RACHIS

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The Center and its Mission

The International Center for Agricultural Research in the Dry Areas (ICARDA) was established in 1977 to undertake research relevant to the needs of developing countries and specifically for the agricultural systems in West Asia and North Africa. The overall objective of the Center is to contribute towards increased agricultural productivity, thereby increasing the availability of food in both rural and urban areas, and thus improving the economic and social well-being of people.

The Center focuses on areas with 200 to 600 mm annual winter rainfall. Where appropriate, research also covers environments with summer rainfall.

ICARDA is a world center for the improvement of barley, lentil, and faba bean; and a regional center for the improvement of wheat, chickpea, farming systems, pasture and forage crops, and livestock. Training agricultural researchers from developing countries is an important component of ICARDA's activities.

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

Cereal researchers and the libraries of institutions conducting research on barley and wheat in West Asia and North Africa may apply for a free subscription by writing to RACHIS, ICARDA. P.O. Box 5466, Aleppo, Syria. Contributions to RACHIS should be sent to the attention of Ms Elizabeth Talmage.

Editor's notes: With issue 10(1), RACHIS readers may notice several changes. As RACHIS will no longer be published in Arabic, the English version will carry Arabic abstracts. With his appointment as Head of Information, Dr S. Varma, who played the role of senior editor on the RACHIS Editorial Committee, has handed over that role to Ms Elizabeth Talmage. Mr Tarek Abdul Malak has moved on to new challenges. Suggestions and comments are welcomed.

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Editorial

Genetic variation for economically important traits is an essential prerequisite for successful breeding of crop species. The increased wheat production during the 1970s and 1980s in many parts of the world was largely or partly due to genetic improvement efforts. Such successful efforts were not possible without the introduction of new germplasm. Realizing the value of external plant material, specialized researchers from all over the world cooperated in creating germplasm pools, or banks, and in exchanging local or introduced germplasm. International organizations played a major role in facilitating the flow of germplasm across geographical boundaries. While this type of cooperation is welcomed by breeders, geneticists, and germplasm specialists, its effectiveness is threatened by new pressures.

Undoubtedly, the free and uncontrolled movement of plant germplasm among continents and countries may introduce pathogens and pests to new areas; indeed, this has happened in certain cases. Quarantine regulations have been established in practically all countries as a preventive measure against unwanted introduction of new pests and diseases. We believe that a proper quarantine process is useful to bar the entrance of pathogens and pests into a country, or at least to hinder such introduction. However, the quarantine system should be based on scientific evidence and a full knowledge of diseases and pests already present in the country or region; and its implementation should not be cumbersome, bureaucratic, or lengthy. Being aware of these risks, international organizations, including CIMMYT and ICARDA, have made large investments to ensure that seed destined to germplasm users is free from pathogens and pests. It is hoped that cooperation and understanding among researchers and quarantine services will enable a smooth application of plant health control without hindering a normal flow of germplasm among users.

Research and Production

Effectiveness of Different Spray Fungicides Against Karnal Bunt of Wheat

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Abstract

Three systemic spray fungicides, Tilt 250 EC, Baycor 25 WP, and Benlate 50 WP, were evaluated during two years for the control of Karnal bunt [*Neovossia indica* (Mit.) Mund.] on a susceptible wheat cultivar. Tilt and Baycor reduced the disease by 79% and 67%, respectively. Benlate reduced the disease by 20% only.

Introduction

Karnal bunt of wheat [*Tilletia indica* (Mit.) Syn. *Neovossia* indica (Mit.) Mund.] causes considerable losses to wheat crop in Sialkot and Gujranwala areas of the Punjab, Pakistan. According to Mitra (1935) the disease incidence reached 20% in 1933 on certain wheat varieties in parts of the Punjab. Bedi *et al.* (1949) observed Karnal bunt epidemics in different parts of the Punjab in 1942 and 1948, with 30% incidence in individual cases. Chona *et al.* (1961) reported its occurrence in northern India, where it caused substantial losses to the wheat crop in the Punjab, western Uttar Pradesh, and Delhi in certain years. The disease also affected the wheat crop in almost all the Pak Punjab districts in the 1985/86 and 1986/87 seasons, with a 30% and 50% incidence, respectively (Anonymous 1987).

Singh and Prasada (1980), Krishna and Singh (1982), Singh *et al.* (1984), and Aujla (1986) indicated the possibility of preventing Karnal bunt infection by spraying fungicides before heading. The objective of this study was to compare the effectiveness of three easily available spray fungicides against Karnal bunt.

Materials and Methods

The experiment was conducted on a highly susceptible wheat cultivar, Kohi Noor-83, at Chak No. 44, Janoobi, Sargodha District in 1986/87, and at the Agricultural Farm, Piplan, Mianwali District in 1987/88. These two disease hot spots were selected on the basis of the disease outbreak during 1985/86 and 1986/87 (up to 30% and 50% incidence, respectively). The design was a randomized complete block replicated four times, with 3-x-12-m plots. The systemic fungicides used in the experiment were Tilt 250 EC (500 ml/ha), Baycor 25 WP (500g/ha), and Benlate 50 WP (500 g/ha). They were applied as a single spray at the boot stage with a knapsack sprayer at the rate of 370 l/ha. Percentages of healthy and diseased grains were recorded at maturity.

Results and Discussion

All three fungicides significantly reduced the percentage of infected grains (Table 1). A single spray of Tilt 250 EC at the rate of 500 ml/ha and of Baycor 25 WP at 500 g/ha effectively reduced the disease incidence by 79% and 67%, respectively. These findings conform with those of

Table 1. The efficacy of three different spray fungicides on the incidence of Karnal bunt of wheat during 1986–87 and 1987–88.

Treatment	Year	Infected grain (%)	Disease control (%)
Tilt 250 EC	1986–87	4.4	79
	1987–88	0.7	
Baycor 25 WP	1986–87	6.4	67
	1987–88	1.5	
Benlate 50 WP	1986–87	16.7	20
	1987–88	2.4	
Control	1986–87	20.3	–
	1987–88	3.6	
LSD	1986–87	1.12	
	1987–88	0.51	

Singh *et al.* (1984) and Aujla (1986), who reported the effectiveness of Tilt and Baycor spray fungicides against Karnal bunt. Spraying Benlate 50 WP at the rate of 500 g/ha was less effective, and provided a 20% disease control only, whereas Singh and Prasada (1980) recorded a significant control of the disease with a Benlate spray at boot stage. These findings suggest that Tilt and Baycor, but not Benlate, be sprayed on wheat at the boot stage in hot spots, or in years of Karnal bunt epidemics.

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Breeding Barley for Stress Tolerance In Krasnodar Region

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Abstract

Good resistance to frost, lodging, and diseases is necessary for high yield and stability of winter barley in the Krasnodar region of the USSR. Spring barley's most important characters are earliness, tolerance to drought and heat, and lodging and disease resistance. To search for new and better sources of resistance, entries from the world barley collection have been screened and promising parental materials were identified among introductions from ICARDA. The barley breeding program at Krasnodar has been using the methods of intraspecific hybridization and chemical mutagenesis successfully. A number of cultivars have been released for the region. Radical (winter), Skorokhod (winter), and Mamluk (spring) are the latest released barley cultivars.

The Kuban region is considered a Russian granary because of its climatic and soil conditions that are favorable to grain production. However, in many environments the weather greatly varies from year to year, and even within seasons. In these areas winter crops are usually more productive than spring ones, because they efficiently use autumn-winter rainfall and escape heat and drought in June.

The level of winter barley productivity and stability is determined by its resistance to frost, lodging, and diseases. In years of severe frost barley yield losses attain 30%–40%, while losses due to lodging can reach 20%–30%. Widespread infestations with mildew, *Helminthosporium*, and rust, the three most important barley foliar diseases in the area, can reduce yield by 15%–30%, and in very severe cases, 40%–50%. These three characters constitute the background for the winter barley breeding program at Krasnodar, which uses the traditional intraspecific hybridization methods and chemical mutagenesis.

Frost resistance of barley is considerably lower than that of winter wheat and rye. While screening the world barley collection for better sources of frost resistance, the local cultivars Odessky 31, Orion, Siluet, and Start were identified. Two American cultivars, Paoly and Harrison, which proved to be useful sources for winter hardiness, were also determined. Some lines from ICARDA showed good winter hardiness, early maturity, and disease resistance in 1988–89. Among them are Foma 72-1144-R-174/Izmir 256-2 and Foma 72-1144-R-174/Lignee 131 (Table 1).

The selection of some unique mutants as parents has led to the development of lines with favorable transgressions. One of them is the released cultivar Radical, which has good frost resistance (Table 2).

Table 2. Performance of three winter barleys in Krasnodar, 1983–89.

Cultivar	Frost resistance* (%)	Plant height (cm)	Lodging resistance+	Grain yield (kg/ha)
Cyclone	7.0	90	8	6870
Debut	42.4	110	5	6050
Radical	88.2	85	7.5	7280
LSD (0.05)	8-12			360-420

* Percent of plants that survived after freezing in cold chambers.
\+ 1 = all plants lodged; 9 = no lodged plants.

Table 1. Performance of promising ICARDA barley lines in field testing, Krasnodar, 1989.

Lines	Reaction to frost*	Heading date	Plant height (cm)	Resistance* to		
				Mildew	Helmintho-sporium	Rust
(Source: BYT-HAA 1988-89)						
Cyclone (local check)	7	2 May	80	5	8	5
Eldorado (check)	4	30 Apr	80	9	8	8
Lignee 131	6	29 Apr	75	7	5	7
OP/Zy/Alger/Union, 385-2-2	5	28 Apr	77	7	7	5
Salmas	4	28 Apr	85	7	8	5
(Source: BON-MRA 1988-89)						
Mrg/Gva//PI 002917	4	5 May	75	7	9	7
(Source: BON-HAA 1988-89)						
Radical (local check)	8	5 May	80	5	9	7
Salmas	5	27 Apr	85	7	7	7
Eldorado (check)	5	29 Apr	80	9	8	8
Antares/Ky 63-1294	7	30 Apr	95	7	7	6
Foma 72-1144...	7	30 Apr	90	9	8	7
Foma 72-.../Lignee 131	7	28 Apr	80	9	9	7
Foma 72-.../Izmir 256-2	8	29 Apr	80	6	9	7
Alpha/Sul/Nacta	7	28 Apr	75	5	9	5
80-5041/Dubois	7	30 Apr	80	9	9	7
Lignee 131/Arabi Abiad	7	27 Apr	72	7	9	8
Tipper	5	4 May	80	7	8	8
Sonja/1658/Emir	7	28 Apr	90	5	8	7
Steptoe/Lignee 640	7	29 Apr	80	5	9	5

* 1 = very susceptible; 9 = very resistant.

Table 3. Performance of the new early maturing winter barley cultivar, Skorokhod, in yield trials, Krasnodar, 1986–1989.

Cultivar	Heading date (April)	Frost resistance (%)	Lodging resistance*	Grain yield (kg/ha)
Cyclone	28	7.0	8	7610
Meteor	22	38.4	4	7270
Radical	28	88.2	7.5	7650
57M15	22	50.3	7.0	6600
Skorokhod	17	74.2	7.5	7270
LSD (0.05)		8-12		320-380

* 1 = all plants lodged; 9 = no lodged plants.

Recently introduced into commercial production, Radical greatly contributed to high barley yields in 1989, yielding 5–7 t/ha in many farms, as well as over whole districts.

Productivity in our environments is associated with vigorous initial growth. Since our cultivars, especially Radical, have a poor rate of initial growth in comparison with ICARDA lines, hybridization should yield lines combining vigorous initial growth with good frost and lodging resistance.

Considering the importance of earliness in some climatic zones, the success of mutagenesis in this respect is worth noting. After treating Regia seeds with 0.033%

Table 4. Performance of the new spring barley cultivar Mamluk, 1986–1989.

Cultivar	Grain yield (kg/ha) Krasnodar	Grain yield (kg/ha) North Caucasus Exp. Station	Lodging resistance*	1000-grain weight (g)	Heading date (May)
Temp	4340	5050	4	41.5	20
Mamluk	4880	5560	7	46.4	18
LSD (0.05)	380-420	380-440			

* 1 = all plants lodged; 9 = no lodged plants.

Table 5. Performance of foreign introductions of spring barley in ecological trials, Krasnodar, 1989.

Entry	Origin	Rate of initial growth*	Heading date (May)	Plant height (cm)	Lodging resistance*	Disease resistance*	Grain yield (kg/ha)
Perelom (check)	USSR	7	15	60	9	8	5190
Giza 134/Apm/CI...	ICARDA	8.5	16	52	9	7	4540
WI 2291/Bus	ICARDA	8.5	10	55	9	7	4380
Kv/Coho	ICARDA	8	14	58	9	9	4370
Kenya Research/Belle	ICARDA	8	9	50	9	9	4540
ACSAD 176	ICARDA	8	19	57	9	9	4710
Pitayo/Cam//Avt...	ICARDA	8	16	63	8	8	4750
Jeger	Canada	7.5	23	95	9	8	4860
Rodeo	Canada	7.5	21	75	9	8	4830
Lignee 527	ICARDA	7	20	56	9	8	4580
Soufara-02	ICARDA	8	23	65	9	8	4610
LSD (0.05)							370

* 1 = poor, 9 = good.

nitroso-ethyl-urea for six hours, an early ripening mutant 54M15, which headed 16 days earlier than Regia, was obtained. This mutant was then crossed with other mutants and cultivars, giving selections that headed much earlier than the parents and checks. One of these selections gave rise to the newly released cultivar Skorokhod (Table 3). Its introduction will make early harvesting of winter barley possible to successfully grow maize as a second crop for silage.

Every year, 5%–15% of the acreage under winter cereals needs resowing in early spring due to poor over-wintering. Late planted winter wheat and barley suffer particularly from frost, which causes 30%–50% plant death. In such fields the number of plants must be restored to 500–600/m^2 for optimal yield. Spring barley is the best crop for this purpose. With this in view, spring barley breeding must emphasize earliness in combination with high productivity, drought and heat tolerance, and resistance to diseases and lodging.

Earlier, a very early mutant spring cultivar Temp was induced. Temp outyielded the check by 300–900 kg/ha and is still widely spread in the Krasnodar region. Later, the Triumph x Temp cross gave rise to another cultivar, Kaskad, which became one of the parents of the promising cultivar Perelom.

Using chemical mutagenesis, a new spring barley cultivar, Mamluk, was developed. It combines earliness, large grain, and good resistance to lodging (Table 4). Due to its earliness Mamluk can escape the attack of the dangerous cereal leaf beetle (*Oulema melanopus*) by developing an extensive vegetative growth before the beetles become active in spring.

In screening foreign introductions for useful traits, some promising spring barleys have been selected from ICARDA supplied nurseries. The six-rowed lines ACSAD 176 and Pitayo/Cam/Avt... have high resistance to diseases, a good rate of initial growth, and rather high productivity (Table 5). The two-rowed lines Kv/Coho, Kenya Research/Belle, and Soufara-02 have good resistance to diseases, and high initial growth vigor. Since these introductions are of distinct geographical and ecological origin, they may be useful for crossing with our cultivars to produce useful genetic variation for selection.

Acknowledgement

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Chemical Control of Simultaneous Cereal Cyst Nematode And Termite Infestations In Wheat in Rajasthan, India

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Abstract

This study investigated the effects of termiticides and nematicides and their combinations on cereal cyst nematode (*Heterodera avenae* W.) and termites (*Odontotermes obesus* R. and *Microtermes obesi* H.), wheat yields, and economics of the treatments. Field trials with the bread wheat cv. Kalyansona were conducted at sites in Jaipur District where the two pests were a problem to wheat production. Two nematicides, aldicarb and carbofuran; two forms of a termiticide, aldrin 5% dust and aldrin e.c.; and their combinations were tested. Aldicarb and carbofuran, alone or in combination with the termiticide, reduced postharvest cereal cyst nematode population by about 50%. All treatments significantly reduced the percentage of cumulative termite-damaged shoots, though the two nematicides alone were less effective. Significantly higher grain and straw yields were obtained with combinations of the nematicides and termiticides. Though all treatments were economical, the highest marginal profits were obtained with the combination of aldicarb and aldrin e.c.

Introduction

Over widespread light-soiled areas in Rajasthan, the wheat crop often suffers from cereal cyst nematode (*Heterodera aveanae* Wollenweber) and termite (*Odontotermes obesus* Rambur and *Microtermes obesi* Holmgren) infestation. Cereal cyst nematode (CCN) causes 'Molya' disease, which can reduce wheat grain and fodder yield by about 50% (Swarup and Singh 1961; Mathur 1969). The two termite species are a major constraint to wheat production, causing up to 35% yield losses (Khan 1983). In certain parts of the tract, simultaneous CCN and termite infestations sometimes result in a complete crop failure.

Termites have been successfully controlled with aldrin seed treatment (Anonymous 1974; Chahal *et al.* 1976; Khan and Singh 1979; Verma *et al.* 1978), while 'Molya' disease can be effectively controlled by the application of systemic nematicides viz. aldicarb and carbofuran (Handa *et al.* 1980; Mathur *et al.* 1986). However, little information is available on the control of simultaneous infestations of both pests. The present study investigated the effects of termiticides and nematicides, individually and in combination, on the pests, the crop yields, and the economics of the treatments.

