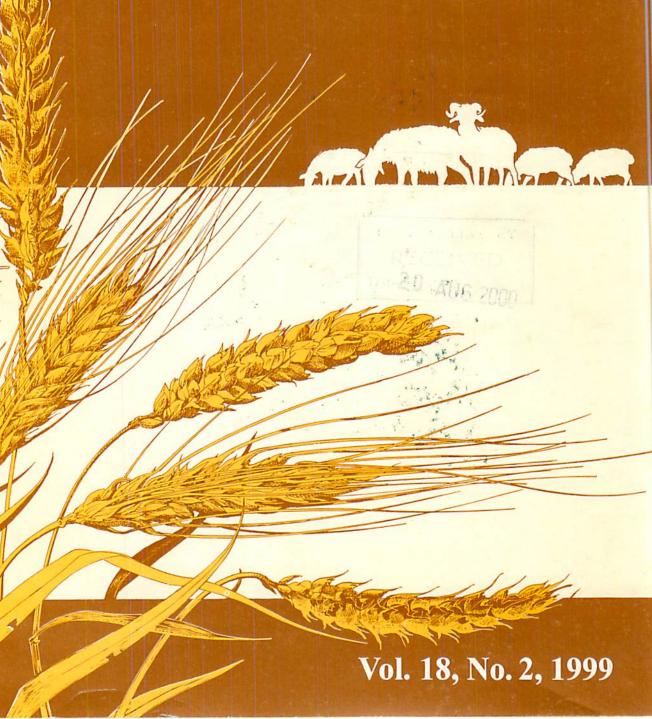


RACHIS

Barley and Wheat Newsletter



About ICARDA and the CGIAR



Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West and Central Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.



The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from a wide variety of country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South-North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

RACHIS

Vol. 18, No. 2, 1999

Barley and Wheat Newsletter

This is the last issue of RACHIS. The ICARDA management regrets to announce that RACHIS, the barley and wheat newsletter published half-yearly by the International Center for Agricultural Research in the Dry Areas (ICARDA), will cease publication after this issue. This newsletter has served the information dissemination needs of wheat and barley researchers from all over the world, particularly those in West Asia and North Africa, since 1982/83, and we have always appreciated the interest of contributors and readers of RACHIS, but financial constraints now stand in our way to continue to produce this newsletter.

The articles in process for future issues will be returned to their authors soon. We regret the inconvenience this may cause, and greatly appreciate the understanding of our cooperators, contributors, readers, and friends all over the world.

Technical Editor

S. Ceccarelli

Technical Reviewers

J. Valkoun

M. Baum

E. de Pauw

S. Grando

T. Pavne

M. Pala

J. Ryan

V. Shevtsov

A. Yahayoui

F. El-Haramein

J. Araus

M. Singh

H. Ketata

Editor

C. Mosquera

Arabic abstracts

Majdi Kebbeh

Typesetting:

Nuha Sadek

CONTENTS

GENERAL ARTICLES

- 1 Workshop on Farmer Participatory Research
- The ICARDA Strategy for Global Barley Improvement S. Ceccarelli, S. Grando, V. Shevstov, H. Vivar, A.Yahyaoui, M. El-Bhoussini and M. Baum

RESEARCH AND PRODUCTION

- 13 Commercial Heterosis in Wheat: An Overview V. Mahajan, S. Nagarajan, M. Srivastava, V. Kumar and N.V.P.R. Ganga Rao
- -17 Path Coefficient Analysis and Correlation of Grain Yield and Yield Components of Wheat (*Triticum aestivum* L.)
 Genotypes
 - T. Dokuyucu and A. Akkaya
- · 21 Gene Effects Controlling Yield Components in Barley (Hordeum vulgare L.)
 - S.C. Vimal and S.R. Vishwakarma
- 25 Early Generation Testing for Isolating the Most Promising Crosses in Bread Wheat
 - E. Gouli-Vavdinoudi and M. Koutsika-Sotiriou
- 31 Phenotypic Diversity among Wheat Landraces from Jordan: Morphological and Developmental Traits

A.H. Abdel-Ghani, M. Duwayri and O. Kafawin

- 38 Prevalence of Karnal Bunt in Wheat Seed Lots in Pakistan A.R. Bhutta, A. Hussain and I. Ahmad
- 43 Variation in Local Genotypes of Durum Wheat Collection (*Triticum durum* Desf.)

K.D. Kolev and S.D. Stoyanova

46 Effect of Presoaking Seed Treatment on Germination and Amylase Activity of Wheat (*Triticum aestivum* L.) under Salt Stress Conditions

N.K. Roy and A.K. Srivastava

51 A Germination Bioassay to Test the Allelopathic Potential of Barley'

M. Ben-Hammouda and O. Queslati

55 Recovery of Heat-Induced Heat Shock Proteins and Evidence of the Binding of Some Small Molecular Weights to the Thylakoid Membranes in Wheat

H. Ouabbou and G.M. Paulsen

60 Evaluation of Exotic and Indigenous Barley Accessions for Resistance against Indian Pathotypes of Puccinnia striiformis hordei

J.R. Yadav and J. Kumar

64 Promising Durum Wheat Genotypes under Normal and Stress Growing Conditions in Northern Sudan A.I.S. Mohamed

66 Seed-Borne Pathogens of Wheat in Pakistan

A.R. Bhutta and S.A. Hussain

69 Genetic Divergence in Facultative and Winter Wheat Germplasm

L. Kant, V.P. Mani and V.S. Chauhan

72 Sustaining Barley Yield by Early Planting and Grazing

S.K. Yau

75 Effect of Leaf Area Removal on Grain Yield and its Components in Spring Wheat

M.A. Chowdhry, N. Mahmood, T.R. Rashad and I. Khaliq

79 Gene Effects for Yield and its Components in Wheat

R.K. Yadav and V.G. Narsinghani

82 Allelopathic Effect of Lantana camara L. on Wheat var. Sujata

P. Oudhia and R.S. Tripathi

SHORT COMMUNICATION

85 First Steps in Barley Improvement in Armenia

A. Petrosyan, R. Kazaryan, E. Melikyan, D. Epremyan and V. Shevstov

CEREAL NEWS

- 87 Forthcoming Events
- 89 Recent Literature
- 91 Agricultural Libraries Receiving ICARDA Publications

ICARDA Publications and Services

General Article

Workshop on Farmer Participatory Research

A Workshop on Farmer Participatory Research (FPR) was held at the International Center for Agricultural Research in the Dry Areas (ICARDA) in Aleppo, Syria, from 6-11 May 1999.

The Workshop was co-sponsored by the Islamic Development Bank, the Food and Agricultural Organization (FAO), the System-wide Program on Participatory Research and Gender Analysis (SWP PRGA) and ICARDA.

The Workshop was officially opened by Prof. Dr A. El-Beltagy, Director General of ICARDA. He underlined the significance of having such a workshop in the area where agriculture began several thousand years ago. He pointed out that there are numerous research activities conducted at ICARDA in collaboration with different national programs that directly involve farmers. FPR has become one of the strategic pillars of ICARDA's present and future research approaches. He indicated the wide range of variation of farmer participation, its types and objectives. ICARDA is currently implementing several participatory plant breeding projects. However, many scientists in the region are not aware of this research approach. Similarly, several Natural Resource Management Projects use farmer-participatory approaches yet there have been few opportunities for interaction among researchers. Many scientists think that farmer participation holds the key to succeed in research, particularly in dry environments where environmental variations and associated risks in agriculture require technologies to be better adapted than in more favored ecosystems. Since farmer-participatory research is based on the involvement of people (men and women) with different interests and stakes in which type of technology is designed, those who have espoused farmer-participatory research are becoming increasingly aware of the need to bring different types of stakeholders into the research process.

During the opening session, Dr J. Dodds, Assistant Director General Research (ICARDA) congratulated the organizers for assembling such a large number of scientists from 16 countries and thanked the donors for supporting the initiative. Representatives of the three major sponsors of the workshop, namely Dr J. A. Ashby, Director of the Natural Resource Management Program at the International Center for Tropical Agriculture (CIAT) and coordinator of the SWP

PRGA, Dr D. Cooper (FAO), and Dr A. Al Journaih (Technical Cooperation Office of the Islamic Development Bank) made also remarks about this project.

The objectives of the Workshop were to generate interest towards FPR and to promote its use as a new research strategy by providing researchers from a number of countries with a forum to discuss and exchange ideas about farmer participation. A number of recommendations resulted from the Workshop. Presentations and discussions will be published later for practitioners and policy makers.



To reach its objective, the Workshop was structured in four components:

- 1. Formal presentations.
- Participation in farmer selection, both in a farmer's field representing the dry areas of Syria and in a research station.
- 3. Discussions with farmers.
- Perspectives for participatory research in various countries.

There were 10 formal presentations:

Principles of Farmer Participation

J. Ashby, CIAT, Colombia

Participatory Research in Plant Breeding at ICARDA

S. Ceccarelli, ICARDA, Syria

Participatory Natural Resource Management at ICARDA

A. Aw-Hassan, ICARDA, Syria

Farmer Participation in Barley Breeding in Morocco

A. Amri, INRA, Morocco

Participatory Plant Breeding in Tunisia

M. El Felah, INRAT, Tunisia

Participatory Plant Breeding in Yemen

Z. Abedin and A. Lutf, AREA, Yemen

Participatory Variety Selection in Ecuador

O. Chicaiza, INIAP, Ecuador

Gender Differences in Barley Grain and Spike Assessment

F. Nassif, INRA, Morocco

Participation and Gender

M. Fernandez, CIAT, Colombia

Participatory Integrated Pest Management

P. Kenmore, FAO, Italy

The participants traveled to Bylounan, a village in Raqqa Province that received only 162 mm rainfall at the time of the visit. A large group of farmers welcomed the participants who visited one of the trials conducted in the framework of a Participatory Barley Breeding Project supported by the German Agency for Technical Cooperation (GTZ), while the farmers did the selection.





The farmers were also invited at Tel Hadya (ICARDA's headquarters) to select from trials planted in the research station and to participate in a discussion with the scientists attending the Workshop.



The perspectives for participatory research in various countries were presented as country reports by scientists from Turkey, Mauritania, Algeria, Libya, Egypt, Pakistan, Jordan, Iraq, Iran, India, China, and Eritrea.



Eventually, the following recommendations were formulated during the Workshop:

- The methodology in Participatory Research should take diversity into account and must be adaptable to specific conditions.
- 2. Farmers should be exposed to a large range of options.
- The sustainability of the process requires stakeholders groups from the community to participate, to consider external stakeholders, and to address cost sharing as one of the many aspects.
- 4. Explore ways of reinforcing existing local systems of seed production and distribution, while encouraging and supporting farmer-producers who have links with sources of new material to emerge as alternative suppliers of quality seed and maintain close and trustworthy relationships with the seed-using community.
- Attempts to introduce certification should be based on real needs and standards that are realistic and achievable and within the capacity of the farmers to manage and sustain
- 6. Where applicable, legal issues of variety release and

- property rights should be made flexible so as to enhance rather than impede farmers' access to, and use of improved seed.
- From the beginning of the Participatory Research, social, physical and biological disciplines and concepts should be involved so the complexity of the system is adequately reflected.
- Indigenous knowledge and traditional rights should be considered and engaged as the core of any partnership between researchers and farmers on equal basis.
- Socioeconomic and technological impacts of both the technologies and the processes developed through Farmers Participatory Research must be assessed.
- 10. A Network on participatory research should be established at a regional level including farmers, researchers, extensionists and trainers. The Network should focus on:

- · sharing experiences
- · education and training
- · elaboration of a newsletter
- elaboration of a program for information to policy makers
- organization of an international workshop on Participatory Research attended predominately by farmers.

The Workshop was attended by 34 scientists from Algeria, China, Ecuador, Egypt, Eritrea, Jordan, India, Iran, Iraq. Libya, Mauritania, Morocco, Pakistan, Tunisia, Turkey, Yemen, representatives of the Islamic Development Bank, Istituto Agronomico per l'Oltremare, Firenze (Italy), FAO. (Italy), DANIDA (Denmark), GTZ, (Germany), CIAT (Colombia), and IPGRI (Italy), together with ICARDA scientists.

The ICARDA Strategy for Global Barley Improvement

S. Ceccarelli, S. Grando, V. Shevstov, H. Vivar, A. Yahyaoui, M. El-Bhoussini and M. Baum International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, SYRIA

1. The Crop

Barley (Hordeum vulgare L. emend. Bowden) was domesticated about 10,000 years ago in the Fertile Crescent of the Near East, at sites not far from where ICARDA headquarters are located today, from wild forms morphologically identical to present-day Hordeum sponta-

neum. The main difference between cultivated barley and *Hordeum spontaneum* is the fragile (brittle) rachis of the wild progenitor.

From this origin, barley is now grown over a broader environmental range than any other cereal, from 70°N in Norway to 46°S in Chile. In Tibet, Ethiopia, Eriteria, Yemen and the Andes, it is cultivated on the mountain slopes higher than other cereals. Barley is considered to be a drought resistant crop, and in many dry areas of North Africa, West Asia, Afghanistan, Pakistan, Eritrea, Yemen, and other countries, it is often the only possible rainfed crop.

Today, barley is grown on 73 million hectares (average of the last five years) (Table 1). The area has increased from 59 million hectares during the period 1961-65 to a maximum of more than 80 million hectares during the period 1976-80. The largest barley growing regions are in Russia, in the Central Asian States (CAS) with almost 29 million

Table 1. Area (million hectares) of barley by region.

Region	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
Africa	4.20	4.33	4.36	4.85	4.93	5.29	5.18
Asia	14.85	12.99	11.72	10.86	11.64	12.48	12.51
N. America	7.04	7.70	8.96	8.07	9.22	8.58	7.23
S. America	1.14	1.04	1.03	0.84	0.56	0.63	0.66
Europe	12.90	15.58	17.79	19.95	19.36	18.15	15.77
Russia + CAS	18.30	20.33	28.37	34.00	30.52	28.50	28.70
Oceania	0.87	1.39	2.15	2.57	3.00	2.31	2.94
World	59.40	63.40	74.47	81.21	79.33	76.04	73.06

Source: Agrostat 1997

hectares, and in Europe where about 15 million hectares are cultivated. There are 25.2 million hectares of barley in developing countries of Asia, including CAS, and Africa.

The world production of barley (Table 2) is about 160 million tonnes (compared with 530 and 29 million tonnes of bread and durum wheat, respectively) with Europe being the largest producer, due to the highest yields (Table 3).

The Canadian Wheat Board (CWB) estimates that barley production will increase by almost 5% by the year 2000 (compared to the average in 1989-93) and by 10% by the year 2005 (Table 4), while the increase in wheat production will be slightly larger (6 and 12%, respectively). These predictions assume that there are few significant new production technologies on the horizon that might sharply raise grain yields beyond existing trends.

Table 2. Production of barley (million tonnes) by region.

Region	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
Africa	3.034	3.392	3.800	4.197	4.162	5.412	4.986
Asia	17.296	15.445	14.675	16.080	17.272	18.651	20.244
N. America	12.711	16.316	19.534	19.74	24.346	23,035	21.520
S. America	1.264	1.063	1.194	1.039	0.695	1.004	1.136
Europe	33.777	44.817	57.167	66.800	70,904	71.198	60.567
Russia + CAS	18.693	28.018	39.819	50.77	40.545	48.154	47.213
Oceania	0.978	1.586	2.5766	3.124	4.127	3.672	4.975
World	87.852	110.810	139.037	162.043	162.487	171.5412	161.019

Source: Agrostat 1997

Table 3. Yield of barley (t/ha) by region.

Region	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95
Africa	0.72	0.78	0.87	0.86	0.84	1.03	0.96
Asia	1.16	1.19	1.25	1.48	1.48	1.50	1.62
N. America	1.82	2.11	2.17	2.45	2.64	2.67	2.98
S. America	1.10	1.02	1.15	1.23	1.25	1.58	1.72
Europe	2.60	2.87	3.21	3.34	3.67	3.93	3.84
Russia + CAS	1.02	1.37	1.41	1.51	1.33	1.70	1.64
Oceania	1.13	1.14	1.20	1.22	1.34	1.58	1.66
World	1.48	1.74	1.87	1.99	2.05	2.26	2.20

Source: Agrostat 1997

Table 4. World production of major grains (in million tonnes).

	1989-93 Average	Projections		
	base period	1999/2000	2004/2005	
All wheat	559	593	625	
Durum wheat	29	27	29	
Coarse grains	813	842	910	
Barley	169	177	186	
Total	1570	1639	1750	

Source: Brophy 1996

Barley grain is used as feed for animals, malt and human feed. Barley straw is used as animal feed in West Asia, North Africa, Ethiopia, Eritrea, Yemen, the Andean region and the Far East. Barley straw is also used for animal bedding and as cover material for hut roofs. After combine harvesting, barley stubble is grazed in summer in large areas of West Asia and North Africa. Barley is also used as animal feed at the vegetative stage (green grazing) or is cut before maturity, and either directly fed to the animal or used for silage.

Malt is the second largest use for barley, and malting barley is grown as a cash crop in a number of developing countries. In the highlands of Tibet, Nepal, Ethiopia, Yemen, Eritrea, in the Andean countries, in North Africa, Turkey, Iran, Iraq, Afghanistan, India and Russia, barley is used as human feed either for bread making (usually mixed with bread wheat but also with other cereals or food legumes) or for traditional recipes. In history, barley was the energy food of the masses. Its use as human feed was very popular during the Roman Empire (gladiators, known as *hordeari*, were fed on a strict barley diet before fighting against the lions), and was common in many European countries until the first part of this century.

In many developing countries, barley is typically a crop of less-favored, low input, stressful environments. In many areas of West Asia and North Africa (WANA). Barley is often the only possible rainfed crop, and the last possible crop before the steppe and the desert.

With the exception of China, Ethiopia, and India, developing countries with the largest area of barley are either in WANA or in Central Asia (Table 5). The two main agroecological environments where barley is grown in WANA and Central Asia are the continental dry lowlands mostly with cold winters, and the continental dry highlands with very cold winters. A third agroclimatic environment is represented by the tropical highlands (Andes, Ethiopia, Yemen, Eritrea, Himalayan countries). This is not very large in area but is inhabited by some of the poorest people in the world

Table 5. Area, production and yield (t/ha) of barley in 15 developing countries with the largest barley growing area (data are averages of the period 1991-1995).

Country	Area (million ha)	Production (million t)	Yield (t/ha)
Russian Federation	15.289	24.168	1.58
Kazakstan	5.890	5.936	0.99
Ukraine	4.286	11.950	2.80
Turkey	3.488	7.340	2.11
Morocco	2.180	1.938	0.83
Syria	2.105	1.353	0.65
Iran	1.972	3.074	1.57
Iraq	1.680	1.137	0.67
China	1.290	3.220	2.51
Belarus	1.146	2.953	2.58
Ethiopia	1.053	1.232	1.16
Algeria	1.014	0.878	0.78
India	0.903	1.531	1.69
Lithuania	0.602	1.132	1.88
Tunisia	0.406	0.399	0.87

for whom barley is one of the main sources of calories. In the Andes, barley is the staple food for farmers at altitudes ranging from 2200 to 4000 meters above sea level. Above 3000 meters, barley, faba bean, potato, and quinoa are the four crops that support human and animal life. Barley is used by subsistence farmers in the preparation of several dishes; barley flour, finely ground and roasted called *machica* or *pito*; barley rice, a coarsely-broken grain used for soups and more recently barley flakes used as a breakfast cereal.

In India, barley is grown as a rainfed crop on residual moisture. In many of these situations, barley yields have not significantly increased and vary mostly in response to fluctuations in climatic conditions.

The major constraints to barley production are associated with the reputation that the crop is able to withstand the most severe conditions such as elevation, aridity, salinity, poor soil fertility, and poor agronomic management. Because the risk of crop failures is high in several environments where the crop is grown in developing countries, the use of inputs such as fertilizer, herbicides or pesticide is virtually absent.

In the majority of developing countries, the seed of barley is usually produced on farm. Even in those countries with a more developed seed production and distribution system such as Morocco, only 3% of the barley seeds are certified seeds (compared to 25% and 80% for durum and bread wheat, respectively).

Because of stagnant yields and increased demand due to population growth, substantial import growth is expected (by the CWB) for Latin America, Pacific Asia, West Asia, and Africa (Table 6).

Table 6. World barley imports by regions, in thousand tonnes.

	1989-93 Average	Projections		
	base period	1999/2000	2004/2005	
Europe	1448	650	670	
Former USSR	4940	1130	1010	
Middle East	6469	7440	8440	
Africa	1275	1570	1420	
Pacific Asia	2757	4050	4290	
Latin America	i 580	790	930	
Total	14,132	10,790	11,540	

2. Objective of the Project

The long-term objective of the Barley Improvement Project at ICARDA is a sustainable increase in barley productivity by adapting the crop to different farming systems and uses in developing countries. Special emphasis is being made in those areas where resource-poor farmers grow the crop, and it contributes to the alleviation of poverty.

The specific objectives of the barley project are:

- To collaborate with national programs in germplasm development.
- 2. To strengthen national barley breeding programs.
- To develop a conceptual framework to improve efficiency of breeding in different environments with emphasis on low-input and stressful environments.

These objectives are pursued with strategies which have evolved over the last 20 years and which differ according to the changing research capacity of the cooperating national programs. Initially, the main emphasis was focused on the centralized development of varieties; gradually the program has highly emphasized the development of breeding methodologies. In the last few years, the project emphasized the decentralized selection of segregating populations based on targeted crosses partially designed by NARS.

3. Project Philosophy: Decentralized Breeding

To target the poor, the breeding philosophy of the project is based on exploiting specific adaptation through direct selection in the target environments using locally adapted germplasm and sustainable levels of external inputs (Ceccarelli et al. 1994).

There are two major implications in the project's philosophy: (1) national programs will generate many varieties, each adapted to specific conditions, and (2) the superior performance of the varieties developed for low-input and less-favored lands will not depend on agronomic practices that require large amount of inputs. A breeding program based on this philosophy will not endanger biodiversity, and is environmentally benign.

A fundamental question the barley program addresses is why plant breeding has been beneficial to those farmers who either enjoy favorable environments or could profitably modify them to suit new cultivars; yet plant breeding has not been equally beneficial to those farmers who could not afford to modify their environment through the application of additional inputs. Farmers in favorable environments, using high quantities of inputs, are now concerned with the adverse environmental effects and the loss of genetic diversity. Poor farmers in less-favored environments continue to suffer from chronically low yields, crop failures and, in the worst situations, malnutrition and famine. Because of its past successes, conventional plant breeding has tried to solve the problems of poor farmers living in unfavorable environments by simply extending the same methodologies and philosophies applied earlier to favorable, high potential environments. We have hypothesized those difficult environments and resource-poor farmers require a different type of breeding.

Using contrasting sites in northwest Syria, repeatable genotype × environment (GE) interactions of crossover type between the main experiment station and experiment sites managed according to farmers' practices were found (Ceccarelli 1994). GE interactions of crossover type are common in the literature, in different crops and in different types of stress environments. We concluded that selection in high input experiment stations is very effective in generating varieties for favorable environments, but does not allow the identification of the best genotypes for less-favored areas, and promotes genotypes which are in fact inferior to local landraces in stressful conditions.

Formal breeding has taken a negative attitude towards GE interactions of crossover type, in the sense that only breeding lines with low GE interaction (good average grain yield, across locations, years) are selected, while lines with good performance at some sites and poor performance at others are discarded. Because lines with good performance in unfavorable sites and poor response to favorable conditions have a low average grain yield, they are systematically discarded. Yet they would be the ideal lines for farmers in unfavorable locations (Ceccarelli et al. 1998). Therefore, having recognized the importance of GE interactions of crossover type, a major conclusion was that breeding for difficult environments must be based on the exploitation of specific adaptation, and this in turn can only be done by selecting directly in the target environments.

While the application of this philosophy started being successful in Syria with the adoption of three varieties in stress environments, the next question was how to reconcile the mandate of an international breeding program with the importance of specific adaptation. The response to this question has been the decentralization of the breeding work. The term decentralization has been often used to describe two fundamentally different processes, namely decentralized selection and decentralized testing.

Decentralized selection is a term first used by Simmonds (1984) and defined as selection in the target environment(s). Decentralized selection has been also termed in situ or onsite selection. In the case of self-pollinated crops, it consists in selection of early segregating populations (such as F₅) in a number of locations representing the target environment(s) (climate, soil, farming system, management) the breeding program aims to serve. Decentralized selection becomes selection for specific adaptation when the selection criterion is the performance in specific environments rather than the mean performance across environments. Decentralized selection is different from decentralized testing, which is a common feature of breeding programs and takes place, usually in the form of multilocation and on-farm trials, after a number of cycles of selection in one or few environments (usually with high levels of inputs).

In decentralized selection, the barley project at ICARDA continues to generate genetic variation by maintaining a large crossing program, but the breeders in the national programs carry out selection. At this moment, decentralization of barley breeding is fully implemented in North Africa. Iraq, and Ethiopia and is gradually being implemented in the Mediterranean highlands in the framework of the ICAR-DA/Iran Project, and in other countries (Table 7).

Details and different ways in which decentralized selection has been implemented in the barley project are given by Ceccarelli et al. (1999). Here, we only emphasize that (i) decentralization is a form of acknowledgment of the increased expertise of national programs during the last 20 years and (ii) the operational approach to decentralization is pragmatic and can take several forms depending on the nature, the capacity, and the expertise of the cooperating national programs.

For each country and/or region where the two most important conditions for decentralized breeding exist — namely (1) large GE interactions with ICARDA research station(s) and (2) availability of local expertise in plant breeding — decentralization follows generally three steps: first, a special nursery to identify suitable parents is sent; second, a specific crossing program aimed at developing a specific germplasm pool for that country/region is started, and, third, the segregating populations are distributed.

When fully implemented, the first step is replaced by the routine in-country screening of various germplasm sources. This, together with the decentralized screening for resistance to pests and diseases (see below), assures that the national programs supply more and more parental material.

Identification of sources of resistance to pests and diseases follows the same concepts. Identification of sources to resistance to the major barley diseases in North Africa (scald, powdery mildew, blotch) is entirely conducted in Tunisia and Morocco, while the screening for resistance to barley stem gall midge (*Mayetiola hordei*) is only conducted in Morocco. The Latin America project follows the same principle by screening segregating populations for disease resistance in the target countries.

The future challenge of the project is to implement the concept of decentralized selection towards all major barley

Table 7. Countries and regions where decentralized barley breeding has been implemented.

Country/Region	Countries/Area	Status
North Africa	Egypt, Libya, Tunisia, Algeria, Morocco	Fully implemented
Iraq (Baghdad)	Central Iraq	Fully implemented
Iraq (Mosul)	Northern Iraq	Fully implemented
EARS (East Africa/ Red Sea)	Yemen, Eritrea, Tigray	First crosses made in 1998
Ethiopia	Ethiopia (except Tigray)	Use of local landraces fully implemented first crosses in 1998.
CAC (Central Asia & Caucasus)		First special nursery in 1997
Turkey		First nursery planned for 1999
Cyprus	Cyprus	First special nursery in 1995, first crosses in 1998
Far East	India, Thailand, Vietnam, China	First special nursery in 1996, first crosses in 1997
Pakistan	Pakistan	First special nursery in 1997
Gulf Countries	S. Arabia, Qatar, Oman	First crosses made in 1992
Ecuador	Ecuador	First nursery planned for 1999

growing areas of the world. For this purpose, the target areas of the project can be divided in six geographic regions shown with circles in Figure 1, namely:

- · Central Asia and Russia
- · Far East
- · North Africa
- West Asia
- · Horn of Africa and Yemen
- · Central and Latin America

These six regions represent a barley area exceeding 47 million hectares, which is more than 60% of the total barley grown in world (73 million hectares).

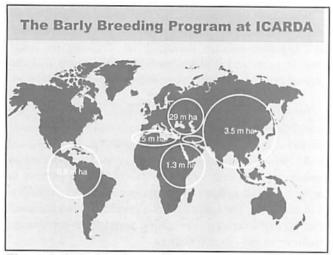


Figure 1. Global barley project to serve 47 million hectares in four continents.

These regions differ in the type of barley grown, e.g., mostly six-row in North Africa and two-row in West Asia and West Africa. Its use also differs. It is mainly used as animal feed in West Asia and North Africa, both as animal and human feed in North Africa, and as animal and human feed, and malt in the rest of the other regions. In East Africa and Yemen, and in Central and Latin America, a large part of barley is grown at high elevations since it is photoperiod insensitive and it develops and matures despite lower temperatures. The opposite occurs in the lowland barley grown in North Africa and West Asia, where the crop develops and matures at increasing temperatures and water stress. Central Asia and Russia on one hand, and the Far East on the other, are very heterogeneous since both winter and spring barley is grown in both high and low rainfall areas. These last two geographical areas are grouped more because of tactical considerations than for biological reasons. In fact they would probably require specific sub-projects conducted by staff acquainted not only with the crop but also with the culture of these populations.

The project works with a very wide range of germplasm to cope with the variety of environments where barley is grown and with the variety of its uses. Thus, the germplasm base ranges from spring to winter, from hulled to hulless, and from the wild progenitor, *Hordeum spontaneum* to landraces and modern cultivars.

These six areas can be effectively served, under the common philosophy of breeding for specific adaptation, and with levels of external inputs that are not harmful to the environment, by developing specific germplasm pools for the specific needs of each geographical area.

When the breeding in the six areas indicated in Figure 1 is fully decentralized, including the screening for resistance to pests, diseases and viruses, 80% of the germplasm development will be in the form of targeted segregating populations, while 20% will be in the form of fixed lines. This residual responsibility for complete cultivar development will be targeted to the environments in which ICARDA has selection sites, and to those countries where the barley area is too small and/or the national program does not have the technical capability of handling segregating populations.

3.1. Project philosophy: from decentralization to participation

Although national programs accepted decentralization very positively, we recently recognized that decentralization per se does not necessarily respond to the needs of resource-poor farmers in less-favored areas. Often it is only decentralization from the research station(s) of ICARDA to the research stations of the national programs, and therefore it is still missing the target because the research stations seldom represent the difficult environments where the majority of crop is grown. To exploit the potential gains from specific adaptation to low-input conditions, breeding must be decentralized from research stations to farmers' fields in target production areas. Participation of farmers in the very initial stages of breeding, when the large genetic variability created by the breeders is virtually untapped, is expected to exploit fully the potential gains from breeding for specific adaptation through decentralized selection by adding farmers' perception of their own needs and farmers' knowledge of the crop (Ceccarelli et al. 1996). Although decentralization and farmer participation are unrelated concepts, decentralization to farmers' fields almost inevitably leads to the participation of farmers in the selection process. Therefore, the ICARDA Barley Program considers farmer participation as a type of decentralized selection to exploit GE interactions and to benefit, within a formal breeding program, from the farmers' knowledge of the crop, its specific uses and its specific adaptation (Ceccarelli et al. 1997).

The first participatory breeding project ("Farmer Participation and Use of Local Knowledge in Breeding Barley for Specific Adaptation," supported by BMZ) started in Syria in 1997. The objective was to test an alternative way to produce improved varieties of crops such as barley grown in marginal environments. This alternative way is to introduce early-generation segregating populations into selected farmers' fields for farmer selection between populations. During the first two years, the project demonstrated that farmers' selection is an efficient alternative to old paradigms, and could become a generalized strategy for the improvement of crops in marginal conditions (Ceccarelli et al. 1999).

All the national scientists who have visited ICARDA during the last three years have been exposed to the activities of this project, and many of them, at the end of their visit, ask ICARDA to help in developing similar activities in their own countries. As a result, there are now participatory barley breeding projects in Tunisia and Morocco (funded by the International Development Research Centre, Canada), in Yemen (funded by the System-wide Program for Participatory Research and Gender Analysis), in Ethiopia (funded by the Government of The Netherlands), and in Eritrea (supported by Italy). Participatory barley breeding projects are being prepared in Jordan, in collaboration with the University of Jordan in Amman, the National Center for Agricultural Research and Transfer of Technology, the Jordan University of Science and Technology, and the Jordanian Hashemite Fund for Human Development, and in Egypt, in collaboration with the Matrouh Resource Management Project.

The most recent development in the area of farmer participation is the study of methodologies, which allow small farmers to participate. The question we are addressing is how to reconcile the large number of entries, which are usually handled by a formal breeding program, with the space limitations faced when dealing with small farmers.

4. Interaction with National Agricultural Research Systems (NARS)

The major areas of interaction with NARS have traditionally been the distribution of germplasm, collaborative research, and training.

4.1 Distribution of germplasm: from international to special nurseries

The major mechanism of germplasm distribution has been through the "International Nurseries." In the case of barley and until 1984, the international nurseries were mostly fixed lines with about 20% of segregating populations. There was little contribution by NARS scientists in the composition of the nurseries and in the crosses which generated the segregating populations.

Progressive emphasis on specific adaptation, better understanding of the characteristics of different agroecological environments achieved partly through exchange of visits from national programs, and availability of more and more barley breeders in the national programs has led to a progressive increase of special nurseries designed to serve the particular needs of a specific country or group of countries.

The trend towards the distribution of early segregating and targeted germplasm has considerably accelerated during the last few years with the implementation of the decentralized approach (Figure 2).

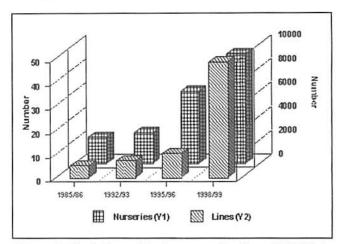


Figure 2. Evolution of barley nurseries from 1985/86 to 1998/99. The number of different types of nurseries (on the left Y axis) rose from 11 to 46, while the total number of lines in all nurseries (on the right Y axis) rose from 959 to 5770.

4.2 Collaborative research and training

The barley project has trained more than 150 scientists through four types of activities:

- · long term residential training course at Aleppo,
- specialized training courses, either in country or in Aleppo,
- · visiting scientists, and
- degree training.

Specialized training courses on barley improvement were held in Ethiopia in 1987, in Nepal in 1989, and on

pedigree and data handling across the years, and nurseries in Cairo in 1995 and in Tunis in 1997.

There have been a number of collaborative research activities conducted with NARS, many of which were associated with the decentralization of the breeding activities.

The future trends in training will largely depend on the demand from national programs. However, within the limits imposed by the concept that training is a service, we expect:

- Training of technical staff should become a responsibility of NARS (the long-term residential course has been discontinued).
- Individual training and degree training will be emphasized and should become a component of special projects.
- Training courses should be used as opportunities to spread new breeding methodologies through the NARS scientific community.

5. Interaction with Advanced Research Institutions (ARI)

The strategy followed in setting up collaborations between the barley project and advanced institutions has evolved from a largely passive to a more pro-active role. The future of basic research in barley will largely depend on our ability to identify suitable scientific partnership in ARIs to tackle a number of key research topics in barley improvement. We expect that the majority of our work on various aspects of molecular breeding will be conducted in collaboration with ARIs.

6. Resistance to Biotic Stresses and Biotechnology

As described earlier, the project will move with national scientists towards developing, in partnership, genetic variability targeted to different environments and uses to be exploited by the end users in their own conditions. Emphasis will be given to using the approach in those geographical areas where the project has been using only the traditional approach (notably Latin America, China, Vietnam, Korea, Nepal, and other countries in the Far East).

The strategy followed in germplasm development also affects the strategy to be followed in breeding for resistance to biotic stresses and in biotechnology.

6.1. Resistance to biotic stresses

Barley is affected by several foliar and root diseases, several insects, nematodes, and viruses. The organisms which

can potentially damage a barley crop can be divided into two broad categories, namely those which are specific (either as an organism or as a physiological race) to a given country or area, and those which are widespread in several countries.

The overall strategy, once the priority biotic stresses have been identified together with NARS, is to decentralize the work on biotic stresses of the first type to NARS following the development of the necessary expertise, and to concentrate at the headquarters on the second type of biotic stresses. The latter will be ideal ground for collaboration with ARIs.

Within this broad strategy, the work on biotic stresses will be integrated in the more general, decentralized approach to plant breeding followed by the project.

In the case of foliar diseases, insects and viruses, the screening of large amounts of breeding material, which has represented 90% of the activities in the past, will be gradually reduced to about 10% of the total work on biotic stresses. Eventually, screening will be entirely transferred to NARS. Specific pests will be tested at 'hot spots', and information circulated to all collaborators. Sources of resistance will be characterized at the ICARDA headquarters, which will focus on the transfer of genes for resistance into the breeding material developed by the decentralized program for specific countries and/or regions. In these cases, the national programs will receive F₄ families, homozygotes for the resistance gene(s), but variable for everything else. This check will be done at the headquarters in the case of genes with non-specific resistance (for example, the genes for resistance to Russian wheat aphid (RWA) and barley yellow dwarf virus (BYDV), and within five years, it will be done routinely with the aid of molecular markers. These first molecular-marker-assisted selection programs will also be used to train national program scientists.

In the case of foliar diseases, where a large variability exists for physiological races, the responsibility of the head-quarters' pathologist will be the identification of genes, which are effective against the virulence of disease in target countries/regions. Sources of resistance for these genes will be used in the targeted crosses at headquarters, but the selection of the segregating populations will be done in the target environments. Marker-assisted selection will be made available to NARS to increase the efficiency of selection.

