87		
	(0.147)	(0.093)	(0.105)	(0.100)	(0.107)	(0.115)	(0.123)	(0.100)		
ADYT 523	0.72	0.72	0.69	0.66	0.89	0.93	0.65	0.65		
	(0.075)	(0.093)	(0.072)	(0.086)	(0.088)	(0.109)	(0.110)	(0.085)		
2777	0.81	0.80	0.78	0.75	0.67	0.51	0.40	0.40		
	(0.107)	(0.113)	(0.147)	(0.128)	(0.095)	(0.061)	(0.051)	(0.060)		

Standard error over six replicates.

ADYT 523 (salt tolerant), Sham 1, ACSAD 65, and 2777 (salt sensitive). This order corresponded well to that obtained with the SP method.

In conclusion, this study confirms that the (P-I)/I ratio decreases with an increase in salinity except in the case of the most tolerant genotypes. Both methods, especially the simple and rapid SL method, could be used for evaluating salt tolerance among durum wheat genotypes. Further studies are in progress to confirm the feasibility of utilizing these methods as a rapid screening tool for salinity tolerance in other cereals such as barley and bread wheat.

Appendix



Typical chlorophyll fluorescence induction curves of durum wheat leaf samples (var. 2777) with the different characteristic levels O (initial), I (intermediary), P (peak), S (quasi-stationary), M (relative maxima), and T (terminal level).

- a) General aspect of the fluorescence induction curve.
- Enlargement of the first part of the same curve, corresponding to the variable fluorescence.

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Evaluation of Wheat and Barley Germplasm from Ladakh as Winter Fodder in Kashmir

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Ladakh is a cold, arid desert with an annual precipitation of 80 mm. Located southcast of Jammu and Kashmir State, India, it is geographically isolated by mountain chains that surround it. Ladakh is characterized by intense sunlight, high evaporation rate, strong winds, fluctuating temperatures, and a long, severe winter. All these factors have strongly influenced both the cultivated and wild local flora. Most of the indigenous crops such as wheat, barley, pea, buckwheat, and millet mature very early in this area: some barley landraces reach maturity within 88 days (Mehra and Arora 1982), while wheat, which is mostly cultivated in Kargil, may mature within 100-120 days. Both these crops have good resistance to low temperatures as well. A total of 14 wheat and 34 barley accessions were collected from the region in Sept 1984 (Appendix) for their earliness and resistance to cold. The present study was undertaken to explore the possibilities of introducing some of these accessions as winter fodder crops in Kashmir.

Materials and Methods

The seeds were sown on 5 Nov 1985 at Jhansi according to a randomized complete block design in 2-m, two-row plots with three replicates. A basal fertilizer dose of 40 kg N/ha was applied. Number of days from planting and green fodder yield were recorded at 50% flowering. Dry matter weight was recorded after sun-drying the samples.

Results

A considerable variation in days to 50% flowering and a significant variation in green and dry fodder yields were found in both wheat and barley (Tables I and 2). The wheat accessions reached 50% flowering within 184-208 days. The highest green fodder yield (39.8 t/ha) was produced by SSL-155, and the highest dry fodder yield (17.3 t/ha) by SSL-145. In barley, 50% flowering was reached in 157-183 days, with SSL-174 and SSL-131 producing the highest green (38.3 t/ha) and dry fodder (17.4 t/ha) yields, respectively. Significant variation in fodder yield was also observed among accessions col-

lected from within individual villages. For instance, the yield range of eight wheat accessions from a single village in Sanku was of 11.8-39.8 and 2.8-13.2 t/ha for green and dry fodder, respectively. Similarly, six barley collections from Chanigund had green and dry fodder yields ranging from 13.0 to 32.9 and 6.3 to 17.4 t/ha, respectively.

Discussion

During winter in Kashmir valley, farmers traditionally grow wheat and barley for fodder, which usually becomes available to animals in Mar or later. In the critical period of Dec-Feb there is always a shortage of green fodder. Lately wheat and barley have been replaced by winter oat, which also produces fodder after Mar, with average green and dry fodder yields sometimes not exceeding 26 and 5.8 t/ha, respectively (Misri et al. 1985). Therefore it was planned to select from Ladakh some early maturing barley and wheat accessions that could provide green fodder during the months of shortage in Kashmir. The evaluation of these accessions in this study revealed that their early maturing in Ladakh is not an inherent character, and is probably due to intense sunlight and other agroclimatic and ecological factors in Ladakh. However, their high fodder yield potential indicates that some of these accessions may be introduced successfully in Kashmir as winter fodder crops.

Table 1. Days to 50% flowering and fodder yield of 14 wheat accessions collected in Ladakh, 1985/86.

Accession	Collection	Days to	Fodder yield (t/ha)		
	site	flowering	Green	Dry	
SSL-43	Andu	208	11.8	4.2	
SSL-47	Andu	208	13.1	4.1	
SSL-145	Thasgam	206	39.6	17.3	
SSL-154	Sanku	206	21.0	9.2	
SSL-155	Sanku	205	39.8	13.2	
SSL-156	Sanku	206	11.8	5.2	
SSL-161	Sanku	186	18.6	5.8	
SSL-166	Sanku	206	18.3	5.3	
SSL-167	Sanku	206	26.1	10.2	
SSL-168	Sanku	206	13.0	5.4	
SSL-171	Sanku	186	13.5	2.8	
SSL-181	Nagmakusar	186	24.7	8.5	
SSL-188	Panikhar	186	21.2	5.2	
SSL-196	Nakpachu	184	19.3	9.6	
LSD (5%)		NS*	13.9	1.9	

^{*} NS = nonsignificant.

Table 2. Days to 50% flowering and fodder yield of 34 barley accessions collected in Ladakh, 1985/86.

Accession	Collection	Days to	Fodder (t/ha	
	site	flowering	Green	Dry
SSL-45	Andu	166	25.1	11.3
SSL-48	Andu	183	15.3	7.7
SSL-49	Andu	166	11.0	6.0
SSL-92	Puyun	160	27.9	15.6
SSL-109	Chanigund	167	14.6	7.9
SSL-110	Chanigund	163	21.8	13.8
SSL-113	Chanigund	163	19.1	7.7
SSL-120	Chanigund	158	32.9	14.9
SSL-130	Chanigund	161	13.0	6.3
SSL-131	Chanigund	161	32.2	17.4
SSL-152	Sanku	163	25.5	9.2
SSL-158	Sanku	167	28.4	13.2
SSL-159	Sanku	160	13.7	5.7
SSL-174	Sanku	172	38.3	16.3
SSL-178	Sanku	168	29.8	11.1
SSL-184	Nagmakusar	162	10.3	5.8
SSL-187	Panikhar	163	28.6	13.0
SSL-197	Nakpachu	161	34.3	13.2
SSL-231	Phayang	160	37.6	15.3
SSL-232	Phayang	161	11.7	4.2
SSL-237	Leh	163	15.2	6.6
SSL-238	Saspool	164	17.7	5.2
SSL-239	Saspool	157	20.3	7.4
SSL-240	Saspool	157	31.3	13.4
SSL-241	Saspool	162	36.9	13.4
SSL-244	Saspool	162	9.4	4. l
SSL-245	Khaltse	159	29.3	11.4
SSL-246	Khaltse	158	26.6	10.1
SSL-247	Khaltse	162	30.3	10.7
SSL-250	Khaltse	162	12.4	5.2
SSL-251	Bodhkharbu	157	23.2	6.9
SSL-252	Bodhkharbu	162	23.2	6.9
SSL-253	Bodhkharbu	163	8.2	5.0
SSL-254	Bodhkharbu	159	27.0	15.8
LSD (5%)		NS*	8.6	5.0

^{*} NS = nonsignificant.

This study has also revealed that the fodder yield potential of accessions that were collected from within individual villages varied significantly. This variability invites more attention, as villages in Ladakh are very small and may consist of not more than 50

houses/families. Besides, the fields are adjacent to each other. Such a variability offers an ample genepool to future crop improvement programs. Gohil and Misri (1986) made eleven buckwheat collections from Kargil within a 15-km radius. After evaluating them at Srinagar, Kashmir, they noted a significant variation in grain yield. Field observations made in Ladakh by Gohil and Misri (1986) and Misri (1987) revealed that the local farmer preserves a part of his harvest for seed, which he normally does not exchange or buy. This may have resulted in the conservation of old landraces and the maintenance of genetic variability within villages.

Appendix

Collections were made from both Kargil and Leh districts in Ladakh following Hawkes (1980) and Mehra et al. (1981). Kargil receives more precipitation than Leh and offers better growing conditions. Most of the farmers of this district practise double cropping. The first crop is sown in Apr and harvested in Aug-Sept. The seed consists of a mixture of local pea varieties and wheat or barley; a pure barley or wheat crop is rarely grown. The second crop, which is sown immediately after harvest, consists of buckwheat or millet like Setaria or Panicum. If the weather is unfavorable due to an early winter, the second crop is harvested before maturity and used as fodder. Leh district is a monocrop area where barley is mostly sown, whereas wheat is only cultivated up to Khalatse.

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Stomatal Frequency in Bread Wheat Under Irrigated and Rainfed Conditions

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Stomata are the major pathways for transpiration and gas exchange. Very little photosynthesis occurs when they are closed. Stomata respond to a large number of internal and external stimuli (Zeiger 1983). Their closure in response to water stress is a powerful mechanism for regulating water loss and reducing the development of further stress (Teare 1971). Miskin et al. (1972) indicated that in some barley varieties a decrease of 25% in stomatal density caused a reduction of 24% of the transpiration rate without affecting the rate of photosynthesis. Low stomatal frequency was found to be associated with greater drought resistance in Panicum antidotale varieties (Dobrenz et al. 1969). This study was conducted to measure the stomatal frequency in a set of bread wheat cultivars grown under irrigated conditions.

Materials and Methods

Three drought resistant bread wheat (Triticum aestivum) lines (HD 1739, HY 65, and Raj 857), nine genotypes (Shera, Hira, Moti, Sharbathi Sonora, Timgalin, Raj 821, HP 916, HD 2009, and EC 57191) highly responsive to irrigation and high fertility, and cultivars (Sonalika and Kalyansona) with good performance under both dry and irrigated, high-fertility conditions were selected based on their past performance in the All India Coordinated Wheat Varietal Trials. These 14 varieties were grown under irrigated, high-fertility (E1) and rainfed, low-fertility (E2) conditions at the Division of Genetics, Indian Agricultural Research Institute, New Delhi, India. The layout of the experiment was a randomized complete block design with three replications.

The second fully developed leaf below the primary spike was collected from the tested varieties at the same stage of development. A strip of the leaf (about 12 cm) was removed from the middle portion by scissors, and half a drop of transparent liquid synthetic gum was applied uniformly as a thin layer (3-4 cm long) on the upper and lower surfaces of the leaf at about the same place. Approximately after one hour of drying, the gum

layer was carefully peeled off from the strip with a forceps. The peeling, which contained the stomatal impressions, was mounted on a glass slide and the stomatal frequencies were recorded. Five counts were made per leaf, and five plants sampled per replication. The frequency of stomata was recorded from both sides of the leaf separately. The actual area observed for stomatal density per microscopic field was 2.98 mm². Measurements of length and breadth of five stomata per leaf impression were taken from the lower epidermis under rainfed conditions only.

Results and Discussion

The analysis of variance indicated highly significant differences among the genotypes in the stomatal frequency of the upper and lower epidermis under both environments. The variety Sharbathi Sonora had the highest number (52.0) of stomata per microscopic field, followed by Hira (51.2) and Shera (46.1) in E1, while Kalyansona, Timgalin, and Moti had the lowest stomatal densities of 30.1, 34.0, and 35.9, respectively (Table 1). In E2, Shera and Hira again had the highest number of stomata, and Sonalika and Timgalin, the lowest.

In general, the genotypes responsive to high fertility and irrigation, with the exception of Timgalin and Moti, had a higher stomatal frequency, while the drought resistant genotypes had intermediate numbers of stomata per unit area (Table 1). These results are not in full agreement with those of Dobrenz et al. (1969) on blue panic grass.

The upper leaf surface had 14.7% more stomata than the lower (Table 1), which is in conformity with the results obtained by Teare (1971) on *Triticium aestivum*, Dobrenz *et al.* (1969) on *Panicum antidotale*, and Miskin

Table 1. Mean number of stomata per microscopic field in upper and lower surface of the leaf under irrigated and rainfed conditions.