Materials and Methods

Field trials with three replicates arranged in a randomized complete block design were conducted at two problematic sites in Gunawta village, Jaipur District, for two years using the bread wheat cv. Kalyansona. The plots consisted of 16 5-m rows spaced 25 cm apart. Seed rate was 100 kg/ha, and the crop was grown under irrigated conditions. Fertilizers were applied at the recommended dose. Five 1-m segments selected randomly along the rows were marked for recording termite-damaged shoots in each plot. Observations were recorded periodically in the early crop stage and during crop maturing phase. Pre- and postharvest CCN populations were determined by the standard sampling method (Southey 1970).

The pesticides used were granular formulations of aldicarb (Temik 10G) and carbofuran (Furadan 3G) at 1.5 kg a.i./ha; aldrin 5% dust at 1.25 kg; and 1100 kg seed

Table 1. Effects of different pesticide treatments on the infestation of cereal cyst nematode (CNN) and termite in wheat, yield, and marginal profit (pooled data for two years).

Treatment	% cumulative termite damaged shoot/m row	Postharvest CCN population[1] (eggs/ml soil)	Yield (kg/ha) Grain	Yield (kg/ha) Straw	Marginal revenue (Rs/ha) a	Marginal cost (Rs/ha) b	Marginal Profit (Rs/ha) a-b
T_1 = Aldicarb (1.5 kg a.i./ha)	12.5[a] (4.7)[b]	6.9	2810	4360	2349	630	1719
T_2 = Carbofuran (1.5 kg a.i./ha)	16.8 (8.4)	6.7	2710	4110	2062	1350	712
T_3 = Aldrin 5% dust (1.5 kg/100 kg seed)	7.1 (1.5)	12.8	2090	3250	559	15	544
T_4 = Aldrin 30 e.c. (400 ml/100 kg seed)	2.3 (0.2)	12.9	22.4	3430	915	60	855
$T_5 = T_1 + T_3$	6.0 (1.1)	6.8	3190	4940	3277	645	2632
$T_6 = T_1 + T_4$	1.6 (0.1)	6.6	3260	5000	3441	690	2751
$T_7 = T_2 + T_3$	6.2 (1.2)	6.4	3020	4740	2874	1365	1468
$T_8 = T_2 + T_4$	5.3	7.2	3290	5000	3491	1410	2081
T_9 = Control	31.0	13.8	1850	2980			
SE ±	3.12	0.92	180	255			

1. Pretreatment CCN population = 8.7 eggs/ml soil.
a. Arcsin/transformed values.
b. Actual mean values.

aldrin e.c. at 120 g a.i./100 kg seed. While aldicarb and *carbofuran* were drilled at sowing, both the aldrin formulations were used as seed treatment. There was a total of nine treatments (Table 1).

Grain and straw yields were measured. Treatment revenue calculation was based on a price of Rs 200/100 kg and Rs 30/100 kg for the wheat grain and straw, respectively.

Results and Discussion

All the treatments significantly reduced termite incidence in comparison with the control (Table 1). Aldicarb and carbofuran applied alone were less effective than aldrin and the different pesticide combinations, which were not significantly different among themselves.

CCN could not be checked by the application of aldrin formulations alone, as no significant differences in postharvest CCN population were observed between these treatments and the control (Table 1). Aldicarb and carbofuran, alone and in combination with aldrin formulations, significantly checked nematode buildup and reduced postharvest CCN by 50%. No marked differences were found among these latter treatments.

Significantly higher grain and straw yields were obtained in treatments where a combination of nematicides and insecticides, as well as nematicides alone, were used (Table 1). No appreciable increase in grain and straw yields was manifested with any of the aldrin formulations. It is further seen that the highest yields were obtained with the combination treatments, and no significant differences were observed between the two nematicides and the two aldrin formulations.

All the treatments were economical as compared with the control (Table 1). The application of aldicarb was more economical than carbofuran when used alone or in combination with aldrin, while the aldrin e.c. formulation was more economical than the dust formulation. The combination of aldicarb with aldrin formulations resulted in the highest marginal profits (> Rs 2600/ha).

Based on these findings, it is concluded that under a mixed infestation of both the pests, a treatment combining the drilling of the nematicide aldicarb and an insecticidal seed treatment with aldrin e.c. effectively controls termite damage and CCN populations, and results in high yields and profits.

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Effect of Wild Plant Extracts on Germination and Seedling Growth of Wheat

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Plants influence each others' growth by exudates, and leachates from residues. Weeds, such as quackgrass [*Agropyron repens* (L.) Beauv.], can inhibit competing plants' growth by releasing chemicals into the soil (Gabor and Veatch 1981). Phytotoxic compounds have been found in oat, bread wheat, corn, and grain sorghum (Guenzi and Norstadt 1967). Guenzi and McCalla (1962) found that ground soybean hay inhibited wheat root growth by 30% and wheat shoot growth by 45%. Some wild plants and their residues are also known to have inhibitory effects on cereal growth by releasing water soluble phytotoxins (Azmi and Alam 1989; Rice 1984).

Sana-e-Mukki (*Cassia angustifolia* Linn.), Mundi-flower (*Sphaeranthus indicus* Linn.), and neem (*Azadirachta indica*), which are common wild plants in the southern part of Sind, have a wide range of antibacterial activities (Naqvi *et al.* 1987). The present experiment was conducted to study the effect of these plants' aqueous extract on the germination and seedling growth of wheat.

Fresh leaves of Sane-e-Mukki and neem, and dried Mundi-flower were collected, washed with water, dried at 75°C for 48 hrs, ground, and stored in plastic bottles at room temperature. Samples were soaked in distilled water for 24 hrs at room temperature, then the extract filtered. Two concentrations, 0.1 and 0.3% w/v, of each plant extract were prepared.

Seeds of the wheat cultivar Sarsabz were surface sterilized with 1% sodium hypochlorite solution for 2 minutes, then washed thoroughly with sterile distilled water. Ten healthy seeds were placed on solidified 0.8% agar-gel containing 10 ml aqueous extract in glass bowls. Bowls with agar-gel only were treated as control. The bowls were covered with petri dishes and incubated at 28°C. Each treatment was replicated four times in a randomized complete block design. The experiment was terminated after 120 hrs. Germinated seeds were counted, and shoot and root length measured. The experiment was repeated once, and results were expressed as the averages of the two trials.

The aqueous extracts of Sana-e-Mukki, Mundi-flower, and neem had no significant effect on germination of wheat seed (Table 1). Wheat shoot growth significantly increased by increasing extract concentration. The Sana-e-Mukki extract produced the maximum increase in length (40%), followed by neem (30%) and Mundi-flower (12%). This increase may be related to the stimulatory effects of water soluble allelochemicals. Rice (1986) found remarkable growth stimulation of radish root (135%) when a small amount of decaying ground ivy (*Geochoma hederacea*) leaves was incorporated in the growing media. A similarly significant growth stimulation of *Bradyrhizobium japonicum* was observed by the incorporation of extracts from shoots of foxtail and lambs-quarters.

Table 1. Effects of different concentrations of three wild plant extracts on the germination and seedling growth of wheat.

Wild plant and extract concentration (% W/V)	Germination (%) (cm)	Shoot length (cm)	Root length (cm)
Sana-e-Mukki			
0.0	100.0a*	7.73c	9.44b
0.1	97.5a	9.57b	9.22b
0.3	97.5a	10.78a	8.64a
Mundi-flower			
0.0	97.5a	5.24b	6.67a
0.1	97.5a	5.79a	6.12b
0.3	97.5a	5.89a	5.42c
Neem			
0.0	97.5a	8.03b	9.85a
0.1	97.5a	9.78a	9.38a
0.3	95.0a	10.40a	8.50b

* Values followed by the same letter are not significantly different ($P < 0.05$) within each species.

Unlike shoot growth, wheat root growth significantly decreased as extract concentrations increased (Table 1). Maximum reduction occurred with Mundi-flower extract (19%), followed by neem (14%) and Sana-e-Mukki (9%). A similar reduction in root growth has been reported in previous studies, which suggested that the roots could have been exposed to phytotoxic chemicals that may have leached out or evolved from microbial action upon decomposition (Azmi and Alam 1989; Rice 1984).

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Self-regenerating Pasture Barley*

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Introduction

In the West Asia and North Africa (WANA) region, large areas are kept as natural pastures, and are traditionally grazed by sheep and goats. This area represents 64% of total land area in Syria, 74% in Iraq, 91% in Jordan, and 27% in Cyprus. A small increase in the animal carrying capacity of pastures, especially in the first three countries, would significantly increase livestock products availability.

The animal carrying capacity of these natural pastures is low because overgrazing and uncontrolled grazing with no concerted efforts to maintain soil fertility have significantly reduced the pastures' productivity. Furthermore, grazing over centuries has reduced the frequency of palatable species and degraded forage quality. Experiments carried out in the three Mashreq countries (Syria, Iraq, and Jordan) have shown that by controlling grazing, the animal carrying capacity of natural pastures can be doubled; by reseeding, it can be increased by 5–10 times.

Research aiming at increasing production of natural pastures is conducted in most WANA countries. In Syria, for example, annual and perennial species have been tested successfully. Around 5 million seedlings and 30–50 tonnes of seeds of shrub species (*Atriplex* and *Salsola* sp.) are annually used to improve pastures in the steppes. In Jordan and Iraq, however, programs lasting from three to five years, aimed at introducing medics and other Australian technology have not succeeded.

Ways to increase pasture production include controlling grazing and reseeding of suitable pasture lands. This review presents the use of wild barley in reseeding natural pastures.

Species for Reseeding Pastures

As pointed out earlier, the introduction of medics in order to establish pastures in the Mashreq countries has not been successful. In Cyprus, work by the Department of Agriculture and the Agricultural Research Institute over the last 40 years on establishing medics and ryegrass pastures have had little success. Unpublished data (D. Droushiotis and I. Photiades) in Cyprus showed that dry matter yield of medics was lower than that of vetches (Tables 1 and 2). Also, in Jordan, vetches were superior to medics in dry matter production, digestibility, and body weight gain. In particular, vetch-fed Awassi lambs gained 40% more liveweight than those fed on medics. At maturity, vetch retained a higher digestibility and protein content than medics.

Hadjichristodoulou (1973, 1976, 1988) showed that barley produces twice as much forage dry matter as vetches in cultivated fields and in pastures (Figure 1, Table 3). Interestingly, at grazing stage, barley crude

* Presented at the Training Course on Techniques and Methodologies of Barley Improvement, Amman, 3–8 February 1990.

protein was found to be as high as that of legumes —20%-30% on a dry weight basis—in Cyprus (Hadjichristodoulou 1983, 1988), Iraq, Jordan, and Syria (personal communications). Thus, vetches, and especially barley, are more productive than medics and ryegrass pasture crops, but they need to be sown every year.

Wild Barley as Pasture Crop

Wild barley behaves as a pasture crop (i.e., medics, clover, ryegrass). It is adapted to the dryland conditions of Mediterranean and Middle Eastern countries, and is rich in protein at the grazing stage.

Figure 2 shows that wild barleys, *Hordeum spontaneum* (C. Kock) and *Hordeum agriocrithon* (natural outcrosses of *H. spontaneum* with *H. vulgare)* are found in abundance in the WANA region (Hadjichristodoulou 1988; Lange and Balkema-Boomstra 1988). Wild barley crosses readily with *H. vulgare* but can be distinguished by its brittle rachis and other seed dispersing mechanisms. A detailed description of *H. spontaneum* in comparison with *H. vulgare* was published by Giles and Von Bothmer (1985).

The dispersal mechanism of the two wild barleys is based on the brittle rachis whereby a triplet of spikelets (with only the central one being fertile) is detached at

Table 1. Dry matter yield (kg/ha) of legume forage crops in cultivated fields 1976/77 (four replications, 4 m^2 plots).

	Location and stage of harvest		
	Athalassa		Ayious
Crop	Flowering stage	Maturity stage	Maturity stage
Barrel medic-FAO, Cyprus	994	164	150
Snail (medic)	1684	1088	300
Harbinger (")	43	78	283
Jemalong (")	960	550	317
Borung (")	988	477	267
Tornata (")	486	252	300
Assor (*V. sativa*)	2837	2531	917
Lana (*V. dasycarpa*)	3313	2150	1400

Table 2. Dry matter yield (kg/ha) of legume forage crops in cultivated fields (four replications, 12.8 m^2 plots).

	Year and location			
Crop	1977/78 Laxia	1978/79 Laxia	1978/79 Dromo-laxia	Mean
Vicos (local *V. sativa*)	5564	5108	4682	5118
Snail (medic)	1904	3249	1247	2133
Borung (")	2367	5168	1561	3032
Harbinger (")	1292	3428	605	1775
Jemalong (")	1344	4921	1083	2449
Tornata (")	1195	4287	896	2126
Barrel medic-FAO, Cyprus	1531	1292	963	1262
Barrel medic-Local	1568	1284	1225	1359
Lana (*V. dasycarpa*)	5459	5011	4414	4961

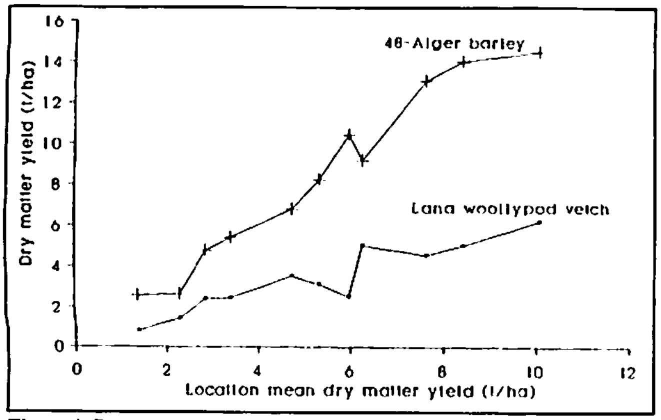

Figure 1. Dry matter yield of 48-Alger barley and Lana woollypod vetch at various locations during the period 1971–75 (after Hadjichristodoulou 1988).

Table 3. Dry matter yield (t/ha) of barley and vetch.

Crop	Yield
A)[a]	
Barley (Morocco 628)	8.98
Woollypod vetch (Lana)	4.09
B)[b]	
Barley (Morocco 628)	13.00
Common vetch (local variety)	6.50

a. After Hadjichristodoulou, 1976
b. After Droushiotis (unpublished data)

maturity and falls to the ground (Figure 3). Long bristle hairs attached to the spikelet facilitate the seed dispersal by animals. The seeds of wild barley are shrunken, thus, better protected from birds and animals than *H. vulgare* seeds (Figure 3).

Wild barley also has a certain level of seed dormancy. About 20% of the seeds germinate, not in the first year (Figure 4), but in the following year, thus safeguarding the survival of the species.

Hordeum agriocrithon a natural hybrid, resembles *H. vulgare,* but it has the wild seed dispersing mechanisms (brittle rachis and shrunken kernels). Both these wild species are abundant in the Mashreq countries (Figure 2), and regenerate themselves successfully, except where overgrazing is practiced.

Establishment of Permanent Pastures

In Cyprus, permanent pastures were established five years ago in several places, using *H. spontanium*, *H. agriocrithon,* and crosses of *H. vulgare* with *H. agriocrithon* and *H. spontaneum*. Repeated sheep grazing did not damage the pasture when plants were left to produce seeds at the end of March–April. When establishing such permanent pastures, the following points must be remembered:

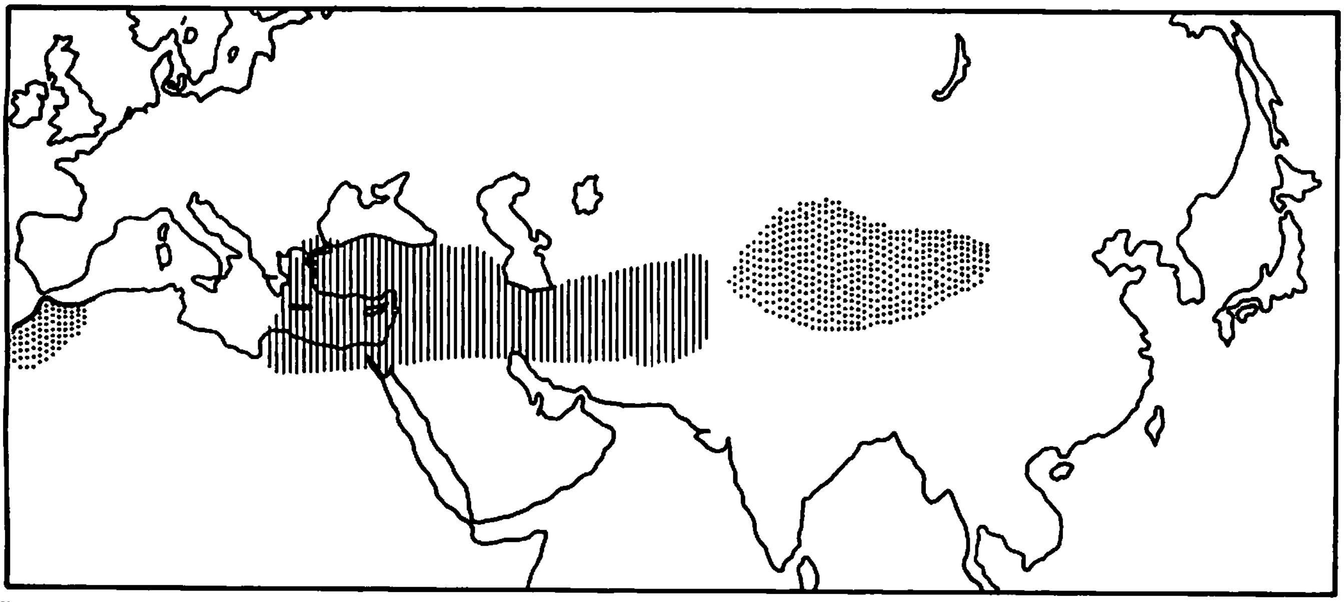
Figure 2. Distribution of *H. vulgare* ssp. *spontaneum;* hatched area is the region where *spontaneum* is considered to be native and in dotted areas *spontaneum* is considered to have a secondary distribution (after Giles and Bothmer 1985).