Two areas that need expansion are a) scab, root diseases and nematodes, and b) durable resistance and population improvement.

To be able to work on resistance to scab, to root diseases and to nematodes, the project needs additional scientists (initially post-doc) to focus on these issues, and to identify molecular markers, which can then be used for selection.

The entire area of durable resistance, and of the consequent changes in the breeding strategies, which are needed, must be addressed perhaps not only by the barley project, but also at the program level. In barley, we will develop at least one case study to address one of the most variable foliar diseases (powdery mildew) with two alternative strategies, one based on deployment of major genes and the other on the increase of horizontal resistance through population improvement.

6.2. Biotechnology

The project has considerably expanded its use of biotechnology in the last two-three years. At the moment, we are completing the work on two mapping populations (WI2291/Tadmor and Arta/H. spontaneum 41-1), two markers, for scald and powdery mildew, have been identified; the genetic diversity within Syrian landraces with microsatellites has been studied, and we have determined the genetic diversity within three populations of random inbred lines (RIL) developed to analyze the adaptation to abiotic stresses using RAPD.

There are four major areas where barley biotechnology will expand:

Molecular breeding

As mentioned above, breeding for resistance to some pest and diseases (particularly root diseases) will be routinely based on molecular markers within five years. During that period we will make available molecular markers to those NARS for which diseases and/or pests are the major constraint to barley production to allow them to start decentralized marker-assisted selection. Within the next five years, we will have molecular markers for undesirable traits of *H. spontaneum* (brittle rachis and rough awns), for osmotic adjustment, and for traits associated with drought resistance.

Double haploid (DH) breeding

Although efficiencies with anther culture have been low so far, microspore culture might offer an alternative with increased efficiencies in green plant production. If microspore culture can improve the efficiency of DH production, a combination of DH-breeding and molecular breeding will increase the efficiency of the breeding program by developing targeted crosses for the marker-assisted selection, and their double-haploidization with the microspore system.

Use of double haploids for genetic studies and for producing mapping populations is currently limited by the lower response of landraces, and even more so of *H. spontaneum*, to various double-haploidization techniques. However, in terms of acceleration of the breeding programs, particularly for the material developed for North Africa and West Asia, the program is mature enough to make full use of the technique.

Transformation

Transformation in barley might become a reality at any time now. A new project beginning in 2000 will give the possibility of using the technology as soon as it is available. Priority genes will be those for self-incompatibility to allow exploitation of heterosis, genes for herbicide resistance, dehydrin genes, and genes controlling nutritional properties.

Strategic research

Molecular markers will be increasingly used to understand plant adaptive strategies, population structure of landraces and wild relatives.

7. Barley as Human Food

Barley was a staple food as far back as 18,000 years ago and it is still important in several developing countries.

The largest consumer of barley as human food is Morocco, where consumption of barley per capita is 64.1 kg per year (FAO estimates for the period 1990-1994), followed by Iraq, Algeria, and Ethiopia with 22.4, 19.3, and 14.1 kg/person/year, respectively. Barley grain accounts for over 60% of the food of the people in the highlands of Ethiopia, for whom barley is one of the main sources of calories. In the Andes, barley is the staple food for farmers at altitudes ranging from 2200 to 4000 meters above sea level. Above 3000 meters, barley, faba bean, potato and quinoa are the four crops that support human and animal life. The largest use of barley for food is found in regions where other cereals do not grow well due to altitude, low rainfall, or soil salinity. A common feature of these diverse regions where barley is a staple food is that they are home to some of the poorest farmers in the world.

Most of the efforts in barley breeding have been devoted to improve feed and malting cultivars. Attributes such as kernel weight, kernel size, protein and lysine content have been determined in the majority of lines in the yield trials, but we have neglected a number of quality characters associated with the use of barley as human food. Because of the interest of a number of NARS, we have recently started

investigating β -glucans (also important for malting), hardness (also important for animals), and cooking time to increase the acceptability of barley as food.

In the future the work on grain quality aspects will be expanded, taking into consideration attributes such as high energy and starch type, in addition to protein, lysine and cooking time.

Table 8. Consumption of barley as human food in various countries (FAO estimates for the period 1990-1994).

Country	kg/person/year	Country	kg/person/year
Morocco	64.1	Libya	11.5
Iraq	22.4	Afghanistan	10.9
Algeria	19.3	Tunisia	10.2
Ethiopia	14.1	Peru	2.8

8. International Barley Information System

For many researchers, especially in developing countries, the information revolution has been more a promise than a reality. Efficient management of information is one of the challenge researchers at international centers are facing. A large amount of information is generated every year on germplasm distributed by international centers. Most of the information is scattered around several institutions, in different countries, often stored in different formats, and not easily accessible and shared. Increasing research costs mean that experimental data must be exploited to achieve greater cost-effectiveness and they must be managed as one of the most valuable resources of NARS and Centers. The International Crop Information System (ICIS) gives researchers the tools to manage and share data more effectively. ICIS is a database system for the management and integration of global information on genetic resources, crop improvement and crop management. Separate implementation of ICIS can be carried out for individual crops, groups of crops, or crops common to a set of farming systems.

ICIS is currently being developed by a team of scientists and programmers, led by a steering committee of two scientists from Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) and one from the International Rice Research Institute (IRRI). Versions of ICIS are available for rice, wheat, cowpea, and common bean.

The project will promote the efficient development and use of the barley information system (IBIS), will ensure that

it is designed to meet the needs of national and international institutions, and will guide acquisition of data.

References

Brophy, M. 1996. Global production and markets for barley in the 21st century. Pages 37-43 in Proceedings of the V International Oat Conference and of the VII International Barley Genetics Symposium (Slinkard, A., G. Scoles and B. Rossnagel, eds.). Mister Print Production Ltd.

Ceccarelli, S. 1994. Specific adaptation and breeding for marginal conditions. *Euphytica* 77: 205-219.

Ceccarelli, S., W. Erskine, S. Grando, and J. Hamblin. 1994. Genotype × environment interaction and international breeding programs. *Experimental Agriculture* 30: 177-187.

Ceccarelli, S., S. Grando, and R.H. Booth. 1996. International breeding programmes and resource-poor farmers: Crop improvement in difficult environments. Pages 99-116 in Participatory Plant Breeding. Proceeding of a workshop on participatory plant breeding, 26-29 July 1995, Wageningen, The Netherlands (Eyzaguirre, P. and M. Iwanaga, eds.). IPGRI, Rome, Italy.

Ceccarelli, S., E. Bailey, S. Grando, and R. Tutwiler. 1997.
Decentralized, Participatory Plant Breeding: A fink between formal plant breeding and small farmers. New Frontiers in Participatory Research and Gender Analysis. Pages 65-74 in Proceedings of an International Seminar on "Participatory Research and Gender Analysis for Technology Development," Cali, Colombia.

Ceccarelli S., S. Grando, and A. Impiglia. 1998. Choice of selection strategy in breeding barley for stress environments. *Euphytica* 103: 307-318.

Ceccarelli, S., S. Grando, R. Tutwiler, J. Baha, A.M. Martini, H. Salahieh, A. Goodchild, and M. Michael. 2000. A methodological study on participatory barley breeding. I. Selection Phase. *Euphytica* 111:91-104.

Ceccarelli, S., S. Grando, A. Amri, F. A. Asaad, A. Benbelkacem, M. Harrabi, M. Maatougui, M.S. Mckni, H. Mimoun, R. A. El-Einen, M. El-Felah, A. F. El-Sayed, A. S. Shreidi, and A. Yahyaoui. Decentralized plant breeding for marginal environments. *In* Broadening the Genetic Basis of the Crops (in press).

Simmonds, N.W. 1984. Principles of crop improvement. Longman, London, UK and New York, USA.

Research and Production

Commercial Heterosis in Wheat: An Overview

V. Mahajan, S. Nagarajan, M. Srivastava, V. Kumar and N.V.P.R. Ganga Rao

Directorate of Wheat Research, P.O. Box 158, Karnal, Haryana, INDIA

Introduction

Exploitation of heterosis through hybrid wheat is more attractive than conventional plant breeding methods which obtain lower yield gain (one percent per year) in North Western Plains Zone-the bread bowl of India. The traditional breeding methods have so far exploited inter-genomic heterosis making yielding higher than other diploid crops. However, the advantage of intra-genomic heterosis in the three genomes can be exploited through the use of hybrid wheat. In India, efforts on hybrid wheat started in the sixties using cytoplasmic male sterility (CMS). However, no significant results were obtained. In 1995, the Directorate of Wheat Research at Karnal, India decided to re-address hybrid wheat with an emphasis on using a chemical hybridizing agent (CHA). Production of hybrid wheat was addressed primarily on two fronts in the CHA approach (i) to evaluate and operationalize chemical hybridizing agent in producing hybrids and (ii) to identify parental lines that exhibit commercial heterosis.

The advantage of commercial heterosis in hybrids over the best check is exploited in both cross-pollinated and selfpollinated crops such as corn, pearl millet, sorghum, sunflower, cotton, pigeon pea, rice and a number of vegetable crops for commercially important characters.

Heterosis in Wheat

Since the mid-sixties, one of the challenges wheat breeders face is identifying/developing superior hybrids and parents with exceptional combining ability.

The issues to identify heterosis can be addressed through components such as:

- Matching the yield components to achieve yield maximization in hybrids.
- 2. Diversity in parental lines.

- 3. Hybrid × environment interaction.
- 4. Use of other characters like disease resistance and quality as a pre-requisite to develop superior hybrids.
- 5. Exploring the advantage of allopolyploidy in wheat.

Extent of Heterosis

Enough reports in literature indicating high heterosis over mid-parent or the best parent are available. However, the real commercial feasibility of hybrid wheat depends upon the heterotic advantage over the best commonly grown variety in a given agro-climatic zone. Wheat breeders dealing with various aspects of hybrid wheat found that the standard heterosis for grain yield on large plot basis (Table 1) ranged from 6% (Borghi et al. 1986) to as high as 41% (Zehr et al. 1997). Fabriozino et al. (1998) stated that the expression of heterosis was due to genetic diversity which was unpredictable and factors not elucidated in their study.

Genetics of Yield

For the majority of the characters, general combining ability (GCA) is more important than specific combining ability (SCA). A number of papers, based on large scale trials (Borghi et al 1989; Bears and Bingham 1989; Morgan et al. 1989; Perenzin et al. 1992; Borghi and Perenzin 1994) confirm this. Due to reciprocal compensation among traits, the large SCA effects of some yield components are difficult to exploit. Non-additive genetic variance, or SCA, is best expressed in space planting (Patrico and Patterson 1973; Winder and Lebsock 1973; Mani and Rao 1977; Cregan and Busch 1978; Rehman 1978; Quick 1978; Mihaljev 1980; Virmani and Edward 1983; Lucken 1986).

Although several yield components appear to be important in determining grain yield in high yielding hybrids (Liver and Hyne 1968), the number of spikelets/spike appears to be important (Borghi et al. 1988). Kernel weight tends to be higher in hybrids but this does not contribute significantly to increase yields (Borghi et al. 1988). A positive association between grain yield and harvest index for the best hybrid combinations (Sinha and Khanna 1975) was observed. It was suggested that hybrids perform better because of their superior capacity to produce and to partition biomass. The high grain yield of hybrids was associated with an increase of plant height while the harvest index was slightly higher than the one found for pure line varieties (Edward et al. 1980).

Table 1. Heterotic advantage for grain yield in large wheat plots under normal planting.

Reference	Heter	rosis (%)	Remarks
	Standard	Best parent	
Winder and Lebsock 1973	16		At a seed rate of 33 kg/ha
	9		At a seed rate of 67 kg/ha
Edward et al. 1980	10-14		Increase plant height and slight increase in harvest inde
Jost and Hayward 1980	32		Spaced planted
Wilson and Driscoll 1983	10-15		-
Perenzin and Borghi 1987	8.2		Best hybrid: RHO1(Frandoc × Festin)
Edward 1987		20	Best hybrid: SHB 032 of Pioneer
USDA 1987		15	•
Borghi et al. 1988	6		
Lucken and Johnson 1988	11-12		-
Bears and Bingham 1989		5-12	_
Borghi et al. 1989	5-10		-
Lang et al. 1989	6-22		12 of 234 hybrids with >15% heterosis
Perenzin et al. 1992		5-10	Yield and kernel weight
Uddin et al. 1992	11.7	26.8	Mid parent heterosis is 31.5%
Borghi and Perenzin 1994	10		Best hybrid: Maestra × Golia
Uddin et al. 1992		10.7	•
Edward 1995	12-17		•
Cukadar et al. 1997	7-16	2	-
Jordaan et al. 1997	28	-	•
Zehr et al. 1997	41		Report from MAHYCO
Morgan 1998		12	

Hybrid × Environment Interaction

Wheat hybrids are found to be stable in their performance in different environments and seasons as Wienhues (1968) and Stroike (1987) observed, while Boland and Walcott (1985) and Borghi and Perenzin (1990) reported that the yield stability of the hybrids was intermediate to that of the parents.

Disease Resistance in Hybrids

Resistance genes could be accumulated in the hybrids (Stroike 1987). Resistance to disease is dominant and is expressed in the heterozygote, so it could be quickly incorporated in the hybrids (Johnson and Schmidt 1968).

Wheat Quality of Hybrids

Among various quality parameters, protein is a key element in determining bread-baking performance. Even though the protein quality is genetically controlled, environmental conditions such as high nitrogen application significantly affected it as well.

Hybrids are generally intermediate to the parents in flour yield, dough properties and baking quality (Johnson and Schmidt 1968; Bequette and Fischer 1980). Wheat hybrids producing large amount of dry matter exhibited a positive correlation between protein content and total biomass (Corbellini and Borghi 1985; Borghi et al. 1986), which suggest that high protein content in hybrids may be partly due to the enhanced source. Edward (1987), who analyzed several hybrids from hard x soft red wheat crosses, emphasized the necessity to use parents with very strong mixing properties to offset the soft wheat effects and concluded that complementing quality characters appears to be the main advantage the hybrid genotypes offered. Perenzin et al. (1992) observed that some hybrids derived from crosses between low quality-high yielding cvs. and high quality-low yielding cvs. revealed a yield level approaching highest yield cvs. coupled with a bread-making quality corresponding to the first class of the Italian market (W>250, P/L<1). Borghi and Perenzin (1994) reported that the hybrid Maestra x Golia was not only statistically at par for yield and agronomically superior to the best check Eridano due to reduced plant height, but also had superior grain quality which represents a 30% higher selling price. Grain and bread-making quality characters (protein and SDS sedimentation) were not adversely affected in the hybrids and depend on the parental material (Cukadar et al. 1997). The present literature revealed that satisfactory bread-making properties combined with high yields can be obtained with at least the first generation of hybrids. Parental lines, which have superior quality parameters when combined with genetically diverse high yielding superior ideotype, may result in hybrid combinations which may be superior in economic yield or quality over the best check. No information is available on the effect of allopolyploidy on heterosis in wheat.

Future Prospects

Heterotic advantage up to 41% on large plot basis has been reported so far. The desired expression of economic heterosis in wheat can be achieved by matching yield components, quality and disease resistance from genetically diverse parents. Though genetic diversity may be one of the most important factors in search of commercial heterosis, there could be unexplored factors that may limit the understanding and the use of heterosis in wheat. Some less explored genetic diversity of Chinese and Australian germplasm may be useful material for future genetic stocks in hybrid program to develop trait specific gene pools. At present, the hybrid wheats in India had to pass through the barrier of free flow of information among public and private organizations and will emerge as a winner to make hybrid wheat an attractive reality.

References

- Bears, T. and J. Bingham. 1989. Exploitation of heterosis in hybrid wheat using gametocides. *Vortrage-für-Planzenznchtung* 16: 397-407 in Science for Plant Breeding: Proceedings of the XII Congress EUCARPIA, 27 February to 4 March 1989, Götting, Germany.
- Bequette, R. and L. Fisher. 1980. Deklab Hybrid Wheat Contribution. *Wheat News* 26: 32-33.
- Boland, O.W. and J.J. Walcott. 1985. Levels of heterosis for yield and quality in an F₁ hybrid wheat. *Australian Journal of Agricultural Research* 36: 545-552.
- Borghi, B. and M. Perenzin. 1990. Yield and yield stability of conventional varieties and F₁ bread wheat hybrids. Journal of Genetics and Breeding 44: 307-310.
- Borghi, B. and M. Perenzin. 1994. Diallel analysis to predict heterosis and combining ability for grain yield, yield components and bread-making quality in bread wheat

- (T. aestivum), Theoretical and Applied Genetics 89: 975-981.
- Borghi, B., M. Corbellini, M. Cattaneo, M.E. Fornasari, and L. Zucchelli. 1986. Modification of the sink/source relationships in bread wheat and its influence on grain yield and grain protein. *Journal of Agronomy and Crop* Science 157: 245-254.
- Borghi, B., M. Perenzin, and R.J. Nash. 1988. Agronomic and qualitative characteristics of ten bread wheat hybrids produced a chemical hybridizing agent. *Euphytica* 39: 185-194.
- Borghi, B., M. Perenzin, and R.J. Nash. 1989. Combining ability estimates in bread wheat and performances of 100 F₁ hybrids produced using a chemical hybridizing agent. *Journal of Genetics and Breeding* 43: 11-16.
- Corbellini, M. and B. Borghi. 1985. Accumulation and remobilization of dry matter and protein in four bread wheat cultivars. Zeitschrift Acker Pflanzenban 155: 1-11.
- Cregan, P.B. and R.H. Busch. 1978. Heterosis, inbreeding and line performance in crosses of adapted spring wheats. *Crop Science* 18: 247-251.
- Cukadar, B., R.J. Pena, D. Dumphy, and M. van Ginkel.
 1997. The potential of hybrid wheat under irrigated conditions in Mexico. Pages 190-191 (Abstract B9) in Proceedings: Genetics and Exploitation of Heterosis in Crops. 17-22 August 1997, Mexico City, Mexico.
- Edward, I.B. 1987. Baking quality of hard red winter and hard red spring wheat hybrids. Pages 215-224 in Hard Wheat (T. aestivum): Agronomic, Technological, Biochemical and Genetic Aspects (B. Borghi, ed.). CEC Publications EUR 11172 EN, Brussels, Belgium.
- Edward, I.B., W.G. Thomson, and D.W. Pingree. 1980. Pioneer Hi-Bred International, Department of Cereal Breeding Report. *Annual Wheat Newsletter* 26: 36-37.
- Fabriozino, M.A., R.H. Busch, K. Khan, and L. Huckle. 1998. Genetic diversity and heterosis of spring wheat crosses. *Crop Science* 38(4): 1108-1112.
- Johnson, V. and J.W. Schmidt. 1968. Hybrid wheat. *Advances in Agronomy* 20: 199-233.
- Jordaan, J.P., S.A. Engelbrecht, J.H. Malan and H.A. Knobel. 1997. Wheat and heterosis. Pages 267-277 in Proceedings: Genetics and Exploitation of Heterosis in Crops. 17-22 August 1997, Mexico City, Mexico.
- Jost, M. and C.F. Hayward. 1980. F₁ hybrid versus 32 selected F₇ lines performance of common winter wheat (*Triticum aestivum* spp. *vulgare*). *Theoretical and Applied Genetics* 57: 177-180.
- Lang, L., L. Ballam and Z. Bedo. 1989. Hybrid wheat breeding and its perspective. Sveriges-Utsadesforenings Tidskrift 99: 121-124.
- Liver, R.W. and E.G. Hyne. 1968. Hybrid vigour in hard red

- winter wheat. Pages 431-436 in Proceedings of the Third International Wheat Genetics Symposium (K. Finely and K. Shephard, eds.). Australian Academy of Sciences, Canberra, Australia.
- Lucken, K.A. 1986. The breeding and production of hybrid wheat. Pages 87-107 in USA Genetic Improvement in Yield of Wheat. Crop Science Society of America and American Society of Agronomy CSSAA Special Publication No. 13, Madison, WI, USA.
- Lucken, K.A. and K.D. Johnson. 1988. Hybrid wheat status and outlook. Pages 243-255 in Proceedings of International Symposium on Hybrid Rice, Chansha, Hunan, China.
- Mani, S.C. and M.V. Rao. 1977. Combining ability and heterosis in wheat (*Triticum aestivum* L.). Pages 23-30 *in* Genetics and Wheat Improvement. (A.K. Gupta, ed.). Oxford and IBH Publications Co., UK.
- Mihaljev, I. 1980. Combining ability for grain yield in F₁-F₆ generations of diallel wheat crosses. Pages 102-109 in Proceedings of the Third International Wheat Conference, Madrid, Spain
- Morgan, C.L. 1998. Mid-parent advantage and heterosis in F₁ hybrids of wheat from crosses among old and modern varieties. *Journal of Agricultural Sciences* 130: 287-295.
- Morgan, C.L., R.B. Austin, M.A. Ford, J. Bingham, W.J. Angus, and S. Chowdhary. 1989. An evaluation of F₁ hybrid winter-wheat genotypes produced using a chemical hybridizing agent. *Journal of Agricultural Sciences* 1212: 143-149.
- Patrico, C.P. and F.L. Patterson. 1973. A comparison of genetic behavior in a six-parent diallel cross of winter wheat grown under northern and southern hemisphere environments. Pages 569-575 in Proceedings of the Fourth International Wheat Genetics Symposium, Columbia, Missouri, USA.
- Perenzin, M. and B. Borghi. 1987. La produttivita degli ibridi di frumento tenero. *Rivista di Agronomica* 21 (4): 155-159.
- Perenzin, M., N.E. Pogna, and B. Borghi. 1992. Combining ability for bread making quality in wheat. *Canadian Journal of Plant Sciences* 72: 743-754.

- Quick, S.S. 1978. Combining ability and inter-relationships among an international array of durum wheats. Pages 635-647 in Proceedings of the Fifth International Wheat Genetics Symposium, New Delhi, India.
- Rehman, A. 1978. Heterosis and combining ability in wheat under normal and late plantings. Pages 655-699 in Proceedings of the Fifth International Wheat Genetics Symposium, New Delhi, India.
- Sinha, S.K. and R. Khanna. 1975. Physiological, biochemical and genetic basis of heterosis. *Advances in Agronomy* 27: 123-174.
- Stroike, J.E. 1987. Technical and economic aspects of hybrid wheat seed production. Pages 177-185 in Hybrid Seed Production of Selected Cereals, Oil and Vegetable Crops. FAO Plant Protection and Production Paper 82, Food and Agriculture Organization of the United Nations, Rome, Italy.
- Uddin, M.N., F.W. Ellison, L. O'Brien, and B.D.H. Latter. 1992. Heterosis in F₁ hybrids derived from cross of adapted Australian wheats. Australian Journal of Agricultural Research 43(5): 907-919.
- USDA (US Department of Agriculture). 1987. Wheat: Situation and Outlook Yearbook, WS 277, Washington DC, USA.
- Virmani, S.S. and I.B. Edward. 1983. Current status and future prospects for breeding hybrid rice and wheat. *Advances in Agronomy* 36: 145-214.
- Wienhues, F. 1968. Long term yield analysis of heterosis in wheat and barley: variability of heterosis, fixation of heterosis. *Euphytica* 17: 49-62.
- Wilson, P. and C.J. Driscoll. 1983. Hybrid wheat. Pages 94-123 in Heterosis (R. Frankel, ed.). Heilderberg, Berlin, Germany and Springer, New York, USA.
- Winder, J.N. and K.L. Lebsock. 1973. Combining ability in durum wheat: I. Agronomic Characters. Crop Science 13:164-167.
- Zehr, B.E., V.P. Ratralikar, L.M.M. Reddy, and L.V. Pandey.
 1997. Strategies for utilizing heterosis in wheat, rice, and oilseed brassica in India. Pages 232-233 (Abstract B28) in Proceedings: Genetics and Exploitation of Heterosis in Crops, 17-22 August 1997. Mexico City, Mexico.

Path Coefficient Analysis and Correlation of Grain Yield and Yield Components of Wheat (*Triticum aestivum* L.) Genotypes

T. Dokuyucu and A. Akkaya

KSU, Agricultural Faculty, Field Crops Department, Kahramanmaras, TURKEY

Abstract

This research was carried out on 22 common wheat varieties in a randomized complete block design with four replications in 1996-1998 in Kahramanmaraş, Turkey. In the trial, the following traits were investigated: number of heads/m², number of grains/head, grain weight/head, test weight, and grain yield. Simple correlation and path coefficients were calculated to determine direct and indirect effects of traits on grain yield.

There were positive and significant correlations between grain yield and number of heads/m², number of grains/head, grain weight/head and test weight. Path coefficients also indicated that both direct effects of number of heads/m² and grain weight/head, and indirect effect of number of grains/head by grain weight/head on grain yield, were significant and positive. Therefore, number of heads/m², grain weight/head, and number of grains/head may be used as selection criteria in breeding programs to develop high yielding bread wheat varieties.

Key words: Triticum aestivum L.; yield components; correlations; path analysis.

Introduction

Grain yield in wheat (*Triticum aestivum* L.) is the result of a number of complex morphological and physiological processes affecting each other and occurring in different growing stages of a vegetation period. Some yield components significantly affect grain yield through effects at different growing stages, from sowing to the harvest. Therefore, one needs to know more about these traits and how they affect grain yield so one can breed new genotypes that have high yields.

In wheat, breeders try to explain the relations between grain yield and agronomic and morphological traits by using

تحليل معامل المسار والارتباط بين الغلة الحبية ومكونات الغلة للطرز الوراثية للقمح aestivum L.

الملخص

نفذ هذا البحث على 22 صنفاً من القمح الشائع باتباع تصميم القطاعات الكاملة العشوائية بأربعة مكررات في الفترة ما بين 1996 و 1998 في ك. ماراش بتركيا. وقد تم في التجربة بحث الصفات التالية: عدد السنابل/م2، عدد الحبات/السنبلة، وزن الحبات/السنبلة، الوزن عند الاختبار، الغلة الحبية. وحسب الارتباط البسيط ومعاملات المسار لتحديد التأثيرات المباشرة وغير المباشرة لهذه الصفات في الغلة الحبية.

وقد وجدت ارتباطات إيجابية ومعنوية بين الغلة الحبية وبين كل من عدد السنابل/م2، وعدد الحبات/السنبلة، ووزن الحبات/السنبلة، والوزن عند الاختبار. كما دلت معاملات المسار على تأثيرات مباشرة لكل من عدد السنابل/م2، ووزن الحبة/السنبلة، وتأثير غير مباشر إيجابي ومعنوي لحاصل ضرب عدد الحبات /السنبلة بوزن الحبوب/السنبلة في الغلة الحبية. وعليه يمكن استخدام عدد السنابل/م2، وزن الحبات/السنبلة وعدد الحبات/السنبلة كمعايير انتخابية في برامج التربية لاستنباط أصناف مغلالة من القمع الطري.

simple correlation coefficient. Although correlation coefficient is very important to determine traits that directly affect grain yield, they are insufficient to determine indirect effects of these traits on grain yield (Bhatt 1973). These situations are more common in cereals because of yield traits that occur at a different growing stage and affect each other, especially where early-occurring traits influence later traits (Dofing and Knight 1992). It was pointed out that there was a dynamic balance among yield traits, which prevent improvement of grain yield through selection for just one yield trait (Grafius 1972).

It has been suggested that yield components have either a direct or an indirect effect on grain yield, or both. Therefore, it was essential to determine the effects of yield components on grain yield. Consequently, path coefficient analysis is the most common statistical method used for this purpose. Wright, an American breeder, first improved this method in 1921 and later researchers have also applied it. Thus, it is possible to calculate both direct and indirect

effects of yield components on grain yield through the other components. In other words, path analysis can be used to calculate the quantative impact on yield of direct or indirect effects caused by one or other components of grain yield, and the relationship between these components. Agronomists in wheat (Bhatt 1973; Fonseca and Patterson 1968; Wiegand et al. 1981; Gebeyhou et al. 1982a, 1982b; Borojevic and Williams 1982; Mou 1990), barley (Pury et al. 1982; Kırtok and Çölkesen 1985; Garcia et al. 1991), bean (Duarte and Adams 1972) and cowpea (Altinbas and Sepetoğlu 1993) commonly use path coefficient analysis to explain clearly the relations among yield components.

The aim of this research, carried out with 22 common wheat genotypes at Kahramanmaraş, was to use path coefficient analysis to determine direct and indirect effects of number of heads/m², number of grains/head, grain weight/head, 1000-grain weight and test weight on grain yield.

Material and Methods

This research was carried out on 22 common wheat genotypes in a randomized complete block design with four replications in 1996-98 in Kahramanmaraş, Turkey. Names and registration numbers of wheat genotypes are given in Table 1. Genotypes were sown in November at a seed rate of 550 seeds/m² in plots sized 5 m × 1 m with six rows. Plots were fertilized at the rate of 60 kg P₂O₅ and 60 kg N/ha at planting, and 80 kg N/ha applied at the tillering stage.

Analysis of soil samples from the experiment field were: pH, 7.56; water holding capacity, 46%; salt, CaCO₃, total nitrogen and organic matter contents were 0.125, 12.5,

0.113, and 1%, respectively; total P_2O_5 was 45 kg/ha (Anonymous 1997). Plants were irrigated at the heading stage.

Genotypes were evaluated for number of heads/m², number of grains/head, grain weight/head, 1000-grain weight, test weight and grain yield. Variance analysis and correlation coefficients were calculated using MSTA-C Statistical Computer Program. Investigated traits were numbered as (1) number of heads/m², (2) number of grains/head. (3) grain weight/head, (4) 1000-grain weight, (5) test weight, and (6) grain yield. The Eurika Computer Program calculated path coefficients through correlation coefficients (Gebeyhou et al. 1982a; Garcia et al. 1991).

Results and Discussion

Simple correlation and path coefficients are summarized in Tables 2 and 3. There were positive and significant correlations between grain yield and number of heads/m², number of grains/head, grain weight/head and test weight. Grain yield increased as number of heads/m2, number of grains/head, grain weight/head, and test weight increased. Meanwhile, it was also determined that grain weight/head was significantly and negatively correlated to the number of heads/m2, and significantly and positively correlated to number of grains/head. On the other hand, there were significant and negative correlations between 1000-grain weight and both number of heads/ m2 and number of grains/head, while there was significant and positive correlation between the 1000-grain weight and grain weight/head. Test weight was also significantly and positively correlated to grain weight/head and 1000-grain weight (Table 2).

Table 1. Registration numbers, names, and pedigrees of genotypes used during 1996-98 in Kahramanmaraş, Turkey.

Registration No.	Cultivars/line	Registration No.	Cultivars/line
1001	Genç-88	1015	Bow/Buc/Bul
1002	Ka's'/NAC (Genç-99)	1016	Bow's'/Crow's'
1003	Panda	1018	(477/2)/Fkn/Gb
1004	84CZT04	1020	Van's'/Bb/KA
1005	84ÇZT04(S)	1021	Pr's'/Pew's'
1006	Seri-82	1023	Tow's'/Pew's'
1007	CHIL's'	1024	Peg's'/HD2206/Horb's'
1009	Ures/Bow's'	1025	Van's'/3/Cndr's'/Anq
1011	KAUZ	1027	Cettia
1013	BR12×4/BH146*6/ALD	1028	Kasyon/Pvn's'/spruv's'
1014	Attila	1029	Car422/ANA/Ures

Table 2. Correlation between all pairs of variables.

	No. grains/head	Grain weight/head	1000-grain weight	Test weight	Grain yield
No. heads/m ²	- 0.06	-0.48**	-0.28**	-0.12	0.57**
No. grains/head	-	0.79**	-0.29*	0.12	0.45**
Grain weight/head	•	•	0.19**	0.25**	0.27**
1000-grain weight	-	-	-	0.26**	-0.14
Test weight	-	-	-	-	0.18*

^{*,**} Significant at P < 0.05 and 0.01, respectively.

Direct effects of number of heads/m², grain weight/head and test weight on grain yield were positive, while direct effects of number of grains/head and 1000-grain weight on grain yield were negative. Direct effects of number of heads/m² and grain weight/head were considerably higher than direct ones of test weight. Therefore, these two yield components increased yield.

The largest negative direct effect was that of number of grains/head on grain yield. But indirect effect of number of grains/head via grain weight/head was positive and high. This result indicated that number of grains/head had a great effect on grain yield via grain weight/head.

Conclusions

The correlation analysis revealed that grain yield was positively and significantly related to number of heads/m², number of grains/head, grain weight/head and test weight. Path analysis indicated that number of heads/m², grain weight/head and test weight had positive direct effects on wheat grain yield, with number of heads/m² and grain weight/head being the most important. In addition, number of grains/head had also positive indirect effect on grain yield via grain weight/head. Therefore, number of heads/m², grain weight/head and number of grains /head may be used as selection criteria in breeding programs to develop high yielding varieties (Figure 1).

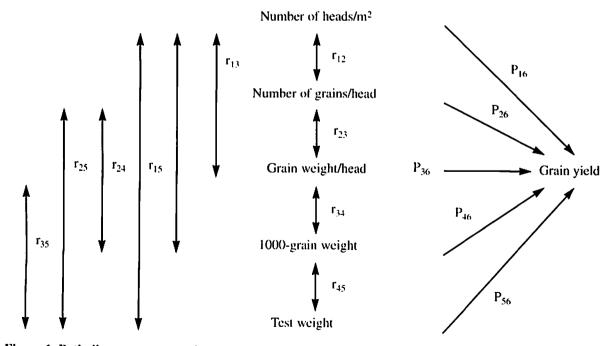


Figure 1. Path diagram representing cause and effect relationships among yield components and grain yield.

Table 3. Path coefficients for the effects of number of heads/m², number of grains/head, 1000-grain weight and test weight on wheat grain yield.

weight and test weight on wheat grain yield.				
Pathway	Path Coefficients			
Number of heads/m ²				
Direct effect on grain yield, P ₁₆	1.09			
Indirect effects via;				
- Grain number/head, r ₁₂ P ₂₆	-0.04			
- Grain weight/head, r ₁₃ P ₃₆	-0.62			
- 1000-grain weight, r ₁₄ P ₄₆	-0.08			
- Test weight, r ₁₅ P ₅₆	-0.02			
- Correlation r ₁₆	0.57**			
Number of grains/head				
Direct effect, P ₂₆	-0.62			
Indirect effects via;				
- Head number/m ² , r ₁₂ P ₁₆	-0.07			
- Grain weight/head, r ₂₃ P ₃₆	1.04			
- 1000-grain weight, r ₂₄ P ₄₆	-0.08			
- Test weight, r ₂₅ P ₅₆	0.02			
- Correlation r ₂₆	0.45**			
Grain weight/head				
Direct effect, P ₂₆	1.31			
Indirect effects via;				
- Head number/m ² , r ₁₃ P ₁₆	-0.52			
- Grain number/head, r ₂₃ P ₂₆	-0.50			
- 1000-grain weight, r ₃₄ P ₄₆	-0.06			
- Test weight, r ₃₅ P ₅₆	0.03			
- Correlation, r ₇	0.27**			
1000-grain weight				
Direct effect, P ₂₆	-0.29			
Indirect effects via;				
- Head number/m ² , r ₁₄ P ₁₆	-0.31			
- Grain number/head, r ₂₄ P ₂₆	0.18			
- Grain weight/head, r ₃₄ P ₃₆	0.25			
- Test weight, r ₄₅ P ₅₆	0.03			
- Correlation, r ₄₆	-0.14			
Test weight				
Direct effect, P ₅₆	0.13			
Indirect effects via;				
- Head number/m ² , r ₁₅ P ₁₆	0.13			
- Grain number/head, r ₂₅ P ₂₆	-0.07			
- Grain weight/head, r ₃₅ P ₃₆	0.33			
- 1000-grain weight, r ₄₅ P ₄₆	-0.07			
- Correlation, r ₅₆	0.18**			

^{*, **} Significant at P < 0.05 and 0.01, respectively.

References

Anonymous. 1997. KSU (Results of the Soil Department Laboratory). In Turkish. Toprak Bölümü Lab. analiz sonuclari. Kahramanmaraş, Turkey.

Altinbaş, M. and H. Sepetoğlu. 1993. Bir börücle (Vigna unguiculata L.) populasyonunda tane verimini etkileyen ogelerin belirlenmesi uzerinde bir çalişma. Doga Tirk Tarim ve Ormancilik Dergisi 13: 775-784.

Bhatt, G.M. 1973. Significance of path coefficient analysis in determining the nature of character association. *Euphytica* 22: 338-343.

Borojevic, S. and W.A. Williams. 1982. Genotype × environment interactions for leaf area parameters and yield components and their effects on wheat yield. *Crop Science* 22: 1020-1025.

Dofing, S.M. and C.W. Knight. 1992. Alternative model for path analysis of small yield. *Crop Science* 32: 487-489.

Duarte, R.A. and M.W. Adams. 1972. A path coefficient analysis of some yield component interrelations in field beans. *Crop Science* 31: 1179-1185.

Fonseca, S. and F.L. Patterson. 1968. Yield component heritabilities and interrelationships in winter wheat (*Triticum aestivum L.*). Crop Science 8: 614-617.

Garcia, M.L.F., J.M. Ramas and M.B. Garcia. 1991. Ontogenetic approach to grain production in spring barley based on path coefficient analysis. *Crop Science* 31: 1179-1185.