Variety		Irrigated		Rainfed		
vanety	Upper epidermis	Lower epidermis	Mean	Upper epidermis	Lower epidermis	Mean
RAJ 857	48.8	36.6	42.7	42.8	36.3	39.5
HD 1739	40.5	38.3	39.4	40.3	40.9	40.6
HY 65	41.5	41.3	41.4	39.3	41.1	40.2
Shera	50.8	41.4	46.1	45.0	42.0	43.5
RAJ 821	42.8	36.0	39.4	40.0	38.2	39.1
HP 916	46.5	39.9	43.2	38.8	31.7	35.2
HIRA	53.8	48.7	51.2	44.6	41.2	42.9
Moti	38.7	33.2	35.9	40.7	29.2	34.9
S. Sonora	54.8	49.3	52.0	38.8	33.9	36.3
HD 2009	45.3	38.5	41.9	39.1	37.1	38.1
Timgalin	33.8	34.3	34.0	32.l	30.2	31.1
EC 57191	43.6	35.0	39.3	35.6	34.9	35.2
Sonalika	45.1	36.9	41.0	32.3	29.1	30.7
Kalyansona	36.1	24.1	30.1	38.2	32.3	35.2
Mean	44.3	38.1	41.2	39.1	35.6	37.4
LSD	8.2	4.9		5.2	5.5	

and Rasmusson (1970) on *Hordeum vulgare*. A greater number of stomata per unit area was recorded on the leaves of the plants grown under irrigated conditions than those grown under rainfed conditions. These findings are in agreement with those reported by Katellarper (1963) on wheat.

The analysis of variance also indicated significant differences among the genotypes in stomatal length, but not in stomatal breadth under rainfed conditions. Stomatal length was maximum in Timgalin and minimum in HD 1739 and HY 65 (Table 2).

Table 2. Mean length and width of stomata under rainfed conditions.

Variety	Width	Length
	(μ)	(µ)
RAJ 857	29.03	45.90
HD 1739	30.46	41.47
HY 65	32.46	41.47
Shera	30.75	49.34
RAJ 821	27.17	51.48
HP 916	31.03	42.90
Hira	29.32	44.19
Moti	29.32	50.76
S. Sonora	29.32	44.33
HD 2009	28.89	46.19
Timgalin	24.74	52.20
EC 57191	28.17	44.76
Sonalika	28.31	42.47
Kalyanson	28.60	44.62
Mean	29.11	45.86
LSD (5%)	2.72	4.26

When both the environments were considered, the varieties Tingalin, Moti, Kalyansona, and Sonalika had the lowest stomatal frequencies among the varieties tested. However, further testing is needed to verify whether these lower stomatal frequencies are associated with better yield performance under rainfed conditions.

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Nitrogen Fertilization of Hessian Fly-resistant 'Saada' Wheat in a Shallow Soil of Semi-arid Morocco

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Cereal production in Morocco, and in the North Africa-West Asia region as a whole, falls short of demand, primarily due to increased population growth. However, the past decade has seen intensified research efforts at stimulating output (Shroyer et al. 1990). Two major approaches or technologies have been identified as being significant: breeding of cereal varieties resistant to indigenous pests, and the use of chemical fertilizers.

Of the insect pests of cereals, Hessian fly (Mayetiola destructor Say) is a major cause of economic loss in Morocco, especially with wheat (Hatchet et al. 1984). However, resistant genes in wheat to this pest have been identified recently (El Bouhssini et al. 1986). Such research has culminated in the development of a bread wheat with resistance to Hessian fly: Saada (SD8036). This new variety was developed in South Dakota, USA, and released in the official Moroccan catalog in 1988. Its superiority over susceptible varieties has been striking, particularly in areas where Hessian fly infestation is most serious (Keith 1988).

However, disease resistance alone is not sufficient to produce satisfactory yield in most soils

without fertilization, particularly with nitrogen. Several years' field trials using Nesma, the principal bread wheat in Morocco, demonstrated the ubiquitous and dramatic response to N (Abdel Monem et al. 1988a; Soltanpour et al. 1989). A recent demonstration trial with Saada showed that N has a greater effect on straw than grain (Abdel Monem et al. 1990). However, this study involved only one N rate, i.e., 60 kg/ha, thus not permitting any meaningful interpretation of the pattern of crop response to N.

Another aspect which has not been considered with N use in Morocco's semi-arid zone is time of application. Where fertilizer is applied, it is done so mainly at planting. If the subsequent crop is lost to or decimated by drought, the economic argument for N use in fall is doubtful. However, spring application of N by top-dressing allows the consideration of crop stand and stored soil moisture. This is particularly relevant to Morocco where financial reserves for fertilizer purchases are scarce and where labor is readily available for top-dressing in spring, if necessary. The objective of the present experiment was to study the effects of time and rate of N application on straw and grain yield of Saada wheat.

Materials and Methods

The site chosen for this study was 5 km east of Settat, with typical cereal-growing shallow soils of the upper Chaouia region (Stitou 1985). Barley was the previous crop at the site. The soil was a fine, mixed, thermic, shallow Petrocalcic Palexeroll. Average precipitation in the area is 390 mm/yr (the current year was 355 mm), while the mean air temperature varies from 18°C in winter to 33°C in summer. Adjacent fields had been used for the past two years for soil test calibration and placement studies (Abdel Monem et al. 1988a, 1988b).

Prior to land preparation, the soil was sampled and analyzed. With 21% CaCO₃ and 4.3% organic matter, the soil was deficient in N (2 ppm) and NaHCO₃-P (4 ppm), but was well supplied with available K (230 ppm). The soil was tilled with an offset disc or 'cover crop' with two passes at right angles to each other.

The treatments were rates (0, 40, 80, 120 kg/ha) and times (spring, fall, or split between spring and fall) of N application. The experimental design was a split plot, with application dates being main plots and N rates the sub-plots. Treatments were in triplicate. In the fall application, N was hand-spread as ammonium nitrate prior to planting. A basal application of 18 kg P as triple superphosphate was given to all plots. Plots were 5 m long and 1.8 m wide. Planting was early in the season (14 Nov 1988) after initial fall rains

using a 6-row plot drill. Saada, a soft red bread wheat resistant to Hessian fly, was sown at 69 kg/ha.

During the tillering stage, 'Certrol H' was applied twice at 0.4 kg a.i./ha to control weeds. Plant growth in the early months (Dec, Jan, Feb) was restricted by below average rainfall (i.e., 25, 7, and 36 mm, respectively). Following the onset of heavy rains in March (77 mm), the spring N top-dressing was applied. Harvesting was accomplished by hand-cutting two inner rows. Following threshing, grain and straw yields were recorded.

Results and Discussion

While spring-applied N and split application were more effective in terms of dry matter yield, the difference was not significant (Table 1). Grain yield was likewise not significantly affected by N application time, though fall-applied N tended to give higher grain yield. The absence of any clear-cut agronomic advantage from spring or split-applied N is consistent with data of Russell et al. (1987) for dryland winter wheat. Several studies cited by these authors generally significant effect of time of N appointed to no plication. However, exceptions to this generalization occur when urea was the source of N (Christiansen and Meints 1982); urea broadcast in the fall was 69% as effective as in spring.

Table 1. Yield of Saada wheat (q/ha) under different times of N application.

Time	Dry Matter	Grain
Fall	41.3	9.5
Spring	46.4	8.3
Fall/spring	46.6	8.6
LSD (5%)	10.0	1.9

Initial losses of N through volatilization occur if urea or ammonium forms of N are broadcasted on bare soil and allowed to remain there under conditions conducive to volatilization, i.e. high soil pH, moist air and soil, and warm temperature. Volatilization was responsible for the loss of efficiency of surface-applied urea in Christensen and Meints' (1982) study. However, in our study, we used ammonium nitrate rather than urea. Though the soil was calcareous, this fertilizer is not subject to significant NH3 loss. In addition, the soil was dry at time of application and the material was immediately incorporated using the offset disc. Thus, the circumstances precluded any NH3 loss.

The only other possible avenue of N loss under conditions in this trial - leaching of available N below the root zone - can also be discounted. The low rainfall distributed over this period (90 mm) could not have exceeded the moisture-holding capacity of the soil; thus no N leaching occurred from the root zone.

Although there appears to be no agronomic advantage of deviating from the traditional practice of fertilizer application at or prior to planting, applying some fertilizer in spring is less risky than in the fall; if the season has favorable rains, additional fertilizer can be used to economic advantage, while if drought limits crop growth, the farmer can reduce or eliminate any further fertilizer application. Even if fertilizer is applied with no current year crop response, it would stay in the ground and benefit the next crop with favorable growing conditions.

Fig. 1 shows that no further increase in grain yield occurred beyond the N rate of 40 kg/ha. However, total dry matter continued to increase with increasing

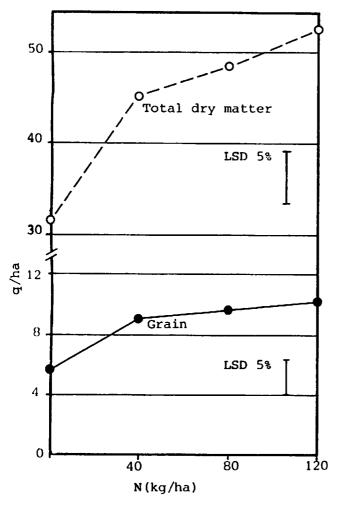


Fig. 1. Yield response of Saada wheat to N application rates.

N; the 120 kg rate produced significantly more straw than the 40 kg rate. Nevertheless, N fertilization had no significant effect on the harvest index, which varied from 0.18 to 0.20. This comparatively low index for Saada, by comparison with Nesma, which normally has an index of 0.30-0.35, reflects its growth habit. Saada is a tall wheat with plenty of vegetative growth. The demonstration trial of Abdel Monem et al. (1990) also showed that N fertilization had a greater impact on straw than on grain. While increased straw yield may predispose the crop to lodging and pose disposal problem in western countries, straw is of importance for animal feed in the farming system of Morocco and of North Africa and West Asia in general.

As the data of this one-year study with Saada on N application rate coincided with previous studies with Nesma (Abdel Monem ct al. 1988a; Soltanpour ct al. 1989), one can conclude that approximately 40 kg N/ha is adequate for wheat on shallow soils, irrespective of variety differences. However, yields probably will increase with higher N rates when cereals are grown on deeper soils. Irrespective of soil type or depth, a well-managed legume may add sufficient N to the following cereal crop as to make N fertilization unnecessary.

Acknowledgement

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N-use Efficiency, N Assimilation, and Morphophysiological Traits in Barley

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The present high-yielding cultivars of wheat, rice, and barley are responsive to nitrogen fertilization. However, chemical nitrogen fertilizer is a costly input that is usually beyond the reach of poor farmers. In addition, considerable nitrogen losses may occur through leaching and volatilization. It is therefore desirable to develop cultivars which can take up maximum nitrogen from the soil and efficiently convert it into dry matter or grain yield (Anonymous 1985). Vose and Breese (1964) and Beech and Norman (1968) reported varietal differences in N uptake and conversion into

grain yield in rye grass and wheat, respectively. This experiment was conducted to screen a number of barley genotypes, and study the variability in production efficiency and nitrate reductase activity and their relationship with grain yield and yield-related attributes.

Materials and Methods

The experiment was conducted at the research farm of IARI, Regional Centre, Karnal. The experimental material comprised 98 barley genotypes planted in two 1-m rows spaced 20 cm apart. Sowing was done in a split plot design with three replications. The main plot treatments consisted of two nitrogen levels: 0 and 80 kg N/ha. Genotypes were assigned to the subplots. Nitrogen was applied in two split doses, half before planting, and the remaining half after the first irrigation. Agronomic practices and irrigation were done as per the recommendations for the region.

The two N levels were provided for the calculation of nitrogen-use efficiency as per the formula given by Patnaik *et al.*(1967):

N-use efficiency =
$$\frac{\text{grain yield at N}_1 \text{ level - grain yield at N}_0 \text{ level}}{\text{N absorbed at N}_1 \text{ level - N absorbed} \quad \text{at N}_0 \text{ level}}$$

All other observations were recorded for N₈₀ plots only. In vivo nitrate reductase activity was assayed in the flag leaves at the time of anthesis according to the method of Klepper et al. (1971), with some modifications. Observations were also recorded on plant height, tiller number, ear length, grain number/ear. 1000-grain weight, biomass, harvest index, grain yield, grain protein content, and N-uptake. Path coefficient analysis of the various characters were computed following the method of Dewey and Lu (1959).

Results and Discussion

Significant phenotypic differences were found in all the measured traits. The mean, range, and coefficient of variation of these traits are given in Table 1. Grain yield varied from 0.43 kg/plot for Karan 903 to 0.92 for Karan 906. Nitrate reductase activity was highest in Karan 906 and Karan 916, and lowest in Karan 903. The entry RD 1421 had the lowest while Karan 906 and Karan 916 had the highest N-use efficiency.