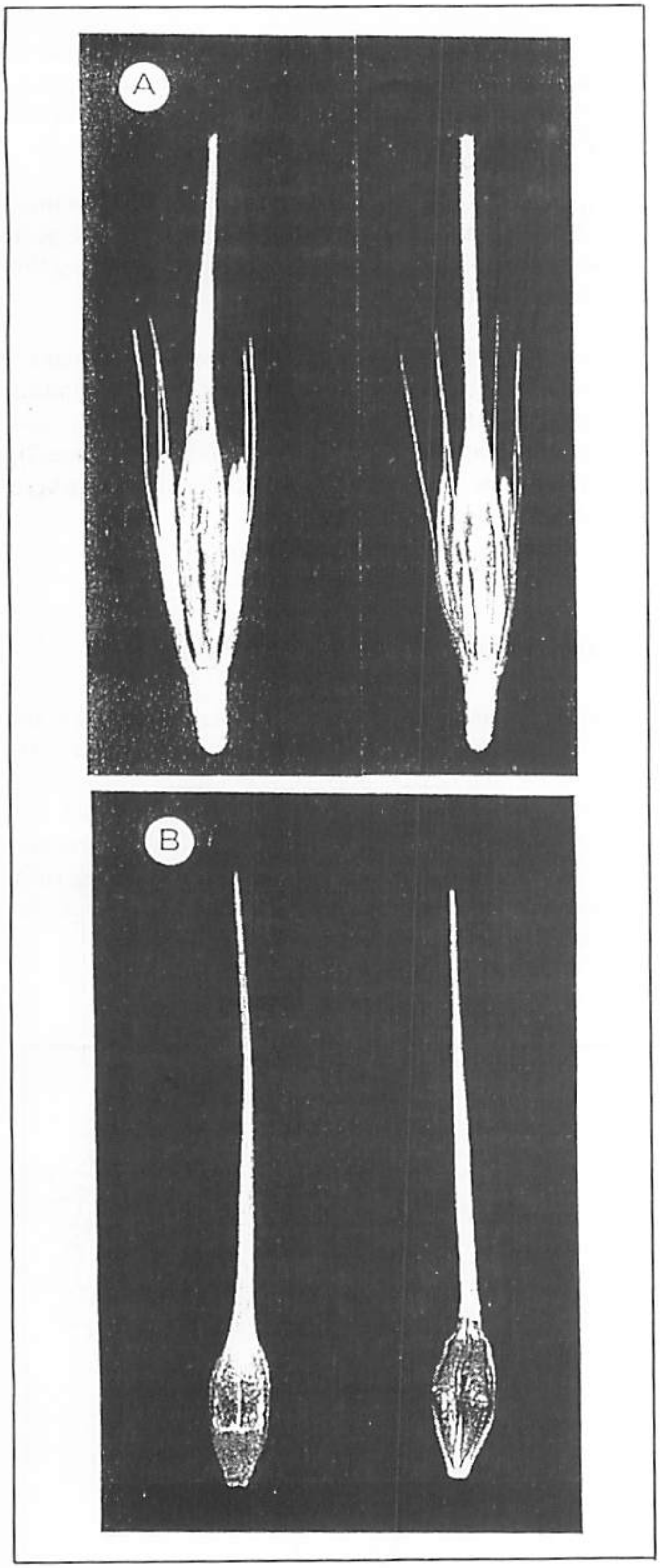

Figure 3. The dispersal unit of A: *H. vulgare* ssp. *spontaneum*; B: *H. vulgare* ssp. *vulgare;* in A the unit consists of a triplet of spikelets attached to one rachis internode (brittle rachis), and in B in one single spikelet (tough rachis) (after Giles and Bothmer 1985).

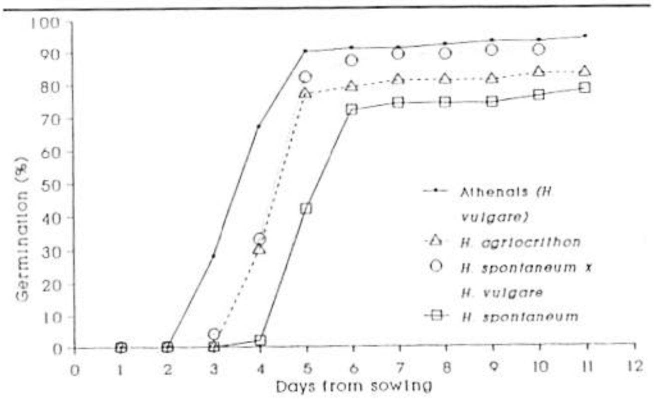

Figure 4. Dormancy of wild barley seeds in comparison with that of cultivated barley (sown November 1988).

- A light tine-cultivation in the first year (at sowing) will cover the seed and result in a better stand establishment. No cultivation is needed in the following years.
- As barley is not a N-fixing crop, N fertilizer should be applied. The rates must be determined according to soil fertility and dry matter production.
- Depending on the time of the first effective rainfall, grazing can begin as soon as adequate leafage develops (tillering stage, before stem elongation) in November–December, and may be repeated according to rainfall conditions. Late in the season the crop must be left ungrazed to produce seeds (end of March–April). After maturity, dry crops can be grazed. Reseeding is not required for the following years.

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Effect of Split Application of Nitrogen on Wheat Yield

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Abstract

The study investigated the effect of split N application on wheat grain yield. The experiment was conducted for three seasons at Jamalpur, Bangladesh. There were six treatments, each consisting of a total of 100 kg N/ha. Averaged over the three seasons, grain yield was not different when N was applied at sowing, from when N was split between a basal application and topdressing(s). Top-dressing without a basal application reduced grain yield significantly. The treatment involving top-dressing at grain-filling stage gave the lowest yield.

Introduction

Splitting the total nitrogen (N) fertilizer dose into a basal application and one or more topdressings is a common practice in irrigated wheat cultivation. However, the efficacy of basal N fertilization is still in question (Selman 1983). It is argued that young plants do not require and consume N fertilizer at the initial stage of growth, thus the major part of the N applied as a basal dose is lost in various ways.

Some studies have reported the advantages of splitting N fertilizer on grain yield (Srivastava and Malhotra 1981; Pomazkina and Ostanin 1982; Stevens *et al.* 1988), but no evidence that splitting N applications affects the efficiency was found in Southeast Asia (Anonymous 1988). At IRRI, the Philippines, full basal application resulted in maximum dry matter production, whereas later application caused more spikes/m^2 and higher harvest index (Anonymous 1987). Boquet and Johnson (1987) did not find any beneficial effect of split N applications on grain yield. Similarly, other researchers (Destri-Nicosia and Quitadamo 1983; Pöttker *et al.* 1984) observed similar responses on yield when N was applied at sowing, or as split dressings at sowing and later growth stages.

The objective of this study was to determine the most efficient way to fertilize with N under the conditions of Bangladesh.

Materials and Methods

The field study was conducted for three growing seasons (1986–89) at the Wheat Research Center, Regional Agricultural Research Station, Jamalpur, Bangladesh. The soil was sandy loam. Six N application treatments (Table 1) were compared in a randomized complete block design with three replications. Each treatment consisted of a total of 100 kg N/ha, and urea was the source of nitrogen.

Table 1. Amount (kg/ha) and timing of N application under the different treatments.

Treatment	Sowing	Crown-root initiation	Head emergence	Grain filling
T_1	100			
T_2	50	50		
T_3	33.3	33.3	33.3	
T_4		50	50	
T_5		33.3	33.3	33.3
T_6	50	25	25	

Phosphorus (as triple superphosphate) and potassium (as muriate of potash) were broadcasted at sowing at 60 kg P_2O_5/ha and 40 kg K_2O/ha, respectively. The wheat variety Kanchan was sown at the rate of 120 kg/ha in 3-x-5-m plots. The crop was irrigated at crown-root initiation, head emergence, and grain-filling stages.

Results and Discussion

There were significant differences in grain yield among the different treatments in 1986/87 and 1988/89, but not in 1987/88 (Table 2). The highest yield in 1988/89 came from applying half the N at sowing, with the rest top-dressed in two equal splits at crown-root and head emergence stages (T_6). In the two other years, applying half the N at sowing, then top-dressing the remaining half at crown-root initiation stage (T_2) produced the highest yield.

Table 2. Grain yield (kg/ha) as affected by split application of nitrogen in three growing seasons.

Treatment	1986/87	1987/88	1988/89	Mean
T_1	1845	1655	2422	1974
T_2	1918	1817	2288	2008
T_3	1863	1777	2333	1991
T_4	1643	1622	1944	1736
T_5	1429	1538	1799	1589
T_6	1890	1766	2477	2044
LSD (0.05)	262	NS	155	175

Averaged over the three seasons, grain yields under application of the whole amount of N as a basal dose or in conjunction with one or two topdressings were not significantly different (Table 2). This trend has been observed in other studies (Destri-Nicosia and Quitadamo 1983; Pöttker *et al.* 1984). Top-dressing without basal application reduced grain yield significantly. Treatment 5, which involved topdressing at grain-filling stage, produced the lowest yield. This result agrees with that of Olugbemi (1984), in which N application at vegetative stage gave a yield 7.2% higher than that obtained with N application at the postanthesis stage. Therefore, the basal N application, whether consisting of the whole N amount or just a part of it, plays a decisive role in yield production. Only split dressings without any basal application of N are not conducive to higher wheat yield.

In conclusion, for high wheat yields, nitrogen must be applied basally before seeding. Whether the total nitrogen amount is applied then or split does not appear to affect yields, the strategy used will be determined by farmers' circumstances.

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Effect of Silver Nitrate On Callus Induction And Plant Regeneration in Wheat

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Abstract

Tissue culture of three wheat varieties was initiated from immature embryos to study the effect of silver nitrate supplement. Calli were subcultured for five months. A distinct varietal difference was found in both callus induction and plant regeneration. Silver nitrate enhanced plant regeneration.

Introduction

In vitro plant regeneration has been demonstrated in wheat somatic tissue cultures for more than a decade (Shimada 1978). However, plant regeneration depends on the genotypes and explants used (Maddock *et al.* 1983), and the frequency of plant regeneration from callus cultures is relatively low and sporadic. It is therefore necessary to develop a reliable method to regenerate plants in sufficient numbers for applying this technique in wheat improvement. In this article, the enhancing effect of silver nitrate on plant regeneration of three wheat genotypes is reported.

Materials and Methods

Immature embryos of three wheat varieties, Local White (Pakistan), Roshan (Iran), and Sabalan (Iran) were collected, approximately two weeks after anthesis, from greenhouse-grown plants. The basal culture medium used was an MS medium (Murashige and Skoog 1962) containing 6.0 g/l agarose (Sigma, Type 1-A).

For callus induction, immature embryos were placed on the medium, with the scutellum upwards. Two media were compared: control versus control plus 10.0 mg/l silver nitrate ($AgNO_3$). The control consisted of MS medium supplemented with 2.0 mg/l 2,4-dichlorophenoxyacetic acid (2,4-D). Each treatment had five embryos in a plastic petri dish, with four replications. Conditions for callus cultures were 25°C and 16-hour day-length, using fluorescent tubes of 5000-lux intensity.

The calli were subcultured every month to a fresh medium and the subcultures were grown for five months. Then they were divided into small pieces approximately 3 mm in diameter. Plant regeneration was initiated by transferring them to the basal medium. The regenerated plantlets were subsequently transplanted into potted soil and grown in a glasshouse until harvest.

Results and Discussion

The number of callus pieces produced, embryoid aggregates obtained, and regenerated plantlets are presented in Table 1. The immature embryos of the three wheat varieties produced calli successfully. The calli propagated vigorously in Sabalan, and were compact and white-yellow. The calli of Local White grew relatively slow, and were soft, waterish, and white.

Embryoids were also produced most frequently in Sabalan. The silver nitrate supplement in the callus induction medium stimulated remarkable embryoid production in all three varieties, although the numbers of embryoids produced were different among the varieties. A small number of embryoids were produced in Local White with silver nitrate supplement, whereas no embryoid was formed in the control.

Most of the embryoids were regenerated to plantlets, or developed green roots without plant regeneration. The highest frequency of plant regeneration was obtained with Sabalan calli on silver nitrate supplemented medium (25 plants per embryo).

These results show the stimulation effect of silver nitrate and genotypic differences on plant regeneration in wheat tissue cultures. At present it is possible to obtain a

Table 1. Callus induction and plant regeneration from five immature wheat embryos.

Wheat variety	Silver nitrate supplement	Number of callus pieces	Number of embryoid aggregates	Number of plantlets
Local White	-	113	0	0
	+	88	11	8
Roshan	-	157	1	1
	+	268	55	44
Sabalan	-	273	24	2
	+	252	146	124
LSD (5%)		43.1	28.0	32.9

sufficient number of regenerated plants from specific genotypes. As shown in the present study and previously reported in wheat and tobacco (Purnhauser *et al.* 1987), adding silver nitrate to the culture medium can enhance plant regeneration ability. Nevertheless, there is a need to develop a method to regenerate plants from suspension cell cultures, which are more suitable for *in vitro* selection and further genetic manipulation. Recent progress in wheat tissue culture is promising to make this possible (Maddock 1987; Inagaki *et al.* 1988; Wang *et al.* 1988).

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A Physiologist's Approach to Improve The Salt Tolerance of Wheat

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UNITED KINGDOM

Abstract

While some wheat genotypes have been identified as salt tolerant, their exploitation in breeding programs has been slow. Breeding for salt tolerance will be more successful if a trait pyramiding approach is adopted. However, not all the traits contributing to salt tolerance have been identified and studied. This paper reviews the progress in two particular areas: potassium/sodium discrimination, and salt exclusion. A high leaf K/Na ratio has been linked with salt tolerance. Experiments showed that the K/Na discrimination character is located in the long arm of chromosome D. The incorporation of this character into durum wheat should help to improve its salt and alkali tolerance. A number of perennial wheatgrasses grow successfully in saline and alkaline habitats because they are able to control the influx of sodium and chloride. A few species of them have been successfully hybridized with wheat. So far the most promising lines have come from a Chinese Spring X *Agropyron junceum* (diploid) hybrid. These plants had lower leaf sodium concentrations than the wheat checks and the highest seed yield under salt stress. Other aspects on the improvement of salt tolerance in wheat are also discussed.

Introduction

Salinity is an important constraint on agricultural productivity over large areas of both irrigated and rainfed land in the arid and semiarid regions. Improvements in crop tolerance to salinity can extend the area available for cereal production, especially in rainfed areas, and increase yields in areas which suffer from marginal problems of salinity and/or alkalinity. They could also allow the use of poor quality water for irrigation, particularly in freely draining soils, and would 'buy time' in which proper drainage and improved management practices could be implemented on less favorable soils. The success of this approach will depend in part on the extent to which the salt tolerance of crops can be improved.

A large number of field, greenhouse, and laboratory experiments have been conducted by many groups throughout the world with the aim of identifying salt tolerant wheat genotypes from commercial cultivars, local landraces, and wild relatives. While some genotypes have been shown to be more tolerant than others, the exploitation of this variation in breeding programs has been slow. One of the major problems is that salinity is not evenly distributed horizontally, vertically, or temporally in the field. Substantial variations can occur over quite small distances, making the initial selection of elite individual plants from field studies unreliable. This could be one reason for the poor correlation often observed between laboratory or greenhouse experiments, and those conducted in the field. Another reason could be the different sensitivity of wheat to salt at different stages in its life cycle. This raises the question of the definition of tolerance. Ultimately a tolerant plant must be able to produce an acceptable yield in a saline environment. In the case of wheat this means grain yield, although in some agricultural systems straw yield is also important. In many laboratory experiments, however, it is short-term vegetative growth rather than yield which is measured.

Tolerance or sensitivity to salt is not a simple phenomenon. It is a consequence of the interaction of several different physiological, biochemical, and developmental traits, each of which is probably itself determined by one or more genes. Some of these traits are obvious and easily measured (e.g., salt exclusion from the shoots) while others are cryptic, i.e., variation for these characters may not be immediately correlated with yield in saline conditions. Examples of cryptic characters are the control of apoplastic salt concentrations in leaves and the compartmentation of solutes within cells. These traits will not be associated with high yield under stress if other mechanisms are limiting. Neither of these traits is easy to determine in the laboratory and at present both are impossible to use as screens for salt tolerance. Nevertheless control of both processes is essential to plants growing in a saline environment.

The cryptic nature of many of these traits has resulted in the suggestion that breeding for salt tolerance will make most progress if a pyramiding approach is adopted (Yeo and Flowers 1986). This envisages selection for individual physiological, biochemical, or developmental traits, regardless of their immediate effects on crop yield, and the combination of these traits in such a way that the individual mechanisms are integrated to produce a plant with optimum salt tolerance. A similar technique, known as the analytical approach, has been proposed for breeding for drought tolerance (Richards 1982).