Gebeyhou, G., D.R. Knott, and R.J. Baker. 1982a. Relationships among durations of vegetative and grain filling phases, yield components, and grain yield in durum wheat cultivars. *Crop Science* 22: 287-290.

Gebeyhou, G., D.R. Knott, and R.J. Baker. 1982b. Rate and duration of grain filling in durum wheat cultivars. *Crop Science* 22: 337-340.

Grafius, J.E. 1972. Competition for environmental resources by component characters. *Crop Science* 12: 364-367.

Kırtok, Y. and M. Çölkesen 1985. Cukurova Kosullarında denemeye alinan arpa cesitlerinde önemli bazi verim unsurlari uzerinde path katsayisi analizi. *Doga Turk Tarm ve Ormanclk Dergisi* 9: 40-50.

Mou, B. 1990. Inheritance of the rate and duration of grain filling in wheat. Agronomy Abstract 109: 21-26.

Pury, Y.P., C.D. Qualset, and W.A. Williams. 1982. Evaluation of yield components as selection criteria in barley breeding. *Crop Science* 22: 927-931.

Wiegand, C.L., A.H. Gebermann, and T.A. Guellar. 1981. Development and yield of hard red winter wheats under semi-tropical conditions. Agronomy Journal 73: 20-37.

Gene Effects Controlling Yield Components in Barley (*Hordeum vulgare* L.)

S.C. Vimal¹ and S.R. Vishwakarma²

Department of Plant Genetics and Plant Breeding, N.D. University of Agriculture and Technology, Kumarganj, Faizabad-224229 (U.P.), INDIA

Abstract

Four crosses viz. NDB 940 × Ratna, NDB 90-1 × Jagrati, NDB 940 × RD 2516, and NDB 206 × BL-2 were made involving seven homozygous and genetically diverse genotypes of barley. P_1 , P_2 , F_1 , F_2 , B_1 and B_2 generations were grown during 1996/97 in a compact family block design and data were recorded on days to ear/emergence, plant height, number of spikelets/main spike, number of grains/main spike and weight of grains/main spike. The genetic analysis using a six parameter model indicated that both additive and non-additive gene effects played an important role in the expression of these traits.

In general, magnitude of dominance effect (h) has a greater value than additive effect (d) in all traits. Digenic interaction and epistasis indicate complex nature of inheritance. Thus improvement by selection in early generation could be advisable.

Key words: genotypes; grain yield; *Hordeum vulgare* L.; generations; gene effects.

Introduction

By virtue of its hardy nature, lower cost of cultivation, superior nutritional qualities and many uses, barley promises much in many least favored and neglected agricultural areas, particularly in problematic soils like rainfed, dry land, saline-alkaline, and flood prone marginal/coastal areas.

At present, a systematic hybridization project to improve malt and feed barley to meet the growing demand

تـأثيرات المورثـة الـتي تـتحكم بمكونـات الـغلـة في الشعير (Hordeum vulgare L.)

الملخص

أجريت أربع تهجينات NDB940×RD2516 شملت سبعة طرز شعير NDB940×Ranta. NDB 206×BI-2 NDB940×Ranta ملت سبعة طرز شعير وراثية متجانسة اللواقح و متباينة وراثياً حيث زرعت نباتات P1P2, F1,F2, .BC1, BC2 خلال موسم 97/1996 في تصميم للقطاعات العائلية المتوافقة، وسجلت البيانات يومياً عن عدد الأيام حتى انبشاق السنبلة، وطول النبات، وعدد السنبلة الرئيسية، وعدد الحبوب/السنبلة الرئيسية، ووزن الحبوب/السنبلة الرئيسية. وقد دل التحليل الوراثي الذي أجري باستخدام نموذج المعايير الستة على أن التأثيرات التجميعية وغير التجميعية للجينات قد أسهمت بدور كبير في التعبير عن هذه الصفات.

بشكل عام، فإن لمقدار تأثير السيادة (h) قيمة تفوق التأثير التجميعي (d) في كل الصفات. ويدل التفاعل ثنائي المورثة والتفوق على الطبيعة المعقدة للتوريث. وعليه قد يكون من الموصى به القيام بالتحسين الوراثي من خلال الانتخاب في الجيل المبكر.

is in progress. Keeping this objective in mind, this study was carried out to improve grain yield through the use of gene effects.

Material and Methods

Seven homozygous and genetically diverse varieties of barley NDB 940, NDB 90-1, NDB 206, Ratna, Jagrati, BL-2 and RS 2516 were chosen for building up the experimental materials. Four crosses viz. NDB 940 × Ratna, NDB 90-1 × Jagrati, NDB 940 × RD 2516 and NDB 206 × BL-2 were obtained during *rabi* 1995/96. During the same year, the F_1 generations of cross combinations obtained from these projects were sown to raise hybrid populations (B_1 , B_2 and F_2). All F_1 populations were planted in rows spaced 25 cm apart. Seed-to-seed distance was kept 15 cm apart.

Half of the emerged spikes from selected female plants of each genotype were chosen to get hybrid populations (B₁,

Part of the thesis submitted for a Master of Science in Agriculture Genetics and Plant Breeding.

² Junior Barley Breeder/Assistant Professor.

 B_2 and F_2) and bagged to prevent out crossing. The middle spikelets were clipped, emasculated and pollinated after 48-72 hours by the desired spike (male parent). Parent-1 was used for making B_1 and Parent-2 for B_2 to obtain back crosses, and F_2 generations were raised by selfing the F_1 plant. Pollinated spikes were bagged with butter paper bags to keep out foreign pollen.

Thus, parents (P₁ and P₂), F₁, F₂, B₁ and B₂ generations were raised during *rabi* 1996/97 at the Genetic and Plant Breeding Research Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad, India in a compact family block design in three replications. The four families (crosses) constituted the main plots while the progenies constituted the sub-plots. Each entry was sown in a 3 m long row. Plants within the rows were spaced at 10 cm. The standard package of practices was followed to raise a good crop.

Five randomly selected plants from parents and F_1 generations, and 20 each from back crosses and F_2 generations in a replication, were tagged before flowering. Data on days to maturity, number of effective tillers/plant, length of main spike (cm), 1000-grain weight (g), and grain yield/plant (g) were recorded. Genetic analysis was done by using a six-parameter model (Hayman 1958) after applying the scaling test suggested by Hayman and Mather (1955).

Results and Discussion

ANOVA

The analysis of variance of the compact family block design indicated that variance, due to differences among progenies, was found significant for all characters studied in all crosses except weight of grains/main spike in cross IV. Therefore, differences among the treatments were sufficient for onward study. Besides, the four sets of crosses were also variable for the majority of the traits (Table 1).

Component of generation mean analysis

The scaling test of Mather (1949) and gene effect for different traits using the six parameter model of Hayman (1958) were estimated and results are presented in Table 2.

The expectation of A, B, C and D scaling tests tend towards zero in the absence of interactions. If there is a significant deviation from zero, then epistasis may play an important role. It could be visualized from the table under

Table 1. Analysis of variance for differences between progenies within families (cross wise).

		Cross I			Cross II			Cross III			Cross IV	
Characters	Rep.	Progenies Error	Error	Rep.	Progenies Error	Error	Rep.	Progenies Error	Error	Rep.	Progenies	Error
	ĊΙ	5	10	2	5	10	2	5	01	2	S.	_ 2
Days to ear	0.389	121.965** 1.789	1.789	2.722	22.889**	1.656	0.389	63.822**	2.322	9.056*	71.422**	2.122
emergence Plant	4.403	205.945** 2.170	2.170	23.011	82.343*	14.498	14.198	58.276*	11.131	18.344	68.356**	11.814
height		÷		9		•						
No. of spikelets/	2.638	17.499**	1.985	8.528*	36.964**	1.398	1.793	16.998**	1.504	1.015	17.405**	0.865
main spike												
Weight of grains/ main spike	0.041*	0.091**	900.0	0.005	0.134**	0.008	0.021	0.106**	0.012	0.017	0.025	0.016
No. of grains/	15.805*	50.214*	9.394	44.150	110.2998	12.242	17.881**	84.784**	0.720	34.432**	0.720 34.432** 66.916**	3.439
main spike												

** Significant at 5 and 1% levels, respectively

Table 2. Scaling test, gene effects, and type of epistasis for five metric traits.

Character			Gen	e effects		Ī	ype of		Scale t		
	m	d	h	i	j		pistasis	A	В	C	D
						940 × Rat		1)		-	
Days to ear	87.00**	-3.67**	11.17**	10.00**	2.83*	-46.33**	D		15.33**	26.33**	-5.00**
emergence	±0.57	±0.94	±3.07	±2.98	±1.13	±4.74		±1.70	±1.70	±2.87	±1.49
•							15	17 05**	7 1300	21.02**	2.40
Plant height	95.60**	-3.54**		-6.95		-18.03**	D			31.93**	3.48
	±0.93	±1.15	±4.50	±4.37	±1.33	±6.42		±2.28	±2.02	±4.47	±2.18
No. of spikelets/	27.53**	1.36	0.55	-4.31	2.09	-1.64	D	5.07**	0.89	10.27**	2.16
main spike	±0.55	±1.82	±4.26	±4.26	±1.86	±7.68		±1.42	±3.45	±2.35	±2.13
man aprice											
Weight of grains/	2.66**	0.13	0.68*	0.47	0.22*	-1,44**	D	0.71**	0.26	0.50*	-0.23
main spike	±0.00	±0.00	±0.26	± 0.26	±0.10	±0.44		±0.14	±0.17	±0.22	±0.14
	C 1 00++	0.01	(16	0.52	0.50	-21.25	D	10.86	9.87**	20.20	-0.26
No. of grains/	64.88**	-0.84	6.46 ±13.48	0.53 ±13.38	0.50 ±4.65	±20.95	17	± 8.85		±10.40	±6.69
main spike	±2.64	±4.55	±13.40	¥15.50	±4.0.7	±=(), 9,7		± 0.05	±0.47	±10.40	10.07
						B 90-1 × J:	agrati (Cr	oss II)			
Days to ear	77.33**	-1.33	9.67*	6.67	0.67	-22.00**	D	8.33**		8.67*	-3.33
emergence	±0.88	±1.10	±4.20	±4.16	±1.27	±5.83		±1.63	±2.00	± 3.80	±2.08
Plant height	85.13	3.62	4.88	-5.07	9.24*	11.03	C	6.25	-12.22	-0.90	2.53
. min neight	±0.39	±3.41	±7.79	±6.99	±3.76	±15.44	•	±5.42	±6.87	±7.24	±3.49
Nto a Camberley I				7.39**	1.85	-24.59**	D	10.45**		9.80**	-3.70**
No. of spikelets/	26.98**	0.25 ±0.62	13.13** ±2.20	7.39** ±2.10	±1.23	±3.71	D	±1.90	±1.60	±2.76	±1.05
main spike	±0.42						•				
Weight of grains/	2.71**	0.16**		0.39	0.22*	-1.40**	D	0.73**		0.62**	-0.20*
main spike	±0.00	±0.00	±0.22	±0.22	±0.10	±0.33		±0.14	±0.10	±0.22	±0.10
No. of grains/	64.15**	-2.63	8.50	0.27	-2.27	-32.80	Ð	14.00	18.53**		-0.13
main spike	±1.62	±5.11	±13.19	±12.11	±5.23	±21.70		±9.47	±4.76	±7.28	±6.06
					NDF	3 940 × RD	2516 <i>(</i> Cr	000 III)			
Days to ear	77.67**	1.00	12.67**			* -13.33*	D			-12.00**	-6.33**
emergence	±0.88	±0.94	±4.10	±4.00	±1.13	±5.60		±2.31	±1.15	±4.14	±2.00
Plant height	84.47**	4.04	19.83	10.39	6.10	-20.88	D	11.35*	-0.86	0.09	-5.20
	±2.37	±3.16	±11.51	±11.38	±3.34	±16.30		±5.03		±10.30	±5.69
No. of spikelets/	24.11**	0.58	17.88*	13.85**	1.01	-25.55**	D	6.86**	4.84**	-2.15	-6.92**
main spike	±0.26	±0.98	±2.40	±2.24	±1.18	±4.45		±2.00	±1.50	±2.06	±1.12
Weight of grains/	2.65**	0.11	0.77*	0.43	0.04	-1.26*	D	0.46**	0.38	0.41	-0.21
main spike	±0.00	±0.10	±0.35	±0.35	±0.10	±0.53	•-	±0.14	±0.20	±0.30	±0.17
•	61.12**			22.29**			D				
No. of grains/ main spike	±0.58	3.51 ±1.94	28.85** ±4.62	±4.52	3.08 ±2.10	-55.51** ±8.39	D	±2.77	13.53** ±3.32	±3.18	-11.14** ±2.26
mant spike	±0.56	#1.74	±4.02	±4)∠	±2,10	五0.37		<i>22.11</i>	E0.04	±.7.16	£4.40
					NDF	3 206 × BL	-2 (Cross	IV)			
Days to ear	78.00**	0.67	48.50**	41.33**	-0.50	-61.00**	D		10.33**	-21.67**	-20.67*
emergence	±1.15	±1.05	±5.24	±5.08	±1.35	±6.87		±2.40	±2.03	±5.43	±2.54
Plant height	89.02**	2.89	-9.67	-19.34*	0.36	46.48**	D	-13.21**		-7.80	9.67*
	±1.33	±2.71	±7.90	±7.61	±3.28	±13.13	D	±4.85	±5.07	±7.39	±3.81
M											
No. of spikelets/	25.65**		9.71**	5.85*	-3.92**		D	-2.36*	5.47*	-2.73	-2.92*
main spike	±0.41	±1.15	±2.85	±2.81	±1.16	±4.95		±1.09	±2.13	±1.85	±1.41
Weight of grains/	2.65**	0.08	0.27	0.04	0.08	-0.11	D	0.11	-0.04	0.03	-0.02
main spike	±0.10	±0.10	±0.42	±0.41	±0.10	±0.57		±0.14	±0.20	±0.39	±0.20
	C 1 11 7 4 4	-0.79	23.71*	18.65	-4.12	-46.23**	D	9.67*	17.91**	8.93	-9.32
No. of grains/	61.97**	-(1, /9					1 1	U m / r			

^{&#}x27;.** Significant at 5 and 1% levels, respectively.

C = Complementary epistasis; D = Duplicate type of epistasis.

reference that for most of the characters, the additive dominance model was found inadequate. The scaling test revealed that epistasis had a predominant role in the expression of all the traits except in plant height (cross II) and weight of grains/main spike in cross IV.

The information on the genetic architecture gathered through generation mean analysis would help detect the gene effects involved in the expression of various metric traits. The estimates of the six parameter model from generation mean analysis showed that additive as well non-additive gene effects were important for all the traits. However, the magnitude of dominance effect (h) was greater than additive effect (d).

Days to ear emergence

Early types are preferred to those emerging late. As evident, from the values of different components, it was observed that additive gene effect with negative value for earliness was present in cross NDB 940 × Ratna and NDB 90-1 × Jagrati. Cross IV (NDB 206 × BL-2) had significant value of dominance gene effect (48.50). Among the digenic epistatic effects, additive × additive (i) components had significant value for all the crosses except cross II, whereas all the crosses had negative estimate for dominance × dominance (1) interaction. The opposite signs of h and 1 expressed the duplicate epistasis for all the crosses. Virk et al. (1989) and Senapati et al. (1994) reported similar findings.

Plant height

A scale test of the crosses indicated that significance of any of the A, B and C scales reflected the presence of non-allelic interaction. None of scales were found significant in case of cross II. The digenic interaction model revealed that significant additive × additive (i) and dominance × dominance(l) gene effect were present in crosses I and IV; only cross II (NDB 90-1 × Jagrati) showed additive × dominance (j) gene effect. Duplicate epistasis was more common for all the crosses except cross where complementary type of epistasis was important. Epistatic effect (i) and (l) indicated the importance of non fixable components. Lonc (1985) and Virk et al. (1989), who emphasized that plant height is determined by partial dominance effects, reported similar findings.

Number of spikelets/main spike

A perusal of Table 2 indicated that all crosses showed highly significant and positive values of dominance gene effect except cross I (NDB 940 × Ratna). In general, the relative

contribution of dominant gene effect was higher than additive gene effect.

Among the digenic epistatic gene effects, additive × additive (i) and dominance × dominance (l) were significant in all families except in cross I. None of the effects were found significant in NDB 940 × Ratna. Preponderance of dominance effect indicated that heterosis could be exploited for this character. An opposite sign of (h) and (l) expressed the duplicate type of epistasis for all crosses. Singh et al. (1988) and Lone (1985) have highlighted how important these ideas are.

Weight of grains/main spike

From the results obtained for weight of grains/main spike major yield attribute-the importance of main effects and epistatic effects could be seen. The presence of additive and non-additive effects in all crosses showed preponderance of both fixable and non fixable gene effects. Duplicate epistasis was mostly observed in all cases, except in NDB 206 × BL-2. In this case, all scales tend towards zero in the absence of interaction. Besides, most of the crosses for additive × dominance (j) and dominance × dominance (l) interaction showed a significant value. The estimates of (l) interaction were negative. Singh et al. (1992) and Gulati and Murty (1982) also registered similar findings.

Considering the overall result, it is apparent that if sufficient amount of additive gene effect (fixable) is present, any selection procedures can be used effectively. For exploitation of non-additive components, which are not fixable, one can go for heterosis breeding, otherwise intermating along with selection in early generations is needed. Several researchers, among them Srivastava et al. (1992), Balyan and Verma (1985), and Yunus and Paroda (1983), have made earlier attempts to solve this problem.

Number of grains/main spike

Referring to the estimate of number of grains/main spike, it becomes evident that its expression was governed mainly by dominant and epistatic gene effects. Additive gene effect was found negative and non-significant in low value in all crosses except NDB 940 × RD 2516. Significant dominance × dominance (1) epistasis was important only in two crosses (III and IV), while cross I (NDB 940 × RD 2516) showed additive × additive (i) gene effect. Thus both additive as well as non-additive gene effect were observed for expression in this trait. This agrees with the results obtained by Bebyakin et al. (1990), Singh et al. (1992). Wallia et al. (1994) and Guo et al. (1994).

References

- Balyan, H.S. and A.K. Verma. 1985. Relative efficiency of two mating system and selection procedure for yield improvement in wheat. *Theoretical and Applied Genetics* 71: 111-118.
- Bebyakin, V.M. and N.I. Karobova. 1990. Effects of the interaction of genes controlling yield components and grain quality in winter wheat. Doklady Vsesoyuznoi Ordena Lenina i Ordena Trudovogo Krasnogo Znameni Akademii Sel'Skokhozyaistvennykh Nauk Imeni VI Lenina 5:2-6.
- Gulati, S.C. and B.R. Murty. 1982. Genetics of some developmental traits in barley. *Indian Journal of Genetics* 42: 399-404.
- Guo, Y.Y. and S.Y. Xu. 1994. Genetic analysis of yield traits in two rowed barley. *Acta Agricultural Zheijiangensis* 6: 156-160.
- Hayman, B.I. 1958. The separation of epistatic from additive and dominance variation in generation mean. Heredity 12: 371-390.
- Hayman, B.I. and K. Mather. 1955. The description of genetic interaction in continuous variation. *Biometrics* 11: 69-82.

Lone, W. 1985. Types of gene effect governing quantitative

Early Generation Testing for Isolating the Most Promising Crosses in Bread Wheat

E. Gouli-Vavdinoudi and M. Koutsika-Sotiriou Department of Genetics and Plant Breeding, Aristotelian University of Thessaloniki, 540 06, GREECE

Abstract

The present investigation was conducted to evaluate the possibility of identifying promising wheat crosses from early generations. Thirteen bread wheat varieties (*Triticum aestivum* L. em. Thell.) were crossed with the cultivar Myconos. The obtained F_1 hybrids were evaluated in single row plots in nil-competition, and differences in yield performance were not significant. The F_2 to F_5 generations were evaluated in a honeycomb design in nil-competition. Additionally, the F_5 lines were evaluated in solid stand at two locations. From F_2 , the three highest-yielding crosses and one low-yielding cross were

- character in winter wheat. *Hodowla Roslin. Aklimatyzacja i Nasiennictwo* 29:3-4.
- Mather, K. 1949. Biometrical Genetics. Dover Publications, New York, USA.
- Senapati, N., S.K. Swain and M.C. Patnaik. 1994. Genetic of yield and it components in wheat. *Madras Agricultural Journal* 81: 502-504.
- Singh, G., G.S. Bhullar, and K.S. Gill. 1988. Inheritance of yield and its components in an invarietal cross of bread wheat. *Crop Improvement* 15: 200-202.
- Singh, R.P., S. Subedar, and S. Singh. 1992. Estimation of genetic parameter through generation mean analysis in bread wheat. *Indian Journal of Genetics* 52: 369-375.
- Srivastava, R.B., S.C. Sharma, and M.D. Yunus. 1992. Additive and non-additive effect for yield and yield components in two crosses of wheat. *Indian Journal of Genetics* 52: 297-301.
- Virk, D.S., P.S. Virk, and H.S. Aulakh. 1989. Detection of additive, dominance and epistasis variation in bread wheat. *Indian Journal of Genetics* 49: 213-217.
- Wallia, D.P., T. Dawa, and P. Plaha. 1994. Genetics of yield components in spring wheat. Cereal Research Communications 22: 185-186.
- Yunus, M. and R.S. Paroda. 1983. Extent of genetic variability created through biparental mating in wheat. *Indian Journal of Genetics* 4: 76-81.

اختبار الجيل المبكار لعزل الهجن الأكثر تبشيراً في القمح الطرى

لملخص

أجري البحث الحالي لتقييم إمكانية تحديد تهجينات مبشرة من القمح من الأجيال المبكارة. وقد هجن ثلاثة عشر صنفاً من القمح الطري (Triticum aestivum L. em. Thell) مع الصنف Myconos. وجرى تقييم لهجن الجيل الأول Fi في قطع تجريبية أحادية الصف بدون منافسة، إلا أن الاختلاف في الغلة لم يكن معنوياً. كما قُيمت كل من نباتات الجيل الثاني إلى الخامس وفق تصميم نخاريب العسل بدون منافسة. وكإجراء الخامس في كثافة عالية في موقعين مختلفين. ومن الجيل الثاني 57 تم انتخاب ثلاثة هجن مغلالة، وهجين واحد منخفض الغلة لإجراء تقييم أكثر تفصيلاً. ومن الجيل الثاني إلى الرابع، تم إجراء انتخاب كتلي للحصول على غلة مرتفعة، كما تم البحث في تفوق مستمر لغلة الهجن المغلالة (4-38%) بالمقارنة مع الهجين المنخفض الغلة في كل من الجيل الثالث والرابع والخامس. وقد تجاوز ما معدله في كل من الجيل الثالث والرابع والخامس. وقد تجاوز ما معدله

selected for a more detailed evaluation. In the F_2 to F_4 generations, mass honeycomb selection was practiced for high yield. A consistent superiority (4 to 38%) of the yield of the high-yielding crosses compared to the low-yielding cross was detected in the F_3 , F_4 and F_5 generations. In nil-competition, 25 to 31% of the F_5 lines derived from high-yielding crosses significantly exceeded the highest-yielding line from the low-yielding cross. In solid stand, this percentage ranged from 25 to 40%. The study demonstrated that the performance of crosses in F_2 could constitute the criterion for identifying the most promising crosses if an appropriate methodology, including appropriate selective criteria, is chosen.

Key words: *Triticum aestivum* L.; yield; breeding; hybrids; Greece; yielding crosses; early generation trials; heterosis.

Introduction

Identifying, from among a large number of crosses, those that are most likely to yield the most productive lines, is a necessary part of plant breeding making it possible to concentrate time and effort on the most promising crosses.

A number of studies (Atkins and Murphy 1949; Fowler and Heyne 1955) have shown that the poorer (rejected) crosses sometimes produce very superior lines, even though the number obtained is much less. Lupton and Whitehouse (1955) considered the twin problem of selecting crosses for further selection and of recognizing the low-yielding crosses, which nevertheless might contain high-yielding lines. Their solution was to use a combination of visual selection and small F_2 progeny tests. On the other hand, Nass (1979) found that lines of crosses identified as high yielding in F_1 had significantly greater mean yield in F_4 than lines of crosses that were low yielding in F_1 . Jensen (1988) believed that if plant breeders could create a new type of early generation bulk field plot, it would be helpful for their evaluation of crosses.

Many breeders used the diallel cross technique to assess the usefulness of parent and early-generation progeny performance for identifying the most promising crosses. Lupton (1961), Leffel and Hanson (1961), and Bhatt (1973) found that the predictions made in F_1 and F_2 agreed very well with those made in F_3 , less so in F_4 and that the F_1 and F_2 trials might have been used to eliminate poorer crosses.

Developments in biometrics have suggested (Jinks and Pooni 1976) that the early generation trials may be used to

31-25% من سلالات الجيل الخامس المشتقة من الهجن المغلالة بدون منافسة، غلة أفضل سلالة ناتجة عن الهجين المنخفض الغلة. وتراوحت هذه النسبة في كثافة عالية ما بين 25 و 40%. وأظهرت الدراسة أن أداء الهجن في الجيل الثاني قد يشكل معياراً لتحديد الهجن الأكثر تبشيراً، شريطة اتباع طريقة مناسبة، بما في ذلك اختيار معيار الانتخاب المناسب.

predict the ranking of the crosses according to their likelihood to produce superior recombinant lines. Nevertheless, applying cross prediction methods in self-pollinating cereals is contradictory (Caligari et al. 1985; Thomas 1987).

It is generally believed that heterotic F_1 generations with a relative small inbreeding depression in the F_2 are promising populations from which to select. However, the plant density under which the breeder should evaluate the F_1 and F_2 generations is open to question. The results of Roupakias et al. (1997) indicate that evaluating F_1 and F_2 generations under low plant density could identify promising faba bean populations in an early generation.

The objective of this study was to detect the important generation to identify superior bread wheat crosses. With this aim, experiments in which crosses were evaluated in F_1 to F_5 generations were carried out.

Material and Methods

Thirteen bread wheat varieties of different geographic origins were crossed with the cultivar Myconos, which was developed in Greece (Gouli and Fasoulas 1989). One of the reasons why Myconos was selected as a common parent is because of its superior yield. When compared with the varieties Siete Cerros (one of its parents), Generoso and Yecora, it outyielded them by 49, 27 and 24%, respectively. Another reason is its way of developing as it was created from an early generation (F₂) selection in nil-competition. The last reason why it was selected is because of its different origin compared to the 13 other varieties.

This investigation lasted six growing seasons. The trials were carried out at the University of Thessaloniki farm. The experimental comparison was made according to the honeycomb design (absence of competition) and under solid stand.

An interplant spacing of 90 cm was used in the honey-comb design to eliminate the masking effects of competition and to maximize phenotypic expression and differentiation (Kyriakou and Fasoulas 1985). To ensure a plant at each position, three kernels were sown per position. Four weeks after sowing, all positions were thinned to a single plant. A few days before threshing, all plants were tagged for identification. Threshing occurred in the field and individual plant grain yield (g/plant) was recorded on a special form with the same layout as the field experiment to facilitate moving grid selection by hand (Fasoulas 1981; Mitchell et al. 1982; Kultarni 1990).

For the solid stand, a randomized complete block design consisting of three replications was used. Each plot consisted of one row 4 m long, separated from the neighboring plot by one alley 100 cm long to exclude interplot competition. The seeding rate was 400 seeds/row. The plants from each plot were threshed and seeds were weighed (g/plot). Standard agronomic practices adopted by farmers in the area were followed in the tests.

Evaluation of 13 crosses in the F₁ and F₂ generations

Thirteen F_1 generations were evaluated for grain yield in single-row plots. The number of plants ranged from 27 to 31 per cross. The cultivar Myconos (check) was planted contiguous to every three plants. The intra-row and the interrow distances were 90 and 50 cm, respectively (Figure 1).

Within each cross, equal number of seeds from the two highest yield F₁ plants were mixed. These seeds were used for evaluating the 13 F₂ generations the following year in a replicated R-49 honeycomb design (Koutsika et al. 1990). This design requires 49 entries which may be coded from iA to iG; i = 1-7. In this investigation, three codes were randomly assigned to each cross for a total of 39 codes; the remaining 10 codes were assigned to the Myconos check (Figure 1). Forty-five F₂ plants per cross and 150 plants from the check were evaluated. The three F₂ top-yielding crosses (Myconos × Chios, Myconos × Sk-7 and Myconos × Satelite) and one low-yielding cross (Myconos × Ciano) were used for evaluation in later generations. Seed of 11 high-yielding F₂ selected plants from each of these four crosses was retained, thus forming 44 F₃ lines for evaluation the following year.

Evaluation of three high-yielding crosses and one lowyielding cross in F₃ to F₅ generations

The F_3 , F_4 and F_5 lines of four crosses were evaluated in an R-49 honeycomb design. The variety Myconos was sown as

a check. In addition, the F_5 lines were evaluated in solid stand in a randomized complete block design with three replications at two locations. Five plots of the Myconos check were sown in each replication (Figure 1).

In the F₃ and F₄ generations, mass honeycomb selection for high grain yield/plant was applied using the principle of

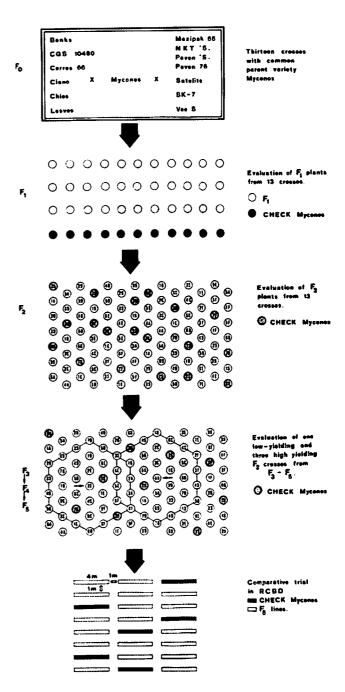


Figure 1. Pathway for isolating the most promising crosses in bread wheat.

the moving hexagonal grid (Fasoulas 1981; Georgakis et al. 1992). The grid contained 37 plant positions and the intensity of selection was 2.7%. A given plant was selected only if it outyielded the other 36 plants in the grid (Figure 1). As a result, the number of selected plants varied across the crosses in the F_3 and F_4 generations. The seed of the selected plants was retained to form the lines of evaluation in the next generation. The number of lines and plants that were grown starting from the F_3 to the F_5 generation are shown in Table 1.

Statistical analysis

The z-test and t-test were applied with Cochran's approximation (Snedecor and Cochran 1967) for different standard deviations to test the hypotheses that: (1) the crosses were equivalent with regard to mean yield per cross in each generation (F₁ to F₅), and (2) the lines of the four crosses were

Table 1. Number of lines and plants per cross from F_3 to F_5 .

<u> </u>	G	eneratio	ns			
Cross	1	F ₃	F	4	F,	:
	lines	plants'	lines	plants	lines	plants
Myconos × Chios	11	376	19	525	8	271
Myconos × Sk-7	11	365	16	421	16	800
Myconos × Satelite	11	363	5	173	5	139
Myconos × Ciano	11	362	5	126	4	129
Myconos (check)	5	167	4	106	5	126
Total	49	1633	49	1351	38†	1465

[†] To complete the 49 codes of the R-49 design, two codes were assigned to some lines of the first two crosses.

equivalent in the F_3 , F_4 , and F_5 generations. In solid stand, the results were subjected to the analysis of variance.

The superiority of each cross over the common parent was calculated for each generation, according to Strivastava (1991), as heterosis over the inbred line parent:

$$H_{ILP} = 100 (F_1 = ILP)$$

Results and Discussion

The thirteen F_1 generations and the check did not show significant differences in yield. Heterosis ranged from -17.4 to 4.07% and positive values was observed only for the cross Myconos \times Satelite (Table 2). Considerable changes occurred in the yield rank between the F_1 and F_2 generations (r = 0.21). In F_2 , the three high-yielding crosses of Myconos with Chios, Sk-7 and Satelite showed significantly higher yield than 11,8 and 6 other crosses, respectively. On the other hand, the low-yielding cross Myconos \times Ciano differed significantly from only two crosses. Heterosis ranged from -31 to 11.6% and positive values were observed only for the crosses Myconos \times Chios (11.6%) and Myconos \times Sk-7 (5.8%). A high level of inbreeding depression was observed for Myconos \times Ciano (Table 2).

Because F_2 is an important generation in which to identify favorable additive genes and measure non-additive effects specific to a cross (Fasoulas 1988; Whitehouse 1953), three high-yielding F_2 crosses and one low-yielding F_2 cross were selected for a more detailed evaluation. A

Table 2. Mean yield (g plant-1) and heterosis (H_{ILP}) in F₁ and F₂.

· · · · · · · · · · · · · · · · · · ·		F,	<u></u>		F ₂	
Crosses	Yield Yield	H _{II.P}	Rank	Yield	Н _{ил}	Rank
Myconos × Satelite	179a*	4.07	ı	101bcd*	-1.9	4
Myconos × (Check)	172a	100	2	103bc	0.001	3
Myconos × Ciano	167a	-2.9	3	86efg	-16.5	9
Myconos × NKT "S"	176ª	-2.9	4	96bedef	-6.7	6
Myconos × Pavon "S"	158	-8.0	5	78gh	-24.2	11
Myconos × CGS 10480	158a	-8.0	6	75gh	-27.0	12
Myconos × Vee S	155a	-9.8	7	81fg	-24.0	10
Myconos × Sk-7	148a	-13.9	8	109 ^{ab}	+5.8	2
Myconos × Cerros 66	148a	-13.9	9	99bede	-3.8	5
Myconos × Lesvos	146ª	-15.1	10	63i	-3.8	14
Myconos × Chios	146a	-15.1	11	115a	+11.6	1
Myconos × Banks	146a	-15.1	12	96cdef	-6.7	7
Myconos × Mexipak 65	146a	-15.1	13	91defg	-11.6	8
Myconos × Pavon 76	142a	-17.4	14	71 ^{hi}	-31.0	13

Spearman's coefficient of rank correlation (r = 0.21)

^{*} Means within a column followed by different letters are significantly different at the 0.05 level.

consistent superiority (ranging from 4 to 38%) of the high-yielding crosses compared to the low-yielding ones was detected in each of the three generations (Table 3). This superiority was significant in F_3 for all crosses and in F_4 and F_5 for the crosses of Myconos with Chios and Sk-7. The cross Myconos × Chios had the highest percentage (78.9 to 100%) of F_3 . F_4 and F_5 lines outyielding the highest-yielding line from Myconos × Ciano. On the other hand, for Myconos × Satelite this percentage ranged from 20 to 80% (Table 4). In these two crosses, 25% of the F_5 lines differed significantly from the highest-yielding line from Myconos × Ciano, whereas in Myconos × Sk-7 this value amounted to 31%.

Table 3. Mean yield (g plant $^{-1}$) in F_3 to F_5 of four crosses classified as high- or low-yielding in F_2 .

		Generation	
Cross	F ₃	F.4	F ₅
High-yielding			
Myconos × Chios	152.4a*	212.1b	178.7a
Myconos × Sk-7	137.3b	211.0b	174.4a
Myconos × Satelite	136.4 ^b	190.7°	171.3ab
Low-yielding			
Myconos × Ciano	110.2c	183.2c	155.8 ^b
Myconos (check)	138.6ab	228.6a	158.2b

Means within a column by different letters are significantly different at the 0.05 level.

Table 4. Number of lines (relative to the total number of lines per cross) of high-yielding crosses exceeding the highest-yielding line from Myconos × Ciano (low-yielding).

	F ₃	F ₄	F ₅
Cross	(%)	(%)	(%)
Myconos × Chios	10 90.9(7)*	15 78.9(4)*	8 100.0(2)*
Myconos × Sk-7	7 63.6(3)	10 62.5(3)	13 81.2(4)
Myconos × Satelite	5 45.4(1)	1 20.0	4 80.0(1)

Number of lines significantly different from the highest-yielding line from Myconos × Ciano at the 0.05 level.

In the experiment under solid stand, the superiority of the high-yielding crosses over the low-yielding cross ranged from 18 to 46% and was significant for the cross of Myconos with Sk-7. In particular, 40% of the F_5 lines from Myconos × Sk-7 and 25% of those from Myconos × Satelite differed significantly from the highest-yielding line from Myconos × Ciano. The crosses of Myconos with Chios and Sk-7 had positive values for heterosis (Table 5).

Table 5. Mean yield (g plot-1) and heterosis ($H_{\rm ILP}$) of $F_{\rm S}$ lines under solid stand at two locations. The number of lines (relative to the total number of lines per cross) exceeding the highest-yielding line from Myconos × Ciano is also indicated.