At both genotypic and phenotypic levels, grain yield was positively correlated with tiller number, ear length, grain number/ear, 1000-grain weight, biomass, harvest index, N-use efficiency, N uptake, and nitrate

reductase activity (Table 2). Nitrate reductase activity was significantly and positively correlated with grain yield and grain protein content, thus conforming to earlier results (Croy and Hageman 1970; Goodman et al. 1974; Nair and Abrol 1982). Grain protein content.

Table 1. Range, mean, standard error, and coefficient of variation of grain yield, N-use efficiency, nitrate reductase activity, and other traits of 98 barley genetypes.

Parameter	Ronge	Mean	Standard error	Coefficient of variation (%)
Grain yield (kg/plot)	0.43-0.92	0.69	0.03	14.5
N-use efficiency (g/g N)	22.9-40.5	31.1	2.1	12.0
Nitrate reductase activity (µmole/g fresh weight/hr)	1.08-7.50	4.63	2.1	12.0
Grain protein content (%)	12.5-16.4	14.2	0.2	6.4
N-uptake (g/plot)	79-168	126	3	15.8
Biomass (kg/plot)	1.31-2.53	1.81	0.04	9.6
Harvest index (%)	30-50	38	1.0	9.3
Plant height (cm)	54-115	80	0.9	12.5
Tiller number/plant	2.0-6.2	4.7	1.2	16.3
Ear length (cm)	6.0-10.6	8.4	0.2	12.0
Number of grains/ear	41-76	58	2.0	13.5
1000-grain weight (g)	24.7-52.4	34.2	1.2	16.7

though not associated with yield, was positively correlated with N-use efficiency and nitrate reductase activity. The two latter traits were also positively correlated. N-use efficiency, which indicates the potential of the plant to produce extra units of economic product per extra unit of absorbed N, was positively correlated with grain yield as expected.

Path coefficient analysis revealed that biomass and harvest index had the maximum while other parameters had only negligible direct effect on grain yield. However, N-use efficiency and nitrate reductase activity indirectly contributed to grain yield through harvest index, whereas tiller number, ear length, and grain number/ear indirectly influenced grain yield through biomass.

It can be concluded that large variations in N-use efficiency, nitrate reductase activity, yield, and other characters exist among the genotypes tested. Selecting genotypes with high N-use efficiency may be useful to increasing yield. However, since this character did not directly contribute towards grain yield, selection for large biomass production and high harvest index would be more efficient.

Table 2. Genotypic and phenotypic (in parentheses) coefficients of correlation between different traits in 98 barley genotypes.

	Tiller number/ plant	Ear length	Grain number/ ear	1000- grain weight	Biomass	Harvest index	Protein %	N-uptake	Nitrate reductase activity	N-use efficiency	Grain yield
Plant heigh	-0.496** (-0.486**)	-0.327** (-0.318**)	-0.255* (-0.246*)	0.163 (0.158)	0.044 (0.042)	-0.643** (-0.619**)	-0.442** (-0.408**)	0.288* (0.281*)	0.655** (0.644**)	-0.161 (-0.145)	-0.382** (-0.372**)
Tiller number/	plant	0.567** (0.538**)	0.353** (0.330**)	-0.183 (-0.172)	0.522** (0.495**)	0.579** (0.527**)	0.356** (0.335**)	0.346* (0.331**)	0.539** (0.512**)	0.208*	0.799** (0.739**)
Ear length			0.698** (0.681**)	-0.149 (-0.145)	0.576** (0.560**)	0.365** (0.346**)	0.369** (0.349**)	0.389** (0.375**)	0.382** (0.366**)	0.199 (0.176)	0.701** (0.668**)
Grain number/e	ear			-0.250* (-0.255*)	0.410** (0.401**)	0.312** (0.297**)	0.277* (0.254*)	0.300** (0.289*)	0.304** (0.298**)	0.305** (0.260*)	0.543** (0.525**)
1000-gra weight	nin				-0.154 (-0.153)	-0.143 (-0.136)	-0.207 * (-0.191)	-0.021 (-0.024)	-0.0308 (-0.0301)	-0.078 (-0.061)	0.221* (0.216*)
Biomass						-0.089 (-0.075)	0.154 (0.144)	0.875** (0.864**)	0.653** (0.620**)	0.054 (0.039)	0.755** (0.750**)
Harvest index							0.170 (0.125)	0.169 (-0.155)	0.053 (0.020)	0.567** (0.516**)	0.581** (0.589**)
Protein 9	%							-0.047 (-0.045)	0.635** (0.604**)	0.375** (0.342**)	0.108 (0.173)
N-uptake	;								0.412** (0.407**)	0.062 (0.043)	0.594** (0.582**)
Nitrate reactivity	eductase									0.651** (0.630**)	0.551** (0.528**)
N-use efficiency	,					_					0.433** (0.381**)

^{*. **} Significant at the 0.05 and 0.01 levels, respectively.

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Wheat Response to Zinc and Copper Application

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In Pakistan, deficiencies in soil micronutrients are likely to occur because the majority of the soils are generally light- to medium-textured, alkaline and calcareous to a varying degree, and low in organic matter. Under these conditions, micronutrients, with the exception of Mo, may form insoluble compounds and become unavailable. The use of nitrogenous and phosphatic fertilizers, increased cropping intensity, and cultivation of high-yielding crop varieties will further aggravate the problem and intensify the depletion of various micronutrients from the soil. P fertilizers may also induce Zn deficiency in wheat as experienced in Western Australia (Brennan 1986).

In a micronutrient survey in Pakistan, 85% of the representative soils of the country have been found to contain a marginal or deficient concentration of Zn. Cu was also found in marginal-to-deficient amounts in other studies. In another survey, Zn deficiency has been reported in the majority (77%) of the soils of the Northwest Frontier Province (NWFP), whereas Cu content was found within the normal range (Sillanpaa 1982). Khattak (1981) reported Cu deficiency in 4% of the soils in NWFP. However, meagre information on

crop response to various micronutrients is available in the country. This study was designed to examine the yield response of wheat to Zn and Cu application in the Swat Valley of the Northwest Frontier Province. The uptake of Zn and Cu was also studied.

Materials and Methods

The experiment was conducted in 1981/82 on deep. noncalcareous, permeable, Mingora silt loam soil, with ochric epipedon and cambic B horizon. The soil belonged to the Ustochrepts group according to the USDA soil classification. It had a pH of 7.6. a low organic matter content (0.98%), and 0.67 and 0.78 mg/kg of DTPA extractable Zn and Cu, respectively. Zn was applied at the rates of 0, 1.0, 2.0, and 4.0 kg/ha. and Cu, at 0, 1.25, and 2.50 kg/ha. The basal applications of nitrogen and phosphorus were 120 and 40 kg/ha. respectively. Wheat variety Pak-81 was used. The experiment was conducted in a split plot design that was replicated three times, with Cu treatments in the main plots and Zn treatments in the sub-plots. The crop was harvested at maturity, and grain and straw yields were recorded. Grain and straw samples were digested in a tri-acid mixture of HNO_3 , $HCLO_4$ and H_2SO_4 adjusted to a ratio of 5:1:2, then their Cu and Zn content determined by using an atomic absorption spectrophotometer.

Results and Discussion

Wheat grain and straw yields were significantly affected by Zn application (Table 1). The highest grain and

Table 1. Wheat grain and straw yields (kg/ha) as affected by Cu and Zn applications.

		Grain				Straw		
-	C	u (kg/h	1)		C	u (kg/ha	1)	
Zn (kg/ha)	0	1.25	2.5	Mean	0	1.25	2.5	Mean
0	1693	1870	2001	1855b	3159	3223	3694	3359b
1	2058	1951	1861	1957b	3414	3791	3699	3635b
2	2242	2317	2234	2264a	3798	4426	4377	4200a
4	2245	2306	2505	2352a	3883	4238	4088	4069a
Mean*	2060a	211Ia	2150a	3563b		3919a	3964a	3964

Menns followed by a same letter are not significantly different atthe 0.05 level. LSD in grain yield among Zn treatments is 278 kg/ha; LSD in straw yield among Zn and Cu treatments is 428 and 249 kg/ha, respectively.

straw yields were obtained with the addition of 4.0 and 2.0 kg Zn/ha, respectively. The difference in both the grain and straw yields between the control and the 1.0 kg Zn/ha treatments, as well as between the 2.0 and the 4.0 kg Zn/ha treatments, was nonsignificant. Zn requirement (at 95% relative yield), as determined by plotting Zn application rates against percent relative yield, was found to be a little less than 2.0 kg/ha (Fig. 1).

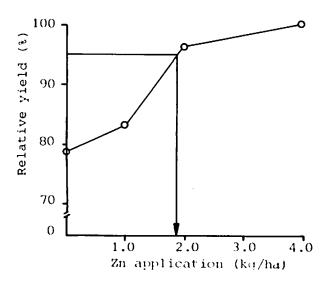


Fig 1. Zn requirement of wheat.

Cu application did not affect the grain yield, but significantly increased straw yield in the 1.25 kg Cu/ha treatment (Table 1). The difference in straw yield between the 1.25 and the 2.50 kg/ha Cu treatments was nonsignificant.

Zn concentration and uptake in grain and straw increased with the Zn application rate at the various

Cu levels (Figs. 2 and 3), but were generally higher at the higher Cu rates. Zn concentration in straw was much lower than in grain. The highest total Zn uptake was recorded when the highest rates of Zn and Cu were applied together.

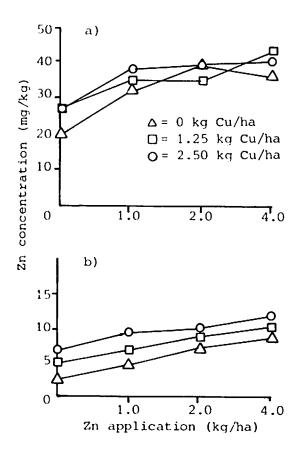


Fig 2. Zn concentration in wheat as affected by Cu and Zn application, (a) grain, (b) straw.

Cu concentration and uptake in grain and straw generally decreased as Zn application rate was increased (Figs. 4 and 5), but increased when Cu was added. Cu concentration in straw was much lower than in grain. Maximum total Cu uptake was recorded at the highest rate of Cu with no Zn addition.

The increase in Zn uptake caused by Cu application may have been due to the fact that the two elements, when present together, have increased each other's solubility by depressing their fixation on the soil components (Hodgson 1960). The increased uptake of Zn due to Zn and Cu application probably caused the increase in grain and straw yield.

Reduced Cu uptake and concentration in wheat grain and straw due to Zn application may have resulted from

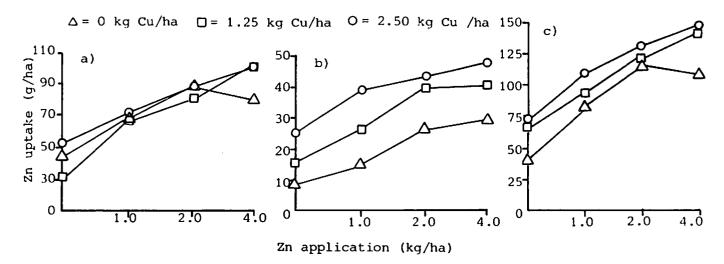


Fig 3. Zn uptake in wheat as affected by Cu and Zn application, (a) grain, (b) straw, (c) total.

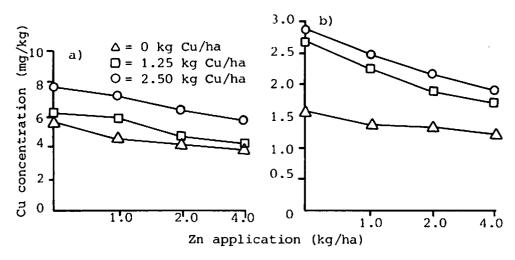


Fig. 4. Cu concentration in wheat as affected by Cu and Zn application, (a) grain, (b) straw.

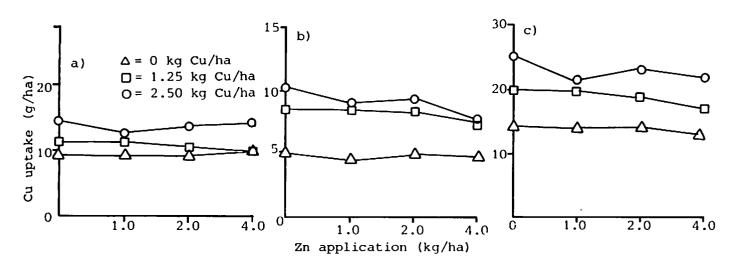


Fig. 5. Cu uptake in wheat as affected by Cu and Zn application, (a) grain, (b) straw, (c) total.

the antagonistic effect of Zn on Cu uptake (Chaudhry and Loneragan 1970). Similar results have been reported by Kausar *et al.* (1976). Since Zn-Cu antagonism is important in fertilizer management, it is recommended that further studies be undertaken to understand the mutual inhibitory effect of these elements on crop uptake under upland and lowland conditions.