The problem with the pyramiding approach is that it assumes that all traits contributing to salt tolerance have been identified, that we have a detailed knowledge about the mechanisms and their genetic control, and further that we know how to integrate them into a whole plant development model. This is far from the case at present, but in this article progress is reported in two particular areas.

Potassium/sodium Discrimination

There are a number of reports in the literature on the differences in salt tolerance and ion uptake in different wheats. In particular a number of recent papers document the differences between tetraploid durum wheats and the hexaploid bread wheats (François *et al.* 1986; Joshi *et al.* 1982; Weimberg 1987). The durum wheats tend to be less salt and alkali tolerant, and to accumulate more sodium and less potassium in their leaves than bread wheats. A high leaf K/Na ratio has been linked with salt tolerance in a number of studies (Rana 1986) and reflects the plant's ability to discriminate between sodium and potassium in uptake at the roots and in transport to the shoots.

Our own studies, initially from a different standpoint, have confirmed and extended these observations. We first showed that the high K/Na character of hexaploid wheat was also exhibited by *Aegilops squarrosa* L., the source of the D genome of wheat (Wyn Jones *et al.* 1984). This character was retained in synthetic bread wheats in which the A and B genomes of a durum wheat (Langdon) were combined with the D genomes from different accessions of *A. squarrosa* (Shah *et al.* 1987). Using disomic substitution lines of D-genome chromosomes in the durum wheat variety Langdon, we were able to show that the K/Na discrimination character is located on chromosome 4D (Gorham *et al.* 1987). Two sets of these substitution lines had been developed by Dr L.R. Joppa in Fargo, North Dakota. In the first set each of the seven pairs of A-genome chromosomes was replaced in turn by the homologous D-genome pair derived from the bread wheat variety Chinese Spring, while in the second set each of the B-genome pairs was similarly replaced. When grown at 150 mol m^{-3} NaCl both the 4D(4A) and the 4D(4B) substitution lines had considerably higher leaf K/Na ratios than Langdon itself or the other substitution lines. This observation was confirmed in an experiment on Chinese Spring bread wheat lines which were aneuploid for all parts of chromosome 4D. In particular the line ditelosomic for the short arm of chromosome 4D had a much lower K/Na ratio than euploid Chinese Spring, whereas the line ditelosomic for the long arm of 4D resembled Chinese Spring. This showed that the K/Na discrimination character was located on the long arm of chromosome 4D (Gorham *et al.* 1987).

Ion flux experiments using ^{22}Na have indicated that there are small differences in sodium flux rates in root cells of Langdon and Chinese Spring, but that there are large differences in the rates of sodium loading into the xylem, and hence transport to the shoots. Total cation and anion contents are relatively unaffected by the 4D(4A) or 4D(4B) substitutions in Langdon, but there are some differences in the chloride and nitrate contents [also evident in the 1D(1A) and 1D(1B) substitution lines] and in the divalent cation compositions of the leaves.

Thus we have identified a character in the D genome of wheat which should help to improve the salt and alkali tolerance of tetraploid wheat if it can be incorporated into tetraploid wheat without the detrimental effects of other genes located on chromosome 4D. Although there is evidence that a high leaf K/Na ratio is correlated with yield in hexaploid wheat, it is not clear whether the ratio is controlled solely by the gene(s) on chromosome 4D or whether other mechanisms also contribute to cation discrimination in bread wheats.

Salt Exclusion and Wide Hybridization

It has been observed that a number of perennial wheatgrasses are able to grow successfully in saline and alkaline habitats. Where physiological studies have been made, it has been found that most grasses and all the important cereals can survive in saline conditions. However, they must be able to limit the influx of sodium and chloride to that required for internal osmotic adjustment to the decrease in soil water potential. That is to say that they are effective salt 'excluders'. In general, existing wheat varieties have a limited ability to control the influx of sodium and chloride and, in the worst cases, salt toxicity soon becomes apparent in mature leaves. In a search for greater salt tolerance, a number of perennial wheatgrasses from saline habitats have been investigated; a few species have been successfully hybridized with wheat and the progeny tested for tolerance to salinity.

Our own work has concentrated on hybrids with the diploid wheatgrass *Thinopyrum bessarabicum* (Savul. and Rayss) Love [*Agropyron junceum* (L.) Beauv.] and other species of *Thinopyrum*. We have examined in some detail a 56-chromosome amphidiploid produced at the Plant Breeding Institute (now the Institute of Plant Science Research), Cambridge, by Dr B.P. Forster. This amphidiploid, which combines the A, B, and D genomes of the bread wheat Chinese Spring with the J genome of *T. bessarabicum*, is more salt tolerant than the parent wheat and other bread wheats, and had lower sodium contents than the wheats in young leaves and in the grain (Gorham *et al.* 1986; Forster *et al.* 1987). By backcrossing this hybrid with Chinese Spring it is hoped to obtain all seven disomic addition lines of *T. bessarabicum* chromosomes in a defined wheat background. This will enable the effects of the individual alien chromosomes to be studied independently.

Chinese Spring is a relatively salt tolerant wheat, but has a number of undesirable agronomic characters, making this particular amphiploid a poor basis for assessing the agricultural potential of such hybrids. The wheat background of the amphiploids needs to be broadened to include agronomically acceptable and rapidly maturing varieties. There are also problems associated with the J genome, such as brittle rachis, non free-threshing grain, and open pollination. Because of these problems, another approach is being pursued by Dr K. Mujeeb Kazi at CIMMYT. He has produced a large number of intergeneric hybrids (many also with Chinese Spring), most of which are maintained in the F1 condition. These are then backcrossed with current CIMMYT commercial wheats to reduce the number of alien chromosomes and to introduce desirable agronomic characters. The aim is to isolate single chromosome addition lines or 42-chromosome wheat plants with alien translocations (after several backcrosses and self-pollinations).

We have examined a number of these backcross lines derived from hybrids with *T. bessarabicum*, *T. junceiforme*, *T. scirpeum*, *T. distichum*, and others. The most promising lines have come from a Chinese Spring x *T. bessarabicum* hybrid produced at CIMMYT. These plants not only had the best seed yield under salt stress but in subsequent trials had lower leaf sodium concentration than the wheat checks. Cytological analysis has shown that the immediate parent of these lines probably had three pairs of alien chromosomes. A major problem with these particular backcross lines is their low fertility. When grown in the absence of salt they produced on average only five seeds per spike.

The work described above parallels the work being done in Dr. J. Dvorak's laboratory on an amphidiploid and addition lines derived from a cross between Chinese Spring and another diploid wheatgrass, *T. elongatum*, and on backcross progeny obtained from a hybrid between Chinese Spring and the decaploid *T. ponticum* (Dvorak and Ross 1986; Dvorak *et al.* 1985; Storey *et al.* 1985).

Further Development

The identification of individual (sometimes cryptic) mechanisms of salt tolerance is a crucial step in the pyramiding approach to breeding wheat with greater resistance to salt stress. In some cases we know how we would use these mechanisms to design our ideal salt tolerant plant. We could, for example, design a model for salt accumulation and distribution based on what we already know about the physiology and biochemistry of salt excluding plants, even though we are still ignorant of many details of how such mechanisms operate.

We lack clear information about fundamental aspects of the responses of plants to salt stress. How and why, for example, does salinity have such a large effect on leaf extension growth? These questions will only be answered when we understand the processes controlling growth in the nonstressed plant and how such processes are modified by salinity. Since we cannot answer all of these questions there is little immediate prospect of being able to integrate the known mechanisms into a satisfactory model which would describe the development of our ideal salt tolerant wheat plant. Thus our enthusiasm for the pyramiding approach is tempered by a need to have a much better understanding of plant physiology in general, and of how it is affected by salinity in particular.

A concept which was of considerable value in the early years of crop physiology, that of limiting factors (Blackman 1905), can also aid understanding of the responses of crop plants to salinity. The implication of this concept is that if one mechanism is deficient and is limiting growth or yield, then improvement in other mechanisms will have little immediate impact on yield, i.e., the other mechanisms will be cryptic until the limiting mechanism is corrected. This idea is central to the argument for a pyramiding or analytical approach to breeding for salt tolerance.

The need for cooperation between different disciplines is always present. Once a salt tolerance mechanism is identified by physiologists or biochemists, it should be tested in isolines or other material in which the particular trait can be evaluated independently of other characters. If the trait proves to be of value in laboratory or field experiments (in physiological terms, not necessarily in terms of yield) and is heritable, it can be incorporated into an idealized model of the crop's response to salt stress. Such ideotypes will need to include input from agronomists, etc., on the best crop characteristics for the area where the crop is to be grown. Having defined (or refined) the ideotype it is then necessary to combine, from whatever sources, the desired characters into new lines (pyramiding), which can be tested in field conditions.

In the immediate future there are a number of questions which we hope to be able to answer. One is the practical usefulness of the K/Na discrimination character on chromosome 4D for enhancing the salt and alkali tolerance of durum wheats. Unfortunately the 4D substitution and aneuploid lines that we have examined so far have all suffered from the unbalancing effect of removing or adding whole chromosomes or chromosome arms. We need to be able to test the effects of the K/Na discrimination gene or genes when added in isolation to a complete durum wheat genome. This problem highlights the need for close cooperation between physiologists, cytogeneticists, and plant breeders.

Acknowledgements

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Short Communications

High-yielding Feed Barley Cultivar CT-16

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Yancheng District, located at the coast of the Yellow Sea, is an autumn-sowing barley area. Barley production of the district is predominant, not only in the Jiangsu Province, but also in all of China. Barley grain is used as feed and malt in Yangcheng.

Our institute began to introduce barley lines from ICARDA in 1984. CT-16, a high-yielding feed barley cultivar, was selected from the 1985/86 Barley Yield Trial for Cold Tolerance. Its full pedigree is Api/CM67//Emir/Nacta/3//MGH 6355/4/Lignee 686, ICB80-0669-0SH-5AP-OAP. It showed good adaptability, and significantly outyielded local varieties and checks in Yancheng regional trials and production experiments.

CT-16 ranked first in the ICARDA Barley Yield Trial for Cold Tolerance planted in our institute in 1985/86, yielding 7.6 t/ha, 9.4% higher than the check, Supi-1. It was further tested at our institute in larger plots in 1986/87 and 1987/88, and at the Haike Seed Farm in 1986/87. At the same time, it was promoted to the 1986/87 and 1987/88 regional barley variety trials, in which its mean yield reached 6.8 t/ha, about 10% higher than the check, Aizao-3. In 1988/89, CT-16 was grown over an area of 8 ha in the Da Zhong Farm for large scale testing and seed production, and broke the large-area yield record of the farm with 6.7 t/ha. Lately, CT-16 has been introduced and tested in other parts of China. In the National Feed Barley Trial conducted at Sian, Shanxi Province, CT-16 gave the highest yield, which was 17.8% higher than that of the check, Xigin-2, the most widely grown cultivar in the province.

CT-16 is a six-row semiwinter type with a prostrate growth habit at the seedling stage. Like the local Chiba barley, it belongs to the medium-maturity groups. Its favorable characteristics are:

- responsiveness to high input conditions;
- lodging resistance;
- cold resistance;
- net blotch, powdery mildew, and rusts resistance; and
- high tillering. The large number of spikes per unit area is the basis of its high yield potential.

The drawbacks of CT-16 are its susceptibility to yellow mosaic virus and to head blight.

The optimum seeding time for CT-16 at Yancheng is 20–25 October; the optimum seeding rate is 90–120 kg/ha. The number of seedlings should be adjusted to 150–180/m^2 in the dry lands, and to about 225/m^2 on paddy soil. For the Jiangsu coastal area, the application of approximately 300, 120, and 150 kg of N, P_2O_5, and K_2O/ha, respectively, gives the optimal yield. An N basal dose to topdressing ratio of 7:3 is recommended. Since the groundwater level in the coastal areas is shallow, and rainfall is high in early spring, there should be a good drainage network in the barley fields to provide good aeration and root environment.

Response to Stem Rust Infection Of Seven Egyptian Wheat Cultivars

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Stem rust disease caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks & Henn. is one of the major problems of wheat production in Egypt. Its importance varies with the cultivars, regions, and seasons. Stem rust disease sometimes becomes epidemic over a wide area when favorable environmental conditions, such as high moisture and relatively high temperatures, are present. Thus the stage of plant development when infection occurs—and subsequent yield reduction—is not constant. The objective of this work is to compare the response to stem rust of seven Egyptian wheat cultivars using different measures of disease development.

Field experiments were carried out at Bahtim Agricultural Research Station during the 1986/87 and 1988/89 growing seasons on seven Egyptian wheat cultivars: Giza 155, Giza 157, Giza 162, Sakha 8, Sakha 61, Sakha 69, and Takamol. The experiment was laid according to a randomized complete block design with four replications. Each replicate, as well as the whole experiment, was surrounded by highly susceptible varieties (*Triticum spelta saharense,* Little Club, Baart, and Ramona), which were artificially inoculated with freshly collected urediospores of the prevalent stem rust races to generate an epidemic. Normal cultivation practices were applied.

Rust severity as percentage was recorded at seven-day intervals at five growth stages: 8–9, 9, 9–10, 10–10.5, and 10.5–11 (Large 1954), after rust symptoms had developed following the method described by Stakman *et al.* (1962)

Table 1: Stem rust infection at different growth stages, rate of disease development (r), and area under disease progress curve (ADPC) of seven Egyptian wheat cultivars.

	Growth stages*											
	8–9		9		9–10		10–10.5		10.5–11			
Cultivar	Score	ACI+	Score	ACI	Score	ACI	Score	ACI	Score	ACI	r	ADPC
Giza 155	Tr MS	1.6	Tr MS-S	1.8	10 MS-S	9	20 MS-S	18	50 MS-S	45	0.362	170
Giza 157	Tr S	2	10 S	10	30 S	30	40 S	40	90 S	90	0.445	309
Sakha 8	Tr S	2	Tr S	2	Tr S	2	10 S	10	80 S	80	0.428	281
Sakha 61	0	0	0	0	0	0	Tr MS	1.6	40 MS-S	36	0.330	140
Sakha 69	0	0	0	0	0	0	0	0	30 MS-S	27	0.290	105
Takamol	Tr S	2	5 S	5	10 S	10	30 S	30	90 S	90	0.445	309
Giza 162	0	0	0	0	0	0	Tr MR	1.6	40 MR-MS	28	0.330	140

* 8-9 = Last leaf and its ligule just visible.
9 = Ligule of last leaf visible.
9-10 = Sheath of last leaf fully developed; spike swollen (in boot).
10-10.5 = Spike out of sheath; begining of flowering.
10.5-11 = Flowering and kernel development until dough ripening.

\+ Average coefficient of infection.

and the modified Cobb's Scale (Peterson *et al.* 1948). Average coefficient of infection (ACI) was calculated using Saari and Wilcoxson's (1974) method. Rate of disease increase was estimated according to Van der Plank (1963), while the area under disease progress curve (ADPC) was determined using Shaner and Finney's (1977) equation.

The seven cultivars reacted differentially to stem rust infection (Table 1) and could be classified under three groups based on infection type:

1. Moderately resistant (MR): Giza 162
2. Moderately susceptible to susceptible (MS-S): Giza 155, Sakha 61, and Sakha 69
3. Susceptible (S): Giza 157, Sakha 8, and Takamol

Moreover, the cultivars differed in the growth stage at which the first visible disease symptoms were noticed. Giza 155, Giza 157, Sakha 8, and Takamol showed the first visible symptoms as early as growth stage 8–9, but had different disease development rates. Sakha 8 could restrict the infection until the end of growth stage 9–10, while Giza 157 lacked this ability.

It seems that what is commonly regarded as a disease-free cultivar is rare. At growth stage 10.5–11, even Giza 162, Sakha 69, Sakha 61, and Giza 155 showed 30%–50% infection. As expected, the ACI corresponded to the disease severity score.

The susceptible cultivars, Giza 157, Takamol, and Sakha 8, showed the highest rates of disease increase (0.445, 0.445, and 0.428, respectively). Though the moderately resistant cv. Giza 162 showed a low rate of increase, Sakha 69 had the lowest (0.290). Giza 155 and Giza 157 showed gradual increases in rust severity, but Sakha 8 had a sharp increase toward the end of the season.

The area under disease progress curve followed the same trend as the rate of disease increase. Sakha 69 had the lowest ADPC (105), followed by Sakha 61 and Giza 162. Takamol and Giza 157 showed the highest ADPC (309). Similar results were reported by El-Daoudi *et al.* (1985).

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Types, Numbers, and Distribution Of ICARDA and ICARDA/CIMMYT* Cereal International Nurseries

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* Changed to CIMMYT/ICARDA from 1989.

The international nursery system of the Cereal Improvement Program, ICARDA, was set up in 1977 to provide regularly and systematically improved barley, durum wheat, and bread wheat germplasm to national programs. Since then, the number of nursery types has increased, and the adaptability of the entries included in the nurseries has gradually improved. The increase in demand and the change in preference for different international nurseries sent from ICARDA were reported by Yau and Srivastava (1989). This article describes the increase in the types and numbers of nurseries over the years, and the change in geographical distribution of nursery sets.