Crosses	Yield	H _{II.P} (%)	Numbe	r of lir	1es(%)
High-yielding					
Myconos×Sk-7	1722.8a*	19.9	15	93	(6)÷
Myconos×Chios	1528.2ab	6.4	8	100	(2)
Myconos (Check)	1436.0ab	100	-	-	-
Myconos×Satelite	1393.6ab	-2.9	4	80	(1)
Low-yielding					
Myconos×Ciano	1181.5 ^b	-17.7	-	-	-

 $LSD = \pm 472.34$; CV = 19%

The consistent superiority of the two high-yielding crosses of Myconos with Chios and Sk-7 in all generations was probably due to the additive genes that were involved in the parents. According to Fasoulas (1988), the additive genes, which are not manifested in F₁ but in F₂ and later generations, render inbred vigor more efficient than hybrid vigor. It implies that in crops where deleterious genes have been eliminated, the F₂ is an important generation to identify favorable additive genes. It also agrees with data that Cregan and Busch (1977; 1978) reported. In this study, the two high-yielding crosses of Myconos with Chios and Sk-7 showed homozygote advantage in F_2 (Table 2), and the F_5 lines derived from these crosses showed positive values for heterosis (Figure 2). On the other hand, the low yielding cross Myconos × Ciano showed negative values for heterosis in all generations (Figure 2). These results agree with the findings of Abugaliev (1979), who studied the heritability of heterosis in various crosses. He found that, if in F₃ and F₃ the phenotypic values of characters undergo a sharp fall, there is little chance of breeding elite varieties from such crosses, but if the reduction is gradual and the lines show transgressive segregation, the crosses are of real breeding value.

Conclusion

The performance of F_2 can constitute the criterion to identify the most promising crosses. However, the procedure will continue effectively only if an appropriate methodology, including appropriate selective criteria, is chosen.

Means followed by different letters are significantly different at the 0.05 level.

Number of lines differing significantly from the highest-yielding line from Myconos × Ciano at the 0.05 level.

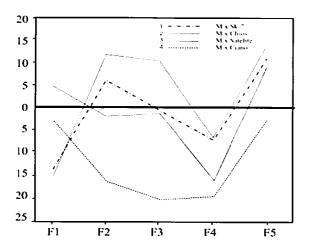


Figure 2. Heterosis for grain yield in each generation and cross (honeycomb selection).

References

- Abugaliev, S.C. 1979. Possible use of heterosis to determine the breeding value of hybrid combinations. *Plant Breeding Abstracts* 51(1981): 1012.
- Atkins, R.E. and H.C. Murphy. 1949. Evaluation of yield potentialities of oat crosses from bulk hybrid tests. *Agronomy Journal* 41: 41-45.
- Bhatt, G.M. 1973. Diallel analysis and cross prediction in common wheats. *Australian Journal of Agricultural Research* 24: 169-178.
- Caligari, P.D.S., W. Powell, and J.L. Jinks. 1985. The use of double haploids in barley breeding. 2. An assessment of univariate cross prediction methods. *Heredity* 54: 353-358.
- Cregan, P.B. and R.H. Busch. 1977. Early generation bulk hybrid yield testing of adapted hard red spring wheat crosses. *Crop Science* 17: 887-891.
- Cregan, P.B. and R.H. Busch. 1978. Heterosis, inbreeding, and line performance in crosses of adapted spring wheats. *Crop Science* 18: 247-251.
- Fasoulas, A.C. 1981. Principles and methods of plant breeding. Department of Genetic Plant Breeding, Aristotelian University of Thessaloniki, Greece. Publication 11.
- Fasoulas, A.C. 1988. The honeycomb methodology of plant breeding. Published and distributed by the author. Thessaloniki, Greece.167 pp.
- Fowler, W.L. and E.G. Heyne. 1955. Evaluation of bulk hybrid tests for predicting performance of pure line selection in hard winter wheat. *Agronomy Journal* 47: 430-434.

- Georgakis, D., E. Gouli-Vavdinoudi, and M. Koutsika-Sotiriou. 1992. The effectiveness of the HS honeycomb selection in Capsicum annum L. Capsicum. Proceedings of Eucarpia 39-44.
- Gouli, E. and A. Fasoulas. 1989. Cultivar development in wheat with the honeycomb selection. Book of Posters Abstracts. Part II 21-5, XII Eucarpia Congress. G'ttingen, Germany.
- Jensen, N.F. 1988. Plant Breeding Methodology. John Wiley and Sons, New York, USA.
- Jinks, J.L. and H.S. Pooni. 1976. Predicting the properties of recombinant inbred lines derived by single seed descent. *Heredity* 36: 233-266.
- Koutsika, M., I. Bos, and A. Fasoulas. 1990. Hybrid reconstruction in maize. *Euphytica* 45: 257-266.
- Kultarni, R.N. 1990. Honeycomb and simple mass selection for herb yield and inflorescence to leaf stem ratio in palmarosa grass. *Euphytica* 47: 147-151.
- Kyriakou, D.T. and A.C. Fasoulas. 1985. Effects of competition and selection pressure on yield response in winter rye (Secale cereale L.). Euphytica 34: 883-895.
- Leffel, R. C. and W. D. Hanson. 1961. Early generation testing of diallel crosses of soybeans. *Crop Science* 1: 169-174.
- Lupton, F.G.H. 1961. Studies in the breeding of self-pollinating cereals. 3. Further studies in cross prediction. *Euphytica* 10: 209-224.
- Lupton, F.G.H. and R.N.H. Whitehouse. 1955. Selection methods in breeding of high yielding varieties. *Heredity* 9: 150-151.
- Mitchell, J.W., R.J. Baker, and D.R. Knott. 1982. Evaluation of honeycomb selection for single plant yield in durum wheat. *Crop Science* 22: 840-843.
- Nass, H.G. 1979. Selecting superior spring wheat crosses in early generations. *Euphytica* 28: 161-167.
- Roupakias, D., A. Zesopoulou, S. Kazolea, G. Dalkalitses, A. Mavromatis, and T. Lazaridou. 1997. Effectiveness of early generation selection under two plant densities in faba bean (*Vicia faba L.*). Euphytica 93: 63-70.
- Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods. 6th Edition. Iowa State University Press, Ames, Iowa, USA.
- Strivastava, H.K. 1991. Theories of heterosis, classical and modern. Pages 5-305 in Advances in Plant Breeding (S.A.K. Mandal, P.K. Ganguli, and S.P. Banerje, eds.). Shahdara, Delhi, India.
- Thomas, W.T.B. 1987. The use of random F₃ families for cross prediction spring barley. *Journal of Agricultural Science* 108: 431-436.
- Whitehouse, R.N.H. 1953. Breeding for yield in the cereals. *Heredity* 7: 146-147.

Phenotypic Diversity among Wheat Landraces from Jordan: Morphological and Developmental Traits

A.H. Abdel-Ghani, M. Duwayri, and O. Kafawin¹

Department of Agricultural Research and Environment, Faculty of Agriculture, University of Jordan, Amman, JORDAN

Abstract

Wheat landraces are genetically heterogeneous populations. They have been commonly developed in traditional agriculture over thousands of years of natural selection as well as farmer-directed selection. Wheat landraces are also indispensable raw materials required for wheat improvement. Using various morphological and development traits, the structure of variation in 164 wheat landraces from Jordan were investigated. As a result, wheat landraces grown in Jordan were classified into either durum (98.8%) or bread wheat (1.2%). The landrace collection was scored for 26 qualitative and quantitative characters, each having two or more phenotypic classes. A relatively large number of landrace accessions had traits that were potentially desirable for wheat improvement programs. The whole collection was monomorphic for growth habit, and to some extent for awnedness and early vigor. Polymorphism was common in varying degree for most traits, thus indicating a wide variability among these landraces. Eighty-three percent of the durum was identified as Hourani landrace, whereas 15.2% was identified as Safra Ma'an landrace.

Key words: wheat landraces; Jordan; genetic erosion; rainfed conditions; biotic stress; abiotic stress; semiarid region; germination; grain yield; glaucousness.

Introduction

Landraces have a significant role in the history of civilization and continue to be important genetic resources for plant breeders and the main sustenance for hundred of millions who live in less favored parts of the earth (Frankel et al. 1995). There are two main reasons for giving special atten-

1. Corresponding author: Kafawin@agr.ju.edu.jo

التنوع المتماثل ظاهرياً بين الأصول المحلية للقمح من الأردن، الصفات الشكلية والتطورية

الملخص

تعتبر الأصول المحلية للقمح عشائر متغايرة وراثياً. وتم تطويرها عموما من خلال زراعة تقليدية استمرت لآلاف السنين من الانتخاب الطبيعي فضلاً عن الانتخاب الموجه من قبل المزارع. كما تعتبر الأصول المحلية للقمح مواد أولية مطلوبة لتحسين القمح، ولايمكن الاستغناء عنها. تم البحث في بنية التباين في 164 من الأصول المحلية للقمح من الأردن باستخدام مختلف الصفات الشكلية والتطورية. ونتيجة لما تقدم، تم تصنيف الأصول المحلية للقمح المزروعة في الأردن إلى قمح قاسى (98.8%) وقمح طرى (1.2%). وتم تقييس مجموعة الأصول المحلية لـ26 صفة نوعية وكمية، لكل منها طائفتين متماثلتين ظاهرياً أو أكثر. وكان لعدد كبير نسبياً من مدخلات الأصول المحلية مواصفات مرغوبة جدأ لبرامج تحسين القمح. وتماثلت المجموعة بأكملها من ناحية طبيعة النمو، وإلى حد ما من ناحية السفا وقوتها المبكرة. وكان التعدد الشكلي شائعاً ويدرجات متفاوتة، لمعظم الصفات. الأمر الذي يشير إلى تباين كبير بين هذه الأصول المحلية. وعرفت ما نسبته 83% من القمح القاسى على أنها تنتمي إلى الأصل المحلى "حوراني"، وما نسبته 15.2% على أنه ينتمي إلى الأصل المحلى "صفرا معان".

tion to landraces germplasm: i) genetic erosion that improved varieties cause, and ii) good adaptation to stressful environments. Landraces generally had tolerance to biotic and abiotic stresses and had survived under low input cultivation conditions where they produced reasonable yield (Chang 1985 as cited by Ehdaie and Waines 1989). Landraces in the Fertile Crescent, including Jordan, were severely subjected to substantial genetic erosion over the past three decades (Lawrence 1984). In Jordan, the present status of landraces is precarious. Many of them have been replaced by newly introduced or locally developed durum wheat cultivars. This led to a country-wide survey and collection of landraces since 1984 (Jaradat 1992a).

There are three major sources of wheat seeds used for cultivating crops in Jordan (Hasan 1995): (i) farmer seeds retained from previous season crop, (ii) seeds obtained from other farmers, and (iii) certified seeds obtained by the Jordan Cooperative Organization. The first and second categories include what farmers called 'Baladi' or landrace wheats, whereas the third category include the recommended varieties released by national seed programs.

A landrace is a mixture of different genotypes. Landraces evolved by natural and artificial selection under environmental conditions where they were grown. In general, they are stable in yield potential, and vary in disease resistance, and maturity (Harlan 1975; Tesemma et al. 1991; Frankel et al. 1995). Landraces are adapted to low soil fertility (Harlan 1975). In self-pollinated crops such as wheat, genotypes of the mixture are mostly homozygous and usually exhibit considerable genetic variation for quantitative and qualitative traits (Ehdaie and Waines 1989).

In the WANA (West Asia and North Africa) region, durum wheat is grown primarily under rainfed conditions, mainly in areas where the annual precipitation is 250-450 mm. In this region, abiotic stresses such as cold, drought and high temperature, prevail during the crop growing period. This is also where primitive cultivars and landraces are still in cultivation, many of which are well adapted to harsh environments. Considerable genetic diversity is known to be present in these populations which can be used in durum wheat improvement (Porceddu and Srivastava 1990).

Landraces are widely distributed in the Fertile Crescent. Polarkova and Blum (1983) studied different characters of collected landraces from the northern Negev. The extensive diversification of this collection makes the genetic resources potentially important for both durum and bread wheat. Jaradat (1992a and 1992b) concluded that Jordanian landraces have maintained a high level of polymorphism and high frequencies of desirable traits and multitraits combinations that are useful for durum wheat to survive under semi-arid environments.

Due to the importance of landraces, their adaptation to stressful environments, their desirable quality characters, and lack of information about them, this study was conducted to explore variability of wheat landraces from Jordan using different morphological and developmental traits.

Material and Methods

During the 1990 planting season, a total of 395 wheat growing farmers from nine districts of Jordan were surveyed (160 in the north of the country, 129 in the center, 94 in the south, and 12 in the Jordan Valley). The National Center for Agricultural Research and Technology Transfer (NCARTT) collected a total of 405 seed samples shortly before planting during November and December. Each sample of 0.5-1.0 kg was stored at 4°C at NCARTT and at the Seed Technology Unit of Jordan University until November 1995 (Hasan 1995).

One hundred and sixty four out of the 405 collected samples were used in this study as representative of 'Baladi' wheats grown in Jordan. The number and source of 'Baladi' wheat samples collected from different districts in Jordan are shown in Table 1. These samples were grown in a semiarid region (Maru Agricultural Station) during the 1995/96 growing season. Geographical data of Maru Agricultural Station, date of sowing and harvest are shown in Table 2.

A germination test was carried out in a laboratory at the Seed Technology Unit of the University of Jordan. Before planting, pure seed fraction was used in germination test. Two replications, each one containing ten seeds, were germinated in a cabinet using pleated filter paper. Seedlings were kept in the dark at a constant temperature of 20°C. The first count was performed after four days, while the second count was done after eight (ISTA Rules 1991). Seeding rate was adjusted according to germination percentage. Before sowing, seeds were treated with 18% penta chloronitrobenzene (PCNB) against common bunt (*Tilletia caries*). Fertilizer was applied prior to seeding at a rate of 100 kg diammonium phosphate (DAP) per hectare. Then, the field

Table 1. Numbers and source of 'Baladi' wheat samples collected from different districts in Jordan.

	Location									
Source	Irbid No.	Mafrak No.	Amman No.	Mshaker No.	Karak No.	Tafila No.	Ma'an No.	Zarka No.	North Shuna No.	Total No.
Owned saved	30	25	43	9	10	7	15	4	2	145
Other farmer	2	0	15	2	0	0	0	0	0	19
Total	32	25	58	11	10	7	15	4	2	164
Percentage (%)	19.5	15.3	35.3	6.7	6.1	4.3	9.2	2.4	1.2	100

Table 2. Geographical data for Maru location, date of sowing and harvesting during the 1995/1996 cropping season.

Location	Maru
Latitude	35° 55′N
Longitude	32° 55′N
Altitude (m)	500
Seasonal (mm) precipitation	333.7 mm
Date of sowing	4 December
Date of harvesting	25 May

was hand weeded.

The experimental design was a 13 × 13 triple lattice and three replications were used. One hundred sixty four collected samples and five durum wheat check genotypes were included in this experiment. The check genotypes were 'Hourani 27', 'F8', 'Acsad 65' ('Stork'), 'Sham 1' and 'Amra'. Plots were one meter square at a seeding rate of 120 kg/ha in four rows 25 cm apart. No space was left between the plots to avoid border effects. As precaution against any possible grain mixture and interplot borders, only plants from the two central rows were considered for analysis. Ten traits were recorded on individual plant basis. Five plants were selected randomly for each entry and replication to record these traits are shown in Table 3.

Thirteen traits were recorded on plot basis (Table 4). Total dry matter and grain yield were determined at harvest maturity stage on the central 0.5 m² of inner rows. The first continuous rain enough to start germination was received on

5 December. The number of days to heading and maturity were counted starting from that day. Traits based on plot basis were recorded according to a descriptor list issued by IBPGR (1985) and Villareal et al. (1994).

Data on length and width of flag leaf were recorded at green stage after heading by taking a sample of five flag leaves per entry in each replication. The flag leaf area was computed using the De Carvalho and Qualset (1978) formula:

flag leaf area = leaf width \times leaf length \times 0.67.

In addition to the previous characters, the following seedling characters were recorded: coleoptile length, seminal root number and seminal root length. Data mean (\bar{x}) and standard deviation (s) were calculated for measuring each plot. These statistics were used to classify the evaluated plots for each character into the following class limits (Jana et al. 1990):

- Group 1: less than or equal to $\bar{x} s$
- Group 2: greater than $\bar{x} s$ to less than x + s
- Group 3: equal to or greater than $\vec{x} + \vec{s}$

The following formula was used for calculating Shannon's information statistics (hs.j) for 'j'th character with (n) states or classes to describe phenotypic diversity (Bowman et al. 1971):

$$hs.j = -\sum_{i=1}^{n} P_i \ln P_i$$
, for $i = 1, 2,...., n$

where P_i is the relative frequency in the 'i'th character with

Table 3. Abbreviations, units of measurement, and scoring systems for measurement traits from 64 'Baladi' wheat populations and five check cultivars had talken on individual plant basis.

No.	Trait U	nit of measurement	Explanation
1	Plant height (PH)	cm	Measured from ground to the peak of the spike, excluding awns
2	Peduncle length (PL)	cm	From base of spike to the top of ligule
3	Tillering capacity (TC)	number	Number of tillers/plant
1	Spikelets/spike (S/S)	number	Counting number of spikelets/spike
5	Average awns length (SL	.) cm	From the top to the base of the spike
5	Average spike length	cm	Length from the base of spike to the top of the awns B spike length
7	Spike density (SD)	ratio	Ratio between number of spikelets/spike over spike length
3	Kernel/spike (K/S)	number	Counting number of seeds/spike
)	Spike weight (SW)	grams	Weighing the main spike
10	Yield/plant (Y/P)	grams	Weighing the total kernels/plant

Measured on the widest part of flag leaf.

Table 4. Abbreviations, unit of measurement, and scoring systems for traits from 164 'Baladi' wheat populations and five check cultivars talken on plot basis.

Number		Unit of neasurement	Explanation
1	Days to heading (DH)	day	Counted from the first day of rainfall which is sufficient for germination to 50% of plants in flowering
2	Days to maturity (DM)	day	Recorded when 95% of the spikes in plot had lost their green coloration from first effective rain for germination
3	Filling period (FP)	day	Days to maturity (DM)/Days to heading (DH)
4	Number of spikes per meter square (S/m ²)	number	Counting number of spikes in 1 m ²
5	Biological Yield (BY)	tonne/hectare	Weighing total dry matter above soil surface
6	Grain yield (GY)	tonne/hectare	Weighing a total kernel weight in unit area
7	Harvest Index (HI)	ratio	Grain yield/Biological yield
8	Straw yield (SY)	tonne/hectare	Biological yield/Grain yield
9	1000-weight (TKW)	grams	Weighing 1000 seeds
10	Growth habit (GH)	score	 1 = erect juvenile growth habit (spring type) 5 = semierect (facultative) 9 = prostrate juvenile growth habit (winter type)
11	Early vigor (EV)	score	1 = excellent early vigor 5 = intermediate 9 = poor early vigor
12	Canopy color (CC)	score	1 = dark green 9 = green
13	Glaucousness (GL)	score	1 = show glaucousness 9 = show nonglaucousness

n character status or class.

Results and Discussion

Jordanian wheat landraces were classified into either durum or bread wheat depending on the spike morphology. Durum wheat (*Triticum turgidum* L. ssp. *turgidum* conv. durum [Desf.] Mackey) is characterized by a long and high number of awns (awned type). About 98.8% (162 accessions) of the collected landraces belonged to durum wheat. Only 1.2% (2 accessions) belonged to bread wheat (*Triticum aestivum* L.) (Table 5). Durum wheat landraces were identified in the field after anthesis. Results showed that 25 landrace acces-

sions belonged to the Safra Ma'an landrace which are found in the southern part of Jordan, especially in Ma'an and Tafila (Table 5). Safra Ma'an landrace was characterized by light green canopy color, but some Safra Ma'an individuals (about one to three in each population) were characterized by dark green leaves due to the presence of bluish-white bloom of wax on photosynthetic surface (plant glaucousness) (Annicchiarico and Pecetti 1995). A high number of durum wheat landraces belonged to the Hourani landrace (83.0%) which is characterized by the presence of bluish-white bloom of wax on photosynthetic surface with dark canopy color. In addition, the two bread wheat landraces are

Table 5. Classification of Jordanian landraces.

Туре	Number	Ploidy level	Percentage	Landrace	Number	Percentage
Durum	162	4X	98.8	Hourani	136	85.0
				Safra Ma'an	25	1
				Unknown	15.5	0.6
Bread	2	6X	1.2	Unknown	2	1.2
Total	164		100%			100%

characterized by the presence of glaucousness.

Overall means and minimum and maximum values for 16 quantitative characters measured on 164 Jordanian landraces and five check varieties in the field are presented in Table 6. The Jordanian landraces are wider in ranges than the improved varieties for most of the traits studied. This suggests a higher level of variation in the Jordanian landraces compared to the check varieties (Table 6). The maximum values for yield-related traits (yield/plant, number of tillers/plant, number of grains/spike and number of spikelets/spike) in Jordanian landraces exceeded those of the check varieties. These results suggest that high yielding genotypes can be selected based on number of tillers/plant, number of grains/spike, number of spikelets/spike and 1000-kernel weight as Razman et al. (1994) suggested.

The number and percentage of landrace accessions with desirable and nondesirable traits (Table 7) show that 13.4% of landraces had a long spike, 15.3% a high number of spikelets/spike, 7.3% heavy kernels, 12.2% high number of kernels/spike and 15.8% heavy spike weight. These results contrast with the findings of Jaradat (1992a), who showed that frequencies in desirable classes of spike related traits reflect a high level of adaptability of these landraces to arid and semiarid environments. The high frequency of short (65.4%) and dense (75.9%) spikes, the low frequency (19.8%) of high number of seeds/spike, and the heavy ker-

nel weight (27.7%) could be the results of the selective pressure of low moisture and high temperature on floral primordia and spike development in these landraces.

A low percentage (11%) of Jordanian landraces were early in heading, 70% were medium in maturity and 15% had a long filling period (Table 7). These results could assist in selecting under water stress conditions within Jordanian landraces, because early heading and early maturity are considered as adaptive traits to water and high temperature stress (Kato and Yokoyama 1992). The combination of drought and terminal heat stress caused pressure towards earlier heading germplasm (Annicchiarico and Pecetti 1995). In terms of yield under water stress, stem reserves used by a long filling period were considered as the most important traits (Blum et al. 1989).

Only 1.2% of landraces were awnless type, whereas the majority (98.8%) were awned (Table 7). The prevalence of awned type can be explained by the importance of awns under water stress conditions (Patterson and Ohm 1975; Negassa 1986). A low percentage of landraces (5.5%) had long awns (Table 7). Awns are considered as assimilatory organs, which can contribute to more than 10% of the total kernel weight (Grundbacher 1963). Only 14% of wheat landraces had large flag leaf area (Table 7). Increasing flag leaf area is an avenue to increase grain yield. Patterson and

Table 6. Minimum, maximum and overall means for both 164 landraces and five improved varieties of different agronomic traits.

	Trait	L	andrace	es .				Improve	d varietio	es .		
		Max.	Min.	Mean	Houran	i F8	Acsad 65	5 Amra	ShamI	Max.	Min.	Mean
i	Days to heading	130.7	117.30	124.7	123.7	125.3	116.3	120.3	118.3	125.3	116.3	120.8
2	Days to maturity	166.8	157.2	162.9	161.7	163.0	161.7	163.0	161.7	163.0	161.7	163.4
3	Filling period	45.13	34.22	38.3	38.0	37.7	45.3	42.7	40.0	45.5	37.7	40.7
4	Plant height	129.3	78.2	109.5	112.3	112.7	86.3	83.9	81.6	112.7	81.6	95.4
5	Peduncle length	30.8	15.15	35.72	27.8	25.8	18.4	13.8	14.2	27.8	13.8	20.0
6	Spike length	9.39	5.36	6.7	7.0	6.30	7.5	7.3	7.4	7.5	6.30	8.6
7	Spike weight	3.0	1.5	2.2	2.5	2.5	2.8	2.9	2.6	2.9	2.2	3.2
8	Awns length	14.73	6.61	10.0	9.5	9.7	11.2	12.3	14.3	14.3	9.5	11.4
9	No. of fertile tillers	4.33	1.2	2.4	2.5	2.4	3.5	3.4	3.4	3.5	2.4	3.1
10	Flag leaf area	42.0	20.0	27.5	27.6	26.6	25.4	21.2	27.6	27.6	21.2	25.6
11	No. of spikes/m ²	499.2	140.8	320.4	388	306	360.6	409.4	409.4	409.4	30.6	453.1
12	1000-kernel weight	48.3	25.3	29.7	30.18	31.27	32.47	30.98	32.47	32.47	28.0	30.6
13	No. of kernels/spike	49.7	28.8	38.9	46.3	39.1	47.5	4.7	48.7	48.7	39.1	44.9
14	Spike density	36.9	2.18	3.2	3.2	3.2	2.6	2.7	3.2	3.2	2.6	2.9
15	No. of spikelets/spike	e 24.5	18.1	21.2	22.3	20.3		19.5			19.5	20.4
16	Yield/plant	6.5	1.9	3.2	3.7	3.2	4.6	4.6	3.7	4.6	3.2	3.9
17	Biological yield 1	5748 3	1969	11203	11067 8	3833	10700	10700	9567 1	1067	8833-10)460
18	Grain yield	2940	663	1937	2213	1690	2245	2245	1117	2780	1117 2	2009
19	Straw yield 1	3500 3	3245	9266	9034 6	5864	8366	8366			3714	845.6
20	Harvest index	0.47	0.11	0.18	0.199	0.17	81 0.211	0.233				

Ohm (1975) found that flag leaf removal reduce yield and test weight of wheat. On the other hand, Duwayri (1983) reported that flag leaf removal, awns removal and their combination significantly reduced grain yield by 10.7, 15.9 and 21.2%, respectively. Awn contributions in the local cultivars, which are adapted to local dry land conditions, are greater than those of the flag leaf. A high percentage of accessions (84.8%) showed glaucousness (Table 7). A significant negative correlation was found between the transpiration and the glaucousness rating of spike and flag leaf. Glancousness reduced residual transpiration by an average of 10% (Clarke and Richards 1988). Most landraces (88.4%) had excellent early growth vigor. Also, all collected landraces (100%) had an erect juvenile growth habit (Table 7). Excellent early vigor and erect juvenile growth habit are considered the most important traits for drought tolerance (Jaradat 1992c). About 15.3% of landraces population showed high number of spikes/m², and 13.4% high number of tillers/plant. A relatively high number of accessions with a high number of tillers/plant and number of spikes/m2 indicate that this trait increases adaptability to arid and semiarid environments as Jaradat (1992) reported. A low percentage (9.2%) of acessions were tall, while 15.9% had long peduncles. The importance of tall plants with long peduncle length may be due to high correlation between culm length, peduncle length and coleoptile length (Allan et al. 1961; Duwayri 1983).

The phenotypic diversity index (H') of 25 characters are given in Table 8. Polymorphism was common in various degrees for most traits, thus indicating a wide distribution of variability among these landraces (Negassa 1986). The phenotypic diversity index (H') for each individual trait ranged from zero for juvenile growth habit (monomorphic) to 0.87 for number of seminal roots (highly polymorphic). Early vigor and awnedness showed a low level of phenotypic diversity. Spike density, 1000-kernel weight, glaucousness, plant height and yield plant showed intermediate levels of diversity. High levels of diversity were observed for spike length, number of spikelets/spike, number of kernels/spike, spike weight, days to heading, length of filling period, flag leaf area, number of spikes/m², peduncle length, biological yield, straw yield, grain yield, number of seminal roots, and maximum seminal root length.

The average diversity (H') estimated for Jordan on traits evaluated in this study was 0.68 which is lower than the H' estimated for wheat landraces collected during the summer of 1984 (H'= 0.707), which was based on 24 characters of which only 14 were included in this study (Jaradat 1992). This estimate was lower than the one reported for the Mediterranean region (0.792) (Jana et al. 1990) that was based on 27 characters. It was also lower than that reported for Ethiopian wheat landraces (H'= 0.81), which was based on 14 morphological traits (Negassa 1986).

Table 7. Number and percentage of landraces with desirable and nondesirable traits recorded in the field for 164 collected landraces from Jordan during the 1990 cropping season.

No	Trait	Desirable trait	Number of populations	Percentage (%)	Non-desira- ble trait	Number of populations	Percentage (%)
1	Spike length	long	22	13.4	short	26	16.8
2	No. of spikelets/spike	high	25	15.3	low	29	17.7
3	1000- kernel weight	heavy	12	7.3	low	15	9.2
4	No. of kernels/spike	high	20	12.2	light	30	18.3
5	Spike weight	heavy	25	15.3	light	23	14.0
6	Spike density	dense	27	16.5	lax	10	6.1
7	Days to heading	carly	18	11.0	late	24	14.6
8	Days to maturity	medium	115	70.0	late	45	27.4
9	Filling period	long	25	15.2	short	21	12.8
10	Awnedness	awned	162	98.8	awnless	2	1.2
11	Awns length	long	9	5.5	short	29	17.7
2	Glaucousness	strong	139	84.8	absence	25	15.2
13	Flag leaf area	large	23	14.0	small	26	15.9
14	Early vigor	excellent	145	88.4	poor	2	1.2
15	Growth habit	erect	164	100	prostrate	0.0	0.0
16	No. of spikes/m ²	high	26	15.9	low	24	14.6
17	No. of tillers/plant	high	22	13.4	low	19	11.6
18	Plant height	tall	15	9.2	short	14	8.5
19	Peduncle length	long	26	15.9	short	19	11.6

No	Trait	н'	No	Trait	H'
1	Spike length	0.82	14	Early vigor	0.012
2	No. of spikelets/spike	0.86	15	Growth habit	0.00
3	1000-kernel weight	0.56	16	No. of spikes /m2	0.83
4	No. of kernels/spike	0.82	17	Plant height	0.59
5	Spike weight	0.81	18	Peduncle length	0.78
6	Spike density	0.67	19	Biological yield	0.80
7	Days to heading	0.74	20	Straw yield	0.83
8	Days to maturity	0.77	21	Yield/plant	0.68
9	Filling period	0.79	22	Grain yield	0.84
10	Awnedness	0.066	23	Number of seminal roots	0.87
11	Awns length	0.67	24	Maximum seminal roots length	0.84
12	Glaucousness	0.43	25	Coleoptile length	0.78
13	Flag leaf area	0.82		· •	

Table 8. Phenotypic diversity index (H') of 25 characters for 164 collected landrace populations from Jordan.

References

Allan, R. E., O. A. Vogel, J. R Burleigh, and C. J. Peterson. 1961. Inheritance of coleoptile length and its association with culm length in four winter wheat crosses. *Crop Science* 1: 328-332.

Annicchiarico, P. and L. Pecetti. 1995. Morpho-physiological trait to complement grain yield selection under semi-arid Mediterranean conditions in each of durum wheat types *Mediterranean typicum* and *syricum*. *Euphytica* 86: 191-198.

Blum, A., G. Golan, J. Mayer, B. Sinmena, L. Shpiler and J. Burra. 1989. The drought response of landraces of wheat from northern Negev Desert. *Euphytica* 43:87-96.

Bowman, O., K. Hutcheson, K.P. Odum, and L. R. Shenton. 1971. Comments on the distribution of indices of diversity. *Statistical Ecology* 3: 315-366.

Chang, T. 1985. Germplasm enhancement and utilization. *Iowa State Journal of Research* 59: 399-424.

Clarke, M. and A. Richards. 1988. The effect of glaucousness, epicuticular wax, leaf age, plant height and growth environment on water loss rates of excised wheat leaves. *Canadian Journal of Plant Science*. 68: 975-982.

De Carvalho, F. and O. Qualset. 1978. Genetic variation for canopy architecture wheat breeding. *Crop Science* 18: 561-567.

Duwayri, M. 1983. Effect of leaf removal on grain yield and yield components of wheat grown under dry land conditions. *Field Crop Research* 8: 307-313.

Ehdaie, B. and G. Waines. 1989. Genetic variation, heritability and path analysis in landraces of bread wheat from south western Iran. Euphytica 41:183-190.

Frakel, H., J. Burdon, and J. Peacock. 1995. Landraces in transit: The threat perceived. *Diversity* 11: 14-15.

Grundbancher, J. 1963. The physiological function of the

cereal awn. Botanical Review 29: 366-381.

Harlan, R. 1975. Our vanishing genetic resources. Science 188: 618-621.

Hasan, M. 1995. A survey of wheat seed quality grown in Jordan. Msc Thesis. University of Jordan, Amman, lordan

ISTA (International Seed Testing Association). 1991. Rules for Seed Testing. Rules and Annex. *Seed Science and Technology*. Wageningen.

IBPGR (International Board for Plant Genetic Resources).1985. IBPGR Secretariat. Descriptors for Wheat. Rome, Italy. 12 pp.

Jana, S., J.P. Srivastava, A.B. Damania, M. Clarke, C. Yang, and L. Pecetti. 1990. Phenotypic diversity and associations of some drought related characters in durum wheat in the Mediterranean region. Pages 27-43 in Wheat Genetic Resources Meeting Diverse Needs (J. P. Srivastava and A. B. Damania, eds.). John Wiley and Sons, England.

Jaradat, A. 1992a. Estimates of phenotypic diversity and trait associations in durum wheat landraces from Jordan. *Journal of Genetics and Breeding* 46: 69-76.

Jaradat, A. 1992b. Breeding potential of durum wheat landraces from Jordan. I. Phenotypic diversity. *Hereditats* 116: 301-304.

Jaradat, A. 1992c. Breeding potential of durum wheat landraces from Jordan. II. Differential response to drought. *Hereditats* 116: 305-309.

Kato, K. and L. Yokoyama. 1992. Geographical variation in heading characters among wheat landraces (*Triticum aestivum* L.) and its implication for their adaptability. *Theoretical and Applied Genetics* 84: 259-265.

Negassa, M. 1986. Estimate of phenotypic diversity and breeding potential of Ethiopian wheats. *Hereditats* 104: 41-48. Patterson, L. and W. Ohm. 1975. Compensating ability of awns in soft red winter wheat. *Crop Science* 15: 403-407
 Polarkova, H. and A. Blum. 1983. Landraces of wheat from northern Negev. *Euphytica* 32: 257-271.

Porceddu, E. and J.P. Srivastava. 1990. Evaluation, documentation and utilization of durum wheat germplasm at ICARDA and University of Tuscia, Italy. Pages 3-8 in Wheat Genetic Resources: Meeting Diverse Needs (J. P. Srivastava and A. B. Damania, eds.). John Wiley and Sons, England.

Ramzan, M., M. Chowdhry, and I. Khalia.1994. Correlation between wheat grain yield and its components. *Journal of Agricultural Research* 32: 222-227.

Tesemma, T., B. Getachew and M. Worede. 1991. Morphological diversity in tetraploid landrace populations from the central high-lands of Ethiopia. *Hereditats* 114: 171-176.

Villareal, L., A. Mujeed- Kazi, V. Rajaram, and E. Del Toro. 1994. Morphological variability in some synthetic hexaploid wheats derived from *Triticum turgidum × Triticum* tauschii. Journal of Genetic and Breeding 48: 7-16.

Prevalence of Karnal Bunt in Wheat Seed Lots in Pakistan

A.R. Bhutta¹, A. Hussain¹ and I. Ahmad²

- Federal Seed Certification and Registration Department, G-9/4, Islamabad, 44000, PAKISTAN
- ² Crop Diseases Research Institute, NARC, PARC, Islamabad, PAKISTAN

Abstract

A total of 730 wheat seed samples were tested to assess the incidence of karnal bunt using the dry inspection method from 1993/94 to 1996/97. High infection percentage (3%) of karnal bunt in various seed lots was found in Central Punjab and northwest areas of Pakistan. Southern parts of the country were found free from 1994/95 to 1996/97. Incidence of karnal bunt showed a decreasing trend (up to 0.5%) at the country level. Since karnal bunt is known to be a quarantine disease, strict quarantine measures are needed to contain the spread of the disease.

Key words: Tilletia indica; wheat seed lots; Pakistan.

Introduction

Karnal bunt of wheat, also called partial or new bunt (*Tilletia indica* Mitra [Syn. Neovossia indica Mitra Mundhur]), is known to be a disease of economic significance in Afghanistan, India, Iraq, Mexico, Nepal and Pakistan (Mathur and Cunfer 1993). In Pakistan, this dis-

تفشي التفحم الكلي في عينات بدور القمح في الباكستان

الملخص

تم في الفترة مابين الموسم الزراعي 94/1993 والموسم الزراعي 97/1996 اختبار 730 عينة من بذور القمح لتقدير حدوث التفحم الكلي/تفحم كارنال باستخدام طريقة التفتيش الجاف. وقد وجدت نسب إصابة مرتفعة (3%) في مختلف عينات البذور التي تم جمعها من منطقة البنجاب الوسطى ومن المناطق الشمالية الغربية من الباكستان. بينما كانت العينات التي جمعت من المناطق الجنوبية خالية من المرض في الفترة ما بين الموسم الزراعي 95/1994 والموسم الزراعي 97/1996 وقد أظهر تفحم كارنال ميلاً للإنخفاض (حتى5.5%) على مستوى البلد. ونظراً لكون التفحم الكلي مرضاً حَجْرياً، فلابد من اتخاذ إجراءات حَجْرية صارمة لوقف انتشاره.

ease was confined to the foot hill areas (District Sialkot and Narowal), and was considered a disease of minor importance (Sattar and Hafiz 1952). Later, the disease was recorded in traces from plains (Hassan 1976) and Central Punjab and northwestern parts of the country (Bhatti and Hyas 1986).