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Cluster Analysis of Bread Wheat Lines Grown in Diverse Rainfed Environments

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Cluster analysis of genotypes based on differential vield responses across environments was first conducted by Mungomery et al. (1974). Its usefulness to plant breeders for G X E investigation was explained by Mungomery et al. (1974) and Lin et al. (1986). Since its first application, many genotype clustering studies have been carried out (Byth et al. 1976; Ghaderi et al. 1980; Imrie et al. 1981; Carver et al. 1987). Lin et al. (1986) advocated the use of cluster analysis which they believe can avoid the difficulty of the traditional univariate approach for measuring genotype stability. Instead of measuring stability by a quantitative parameter. genotypes are assigned qualitative groups based on similarity of response.

This study applied cluster analysis on data of an international bread wheat yield trial, which included lines selected mainly under low to moderate rainfall conditions at Aleppo, Syria, or under high rainfall or irrigation but disease-prone conditions outside Syria. The objectives were to investigate if meaningful clusters of entries could be detected, how close such a classification followed the pedigrees of the entries, and what are the underlying differences between the clusters.

Materials and Methods

Data of the 1985/86 ICARDA/CIMMYT Regional Bread Wheat Yield Trial assembled at ICARDA and distributed from Aleppo. Syria, were analyzed. The trial was grown in a randomized complete block design with 4 replicates and a plot size of 4.5 m² (6 rows 2.5 m long spaced 30 cm apart). There were 24 entries (including 4 checks) of different origins: CIMMYT, ICARDA/CIMMYT, and Turkey. Most entries were of spring types, but there were also some facultative ones from spring by winter crosses. Before being promoted to the trial, they had initially passed through 2-3 years of yield testing at Aleppo, Syria, and a few other sites, and were subsequently selected from the 1983/84 Regional Bread Wheat Observation Nursery. which was tested in many countries in West Asia, North Africa, and beyond. Detailed description of the entry. performance data, test sites and management information is given in ICARDA (1987).

Grain yield of each entry (excluding the national check) from 24 sites in West Asia, North Africa, and Mediterranean Europe was analyzed. These sites were rainfed or under supplemental irrigation (i.e. not under full irrigation) and had a CV for grain yield less than 32% with yield data for all 4 replicates. A hierarchical, agglomerative, and polythetic program (Engelman 1985) was employed for cluster analysis on mean yield of each entry from each site. Data were standardized within sites. The Euclidean distance and the centroid linkage were used. A large increase in amalgamation distance between two clustering steps acted as an indicator of cluster truncation.

In order to give an indication of the drought tolerance of the entries, the drought index of Bidinger

et al. (1987), which removes the effect of potential yield and flowering time of the entries, was calculated. Breda, Syria (218 mm rainfall, mean yield of 1290 kg/ha, 35°56 N, 37°10 E, 350 m a.s.l.) was taken as the stressed environment, and Tel Hadya, Aleppo, Syria (322 mm rainfall, mean yield of 4430 kg/ha, 36°01 N, 36°56 E, 282 m a.s.l.) was regarded as the non-stressed environment. The susceptibility or tolerance of a genotype is indicated by the sign of the index. If negative, it indicates that the performance of the genotype is poorer than expected, i.e. susceptible; if positive, it indicates that the genotype performs better than expected, i.e. tolerant.

Results

The dendrogram obtained from the cluster analysis is given in Fig. 1, and the pedigrees of the entries are provided in Table 1. Interestingly, two main clusters were noted: (A) lines selected for four or more generations under low to moderate rainfall, cool winter, and terminal heat stress conditions at Aleppo, Syria, without selection in Kenya (entries 2, 3, 4, 9, 10, 13, 15, 18, and 23), and (B) lines selected under favorable.

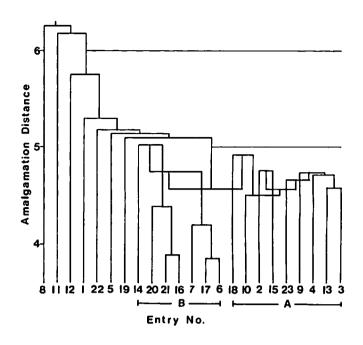


Fig. 1. Dendrogram obtained from the cluster analysis of the 23 entries based on differential yield responses across 24 sites.

Table 1. Name/cross and pedigree for each of the 23 entries and their mean relative yield and ranking over the 24 sites.

Entry	Name/cross	Pedigree ¹	Mean ² Relative yield	Rank
8	Ymh/Tob//Ron	SE 1756-9S-2S-5S-0S-3K-0K	0.961	17
11	Vœ'S'	CM 33027-F-15M-500Y-0M-18B-0Y-0Ptz	1.045	7
12	Sham 1 (Improved durum wheat check)	•	0.998	12
1	Mexipak 65 (long-term check)	•	0.968	15
22	C182-24/C168-3/3/(Cno/7C)*7C*2//Cc/Tob	SWM 6828-6AP-2AP-2AP-2AP-0AP	0.957	18
5	Kvz/3/Cc/Inia//Cno/Elgau//Sn64	SE 381-4S-1S-1S-0S-2Mb-1Mm-0Mm	0.949	21
19	Bch'S'/3/Bb/Nor67//Cno'S'/7C	CM 35297-1L-3AP-0AP-2K-0AP	0.892	23
Cluste	r A			
18	Jup'S'/7/Pch/6/Kt54A/N10B//Kt54B/5/Nar59*2/4/Lfn	SWM 5090-3Sa-1AP-0AP-3AP-0AP	1.051	4
10	SD 648.511/SD 648.5/5/8156//Chr//SN64//Kbre/3/Bb/4/Zbz	CM 32670-6Sa-1AP-1AP-2AP-0AP	0.956	9
3	P106.19//Soty/Jt*3	L 489-2L-2AP-0AP-8AP-0AP	0.963	16
13	Yd'S'/Pci'S'	CM 35044-0L-7AP-1AP-1AP-0AP	0.954	20
4	P106.19//Soty/Jt*3	L 489-2L-IAP-2AP-IAP-IAP-0AP	0.993	14
9	Bb/7C*2//Y50E/Kal*5	CM 29014-7Sa-2AP-1AP-2AP-0AP	1.046	5
23	Sham 2 (Improved bread wheat check)	•	0.939	22
15	Maya 74/Cli	CM 39427-14AP-2AP-1AP-0AP	1.005	11
2	K6290.9/4/Cno/K58N//Tob/Cno/3/We/Sx	L 51-2Sa-4Sa-2AP-2AP-6AP-0AP	1.043	8
Cluste	т В			
6	Kvz/Cgn	SE 1066-9S-1S-6S-0S-1K-0K	1.069	2
17	Hoopoe'S'	SWM 2185-2Y-3M-1Y-2M-0Y-3K-0K	1.028	9
7	Kvz/Cgn	SE 1066-9S-1S-6S-0S-6K-0K	1.074	1
16	Kai//Bb/Kai//3/AU//Y50E/Kai+3	CM 48418-A-3M-2Y-1M-3Y-0M	1.061	3
21	WA476/3/391//56D-81-14-53/3/1015.6410/4/W22/5/Ana	SWM 6525-1AP-0AP-1K-0AP	1.023	10
20	WA476/3/391//56D-81-14-53/3/1015.6410/4/W22/5/Ana	SWM 6525-1AP-0AP-2K-0AP	.997	13
14	Condor'S'/Ald'S'	CM 36903-1Y-1M-1Y-0M-3K-0K	1.046	6

¹ Explanation on pedigree: CM = CIMMYT cross; SWM = CIMMYT spring x winter cross; SE = Turkish cross;

L = ICARDA cross in Lebanon; AP = Aleppo (Syria); S = Izmir (Turkey); K = Kenya; Sa = Sakha (Egypt);

M, Y, B and Ptz = sites in Mexico; Mb and Mm = trials at Izmir in Turkey.

² Entry yield divided by site mean yield and then averaged over sites.

but disease-prone conditions outside Syria, i.e. high fertility and full irrigation at CIMMYT, Mexico, or in Kenya, or under high rainfall conditions at Izmir, Turkey (entries 6, 7, 14, 16, 17, 20 and 21), except entries 20 and 21, which were screened for three seasons at Aleppo and one season in Kenya. Entries 8, 11, 12, 1, 22, 5, and 19 formed single cell clusters. Five of these seven entries were different from the rest. Entry 22 was the only line selected solely at Aleppo, Syria, and was derived from a spring X winter cross. Entry 11 was a line developed and selected under high moisture conditions, including one cycle of bulk selection at Patzcuaro, Mexico. Entry 5 was a line selected at Izmir, Turkey; entry 1 was an old variety developed in Mexico/Pakistan; and entry 12 was a durum wheat.

Table 2 shows that cluster A yielded more than cluster B in the three lowest yielding sites while the reverse happened in the three highest yielding sites.

Table 2. Grain yield (kg/ha) of clusters A and B in the three lowest and three highest yielding sites.

		Site			
Site name	mean	CV%	LSD	Cluster A	Cluster B
Lowest yielding sites					
Mosul, Iraq (252 mm) ²	1110	26	336	1180 (940-1430)	1080 (870-1320)
Breda, Syria (218 mm)	1290	17	259	1340 (1120-1520)	1230 (990-1400)
Setif, Algeria (313 mm)	1500	13	233	1540 (1300-1820)	1470 (1330-1600)
Highest yielding sites					
Le Rheu, France (250 mm) ³	5760	6	427	5300 (4220-6270)	6490 (5500-6830)
Zahle, Lebanon (501 mm)	6260	16	1195	6290 (5660-7690)	6360 (5500-6830)
Diyarbakir, Turkey (434 mm)	6760	12	964	6530 (5670-7190)	7460 (6790-8340)

¹ P=0.05, 1-sided.

Lines in cluster B were later in heading and maturity but more resistant to the three rusts, especially yellow rust, than lines in cluster A (Table 3). Three lines in cluster A but none in cluster B had a positive drought index. Two entries in cluster B had negative indices. Entry no. 1 and 22 that formed single cell clusters also had positive indices.

Discussion

Information presented by the dendrogram confirmed to a great extent our belief that there are major differ-

Table 3. Averaged days to heading and maturity, averaged reaction to four diseases: stem rust (*Puccinia graminis*), leaf rust (*P. recondita*), yellow rust (*P. striiformis*) and glume blotch (*Septoria nodurum*), and drought index for each of the 23 wheat lines.

	_		Coef	of in	fection		
Entry no.	heading	maturity	Stem	Leaf	Yellow rust	Glume blotch I	Drought index
-8	116	160	13	27	6	4	0
11	111	155	Ö	i	2	4	-1.76
12	108	153	22	29	1	9	Ô
ı	111	155	13	35	28	9	1.06
22	125	164	0	8	5	2	1.05
5	104	152	0	0	3	4	0
19	114	158	Ö	4	8	3	Ö
Cluster	A						
18	107	156	8	12	20	3	0
10	110	155	0	1	13	4	0
3	110	155	0	0	16	4	0
13	105	155	23	11	21	4	0
4	110	155	0	0	13	3	-1.03
9	108	155	0	10	10	4	1.23
23	112	156	6	3	29	9	1.68
15	112	157	2	20	21	4	0
2	111	156	0	9	9	4	1.03
Cluster	В						
6	118	159	0	0	5	3	0
17	114	157	0	0	8	4	0
7	119	160	0	0	1	3	0
16	112	158	0	0	3	3	0
21	113	157	0	ı	8	3	-1.07
20	112	156	0	0	3	4	-1.68
14	115	158	0	ı	4	4	0
No. of sites	47	36	6	11	9	2	

^{1 0} to 9 scale, 0=fully resistant, 9=completely susceptible

ences between lines selected under low to moderate rainfall conditions and those selected under favorable conditions. However the dendrogram also revealed that the grouping of the genotypes could not be predicted by only knowing the pedigrees. For example, based on pedigree alone, we would have placed entry no.8 and no.11 in cluster B, no. 22 in cluster A, and no.19 with no.20 and no.21.

The Aleppo-based CIMMYT/ICARDA bread wheat program has concentrated its breeding efforts for tolerance/resistance to stresses prevailing in West Asia and North Africa. In the lower rainfall areas of the region, abiotic stresses such as cold, drought, and terminal heat are the main constraints responsible for reduced yields. In the wetter areas, such as the coastal Mediterranean environments, biotic stresses are more important. The current objective of the program is to develop germplasm tolerant to all or most of these stresses. In this context, results of the present study have two important implications.

First, the finding that the cluster of lines selected mainly at Aleppo. Syria, performed better in the low rainfall and low yielding sites suggested that to breed for low rainfall areas, it is important to

² Rainfall of the year.