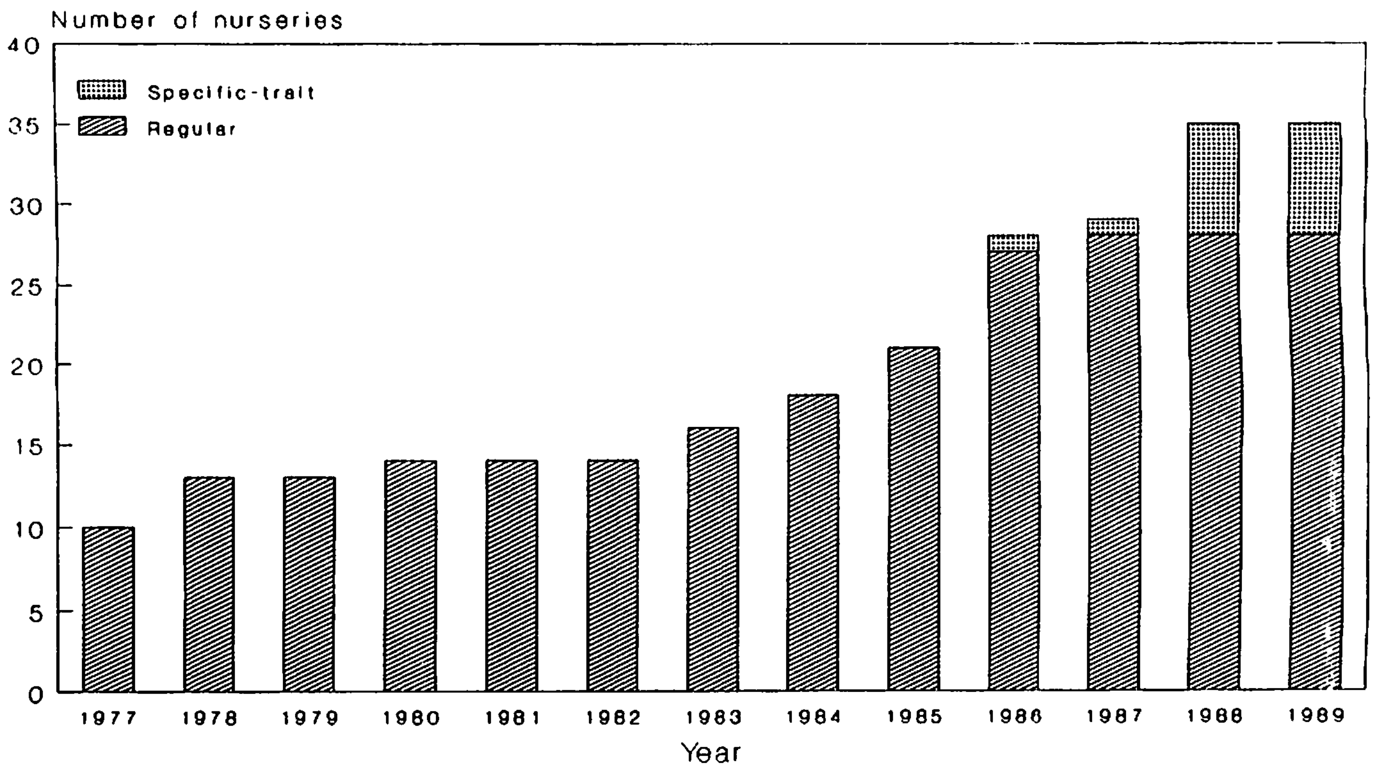

Figure 1. Numbers of international cereal nurseries assembled at ICARDA each year from 1977 to 1989.

Figure 1 presents the numbers of international cereal nurseries available from ICARDA, Aleppo, to national programs since 1977. From the initial 10 nurseries, the number had increased to 33 by 1990.

As the level of infrastructure and technical expertise reached by national cereal improvement programs in West Asia and North Africa (WANA) greatly varies, different types of nurseries should be prepared in order to cater for the needs of every country. In 1977, yield trials, observation nurseries, and segregating populations, mainly consisting of spring materials, were assembled by ICARDA. Crossing blocks of the three crops became available the next season. Since then, the four basic types of nurseries have been prepared every year.

Although the ICARDA region has diverse and variable climatic conditions, cereals are grown in two major types of environments. The first is a coastal Mediterranean environment with wet, cool winters and hot, dry summers that can be divided into high- and low-rainfall zones. The second is a high-altitude or continental environment with long, severe winters, and short, hot summers. Within each environmental zone, requirements for high yield are different. Since general adaptation across environments may lead to some yield sacrifice in each environment, cultivars with adaptation to a specific environmental zone should be bred. Accordingly, beginning in 1983, the international nurseries were gradually split into those for low rainfall areas, and those for moderate rainfall or supplementary irrigated areas. Winter and facultative types of materials for high-elevation areas in the temperate region of WANA were made available starting from 1983 for barley, and from 1986 for wheat (although there were special nurseries for wheat before 1986).

In 1986, the first specific-trait nursery, the Heat Tolerance Observation Nursery, was assembled for lower latitude countries under ICARDA's mandate. With the addition of the Heat and Drought Observation Nursery and three germplasm pools for disease resistance, the total number of specific-trait nurseries increased to five in 1988. The demand for such specific-trait nurseries has been high. More of this type of nursery is expected to be assembled in the future.

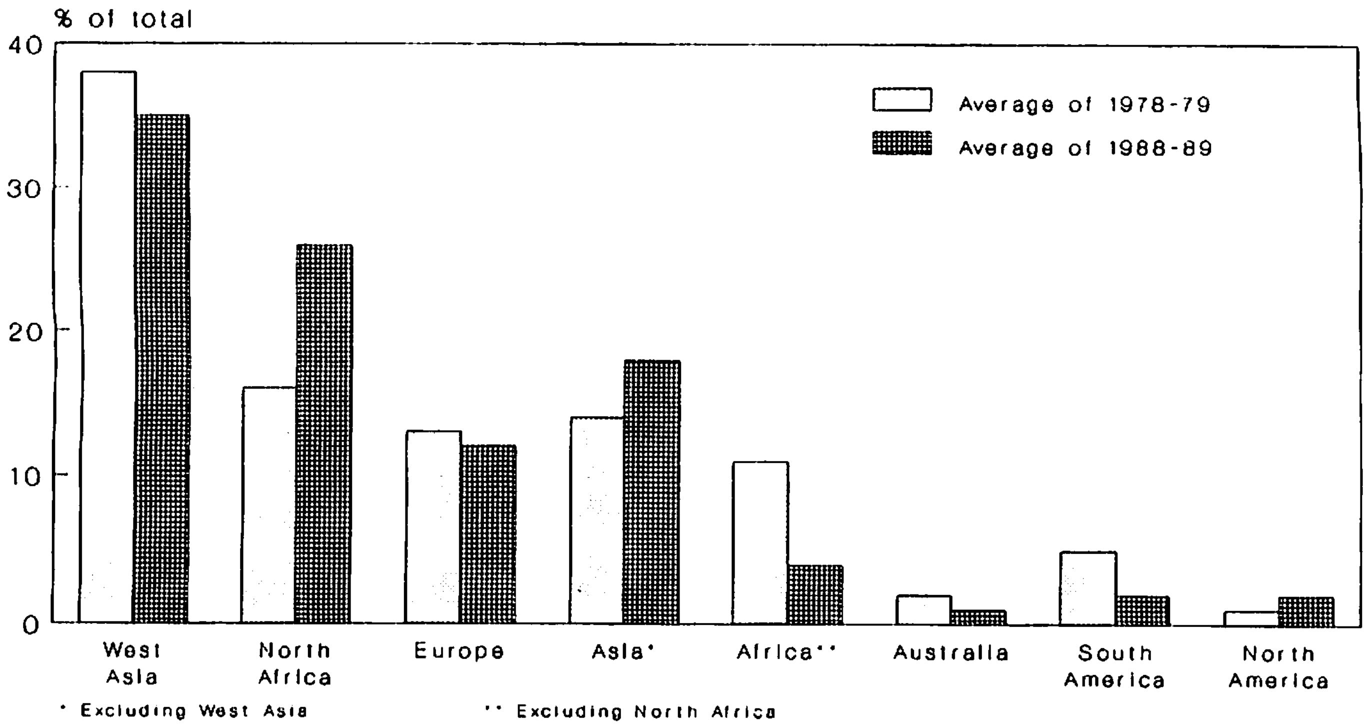

Figure 2. Distribution of international nursery sets from ICARDA, Aleppo, Syria, in two periods: mean of 1978–79 versus 1988–89.

Figure 2 compares the mean distribution of nursery sets in two periods: 1978–79 versus 1988–89. Requests for international nurseries were received from cereal scientists worldwide. In both periods, West Asia received the largest share (35%–38%), followed by North Africa; while Australia, South America, and North America received the least number of sets. Countries in Europe, mainly those from around the Mediterranean Sea, received 12%–13% of the total. Between the two periods, the percentage of nurseries distributed to North Africa registered the largest increase, from 16% to 26%, while the percentage distributed to other parts of Africa recorded the largest decrease, from 11% to 4%. In the same period, the proportion of nursery sets sent to West Asia and North Africa increased from 54% to 64%, and the average total sets of nursery distributed from ICARDA, Aleppo, increased from 387 to 1382.

It should be noted that in the 1988–89 period, 72% of the nursery sets was sent to countries under ICARDA's mandate—which includes countries in WANA, in addition to Ethiopia, Pakistan, and Sudan—as compared to 64% in the 1978–79 period. Under the mandates of the new collaborative agreement between CIMMYT and ICARDA in 1989, the percentage of nursery sets sent outside ICARDA's mandate countries is expected to decrease further. However, the barley nurseries will continue to be sent to national program scientists throughout the world as ICARDA is given the world mandate of barley research by the CGIAR.

In addition to the regular and specific-trait nurseries, other special germplasm were also provided to national scientists on specific requests and agreement. These exceptions and the barley nurseries sent from Mexico through the joint ICARDA/CIMMYT project are not reported here.

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Screening High-Yielding Barley Lines for the High Plateaux of Algeria

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After wheat, barley is the most important crop grown in Algeria. It is cultivated over a total area of 900,000 ha in a fallow system in the drier areas where durum wheat cannot be grown successfully, and is mainly used as feed for livestock. Demand for barley continues to outpace supply, and will not be met unless high-yielding cultivars are grown. The purpose of this study is to determine grain yield and yield stability of 15 barley lines from ICARDA, INRA-Montpellier, and local programs, in comparison with the widely cultivated cultivar Tichedrett.

Trials were conducted during two years in each of Sersour, Setif, and Beni-Fouda sites. The sites differed mainly in soil types and rainfall. Sersour represents the southern zone, with low rainfall (less than 350 mm/year), frequent terminal drought and heat stress at grain filling, large climatic variation, and possible crop failures. Setif site represents the central zone, with moderate rainfall (no more than 400 mm/year). Abiotic stresses include spring frost, and high evapotranspiration and temperature by the end of the season. Beni-Fouda site represents the north zone, with moderate to high annual rainfall (more than 450 mm/year). Snow cover is frequent, but spring frost and terminal heat stress are not a problem as compared to the southern and central zones.

The experimental design was a randomized complete block with four replications. The experimental unit area was 12 m^2. A seed rate of 350 viable seeds/m^2 was used. All the trials were fertilized with 100 kg/ha of superphosphate, while 100, 150, and 200 kg/ha of ammonitrate were applied at Sesour, Setif, and Beni-Fouda sites, respectively. P fertilizer was applied just before seeding, and N was given at tillering stage. Weeds were controlled with 2,4-D.

Mean grain yield ranged from 1130 to 5490 kg/ha for the trials, indicating high site and year differences (Table 1). Significant differences in grain yield existed among lines in each trial.

The grain yield of each entry in each trial was transformed to a percent of the mean grain yield of the local check as proposed by Jestin (1985) and shown in Table 1. The highest yields were produced by Roho/Delissa, followed by Soufara's' and Tatiana, at Setif; Tina, Roho/Delissa, Begoha, and Soufara's' at

Table 1. Relative yield (as % of local check, Tichedrett) of 15 barley entries at three sites in 1986/87 and 1988/89.

Entry	Setif			Sersour			Beni-Fouda			Overall
	86/87	88/89	Mean	86/87	88/89	Mean	87/88	88/89	Mean	Mean
Soufara 's'	130	115	126	116	110	114	103	132	115	118
Roho/Delissa	125	141	129	124	118	122	104	91	98	116
Rihane	125	46	105	78	63	72	98	90	95	91
Barberousse	121	58	105	85	55	72	104	115	109	95
Harmal	119	112	117	127	83	107	104	75	91	105
Tina	111	123	114	116	139	127	137	129	134	125
Gerbel	110	73	101	108	89	99	139	122	132	111
Jaidor	109	28	89	65	57	62	129	109	121	91
Saida	108	70	101	89	69	80	111	110	111	97
ACSAD 176	105	25	85	92	53	75	107	95	103	88
Tichedrett	100	100	100	100	100	100	100	100	100	100
Tatiana	99	180	120	81	119	98	152	104	133	117
Begoha	94	160	111	127	110	119	134	122	130	120
Tabaissa	92	128	102	103	73	89	125	113	120	104
Kerv/MA	91	114	97	110	100	106	109	102	106	103
Mean (kg/ha)	5490	1670		1610	1130		5190	3190		

Sersour; and Tina, Tatiana, Gerbel, and Begoha at Beni-Fouda. Averaged over the trials, the yields of Tina, Begoha, and Soufara's' were the highest. These three lines demonstrated a wide adaptation and maintained a good performance in all the trials.

Although high grain yield is the main selection criterion for variety release, in the high plateau of Algeria where sheep raising is associated with cereal production, plant height is as important as grain yield. This is because tall varieties generally produce more straw, which is an important source of feed. Tina and Begoha (six-row barley) are as high as the local cultivar Tichedrett, but Soufara's' is 25 cm shorter. These three lines will be proposed for large scale testing in the Farmer's Field Verification Trial.

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Genotype and Management Effects on The Degree of Frost Damage To Barley in Northern Syria

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Barley is the dominant crop in the dry areas of Syria. It is grown as a cash crop to be used as both grain and straw feed for sheep, which are an important income source in the farming system.

Efforts have been made to increase barley productivity in such areas by conducting trials at the farm level to fill the gap between experimental station work and real farming. The objective of the experiment was to test the interaction between barley varieties and management in their effects on yield. However, the large differences in frost damage were worth reporting in advance of yield data.

Ten trials were planted, one each at Jifr Mansour, Tawaleil, Em Amoud, Shweiht El Heib, Marhameieh, Rashadeieh, Nawara, Shkedla, Breda, and Khanasser. The mean annual rainfall of the sites ranges between 350 and 200 mm. The experimental treatments were:

- twenty lines of barley, of which 10 were selected for Zone 2, and 10 selected for Zone 3 (Table 1);
- two seed rates, 80 and 120 kg/ha; and

Table 1. Mean cold damage score for the 20 barley lines with and without fertilizer application.

Lines	Zone selected for	Cold damage score+ Fertilized	Not fertilized	Mean
Arabi Abiad	3	1.3	2.0	1.7
Tadmor	3	1.4	2.1	1.7
SLB 39-60	3	1.5	2.1	1.8
Arta	3	1.5	2.1	1.8
SLB 39-10	3	2.0	2.2	2.1
WI 2291	3	2.1	2.9	2.5
WI 2269	3	2.2	2.8	2.5
Harmal	3	2.2	2.9	2.5
Roho/Masurka	2	2.2	2.9	2.6
Salmas	2	2.2	3.0	2.6
CI 08887/CI 05761	2	2.5	2.8	2.6
Wadi Hassa	3	2.4	3.0	2.7
AS 46/Aths*2	2	2.4	3.1	2.7
ER/Apm	2	2.4	3.1	2.7
Deir Alla	3	2.3	3.3	2.8
Rihane 03	2	2.6	3.0	2.8
Giza 121/Apm/Gva	2	2.7	2.9	2.8
Pitayo/Cam	2	2.7	3.3	3.0
Arabi Abiad	2	2.7	3.6	3.1
Cm/3 API/CM 67/Mona	2	2.7	3.8	3.2
Mean		2.2	2.8	

+ 1 = least damaged; 5 = highly damaged.

- two fertilizer rates, 0 versus 30 kg N + 60 kg P_2O_5/ha, applied at planting time.

These treatments were factorially combined in a randomized unreplicated design of 80 plots at each site. Seed was drilled between late October and early November 1989. Plot size was 2.5 x 7.5 m, and row spacing was 17.5 cm.

Early in the season the temperature fell below 0°C for several days, and the degree of frost damage to the crop was apparently affected by sites, varieties and treatments. All 10 trials were scored for frost damage in mid-January following a 1-to-5 scale, where 1 represents least damage and 5, the greatest damage. Crop growth was between the third-leaf stage and tillering.

The ANOVA on frost damage scores showed that line and fertilizer effects were significant. Seed rate and site had no significant effect, and there were no significant interaction between seed rate and fertilizer, seed rate and lines, and fertilizer and line.

Following is a brief summary of the findings:

- Lines selected for Zone 3 are more frost resistant than those selected for Zone 2 (Table 1). The local landraces, Arabi Aswad and Tadmor (developed from Arabi Aswad), are the most resistant to frost.

- Results confirm previous, unrecorded observations that the application of fertilizer, particularly phosphate, tends to increase the frost resistance of barley (Table 1).

- Cold damage of the sites showed no clear trend from north to south or east to west. Differences could be due to local effects. For instance, one of the sites with the greatest damage, Jifr Mansour, is located at the bottom of a valley.