Research, carried out from 1984/85 to 1992/93 at the Danish Government Institute of Seed Pathology for Developing Countries, Denmark, and at the Federal Seed Certification and Registration Department (FSC & RD), Pakistan, revealed that the disease increased from 0.03 to 8.72% (Begum and Mathur 1989; Bhutta and Ahmad 1994; Ahmad and Bhutta 1997). This situation is alarming as the

disease is known to have direct relationship between karnal bunt infection and seed weight reduction, and between seed germination and vigor of infected seeds (Bansal et al. 1984; Warham 1990). The disease has attained importance worldwide because of its seed and soil-borne nature, and its interference with wheat international trade (Warham 1986).

Since karnal bunt represents a potential hazard as a quarantine disease, recent and detailed information about its distribution and prevalence should be available for breeders, seed technologists, traders and seed procurement agencies to plan better disease management strategies. For this reason, seed samples obtained from all over the wheat growing area of Pakistan were tested at the Central Seed Health Laboratory of the FSC&RD, Islamabad.

Material and Methods

Collection of wheat seed samples

A total of 730 seed samples were collected from major growing regions of three provinces: Punjab, Sindh and North West Frontier Province (NWFP), from 1993/94 to 1996/97 (Figure 1) according to ISTA rules (ISTA 1985). Primary samples were drawn randomly and mixed thoroughly to make submitted samples.

Dry inspection (visual) of seed samples

A working sample of 120 g (approx. 3000 seeds) of each sample submitted was thoroughly examined visually for bunted grains. Doubtful seeds were observed on a stereomicroscope at 12 × 15 magnification. Slides were prepared to avoid confusion with black point diseases. In karnal bunt, a powdery mass of teliospores could be easily seen on the slide, while for black point there was only a brown colored tissue of the seed. Bunted grains were counted and the incidence percentage for each sample was then calculated (Begum and Mathur 1989).

Results and Discussion

Prevalence and incidence of the disease was observed in all the regions. The highest number of seed samples was found with bunted grain in Central Punjab (37.15%) and in NWFP, (25%) during 1993/94. Infected samples percentages were found in decreasing order in these regions (Figure 2). The cumulative infected samples percentage also showed a decreasing trend from 8.90 to 5.90% from 1993/94 to 1996/97. Ahmad et al. (1990) and Begum and Mathur (1989) also observed that southern parts of the country had been free from karnal bunt until 1987. This might have been due to the dry conditions of these areas. Zhang et al. (1984)

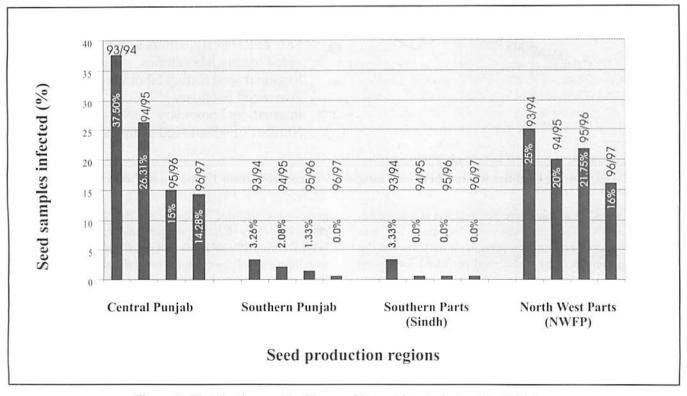


Figure 1. Distribution and incidence of karnal bunt of wheat in Pakistan.

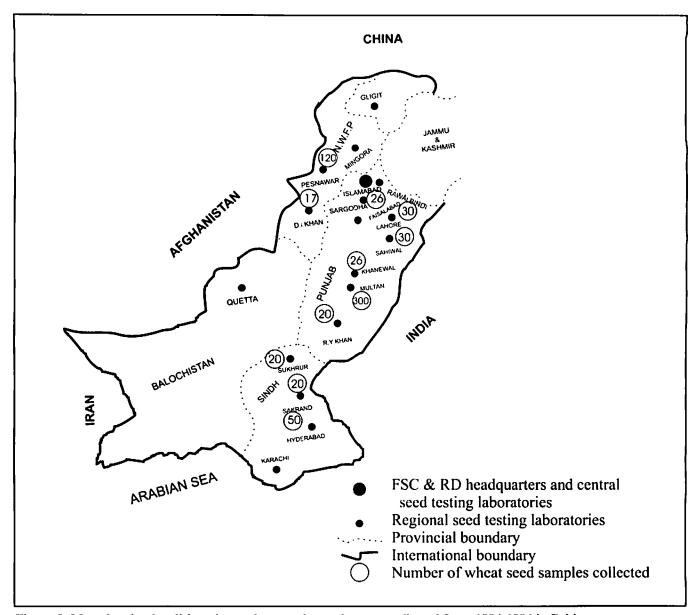


Figure 2. Map showing localities where wheat seed samples were collected from 1994-1996 in Pakistan.

observed inhibition of teliospore germination at a temperature above 30°C. They also observed that free water was essential for spore germination process. It may also be the reason why farmers used wheat seed produced locally by both public and private seed companies in the southern parts of the country, so there was no inflow of seed from Central Punjab.

Minimum incidence was recorded in southern parts of the country and southern Punjab regions (Table 1). Areas such as R.Y. Khan, Sukkur and Sakrand were found free from bunted samples. High infection of 3.0% due to bunted grains were recorded on the variety Pak. 81 during 1993/94 and 1994/95 in Central Punjab, and on Pirsabak 85 in NWFP during 1993/94. None of the 10 cultivars were found free from bunted grains in the central and northern parts of the country. Infected sample percentage and infection of bunted grains showed a similar pattern in both regions. This is due to climatic conditions and to continuous seed supply from Central Punjab to NWFP (Bhutta and Ahmad 1994). The amount of inoculum present in the field from previous crops, level of susceptibility of cultivars sown and climatic conditions of these areas have affected the quality of seeds (Ilyas et al. 1989; Warham 1990).

Table 1. Incidence of karnal bunt (Tilletia indica) in wheat seed lots from 1993/94 to 1996/97 in Pakistan.

Seed production regions	Cultivars		Infection per	centage range	
		1993/94	1994/95	1995/96	1996/97
Central Punjab	Pak. 81	0.0-0.30	0.0-0.12	(-)	(-)
(Lahore, Sahiwal,	Fd 83	0.0-0.40	(-)	0.20	0.0-1.50
Khanewal and	Fd 85	0.0-3.00	1.00	(-)	(-)
Sargodha)	Pb 85	0.0	0.10	(-)	0.0
	Pirsabak 85	0.0-10	(-)	(-)	(-)
	Pasban 90	0.0-0.20	0.0	0.0	0.0
	Inqlab 91	0.0	0.0-0.10	0.03-0.50	0.0-0.50
Southern Punjab	Pak. 81	0.0-0.10	0.50	0.50	(-)
(Multan and	Fd 83	0.0	(-)	(-)	0.0
R.Y. Khan)	Fd 85	0.20	(-)	0.0	(-)
ŕ	Pb 85	0.0	0.0	0.0	(-)
	Pasban 90	0.0	0.0	(-)	0.0
	Inglab 91	0.10	0.0	0.0	0.0
	Perwaz	(-)	(-)	0.0	(-)
Southern Parts	Jauhar 78	0.0	(-)	0.0	(-)
Sinddh (Sukkur,	Sindh 81	0.03	0.0	0.0	0.0
Sakrand and	T.J-83	0.0	0.0	0.0	(-)
Hyderabad)	Mehran 89	0.0	0.0	(-)	0.0
•	Anmol 90	0.0	(-)	0.0	0.0
	Soghat 90	0.0	0.0	0.0	(-)
	Sarsabz	0.0	(-)	0.0	0.0
	Kiran 96	(-)	(-)	(-)	(-)
North West Parts-	Pak. 81	0.0-0.20	(-)	0.50	(-)
NWFP (Peshawar	Pirsabak 85	0.03-3.00	0.0-1.50	(-)	0.0-0.50
and D.I. Khan)	Pirsabak 91	(-)	(-)	0.05-1.00	0.03-0.50
•	Fd 85	0.0-0.10	0.50	(-)	(-)
	Khyber 87	(-)	(-)	0.05	(-)
	Bakhtawar	(-)	(-)	0.50	0.0

Note: (-) Seed samples were not available.

Previous investigations revealed that disease severity came down from 4.6% in 1981/82 to 0.65% in 1983/84 but went up from 3.16 to 5.50% in 1984/85 and 1985/86, respectively (Begum and Mathur 1989; Ahmad and Bhutta 1995). Low incidence of karnal bunt observed during 1993/94 to 1996/97 in this study is due to strict seed certification standards (Ahmad and Bhutta 1997) and seed treatment with fungicide at a pre-basic level under the Seed Health Certification Program (Bhutta et al. 1992).

Conclusion

Wheat seed health testing for karnal bunt from 1993/94 to 1996/97 showed that the incidence of karnal bunt in wheat seed lots decreased. Seed lots that have infection levels higher than the disease tolerance limit must be excluded from the seed production cycle (pre-basic and basic = 0%, certified seed = 0.2% in crop and 0, 0.05 and 0.2% in seed, respectively).

Southern parts of the country were found free from karnal bunt. Therefore, disease-free seeds should preferably be produced in these regions. Due to easy detection of karnal bunt in seed, every seed lot must be tested at all regional seed testing laboratories of the FSC & RD along with routine purity testing of wheat seed lots. Besides, seed must be treated at pre-basic and basic levels to reduce the spread of inoculum to a certified level.

Cultivation of susceptible cultivars, that is., Pak. 81, Pirsabak 85, Fd 83, Blue Silver, and Wl 711, should be avoided in areas where karnal bunt is endemic. Consequently, breeding resistance programs should be encouraged and introduction of pathogens to non-infected regions should be strictly checked through internal quarantine services.

The Agriculture Development Authority in NWFP should develop its own wheat seed program, instead of purchasing seed from Punjab province, to avoid further spread of karnal bunt and buildup of disease inoculum.

References

- Ahmad, S.I. and A.R. Bhutta. 1997. Seed pathology: An emerging science of plant disease management for production of quality seed in Pakistan. Proceeding of the Seed Pathology DGISP-DC/ISTA Pre-congress Seminar, 6 June 1995, Copenhagen, Denmark.
- Ahmad, S.I., M.A. Salam and A.R. Bhutta. 1990. Status of seed-borne diseases (Loose smut and karnal bunt) in wheat seed lots procured and distributed from 1981/82 to 1985/86 in Pakistan. Pages 41-75 in Seed Pathology in Pakistan, FAO/DANIDA Course Proceedings, 10-21 January 1988, FSCD, Islamabad, Pakistan.
- Bansal, R., D.V. Singh and L.M. Joshi. 1984. Effect of karnal bunt pathogen (*Neovossia indica* [Mitra] Mundkur) on weight and viability of wheat seed. *Indian Journal of*

- Agricultural Science 54: 663-666.
- Begum, S. and S.B. Mathur. 1989. Karnal bunt and loose smut in wheat seed lots of Pakistan. FAO Plant Protection Bulletin 37: 165-173.
- Bhatti, M.A.R. and M.B. Ilyas. 1986. Wheat diseases in Pakistan. Problems and Progress of Wheat Pathology in South Asia. Malhotra Publications House, New Delhi, India.
- Bhutta, A.R., M.A.R. Bhatti and S.B. Mathur. 1992. Seed health certification program for production of quality seed. Science Technology and Development 11: 21-25.
- Bhutta, A.R. and S.I. Ahmad. 1994. Distribution of karnal bunt in Pakistan. *Pakistan Journal of Scientific and Industrial Research* 37(8): 335-338.
- Hassan, S.F. 1976. Improved resistance to grain crops to rust and smuts in Pakistan. Final Technical Report 1971/76. PL-480 Project No. A-17. PSR-I Cereal Diseases Research Institute Department of Plant Protection, Islamabad, Pakistan, 40 pp.
- Ilyas, M.B., M. Majeed, and K. Iftikhar. 1989. Survey of karnal bunt disease of wheat in the Punjab. *Pakistan Journal of Phytopathology* 1(1): 48-51.
- ISTA (International Seed Testing Association). 1985.
 Proceedings of the International Seed Testing
 Association. Zurich, Switzerland.
- Mathur, S.B. and B.M. Cunfer. 1993. Page 168 in Seedborne Disease and Seed Health Testing of Wheat. DGISP-DC, Denmark.
- Sattar, A. and A. Hafiz. 1952. Researches on plant diseases of the Punjab. Scientific Monograph No. I. Pakistan Association for the Advancement of Science. Lahore, Pakistan. 158 pp.
- Warham, E.J. 1986. Karnal bunt disease of wheat. A literature review. *Tropical Pest Management* 32: 229-242.
- Zhang, Z., L. Lange, and S.B. Mathur. 1984. Teliospore survival and plant quarantine significance on *Tilletia indica* (Causal agent of karnal bunt) particularly in relation to China. *EPPO Bulletin* 14: 119-128.

Variation in Local Genotypes of a Durum Wheat Collection (*Triticum durum* Desf.)

K.D. Kolev and S.D. Stoyanova

K. Malkov Institute for Plant Genetic Resources 4122 Sadovo, BULGARIA

Abstract

Durum wheat (*Triticum durum* Desf.) accessions collected in Bulgaria during 1960-1980 and preserved under long-term seed storage in the gene bank were evaluated by gliadin electrophoresis. Several genotypes differing by gliadin spectra were observed. Variation in heterogeneous accessions was described when comparing specific yield traits during two-year investigations. The differences among gliadine genotypes observed in wheat accessions were statistically analyzed.

Key words: *Triticum durum* Desf.; Bulgaria; prevailing genotypes; grain yield; seed accessions; gliadin.

Introduction

Durum wheat can be an important crop in Bulgaria where climatic conditions are related to those of the Mediterranean. About 1800 seed accessions are preserved in the National Seed Genebank. Most of this collection comprises local populations collected in the east and southeast regions of the country during 1960-1980. The great variation of local and primitive varieties formed the basis for breeding durum wheat cultivars in Bulgaria (Mitov 1962).

Protecting and conserving the original germplasm collections are the main goals of the gene bank. Because survival and productivity of seed is unforeseen, changes in a heterogeneous seed accession may occur (Roos 1982) as well as changes due to the genetic shifts under storage and multiplication (Stoyanova 1991, 1992, 1994, 1996). Unpredictable changes may originate under storage conditions (Roos 1982; Stoyanova 1991, 1994; Sergio and Spagnoletti-Zeuli 1992) which could increase during multiplication (Stoyanova 1992, 1996). It was established that changes in the genetic composition because of seed maturity and regeneration may be because of a decrease in seed viability, composition coefficients of genotypes in a heterogeneous seed accession, seed productivity per genotype.

التباين في الطرز الوراثية المحلية لمجموعة القمح القاسي (Triticum durum Desf.)

الملخص

تم تقييم مدخلات من القمح القاسي (Triticum durum Desf.) كان قد تم جمعها كأصول وراثية محلية في بلغاريا في الفترة مابين عام 1960 و 1980، وحفظها في مخزن البذور طويلة الأجل في بنك للمورثات باستخدام تقنية الرحلان الكهربائي للغليادين. وتمت ملاحظة العديد من الطرز الوراثية التي تختلف عن بعضها بواسطة أطياف الغليادين ووصف التباين في المدخلات المتغايرة بمقارنة الصفات الخاصة بالغلة في فترة البحث التي دامت سنتين. كما وصفت نسبة الاختلافات بين الطرز الوراثية الغليادينية في مدخلات القمح بطريقة إحصائية.

number of regeneration and seed sample sizes (Stoyanova 1996).

The aim of this study is to describe the variation in the spike structure between genotypes, which together form heterogeneous durum wheat accessions to illustrate the differences in grain yield and reproductive capacity.

Material and Methods

Nine durum wheat accessions were used in this study; two Bulgarian cultivars (Zagorka and Chirpan) and seven local populations, which were described as heterogeneous by gliadin spectra (Stoyanova and Kolev 1996). Seed accessions were sown after chickpea in the experimental field at the Institute for Plant Genetic Resources (IPGR) in Sadovo during two successive years (1994 and 1995). A fertilizer application of 100 kg P₂O₅/ha was made before sowing, and at the beginning of March, 40 and 80 kg N/ha, respectively, were applied. Seeds were usually hand planted during 10-15 October in plots 2 m wide and at a space of 20 and 10 cm between rows and between plants, respectively. Every genotype was sown in three rows.

Twenty-five plants per genotype were evaluated using four characters: spike length, number of spikelets/spike, number of seeds/spike and kernel row weight in the ear. The data were analyzed statistically by comparing the prevailing genotype in the heterogeneous accession.

Results and Discussion

The previously-determined composition coefficients of gliadine genotypes are presented in Table I (Stoyanova and Kolev 1996). The prevailing genotype was designated A, then B, C, and D according to their frequency.

Table 1. Composition of gliadine genotypes observed in durum wheat cultivars and local populations from Bulgaria, which were used in this study (after Stoyanova and Kolev 1996).

Durum wheat	Ge	notype con	nposition	
accessions	A	В	С	D
Zagorka	0.6	0.3	0.1	
Chirpa	0.5	0.5		
43/7	0.9	0.1		
63/1	0.7	0.2	0.1	
87/9	0.5	0.3	0.1	0.1
99/8	0.9	0.1		
110/5	0.5	0.5		
120/5	0.4	0.4	0.2	
142/10	0.7	0.2	0.1	

Results calculated on the basis of two years investigations, i.e., 1994 and 1995 are presented in Tables 2 and 3, respectively. The rate of differences between characters of gliadine genotypes was evaluated statistically.

Although the differences in number of spikelets/spike were more often confirmed, the value of variation differed from year to year. The interaction between genotypes and the environment probably influenced this character significantly.

During two years of investigations, unidirectional variation toward the prevailing genotype was estimated in spike length for Zagorka (C) and 63/1 (B); number of seeds/spike for 87/9 (B) and (D); kernel row weight in the ear for 145/10 (B). For other genotypes, controversial variation was observed in number of spikelets /spike for Chirpan (B), 87/9 (B), 110/5 (B), 145/10 (C) and number of seeds/spike for 63/1 (B).

All of the examined characters influenced grain yield and described seed productivity of the genotypes. The observed variation as well as the confirmed differences illustrated that every multiplication of a heterogeneous seed accession could affect the seed production. As a result, the composition of compound genotypes in the regenerated seed accession will be different.

Conclusions

Genotypes observed in durum wheat cultivars considered heterogeneous by gliadin spectra and local populations differ in spike characters under regeneration-year conditions. These differences could have an unpredictable effect on seed productivity of the genotypes every time they regenerate. The negative effect of seed multiplication could be limited by control over regeneration events.

Storage protein electrophoresis should be used to describe the heterogeneity of durum wheat accessions and to monitor genetic integrity after several regeneration events.

Acknowledgement

The National Foundation for Research Investigations at the Ministry of Education and Sciences, Bulgaria, supported this study.

References

Mitov, L. 1962. (New durum wheat cultivars.) in Bulgarian News from the Institute for Durum Wheat and Cotton (2): 29-42.

Roos, E.E. 1982. Induced genetic changes in seed germplasm during storage. Pages 409-434 *in* The Physiology and Biochemistry of Seed Development, Dormancy and Germination (A.A. Khan, ed.). Elsevier Biomedical Press, Holland. 447 pp.

Sergio, L. and P.L. Spagnoletti-Zeuli. 1992. Study of the genetic structure of wheat germplasm entries by means of storage protein electrophoresis. *FAO/IBPGR Plant Genetic Resources Newsletter* 90: 1-5.

Stoyanova, S.D. 1991. Genetic shifts and variation induced by seed aging. *Seed Science and Technology* 19: 363-371.

Stoyanova, S.D. 1992. Effect of seed aging and regeneration on the genetic composition of wheat. *Seed Science and Technology* 20: 489-496.

Stoyanova, S.D.1994. Expression of gliadin in a dominant mutation of wheat seeds. *Seed Science and Technology* 22: 477-484.

Stoyanova, S.D. 1996. Variation of gliadins in wheat cultivars associated with seed survival and multiplication. Seed Science and Technology 24: 115-126.

Stoyanova, S.D. and K. Kolev. 1996. Gliadin electrophoresis in the evaluation of Bulgarian wheat germplasm. Plant Genetic Resources Newsletter 108: 59-63.

Table 2. Variation and statistical significance of differences observed between genotypes by evaluating the spike structure as yield characteristics in 1994.

		:	(, , , 41.			2		-	7 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -
Durum wheat accessions	Biotype	Spike	Spike length (cm)	No. of sp	No. of spikelets/spike	No. of s	No. of seeds/spike	Kernel row	Kernel row weight/spike (g)
		mean	difference	mean	difference	mean	difference	mean	difference
	⋖	7.55		20.8		42.9	:	1.84	
Zagorka	В	7.60	+0.05	21.1	+0.3	41.1	-1.8	1.50	-0.34
	S	9.20	+1.65***	21.2	+0.4	40.8	-2.1	09:1	-0.24
	٧	8.35		24.6		47.0		1.85	
Chirpan	В	7.40	-0.95***	22.5	-2.1**	41.2	-5.8**	1.45	-0.40
	V	6.90		22.1		37.7		18.1	
63/1	В	8.90	+2.00**	24.6	+2.5**	35.1	-2.6	1.81	
	C	7.10	+0.20	21.5	9.0-	31.8	-5.9**	1.64	+0.17
	∢	7.75		21.9		44.9		1.62	
6/18	В	8.73	+0.0*	23.3	+1.4*	30.9	***0.41-	1.36	-0.26
	ပ	7.05	-0.70	21.7	-0.2	32.4	-12.5**	1.60	-0.02
	О	7.75		21.6	-0.3	41.9	-3.0	1.35	-0.27
	∢	9.15		24.2		36.2		1.53	
8/66	В	7.95	-1.20**	22.2	-2.0**	30.5	-5.7*	1.30	-0.24
	∢	8.00		20.5		33.1		1.31	
110/5	B	8.10	+0.10	22.8	+2.3**	32.3	-0.8	0.97	-0.34
120/5	∢	8.55		22.6		32.0		1.40	
	В	8.80	+0.25*	23.9	+1.3*	31.8	-0.20	1.18	-0.22
	C	6.95	-1.60**	18.4	-4.2**	42.9	+10.9*	1.77	+0.37*
	∢	8.50		22.2		30.7		1.27	
145/10	В	8.65	+0.15	24.6	+2.4**	32.2	+1.5	1.39	+0.12
	ပ	8.05	-0.45*	20.9	-1.3*	33.9	+3.2**	1.57	+0.30**

Statistical significance of the calculated differences: * = 95%; ** = 97.0%; *** = 99.9%.

Effect of Presoaking Seed Treatment on Germination and Amylase Activity of Wheat (*Triticum aestivum* L.) under Salt Stress Conditions

N. K. Roy & A. K. Srivastava

Department of Botany and Plant Physiology Rajendra Agricultural University, Bihar Pusa (Samastipur)-848 125, INDIA

Abstract

Seed germination is one of the most serious problems affecting crop stand and, ultimately, productivity in saline and alkaline soils. The objective of this study was to assess and compare the effect of a presoaking seed treatment on seedling characteristics (seed germination percentage, root and shoot length, root:shoot ratio) and amylase activity with soaked and unsoaked seeds of wheat (var. UP 262) under salt stress conditions 0.35 (Control), 4, 8, 12 and 16 dSm⁻¹. The results indicated that seed germination percentage, root and shoot length, root:shoot ratio and amylase activity were significantly reduced when salt concentrations were increased. Presoaking seed treatments with chemicals such as sodium benzoate (50 ppm), calcium chloride (100 ppm), and ascorbic acid (50 ppm) increased seed germination, root and shoot length, root:shoot ratio and amylase activity in seven-day-old wheat seedlings under five salt concentrations levels. Analysis of variance showed high significant salt concentrations × treatment interaction for all seedling characteristics studied and amylase activity indicating that presoaked seed treatment was effective in alleviating the adverse effect of salt stress.

Key words: *Triticum aestivum* L.; germination; roots; stems; salinity; alkalinity; amylase assay; presoaked seeds.

Introduction

Salt affected soils are an important ecological entity in the landscape of any arid or semi-arid country. In India, they occupy 8.6 million hectares and represent a serious threat to the ability of increasing food production to meet the expanding needs. Because of the increased competition for

تأثير معاملة البذور قبل النقع على الإنبات ونشاط الأميلاز في القمح (Triticum aestivum L.) تحت ظروف الإجهاد الملحي

الملخص

تعتبر مشكلة إنبات البذور إحدى أكثر المشاكل التي تؤثر في كثافة المحصول وبالتالي في إنتاجيته في تربة ملحية وقلوية. وقد هدفت هذه الدراسة إلى تقييم تأثير معاملة ماقبل نقع البذور في مواصفات البادرات (نسبة إنبات البذور، طول الجذر والساق، نسبة الحذر: الساق)، ونشاط الأميلاز مقارنة مع بذور قمح صنف UP 262 وغير منقوعة تحت ظروف الإجهاد الملحى 0.35 (شاهد) ، 4، 8, 16.12 dsm/l أدلت النتائج أن نسبة إنبات البذور، وطول الجذر والفروع، ونسبة الجذر: الفروع، ونشاط الأميلان انخفضت بشكل كبير عند زيادة تراكيز الملح. وأدت معاملات قبل النقع بمواد كيميائية مثل بنزوات الصوديوم بتركين 50ppm، كلوريد الكالسيوم (100ppm)، وحمض الأسكورييك (50ppm)، إلى زيادة نسبة إنبات البذور وطول الجذر والساق، ونسبة الجذر: الساق بعمر 7 أيام، تحت خمسة مستويات مختلفة من التراكيز الملحية. وقد أظهر تحليل التياين تأثراً معنوياً بين التراكيز الملحية المرتفعة × المعاملات لجميع مواصفات البادرات التي تمت دراستها ونشاط الأميلان، الأمر الذي يشير إلى أن معاملات ما قبل النقع كانت فاعلة في التخفيف من الآثار السيئة للإجهاد الملحي.

good quality lands and water resources, agriculture will be pushed more and more into marginal environments. The wastelands which now cover a large area may be needed for crop cultivation to meet the needs of the increased population. The most dominating and widespread wastelands have saline and alkaline soils. Seed germination is a serious problem affecting wheat production and ultimately productivity in saline and alkaline soils. Various techniques have been suggested to improve seed germination, ranging from simple seed soaking with water (Aschermann-Koch et al. 1992) to treatment with GA (Lecat et al. 1992) and fungicide (Scudamore and Goodship 1992). Increased soil salinity and sodicity decreased germination percentage and root:shoot ratio in Swati wheat cultivars. Increasing salinity did not affect germination rate but increasing sodicity delayed it (Ray and Khaddar 1989). The NaCl treatment affected plant performance more than the same concentration of any of the two components. The synergistic effect of sodium and chloride showed that neither of these ions alone is responsible for salt-stress-induced damage (Martin and Koebner 1995). Presoaking with ascorbic acid significantly enhanced root and shoot growth, leaf nitrate and protein contents. Most of the parameters studied gave optimum response to the two highest concentrations (0.01 and 0.1%) of the vitamin (Haque and Ahmad 1988).

The objective of this study was to assess and compare the effect of presoaking seed treatment on seedling characteristics such as germination percentage, root and shoot length, root:shoot ratio and amylase activity in comparison with unsoaked seeds.

Material and Methods

Wheat genotype UP 262 was grown in petri dishes in the laboratory in the 1996/97 winter season. Petri dishes were sterilized by autoclave at 15 lb pressure before use. Seeds were surface-sterilized with 0.1% mercuric chloride and subsequently washed thoroughly with distilled water before use. Bold and healthy seeds were presoaked in a mixture of water, sodium benzoate (50 ppm), calcium chloride (100 ppm) and ascorbic acid (50 ppm) for 8 h and dried to their original weight. Unsoaked seeds were used as control and moistened with deionized water (0.35 dSm-1). Thirty seeds were sown in each petri dish with Whatman filter paper No.1, moistened with salt solution of different concentrations and kept under controlled conditions in a growth chamber maintained at 20±2°C with 80% humidity and light intensity of 2500 lux with 11:13 light:dark cycle. The salt solution was prepared using deionized water with NaCl: CaCl₂: NaSO₄ in the ratio of 7:2:1. The relative concentrations of salt stress were maintained by direct reading conductivity meter (Sr. No.1039) follows: Control (0.35 dSm⁻¹) 4, 8, 12 and 16 dSm⁻¹.

The experiment was conducted in a complete randomized block design with three replications. The mean of the three replications of germination percentage of seeds are shown as transformed value in Table 1. An arc sine transformation has been used for the data recorded in percentage to stabilize the variance.

Critical difference (CD)

The least significant difference, which is greater than all the significant differences, is known as critical difference:

CD = Standard error (SE) difference × t error degree of freedom (df)

= SE × $\sqrt{2}$ X t (0.05, 0.01) error degree of freedom Standard error difference = 2VE/r, where VE = Error variance, r = replication

Germination percentage was calculated after seven days. Roots were measured from stem base to maximum length. Shoots were measured from the base to the tip portion. Root:shoot ratio was calculated on length basis using the formula:

root: shoot ratio:

Length of root (cm)

Length of shoot (cm)

Rate of germination of germination relative index (GRI) was determined using:

 $GRI = \sum_{n} Xn \text{ (h-n)}$ Where xn = n number of seeds germinated in the count n = n number of counts n = n

Amylase assay in germinated seeds was estimated using the method of Bernfield (1955) after 48 h of seed soaking. Amylase assay was done in the aleurone layer attached to the pericarp of wheat seeds. One unit of amylase activity was defined as the amount of enzyme which liberated one microgram of reduced sugar under assay conditions and was expressed in terms of units per milligram fresh weight of aleurone layer.

Results and Discussion

The increase in salinity level decreased the percentage of germination percentage from 0.35 (Control) to 16 dSm⁻¹ (Table 1). Seed germination decreased from 64.36% at control (0.35 dSm⁻¹) to 50.20% at 16 dSm⁻¹. However, presoaked seeds with water and chemicals showed tremendous improvement in germination percentage and germination relative index (GRI). Among the various presoaking treatments, the one with calcium chloride (100 ppm) recorded the highest germination (%) and germination relative index at all levels of salt concentration. Inhibited germination and early seedling growth are consequences of salt stress. They have been mostly attributed to either reduced availability of water to germination seeds, growing seedlings in the later stages, or to ionic imbalance. This causes abnormal situations in metabolism magnified by drought situations as many breeders have reported (Srivastava et al. 1972; Kuhad and Garg 1983; Sehtiya and Srivastava 1985). Improvement of germination percentage and GRI is probably due to an increase in the potential of seeds to extract

Table 1. Effect of presoaked seeds in different chemicals and in water on seed germination percentage and germination relative index (GRI) in seven-day-old wheat (UP 262) seedlings, in response to different salt concentrations from 0.35 to 16 dSm⁻¹.

Parameter	ı	;	Germin	Germination percentage	centage				Ger	Germination relative index (GRI)	clative ind	ex (GRI)
Salt concentrations (dSm ⁻¹)	6 0.35 (Control)	4	∞	12	16	Mean (S)	0.35 (Control)	4	∞	12	16	Mean (S)
Unsoaked Control	81.28 (64.36)	76.45 (60.95)	70.78 (57.12)	64.24 (53.18)	56.84 (50.20)	69.92 (57.16)	135.86	124.69	117.62	110.13	89.76	117.20
Pre-sown seed soaking media:												
Water	85.41 (67.12)	80.14 (63.52)	75.27 (60.08)	68.72 (56.10)	62.33 (52.14)	74.37 (57.79)	161.08	152.54	143.88	135.92	128.75	144.43
Sodium benzoate (50 ppm)	88.29 (70.08)	84.62 (66.90)	80.18 (63.84)	73.68 (58.23)	65.47 (54.01)	78.45 (62.61)	19.891	159.84	150.23	141.64	134.98	151.06
Calcium chloride (100 ppm)	94.65 (76.91)	89.17 (71.02)	83.64 (65.90)	77.72 (61.34)	73.85 (58.61)	83.81 (66.76)	197.24	185.43	176.31	169.12	157.28	177.08
Ascorbic acid (50 ppm)	90.52 (72.82)	86.13 (68.13)	81.27 (64.34)	74.62 (59.68)	69.14 (56.41)	80.34 (64.27)	176.41	169.28	160.17	149.23	141.47	159.31
Mean (T)	88.03 (70.26)	83.30 (66.10)	78.23 (62.26)	71.80	65.53 (54.19)		167.84	158.36	149.52	141.21	132.21	
Factor	33	Salt concentration (S)	Treatment (T)	S × T			-	Salt concentration (S)	Treatment n (T)	S×T		
CD(P = 0.01)		1.98	1.98	6.12 (3.48)				1.22	1.22	3.84		

Values in parentheses are transformed mean.

more moisture from the atmosphere due to a change in lipophilic colloids (Acharya 1968; Chinoy et al. 1970).

The data presented in Tables 2 and 3 show a gradual decline in root and shoot length and root:shoot ratio at a high salt concentration. Allem et al. (1992) supported these results. They reported that the increasing salinity levels significantly decreased root length, shoot length, coleoptile length, and leaf area. Sharma and Sharma (1987) reported highly significant correlation between soil water potential. radicle emergence and plumule elongation of barley indicating that, with the decrease in soil water potential, there was a linear decrease in emergence percentage, plumule and radicle elongation. The effect of salt stress that NaCl created caused inhibition in germination, coleoptile length and roots, and shoot length in eight durum varieties (Boubker 1996). However, presoaked seeds in a mixture of different chemicals and water recorded an increased root length, shoot length and root; shoot ratio. The maximum increase in root length, shoot length and root:shoot ratio was observed in seeds presoaked in 100 ppm of calcium chloride. A presoaking treatment of a mixture of chemicals and water increases root length, shoot length and root; shoot ratio over unsoaked seeds as control in the following sequence: CaCl₂ > ascorbic acid > sodium benzoate > water. Such increase in the root and shoot length and root; shoot ratio could be attributed to increased photosynthetic activity reflected in higher dry matter production and an increase in relative growth rate of seedlings. Long roots might increase seedling ability to absorb water from high salinity levels. Long shoots indicate possible high photosynthesis under high salinity levels.

The results of amylase activity are shown in Table 3. Negligible amylase activity was found in unsoaked seeds. Amylase activity decreased when salt concentrations in seeds presoaked in a mixture of chemicals and water increased. Maximum amylase activity was found in seeds presoaked in calcium chloride (100 ppm). All the three seed treatments presoaked with chemicals like sodium benzoate (50 ppm), calcium chloride (100 ppm), and ascorbic acid (50 ppm) increased amylase activity higher than watersoaked seeds. Results of this study agree with what Dubey (1984) reported, which shows that salinity decreased α-amylase activity with slow accumulation of starch and sugars in embryo, whereas the activity in the endosperm was high at low NaCl concentration leading starch to degradate and accumulate sugars rapidly.

At the initial stage of germination, amylase activity increased in response to presoaking treatments at all levels of the salt concentrations (Table 3). As a result, a higher rate

Table 2. Effect of presoaked seeds in different chemicals and in water on root length and shoot length in seven-day-old wheat (UP 262) seedlings

in response to	differen	t salt concen	in response to different salt concentrations from 0.35 to 16 dSm-1.	0.35 to 16	dSm-1.))	•			
Parameter		Ro	Root length (cm plant-1)	plant-1)				Shoot	Shoot length (cm plant-1)	n plant-1)		
Salt concentrations	0.35	4	œ	12	16	Mean	0.35	4	œ	12	16	Mean
(dSm·1)	(Control)	ol)				(S)	(Control)	٥				(S)
Unsoaked Control Pre-sown seed	6.11	5.61	4.89	2.28	1.65	4.11	5.00	4.81	4.19	2.19	1.68	3.58
Water	7.67	7.34	6.49	3.28	2.91	5.54	6.14	60.9	5.93	3.19	2.99	4.87
Sodium benzoate	8.30	8.00	7.42	4.24	3.02	6.20	6.32	6.20	5.93	3.64	2.89	5.00
(50 ppm)												
Calcium chloride	8.82	8.28	7.93	4.43	3.27	6.55	95.9	6.38	6.31	3.77	3.03	5.21
(100 ppm)												
Ascorbic acid	8.48	8.22	7.52	4.17	3.37	6.35	6.38	6.28	6.05	3.59	3.21	5.10
(50 ppm)												
Mean (T)	7.87	7.49	6.85	3.68	2.84		80.9	5.95	2.68	3.28	2.76	
Factor		Salt	Treatment					Salt	Treatment	1		
		concentration	Ĕ				•	concentration	on			
		(S)	Ð	$S \times T$				(S)	E	$S \times T$		
CD(P = 0.01)		7.09	7.09	0.21				5.35	5.35	0.16		

Table 3. Effect of presoaked seeds in different chemicals and in water on seed root;shoot ratio in seven-day-old wheat (UP 262) seedlings and amylase activity in response to different salt concentrations from 0.35 to 16 dSm⁻¹.