³ Rainfall during growing period (3 Mar-14 Aug) only.

conduct selection in environments where those stresses prevalent in the low rainfall areas occur. The earlier heading and maturity of this cluster of lines suggested that drought escape was involved. However the drought index indicated that some lines in this cluster possessed drought tolerance as well.

Second, results showed that lines selected mainly at Aleppo, Syria, had less resistance to the three rusts, which are more prevalent in high yielding and wetter environments, than the other cluster of lines. Tel Hadya, Aleppo, is an excellent site to screen for abiotic stress tolerance, but not for foliar disease resistance. To overcome this problem, a modified bulk method of breeding which allows early selection of crosses based on disease reaction and other highly heritable characters in a number of disease-prone locations has been used by the CIMMYT/ICARDA bread wheat program since 1983/84 (Ortiz-Ferrara and Deghais 1988). Artificial inoculation of foliar diseases has also been employed to screen for resistance at the main station (ICARDA 1989). In addition, the program places emphasis on multi-location testing of the advanced material in the region.

Entries no. 1 (Mexipak 65) and no. 22 need to be mentioned here. They both had a positive drought index. Although Mexipak 65 is an old variety, it is still widely grown in the low rainfall areas of Syria. Its susceptibility to the three rusts is apparently not a constraint to its good performance in disease-free areas. Entry no. 22 has both drought tolerance and disease resistance, and is currently under on-farm testing in the moderate rainfall zone of Syria.

Standardized Euclidean distance was used as a similarity measure in this study to ensure that each site had a comparable phenotypic range, thus giving fairly equal weight to each site. In this study there were large differences in within-site yield range (534 to 5312 kg/ha), which was positively correlated with mean site yield (r=0.57, p<0.01). If unstandardized distance had been used or range transformation had not been conducted in such circumstances, the entries would have been clustered together, based primarily on performance at those sites with a large absolute phenotypic range, or in other words, those sites with higher mean yields.

Among the different types of clustering strategies, the centroid linkage was chosen in this study because it is 'space-conserving' although it is not monotonic (Williams 1976). Its use can avoid the distortion or misleading results prone to be created by 'space-dilating' strategies like complete linkage and incremental sum of squares, which have been used by many researchers (e.g. Byth et al. 1976; Johnson 1977;

Ghaderi et al. 1980: Imrie et al. 1981; Carver et al. 1987). Westcott (1986) criticized cluster analysis on the ground that many different clustering strategies and dissimilarity measures can be used, so particular choices may be difficult to justify. However, we believe that there is only one suitable strategy: the 'group-size independent' strategy, like centroid or average linkages. In fact when cluster analysis was first used to investigate genotype responses, average linkage was chosen (Mungomery et al. 1974). However, due to the intense clustering property of complete linkage and incremental sum of square linkages, which tend to give appealing, contrasting groups, the use of 'space-conserving' strategies has been gradually ignored.

In conclusion, we have demonstrated that cluster analysis on grain yield data from different environments can provide information useful for plant breeding purposes. This type of study is needed by plant breeders who would like to get a better understanding of their materials.

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Short Communications

Wheat Wild Relatives as Possible Sources of Resistance to Barley Yellow Dwarf Virus

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Barley yellow dwarf virus (BYDV) is an important viral disease of cereals, where 60 to 80% reduction in yield due to natural infection has been reported (Gill 1980). Recent work in North Africa indicated that BYDV is of economic importance in Tunisia and Morocco (Makkouk *et al.* 1989).

The level of BYDV tolerance in bread and durum wheat seems to be lower than that conferred by the Yd2 gene in barley. So the search for better resistant/tolerant genes to be incorporated into bread and durum wheat continues in many research centers worldwide. With the progress made in interspecific and intergeneric hybridization over the last decade, more emphasis is being placed at present on wild species as potential sources of useful genes.

In this study 378 accessions of Aegilops spp., 13 accessions of Agropyron spp., and 24 accessions of Hordeum spontaneum were tested for their reaction to BYDV. The different species were planted in a plastic house in single 50-cm rows, and inoculated with a PAV isolate of BYDV using the aphid vector Rhopalosiphum padi. Observations were made 6-8 weeks after inoculation. To confirm the presence or absence of the virus, leaf samples were collected from all accessions and tested by ELISA using an antiserum against the PAV isolate of BYDV.

Results are summarized in Table 1. In this study 12 of the 13 Agropyron accessions tested were found apparently immune, since neither symptoms were produced nor virus was detected by ELISA. Earlier reports however, indicated that BYDV reaction in Agropyron spp. varied from apparent immunity to obvious symptoms (Bruehl and Toko 1957; Rochow 1959; Sharma et al. 1984; Comeau and Plourde 1987). When Comeau (unpub-

Table 1. Reaction of Aegilops, Agropyron, and Hordeum spp. to infection with barley yellow dwarf virus.

Plant species	Number	of accessions
	Tested	Resistant
Aegilops triuncialis	118	22
Aegilops ovata	85	2
Aegilops biuncialis	43	2
Aegilops squarrosa	37	2 2 3
Aegilops speltoides	27	3
Aegilops triaristata	20	0
Aegilops umbellulata	15	3
Aegilops peregrina	7	0
Aegilops columnaris	5	0
Aegilops caudata	1	0
Aegilops crassa	1	0
Aegilops ventricosa	2	0
Aegilops cylindrica	1	0
Aegilops sharonensis	1	0
Aegilops mutica	3	0
Aegilops longissima	2	0
Aegilops unistaristata	4	0
Aegilops comosa	2	0
Aegilops kotschyi	1	1
Aegilops spp.	3	0
Agropyron cristatum	3	3
Agropyron repens	1	1
Agropyron italian	1	1
Agropyron inerme	1	1
Agropyron intermedium	4	4
Agropyron elongatum	3	2
Hordeum spontaneum	24	0

^{*} An accession was considered resistant when no symptoms were produced and no virus was detected by ELISA.

lished) tested a number of Aegilops spp., all were found to produce symptoms, whereas in this study 35 accessions of the 378 tested were found to be apparently immune.

Although the promising BYDV-resistant accessions of Agropyron and Aegilops will be further tested to confirm the results obtained, the objective of this short communication is to offer this material to

researchers interested in sources of BYDV resistance in wheat wild relatives. The preliminary results indicated that some Agropyron and Aegilops accessions demonstrated high levels of BYDV resistance, not found in any of the known bread or durum wheat cultivars or breeding lines, and that they seem to possess genes that confer better resistance than the Yd2 gene of barley.

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Multilines of Wheat: Prevention of Leaf Rust Epidemics in India*

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Studies were conducted at the Indian Agricultural Research Institute, New Delhi, to understand how wheat multilines prevent or minimize leaf rust epidemics, and to develop strategies of using multilines for long-term and short-term control of leaf rust in India.

Results of four field experiments conducted at Delhi (located in the Northern Plains Zone of India) indicated that multilines restrict the development of leaf rust by reducing three epidemiological variables, viz., initial infection, infection rate, under disease progress curve. The development of leaf rust on multilines is probably influenced by the interaction among leaf rust races on the component lines. Field experiments conducted at Delhi and at two representative locations in the 'foci of infection' of leaf rust in India indicated that the genes Lr 9, Lr 19, Lr 23, Lr 24, Lr 25, and Lr 27 could be useful in developing single gene components of the multilines to provide resistance against the Indian races of leaf rust. Virulence analysis of leaf rust samples collected from the multilines and pure stands of their components indicated that out of the two types of multilines, 'dirty crop' or 'clean crop' (Marshall 1977), the 'dirty crop' multilines may be useful to stabilize the race structure of the leaf rust population.

The study suggested that for long-term and effective control of leaf rust in India, the cultivation of 'dirty crop' multilines at the 'foci of infection.' namely, the Himalayan ranges in the North, and Nilgiris and Pulney hills in the South, and 'clean crop' multilines in the plains, where the disease cycle ends. could be practised. Each year, leaf rust inoculum built up at the first two zones is blown down to the plains, where the bulk of the wheat crop of the Indian subcontinent is raised. The cultivation of 'dirty crop' multilines in these two zones would stabilize the race structure of the leaf rust population and prevent the development of epidemics, which in turn will stabilize the race pattern of leaf rust in all the wheat growing areas in this subcontinent, besides reducing the inoculum load. The stabilization of the pathogen population will increase the functional life of resistant genes in wheat cultivars grown in the Indian sub-continent. The cultivation of 'clean crop' multilines in the plains would reduce the threat of catastrophic disease losses if there is a shift in the racial composition of the leaf rust population. This will stabilize the wheat production in the country.

Though multilines would provide a means of stabilizing yields, they present an important drawback: by the time a multiline in a widely adapted agronomic background is released, it is already outyielded by new, pure-line varieties. A mixture of these varieties may be an alternative to overcome this disadvantage of multilines. Another advantage of cultivating mixtures is that they may act as multilines for more than one disease. However, groups of varieties with agronomic superiority as well as agronomic uniformity need to be made availabl

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egy. Moreover, cooperation between the neighboring countries, which include Pakistan, Nepal, Bhutan, Bangladesh, and Burma, may be needed to enhance the success of this strategy.

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A Simple Formula for Calculating Area Under Disease Progress Curve

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In plant pathology studies, the area under disease progress curve (AUDPC) has been recognised by many workers as one of the most suitable parameters for quantifying a plant disease epidemic, measuring the other slow rusting characteristics or resistance of different cultivars, or studying the sporulation of pathogenic fungi in environments. Johnson and Wilcoxon (1980) reviewed the use of the AUDPC and concluded that since the AUDPC indicates in a single value both the severity of the disease and the rate at which the disease or pathogen has increased during the crop season, it should find wide application in plant disease studies.

The AUDPC from time t_0 to time t_n can be written as $\int_{\Gamma} F(t)dt$, where F_t is the mathematical function describing the disease progress curve. The calculation of AUDPC in this way involves determining the form of F(t) by empirical studies and then obtaining the values of the integral. This often involves much labor and difficulty, and many workers have been discouraged from using it. Johnson and Wilcoxon (1980) have solved this problem to some extent by bringing out a series of tables from which one can read out the AUDPC for a given set of disease observations.

The use of Johnson and Wilcoxon's tables, however, has some limitations. When the observed disease values

are in between those tabulated or when dealing with composite values such as coefficient of infection, these tables cannot be used. In this article, a simple formula for easily calculating the AUDPC without any computing device and in as little time as it takes to get it from the tables is presented. The principle involved is the same as that behind Johnson and Wilcoxon's tables and is based on approximate integration.

Derivation of the Formula

Assume there are 5 disease recordings Y_1 , Y_2 , Y_3 , Y_4 , and Y_5 at a fixed interval of D days between two consecutive recordings as shown in Fig. 1. The disease progress curve is given by 'abcde'. The area under the curve and between the first and fifth observations is equal to the sum of the areas of the rectangles and triangles depicted in Fig. 1.

AUDPC =
$$DY_1 + DY_2 + DY_3 + DY_4 + 1/2D(Y_2-Y_1) + 1/2D(Y_3-Y_2) + 1/2D(Y_4-Y_3) + 1/2D(Y_5-Y_4)$$

= $D[(Y_1+Y_2+Y_3+Y_4) + 1/2(Y_5-Y_1)]$
= $D[1/2(Y_1+Y_5) + (Y_2+Y_3+Y_4)]$

In general, if $Y_1,\ Y_2,\ \ldots,\ Y_k$ are the k disease recordings at a constant interval of D days, then

AUDPC =
$$D[1/2(Y_1 + Y_k) + (Y_2 + Y_3 + + Y_{k-1})]$$

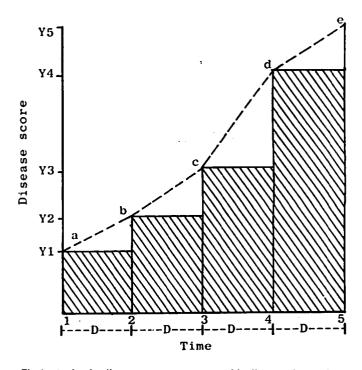


Fig.1. A simple disease progress curve with disease observations taken at regular interval (D).

In other words, AUDPC can be easily calculated as:

AUDPC = Time interval x [1/2(Sum of first and last disease scores) + (sum of all in-between disease scores)]

The formula is applicable for any number of disease recordings where the disease scores are monotonic, increasing, or constant, provided the interval between two consecutive recordings is constant. It is also applicable even if the first one or more observations are zero values. The disease scores can be either percentage disease severity or coefficient of infection. In case of two observations, the sum of inbetween observations will be equal to zero.