Acknowledgement

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Water-use Efficiency of Wheat Varieties Under the Rainfed Conditions Of Northern India

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Under the rainfed conditions of northern India, the performance of post-rainy season crops, such as wheat, depends on the moisture stored in the soil profile at sowing, and the amount and distribution of rainfall received during the growing season. To increase wheat yields under such conditions, genotypes with high water-use efficiency should be identified. This study was conducted to investigate the water-use efficiency of one tall and five dwarf varieties developed for the rainfed conditions of Northern India.

The four dwarf varieties were WL 410, WL 2265, PBW 65, and PBW 175, developed by the Punjab Agricultural University for rainfed areas of the state. WL 410, WL 2265, and PBW 65 were also recommended at the national level in 1976 (for Northwestern Plain Zone), 1981 (for Northern Plains Zone), and 1984 (for Northern Plain Zone), respectively. PBW 175 was included in 1988 in the list of varieties for the Punjab State. The tall variety, C 306, recommended in 1965 for rainfed conditions of Northwestern Plains Zone and Northeastern Plains Zone was used as check in variety trials for rainfed conditions in these zones. The five varieties were grown in a randomized complete block design with three replications during the post-rainy season of 1988/89. The experiment was conducted on sandy-loam soil. No irrigation was applied and the material was grown on residual moisture in the soil after the harvest of maize.

The water-use efficiency was defined as grain yield (kg/ha) per unit of water used (cm). Moisture was determined following the thermo-gravimetric method from soil samples taken at sowing and at harvest from 0–15, 15–30, 30–60, 60–90, 90–120, 120–150, and 150–180 cm layers. Total water use (up to 180 cm depth) was determined as: profile water storage at sowing + rainfall during the crop season - profile water storage at harvesting.

The entries differed significantly for water-use efficiency, harvest index, and grain yield. WL 410 recorded the highest water-use efficiency and harvest index (Table 1). The water-use efficiency of the other four varieties was significantly lower than that of WL 410. However, WL 410 yielded significantly lower than the recently bred variety PBW 175.

Under rainfed conditions, genotypes with high water-use efficiency and high harvest index are desirable. The present study shows that WL 410 has better water-use efficiency than the check, C 306, and three other dwarf varieties developed after its release. In a study conducted by Singh *et al.* (1987) to compare water-use efficiency of rainfed wheat, WL 410 also had higher water-use efficiency than C 306 on sandy-loam as well as on clay-loam soils. Therefore, WL 410 may serve as a good parent in breeding for rainfed conditions.

Table 1. Water-use efficiency, harvest index, and grain yield of five wheat varieties.

Variety	Water-use efficiency (kg/ha/cm)	Harvest index (%)	Grain yield (kg/ha)
WL 410	121	37	2710
WL 2265	89	36	2930
PBW 65	90	36	3200
PBW 175	98	37	3360
C 306	82	32	2930
LSD (5%)	21	3	510

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Seed Village for Increasing Grain Production

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In India, the agricultural model of industrialized countries has been successful in large- to medium-sized farms, but not in small farms, which represent 75% of the country's holdings. In states where the green revolution had the highest impact, more energy has been spent to produce a unit of wheat or rice than in areas following the traditional system. The development of a low-input agricultural system directed towards the need of small farmers should be given more attention.

From a technological viewpoint, the green revolution has considerably contributed to boosting agricultural production. One of its most important promoters was the creation and development of an organized seed industry in the 1960s and the 1970s. Although the Indian seed industry has developed rapidly during the last 15 years, about 80% of the seed is still "traditionally supplied," i.e., saved from the farmers' produce as seed for the following season, bought at the local market, or exchanged among farmers.

A great potential exists for improving the Indian agricultural production if small farmers get good quality seed of improved varieties and other agricultural inputs. Agricultural universities, Indian Council of Agricultural Research institutes, and state departments of agriculture are aiming to reach more and more farmers, but the program is slow due to the vastness of the country. In view of the low replacement rate of crops such as wheat and rice (8% on average), the traditional seed supply system is important and will remain so at the end of the century. Therefore, the traditional system should be improved so that small farmers receive quality seed of improved cultivars. This could be achieved by stimulating the seed village concept involving the local village council (panchayat) and women.

The concept emerged in the 1960s when an introduced Mexican dwarf wheat significantly outyielded local varieties in demonstrations conducted in small farmer fields. A great demand for the Mexican dwarf wheat seed ensued and the Indian Agricultural Research Institute (IARI) organized field demonstrations and seed multiplication in Jyonti village in Delhi State (Khanjhawla Block), which was converted into a seed village.

Genetically pure seed could be multiplied by all or a few selected farmers initially under the supervision of seed experts. The seed should be harvested separately and threshed, and physical admixture of cultivars should be avoided. The threshed produce should be cleaned, graded, tested for germination, treated, and bagged. A mobile processing plant for cleaning and grading of seeds could be made available on rent either by village panchayat or by the state's department of agriculture. Otherwise, cleaning and grading could be done manually. Training farmers for seed production and testing should form a very important element of the program. However, the production of hybrid seed by farmers would be difficult.

One of the most important constraints faced by the small farmers is the unavailability of quality seed of improved varieties at sowing time. Even if the seed is produced at the village by small and marginal farmers—which makes it significantly less expensive—it is all sold out soon after harvest, as the farmers prefer to recoup the previous season's input costs as soon as possible. Bank credit extended to individual farmers or to village panchayat by pledging the seed may partly solve the problem. Alternatively, a cooperative society may be formed in the village for seed production, distribution, and sale. (In Jyonti village, a cooperative society was formed with about 44 members.) Furthermore, the concept of exchange of seed against grain could also be developed. This could be arranged either through the panchayat or cooperative society.

By involving the villages in seed production, high-yielding varieties could be spread very fast all over the country, increasing grain production. IARI is presently seeking to spread high-yielding varieties of wheat, rice, and other crops by training farmers on seed production in some districts of Uttar Pradesh, e.g., Fatehpur, Banda, Sultanpur, Rae Bareilly, Madhya Pradesh, and Bihar. Investment in this kind of venture is modest as compared with the establishment/expansion of seed corporations, and spin-off is great.

Cleistogamy in Wheat

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Flowers may be primarily divided into those which open, and thus expose their stamens and stigmas to the air, i.e. chasmogamic, and those which remain closed (necessarily self-fertilized), i.e. cleistogamic. Generally, wheat is chasmogamic. During anthesis, the lodicules swell at the base and force the lemma outward, thus opening the flower (Vries 1971).

In the present study 350 strains of *Triticum durum* and 515 strains of *Triticum aestivum* were examined for two consecutive seasons (1987/88 and 1988/89) to see the extent of floret opening. Most of the strains were chasmogamic, except two strains of *T. durum* (HI 8332 and WH 880) and one strain of *T. aestivum* (V 79143),

Figure 1a. *T. durum* var. HI 8332.

which were cleistogamic. Observations were recorded from anthesis to maturity. Anthers were found to be retained inside the floret until maturity in all three genotypes (Figure 1).

The frequency of chasmogamic flowers varies with strains. Maksimov (1964) observed 61.9% flower opening in *T. durum,* while Milohnic and Jost (1970) reported variation in anther extrusion (32% to 83%) in *T. aestivum.* A maximum anther extrusion of 97% was observed in the present study in the *T. durum* variety IWP 5308.

Cleistogamic flowers are characterized by a reduced number and size of floral parts (such as stamens) and a modified perianth (Uphof 1938). However, all three cleistogamic genotypes observed in the present study had a normally developed perianth. Uphof (1938) reported that chasmogamic flowers may become cleistogamic due to unfavourable environmental factors (ecological cleistogamy), such as drought, cold, shade, and poor soil. Fruwirth (1905) observed that low temperature and rain may also increase the number of cleistogamic flowers. However, the change in flowering behavior in the present investigation cannot be attributed to environmental factors since the observations were recorded for two seasons during which normal weather prevailed and normal cultural practices were followed.

This change in flowering behavior may be due to poorly developed lodicules in the cleistogamic florets in comparison to those of chasmogamic florets, as was reported in barley by Bergal and Clemencet (1962). In alloplasmatic rye (rye genome in wheat cytoplasm) the lodicules were transformed to glume-like organs and, consequently, lost their function, which resulted in cleistogamic flowering (Lein 1948). In addition to retarded lodicules, WH 880 had a stiff perianth, which might have hindered lemma and palea expansion. When tightly adhered lemma and palea were pushed apart with forceps, anthers were found inside the folded tips of the palea restricting their extrusion. Four crosses were made between cleistogamic and chasmogamic lines to study the inheritance of this trait. Results from the F_1 generation showed that chasmogamy is dominant. The number of genes governing this trait will be determined in future studies.

Figure 1b. *Triticum durum* var. WH 880.

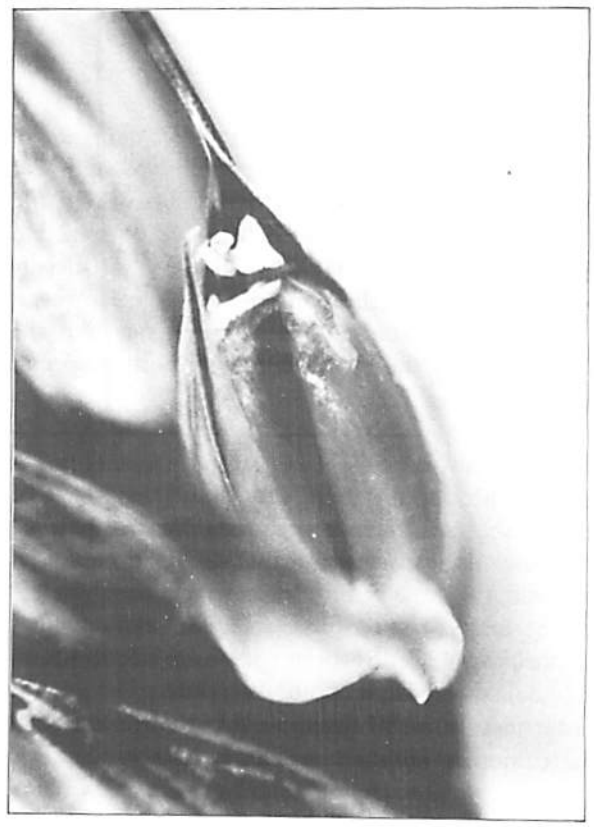

Figure 1c. V 79143 (*Triticum aestivum*).

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Interspecific Crosses (*Triticum durum* Desf. x *T. aestivum* L.) Involving Ethiopian Wheat

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Triticum durum Desf. (2n = 4x = 28) and *T. aestivum* L. (2n = 6x = 42) are the two most widely grown wheat species in Ethiopia. All the improvement work in the country on these two species has been based on selection from the naturally existing variability, or artificially created variation within the same ploidy level. However, Hailu (1986) and Tesfaye (1986) pointed out that the variation created by the hybridization of the two species may be useful.

In interploidy crosses, the degree of success in obtaining healthy and viable seeds depends upon the direction of the cross. In wheat, it is generally believed that when the species with the higher ploidy level is used as the female, the cross is more successful than when it is used as the male (Thompson 1930a). However, Hadley and Openshaw (1980) recommended breeders to try crossing their material in both directions. The results obtained from reciprocal tetraploid-hexaploid crosses that involved Ethiopian landrace wheats are reported in the present paper.

Two *T. durum* (6905, 6861) and three *T. aestivum* (6866, 6950, 7052) accessions, all of Ethiopian origin, and two Swedish hexaploid spring wheat cultivars (Sam and Kadett) were used to make the crosses. The chromosome number of each plant used in the crossing was first checked by somatic cell counts. Due to differences in flowering time it was not possible to make all the reciprocal crosses. Sam and Kadett were used only as pollen parents. The crosses were made in the summer of 1987 in a greenhouse at the Institute of Genetics, Lund, Sweden, using the twirl technique. Hybrid grain formation was calculated as a percentage of the total number of seed produced with regards to the number of florets pollinated. From each cross, up to 20 hybrid seeds, together with their parents, were germinated on moist filter paper, then transferred into 16-cm diameter pots and placed in a greenhouse for growth and seed set evaluation in mid-February 1988.

Grain set ranged from 53% to 87% when *T. durum* was used as the female parent, but reached only 24% when *T. durum* was used as the male (Table 1). The tetraploid-hexaploid crosses gave percentages comparable to those of the hexaploid x hexaploid crosses.

Bigger seeds were obtained when *T. durum* was the seed parent, while the reciprocal hybrids, as a whole, gave shrivelled seed with reduced germinability. Some of the shrivelled seed, even if they germinated, only formed a coleoptile. Others gave one or two seminal roots, which were very short and thick. This caused difficulties in collecting root tips for chromosome counts. To a lower degree, these abnormalities were also observed in the hybrids with the tetraploid as the seed parent.

In both reciprocal crosses, there was variation in the number of days to germination and the young F_1 seedlings' growth, even with the same cross. The results

Table 1. Seed set results from crosses involving *T. durum* and *T. aestivum*.

Cross	Number of pollinated florets	Seed set (%)
(4x) x (6x)		
6905 x 7052 a*	94	87
6905 x 6866 b	346	53
6905 x 6950 c	42	71
6905 x Sam	22	86
6905 x Kadett	118	75
(6x) x (4x)		
7052 x 6905 a	108	24
7052 x 6861	228	4
6866 x 6905 b	224	12
6866 x 6861	20	5
6950 x 6905 c	28	0
6950 x 6861	282	6
(6x) x (6x)		
6866 x Sam	608	67
6866 x Kadett	377	67
7052 x Sam	384	68
7052 x Kadett	490	68

* Crosses followed by the same letter are reciprocals.

of the seed set and the characteristics of the hybrid seeds are in agreement with those of Thompson (1930b). However, a further study is needed to conclusively show that using the hexaploid as a mother provides a clear advantage in the germinability of the F_1 seed over using the tetraploid as a female.

In gross morphology, the F_1 plants showed no differences within each reciprocal cross, indicating that the cytoplasm had no significant effect on hybrid morphology. Regardless of the direction of the cross, all the F_1 progenies were highly sterile. This was also true for hybrids of other tetra-hexaploid reciprocal crosses tested at Debre Zeit, Ethiopia, in 1989 (Getachew, unpublished).

Results of this study indicate that it is possible to obtain enough initial seed material from the tetraploid-hexaploid crosses. Meanwhile, a search for more compatible genotypes that can give healthy F_1 seeds is important. Backcrossing may be necessary to overcome the fertility problem of the hybrid progenies.

Acknowledgement

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Field Crop Response to Phosphorus

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While P deficiency is extensive in the semiarid North Africa-West Asia zone, crop response varies with soil type. This response is influenced by environmental conditions and the amount of previously applied P, which tends to build up in the soil (Ryan 1983). Despite the voluminous research literature on soil P (Khasawneh *et al.* 1980), many aspects of its behavior are as yet unclear.

For dryland rainfed areas of the Mediterranean zone, whose soils are invariably calcareous, P availability can be reliably estimated by the $NaHCO_3$ or Olsen extraction procedure (Fiedler *et al.* 1987; Azzaoui *et al.* 1989). Several years of field research involving various national soil fertility scientists in the region has culminated in the conclusion that about 5 ppm generally separates responsive from nonresponsive soils (Pala and Matar 1987; Soltanpour *et al.* 1989). Numerous field trials with rainfed wheat in Morocco established that no crop response will occur where soil P test levels exceed this range (Abdel Monem *et al.* 1988).

Despite the general consistency of the $NaHCO_3$ test to predict crop response, exceptions occur; these are mainly related to environment, particularly rainfall. Low relative responses to P have been observed in wet years, while relative response to P seems higher in dry years (Matar 1977; Soltanpour *et al.* 1989).

The objective of this study was to examine the response to P of Saada, a potentially important new wheat variety in Morocco because of its Hessian fly resistance.

The soil for this trial was a fine, mixed, thermic, shallow Petrocalcic Palexeroll previously planted to barley. The $NaHCO_3$-P level was 4.0 ppm, i.e., less than the critical level. The P treatments were 0, 15, 30, and 60 kg/ha hand-broadcast as triple superphosphate, with a basal dressing of 120 kg N in each plot (5 x 1.8 m). Broadcasting was used as it is the common practice in the region. The design was a Latin square with four replications. Saada wheat (*Triticum aestivum*) was planted by drill at 69 kg/ha. Weeds were subsequently controlled by Cetrol H. Growth and rainfall were monitored throughout the growing season (14 November–2 June) and yield was estimated from harvesting 2-x-5-m rows.

The postplanting period was characterized by lower than normal rain, which was erratically distributed. Only 25 mm was received in December. The period of tillering was even drier, with only one rain of 7 mm in January, and another of 10 mm on 11 February. In late February, 26 mm fell. March had good rains (77 mm), as did April (88 mm). Thus, the growing season was one of early drought followed by rain which permitted eventual satisfactory crop yield.

Crop growth at the tillering to stem-elongation stages indicated visual differences due to P fertilization. Growth appeared to increase up to the highest P rate. However, following the onset of favorable rains, differences due to P became less evident during the heading and ripening stages. There was no significant response to P in terms of either dry matter or grain yield (Table 1), though a trend existed.

Table 1. Effect of P fertilization on Saada wheat yield.

P level (kg/ha)	Total dry matter	Grain (t/ha)
0	3.20	0.78
15	3.39	0.84
30	3.39	0.85
60	3.70	0.88
LSD 5%	0.67	0.21

The data from the trial, in fact, raised more questions than they answered. The first discrepancy was the absence of a clear-cut crop response when the soil test level was below the critical value. In the study of Soltanpour *et al.* (1989) using Nesma, responses occurred with such low levels of soil P.