Parameter		Roo	Root:Shoot ratio	0			Amylase	activity (Amylase activity (Unit mg-1 fresh weight)	fresh wei	ght)	
Salt concentrations (dSm ⁻¹)	0.35 (Control)	1) 4	œ	12	16	Mean (S)	0.35 (Control)	4	∞	12	16	Mean (S)
Unsoaked Control Pre-sown seed soaking media:	1.22	1.16	1.15	1.03	0.98	1.11	•	•	1	,	,	
Water	1.24	1.20	1.09	1.02	0.97	1.10	238.27	231.36			209.33	223.74
Sodium benzoate (50 ppm)	1:31	1.28	1.24	1.16	1.04	1.21	292.25	285.39	280.55	269.88	258.06	277.23
Calcium chloride (100 ppm)	1.34	1.29	1.25	1.17	1.07	1.22	303.80	294.47	284.49	277.98	266.03	285.36
Ascorbic acid (50 ppm)	1.32	1.30	1.24	1.16	1.05	1.21	262.49	250.03	243.95 231.12	231.12	222.46	242.01
Mean (T) Factor	1.29	1.25 Salt	1.20 Treatment	Ξ.	1.02		274.20	265.31 Salt	258.32 248.61 Treatment	248.61 It	238.97	
CD (P = 0.01)	ៜ	concentration (S) 1.40	on (T) 1.40	S × T 0.04			loo	concentration (S)	£ £ £	S×T 4.15		

of hydrolysis of starch was produced making soluble sugars available to be used as a source of energy and structural material required for cells to grow and develop, leading to an overall improvement in seedling growth. These improvements may be attributed to an increase in nutrient reserves at various physiological stages of growth through increased physiological activities and root proliferation (Dave and Gaur 1970; Garg and Srivastava 1970; Singh and Darra 1971).

Analysis of variance showed highly significant salt concentration × treatment interaction indicating that seed soaking was effective in alleviating adverse effects of salt stress. Thus, presoaking seeds increased germination percentage, and vigor and growth of seedlings. These might improve crop growth as well as increase resistance to the adverse effects of salt stress.

References

- Abel Allem, M.M.M., S.R.S. Sabry, and M.S. Hanna. 1992. Seedling characteristic as selection criteria for salinity tolerance in wheat. *Rachis* 11 (1&2): 33-40.
- Acharya, O.H. 1968. PhD Thesis. Gujarat University, Ahmedabad, India.
- Aschermann-Koch, C., P. Hoffmann, and A.M. Steiner. 1992. Presowing treatment for improving seed quality in cereals. I. Germination and vigor. Seed Science and Technology 20: 435-440.
- Bernfield, P. 1955. Methods of Enzymology: Assay of α -and β -amlyse (S. Colowick and N.O. Kaplan, eds.). Academic Press, New York, USA.
- Boubker, M. 1996. Salt tolerance of durum wheat cultivars during germination and early seedling growth. *Agricoltura Mediterranean* 126(1): 32-39.
- Chinoy, J.J., P.G. Abraham, R.B. Pandya, O.P. Saxena and I.C. Dave. 1970. *Indian Journal of Plant Physiology* 13: 40.
- Dave, I.G. and B.K. Gaur. 1970. Effect of pre-sowing treatment with GA and ascorbic acid on growth and development of barley. *Plant Physiology* 13: 76-85.
- Dubey, R.S. 1984. Effect of sodium chloride salinity on enzyme activity and biochemical constituents in germinating salt tolerant rice seed. *Oryza* 21: 213-217.
- Garg, O.K. and M.P. Srivastava. 1970. Yield response of IR-8 to presowing chemical treatments: Proceedings of the 58th Session of Indian Science Congress. Part-III: No. 86.
- Haque, I. and A. Ahmad. 1988. Increased nitrate content, nitrate reductase activity and growth of wheat seedlings

- by presowing seed treatment with ascorbic acid. *Indian Journal of Plant Physiology* 31(3): 233-237.
- Kuhad, M.S. and P.O. Garg 1983. Current Agriculture 7:181-186.
- Lecat, S., F. Cordineau, and D. Come. 1992. Effect of gibberellic acid on the germination of dormant oat (Avena sativa L.) seeds as related to temperature, oxygen and energy metabolism. Seed Science and Technology 20: 421-434.
- Martin, P.K. and R.M.D. Koebner. 1995. Sodium and chloride ions contribute synergistically to salt toxicity in wheat. *Biologia Plantarum* 37(2): 265-271.
- Ray, N. and V.K. Khaddar. 1989. Influence of salinity, sodicity and their combinations on wheat (*T. aestivum L.*). *Advances in Plant Sciences* 2(2): 216-223.
- Scudamore, K.A. and G. Goodship. 1992. The effect of fumigation with methylbromide on the germination of different varieties of wheat, barley and oats. Seed

- Science and Technology 120: 375-390.
- Sehtiya, H.L. and A.K. Srivastava. 1985. Effect of some regulants on water potential and metabolism of leaves of wheat (*Triticum aestivum* L.) seedling under induced water stress. *Indian Journal of Plant Physiology* 28: 215-222.
- Sharma, R.A. and R. Sharma. 1987. Seedling growth of barley in relation to varying needs of soil water potential. *Seed Research* 15: 133-137.
- Singh, H. and B.L. Darra. 1971. Influence of presoaking of seeds with gibberellin and auxins on growth and yield attributes of wheat (*Triticum aestivum* L.) under high salinity, sodium absorption ration, and boron levels. *Indian Journal of Agricultural Sciences* 41:998-1003.
- Srivastava, A.K., V.K. Sharma, K.L. Ahuja, and K.S. Sekhon. 1972. Biochemical basis of salt stress resistance in germination seeds of soybean (Glycine max L.). Oleogineux 27: 263-264.

A Germination Bioassay to Test the Allelopathic Potential of Barley

M. Ben-Hammouda¹ and O. Oueslati²

- ¹ Laboratory of Crop Physiology, E.S.A-Kef, TUNISIA
- ² Laboratory of Plant Physiology, Faculty of Science, TUNISIA

Abstract

In a preliminary study, results of bioassays showed that leaves are the most phytotoxic plant component of barley. They exhibited a significant inhibitory activity on seed germination of barley (autotoxicity) and durum wheat (heterotoxicity) but not on bread wheat. It appeared that autotoxicity is more common than heterotoxicity. In addition, the differential responses to the allelopathic potential of barley leaf residues among durum wheat cultivars were more distant than among barley cultivars. These findings suggest that barley should be considered as an allelopathic crop with a high risk of depression on a following straw cereal crop, especially when barley residues are left in the field.

Key words: barley; allelopathic potential; autotoxicity; heterotoxicity; phytotoxic.

اختبار حيوية الإنبات لفحص التأثير الضار المحتمل للشعير

الملخص

في دراسة أولية، أظهرت نتائج الاختبارات الحيوية، أن أوراق الشعير هي أكثر أجزاء النبات سمية. فقد أبدت نشاطاً تثبيطياً معنوياً في إنبات بذور الشعير (ذاتي السمية) وبذور القمح القاسي (غيري السمية)، إلا أنها لم تؤثر في إنبات بذور القمح الطري. ويظهر أن السمية الذاتية أكثر شيوعاً من السمية الخارجية. فضلاً عن ذلك، تعتبر الاستجابات المتباينة للتأثير الضار لبقايا أوراق الشعير في أصناف القمح القاسي أكثر اختلافاً من تلك التي بين أصناف الشعير. وتقترح هذه النتائج أنه يجب اعتبار الشعير كمحصول ضار مع وجود الخطر الكبير لتدني تبن المحصول الحبي وبخاصة عندما تترك بقايا الشعير في الحقل.

Introduction

In a cereal-cereal cropping sequence, the yield of the first crop often reduces the yield of the second one. Causes of yield depression are diverse. However, it can be partially attributed to an allelopathic effect. Allelopathy is defined as a detrimental effect of a plant species on germination, growth or development of a plant of a different species (Putnam and Duke 1978). Allelopathy may occur in the form of autotoxicity among plants of different or same species as in the well-known cases of alfalfa (*Medicago sativa* L.) (Hedge and Miller 1990) and bread wheat (*Triticum aestivum* L.) (Kimber 1973).

Cereal crops such as sorghum (Sorghum bicolor L.), oat (Avena sativa L.) and rye (Secale rye L.) are known to posses an allelopathic potential (Worshman 1989). Water extracts of a suspected allelopathic crop are usually bioassayed on an indicator species. Germination, radicle and shoot growth often measure the allelopathic potential of a plant species (Guenzi et al. 1967; Hedge and Miller 1990). When the allelopathic potential of a species is detected at the germination bioassay level, it is highly expected to be the case for the radicle and shoot growth bioassays (Guenzi et al. 1967; Hedge and Miller 1990; Moncef et al. 1995). A plant of an allelopathic species may exhibit differential potentials among its components (Guenzi et al. 1967; Moncef et al. 1995).

Since little is known about barley (*Hordeum vulgare* L.) phytotoxicity, this preliminary study aimed to: i) determine which plant part of barley is the most phytotoxic, ii) identify the presence of an allelopathic potential for barley residues in an autotoxic and/or heteretoxic form, and iii) test the possibility of a differential response among cultivars of a sensitive cereal species.

Material and Methods

Collection of barley plant material

A barley cultivar, 'Rihane-03', was cultivated under rainfall conditions at the experimental station of the École Superieure d'Agriculture du Kef (E.S.A, Kef), located in the semi-arid zone of the northwest of Tunisia. Rihane-03 was seeded on 16 November 1995 at the rate of 120 kg/ha in a clay type of soil (42% clay, 36% sand, 22% silt) with the following properties: pH = 7.9; total calcium = 18%; electric conductivity = 0.82 dsm⁻¹; organic matter = 1.6%.

From soil preparation to harvest, standard cultural practices for the semi-arid zone were applied. Whole fully mature plants were randomly collected from the field during mid-May 1996.

Preparation of water-extract

All plants were first washed with tap water. Plant parts (leaves, stems, roots) were separated by hand and rewashed with distilled water before chopping them into 1-cm fragments. Samples of 50 g leaves, stems and roots each were

extracted in 500 ml of distilled water. Each sample was placed in a 1-liter flask on a horizontal agitator for 48 h at 200 rpm. Water-extracts were passed through filter paper and stored at a temperature less than 5°C until bioassayed.

To test which plant part of barley is the most phytotoxic (autotoxic and/or heterotoxic), water-extracts from leaves, stems and roots were bioassayed on germination of barley, durum wheat (*Triticum durum* L.) and bread wheat. 'Rihane-03', 'Karim' and 'Vaga' were the three cultivars representing barley, durum wheat and bread wheat, respectively.

When the most phytotoxic plant part of barley and sensitive species was identified, its water-extract was bioassayed to test the possibility of a differential response among three cultivars within the same sensitive species.

Bioassays of barley extracts

Germination bioassays were conducted in 10×100 mm petri dish (PD) following the techniques that Li et al. (1992) described. In each PD, 25 seeds of any tested cultivar were placed with the crease facing a germination paper that was saturated with 2 ml of leaf, stem or root water-extracts. For the control treatment, the germination paper received 2 ml of distilled water. Seed germination of the test-cultivars was reported after incubation for 35 h at 25°C. Seeds with radicles of at least 2 mm were counted as germinated.

Experimental design and statistical analysis

Germination bioassays were conducted in a complete randomized design (CRD) where each treatment (water-extract or a control, a cultivar within a species) was replicated four times. Individual observations for the tested parameter (number of germinated seeds) were registered as a mean over four PD per experimental unit.

An analysis of variance was carried out using SAS (SAS Institute 1985). The least significant difference (LSD) test (Thomas and Hills 1978) was used to separate means of significant main effects after applying a protect Fisher test (Steel and Torrie 1980).

Results and Discussion

Autotoxicity and heterotoxicity of barley residues

Water-extracts of Rihane-03 exhibited a significant inhibitory effect on barley and durum wheat seed germination. However, bread wheat appeared not to be significantly sensitive to Rihane-03 extracts. Results showed that barley residues could be both autotoxic and heterotoxic (Table 1).

Table 1. Mean squares for effects of plant part extracts from 'Rihane-03' on seed germination of barley cv 'Rihane-03', durum wheat cv 'Karim' and bread wheat cv 'Vaga'.

Source	df	Barley	Durum wheat	Bread wheat
Extract	3	5.8*	19.0*	3.4ns
Error	12	1.1	3.8	1.6

^{*} Significant at the 0.05 level of probability. ns = not significant.

Table 2. Effect of plant part extracts from 'Rihane-03' on seed germination of barley cv 'Rihane-03' and durum wheat cv 'Karim'.

	Number of ger	minated seeds
Source of water-extract	Barley cv 'Rihane-03'	Durum wheat cv 'Karim'
Roots	23.8 a*	21.8 a
Control†	23.5 a	21.3 a
Stems	23.5 a	21.8 a
Leaves	21.8 b	17.3 b
LSD (0.05)	1.6	2.9

[†] The treatment is only distilled water.

Table 3. Mean squares for effects of leaf extracts from 'Rihane-03' on seed germination of three cultivars ('Rihane-03', 'Manel-92' and 'Roho') of barley and three cultivars ('Karim', 'Razzak', 'Khiar') of durum wheat.

Source	df	Barley	Durum wheat
Cultivar	2	32.2**	39.3**
Error	9	1.7	2.2

^{**} Significant at the 0.01 level of probability.

Table 4. Effect of leaf extracts from 'Rihane-03' on seed germination of three cultivars ('Rihane-03', 'Manel-92' and 'Roho') of barley and three cultivars ('Karim', 'Razzak', 'Khiar') of durum wheat.

	Barley		Durum wheat
Cultivar	Number of germinated seeds	Cultivar	Number of germinated seeds
Rihane-03	24.5 a*	Karim	17.0 a
Manel- 92	24.3 a	Razzek	13.5 Ь
Roho	21.8 b	Khiar	10.8 c
LSD (0.05)	2.1	LSD (0.05)	2.4

^{*} Means followed by different letters are significantly different at the 0.05 level of probability.

Means followed by different letters are significantly different at the 0.05 level of probability.

Root and stem extracts of Rihane-03 did not significantly reduced seed germination of both barley and durum wheat when compared to the control treatment. However, leaf extracts in both cases significantly inhibited seed germination with durum wheat being more sensitive than barley (17.3 vs 21.8) making heterotoxicity more pronounced than autotoxicity (Table 2).

Differential responses of cultivars within species

A significant differential effect of extracts from leaves of Rihane-03 was observed among cultivars of barley and durum wheat species (Table 3).

As reported before (Table 2), autotoxicity across barley cultivars is inferior to the heterotoxicity across durum wheat cultivars (23.5 vs 13.8). In addition, responses among durum wheat cultivars to leaf extracts of Rihane-03 were significantly more distinguished than in barley (Table 4).

Conclusion

Based on germination bioassays, results of this preliminary study demonstrated that barley possesses an allelopathic potential that can be observed on straw cereal crops. This means it may have to be considered a depressive prior crop especially when residues of barley are kept in the field for a crop management reason, and followed by a sensitive crop in a cereal-cereal cropping sequence. Consequently, it is recommended to continue the study of barley allelopathy over time with a more comprehensive experimental approach.

References

- Guenzi, W. D., T. M. MacCalla, and F. A. Norstad. 1967. Presence and persistence of phytotoxic substances in wheat oat, corn, and sorghum residues. Agronomy Journal 59: 163-165.
- Hedge, R. S. and D. A. Miller. 1990. Allelopathy and autotoxicity in alfalfa: Characterization and effects of preceding crops and residue incorporation. *Crop Science* 30: 1255-1259.
- Kimber, R. W. L. 1973. Phytotoxicity from plant residues: III. The relative effect of toxins and nitrogen immobilization on the germination and growth of wheat. *Plant Soil* 38: 543-555.
- Li, H. H., H. Nishimura, K. Hassegawa, and J. Mizutani. 1992. Allelopathy of Sasa cernua. Journal of Chemical Ecology 18: 1785-1796.
- Moncef, B.H., R. J. Kremer, and H.C. Minor. 1995. Phytotoxicity of extracts from sorghum plant components on wheat seedlings. *Crop Science* 35: 1652-1656.
- Putnam, A. R. and W. B. Duke. 1978. Allelopathy in agroecosystems. *Annual Review of Phytopathology* 16: 431-51.
- SAS (Statistical Analysis System) Institute. 1985. SAS User's Guide: Statistics, Version 6.0. SAS Institute, Cary, NC, USA.
- Steel, R.G.D. and J. H. Torrie (eds.). 1980. Principles and Procedures of Statistics. Second Edition McGraw-Hill Book Co., New York, USA.
- Thomas, M. L and F. J. Hills (eds.). 1978. Agricultural Experimentation. John Wiley and Sons, New York, USA and Toronto, Canada.
- Worshman, A. D. 1989. Current and potential techniques using allelopathy as an aid in weed management. *Phytochemical Ecology* 9: 275-291.

Recovery of Heat-Induced Heat Shock Proteins and Evidence of the Binding of Some Small Molecular Weights to the Thylakoid Membranes in Wheat

H. Ouabbou¹ and G. M. Paulsen²

- ¹ Institut National de la Recherche Agronomique, Centre Aridoculture, CRRA B.P. 589, Settat, MOROCCO
- ² Department of Agronomy, Kansas State University, Manhattan, KS 66506-5501, USA

Abstract

The pattern of protein synthesis in leaves of eight-dayold seedlings of wheat (*Triticum aestivum* L. cv Len) is dramatically altered when the incubation temperature is raised from 15 to 37°C. One-dimensional sodium dodecyl sulfate gels reveal that although synthesis of the proteins observed at 15°C continues at 37°C, a new set of heat shock proteins (HSP) is induced within 4 h of temperature transition. Total leaf HSP (heat induced) has molecular weights of 17, 18, 22, 70 and 80 kD. HSP-22 is bound to the thylakoid membrane. Shifting the temperature back to 15°C causes a decline in synthesis of HSP-22. This disappears four days after recovery, suggesting its importance during heat stress and also for recovery processes.

Key words: *Triticum aestivum*; wheat; heat shock proteins; recovery; thylakoid membrane; heat stress.

Introduction

Plants are often exposed to fluctuations in atmospheric temperature, which influences photosynthetic activity. At elevated temperatures, photosynthetic efficiency is inhibited (Berry and Bjorkman1980; Quin and Williams 1985). High temperature disrupts the functional integrity of photosynthetic activity and inhibits whole-leaf photosynthesis at the chloroplast level (Armond et al. 1978; Bauer and Senser 1979; Pearcy et al. 1977). Thylakoid membranes appeared to be more heat-sensitive than other biomembranes (Sundby and Anderson 1986). Treatment with high temperature results in significant or complete loss of photosystem II (PS II) electron transport activity (Berry and Bjorkman 1980; Ouin and Williams 1985).

استعادة نشاط بروتينات الصدمة الحرارية المحرضة حرارياً ودليل ارتباط بعض الأوزان الجزيئية بأغشية الثيلاكويد في القمح

الملخص

لقد تبدل نمط البناء البروتيني في أوراق بادرات القمع لامر (Triticum aestivum) من الصنف Len بعمر 8 أيام بشكل كبير عند رفع درجة حرارة التحضين من 15 إلى 37°م. وكشف هلام سلفات دوديسيل الصوديوم الأحادي البعد أنه على الرغم من أن بناء البروتينات الملاحظ عند الدرجة 15°م يستمر عند الدرجة 37°س، إلا أنه تم تحريض مجموعة جديدة من البروتينات تعرف ببروتينات الصدمة الحرارية HSP خلال فترة 4 ساعات من الانتقال لدرجة الحرارة الجديدة. وبلغت الأوزان الجزيئية لإجمالي بروتينات الصدمة الحرارية PSP الخاصة بالأوراق (المحرضة حرارياً) 17. 18. 22. 70. و 80 كيلودالتون. ويرتبط ESP-22 بغشاء الثيلاكويد. وتسببت إعادة درجة الحرارة إلى الدرجة ألى انخفاض في بناء السلاكويد وتسببت إعادة درجة الحرارة إلى الدرجة ألى انخفاض في بناء السلاكويد وتسببت إعادة المنات في هذه الدرجة، الأمر الذي يشير إلى أهمية البروتين في فترة الإجهاد الحراري ومراحل استعادة النشاط بعد زوالها.

Plants respond to high temperature stress by synthesizing an assortment of proteins, such as heat shock proteins (HSP), which are usually undetectable at optimal growing temperatures (Kimpel and Key 1985; Sach and Ho 1986). These proteins can be arbitrarily divided into two different size groups: high and low molecular weights that range from 68 to 110 kD and from 15 to 27 kD, respectively. The latter group is the most prominent in higher plants. Although no specific functions have been established for these proteins, it is widely assumed that HSP confer at least a transient protection against heat-induced damage (Key et al. 1985; Schlesinger 1990).

In plants, as in other organisms, evidence suggests that heat shock production is an essential component of thermotolerance (Key et al. 1985; Kimpel and Key 1985; Lindquist 1986; Nago et al. 1986; Nover et al. 1984). Plant species adapted to temperate environments, including crop plants such as soybean, pea, maize, and wheat, begin to synthesize HSP when tissue temperature exceeds 32-35°C. HSP syn-

thesis increases when temperature increases. The temperature of maximum HSP synthesis is positively correlated with each species' optimum growth temperature. Kloppstech et al. (1985) showed that a 22 kD nuclear coded heat-shock protein (HSP-22) is transported into the chloroplast and incorporated into the photosynthetic membranes under heat stress. In addition to the HSP-22, nuclear coded proteins of 25-29 kD were also detected in thylakoids of soybean (Vierling et al. 1986) and pea (Kloppstech et al. 1985) under heat stress.

Levels of chloroplast HSP remain essentially unchanged during the first 12 h following stress. Some HSP in plants are stable for at least 24 h following stress (Lin et al. 1984; Nago et al. 1986). This long period of stability suggests that chloroplast HSP are necessary during the stress as well as during the recovery processes. Kloppstech et al. (1985) have proposed that the chloroplast HSP function to protect or repair PS II during stress. The hypothesis that HSP may be involved in protecting photosynthetic partial reactions is based on the observations that the pea chloroplast HSP-22 was bound to thylakoid membranes (Cooper et al. 1984).

In the present study, presence of binding of the chloroplast HSP to thylakoids isolated from intact wheat seedlings and their stability during recovery processes were investigated.

Material and Methods

Plant culture and treatments

Wheat (*Triticum aestivum* L. cv Len) seeds were germinated in vermiculite moistened with full-strength Hoagland's solution (Hoagland and Arnon 1950). Seedlings were grown in the same environment under 16/18 h light/dark periods, 450 µmol m⁻² s⁻¹ PAR measured with LI-188 B quantum meter and LI-1905 B sensor Li-Cor, Lincoln, NE. Temperature was maintained at a 15°C/10°C day/night regime.

Heat-shock treatment

Plants were watered immediately before heat-shock. These plants were used for isolation of chloroplasts either exposed to 37°C for 4 h or kept at 15°C. The heat-shocked plants were used immediately or after four days recovery.

In vivo labeling and extraction of proteins

In vivo labeling and extraction of proteins were performed as Cooper et al. (1984) described. Briefly, second leaves of the intact plants were labeled by first lightly abrading a small section of adaxial leaf surface with emery paper. To

this surface, 10 µL of ³⁵[S] methionine (specific activity 39.9 TBq/mmol, New England Nuclear) was applied. The labeled section was covered with cellophane to prevent evaporation of the label and drying of the leaf tissue. Two hours after labeling, the abraded sections were cut out with a razor blade, rinsed in non-radioactive ice-cold 1-mM methionine, and then processed. The leaf section was drycrushed in liquid nitrogen. The powder was suspended in 500 µL SDS buffer (Lin et al. 1984), heated for two minutes, and then centrifuged at 11,000 g for five to remove insoluble debris. Protein content was determined using the method of Lowry et al. (1951).

For isolation of thylakoid membranes, thylakoids were extracted from the labeled leaf section in a solution of 300-mM sorbitol, 40 mM Hepes-NaOH (pH 7.6), 60 mM NaCl, and 5 mM MgCl₂ by homogenizing leaves with a polytron (Brinkman Instruments, Westbury, NY). The homogenate was filtered through two layers of Miracloth (Calbiochem, La Jolla, CA) and centrifuged at 10,275 g for five minutes. The pellet was resuspended in 100 μ L of the same extract medium. The aliquot was solubilized in SDS buffer, and the protein content was determined using the same method as for determining the protein content.

Gel electrophoresis of proteins and autoradiography

Radio-labelled proteins were analyzed by one dimensional SDS-PAGE as described by Schagger and von Jagow (1987). For total leaf and thylakoid membrane extracts, 10 and 16% acrylamide gels, respectively, were used. Gels were loaded with equal amounts of proteins, fixed in 12% TCA, and stained in 2% TCA, using coomassic blue G-250. After being stained, gels were dried at 60°C. Autoradiography was carried out using Fuji X-ray film (Fisher Scientific, St. Louis, Missouri).

Results

Most organisms respond to a shift to a temperature higher than normal growing temperature with the production of a set of heat-shock proteins. Experiments presented here further demonstrate the tightly-regulated nature of this response in wheat (*Triticum aestivum* L. ev Len.). Synthesis of these HSP increases as the temperature is increased. Inversely correlated with the increase in HSP is a decrease in the apparent synthesis of both chloroplast and total leaf proteins.

Total leaf protein synthesis

The effect of temperature on the synthesis of total leaf proteins was examined using *in vivo* labeling experiments.

Plants were maintained at the normal 15°C growth temperature or subjected to heat-shock for 4 h at 37°C. Proteins synthesized during these treatments are shown in Figure 1. When plants were transferred to 37°C, the pattern of protein synthesis was different from control plants incubated at 15°C (Figure 1, lanes 1 and 2). New HSP, indicated by arrows, are synthesized in response to high temperature and have apparent molecular weights of 17, 18, 70, and 80 kD. These proteins are absent in control tissue maintained at 15°C growth temperature. Figure 1 (lane 3) shows the effect of shifting heat-shocked plants back to 15°C. When plants were subjected to 37°C temperature for 4 h and then returned to 15°C, the heat-shock pattern was completely absent after four days of recovery.

Thylakoid membrane protein synthesis

Plants were heat-treated at 37°C for 4 h to find out whether any binding of HSP on the thylakoid membrane could be observed and to determine how long the binding would persist after the end of the heat treatment. Thereafter, the plants were kept at ambient temperature of 15°C for four days. Thylakoid membranes were isolated either at the end of the

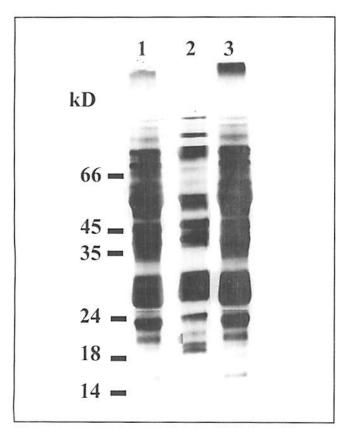


Figure 1. Autoradiogram of the total leaf proteins synthesized at control, heat shock, and four days after recovery.

heat treatment or after four days of recovery. Control plants were kept at 15°C all the time. It is evident from Figure 2 (lane 2) that the synthesis of HSP-22 was induced at 37°C, while the synthesis pattern of other membrane proteins was dramatically altered. HSP-22 is not detectable neither in the tissue of the controls that were maintained at 15°C nor in the plants allowed to recover for four days after the heat shock (Figure 2, lanes 1 and 3).

Discussion

Many pre-existing proteins persist through the investigated temperatures, while a few other proteins are no longer expressed and more are probably no longer present after heat-shock for 4 h at 37°C (Figures 1 and 2).

One property of the induction process is the synthesis of HSP-22, which is induced at 37°C (Figure 1). When the plant is returned to normal temperature (15°C), HSP-22 quickly disappears. This indicates that the synthesis of this protein is rapidly turned off during recovery. The data pre-

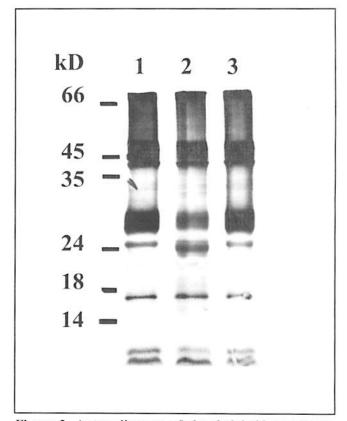


Figure 2. Autoradiogram of the thylakoid membrane proteins synthesized by leaf tissue at control, heat shock, and four days after recovery.

sented in this paper confirm and extend previous findings (Kimpel and Key 1985): Nuclear-coded HSP-22 is bound to the thylakoid membranes given that leaves used for the *in vivo* labeling come from plants which have been treated by high temperature before isolating the thylakoid membranes. Binding of thylakoid membranes should be a coordinated process. Conditions for this process take place during heat-shock treatment and are preserved during the isolation step and thereafter (Kimpel and Key 1985).

Glaczinski and Kloppstech (1988) have proposed that the chloroplast HSP-22 protects/repairs PSII during heat stress. PSII is one of the most heat-sensitive components of the chloroplast (Berry and Bjorkman 1980). The hypothesis that it may be involved in protecting photosynthetic partial reactions is based on observations that pea chloroplast HSP-22 was bound to thylakoid membranes. However, thylakoid localization occurred only at temperatures above 38°C at relatively high light intensities. Below this temperature, the protein showed no strong association with membranes (Glaczinski and Kloppstech 1988). Other evidence for the role of HSP in protecting photosynthesis has come from studies of chlamydomonas. In chlamydomonas, a pretreatment at high temperature in the dark ameliorated PSII damage during subsequent heat treatment in the light (Schuster et al. 1988). This was accredited to HSP-22 protection of PSII. However, in chlamydomonas, HSP-22 synthesized in vivo co-migrates in a sucrose gradient with numerous fractions of chloroplast membranes and is enriched in the thylakoid particle (Kloppstech et al. 1985). This strongly indicates its presence within the *chlamydomonas* chloroplast.

Even though the molecular basis for binding and transiencing this process are not understood, data show that the membrane binding process in wheat is specifically heat-induced. Furthermore, it is apparent that the altered status does not last long. This means that the membrane alterations are transient, as are the heat-induced changes of HSP-22.

An emerging principle is the role of high-molecular weights HSP 70 and 90 (Figure 2). In plants, as in other eukaryotes, HSP 70 is found constitutively in the cytoplasm of all tissues, and additional HSP 70 is produced during high temperature stresses (Chen et al. 1990; Lindquist 1986; Neuman et al. 1987). Pelham (1986) stated that HSP 70 and HSP 90 (which ranges in size from approximately 80 to 94 kD) played a role in ATP-dependent protein folding and assembly, a hypothesis that has received support from HSP studies in stressed and unstressed plants (Pelham 1986). However, it has been proposed that high-molecular weight HSP bind to dissociated or denatured proteins produced during heat stress, facilitating protein to refold or reassemble

together with the hydrolysis of ATP (Pelham 1986). Evidence indicates that through this mechanism, HSP 90 and HSP 70 facilitate a wide diversity of important processes, including protein folding and transporting proteins across membranes. All these functions require altering or maintaining specific polypeptide conformations.

The reversal of heat-induced heat shock proteins and the binding of HSP-22 to thylakoid membranes may involve HSP-22 in restoring heat-induced alterations of the photosynthetic apparatus, especially PS II.

References

- Armond, P.A., U. Schreiber and O. Bjorkman. 1978. Photosynthetic acclimation to temperature in the desert shrub *Lerrea diverticata*. II. Light harvesting efficiency and electron transport. *Plant Physiology* 61: 411-415.
- Bauer, H. and M. Senser. 1979. Photosynthesis of Ivy leaves (Hedera helix L.) after heat stress. II. Activity of ribulose biphosphate carboxylase, Hill reaction and chloroplast ultrastructure. Z Pflanzenphysiologie Bd 91:359-369.
- Berry, H. and O. Bjorkman. 1980. Photosynthetic response and adaptation to temperatures in higher plants. *Annual Review of Plant Physiology* 31: 491-454.
- Chen Q., L. Lauzon, A. DeRocher, and E. Vierling. 1990. Accumulation, stability, and localization of a major chloroplast heat-shock protein. *Journal of Cellular Biology* 110: 1873-1883.
- Cooper, P., T.H.D. Ho, and R.M. Hauptmann. 1984. Tissue specificity of heat-shock response in maize. *Plant Physiology* 75: 431-441.
- Glaczinski, H. and K. Kloppstech. 1988. Temperature-dependent binding to the thylakoid membranes of nuclear-coded chloroplast heat-shock proteins. *European Journal of Biochemistry* 173: 579-583.
- Hoagland, D.R. and D.I. Arnon. 1950. The water-culture method for growing plants without soil. *California Agricultural Experiment Station*. Circular 347.
- Key, J.L., J.A. Kimpel, C.Y. Lin, R.T. Nago, E.C. Vierling. E. Zarnicka, W.B. Gurly, J.K. Roberts. M.A. Mansfield and L. Edelman. 1985. The heat shock response in soybean. Pages 161-179 in Cellular and Molecular Biology of Plant Stress. (J.L. Key and T. Kosuge, eds.). Alan R. Liss, New York, USA.
- Kimpel J.A. and J.L. Key. 1985. Heat-shock in plants. *Trends in Biochemical Sciences* 10: 353-357.
- Kloppstech, K., G. Meyer, G. Schuster, and I. Ohad. 1985. Synthesis, transport and localization of a nuclear-coded 22 kD heat-shock protein in the chloroplast membranes

- of peas and *Chlamydomoonas reihardi*. *EMBO Journal* 4: 1902-1909.
- Lin, C.Y., J.K. Roberts, and J.L. Key. 1984. Acquisition of thermotolerance in soybean seedlings. *Plant Physiology* 74: 152-160.
- Lowry, O.H., N.J. Rosebrough, A.L. Farr, and R.J. Randall. 1951. Protein measurement with the Folin Phenol Reagent. *Journal of Biological Chemistry* 193: 265-275.
- Lindquist, S. 1986. The heat-shock response. *Annual Review of Biochemistry* 45: 39-72.
- Nago, R.T., J.A. Kimpel, E. Vierling and J.L. Key. 1986.
 The heat shock response: A comparative analysis.
 Pages 384-438 in Oxford Surveys of Plant Molecular Biology of Plant Stress (Vol. 3) (B.J. Miflin, ed.).
 Oxford University Press, England, U.K.
- Neuman, D., U. Zur Nieden, R. Manteuffel, G. Walter, K.D. Scharf, and L.Nover. 1987. Intracellular localization of heat-shock proteins in tomato cell cultures. *European Journal of Biology* 43: 71-81.
- Nover, L., D. Hellmund, D. Neumann, K.D. Scharf, and E. Serfling. 1984. The heat-shock response of eukaryotic cells. *Biologisches Zentralblatt* 103: 357-435.
- Pearcy, R.W., J.A. Berry, and D.C. Ford. 1977. Effect of growth temperature on the thermal stability of the photosynthetic apparatus of *Atriplex lentiformis* (Torr.) Wats. *Plant Physiology* 59: 873-878.
- Pelham H.R.B. 1986. Speculations of the functions of the major heat-shock and glucose regulated proteins. *Cell*

- 46: 959-961.
- Quin, P.J. and W.P. Williams. 1985. Environmentally induced changes in chloroplast membranes and their effects on photosynthetic function. Pages 1-47 in Photosynthetic Mechanisms and the Environment. (J. Barber and N.R. Baker, eds.). Elsevier Science Publishers, New York, USA.
- Sach, N.M. and T.H.D. Ho. 1986. Alteration of gene expression during environmental stress in plants. *Annual Review of Plant Physiology* 37: 363-376.
- Schagger, H. and G. Von Jagow. 1987. Tricine-Sodium Dodecyl Sulfate gel electrophoresis for the separation of proteins in the range from 1 to 100 kD. *Analytical Biochemistry* 166: 368-379.
- Schuster, G., D. Even, K. Kloppstech, and I. Ohad. 1988. Evidence for protection by heat-shock proteins against photoinhibition during heat-shock. *EMBO Journal* 7: 1-6.
- Schlesinger, M.J. 1990. Heat-shock proteins. *Journal of Biological Chemistry* 265: 12111-12114.
- Sundby, C. and B. Anderson. 1986. Temperature-induced reversible migration along the thylakoid membrane of photosystem II regulates its association with LHC-II. *FEBS Letters* 191: 24-28.
- Vierling, E., M.L. Mishkind, G.W. Schmidt, and J.L. Key. 1986. Specific heat proteins are transported into chloroplasts. *Proceedings of the National Academy of Sciences USA* 83: 361-365.

Evaluation of Exotic and Indigenous Barley Accessions for Resistance against Indian Pathotypes of *Puccinia striiformis hordei*

J.R. Yadav and J. Kumar

Crop Improvement, Directorate of Wheat Research, P.O. Box 158, Kunjpura Road Karnal-132001 (Haryana), INDIA

Abstract

One hundred and sixty-eight accessions of *Hordeum vulgare* L. were evaluated in 1995/96 at Karnal, India for yellow rust resistance under artificial epiphytotic conditions, and for net and spot blotch, leaf stripe, and aphid infestation under natural conditions. Seven exotic and seven indigenous lines were found completely resistant to yellow rust. These entries, as well as those with moderate resistance, were retested the following year. Accessions BCU 26, 51 and BCU 127, from the exotic, and BCU 167, from the indigenous collection, showed some degree of multiple resistance.

Key words: *Hordeum vulgare*; yellow rust; *Puccinia stri-iformis hordei*; resistance; Indian pathotypes.