Examples

(1) Suppose there are 3 observations: 0%, 10%, and 20% disease severity, and the interval between two consecutive observations is 10 days, then

AUDPC = 10 [1/2(0+20) + (10)] = 200

(2) Suppose values are in terms of coefficient of infection: 2.4, 5.5, 15.5, and 25.6, and time interval between two consecutive observations is 10 days, then

$$\begin{array}{l} \text{AUDPC} = 10 \left[\frac{1}{2}(2.4 + 25.6) + (5.5 + 15.5) \right] \\ = 350 \end{array}$$

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The European Barley Database of the ECP/GR

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The European Barley Database (EBDB) of the European Cooperative Programme for the Conservation and Exchange of Crop Genetic Resources (ECP/GR) is maintained at the Zentralinstitut fur Genetik und Kulturpflanzenforschung (ZIGuK) of the Academy of Sciences of the Democratic Republic of Germany at Gatersleben since 1985. The third meeting of the ECP/GR Barley Working Group at Gatersleben. 18-20 April 1989. recommended that information about the EBDB be widely publicized among barley breeders and researchers.

The EBDB has the following objectives:

- to catalog the barley germplasm in European genebanks;
- to provide information on the barley germplasm on request;
- to facilitate the identification of duplicates in order to rationalize the maintenance and evaluation of the material in genebanks; and

- to identify geographical gaps in European collections as a basis for further collection strategies.

Present Status of the EBDB

The EBDB is maintained under the database management system dBASE II. It contains passport data of 55 369 accessions from 35 barley collections in 26 countries. largest collections are those in Gatersleben (10 266 accessions); Cambridge. U.K. (9458): Braunschweig, F.R.G. (8274); Addis Ababa, Ethiopia (5335); and Wageningen, the Netherlands (2912). In addition, information on 5142 barley cultivars and lines extracted from Arias et al. (1983)incorporated for reference. Data on the following descriptors are stored in the EBDB; EBL Number (unique identifier in the EBDB), Genebank, Accession Number, Donor, Donor's Number, Growth Type, Row Number, Country of Origin, Accession Name, Breeder, Other Numbers. Species. Subspecies. Varieties. Subvarieties, Expedition/Collector, Collector's Number, Province, Site, Latitude, Longitude, Altitude, Data on Country of Origin, Genebank, Donor, Breeder, and Expedition/Collector are stored as codes or acronyms.

The European Barley List (EBL) (Knupffer 1987) presents the barley germplasm in three parts:

- Part 1 (23 418 accessions): cultivars, lines, and special resources of *Hordeum vulgare* L. sorted alphabetically by accession name.

- Part 2 (29 166 accessions): collected (primitive) material and unnamed accessions of *H. vulgare*, sorted by country of origin and geographical information (province/site).
- Part 3 (2785 accessions): wild species of *Hordeum*, sorted by scientific name, country of origin, and geographical information.

A survey of the provenance and botanical composition of the material documented in the EBDB is given in Knupffer (1988).

Access to Information from the EBDB

Information from the EBDB is provided to genebanks, breeders and scientists free of charge. The complete contents of the database are available on magnetic media (preferably diskettes) and in printed form (European Barley List, some copies available from Mr. P.M. Perret, IBPGR, Via delle Terme di Caracalla, 1-00100 Rome, Italy). Searches in the database will be conducted on request; the resulting data are provided as printouts or on diskettes. Common types of inquiries are "Print a list of all two-rowed winter barleys originating from the Far East" or "From where could I obtain living seeds of the cultivars and strains listed below?"

If data are requested on diskettes, an appropriate number of blank diskettes should be sent to the EBDB in advance. Data are available on 5.25" MS-DOS diskettes (360 or 720K bytes) in ASCII fixed format files or as dBASE III files. The complete database occupies approximately 20M bytes*.

Future Development of the Database

As soon as appropriate hardware becomes available, the database will be transferred from dBASE II to dBASE III. The following activities will be undertaken:

- Updating of the EBDB: correction and completion of data, and inclusion of new accessions.
- Registration of additional data from genebanks.
 e.g., summary information on characterization and evaluation (number of accessions investigated per trait, ranges, histograms, etc.).
- Identification of duplicates in named accessions.

 The aim is to rationalize genebanks' efforts by producing a list of duplicates with indication of

- the 'best representative' of each group of duplicated accessions and a safety duplicate of each unique accession. The identification of duplicates is illustrated in Knupffer (1988).
- Establishment of links with other databases on barley germplasm; implementation of a worldwide network.

More detailed information on the EBDB is presented in the reports of the 1983, 1986, and 1989 Barley Working Group meetings and of the 1985 Barley Workshop, and in Knupffer *et al.* (1987) and Knupffer (1988, 1989). Copies of the reports mentioned are available from the IBPGR.

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Diversity Among Barley Accessions Under Rainfed Conditions

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The present study was undertaken to analyze the genetic variability among barley lines of diverse origins under rainfed conditions. A total of 201 accessions from the world collection of barley were grown under rainfed conditions in a randomized complete block design with three replications. Each entry was sown in a single 2-m

^{*}More details and required number of diskettes are available from the author.

row, with a 30-cm row spacing. Five plants were randomly selected from each row, and measurements were taken on eleven characters, namely, root length, shoot length 60 days after sowing, third-leaf area, plant height (excluding awns), awn length, tillers/plant, days to 75% flowering, days to 75% maturity, spike length (excluding awns), 1000-kernel weight, and grain yield/plant. Genetic divergence was calculated according to Mahalanobis (1936), and accessions were grouped into clusters on the basis of minimum generalized distances following Tocher's method (Rao 1952).

Significant differences among the accessions were detected in all studied characters. except in tillers/plant and days to maturity. The 201 accessions were grouped into twenty-three clusters. A wide range of variation in the cluster means of all the characters, except days to maturity, was observed.

In general hull-less and hulled accessions were distributed among the clusters, except cluster II. which had 3 hulled accessions only and had the highest yield. Within clusters, accessions from different locations were included, while accessions developed at the same institute fell into different clusters. A similar result has been reported by Murty and Arunachalam (1966), Bhatt (1970), and Tewari (1975).

Harrington (1940) pointed out that the magnitude of heterosis depends on the degree of genetic diversity in the parental lines. So genotypes from contrasting clusters should be selected for a hybridization program. However, the yield potential should also be taken

into consideration, particularly under rainfed and/or problem-soil conditions. The present investigation indicated that accessions IHLD-173 and 317, and IHLS-30, 33, 137, and 146 are high-yielding under rainfed conditions, have good agronomic types, and are also divergent from each other.

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Demand for ICARDA and ICARDA/CIMMYT International Nurseries Over the Last Ten Years

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The development of improved barley, durum wheat, and bread wheat germplasm has been one of ICARDA's main activities since its establishment. Within the system of international agricultural research centers, the Consultative Group on International Agricultural Research has given ICARDA a world mandate on barley improvement, and a joint mandate with CIMMYT for

wheat improvement in West Asia and North Africa (WANA).

In order to provide regularly and systematically the improved barley and wheat germplasm to the national programs, the international nursery system was set up. Each year nursery request forms are sent to national scientists who fill them and return them to the Center. Nurseries conforming as much as possible to the returned forms are then dispatched to the national scientists at the beginning of September. The objective of this investigation was to find out the trend of the demand for ICARDA and ICARDA/CIMMYT international nurseries by national programs in WANA over the last ten years.

Average demand for the regular international nurseries in 1978/79 and 1979/80 was compared with that of 1987/88 and 1988/89. Written requests from national programs were used as a measure of actual demand.

Four main types of regular nurseries have been assembled at ICARDA since 1978/79, namely, yield trials, observation nurseries, segregating populations, and crossing blocks, to meet the need of the national programs which have reached different levels of infrastructure and technical expertise. The number of nurseries within each type, except in the crossing block. increased gradually from 1979/80 to 1987/88 as a result of targetting the germplasm to three macro-environments within WANA: low rainfall areas and moderate rainfall areas in the lowlands, and high altitude areas. In order to allow a fair comparison among the nursery types and between the two periods studied, requests were adjusted to three nurseries within each type, i.e. one nursery for each crop. For example, in the second period, there were six yield trials, so the number of yield trial requests was multiplied by 1/2. Requests for high altitude areas nurseries in 1987/88 and 1988/89 were not included because they were not available in the previous period.

The adjusted total nursery demand within the WANA region in the second period was 97% higher than in the first (Table 1). This showed clearly that there was a true increase in nursery demand which was not caused by a concurrent increase in the number of nurseries. The actual non-adjusted nursery requests were 247 and 896 sets for the first and second period, respectively.

Table 1. Averaged requests (adjusted to 3 nurseries within each type) for the 4 different types of regular nurseries from West Asia and North Africa in two periods: the first in 1978/79 and 1979/80, and the second in 1987/88 and 1988/89.

Period	Total	Yield trial	Observation	ing	Segre- gating population	
First	224	68 (30%*)	69 (31%)	49 (22%)	38 (17%)	
Second	434	157 (36%)	125 (29%)	86 (20%)	66 (15%)	
Increase (1st to 2nd period)	97%	131%	81%	76%	74%	

^{*} Percentage of each type of nursery.

In the 1978/79 and 1979/80 seasons, the most popular nurseries were observation nurseries and yield trials, followed by crossing blocks and segregating populations (Table 1). In 1987/88 and 1988/89, the

proportion of yield trials increased to 36%, while there was a 2% decrease in all the other three types of nurseries. Over the 9 or 10 years, the requests for vield trials recorded the highest rate of increase (131%). This finding is not in accordance with opinions that as national programs improve, the demand for advanced lines will decrease and that for segregating populations and basic parental material will increase. It is unlikely that national programs in WANA had not improved their capability over the years, or the segregating populations and crossing blocks were of poorer quality than the yield trials. Preference for non-specific segregating lines over advanced populations by national program scientists was also observed by CIMMYT and Oregon State University (Dr B. Curtis and Prof W. Kronstad, personal communication).

There are two possible explanations for the observed increase in demand for yield trials. First, many national scientists who did not request any nurseries in the first period, did so in the second, and the nurseries they requested most often were yield trials. From an average of 23 written requests in the first period, the number increased to 60 in the second. The second explanation is that many national programs gradually realized that testing at the main station only is inadequate, and started to conduct yield trials at sub-stations.

For the next 5 to 10 years, there will probably not be any substantial changes in the demand for yield trials or segregating populations. Whether a national breeding program is advanced enough or not, it does not require much effort and resources to yield test ICARDA or CIMMYT/ICARDA's best advanced lines which generally have good adaptation within WANA. Varieties may or may not be released directly from these introduced lines, but some of them may be valuable as parental lines. As younger national programs get more advanced, they may prefer to make their own crosses and subsequent selections rather than request segregating populations from ICARDA. Besides, selecting segregating populations at two or more sites is not always easy.

Although the increase in demand for regular observation nurseries was less than that for yield trials over the last 10 years, the demand for trait-specific observation nurseries has been high. The Heat Tolerance Observation Nursery, which was the first trait-specific nursery to be assembled, was launched in 1987. In 1988 the Durum Wheat Drought and Heat Tolerance Observation Nursery and three germplasm pools for disease resistance were also assembled, and a total of 163 sets were requested. The Cereal Improvement Program is planning to develop more trait-specific nurseries to satisfy the high demand for this material.

Inheritance of Glume Hairiness and Stem Waxiness in Crosses of Triticale (X Triticosecale Wittmack) and Wheat (Triticum aestivum L.)

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The present study was undertaken to determine the inheritance of glume hairiness and stem waxiness in triticale x wheat crosses. The parent material comprised three triticale lines (UPT 72142, TL 68, and Rahum) and three wheat varieties (Shailaja, HS 74, and

Sonalika). The triticale lines were characterized by hairy glumes and waxy stem, whereas the wheat varieties had nonhairy glumes and nonwaxy stem. Four crosses between these triticales and wheats were made (Table 1).

The F_1 plants in all the four crosses between triticale and wheat exhibited hairy glumes, which indicates that hairy glume is a dominant trait. The F_2 segregation ratio of 9 hairy: 7 nonhairy glume plants in each cross (Table 1) indicated that glume hairiness is under the control of two complementary genes with complete dominance.

Waxy stem is dominant over nonwaxiness since all the F_1 plants had waxy stems. The F_2 segregating ratio of 15 waxy: 1 non-waxy plants (Table 1) shows that waxiness is controlled by two duplicate genes with complete dominance.

However, it is possible that these ratios might have been distorted to an unknown extent in favor of wheat due to the preferential functioning of gametes carrying wheat chromosomes in comparison with those carrying the rye chromosomes.

Table 1. Segregation for glume hairiness and stem waxiness in F_2 populations of four triticale x wheat crosses.