The reason for the apparent disappearance of a crop response to P is still unclear. Though the early response during the dry period maybe due to a stimulating effect of P on plant roots, and therefore on crop growth and development, one cannot discount mineralization of organic P as a result of the warm, dry period. However, no soil measurements of available P were taken during the season. Detailed studies are planned to clarify the impact of soil moisture and other factors on crop response to P fertilizers.

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Response of Bread Wheat To Phosphorus Fertilization Under Sprinkler Irrigation

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Earlier phosphorus fertilization trials at Salalah, southern Oman, with the bread wheat cultivar Mexipak indicated that the application of 60 kg P_2O_5/ha would give maximum yields (Anonymous 1979, 1983). However, this was the maximum level of phosphorus used in the experiments, and it was not clear whether further increases in the P rates would result in higher yields. As examination of the response of more than one cultivar is needed to give a general fertilizer recommendation, a phosphorus fertilization experiment was conducted at Wadi Quriyat in 1988/89 on six bread wheat cultivars.

The six cultivars were Gonnen, Yecoro Rojo (from Saudi Arabia), Sanning, W.Q. 151 and W.Q. 160 (locally bred), and Cooley (check). Four phosphorus levels were used: 0, 30, 60, and 90 kg P_2O_5/ha as triple superphosphate (48% P_2O_5) placed in furrows 5 cm deep before seeding, along with one quarter of the nitrogen dose (100 kg N/ha). One week after seeding, the full dose of recommended potassium level (60 kg K_2O/ha) and another quarter of the recommended nitrogen dose were applied to all the plots. The third quarter dose of nitrogen was applied at the heading stage, and the last was top-dressed at the milky grain stage.

The experiment was laid out in a strip-plot design with four replications and 3-x-3-m plots, each consisting

Table 1. Grain yield (t/ha) of six wheat cultivars in response to four phosphorus levels.

Cultivar	P_2O_5 (kg/ha) 0	30	60	90	Mean yield
Gonnen	1.3	1.4	1.4	1.7	1.4
Yecoro Rojo	1.5	1.7	2.0	2.1	1.8
Sannin	1.8	1.8	1.6	1.8	1.7
Cooley*	0.9	1.5	1.7	1.9	1.5
W.Q. 151	1.6	1.9	1.8	2.1	1.8
W.Q. 160	1.9	1.9	2.3	2.8	2.2
Mean	1.5	1.7	1.8	2.1	1.7

* = Check.

of 15 rows spaced 20 cm apart. Sowing was carried out on 24 November 1988 at a seed rate of 100 kg/ha. The crop was irrigated daily until good germination was observed, and subsequently irrigated with sprinklers once every five days for four hours. Thinning was done two weeks after sowing, and the plots were weeded twice.

The analysis of variance indicated that grain yields among the different P levels were significantly different ($P<0.05$), but differences among cultivars were not.

The response to increasing phosphorus levels was linear and positive (Table 1), suggesting that even 90 kg P_2O_5/ha may not be the optimal dose and that higher levels of phosphatic fertilizers should be considered. This refutes earlier results where the application of 60 kg P_2O_5/ha was believed to give maximum yields (Anonymous 1979, 1983). The trial will be repeated with higher phosphorus levels. Furthermore, the optimum fertilizer dose should be determined based on the cost/benefit analysis of fertilizer application.

The highest yielding entry was W.Q. 160, followed by W.Q. 151, both of which are improved genotypes locally selected at Wadi Quriyat from ICARDA material. This emphasizes the need to survey local selections rather than directly introducing foreign cultivars.

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Response of Wheat to Nitrogen And Phosphorus in Eastern Sudan

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New Halfa Scheme (15°19'N, 38°41'E) is an important wheat-growing scheme in the Sudan. Nitrogen fertilizer is recommended at the rate of 86 kg/ha, but not phosphorus because the soil has sufficient P. Recently, however, it was reported that New Halfa soils have become deficient in P (Salih 1988, unpublished). Also, P application in presence of N substantially increased seed yield in other schemes (Ageeb 1987). Some researchers at New Halfa Research Station have previously found a response to P, while others found no response. The objective of this study was to find out if P application is necessary, and to determine the optimum N dose for New Halfa Scheme.

The trial was conducted in 1988/89 at Block 4 (Village 24) in New Halfa Scheme. The wheat cultivar Condor was sown on 30 November 1988. Four N levels (0, 43, 86, and 129 kg N/ha) and 5 P levels (0, 43, 86, 129, and 172 kg P_2O_5/ha) were arranged in a randomized complete block design with four replications. Nitrogen was hand- broadcasted at sowing as urea. Phosphorus, in the form of triple superphosphate, was placed by hand with the seed, as this method proved more effective than broadcasting (Duey 1930, Rudd and Barrow 1973). The wheat crop was sown at a rate of 120 kg seed/ha on a flat seedbed in rows spaced 20 cm apart. All cultural operations were carried out manually from sowing until threshing. The plots were weeded twice and given seven irrigations at 14-day intervals. Yield, yield components, and plant height were studied.

The analysis of variance on grain yield showed that N effects were significant, but P and N x P were not. Yield increased by 76%, 27%, and 8% at each successive N increment (Table 1). Since there was only a small gain in yield beyond the level of 86 kg N/ha, the recommended dose of 86 kg N/ha is still valid for New Halfa.

Although P application effects on grain yield were not significant, grain yield increased by 9% between 43 and 86 kg P_2O_5/ha (Table 1). The highest yield increase (13%) was obtained between 43 and 86 kg P_2O_5/ha with the 86 kg N/ha level. P application did not significantly increase grain yield even with 129 kg N/ha fertilization. Grunes (1959) reported that increased P absorption is a common consequence of adding N fertilizer. However, although the concentration of P in wheat tissue and the rate of P application to the soil were linearly related, the yield and % P were not (Baker and Tucker 1973). Olsen *et al.* (1954) found that a level of 10 ppm $NaHCO_3$ extractable P was adequate for wheat. New Halfa soils are reported

Table 1. **Wheat grain yield (kg/ha) under four nitrogen and five phosphorus rates.**

N levels (kg/ha)	P levels (kg/ha) 0	43	86	129	172	Mean
0	1135	1202	1202	1302	1278	1223
43	1952	2035	2242	2249	2266	2149
86	2361	2523	2856	2963	2992	2739
129	2873	2820	3015	3027	3015	2951
Mean	2080	2144	2330	2385	2389	2266

SE for N = 40; P = 45; N x P = 90

to have 8 ppm available P, which is close to the critical level.

N application significantly increased number of grains/head, weight of grains/head, 1000-kernel weight, number of productive tillers/m^2, number of total heads/m^2, and plant weight. But P application had no significant effect on any of these traits.

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Effect of Irrigation Interval On Bread Wheat Yield and Yield Components in Northern Sudan*

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One of the important agronomic practices affecting grain yield of bread wheat (*Triticum aestivum* L.) in the arid tropics of northern Sudan (16°–22°N) is the irrigation interval. Dafalla and Gabar (1967, 1968) found that considerable increase in yield is achieved with a short watering interval of 7 days, in contrast to intervals of 12 and 17 days. Yield reduction due to a long watering interval was associated with reduced 1000-seed weight. Similar results were reported in different parts of the country (Khalifa 1962–68; El Rayah 1970–75; Akasha 1978). The objective of the present work was to determine the effect of irrigation interval on the yield of a recently released cultivar Wadi El Neel, believed to be drought tolerant (Mohamedali 1987) in comparison to a promising introduction Sakha 69.

The experiment was conducted at Hudeiba Research Station (17°34′N, 33°56′E, and 350 m above sea level) during 1983/84 and 1984/85 seasons. The two cultivars were tested under four irrigation intervals of 7, 10, 14, and 21 days. Since the amount of water was the same for each irrigation, the total irrigation amount differed among the treatments during the same season. A split-plot design with four replications was used, with the irrigation treatments as main plots and the cultivars as subplots. The experimental subplots measured 32 m^2 in the first season and 16 m^2 in the second.

Planting was done by hand in rows spaced 20 cm apart at a seeding rate of 167 kg/ha in the first week of November. Two basal irrigations were given before the differential treatments were followed. A total of 143 kg N/ha was equally split-applied at planting and three weeks later. The plots were kept free from weeds. One

* This work was partially supported by ICARDA/OPEC Wheat Improvement Project, Sudan.

chemical spray against aphids during the third week of January was necessary each season, and there was no disease incidence.

The recorded data included days to 50% flowering and days to maturity besides grain yield. A random sample of 1 m^2 was taken from each subplot prior to harvest to determine the number of heads, seeds/head, and 1000-seed weight.

Differences in grain yield among the irrigation treatment were significant in both seasons (Table 1). The highest grain yield was obtained with the seven-day irrigation interval. Differences between the 7- and 10-day intervals were significant in 1984/85 but not in 1983/84, while differences between irrigation intervals of 10 and 14 days were nonsignificant in both seasons. The decrease in yield with increasing irrigation interval from 7 to 14 and from 14 to 21 days was significant, averaging about 1 t/ha

Table 1. Effects of irrigation interval on yield and yield components.

Irrigation interval	Grain yield (kg/ha)	Heads/ m^2	Seeds/ head wt.(g)	1000- seed	Days to flowering	Days to maturity
1983/84						
7 days	3826	377	42	42.0	59	106
10 days	3287	396	35	41.8	58	104
14 days	2979	404	33	40.9	56	101
21 days	1794	406	19	37.9	53	101
SE ±	374.1^{*}	26.6	$1.2^{\wedge}$	0.82^{*}	1.2	$0.8^{\wedge}$
1984/85						
7 days	3270	561	34	37.3	61	101
10 days	2430	460	30	37.6	58	96
14 days	2280	566	30	38.1	58	98
21 days	1361	493	26	35.3	55	97
SE ±	$207.1^{\wedge}$	35.1	$1.2^{\wedge}$	1.20	$0.5^{\wedge}$	$0.8^{\wedge}$

$*$ = Significant at $P<0.05$.
$^{\wedge}$ = Significant at $P<0.01$.

Table 2. Yield and yield components of the two bread wheat cultivars.

Cultivar	Grain yield (kg/ha)	Heads/ m^2	Seeds/ head	1000- seed wt.(g)	Days to flowering	Days to maturity
1983/84						
Wadi El Neel	3414	401	39	39.4	63	108
Sakha 69	2529	390	25	41.9	50	98
SE ±	209.3^{*}	10.5	$0.98^{\wedge}$	$0.47^{\wedge}$	$1.1^{\wedge}$	$0.6^{\wedge}$
1984/85						
Wadi El Neel	2677	516	35	36.5	60	100
Sakha 69	1993	523	24	37.6	55	96
SE ±	$127.4^{\wedge}$	22.8	$0.8^{\wedge}$	0.70	$0.3^{\wedge}$	$0.5^{\wedge}$

$*$ = Significant at $P<0.05$.
$^{\wedge}$ = Significant at $P<0.01$.

in each case. It is evident that in such arid conditions, if water availability is not a problem, it is advisable to irrigate frequently, which is the traditional practice in the numerous small farms irrigated with underground water. However, in the state farms the irrigation interval often reaches more than 21 days, due to several handicaps, and consequently yields are about one-third of those obtained in the small farms.

Days to flowering and maturity decreased with increasing the irrigation interval (Table 1). The number of heads/m^2 was not affected by the irrigation treatment, but seeds/head differences were highly significant ($P<0.01$). Prolonging the irrigation interval resulted in reduced number of seeds/head. The same effect was observed on 1000-seed weight in 1983/84.

Yield differences between the two cultivars were significant in both seasons (Table 2). However, the interactions between variety and irrigation interval were nonsignificant ($P<0.05$). Wadi El Neel yielded consistently higher at every irrigation treatment than Sakha 69. Comparatively, 1983/84 season was cooler, hence yields were higher.

Wadi El Neel needed significantly ($P<0.01$) more days to reach heading and maturity than Sakha 69 (Table 2). The two varieties also differed significantly in seeds/head and 1000-seed weight in 1983/84, and in seeds/head in 1984/85. The recently released Wadi El Neel appeared to derive its yield advantage from the high number of seeds/head.

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Recent Publications

Srivastava, J.P. and Damania, A.D. (eds.). 1990. Wheat genetic resources: meeting the diverse needs. John Wiley, Baffins Lane, Chichester, West Sussex, England. 411 pp.

This book is a collection of papers presented at an international symposium on wheat genetic resources, held at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, in May 1990. The papers describe worldwide efforts to evaluate and utilize the stocks of wheat germplasm held by genebanks. They discuss the problems of managing and evaluating large collections of germplasm, the statistical techniques that can be used to improve the reliability of results, and the recent advances in cytogenetics that can be applied to increase the efficiency of both evaluation and plant breeding efforts, facilitating the process by which valuable genes can be located and transferred between species. The book is divided into four parts: (i) evaluation of biodiversity, (ii) evaluation constraints and germplasm networks, (iii) research at national genebanks, and (iv) utilization for diverse needs.

Scharpenseel, H.W. (ed.). 1990. Soils on a warmer earth. Effects of expected climate change on soil processes, with emphasis on the tropics and subtropics. Elsevier, Amsterdam, The Netherlands. 274 pp. ISBN 0-444-88838.

This book contains the proceedings of an Internatinonal Workshop on Effects of Expected Climate Change on Soil Processes in the Tropics and Subtropics, Nairobi, 12–14 February 1990. This book should attract great interest, both in developed and developing countries. Although the question of climate change and its effects on soil productivity is overshadowed by so many current events, it is almost certain that this subject will remain on the international agenda for the years to come, not only as science and research are concerned, but also in relation to development policies, agricultural policies, and others, especially since poor and rich, developed and developing countries are equally threatened by these problems.

Cereal News

Sudan Travelling Workshop. Drs G. Ortiz-Ferrara, ICARDA-based CIMMYT Cereal Breeder, and R.H. Miller, Cereal Entomologist, ICARDA, attended the ARC-ICARDA travelling workshop held in Sudan 3–11 February 1990. Two participants from Egypt and one from Ethiopia attended the cereal aspect of the workshop. Dr Kohli, CIMMYT-Paraguay, also joined the group. On-farm and researcher-managed trials were visited and results of the ICARDA-ARC Nile Valley Regional Project (NVRP) were very encouraging. Sudan grew 620,000 feddans (one feddan = 4200 m^2) of bread wheat during 1989, and the yield potential of some farmers' fields is up to 6 t/ha.

Biometry Training Course. A training course on biometrical techniques for cereal breeders was jointly conducted at ICARDA headquarters, Tel Hadya, Aleppo, from 4 to 22 February 1990 by the Cereal Improvement Program and the Computer Services of ICARDA. Nine researchers from NARS participated in the course and gained useful knowledge in breeding and/or biometry, as well as training at the MS level. The course reviewed the major experimental designs used by cereal breeders, as well as the concept, measure, and interpretation of heritability, genotype-environment interactions, varietal stability, and other genetic and environmental factors influencing selection efficiency. An important part of the schedule was devoted to computer applications.

Dr Byrd Curtis, ICARDA-based CIMMYT Cereal Breeder, visited Cairo from 15 to 20 February 1990, where he was involved as the CIMMYT representative in the preliminary work plan development for a new joint venture of Egypt/CIMMYT/ICARDA. This is yet another action whereby CIMMYT and ICARDA have joined forces within the WANA region. Just prior to his trip to Cairo, Dr Curtis visited the CIMMYT scientists in Ankara to discuss plans for winter and facultative wheat breeding for the current crop year.

Dr R.H. Miller toured sites in Middle Egypt and near Ismailia 11–16 February 1990 with scientists at ARC, Giza. A high incidence of BYDV symptoms was observed on wheat and barley in Giza, and populations of birdcherry oat aphid were extremely high near Sids Research Station. Barley planted under pivot irrigation near Ismailia was infested with corn leaf aphids.

Dr M. Nachit, ICARDA-based Durum Wheat Breeder from CIMMYT, visited the Jordanian national program 3–7 February 1990. Along with NCARTT scientists, he visited Irbid, Ramtha, and Moshaqqer stations, where selections were made for cold tolerance with the University of Jordan.

Dr M. Tahir, Cereal Breeder, ICARDA, travelled to Algeria from 11 to 18 February 1990 and visited Setif, Tiaret, and Algiers agricultural research stations to discuss research and production constraints to cereal production in mountainous regions of Algeria. In addition to the well-known problems of dryland regions, he observed, for the first time in the region, a widespread attack of Russian Wheat Aphid (*Diuraphis noxia*) on wheat and barley. RWA was also found on wheat and barley volunteers in fallow fields.

Dr Mohamed El-Hadi Maatougui, Director, ITGC Station, Sidi Bel Abbas, Algeria, visited ICARDA's Cereal Improvement Program 23–27 February 1990. He spent most of his time observing cereal research facilities and field plots at Tel Hadya, Breda, and Bouider. He met all cereal scientists at the Center and enjoyed exchanging information on wheat and barley research and results at Sidi Bel Abbas and Aleppo. He said he was impressed with the diversity of the activities undertaken in the Program and the methodologies used for developing and identifying germplasm tolerant to drought and cold. He also spent time reviewing the training opportunities at the Program in conjunction with the joint collaborative workplan.