Introduction

Barley (Hordeum vulgare L.) has recently assumed a significant status in India. The present day varieties are more productive and offer greater protection against diseases and insect pests. But most of them possess one or two common resistant genes and are therefore vulnerable to epidemic breakdown of resistance. Among the various diseases of barley, stripe (yellow) rust caused by Puccinia striiformis f. sp. hordei, is an important disease and will remain so because of the continuous appearance of new pathotypes. Four major resistance genes, namely, Rps1, Rps2, Rps3, Rps4 have been identified and used in barley breeding throughout the world (Jorgensen 1987). Resistance breeding in India has been based on confirmed sources available in landraces of indigenous or exotic origin, as in cultivated barley available sources of resistance are limited. Systematic and concerted effort to evaluate the available germplasm collections maintained at the various breeding centers of India for new possible sources of resistance have

تقويم مدخلات الشعير المحلية والمستقدمة لمقاومة الطرز الممرضة الهندية لـ Puccinia striiformis . hordei

الملخص

أجري في موسم 96/1995 في كارنال بالهند تقييم لـ 168 مدخلاً من الشعير Hordeum vulgare لتحديد مقاومتها للصدأ الأصفر تحت ظروف وبائية مرضية مصطنعة، وللإصابة بكل من التبقع الشبكي، وتبقع الأوراق، والتخطيط المتوازي للأوراق، والمن تحت الظروف الطبيعية. ووجد أن سبعة من السلالات المدخلة (المستقدمة) وسبعة من السلالات المحلية تتسم بمقاومة كاملة للصدأ الأصفر. وأعيد اختبار هذه المدخلات مع تلك التي تتسم بمقاومة متوسطة في السنة التالية. حيث أظهرت كل من المدخلات التالية 16, 26, 26 BCU من المجموعة المحلية مقاومة متعددة لدرجة ما للإجهادات المجموعة المحلية المختبرة.

been lacking. Therefore, the present study was undertaken to evaluate the germplasm collection available at the Directorate of Wheat Research (DWR), Karnal (India) against yellow rust under artificial epiphytotic conditions, and for other foliar diseases under natural conditions.

Material and Methods

Seeds of 168 accessions of barley from the DWR repository were sown in the field at Karnal, India, during 1995/96 in augmented block design. Each entry was grown in two rows, each 2 m long. All recommended package and practices were followed. Spreader rows of highly susceptible varieties were planted after every ten rows and also on the borders of the experimental block. Urediospores of *P. striiformis* f. sp. *hordei* isolates (mixture of pathotypes M, Q, 24 and G) were suspended in light mineral oil and syringe-inoculated into two-week-old seedlings. Suspension of uredospore was again sprayed after 10 days to create the maximum disease pressure. Plants were scored when the disease showed the maximum development on the infector rows. Scoring for yellow rust was done as per Loegering

(1959) and on the basis of modified Cobb scale (Peterson et al. 1948). Other diseases, such as spot blotch, net blotch, and leaf stripe and also the aphid infestation were scored on a 0-8 scale (0 being completely free and 8 being maximum infestation under natural conditions) to explore multiple resistance. The entries with complete or partial resistance to yellow rust were again tested against the same isolates under artificial epiphytotic conditions in 1996/97.

Results and Discussion

Complexity of the pathosystem of Puccinia striiformis f. sp. hordei has led to adoption of different breeding strategies which, when classified according to the genetic basis, are major genes, polygenic resistance and genetically-undefined resistance. Major genes have been the most widely used kind of resistance (Jorgensen 1987) as it provides effective control of the disease and it is easy to incorporate. Pyramiding major genes thus appears to be the most attractive choice. However, for this strategy we need resistant genes with a good genetic background since resistant genes from other species or with poor genetic background do not have immediate breeding value. The germplasm collection maintained at DWR repository includes the local cultivars, the material developed by the various breeding centres of India, and the lines selected from international trials material coming from ICARDA or CYMMIT. Therefore, most of the material has immediate breeding value and can be used as a parent in breeding programs.

The severity of infection recorded on the infector and other established susceptible varieties like BHS 169 and DL-88, which were repeated in each block, was used as an indicator for the intensity and uniformity of disease development. Severity on all the infector rows ranged from 60S-100S while on the varieties it was between 50S-100S. The disease pressure was very high and chances of an escape were negligible, as the weather was also favorable for disease development. The weather data for the 1995/96 and 1996/97 barley-cropping seasons are presented in Figure 1. The inoculum comprised the races prevalent in India, i.e., pathotypes M (1SO), G (4SO), Q (5SO), 24(0SO) and their relative virulence is presented in Table 1. Pathotype M (1SO) is the most frequent and pathotype Q (5SO) the most virulent. The entries, which were found free, i.e., with zero infection against yellow rust in 1995/96, are given in Table 2. These entries when tested again in 1996/97 were found free or resistant. This confirmed their immunity/resistance against vellow rust. Resistance was more common among the exotic material as seven out of 75 exotic accessions exhibited no infection to the mixture of isolates. These accessions are likely to possess resistant genes against those races prevalent in India. The exact origin of these entries is not known but many of them might have in their pedigree the landraces originating from the region where the host and pathogen have coevolved (Anikster and Wahl 1979). The four exotic accessions namely BCU24, BCU25, BCU26, and BCU27 are medium in plant height and maturity and are two-row types with acceptable grain size. All of these four entries share a common parentage and therefore need to be tested for the source of resistance using the allelism test. During 1995/96, the accessions BCU25 and BCU26 were found to be free from foliar diseases and aphids under natural conditions. In the 1996/97 season, three entries, that is., BCU24, BCU25 and BCU26 (Table 3) were completely free from yellow rust. However, they were susceptible to aphids. The entry BCU27, though exhibiting variable reaction (0 and MR) in two years, was comparatively less attacked by aphids in both cropping seasons. Since all of these accessions are also agronomically better, they can serve as a valuable genetic resource for barley improvement against biotic stress. Other exotic accessions, namely BCU51 and BCU127, were also completely free from yellow rust infection and showed multiple disease resistance. The accession BCU51, a six- row type, was tall and late in maturity whereas BCU127 was of short stature and can be used in creating diversity against yellow rust with simultaneous selection for the desired plant type. Most of the indigenous lines were susceptible and only six entries, namely, BCU130, BCU131, BCU134, BCU135, BCU167, and BCU182, were completely free from yellow rust infections. However, all of these entries showed moderate to high susceptibility to other foliar diseases such as net blotch, spot blotch, and stripe, and to aphids. Some of the exotic accessions like BCU21, BCU22, BCU23, BCU28, BCU29, BCU32 and BCU33 and some of the indigenous material like BCU nos. 79, 125 and 158 (Table 4) showed low-type infection with a moderatelyresistant on moderately-susceptible type of reaction. Therefore, they were again tested for their reaction type and disease severity in 1996/97 and were found to be slow rusting or with adult type of resistance behavior. Therefore, after further confirmation and testing against the individual races, these lines can be used in breeding for durable resistance. Such wide differences in frequency of resistance genotypes among the exotic and indigenous collections might be due to the different racial structure of pathotypes.

Gulati and Verma (1987), in their study on the pattern of variability in relation to geographical regions reported yellow rust-resistant stocks from Ethiopia, Europe and high areas of Tibet and Nepal. Though the wealth of genetic variability has been used in the barley breeding programs of India, resulting in release of a number of varieties, the

entries identified under the present study will help in increasing the effort towards a disease-free barley crop. Besides, the landraces and populations of *H. vulgare* in European gene banks have been screened thoroughly for disease resistance (Jorgenson 1988) and form a European database which will be part of the planned Global Barley Germplasm network (IBPGR 1989). This study is a step toward formulating a database of the accessions available in India and thus complements the global network.

Table 1. Relative virulence of the races used in the screening.

Races Differential	24(0SO)	M(1SO)	G(4SO)	Q(5SO)
Chinese 166	S	S	R	R
Heines kolbew	R	S	R	S
T. diccocum t.	S	S	R	S
Barley local	S	S	S	S

S = susceptible; R = resistant

Table 2. The yellow rust free accessions and their reaction to other diseases evaluated in 1995/96.

Sr. No.	Acc. No.	Origin‡	Yellow rust	Spot blotch	Net blotch	Stripe	Aphid
i	BCU24	E	0	1	F	F	l l
2	BCU25	Е	0	F	F	F	2
3	BCU26	Е	0	F	F	F	1
4	BCU27	Е	0	F	F	F	1
5	BCU35	Е	0	1	F	2	1
6	BCU51	E	0	F	F	F	F
7	BCU127	Е	0	F	F	F	F
8	BCU130	I	0	F	F	2	2
9	BCU131	I	0	2	F	2	4
10	BCU133	I	0	F	2	F	5
11	BCU134	I	0	2	F	2	2
12	BCU135	I	0	2	4	F	3
13	BCU167	I	0	F	F	F	5
14	BCU182	I	0	F	5	F	5

[†] 0-8 Scale = 0 = resistant, 8 = susceptible, F = free

[#] E= exotic; I= indigenous

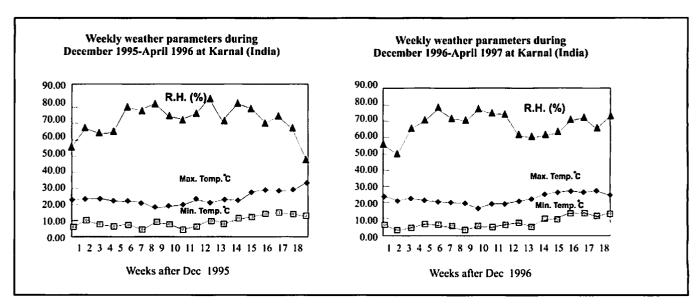


Figure 1. Weather data for the 1995/96 and 1996/97 barley cropping season.

Table 3. Yellow rust reaction† and aphid‡ of the selected resistant lines in 1996/97.

Sr. No.	Entry No.	Yellow rust	Aphid resistance
1	BCU24	0	3
2	BCU25	0	5
3	BCU26	tMR	5
4	BCU27	0	5
4 5	BCU35	0	5
6	BCU51	0	3
7	BCU127	0	3
8	BCU130	0	3
9	BCU131	0	3
10	BCU134	0	2
11	BCU135	0	4
12	BCU167	0	3
13	BCU182	0	3

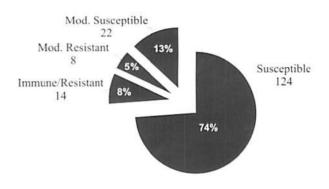
[†] Modified Cobb Scale

Table 4. Yellow rust reaction† of some of the moderately-resistant (MR) / moderately-susceptible (MS) lines over two seasons.

Sr. No.	Entry No.	Yellow	rust	Aphie resista	
		1995/96	1996/97	1995/96	1996/97
1	BCU21	tMS	tMS	2	3
2	BCU22	tR	tMR	2	5
3	BCU23	tMS	10MS	2	5
4	BCU28	15MS	15MS	2	5
5	BCU29	tMS	tS	2	4
6	BCU31	15MS	15S	2	4
7	BCU41	tMS	5MS	1	2
8	BCU53	MS	10MS	2	3
9	BCU79	ts	tMS	1	2
10	BCU125	10MR	10MS	2	4
11	BCU158	tMS	5MS	3	4

[†] Modified Cobb scale

Classification of accession on the basis of disease reaction.



References

Anikster, Y. and I. Wahl. 1979. Coevolution of rust fungi on gramineae and liliaceae and their hosts. *Annual Review* of *Phytopathology* 17: 367-403.

Gulati, S.C. and N.S. Verma. 1987. Proceedings of the National Symposium on Plant Genetic Resources, New Delhi, India.

Jorgensen, J.H. 1987. Sources and genetics of resistance to fungal pathogens. Pages 441-457 in Barley: Genetics, Biochemistry, Molecular Biology and Biotechnology (P.R. Shewry, ed.). CAB International, Wallingford, UK. 610 pp.

Jorgensen, J.H. 1988. Screening of Hordeum vulgare for powdery mildew resistance (Abstract). Nordisk Jordbrugsforskining 70:529.

IBPGR (International Board for Plant Genetic Resources).
1989. International Crop Network Series 1. Report of International Barley Working Session, Rome, Italy.

Loegering, W. Q. 1959. Method for recording cereal rust data, USDA, International Spring Wheat Nursery, USA.

Peterson, R.F., A.B. Campbell and A.E. Hannah. 1948. A diagrammatic scale for estimating rust intensity of leaves and stem of cereals. *Canadian Journal of Research Section C26*: 496-500.

^{± 0 =} resistant; 8 = susceptible

t = traces; MR = moderately resistant

t = traces; S = susceptible, R = resistant

Promising Durum Wheat Genotypes under Normal and Stress Growing Conditions in Northern Sudan

A.I.S. Mohamed

Hudeiba Research Station, P.O. Box 31, El- Damer, SUDAN

Abstract

In Sudan, durum wheat is considered as a possible productive crop. Eighteen durum wheat genotypes were tested under normal and stress growing conditions over a bread wheat check. Days to heading, days to maturity, plant height, number of spikes/m², number of seeds/spike, 1000-kernel weight, and seed yield were positively associated but showed significant differences. Therefore, four of the genotypes studied were recommended for commercial production.

Key words: *Triticum turgidum*; Sudan; stress; genotypes; adaptation.

Introduction

Durum wheat (*Triticum turgidum* var. durum) is a potential crop in Sudan. Correlation studies of seed yield in durum wheat were positively associated with plant height, number of tillers/plant, number of seeds/spike 1000-kernel weight, biological yield, and harvest index (Nachit and Jarrah 1986; Amin et al. 1992; Belay et al. 1993).

The objective of this study was to show the performance of introduced durum wheat genotypes under normal and stress growing conditions in northern Sudan and recommend their suitability for commercial production.

Material and Methods

Eighteen durum genotypes received from the International Center for Agricultural Research in the Dry Areas (ICARDA) were grown under normal conditions (late November sowing, two-week interval irrigation) and stress conditions (late December sowing, three-week interval irrigation), in the 1993/94, 1994/95, and 1995/96 seasons at Hudeiba in northern Sudan. A split plot was designed, with growing conditions in the main plots and genotypes ran-

الطرز الوراثية المبشرة للقمح القاسي تحت ظروف النمو العادية والإجهادية في شمالي السودان

الملخص

يعتبر القمع القاسي في السودان كمحصول إنتاجي ممكن. فقد تم اختبار 18 طرازاً وراثياً منه تحت ظروف نمو عادية وظروف أجهاد مقارنة مع شاهد من القمع الطري. وكانت علاقة الارتباط بين عدد الأيام حتى الإسبال، وعدد الأيام حتى السناحي، وارتفاع النبات، وعدد السنابل/م²، وعدد الموب/السنبلة، ووزن 1000 حبة، والغلة البذرية إيجابية، بيد أنها أظهرت اختلافات كبيرة. وعليه تمت التوصية بأربعة من الأصول الوراثية، أجريت عليها الدراسة للإنتاج التجارى.

domized in the subplots replicated twice. The plot size was 6 m x 2.5 m and the harvested area was 10 m². Planting was done by hand drilling the seeds in rows 30 cm apart on flat plots using a seed rate of 120 kg/ha. Nitrogen fertilizer was added as urea at a rate of 86 kg N/ha in two equal doses during the second irrigation and at heading. Weed control was done twice by hand. No insect or disease problems were experienced. Characters studied were days to heading, days to maturity, plant height, grain yield, and yield components.

Results and Discussion

The genotype showed significant differences in all characters studied (Tables 1 and 2). The best grain yield under normal growing conditions was obtained by the genotype 'Somo/Auk' (1) with yield advantage of 7% over the bread wheat check ('Wadi El Nil'). The best genotype in grain yield under heat stress was 'Mrb 15/Ru' with yield reduction of only 2% from normal sowing and 18% yield advantage over the check (Wadi El Nil). The genotype Somo/Auk (1) was the best in grain yield under water stress with yield reduction of 14% from normal irrigation and yield advantage of 2% over the check (Wadi El Nil) (Table 2). The average grain yield reduction of genotypes was 18% under both heat and water stress growing conditions (Table 2).

The stress affected all yield-related characters with more effect on maturity, plant height, tillering capacity, and grain filling of the genotypes (Table 2).

Table 1. Mean grain yield (kg/ha) of durum wheat genotypes under normal and stress growing conditions over the 1993/94, 1994/95 and 1995/96 seasons (order of the first five shown in parenthesis).

Genotype	Normal	Heat stress	Water stress	% reduction heat	Under stress water
Mrb 15/Ru	2591	2552(1)	2108	2	19
Wadelemez	2473	2297	1742	7	30
StR/-11-/cit 71	2578	2064	1829	20	29
Stojocri 6	2667(5)	1707	2078	30	22
Godovz 5121-1 Dwl	2522	2184	1623	13	36
Genil-4	2525	2165	2093	14	17
Sohaj-1	2136	1719	1928	20	10
Sohaj-2	2367	1871	1929	21	19
Sohaj-3	2597	2138	1983	18	24
Benisuaf	2801(3)	2377(4)	2292(5)	15	18
Lagost	2552	2205	1984	14	22
Massarra-1	2252	1772	1873	24	17
Hider/Mt/HO	2565	1795	2353(3)	30	8
Omruf-2	2798(4)	2025	1963	28	30
Qt/kill	2681	2493(2)	2182	7	19
Somo/Auk(1)	3061(1)	2187	2626(1)	29	14
Stn/Alter 84	2554	2415(3)	2300(4)	5	10
Sham-1 (check)	2589	2351(5)	2170	9	16
Wadi El Nil (bread wheat check)	2848(2)	2164	2561(2)	24	10
Mean	2588	2131	2085	18	18
S.E.±		300			
Sign. Level		*			

^{*} Significant at P = 0.05.

Table 2. Performance of durum wheat genotypes according to yield related characters under normal and stress growing conditions over the 1993/94, 1994/95, and 1995/96 seasons.

Character	Range	Mean	S.E.±	Sign. level
Days to heading	53-59	61	1	**
,	52-65	60		
	51-65	59		
Days to maturity	91-105	100		
,	86-97	92	2	**
	89-102	97		
Plant height (cm)	70-87	81		
	63-80	72	2	**
	66-78	69		
No. of spikes/m ²	301-570	414		
•	323-544	405	36	**
	289-513	370		
No. of seeds/spikes	30-46	38		
•	30-50	42	3	**
	24-45	34		
1000-kernel weight (gm)	37-53	46		
	30-46	37	2	**
	39-55	46		
Seed yield (t/ha)	2.1-3.1	2.6		
•	1.7-2.6	2.1	0.3	*
	1.6-2.6	2.1		

For each character:

upper = normal

middle = heat stress lower = water stress

^{* ,**} Significant at P = 0.05 and 0.01, respectively.

Conclusion

Durum wheat showed good adaptation and comparable performance to bread wheat under northern Sudan conditions. The genotypes Somo/Auk (1), Mrb 15/Ru, Sham-1 and Stn/Altar 84 could be considered for commercial production under normal, heat stress and water stress growing conditions in northern Sudan.

Acknowledgements

The funds available for the study through the ARC/ICAR-DA Nile Valley and Red Sea Regional Program on wheat are highly appreciated.

Seed-Borne Pathogens of Wheat in Pakistan

A.R. Bhutta and S.A. Hussain

Federal Seed Certification & Registration Department, Mauve Area, G-9/4, Islamabad-4400. PAKISTAN

Abstract

A total of 246 seed samples collected from eight major wheat growing areas in Pakistan were studied for their health status between 1993/94 and 1996/97, using ISTA techniques. Among the important pathogens isolated were Alternaria triticina, Bipolaris sorokiniana, Fusarium graminearum, F. moniliforme, and F. semitectum. The incidence of fungi ranging from 0.50 to 11.0% that were found varied from year to year and locality. B. sorokiniana appeared to be the major fungi found in all the localities except in Sakrand. Southern parts of the country showed less prevalence and incidence of seed-borne pathogens associated with wheat seeds.

Key words: pathogens; wheat seeds; Pakistan; infections; fungi; plant diseases.

Introduction

The most regular seed-borne diseases of wheat (*Triticum aestivum* L.), which generally occur in Pakistan and are responsible for crop losses in crop production, are smuts, bunts, foot rot, leaf/spot/blight, and ear cockle. A total of

References

Amin, M.R., N.C.D. Barma, and M.A. Razzague. 1992. Variability, heritability, genetic advance, and correlation study in some quantitative characters in durum wheat. *Rachis* 11(1&2): 30-32.

Belay, G., T. Tesemma, and D. Mitiku. 1993. Variability and correlation studies in durum wheat in Alema-Tenna, Ethiopia. *Rachis* 12(1&2): 38-40.

Nachit, M.M. and M. Jarrah. 1986. Association of some morphological characters to grain yield in durum wheat under Mediterranean dryland conditions. *Rachis* 5(2): 33-3.

الممرضات المنقولة مع البذور للقمح في الباكستان

الملخص

تم جمع 246 عينة حبية من المناطق الثمان الرئيسية لزراعة القمح في الباكستان، ودرست حالتها الصحية في الفترة مابين الموسم 94/1993 والموسم 97/1996 باتباع تقانات المنظمة التي الموسة 94/1993. ومن بين الممرضات المهمة التي ISTA عزلها نذكر: ISTA ومن بين الممرضات المهمة التي Alternaria triticina, Bipolaris sorokiniana. تم عزلها نذكر: Fusarium graminearum, F. moniliforme, and F. semitectum حيث تراوح مدى الإصابة بها ما بين 0.50-11.00%، وتباينت مذه النسبة من سنة لأخرى ويحسب الموقع. وكان فطر هذه النسبة من سنة لأخرى ويحسب الموقع. وكان فطر وأظهرت العينات المجموعة من المناطق الجنوبية من الدولة سيادة وتردداً أقل للمرضات المنقولة مع البذور والمرافقة لحبوب القمح.

246 seed samples were collected from major growing regions of Pakistan to find out incidence of various pathogens that cause these diseases. The information about the incidence and prevalence of seed-borne pathogens of wheat may be useful to the breeders and seed technologists for planning better disease management strategies.

Material and Methods

A total of 246 seed samples were collected according to ISTA rules from the certified wheat crop from the 1993/94 to the 1996/97 seasons and tested by using standard blotter

Table 1. Fungi detected from wheat seed lots in Pakistan from 1993/94 to 1996/97.

		1993/94			1994/95			1995/96		61	1696/97	
Seed production locality	No. of samples tested	Fungi	Range (%)	No. of Samples tested	Fungi	Range (%)	No. of Samples tested	Fungi	Range (%)	No. of Samples tested	Fungi	Range (%)
Peshawar	5	Alternaria triticina Bipolaris sorokiniana	0.5-0.4				01	A.t. B.s.	0.0-3.0	\$	A.t. B.s.	0.5-2.0
		Fusarium graminearum	0.5-2.5		•	• !		F. 7.	0.0-3.0		بر دي د	0.0-2.0
		г. понивутия Е. semitectum	0.5-4.0					F.s.	0.5-2.0		F.S.	0.2-2.0
Islamabad	30	A. triticina	0.5-3.0	S	A.t.	0.5-1.0	٣	A.t.	0.5-2.0	ı		
		B. sorokiniana	0.0-3.0		B.S.	0.0-2.0		B.s.	0.0-1.0	•		
		E. grammearum E. moniliforme	0.0-1.5		F.S.	0.0-2.5		1:8: F.m.	6.0-0.5 0.0-0.5			
		E. semirechum	0.5-2.0		F.s.	0.0-1.0		F.s.	0.0-50	•		
Lahore	•	•		10	A.1.	0.5-2.0	œ	A.1.	0.0-1.0	S	A.1.	0.0-0.5
			•		B.s.	0.0-6.0		B.s.	0.0-4.0		B.s.	0.0-3.0
		•			F. 9.	0.0-2.0		F.8.	0.0-1.0		F.m. F.c	0.5-1.0
					F.s.	0.5-5.0		F.S.	0.0-4.0			
Sahiwal	33	A. triticina	0.0-5.0	S	A.t.	0.0-1.5	9	A.t.	0.0-1.0	ĸ	A.t.	0.0-1.5
	i	B. sorokiniana	0.8-0.0		B.s.	0.5-5.0		B.s.	0.5-3.0		B.s.	0.0 - 2.0
		E. graminearium	0.0-1.5		F.g.	0.5-2.0		F.8.	0.0-1.0		F.m.	0.0-0.5
		1. memulyonme	0.071.5		;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;	0.1-0.0						
Sargodha	'n	A. triticina	0.0-1.0	9	B.s.	1.0-10.0	15	A.t.	0.0-4.0	v.	A.1.	0.0-3.0
		B. sorokiniana r	2.0-11.0		e	0.5-1.0		B.s. E.:	0.5-3.0		B.s. E.s.	0.0-2.0
		r. grammearum F monilitorme	0.5-5.0		F.M.	0.0-2.0		sis Li	0.1-0.0		ė	C.O-O.O
		E. semitectum	0.0-1.0									
Multan	30	B. sorokiniana	0.0-1.0	9	B.s.	0.0-0.5	20	B.s.	0.5	v	B.s.	0.5
		F. moniliforme	0.0-0.5	9	F.m.	0.50			•		F.s.	0.5
		E. semitectum	0.0-1.0		F.S.	0.50			•		F.S.	0.5
Sakrand	•		•	∞	F.s.	0.0-0.5	ď	1	0.0	7		0.0
Hyderabad	15	B. sorokiniana	0.5	i	•		•	,	•	01	B.s.	0.5
Total	99		•	40	•	ı	19	1		39	•	,
							į					

paper method. Four hundred seeds were planted on three pieces of moistened blotter paper and around 25 seeds per petri plate and incubated at 20°C± for seven days where seeds were examined under stereomicroscope. Fungi growing from seeds were identified based on colony habit. Characters and species were confirmed after culturing the fungus on potato dextrose medium, using a compound microscope where necessary.

Results and Discussion

Five important seed-borne pathogens detected by the blotter paper method from 246 seed samples are presented in Table 1. Incidence of fungi that varied from year-to-year and locality were found. *Bipolaris sorokiniana* (Sacc.) Shoem was isolated in high percentage ranging from 0.50 to 11.0% in all the localities except in the Sakrand areas. This pathogen can adversely affect germination and development of root system or kill the seedlings within a few days depending on the severity of the infection. Yield losses caused by this fungal disease (spot blotch) are not known yet in Pakistan.

Three species of Fusarium (F. graminearum, F. moniliforme and F. semitectum) were recorded with an infection percentage of 0.0-3.0, 0.0-5.0 and 0.0-5.0, respectively. F. graminearum was not recorded in seed samples from Multan, Hyderabad and Sakrand, whereas F. moniliforme and F. semitectum were observed in all the localities except in Hyderabad. High incidence of F. graminearum Schwabe was found in central Punjab (Sargodha, Lahore, and Sahiwal) and northern parts of the country (Islamabad and Peshawar). It might be because the distribution of scab (Fusarium head blight) varies with geography and climate, and especially with temperature (Sutton 1982). F. graminearum produced the predominantly estrogenic compound zearalenone and Trichothecene compound deoxynivalenal (Marasas et al. 1984).

Alternaria triticina was recorded in almost all the localities except Multan, Hyderabad and Sakrand. The highest infections (4.0 and 3.0%) were observed at Peshawar, and Islamabad, respectively. Alternaria leaf blight normally appears at later stage of wheat maturity. All the pathogens decreased trend in incidence when compared to a previous study by Khan and Bhutta (1994). This trend may be due to chemical treatment at pre-basic and basic seed production.

Pathologists have emphasized seed testing to control diseases which are seed-borne and the use of chemical seed treatment to improve seed quality and planting value. Keeping in mind distribution and incidence of fungal pathogens in wheat seed lots, there is a need for continuous monitoring of seed-borne fungi using seed health technology and fungicidal treatment on infected seeds. It should be done at pre-basic and basic levels for control of plant diseases under a strict seed health certification program of the country (Bhutta et al. 1992).

References

- Bhutta, A.R., M.A.R. Bhatti, and S.B. Mathur. 1992. Seed health certification programme for production of quality seed. Science Technology and Development 11(12): 1-25.
- ISTA (International Seed Testing Association). 1985.
 Proceedings of the International Seed Testing
 Association, Zurich, Switzerland.
- Khan, M.Q., A.R. Bhutta. 1994. Seed-borne fungi of wheat cultivars in Pakistan. *Pakistan Journal of Scientific and Industrial Research* 37(9): 397-398.
- Marasas, W.F.O., P.E. Nelson, and T.A. Toussoun. 1984.
 Toxigenic Fusarium species. Identity and Mycotoxicology. The Pennsylvania State University Press, University Park, Pennsylvania, USA.
- Sutton, J.C. 1982. Epidemiology of wheat head blight and maize ear rot caused by *Fusarium graminearum*. Canadian Journal of Plant Pathology 4:195-209.

Genetic Divergence in Facultative and Winter Wheat Germplasm

L. Kant, V. P. Mani, and V. S. Chauhan Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR), Almora, U.P., INDIA 263 601

Abstract

The present study was conducted to measure the genetic diversity amongst 199 germplasm of facultative and winter wheat based on four quantitative characters. The genotypes were grouped into 11 clusters. The highest intercluster distance was obtained between I \times VII (4.122). Inter-mating desirable genotypes of one cluster with genotypes of another cluster may give rise to recombinants, having high heterotic vigor for yield, earliness and adaptability.

Key words: *Triticum aestivum* L.; wheat germplasm; genetic divergence.

Introduction

Wheat (Triticum aestivum L. em Thell.) is one of the most important cereal crops in India. Although varieties have an average yield potential of 5-6 t/ha, the national productivity is only 2.7 t/ha. Exploitation of winter × spring gene pools of wheat holds promise for further enhancement of yield levels. The diverse parents should be used to succeed in any hybridization program to get better yield recombinants. Multivariate analysis (Mahalnobis D² statistic) has been used in spring wheat (Bhatt 1970; Singhal and Upadhyay 1977; Jatasra and Paroda 1978; Somayajulu et al. 1970) and in winter wheat (Jag Shoran and Tandon 1995) identifying genetically-diverse parents for hybridization. The present study was undertaken to estimate genetic diversity in a set of facultative and winter wheat germplasm as well as to identify genetic stocks which may serve as potential donors using the non-Hierarchical Euclidean analysis.

Several breeders in different crops have used D² statistics, but Arunachalam (1981) has suggested the technique has limitations. Beale (1969) has advocated classificatory approaches, like principal component and clustering of genotypes, to overcome the limitations of D².

التنوع الوراثي في الأصول الوراثية للقمح الشتوي والاختياري

الملخص

أجريت الدراسة الحالية لقياس التنوع الوراثي بين 199 مدخلاً من الأصول الوراثية للقمح الشتوي والإختياري، بالاعتماد على أربع صفات كمية. حيث تم فرز الطرز الوراثية إلى 11 مجموعة. و تم الحصول على أكبر مسافة بين المجموعتين في التهجين بين (4.122) VII × I وقد يؤدي إجراء التصالب بين الطرز الوراثية المرغوبة من مجموعة ما مع الطرز الوراثية من مجموعة أخرى إلى ظهور توافيق وراثية تمتلك قوة متباينة على مستوى كل من الغلة، والمبكارية، والقدرة على التكيف.

The non-Hierarchical Euclidean analysis proved quite useful for estimating the genetic divergence using unreplicated data in large germplasm collections (Garg and Gautam 1997).

Material and Methods

A total of 199 accessions were evaluated during rabi 1996/97 in an augmented design with one intermittent check, VL Gehun 616, at the experimental farm Hawalbagh, VPKAS, Almora. Each accession was grown in two rows 3 m long and spaced at 20 cm with 5 cm plant-to-plant distance; a recommended package of practices was followed to raise a healthy crop. Four quantitative characters, that is, days to 50% heading, plant height (cm), grain yield (g/plot) and test weight (g) were subjected to statistical analysis. Five plants were randomly selected to record observations on plant height. The rest of the observations were recorded on a plot basis. The Cluster Analysis Programme of SPAR 1 package developed by IASRI, New Delhi, was used to classify the genotypes. Different cluster solutions were compared using a sequential F ratio test. These components were used to group the genotypes as described by Beale (1969) and as elaborated by Spark (1973).

Results and Discussion

The range of various characters showed wide differences (Table 1) present in this set of facultative and winter wheats, which indicates ample scope for genetic manipulation.

The eigen root vectors and their associated variances have been given in Table 2. The first latent vectors showed a maximum variation of 41.8%, followed by the second vector whose variation was 30.69%. The first two vectors explained around 72% of variations and the other two the remainder.

On the basis of four quantitative characters, the 199 genotypes were grouped in eleven clusters (Table 3) as Ftest-determined on the basis of the Euclidean distance of the variable with respect to the desired objective. Cluster I is the smallest, containing only two accessions. It had the lowest mean value for days to 50% heading (94). Cluster II consisted of 14 accessions and had the lowest mean values for plant height (88.21) and test weight (32.74). Clusters III, IV, V, VI and VIII consisted of 19, 28, 29, 23, and 26 accessions, respectively having moderate values for the four characters under study. Cluster V, which had a maximum of 29 accessions, also had moderate mean values for all the characters. Cluster VII contained 20 accessions which had the highest mean value for grain yield/plot. Cluster IX consisted only of 13 accessions which had the highest values for grain yield (820 g/plot) and test weight (45.92 g). Cluster X contained 14 accessions with the highest mean values for days to 50% heading (182.07). Cluster XI consisted of 11 accessions and had the lowest mean values for grain yield (87.82 g/plot). All the clusters had exotic strains indicating existence of wide diversity in exotic germplasm.

The average intra- and inter-cluster D value has been presented in Table 4. The generalized intra-cluster distance (D) ranged from 0.841 (cluster X) to 1.400 (cluster XI). Less genetic variability exists in cluster X and the reverse is true for cluster XI. The minimum inter-cluster distance was observed in clusters VI and VIII.

The maximum inter-genetic distance was marked for groups $I \times VII$ and $I \times III$. Hybridization between clusters I and VII and clusters I and IX may result in heterotic combinations with desirable recombinants for better yield coupled with earliness. Group I contained germplasm with the lowest days for 50% heading and groups VII and IX contained germplasm with the highest value for grain yield (g/plot) and test weight (g), respectively (Table 4).

Table 1. Character mean, check mean and range for various characters in wheat germplasm.

Character	Mean	Mean check CV Mean % VL 616	CV %	Name	Origin	Value	Group	Value Group Name	Origin Value Group	Value	Group
Days to 50% heading	163.18	163.18 149.00	9.60	DOVE/BUC/PLK Syria-CIT	Syria-CIT	949	1	CH75460	Switzer	161	×
Plant height (cm)	101.68	103.3	11.96	SERI YUMA115, BUL 1518.4.38 BUL 5554.2 BUL7. BC.P2.11	Mexico, China Bulgaria, Dobrudja Bulgaria, Dobrudja Bulgaria, Dobrudja Hungary, Martonvasar	80 ar	, , , ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;	BOLAL	Nebraska 140 Turkey	140	≥
Grain yield	544.37	9.969	30.36	MVMA ID131/MTýLT/3/ RFZ/NAD//KZM	CIT	001	×	SXL/VEE//TRK	CIT	1240	IIA
Test weight (g)	40.2	44.13	11.79	BUL21.BC1.P2.4	BUL21.BC1.P2.4 Bulgaria, Dobrudja	26.2 IV	≥	LCR/SERI/3/MEX CIT -DW/BACA//VONA	CIT	51.5 IX	×

1

| <u>a</u>.

Table 2. Eigen root vector, eigen roots and associated variances for different components in wheat germplasm.

Characters	1	2	3	4
Days to 50% heading	0.605	-0.243	-0.571	-0.499
Plant height (cm)	0.290	0.749	0.386	-0.454
Grain yield (g/plot)	0.393	0.467	-0.387	0.691
Test weight (g)	0.629	-0.403	0.613	0.258
Eigen roots	1.675	1.228	0.623	0.475
% variation	41.87	30.69	15.56	11.88

Table 3. Characters in different clusters of wheat.

	I (2)	11 (14)	III (19)	IV (28)	V (29)	VI (23)	VII (20)	VIII (26)	IX (13)	X (14)	XI (11)
Days to 50% heading	96.00	172.36	150.05	174.39	147.76	169.78	168.85	174.00	147.08	182.07	154.64
Plant height (cm)	92.50	88.21	108.16	100.54	93.28	90.00	123.75	108.27	103.85	93.93	110.45
Grain yield (g/plot)	445.00	340.71	546.84	551.07	536.55	476.96	615.50	485.00	820.00	367.86	87.82
Test weight (g)	44.45	32.74	40.24	34.33	44.57	43.27	38.50	41.11	45.92	39.45	37.69

Table 4. Average intercluster and intracluster distance D values among 11 clusters in wheat germplasm.

	1	2	3	4	5	6	7	8	9	10	11
1	1.242										
2	3.701	1.344									
3	3.813	1.980	1.047								
4	3.787	1.724	2.104	0.994	•						
5	3.152	2.145	1.405	2.855	1.067						
6	2.980	2.452	2.002	2.201	1.613	0.985					
7	4.122	3.488	1.674	2.041	2.047	2.164	1.175				
8	4.021	2.578	1.685	1.605	2.019	1.389	1.569	0.874			
9	3.187	2.529	1.775	2.082	1.866	2.833	2.967	2.877	1.097		
10	3.679	1.532	2.636	1.676	2.675	1.453	3.039	1.642	2.149	0.841	
11	2.873	2.719	2.131	2.632	2.903	3.228	1.889	2.748	1.800	2.811	1.400

Acknowledgement

The authors acknowledge Mr B.D. Pande and Mr Dayashankar for their technical help.