	Glume hairiness				Stem waxiness				
Cross	Hairy	Non- hairy	Segregation ratio	on	χ²	Waxy	Non- waxy	Setregatio ratio	n X²
UPT 72142 x Shailaja	28	22	9:7	0.715	(P<0.25)	80	4	15:1	0.159 (P<0.50)
TL 68 x HS 74	70	5 6	9:7	0.030	(P < 0.75)	40	2		0.159 (P<0.50)
Rahum x Sonalika	66	52	9:7	0.005	(P<0.90)	106	8		0.115 (P<0.50)
Rahum x HS 74	30	26	9:7	0.262	(P<0.50)	54	4		0.041 (P<0.75)

Recent Publications

Olson, R.A. and Frey, K.J. (eds.). 1987. Nutritional quality of cereal grains: genetic and agronomic improvement. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, 677 South Segoe Road, Madison, WI 53711 USA. 511 pp. ISBN 0-89118-092-3.

This monograph is number 28 in the series Agronomy. It provides a documentation on the extent of nutritional deficiencies in cereal grains and insights as to how the nutritional quality of cereals may be improved. Current research and knowledge based on genetic and manipulation of nutritional quality of agronomic cereals are evaluated, and the present situation with respect to use of this knowledge in development and utilization is assessed. Future needs in research and development of nutritional quality of cereal grains are also suggested. This book is addressed to researchers, and administrators scientists. policymakers. developed and developing countries engaged in setting up future policies on food research and production.

Nordic Gene Bank. 1989. The Nordic barley catalogue. Nordic Gene Bank for Agricultural and Horticultural Plants, P.O. Box 41, S-230 53 Alnarp, Sweden. 162 pp. ISBN 91-87814-00-5.

This book is supplied free of charge upon request by the Nordic Gene Bank for Agricultural and Horticultural Plants. It aims to present the barley germplasm and data at the NGB to barley researchers and breeders within and outside the Nordic countries. A guide to utilizing the data in Nordic Barley Database and various other barley databases available from the NGB is also provided.

Wiese, M.V. 1987. Compendium of wheat diseases. Second edition. The American Pathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121, USA. 112 pp. ISBN 0-309-04263-1.

This book is an amply illustrated practical reference for both plant pathologists and general audience. In its second edition, post-1976 literature citations have been added, and the nomenclature, symptoms, and description of over 100 infectious diseases caused by bacteria, fungi, nematodes, viruses, and viruslike

organisms have been brought up to date. With respect to control, only principles are presented due to the variations of methods with time and location.

National Research Council. 1989. Triticale: a promising addition to the world's cereal grains. National Academy Press, Washington, D.C. 105 pp. ISBN 0-309-04263-1.

This book contains a report that mainly aims at reviewing the status of triticale types developed at the Centro Internacionale de Mejoramento de Maiz y Trigo (CIMMYT) as a food crop for developing countries, and at reintroducing this crop to research communities outside the Third World. The history, constraints, uses, breeding, experiences around the world, and research needs related to triticale are briefly discussed.

Anderson, J.R. and Hazell, P.B.R. (eds.). 1989. Variability in grain yields: implications for agricultural research and policy in developing countries. International Food Policy Research Institute. Johns Hopkins University Press, 701 West 40th Street, Baltimore, Maryland 21211. 395 pp. ISBN 0-8018-3793-6.

This book includes selected papers from the Feldafing 1985 Workshop sponsored by the Deutsche Stiftung fur Internationale Entwicklung (DSE) and IFPRI. About 60 participants took part in this workshop, with strong representation of the centers of the CGIAR. They discussed the relationship between changes in yield variability and yield correlation and such causal factors as changes in agricultural technology, weather, irrigation, input variability, and related variables. The consequences of increasing yield variability were also discussed. The book is divided into four parts: (i) evidence on patterns of changing yield variability, (ii) plant breeding and yield variability, (iii) input management and yield variability, and (iv) impacts of yield variability and implications for policy.

CIMMYT (Centro Internacional de Mejoramento de Maiz y Trigo). 1989. Wheat Research in Pakistan. CIMMYT, Mexico, D.F. 129 pp. ISBN 968-6127-31-3.

Cereal News

Dr Nikolai S. Vassiltchouk, Leader, Durum Wheat Breeding Program, Agricultural Research Institute for the Southeast Region based at Saratov, USSR, joined the Cereal Improvement Program of ICARDA on 15 Oct 1989 as a visiting scientist for three months to work on durum wheat breeding for drought tolerance and grain quality. Eight breeding lines from the USSR with superior drought tolerance and grain quality will be used in crosses with durum wheat lines to create improved germplasm which will subsequently be shared by both institutes.

An In-country Training Course on Cereal Research Techniques and Methodologies was held 27 May-4 June 1989 at the Seed and Plant Improvement Institute (SPII). Karaj. Iran. The course was sponsored by the Agricultural and Natural Resources Research Organization (ANRRO) and ICARDA, and covered the following topics: genetics, breeding, pathology, agronomy, and on-farm trials. Fifty-three trainees (15 M.Sc. and 38 B.Sc. degree holders) and ten instructors participated in the course. ICARDA was represented by Drs H. Ketata, O.F. Mamluk, G. Ortiz-Ferrara, M. Pala, A. Zahour, and Mr. Issam Naji. In addition to classroom lectures and discussions, the trainees worked with instructors in cereal research plots at Karaj and made a two-day field visit to six research stations in northern Iran.

Dr Acevedo, Cereal Physiologist, ICARDA, participated in an International Workshop on Soil and Crop Efficiency that was held in Ankara, 15-19 May 1989, and presented a paper on 'Crop Architecture and Water-use Efficiency.' During his stay in Turkey he also conducted analysis on water-use efficiency at crop rotation levels in Ankara. Dr Acevedo then travelled to Portugal to participate in discussions on physiological processes at plant, organ, cellular, and subcellular levels that are restricting plant growth and photosynthesis in the Mediterranean environments. He was invited by CIHEAM and the Organization for Economic Cooperation and Development to present a lecture on 'Physiology and Barley Improvement for Drought Resistance in the Rainfed Mediterranean Environments' at the International Seminar on Photosynthesis and Growth Under Mediterranean Conditions: Influence of Dryness and Salinity held 22-24 May at Oeiras, Portugal, At the meeting scientists from various countries presented the state-of-the-art in their disciplines.

An FAO/ICARDA Cereal Travelling Workshop was held in Turkey, 11-16 June 1989. ICARDA's Cereal Improvement Program was represented by Dr. H. Ketata, Training Scientist: Dr O.F. Mamluk, Wheat Pathologist; and Ir Joop van Leur, Barley Pathologist, who participated in the workshop along with scientists from Algeria, Egypt. Jordan, Iran, Iraq, Libya, Pakistan, Morocco, Syria, Tunisia, Turkey, and Yemen. Dr D. Keatinge from the ICARDA office in Pakistan was also present. The workshop travelled to Erzurum (11 June). Eskisahir (13 June), Altinov and Konya (14 June), and Haymana (15 June), and finally returned to Ankara (16 June). The purpose of this workshop was to bring together barley and wheat scientists from the WANA region to exchange information and experiences on crop production and management in rainfed areas. The workshop also emphasized problems of crop production in the high altitude areas and exposed the participating scientists to the Turkish experience in dealing with rainfed agriculture through visits to experimental stations, research institutes, and state-managed farms.

Dr Heiko Becker from the Swedish University of Agricultural Sciences, Svalov, Sweden, visited ICARDA from 17 to 20 June 1989. The main purpose of his visit was to acquaint himself with the Center's work. He met several scientists from the Cereal Improvement Program and discussed possibilities for collaborative research in general, and in selection of germplasm for nutrient efficiency in particular. During his visit Dr Becker also gave a seminar on 'Concepts of Breeding for Nutrient Efficiency.'

Dr Philippe Lashermes, Cereal Biotechnologist, ICARDA, attended the Symposium on Plant Biotechnologies for Developing Countries held in Luxembourg, 26-30 June 1989. The symposium was sponsored by ACP-EEC, Technical Center for Agricultural and Rural Cooperation (CAT), and the Food and Agriculture Organisation of the United Nations (FAO) with an aim to design an action plan for further development of plant biotechnology in developing countries. In the symposium, the current status of plant biotechnology was reviewed, with specific reference to developing countries' needs, the socioeconomic impact of biotechnological developments, and activities that should be promoted to achieve these goals.

Mr Michael Mayer, Ph.D. student at Hohenheim University, Stuttgart, returned to Germany on 22 June 1989 after spending more than three months at the barley project of the Cereal Improvement Program at ICARDA. During his stay, Mr Mayer conducted field trials on barley under the framework of a collaborative project between ICARDA and Hohenheim University on 'Recurrent Selection for Drought and Salt Tolerance in Barley Using F₂ Bulks versus Double Haploid Lines.' Prof H.H. Geiger is Mr Mayer's advisor in Germany, whereas Dr S. Ceccarelli supervises his work at ICARDA. The main objective of this work is to compare the efficiency of two recurrent selection (RS) methods for improving the drought and salt tolerance of barley and thereby develop breeding materials for the arid climatic conditions of the West Asia and North Africa (WANA) region.

Dr Barbara Ballantyne, Pathologist/Breeder from the Agricultural Research Institute, NSW Agriculture and Fisheries, Waga Waga, Australia, visited the Cereal Improvement Program, ICARDA from 27 June to 1 July 1989. Dr Ballantyne discussed cereal pathology and breeding activities with the program scientists and explored possible areas of joint research.

The International Symposium on Physiology/Breeding of Winter Cereals for Stressed Mediterranean Environment took place in Montpellier, France, 3-6 July 1989. The symposium was sponsored by ENSA, INRA (France), and ICARDA. ICARDA participants included Director General Dr Nasrat Fadda, Deputy Director General (Research) Dr Aart van Schoonhoven, Acting Deputy Director General (International Cooperation) Dr J.P. Srivastava, and Drs H. Ketata, E. Acevedo, M. Nachit, G. Ortiz-Ferrara, P. Lashermes, and S.K. Yau from the Cereal Improvement Program. Dr A. Conesa, President of INRA, Montpellier, and member of ICARDA's Board of Trustees, also took part. Other participants came from Algeria, Belgium, Australia, Canada, France, India, Italy, Morocco, Portugal, Spain, Syria, the UK, and the USA. Twenty-eight invited papers were presented, largely on physiological traits having the potential for screening/ cereals under abiotic stresses in the breeding Mediterranean environments, and were followed by lengthy discussions.

During the last day of the symposium, a vivid discussion on future physiology/breeding activities was held. It was recommended that ICARDA take a leading role in coordination among the participating research institutes. ICARDA scientists will develop a differential set of varieties to be grown by the interested participants. Small working groups were informed to cooperate in such areas as root studies, growth at low temperature, desiccation techniques, C13 screening, rate of grain filling, and excised-leaf water loss.

The ICARDA-Jordan Coordination Meeting was held at the University of Jordan in Amman 19-20 Aug 1989. The meeting was attended by participants from the Jordan University for Science and Technology (JUST), NCARTT, and Australia, as well as from ICARDA's Cereal Improvement Program, Genetic Resources Unit, and Food Legume Improvement Program. The topics discussed centered on joint research efforts to be undertaken in Jordan in 1989, and the linkages between Jordanian NARS activities and the Mashreq Project.

Coordination Meetings in Sudan and Egypt. Drs Aart van Schoonhoven, J.P. Srivastava, H. Ketata, O.F. Mamluk, and R.H. Miller, as well as Drs Bhup Bhardwaj and S. Baniwal from Cairo and Addis Ababa ICARDA offices, respectively, attended the Sudan National Coordination Meeting at the Agricultural Research Corporation (ARC), Wad Medani, 4-7 Sept 1989. Also present were H.E. Prof Ahmed Ali Geneif, Sudanese Minister for Agriculture, a representative of the Government of the Netherlands, and representatives of other international agencies based in Khartoum. At the end of the meeting, the minister received the ICARDA group in his office where they presented their conclusions and recommendations.

In Egypt, the Coordination Meeting was held at the Agricultural Research Center, Giza, where Drs S. Ceccarelli and G. Ortiz-Ferrara joined the group of scientists from ICARDA. The meeting was inaugurated by Dr Ahmed Mumtaz, Director, ARC. Representatives of the EEC, IDRC, and other international organizations also attended the meeting.

In both Sudan and Egypt, the meetings discussed with national program scientists the Nile Valley Regional Program on cool-season food legumes and cereals. The results of the 1988/89 season were presented, and a work plan for the 1989/90 season was developed by NARS and ICARDA scientists.

Dr Roger Rowe. Deputy Director General (Research), CIMMYT, visited ICARDA 14-19 Sept 1989. He acquainted himself with ICARDA's work in general, and the Cereal Improvement Program in particular, and met with the CIMMYT staff based at ICARDA, viz. Drs Byrd C. Curtis, Miloudi Nachit, and Guillermo Ortiz-Ferrara. He showed interest in the Genetic Resources Unit's activities and held discussions with scientists regarding germplasm and data exchange between CIMMYT and ICARDA.