Ms Antonella Grillo and Mr Rudi Petti spent a month and a half at ICARDA, March/April 1990. The main objective of their visit, which came within the framework of collaboration between the University of Perugia and ICARDA, was to summarize the results of their work in the special project 'Improving Yield and Yield Stability of Barley in Stress Environments.'

Dr N.P. Bhal, Assistant Director General, ICAR; Dr R.S. Rana, Director, NBR; and Mr H. Lal, Assistant Secretary, ICAR, visited ICARDA 5–11 March 1990. They exchanged scientific information pertaining to barley research in India with the Cereal Improvement Program scientists, and discussed strategies for barley improvement in rainfed, low-rainfall areas and in mountainous regions. The joint CIMMYT/ICARDA wheat activities in WANA were also highlighted, and a keen interest was expressed by the delegation in research on dryland wheat.

Mr M.S. El-Gharbi, Durum Wheat Breeder, INAT, Tunisia, visited ICARDA 14 February–7 March 1990. During his stay, he participated in the specialized course on 'Biometrical Techniques for Cereal Breeders' and benefitted thereafter from individual training on data analysis and interpretation under the guidance of Drs H. Ketata and S.K. Yau. Mr El-Gharbi brought with him NARS data from durum wheat varietal and agronomic experiments conducted over three years at several sites in Tunisia. He also spent some time with Dr M. Nachit and learned the techniques devised in the Cereal Program's durum wheat project for developing germplasm with adequate levels of tolerance to prevailing stresses in WANA.

Dr Luo Shuzong, from the Zheijang Academy of Agricultural Sciences, China, visited ICARDA for four months, during which he was involved in the barley breeding activities.

Drs Fathi Farag El-Sayed and Nabil Suleiman Hanna from ARC-Giza, Egypt, joined the Cereal Improvement Program as Visiting Scientists from 20 March to 10 May 1990 and from 20 March to 30 May 1990, respectively, to work on wheat breeding and wheat physiology.

Cereal Disease Methodology Course, 20 March–4 April 1990. Thirteen researchers from eight countries (Afghanistan, Algeria, Egypt, Libya, Morocco, Oman, Syria, and Yemen) participated in this course, which focused on techniques and methodologies for assessing disease resistance of barley and wheat germplasm. The major part of the course was devoted to practical sessions and visits. Instructors included Dr A. El-Ahmed, Aleppo University, Dr E.E. Saari, CIMMYT-Turkey, and scientists from the Cereal Improvement Program of ICARDA.

Drs R.H. Miller and Byrd C. Curtis participated in the Nile Valley Regional Project's wheat travelling workshop in Egypt, 18–24 March 1990. Dr Salvatore Ceccarelli joined a similar workshop on barley, but in different areas. After Egypt, Dr Miller visited the insect research program in Cyprus and Dr Ceccarelli travelled to Morocco and Algeria to inspect on-going barley research. The cereals workshop in the Nile Valley focused on cereal production expansion in the dry areas of the northern coast. Water harvesting is a key feature of this expansion, and research is underway to identify improved germplasm of wheat and barley for these conditions of extreme stress. A secondary focus was on intensification of production on the irrigated lands of the Nile, particularly the crop rotation of wheat and cotton, rice and wheat, etc. Earlier maturity of the crops and the adoption of cultural practices allowing no-till in the rotations are paying off in increased total annual production per unit area.

Dr H. Ketata, Acting Program Leader, Cereal Improvement Program, ICARDA, visited CIMMYT 25 March–2 April 1990, where he met with officials and scientists of the Wheat Program to discuss joint collaborative work in barley and wheat improvement. Dr Ketata was invited to attend the final session of the Board of Trustees meetings at El Batan, and to observe barley, wheat, and triticale nurseries and trials at Obregon. He also visited Oklahoma State University (2–6 April), where he met with OSU scientists, gave a seminar on ICARDA's cereal improvement activities, and discussed collaboration in cereal improvement with OSU and the United States Department of Agriculture, Plant Research Laboratory, Stillwater, Oklahoma.

Dr G. Ortiz-Ferrara travelled to Mexico 25 March–4 April 1990 for his official annual visit to the CIMMYT wheat program. Good progress has been realized in coordinating the bread wheat program of both centers. He also participated in the selection and evaluation of genetic material. Dr Ortiz-Ferrara spent time with the agronomist/physiologist at CIMMYT, where a joint project on line source to screen for simulated drought has been performed. Several drought-tolerant bread wheat lines have been identified through this special project. These lines will soon be made available to NARSs where drought is a problem.

Dr Stefania Grando travelled to Morocco, Tunisia, and Sicily from 20 March to 3 April 1990. During the tour she discussed with national program scientists ongoing barley research and visited barley nurseries in several stations to assess the performance of ICARDA breeding materials in the region.

Dr M. Nachit visited the CIMMYT wheat improvement projects, and the durum and bread wheat breeding programs from 22 March to 7 April 1990. Accompanied by Dr H. Ketata, Dr Nachit also had a look at those branches of CIMMYT working in agronomy and physiology. The aim of the visit was the selection of durum wheat germplasm under reduced moisture and high input conditions, and the development of work plans for 1990/91. During his stay, Dr Nachit also gave a lecture to CIMMYT trainees on breeding for abiotic stress tolerance.

Drs Lynell Tanigoshi and Keith Pike from Washington State University visited ICARDA from 7 to 12 April 1990 as part of an extended Russian Wheat Aphid (RWA) survey and parasite collection trip that included Morocco, Jordan, Syria, and Turkey. Along with Dr Ross Miller, they located infestations of this devastating aphid pest on Ram Farms, near Wadi Ram, in Wadi Musa, and in the Jordan Valley. While travelling with M. Izzat Ghannoum and Dr A. Bushara, they found the aphid at Tel Hadya and near the Euphrates river northeast of Al-Bab. An especially parasite-rich infestation was found in barley planted in terraces at Qatura. In Turkey, the aphids were found outside Ankara. The American scientists reported that the infestation in Annaceur in Morocco was particularly heavy. Parasites were collected from all sites and sent to a special rearing facility at Texas A&M University, where they will be identified and populations increased for subsequent release in RWA infested areas around the world. During his stay at ICARDA, Dr Pike presented a lecture to an entomology short course on the identification of cereal aphids.

Dr Philippe Lashermes, Cereal Biotechnologist, ICARDA, attended the 14th American Barley Research Conference and participated in the US-Canadian barley genome network coordination meeting, held 13–17 May 1990 in Sacramento, California. Dr Lashermes also visited institutions involved in the development and use of the barley genome map. On his way back to ICARDA, Tel Hadya, he stopped at GIS Moulon, Paris, to discuss the collaborative projects on heat shock protein analysis.

Maghreb Cereals Travelling Workshop, 7–13 May 1990. A group of 37 scientists from Algeria, Libya, Morocco, Tunisia, Spain, Portugal, Syria, and Egypt, as well as scientists from ICARDA–North Africa and ICARDA-Aleppo, participated in the workshop. Selection work on wheat and barley was successfully completed at the stations of Merchouch, Fez, and Annaceur. The workshop started at the driest site, Tessaout, and ended at the high elevation station of Annaceur. During the last day, the group members exchanged views on their respective research strategies and on ways to further cement ICARDA-Maghreb cooperation.

This workshop was preceded by the disease and insect survey of Algeria and Eastern Morocco that covered around 4000 km^2. In addition to Algerian scientists, Dr Hachett (a world leader on Hessian fly research), Dr Amri (also known for his breeding work for Hessian fly resistance), and Dr Mekni participated. The survey highlighted the effectiveness of combining field survey and training, as two junior research scientists participated in this activity. Encouraged by this first experience, the Maghreb scientists have planned a cereal disease and insect course for the benefit of junior researchers from all Maghreb countries, to be carried out next year in Constantine Wilaya, Algeria.

Dr B.C. Curtis visited Quetta, Pakistan, 11–12 May 1990. During his stay he obtained much information on the cereal growing environments and the problems of agricultural research there. Agreements were made for screening CIMMYT/ICARDA winter and facultative wheats in Balochistan. Dr Curtis also visited Cairo, Egypt, 18–22 May, where he assisted in developing the 1990/91 Egypt/CIMMYT/ICARDA work plan for wheat and maize.

CIMMYT/ICARDA talks. A delegation comprising Drs G. Varughese, Wheat Program Associate Director; S. Rajaram, Germplasm Improvement Subprogram Leader; and O. Abdullah, Durum Wheat Breeder, arrived in Aleppo to discuss the joint CIMMYT/ICARDA spring wheat nurseries within the context of the collaborative agreement between CIMMYT and ICARDA signed in 1989. Between 4 and 7 June 1990 two fruitful meetings were held, resulting in a new and more efficient scheme for germplasm movement between the two centers and within WANA. International nurseries consisting of materials selected by scientists of both centers for targeted environments will be sent from Aleppo to national programs in the WANA region starting from 1991.

The CIMMYT Winter Wheat Review Team, consisting of Drs E. Everson, G. Varughese, S. Rajaram, H.L. Wang, K.S. Gill, and B. Susen, spent two busy days at ICARDA before travelling to Turkey. At Tel Hadya they visited the fields of winter/facultative wheat, and held detailed discussions with Drs B.C. Curtis and M. Tahir.

Dr G. Ortiz-Ferrara visited the Soviet Union from 5 to 13 July 1990. During his stay, he followed up on the Vaskhenil/ICARDA agreement of cooperation in cereals and food legumes. He participated in the selection and evaluation of wheat germplasm and familiarized himself with the research activities carried out at the Agricultural Research Institute of the South East Region (NPO "Elita

Povolzhie"). Dr Nikolai S. Vassiltchouk, Wheat Breeding Leader, and former visiting scientist to ICARDA, accompanied him through his visits to Vaskhenil, Saratov, and Kraschnikvt Institutes. Academician V.S. Shevelvkha, President of Vaskhenil, ratified the agreement and expressed his desire to amend it to include cooperation in biotechnology, and to see a more dynamic exchange of visits between scientists of both institutions.

Drs Salvatore Ceccarelli and Byrd Curtis visited Rumania 14–18 July 1990 to discuss needs and expectations of the Rumanian national agricultural research organization, who would like to enter into an agreement with ICARDA for future cooperation. During the trip, a better understanding of Rumania's agriculture was obtained. There are about 10 million ha of arable land, with rainfall ranging from 400 mm in the east to 650 mm in the west. Wheat, 99% winter, occupies 2.3 million ha, and barley, 92% winter, and mostly two-row, occupies 0.7 million ha. They are the most important winter grown cereals in the country.

Dr M. Nachit departed 15 August 1990 to Cornell University, Ithaca, New York, to spend his sabbatical during which he will analyze accumulated research data, study genotype x environment interaction using durum wheat genotypes grown in WANA, write scientific papers, and get acquainted with new biotechnologies.

Drs H. Ketata and S.K. Yau attended the annual coordination meeting at ARC, Wad Medani, Sudan, 27-30 August 1990. The meeting was attended by 150 participants from different agricultural institutions in the Sudan, as well as guests from Egypt and Ethiopia. Around 30 wheat-related papers were presented, covering on-farm testing and demonstration, agronomy, breeding, diseases, insects, socioeconomic studies, as well as other topics. After review and discussion of the 1989/90 results, the Sudanese researchers presented their 1990/91 plans.

Dr G. Ortiz Ferrara, Dr S. Ceccarelli, and Ir J. van Leur attended coordination meetings in North Africa 17–26 September 1990, where research results and future collaboration plans were discussed. Algeria reported that the latest released bread wheat variety Zidane 89, introduced from CIMMYT/ICARDA international nurseries, yielded 18% higher than the main local variety under less than 300 mm rainfall. This variety was released in 1989 by the national program after being tested for three consecutive years under farmers' conditions. The Algerians have requested ICARDA's support in providing seed of other promising bread wheat, durum, and barley lines.

Second coordination meeting in Libya, 23-26 September 1990. The ICARDA-ARC meeting, held in Tripoli, was very well planned by Dr M. Black, head of the center, and widely publicized in the higher spheres of the General Secretariat for Agriculture. Messrs Suleiman Sebaii, Attia Gwettin, Ali Shreidi, and Ahmed Zentani from ARC Tripoli, and Dr M. Mekni from ICARDA were all very pleased with the first year's results. Om Rabia 5 durum wheat, and Rihane and Harmal barleys have become the standard checks. Eight of the 10 barley lines provided by ICARDA performed very well in on-farm trials.

A specialized short-term training course "Use of Electrophoresis in Cereal Improvement" was conducted jointly between Cereal Improvement Program and the Genetic Resources Unit at ICARDA 15–25 October, 1990. The course, which was sponsored by the University of Tuscia and ICARDA, attracted eight trainees: Cyprus (1), Iran (1), Pakistan (1), Syria (2), Turkey (1), and ICARDA (2). Two experts from Italy, Professor D. Lafiandra and Mr G. Colaprico, provided most of the lectures and practical demonstrations, respectively. Senior staff of ICARDA also participated as instructors. The trainees profited in learning the latest uses and techniques in electrophoresis.

Forthcoming Events

International Symposium on Physiology and Determination of Crop Yield, Gainesville, Florida, 10–14 June 1991. Internationally recognized authors will present state-of-the-science papers giving an integrated understanding of physiological processes which contribute to crop growth and yield. These papers will be followed by extensive discussion periods, including voluntary posters sessions. Four topics areas include (i) Growth and development: germination and seedling establishment, root growth and establishment, leaf and shoot growth, seed growth, and crop ontogeny and development; (ii) Metabolism: photosynthesis and C assimilation, respiration and use of assimilates, N_2-fixation, N metabolism, and nutrient uptake and plant nutrition; (iii) Environmental Challenges: drought, heat, cold, increased CO_2, and air pollutants; and (iv) Physiological challenges: limits to crop yield, low input crop production, genetic opportunities, biotechnological opportunities, and modeling genetic yield potential. Sponsors of this symposium are the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. To request registration forms and program information, contact Dr K.J. Boote, Agronomy Department, University of Florida, Gainesville, FL 32611 (904-392-1811; FAX 904-392-1840).

Cereals International 91, Brisbane, Queensland, 9–13 Sept 1991. This international cereal chemistry conference will be held under the sponsorship of the Cereal Chemistry Division of the Royal Australian Chemical Institute. It will incorporate meetings of the International Association for Cereal Science and Technology and the American Association of Cereal Chemists, as well as the 41st Annual Australian Cereal Chemistry Conference. The conference will provide an overview of current and future directions of cereal science and the latest cereal chemistry research, as well as the opportunity to make contact with leading cereal chemists. Further information can be obtained from: Cereal Conference Secretariat, Uniquest Limited, University of Queensland, St Lucia, Qld 4067, Australia.

International Symposium on Grain Ecosystems, Winnipeg, Canada, 7–10 June 1992. The symposium, organized by the Department of Agricultural Engineering of the University of Manitoba, will aim to synthesize knowledge from different areas of grain research and to explore future research directions for optimum management of stored grain ecosystems in the next century. Both scientific and practical aspects of grain storage problems will be emphasized, as well as multidisciplinary studies and, in particular, the development of expert systems in the postharvest arena. A comprehensive program of oral and poster paper presentation is being organized for the conference. For more information contact D.S. Jayas, Associate Professor, Agriculture Engineering, University of Manitoba, Canada; or N.G.D. White, Project Leader, Stored Products, Agriculture Canada Research Station, Winnipeg, Canada.

XIX International Congress of Entomology, Beijing, 28 June–4 July 1992. The congress, which will of interest to postharvest specialists, will be sponsored by the Entomological Society of China. For more information contact Prof Z.L. Zhang, Secretary General, XIX International Congress of Entomology, 19 Zhongguancun Lu, Beijing 100080, China.

First International Crop Science Congress, 14–22 July 1992. The Crop Science Society of America and Iowa State University (ISU) will sponsor this congress, which will be held in the ISU campus.The congress mission is (i) to present and discuss recent research results; (ii) to integrate and apply knowledge from crop science to such issues as biodiversity, sustainable agriculture, cropping systems, global climate change, and the physiology and genetics of crop adaptation and productivity; (iii) to propose future thrusts in research and development; (iv) to examine future scientific and education needs and directions of crop-based agriculture; (v) to initiate and nurture scientific and educational partnerships; and (vi) to contribute a comprehensive, written proceedings from the Congress. The program will consist of plenary sessions, symposia, and voluntary poster papers as well as professional tours organized so as (a) to present knowledge pertinent to crop scientists from all regions of the world, (b) to emphasize integration of knowledge from crop science to solve global and regional problems and issues, and (c) to focus on global research needs. Entertainment, meal functions, recreational and agricultural tours, and opportunities for group sessions will be provided on the Congress program. Further information on the First International Crop Science Congress will be issued during spring 1991. For more information write to Kenneth Frey, Chair, International Crop Science Congress, c/o Agronomy Department, Iowa State University, Ames, IA 50011 USA.

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), m^2.

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 m^2, 4 Mar 1983; 27%; 50 five-day old plants; 1.6 million; 23 µg; 5°C; 1980/81 season; 1981-83; Fig., No.; FAO, USA. *Fertilizers*: 1 kg N or P_2O_5 or K_2O/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
Journal articles: Baker, R.J. and Briggs, K.G. 1983. Relationship between plant density and yield in barley. Crop Science 23(3): 590-592.

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

Articles from books: Zadoks, J.C. and van Leur, J.A.G. 1983. Durable resistance and host pathogen environment reactions. Pages 125-140 *in* Durable Resistance in Crops. Plenum Publications Corporation, New York.

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.

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