Dr Donald Winkelmann, Director General, CIMMYT, visited ICARDA 28-30 Sept 1989, and held talks with ICARDA Director General Dr Nasrat Fadda on collaboration between the two Centers. He also conferred with CIMMYT personnel posted at ICARDA, as

well as Turkey-based CIMMYT staff member Dr Sutat Sriwatanapongse and Dr R. Paliwal, who were also on a visit to ICARDA, on CIMMYT's new Strategic Plan and Five-year Budget. From Aleppo Dr Winkelmann proceeded to Turkey to hold discussions with CIMMYT staff and NARS officials.

The Second Annual Coordination Meeting of the Arabian Peninsula Regional Program was held at ICARDA on 27 and 28 Sept 1989 at ICARDA's headquarters at Tel Hadya, Aleppo, Syria. The purpose of the meeting was to discuss training and research activities in the region for the 1989-1990 season, and to develop long-term plans for coordination and cooperation between ICARDA and the countries of the Arabian peninsula.

The Regional Program was initiated in Oct 1988 during a first meeting that took place in Sana'a, Yemen Arab Republic, between representatives from Saudi Arabia, Kuwait, the People's Democratic Republic of Yemen (PDRY), Yemen Arab Republic, the Arab Fund for Economical and Social Development, CIMMYT, and ICARDA.

In the second meeting this year more participants were present. In addition to countries and organizations represented last year in Sana'a, the United Arab Emirates, the Sultanate of Oman, the Gulf Cooperation Council (GCC), and the Arab Center for Studies of Arid Zones and Dry Lands (ACSAD), took part in the meeting. A book of proceedings containing the presentations and recommendations made during the meeting will be published.

Syria-ICARDA Annual Coordination Meeting. The eighth annual coordination meeting on collaborative research between the Syrian Ministry of Agriculture and Agrarian Reform and ICARDA, held 3-5 Oct 1989, ended with 23 recommendations designed to enhance and upgrade joint research and training programs. In particular, there was emphasis on increased collaboration between extension and research, as well as intensified attention on economic and social studies. Regar-

ding cereals, the plan foresees on-farm trials at 86 sites for experimentation on barley, durum wheat, and bread wheat, in addition to studies on barley and wheat diseases. Field days intended to demonstrate research results have also been planned. The work plan also recommends joint tours for germplasm selection in different locations in Syria and the evaluation of local species, with a view to adding them to ICARDA's genebank. In the area of training, it was recommended that 90 individuals participate in 32 training courses covering all aspects of ICARDA's work. ICARDA was also requested to assist six M.Sc. students to conduct their research.

Cereal Improvement Program Planning Meeting. 1989-90. In a meeting held 7 and 8 Oct 1989 at ICARDA's headquarters at Tel Hadya, Syria, ICARDA's Cereal Improvement Program scientists presented their major achievements during the 1989-90 season and discussed their plans for the coming year. The meeting was also attended by experts from outside ICARDA who were invited to give their impression and offer suggestions for the future strategy and work plan in cereal breeding. Among the visitors were, from CIMMYT, Dr R.A. Fisher, Director, Wheat Program; Dr E. Saari, Phytopathologist; and Dr Hans Braun, Winter Wheat Breeder who attended some of the sessions of the Meeting and discussed with ICARDA's cereal scientists the joint CIMMYT-ICARDA work plan in WANA. Dr Warren E. Kronstad, Professor of Plant Breeding and Genetics (Wheat), Oregon State Universi-Corvallis; Dr Tom Blake, Biotechnologist/ Breeder, Montana State University, Bozeman; and Dr Pat Hayes, Barley Breeder, Oregon State University, also attended the Meeting.

Outreach staff, viz. Dr Hugo Vivar, CIMMYT-based ICARDA Barley Breeder, and Dr Mekni, ICARDA/Rabat, also presented their work. Dr Vivar talked about the decentralization of barley breeding work in Latin America, which was very well received as a significant step in the transfer of knowledge to the farmers. Dr Mekni presented highlights of joint research with the NARS in North Africa.

Forthcoming Events

First International Conference on Soil Solarization, 19-25 Feb 1989, Amman, Jordan, The Conference is organized by the Faculty of Agriculture, University of Jordan, and the Food and Agriculture Organization (FAO). It is sponsored by the United Nations Development Programme (UNDP); the University of California. Davis, USA; the Consiglio Nazionale delle Ricerche (CNR). Italy; the Ministry of Agriculture, Jordan: USAID; the Arab Organization for Agriculture Development (AOAD), the Arab Society for Plant Protection (ASPP); and the German Agency for Cooperation. The objective of the Conference is to discuss and illustrate available technology on soil solarization as an integrated method of improving plant health, growth, and yield in arid agriculture and as a safe, cheap, and effective alternative to chemical treatment. The program of the Conference will include invited papers on (i) principles and technology of soil solarization. (ii) application in different cropping systems and the control of multiple plant pathogens and pests, and (iii) future technological developments and uses of soil solarization. Contributed research papers on new findings on soil solarization will also be presented. and there will be a special hall for poster display. The program also includes demonstrations on soil solar-The language of the Conference will be English. No simultaneous translation will be provided. All correspondence should be addressed to Dr W. Abu-Gharbieh, Faculty of Agriculture, University of Jordan, Amman, Jordan, Telex 21629 UNVJJO.

International Course on Plant Protection, 16 April-27 July 1990, Wageningen, the Netherlands. This course is organized by the International Agricultural Center. Wageningen, in collaboration with several departments of the Agricultural University at Wageningen, Research Institutes and Experimental Stations, and the Protection Service. The course intends to knowledge of the participants and to provide information skills on an integrated approach of disease, and weed management. It has been designed for university-trained plant protection and advisory cers who are engaged in advising farmers on all aspects of plant protection as well as for lecturers in general plant protection at agricultural colleges and those engaged in applied plant protection research. Participants should hold a B.Sc. degree or equivalent in

agriculture or biology, have at least a 3-year experience in plant protection or closely related subjects, and be competent in English. Those wishing to participate are invited to communicate with: The Director, International Agricultural Center (IAC), P.O. Box 88, 6700 AB Wageningen, the Netherlands. Telex 45888-INTAS NL, Fax 08370-18552.

A Symposium on Wheat Breeding - Prospects and Future Approaches will be organized by the Agricultural Academy of Bulgaria on 4-8 June 1990 at Droujba Resort. Bulgaria. The Symposium will provide an opportunity to discuss the following topics: (i) wheat breeding. results and new approaches, (ii) disease and herbicide resistance, current status and approaches on a plant and cell level, (iii) drought, acid, and salt resistance on plant and cell level, (iv) cold and other stress resistance, and (v) genetic specificity of nutrition and utilization. All the papers presented will be published in a book of proceedings in English. Please forward your correspondence to Prof Dr Ivan Panayotov, Wheat and Sunflower Institute 'Dobroudja,' General Toshevo, Varna District, Bulgaria.

Third International Seed Technology Course and Workshop, 2-13 July 1990. This course will be given at the National Institute of Agricultural Botany, Cambridge, UK, and will be divided into two parts. The first will be allocated to seed certification and the second to seed testing. A third optional part which will deal with seed pathology or tetrazolium testing procedures will be given after the completion of the first two. The course will be conducted in English. Delegates will therefore need to be reasonably proficient in this language. A certificate of attendance will be presented to those delegates who complete the course. Address for correspondence: P.T. Nelson, National Institute for Agricultural Botany, Huntingdon Road, Cambridge, UK. Fax number: 44 223 277707. Telex number: 817455 NIAB G.

Statistics in Agriculture, 11 July-19 Sept 1990, University of Reading, UK. This course will be given at the University of Reading, Whiteknights, with an aim to review the most widely-used techniques for agricul-

tural applications, starting from basics but moving quickly to points of real professional interest, making the purpose and use of each technique clear with a minimum of mathematics. Participants are introduced to the use of computers for data management and analysis. Methods of collecting agricultural data are considered critically, and appropriate data management and statistical techniques to analyze such data are explained. Practical help will be offered with the special problems faced in developing countries. There are no formal qualifications for entry to the course. At the end of the course, a certificate of attendance will be provided, but the course itself does not provide any academic qualification. Address for correspondence: Mrs Alison Ansell, Statistical Services Center, Department of Applied Statistics, University of Reading, Whiteknights, P.O. Box 217, Reading RG6 2AN, UK. Telex 847813 A/B RULIB G (marked CENTER APPSTAT). Fax: Reading (0734) 314404.

Statistics in Agricultural Climatology, 11 July-19 Sept 1990, University of Reading, UK. The broad aim of this course is to provide a foundation for using statistical climatology in operational situations to help improve and stabilize agricultural production. Most course members will have a university degree or similar qualification, though there are no formal qualification for entry to the course. Address for correspondence: Mrs Alison Ansell, Statistical Services Center, Department of Applied Statistics, University of Reading, Whiteknights, P.O. Box 217, Reading RG6 2AN, UK. Telex 847813 A/B RULIB G (marked CENTER APPSTAT). Fax Reading (0734) 314404.

The Sixth International Symposium on Genetics of Industrial Microorganisms (GIM 90) will be held at the Palais des Congres, Strasbourg, France, 12-18 Aug 1990, under the auspices of the GIM International Committee. The GIM 90 is organized by the Societe Francaise de Microbiologie (SFM) with the support of the French Ministries of Agriculture, Education, Industry, and Research, the Institut National de la Recherche Agronomique, and the Centre National de la Recherche Scientifique. The scientific program, of international scope, will include lectures by renowned scientists and industrialists. Poster sessions will play a key role in the program. More information is available from: the Societe Francaise de Microbiologie, 28 rue du Docteur Roux, 75724 Paris Cedex 15, Fax 45.67, 46.98.

Second International Triticale Symposium. The National Research Center for Wheat of the Brazilian Agricultural Research Enterprise (CNPT/EMBRAPA), the International Triticale Association (ITA), and the International Maize and Wheat Improvement Center (CIMMYT) will hold the Second International Triticale Symposium in Passo Fundo, Rio Grande do Sul, Brazil. from 1 to 5 Oct 1990. The Symposium will provide a worldwide forum for discussion and dissemination of current knowledge related to triticale, and will offer an opportunity for scientists to interact with colleagues from other scientific fields or geographic areas. The Symposium language will be English, with translation to and from Portuguese. Please mail your correspondence to: Second International Triticale Symposium, CNPT/EMBRAPA, P.O. Box 569, 99001 Passo Fundo RS, Brazil. Telex 545319 EBPA BR.

CONTRIBUTORS' STYLE GUIDE

Policy

The aim of the 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.

Editing

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

Disclaimers

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.

Manuscript

Articles should have an abstract and be typed double spaced on one side of the page only. The original and two other legible copies should be submitted. The contributor should include his name and initials, title, program or department, institute and postal address and telex number if available. Photographs, figures, tables etc. should be either 8.5 cm wide (single column) or 17.5 cm wide (double column including space). Figures and diagrams should be drawn in India ink; send original artwork, not photocopies. Define in footnotes or legends any unusual abbreviations or symbols used in a figure or table.

Units of measurement are to be in the metric system, e.g., t/ha, kg, g, m, km, ml (= milliliter), m².

The numbers one to nine should be written as words except in combination with units of measure; all other numbers should be written as numerals, e.g., Nine plants, 10 leaves, 9 g, ninth, 10th, 0700 hr.

Examples of common expressions and abbreviations

3g, 18 mm, 300 m², 4 Mar 1983; 27%; 50 five-day old plants; 1.6 million; 23 μ g; 5°C; 1980/81 season; 1981-83; Fig., No.; FAO, USA. Fertilizers: 1 kg N or P₂O₅ or K₂O/ha.

Mon, Tues, Wed, Thurs, Fri, Sat, Sun; Jan, Feb, Mar, Apr, May, June, July, Aug, Sept, Oct, Nov, Dec.

Versus = vs, least significant difference = LSD, standard error = SE \pm , coefficient(s) of variation = CV(s). *Probability:* Use asterisks to denote probability * = P < 0.05; ** = P < 0.01; *** = P < 0.001.

Botanical. Include the authority name at the first mention of scientific names. Cultivar(s) = cv(s), variety = var(s), species = sp./spp., subspecies = subsp., subgenus = subg., forma = f., forma specialis = f.sp.

Reference

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Papers 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-1, ICARDA/the Government of Netherlands, 20 Apr - 6 May 1982, Aleppo, Syria. Available from ICARDA.



International Center for Agricultural Research in the Dry Areas (ICARDA)

P. O. Box 5466, Aleppo, Syria