References

Arunachalam, V. 1981. Genetic divergence in plant breeding. *Indian Journal of Genetics* 42(2): 226-236.

Bhatt, G. M. 1970. Multivariate analysis approach to selection of parents for hybridization aiming at yield improvement in self-pollinated crops. *Australian Journal of Agricultural Research* 21: 1-7.

Beale, E.M.L. 1969. Euclidean Cluster Analysis. Contributed paper to the 37th session of the International Statistical Institute, U.K.

Garg, D. K. and P. L. Gautam. 1997. Genetic divergence

studies in wheat germplasm using Non-Hierarchical Euclidean cluster analysis. *Indian Journal of Plant Genetic Resources* 10(1): 11-15.

Jag Shoran and J.P. Tandom. 1995. Genetic divergence in winter wheat (*Triticum aestivum* L. em. Thell). *Indian Journal of Genetics* 55(4): 406-409.

Jatasra, D.S. and R. S. Paroda. 1978. Genetic divergence in wheat under different environmental conditions. *Cereal Research Communication* 6: 307-318.

Singhal, N.S. and M.K. Upadhyay. 1977. Genetic divergence in wheat. *Cereal Research Communication* 5: 275-286.

Somayajulu, P.L., A. B. Joshi, and B. R. Murty. 1970. Genetic divergence in-wheat. *Indian Journal of Genetics* 30: 47-58.

Spark, D.N. 1973. Euclidean cluster analysis Algorithm. *Applied Statistics* 22: 126-130.

Sustaining Barley Yield by Early Planting and Grazing

S.K. Yau

Department of Crop Production and Protection, Faculty of Agricultural and Food Sciences, American University of Beirut, P.O. Box 11-236, Beirut, LEBANON

Abstract

In Lebanon, barley is widely grown in semi-arid areas where sheep raising is an important agricultural activity. The objective of this experiment was to show that with a suitable cultivar, a slight grazing during winter in early-planted barley would not lead to grain yield reduction relative to a non-grazed crop planted at the normal time. The experiment was conducted in 1997/98 in a fallow field at the Agricultural Research and Education Center in the Bekaa Valley.

Two varieties of barley, 'ER/Apm' and 'Rihane-03', were hand-planted. There were three planting dates by grazing treatments: (T1): Early planting without grazing, (T2): Early planting with early grazing, and (T3): Normal planting without grazing. Clipping at 10 cm above ground level simulated grazing. There was no significant difference in mean grain yield between the three treatments. Early planting without grazing gave the highest straw yield, but the lowest harvest index. Normal planting yielded the smallest amount of grain and straw. Rihane-03 had a higher mean grain yield and harvest index than ER/Apm. Planting Rihane-03 early and subjecting it to grazing gave the highest grain yield with average straw yield. This study confirmed the belief that green-stage grazing could be encouraged in higher rainfall areas. But before a recommendation can be made, the study needs to be repeated using actual sheep grazing to check whether similar results will be obtained in a drier season.

Key words: grain yield; harvest index; *Hordeum vulgare*; semi-arid areas; simulated grazing; straw yield.

Introduction

Barley (*Hordeum vulgare*) is the dominant winter crop in semi-arid areas of West Asia and North Africa, where it usually gives higher yield than wheat. Sheep raising is an

استدامة غلة الشعير من خلال مبكارية زراعته ورعيه

الملخص

يزرع الشعير في لبنان على نطاق واسع في المناطق شبه القاحلة، التي تشكل تربية الأغنام فيها نشاطاً زراعياً هاماً. وقد هدفت هذه التجربة إلى إظهار أنه عند توافر الصنف المناسب، فإن الرعي الخفيف في الشتاء على الشعير المزروع على نحو مبكر لن يؤدي إلى إنقاص الغلة الحبية مقارنة مع المحصول المزروع في الوقت المألوف، وغير المتعرض للرعي. وقد أجريت التجربة في الموسم 98/1997 في حقل للبور تابع لمركز البحوث الزراعية والتعليم في وادي البقاع.

زرع صنفان من الشعير ER/Apm, Rihane-03 يدويا. وكانت هناك ثلاث مواعيد ومعاملات رعى. المعاملة الأولى TI: الزراعة المبكرة بدون رعى، المعاملة الثانية T2: زراعة مبكرة مع رعى مبكر، والمعاملة الثالثة T3: زراعة عادية بدون رعى. وقد اعتبرت عملية القص على ارتفاع 10 سم فوق سطح التربة محاكية للرعج. ولم تلاحظ أية فروقات معنوية في معدل الغلة الحبية بين المعاملات الثلاثة. حيث أعطت الزراعة المبكرة ويدون رعى أعلى غلة من التبن، غير أن قيمة دليل الحصاد انخفضت. كما أعطت الزراعة العادية أقل كمية من الحبوب والتبن. وكان معدل الغلة الحبية ودليل الحصاد للصنف Rihane-03 أعلى من مثيلتها للصنف ER/Apm وأعطت الزراعة المبكرة للصنف Rihane-03 ورعيه أعلى غلة حبية مع معدل متوسط من غلة التبن. وقد أكدت هذه الدراسة الاعتقاد القائل بأن الرعى في المرحلة الخضراء قد يُحفِّز في المناطق التي تتسم بهطولات وفيرة. ولكن قبل تقديم التوصية، يجب أن تكرر هذه الدراسة بالقيام بعمليات رعى فعلية بوساطة الأغنام للتأكد فيما إذا كان بالإمكان الوصول إلى نتائج مماثلة في فصل أكثر جفافاً.

important agricultural activity in these areas and barley is the traditional and predominant animal feed. For sheep, barley straw and stubble are also more preferable than wheat.

In some areas of the world, sheep and cattle may use winter cereals for grazing during winter due to a lack of green feed (Yau et al. 1989a). The crops are often allowed to recover for grain production. In West Asia and North Africa, barley is the main winter cereal used for this pur-

pose. Some farmers believe that grain yield may be enhanced or at least should not be reduced by such practice. In a five-year study (1981/82 to 1985/86), at a site in Syria with an average annual rainfall of 330 mm, green-stage grazing increased net revenue by 5.5% or 320 SL1/ha on average over seasons. However, grain and straw yield were reduced by 15.7 and 22.7%, respectively (Yau et al. 1989b).

Sowing time generally has an influence on yield. Early sowing may or may not increase final grain yield, but is generally known to encourage plant growth giving it a higher biomass before winter sets in. The early availability of a sizable amount of forage definitely makes early planting attractive to farmers who allow sheep grazing in their barley fields.

Yau et al. (1989b) suggested that green-stage grazing could be encouraged in higher rainfall areas. In Lebanon, barley is widely grown in semi-arid areas where annual precipitation is between 350 and 500 mm and wheat is still not a reliable crop. The authors believed that in these higher rainfall areas, green-stage grazing could greatly increase farmers' revenues as final grain yield would not be reduced as much as in arid areas. The main objective of this experiment was to show that with a suitable cultivar, a slight grazing during winter in an early-planted (late October) barley would not lead to grain yield reduction relative to a nongrazed crop planted at the normal time (mid-November or later).

Material and Methods

The experiment was conducted in 1997/98 in a fallow field at the Agricultural Research and Education Center (33°56′ N, 36°05′ E, 995 m above sea level, 513 mm long-term annual precipitation) on the Bekaa Valley. Two varieties of barley, ER/Apm and Rihane-03, were hand-planted. Both were introduced in Lebanon from the International Center for Agricultural Research in the Dry Areas (ICARDA). ER/Apm is a two-row barley released in 1997, and Rihane-03 is a six-row type released in 1987. Rihane-03 is later in heading than ER/Apm, and was shown to be a good dual-purpose type (Yau and Mekni 1987).

There were three treatments:

(T1): Early planting (27 October) without grazing.(T2): Early planting (27 October) with early grazing.(T3): Normal planting (20 November) without grazing.Clipping at 10 cm above ground level on 23 February simulated grazing. According to the Feekes Scale, ER/Apm was

at stage six of growth, and Rihane-03 was at stage five (leaf sheaths strongly erected). From each plot, the clippings from one-meter row were bagged, dried at 80°C for 24 h, and then weighed.

The experiment was laid out in a randomized complete block design with three replicates. Each plot consisted of six rows of plants. Each row was 5 m long, and spaced at 30 cm. Seeds were sown at a rate of 100 kg/ha. Nitrogen (as ammonium sulfate) at a rate of 42 kg/ha along with 45 kg P_2O_3 /ha (as triple-superphosphate) was applied before early sowing for the whole experiment. Nitrogen (as ammonium nitrate) was also broadcast to all plots at a rate of 20 kg/ha immediately after grazing. Two one-meter rows of plants were harvested at maturity from the middle of each plot, weighed, and then threshed.

Results and Discussion

The season received an above-average precipitation of 569 mm. There were unusual large fluctuations in temperature in the spring. Slight leaf frost damage was observed. Lodging occurred in the early-planted ungrazed plots.

Simulated grazing gave a dry-matter yield of 2400 kg/ha with no significant differences between the two cultivars. Mean days to heading were shorter for ER/Apm than for Rihane-03.

As envisaged, there was no significant difference in mean grain yield between the three treatments (Table 1). Early planting without grazing gave the highest straw yield, but the lowest harvest index. Normal planting yielded the smallest amount of grain and straw. There were significant differences between the two cultivars. Rihane-03 had a higher mean grain yield and harvest index than ER/Apm.

Grain yield of Rihane-03 was higher under early planting, but that of ER/Apm was not changed by the different treatments. In fact, the highest grain yield with average straw yield was obtained by planting Rihane-03 early and subjecting it to grazing. Grazing tended to increase the harvest index in both cultivars.

This study confirmed the belief of Yau et al. (1989b) that green-stage grazing should be encouraged in higher rainfall areas. This encouraging result suggests that farmers, in nearby areas with similar climatic conditions, can get higher grain yield and benefits than their present practice by planting barley early and allowing an early grazing. In a recent survey of small ruminant production systems in the Bekaa, farmers ranked inadequate feed supplies and high

¹SL = Syrian lira (US\$1 = 46SL; 1999 official rate)

prices of feeds among the top problems (Hamadeh et al. 1994). Planting early and allowing sheep to graze the crops also helps to solve this problem. But farmers who are going to follow this practice must be careful in choosing the right cultivar. Only a cultivar like Rihane-03, which has good regrowth ability after grazing, should be used.

Before making a concrete recommendation, the following points need to be assessed. First, results of this study were obtained in a season with above-average precipitation. The study needs to be repeated to check whether similar results will be obtained in a drier season. Second, actual grazing by sheep is needed to support the results. Simulated grazing may differ from actual grazing because the adverse effect on animal trembling is absent in simulated grazing.

Acknowledgment

The author thanks the Terbol Station of ICARDA for supplying the seeds used in this study.

Table 1. Grain and straw yields and harvest index for the two barley cultivars under the three planting-date and simulated-grazing treatments during 1997/98.

Cultivar	Treatme	nt	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index
	Planting time	Grazing	(купа)	(%)	
ER/Apm	early	no	3054	7622	28
Rihane-03	early	no	3869	6050	39
ER/Apm	early	yes	2794	3992	41
Rihane-03	early	yes	4963	5116	50
ER/Apm	normal	no	2618	4351	38
Rihane-03	normal	no	2820	3038	48
LSD (5%)			1772	1720	14
Treatment mean					
	early	no	3461	6836	33
	early	yes	3878	4554	46
	normal	no	2719	3694	43
	LSD (5%)	ns	1216	10	
Cultivar mean					
ER/Apm		2822	5321	36	
Rihane-03		3884	4734	46	
LSD (5%)		1023	ns	8	

ns: not significant at 5% level.

References

Hammadeh, S.K., F. Shomo, T. Nordblom, and T. Goodchild. 1994. A rapid survey of small ruminant production in the Bekaa Valley, Lebanon. Small Ruminant Research 21: 173-180.

Yau, S.K. and M.S. Mekni. 1987. Breeding dual-purpose barley. *Field Crops Research* 15: 267-276.

Yau, S.K., M.S. Mekni, and I. Naji. 1989a. Effects of greenstage grazing on rainfed barley in northern Syria. I. Tiller production and other agronomic characters. *Experimental Agriculture* 25: 493-500.

Yau, S.K., M.S. Mekni, I. Naji, and J.P. Srivastava. 1989b. Effects of green-stage grazing on rainfed barley in northern Syria. II. Yield and Economic Returns. *Experimental Agriculture* 25: 501-507.

Effect of Leaf Area Removal on Grain Yield and its Components in Spring Wheat

M.A. Chowdhry, N. Mahmood, T.R. Rashad, and I. Khaliq

Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, PAKISTAN

Abstract

Ten varieties/lines of wheat (Triticum aestivum L.) were planted in a split-plot arrangement to study the effect of flag leaf removal on grain yield and its components. The genotypes differed significantly for flag leaf area, stomatal frequency and yield parameters while leaf venation and protein content were not significantly different. Flag leaf removal significantly reduced plant height, number of grains/spike, 1000-grain weight and grain yield while grain protein content significantly increased. Flag leaf removal did not show any significant effect on number of spikelets/spike. Association of flag leaf area with 1000-grain weight and grain yield was positive and significant while protein content was shown to be negatively correlated with grain yield.

Key words: *Triticum aestivum* L.; flag leaf; potential grain yield; yield components; genotypic means; varieties, removal; phytosynthetic efficiency.

Introduction

Grain yield is the ultimate aim for cereal breeders. Wheat, being a complex character, is dependent on the associated yield contributing factors. Grain weight is the outcome of dry matter accumulation in the form of photosynthates. Leaves, being the major sites of photosynthetic activity, appear to have an obvious relation to grain yield. Compared to other leaves, particularly in wheat, the flag leaf contributes most of the photosynthetic assimilates and thus assumes the greatest importance from the grain yield point of view (Lupton 1973). Thus, it would be helpful to know how much the flag leaf contributes to grain yield. Monyo and Whittington (1973) found that the flag leaf area is an indicator of potential grain yield in wheat. Therefore,

تأثير إزالة الأوراق في الغلة الحبية ومكوناتها في القمح الربيعي

الملخص

تم زرع عشرة أصناف/سلالات من القمح (... Triticum aestivum L.) باتباع تصميم القطاعات العشوائية المنشقة لدراسة تأثير نزع الورقة العلمية في الغلة الحبية ومكوناتها. وقد تباينت الطرز الوراثية بشكل كبير من حيث سطح الورقة العلمية، وتردد المسامات /الثغور، ومعايير الغلة، بينما لم تكن الاختلافات في تعريق الأوراق ومحتواها البروتيني معنوية. ونجم عن إزالة ورقة العلم انخفاض معنوي في طول النبات، وانخفاض في عدد الحبات/السنبلة، ووزن الألف حبة، والغلة الحبية، في حين تزايد المحتوى البروتيني لهذه الحبوب على نحو معنوي. إلا أنه يكن لإزالة الورقة العلمية أي أثر معنوي في عدد السنبلات/السنبلة. وكان ارتباط مساحة الورقة العلمية مع وزن الألف حبة والغلة الحبية معنوياً وإيجابياً. في حين كان ارتباط المحتوى البروتيني للحبة مع الغلة الحبية سلبياً.

this character would be of great importance as a criterion for selection.

Flag leaf removal reduces final yield heavily. Vogele and Grossman (1985), in a pot experiment, found that flag leaf removal after ear emergence caused a 7 to 9% reduction in 1000-grain weight. Similarly, grain yield and number of kernels/spike were reduced by up to 10.7 and 11.1%, respectively (Duwayri 1984), number of endosperm cells by 6 and 11%, single grain weight by 10 to 29%, and grain yield by 15 to 25% (Natt and Hofner 1987). These results indicate the association of flag leaf with yield and its components in the positive sense. Many researchers (Briggs and Aytenfisu 1980; Mahmood et al. 1991; Adnan et al. 1994) have reported a positive correlation of flag leaf with grain yield, number of grains/spike and 1000-grain weight. This study examines the effect of flag leaf removal on grain yield of wheat and its components and their correlated response.

Material and Methods

Ten local wheat (*Triticum aestivum* L.) genotypes comprising eight commercial varieties viz., LU26S, Pak. 81, Kohinoor 83, Faisalabad 83, Punjab 85, Pasban 90, Rohtas

90, Inqalab 91, and two promising strains namely 4072 and 5039 were incorporated in the investigation.

Studies were conducted at the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad (Pakistan). The material was sown in a replicated randomized complete block design with splitplot arrangements. The genotypes were randomized in main-plots, while treatments (flag leaf removal and flag leaf intact) were kept in sub-plots. The experimental units consisted of five rows 5 m long each. Row-to-row and plant-to plant-spacing were kept as 30 and 22 cm, respectively. The material was grown under appropriate sowing conditions (i.e., fertilizer was applied at a recommended dose of 84 of N and P per hectare, and irrigation was applied at proper time) and there was not any sort of stress. The flag leaves of 10 randomly selected plants were removed by cutting the leaf blade at the collar after spike emergence. The plants were tagged. Similarly, 10 plants were tagged on the same day with the flag leaf intact. The flag leaf area of the selected plants was measured using an electronic leaf area meter.

One-centimeter-long strips, from the middle portion of the flag leaf (excised flag leaves were used for this purpose), were preserved in Carnoy's solution (absolute alcohol, chloroform, and acetic acid in the ration of 6:3:1). After 24 hours, these strips were washed in acetone to remove the chlorophyll and were stored in formalin solution. These strips were used to determine stomatal frequency at 30x magnification and leaf venation at 10x magnification.

At maturity, data on plant height, number of spikelets/spike, spike length, number of grains/spike, 1000-grain weight, and grain yield/plant were recorded. Total protein content of grain was also determined using the Kjeldahl method.

Data collected were subjected to analysis of variance. Simple correlation coefficients were also estimated on a plant mean basis among all the characters studied. Differences (A—B) between the values of plants with flag leaf intact (A) and plants with flag leaf removed (B) were calculated for all the traits and were compared using t-test. Overall increase (+) or decrease (-) was also computed in percentages. Procedures described by Steel and Torrie (1984) were adopted for these statistical analyses.

Results and Discussion

Analysis of variance revealed that genotypic means were significantly different for flag leaf area, stomatal frequency, protein content and other yield components studied, while for leaf venation, genotypes remained statistically at par. Flag leaf removal produced a significant impact on all yield related characters except for number of spikelets/spike. Interaction between the genotype and the treatment was not significant for spike length and number of spikelets/spike, which showed that, for these characters, varieties had similar response to flag leaf removal (Table 1).

As can be seen in Table 2, the flag leaf area ranged from 22.70 (minimum in Inqalab 91) to 36.621 cm² (maximum in Kohinoor 83). The treatment also significantly reduced the height of four varieties/lines, i.e., Inqalab 91, 4072, Kohinoor 83 and Faisalabad 83. The spike length of all the genotypes was also reduced. However, flag leaf removal did not show any effect on the number of spikelets/spike.

Flag leaf removal significantly reduced number of grains/spike in almost all the varieties/lines except in Rohtas 90 and Faisalabad 83 (Table 2). This indicated that this treatment negatively affected sink capacity of the variety. Similar findings have also been reported by Mahmood et al. (1991). Thousand-grain weight of all the varieties was also affected by this treatment, the effect being more severe in the case of LU26S, Inqalab 91, 4072, Kohinoor 83, Punjab 85, and Faisalabad 83.

Flag leaf removal affected grain yield of all the genotypes, however, the effect was not significant in Pak. 81 (Table 2). Varieties which were the most reduced also had large flag leaf area, and therefore, flag leaf removal contributed a greater proportion of assimilates in relation to the remaining leaves in these varieties. Duwayri (1984), Natt and Hofner (1987), Blade and Baker (1991), Das and Mukherjee (1991) and Mahmood et al. (1991) have also reported reduction in grain yield upon flag leaf removal. Flag leaf removal increased protein content of grain, with Rohtas 90, Kohinoor 83 and Faisalabad 83 being the varieties whose protein content increased significantly.

On an overall mean basis, grain yield was the most affected character. Because of flag leaf removal, grain yield/plant was reduced by 10.77%, followed by 1000-grain weight and spike length which were reduced by 10.33 and 6.63%, respectively. Plant height was the least affected, i.e., 2.27% while the number of spikelets/spike were not affected at all. Flag leaf removal increased protein content of the grains by 9.88%, while number of grains/spike were reduced by 4.82%. The values of correlation coefficient (Table 3) showed significant positive association of flag leaf area with grain yield/plant and 1000-grain weight, while it had significant negative correlation with protein content and stomatal frequency (Mahmood et al. 1991). This indicates that expansion of flag leaf results in increased grain yield but reduced stomatal frequency and number of grains.

Table 1. Analysis of variance of leaf area, stomatal frequency, and some yield components in wheat (mean squares).

Source of variation	DF	Flag leaf Leaf area venal	Leaf venation	Stomatal frequency	Plant height (cm	Spike length (cm)	No. spikelets/ spike	No. grains/ spike	1000-grain weight (g)	Grain yield/ plant (g)	Protein content (%)
Replication	2	0.12	0.002	0.417	0.43	0.509	1.09	0.34	3.23	80.0	0.11
Varietics (V)	6	66.32**	0.368	0.925**	297.97**	3.882**	18.55**	407.45**	115.94**	61.44**	9.78**
Error	81	0.50	0.168	0.139	0.85	0.265	0.19	0.67	4.05	0.16	0.23
Treatments	_	1	•	•	84.04**	9.576**	0.01	167.53**	288.42**	161.51**	23.29**
Ð	6	1	•	,	9.58**	0.124	0.02	10.66**	22.78	12.29**	1.21*
T×V	20	•	•	•	69.0	0.104	0.24	0.23	2.24	0.11	0.41
Error											

^{*, **} Significant at $P = \le 0.05$ and 0.01, respectively.

Table 2. Effect of flag leaf removal on yield components in some wheat genotypes.

Varieties/ lines	FLA (cm ²)		Plant height (cm)	ight	Š	Spike len	length m)	Z	No. spikelets/ spike	elets/	F-4	No. grains/ spike)SI	= *	OOO-grain weight (g)	<u>.</u> = 20	ບ ⁻	Grain yield/ plant (g)	/g _	Pro	Protein content $(\%)$	ŧ
		4	a	A-B A	<	m	A-B	~	. =	A-B	A A	B	A-B	< <	=	A-B	~	B	A-B	*	В	A-B
LU26S	32.8c	100.7	6.66	0.8	6: =	 =	i	∝ ∞.	18.8	0.0	54.0	48.3	5.7*	53.0	48.3	*9°F	31.4	28.7	2.8*	13.1	14.2	Ξ
Pasban 90	27.4f	7.76	96.5	Ξ	12.4	11.3		9.5	22.9	-0.02	76.3	74.2	2.1*	38.9	74.2	2.2	29.2	27.9	1.3*	13.7	8.7	=
Inquiab 90	22.7h	98.6	96.2	2.4*	6:1	Ξ		9.1	21.6	0.0	68.4	<u>-</u> .5	4.2*	43.6	<u>I</u>	3.2*	29.6	27.5	2.1	13.3	13.7	0.4
Pak. 81	20.5g	104.9	104.4	0.5	11.3	10.6		3.1	23.4	-0.30	70.6	9.59	5.0*	38.2	9.59	7 .	22.6	22.3	0.4	12.9	13.9	6.0
4072	35.7ab	114.3	110.3	4 .0*	12.2	æ. =		3.5	23.6	-0.10	77.8	1.69	8.7*	45.4	69.1	2.3*	33.8	32.7	*-	9.5	10.2	0.7
Rohtas 90		96.2	95.7	0.5	4.	9.01		3.7	23.7	9.0	73.4	72.8	9.0	38.6	72.8	1.7	32.9	30.9	2.0*	12.0	14.7	2.7*
Kohinoor 83		109.4	101.1	8.2*	12.4	7.1		 8:	21.9	-0.10	74.4	72.8	1.6*	39.9	72.8	* •	33.4	28.2	5.2*	11.5	13.5	-2.0
5039		110.1	108.8	1.3	1.7	10.0		9.1	21.6	0.0	58.5	54.8	3.8*	41.5	54.8	0.2	29.7	28.4	1.3*	14.0	9.41	9.0-
Punjab 85	30.7d	92.2	616	0.4	11.7	10.4		8.0	20.8	0.0	8.49	63.2	1 .6*	40.8	63.2	* 9'8	30.4	23.9	6.5*	13.5	13.9	-0.3
Faisalabad 83	34.6b	113.6	109.2	4	14.0	13.4	0.6* 2	25.0	24.9	0.12	74.4	74.3	0.1	44.5	74.3	12.5*	33.6	24.3	9.3*	6.11	9.4	-2.7*
Mean	30.0	103.8 101.4	101.4	2; 4:	12.1	11.3	0.8	22.3	22.3	-0.05	69.3	62.9	3.3	42.4	62.9	7.	30.4	27.1	3.3	12.6	13.8	.1.3
Overall increase (+) or decrease (-)	ıse (+) or			-2.3%			÷.1⊊			÷0.1%			4.8%		•	10.4%		•	-10.8%			26.6

Fl.A = Flag leaf area * Significant at $P \le 0.05$.

Stomatal frequency and number of grains are negatively and significantly correlated with protein contents. Number of spikelets/spike showed significant positive correlation with number of grains/spike.

From this study, it was suggested that varieties/lines with large flag leaf area gave high grain yield with generally low protein content. Meanwhile, genotypes with more

1000-grain weight showed extra grain yield. It was anticipated that varieties/lines with large flag leaf area showed higher grain yield due perhaps to broader photosynthetic area and thus, improved photosynthetic efficiency which resulted in well nourished grains. Berdhal et al. (1972) also reported positive association of flag leaf area and grain yield. Thus, the importance of flag leaf in terms of photosynthetic accumulation in grain becomes unquestionable.

Table 3. Correlation matrix showing association between various traits of wheat with flag leaf area.

Trait	Yield/ plant	Protein content	1000-grain weight	No. grains/ spike	No. spikelets spike	-		Stomatal frequency	Leaf venation
Protein content	-0.568	" -	-						
1000-grain weight	0.651*	0.450							
No. grains/spike	0.187	-0.594	0.094						
No. spikelets/spike	0.129	0.373	0.403	0.810**					
Spike length	0.498	-0.275	0.730*	0.335	0.429				
Plant height	0.320	-0.582	0.542	0.016	0.409	0.509			
Stomatal frequency	-0.618	0.119	-0.532	0.084	0.037	0.524	-0.419		
Leaf venation	0.254	-0.664*	0.218	0.564	0.324	0.394	0.443	0.151	
Flag leaf area	0.858**	-0.662*	0.633*	-0.198	0.068	0.525	0.522	-0.725*	0.065

^{*, **} Significant at $P = \le 0.05$ and 0.01, respectively.

References

Adnan, M., M.A. Chowdhry, and T. Mahmood. 1994. Association of flag leaf area and spike characteristics with grain yield in aestivum spp. *Pakistan Journal of Agricultural Sciences* 31(1): 51-53.

Berdhal, J.D., D.C. Rasmusson, and D.N. Moss. 1972. Effect of flag leaf area on photosynthetic rates, light penetration, and grain yield in barley. *Crop Science* 12:177-180.

Blade, S.F. and R.J. Baker. 1991. Kernel weight response to source-sink changes in spring wheat. *Crop Science* 31(5): 1117-1120.

Briggs, K.G. and A. Aytenfisu. 1980. Relationship between morphological characters above the flag leaf node and grain yield in spring wheat. *Crop Science* 20: 350-354.

Das, N.R. and N.N. Mukherjee. 1991. Grain yield contribution by leaf and awn in dwarf wheat (*Triticum aestivum* L.) after rice (*Oryza sativa* L.). Environmental Ecology 9(1): 33-36.

Duwayri, M. 1984. Effect of flag leaf and awn removal on grain yield and yield components of wheat grown under dry land conditions. *Field Crops Research* 8(4):307-313.

Lupton, F.G.H. 1973. Selection criteria determining yield in semi dwarf wheat varieties. Annals of Applied Biology 72: 47-50.

Mahmood, A., K. Alam, A. Salam, and S. Iqbal. 1991. Effect of flag leaf removal on grain yield, its components and quality of hexaploid wheat. *Cereal Research Communications* 19(3): 305-310.

Monyo, J.H. and W.J. Whittington. 1973. Genotypic differences in flag leaf area and their contribution to grain yield in wheat. *Euphytica* 22: 600-606.

Natt. C. and W. Hofner. 1987. Influence of an exogenously changed source-sink relationship on the number of endosperm cells and grain development in spring wheat. *Zeitschrift für Pflanzenernauhrung und Bodenkunde* 150(2): 81-85 (*Field Crop Abstracts* 40: 6288).

Steel, R.G.D. and J.H. Torrie. 1984. Principles and procedures of statistics: A biometrical approach. Second Edition. McGraw Hill Book Corporation, New York, USA.

Vogele, J. and F. Grossman. 1985. Comparison of defoliation and brown rust infection of the flag leaf with regard to grain yield production in winter wheat. Zeitschrift für Pflanzenhrankeiten und Pflanzenschutz 92(6): 650-653.

Gene Effects for Yield and its Components in Wheat

R.K. Yadav¹ and V.G. Narsinghani²

- Regional Agricultural Research Station, Boirdadar, Raigrah (M.P.) 496 001, INDIA
- Department of Plant Breeding & Genetics, J.N.K.V.V. College of Agriculture, Jabalpur (M.P.) 482 004, INDIA

Abstract:

Using the means of P_1 , P_2 , F_1 , BC_1 , BC_2 and F_2 generations of four crosses of wheat, estimates of various gene effects were obtained using the partitioning method of a six parameter model that assumed the presence of epistatic gene effects. Most of the yield components had predominance of additive gene effects which would be useful in exploiting transgressive variation for those traits among the progenies. Duplicate type of epistasis played a significant role in the expression of the majority of characters in all crosses of wheat. Complementary type of epistasis was found to be important to expression of spike length and grain yield/plant, which indicated the possibility of improving to these traits in JWJ 866 \times GW 190.

Key words: yield; gene interaction; genotypes; generations; *rabi*; traits; epistasis.

Introduction

Yield and its components are controlled by many genes, which contribute to the final expression of the character. It is not practically possible to analyze the effect of individual genes. The alternative option left for the plant breeder is to obtain an estimate of gene effects averaged over all the genes. The estimates of gene effects have direct bearing on the method of hybridization and selection which may be adopted in a variety of specific breeding programs.

Material and Methods

The four crosses, namely A206 \times Raj 1555, JWJ 2914 \times HI 1077, HUW 201 \times GW 190 and JWJ 866 \times GW 190, used in this study were selected for gene effects. Seven genotypes of *Triticum aestivum* L. and *T. durum* Desf., viz. A 206, Raj 1555, JWJ 2914, HI 1077, HUW 201, GW 190 and JWJ 866, differing in origin, plant type and good yield potential, were selected in 1993/94. The six populations,

تأثيرات المورثة في غلة القمح ومكوناتها

الملخص.

تم الحصول على التأثيرات المختلفة للمورث، باستخدام متوسطات الأب الأول، الأب الثاني، الجيل الأول، الهجين الرجعي الثاني، الجيل الثاني لأربعة الرجعي الأول، الهجين الرجعي الثاني، الجيل الثاني لأربعة تهجينات من القمح، وذلك باستخدام طريقة التوزيع لنموذج من ستة معايير افترض إزالة تأثير المورثة بمورثة غير أليلية. واتسمت معظم مكونات الغلة بسيادة تأثيرات تجميعية للمورثة التي قد تفيد في استغلال التباين الرجعي لهذه الصفات بين الأنسال. وأسهم طراز التفوق المضاعف بدور مهم في إظهار معظم الخصائص في كل تهجينات القمح. كما تم الكشف عن أهمية الطراز التكميلي من التفوق في إظهار طول السنبلة والغلة الحبية/نبات، والذي يشير إلى إمكانية تحسين مذه الصفات في الهجين 18366 X GW190

viz. both parents, F_1 , F_2 , BC_1 ($F_1 \times Parent 1$) and BC2 ($F_1 \times Parent 2$) of these crosses, were planted under irrigated conditions in a randomized complete block design with four replications during *rabi* 1995/96. The plot consisted of two-metre long rows spaced at 20 cm and 10 cm between and within rows, respectively. The plots received 80 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha , with four irrigations at appropriate intervals. Observations on five competitive plants from each row and each replication in all the six generations were recorded for days to heading, plant height (cm), number of tillers/plant, spike length (cm), number of spikelets/spike, number of grains/spike, 1000-grain weight (g), grain yield/plant (g), and biological yield/plant (g). The generation mean analysis for the six parameter model were worked out as per the method of Hayman (1958).

Results

The means of P₁, P₂, F₁, BC₁, BC₂ and F₂ generations for yield and its components in all the four crosses of wheat are presented in Table 1.

The additive components of gene-effects were significant for number of tillers/plant, spike length, number of spikelets/spike, number of grains/spike, grain yield/plant, and biological yield/plant in A206 \times Raj 1555; for days to heading, number of tillers/plant, spike length, number of spikelets/plant, 1000-grain weight, and grain yield/plant in JWJ 2914 \times HI 1077; for days to heading, plant height,

Table 1. Gene effects for yield and its components in crosses of wheat.

Days to heading Plant height (cm) No. tillers/ plant Spike length (cm) No. spikelets/ spike	C ₁ C ₂ C ₃ C ₄ C ₁ C ₂ C ₃ C ₄ C ₁ C ₂ C ₃	79.50** 80.00** 78.00** 78.00** 96.05 112.50** 117.27**	-01.50 -12.00** -08.50** 08.50** 01.33** 00.16	-44.25** -08.28 -04.50 -04.45 15.96	-45.00** -30.00* -27.00**	-72.50 05.25 -06.00**	68.50** 42.50	D
No. tillers/ plant Spike length (cm) No. spikelets/	$C_3 \\ C_4 \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_1$	78.00** 78.00** 96.05 112.50** 117.27**	-08.50** 08.50** 01.33**	-04.50 -04.45	-27.00**			D
No. tillers/ plant Spike length (cm) No. spikelets/	$C_3 \\ C_4 \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_1$	78.00** 96.05 112.50** 117.27**	08.50** 01.33**	-04.45		-06 00**		D
No. tillers/ plant Spike length (cm) No. spikelets/	C_4 C_1 C_2 C_3 C_4 C_1	96.05 112.50** 117.27**	01.33**		13.00	-00.00	31.00**	D
No. tillers/ plant Spike length (cm) No. spikelets/	C_2 C_3 C_4 C_1	112.50** 117.27**		15.96	13.00	07.75*	01.85	D
plant Spike length (cm) No. spikelets/	C ₃ C ₄ C ₁	117.27**	00.16		-86.22**	-13.70	131.93**	D
plant Spike length (cm) No. spikelets/	C ₃ C ₄ C ₁			-118.45**	-121.68**	01.44	176.91**	D
plant Spike length (cm) No. spikelets/	C_4 C_1	115.00	-17.91*	-50.24	-150.29**	-08.16	170.39**	D
plant Spike length (cm) No. spikelets/	C_1	115.00	02.99	-25.98	-60.00**	08.97	65.96*	D
Spike length (cm) No. spikelets/	-	09.81**	-10.33**	-02.06	-25.21**	-01.33	31.92**	D
Spike length (cm) No. spikelets/	C_2	10.82**	29.67	40.27	-38.12	30.52	-101.74	D
No. spikelets/	C_3	10.24**	-11.33**	-09.03	-16.97	-01.07	19.11*	D
No. spikelets/	C ₁	10.20**	10.67**	-23.63**	-24.14**	-00.49	28.47**	D
No. spikelets/	C ₁	11.45**	-11.33**	-14.45*	-16.48*	02.89	28.77*	D
	C_2	11.45**	-11.33**	-14.45*	-16.48*	02.89	28.77*	D
	C_3	11.00**	-01.15	-09.56**	-09.17**	-00.13	10.83**	D
	C_4	11.87**	11.34**	02.63	01.82	-01.82	07.23	С
	C_{i}	22.10**	-12.16**	109.31	-32.74**	-01.60	38.23**	D
	C_2	22.10**	-10.49*	-38.65**	-40.07**	-01.65	62.14**	D
	C_3	20.90**	-01.83	-02.06	-20.61**	-02.79**	27.72**	D
	C ₄	21.90**	-12.16*	-11.81*	-20.61**	-01.12	38.02**	D
No. grains/spike	C ₁	57.69**	05.44**	14.21	11.17	06.17*	-31.20*	D
rio. grammpino	C_2	60.43**	03.79	-03.75	-05.63	00.29	19.84	D
	C_3	62.42**	13.34**	-12.01	-13.02	02.79	06.13	D
	C ₄	55.18**	-12.10*	14.71*	11.84	-02.21	-15.64	D
1000-grain	C ₁	32.87**	16.27**	-24.77	-22.00	-07.85	73.05	D
weight (g)	C_2	32.87**	16.27**	-24.77	-22.00	-07.85	73.05	D
worght (g)	C_3	42.50**	-14.25**	-33.93*	-33.85*	-00.37	53.07**	D
	C ₄	37.50**	-19.95**	25.64	13.93	-15.66**	-35.28	D
Grain yield/	C_1	11.75**	-06.94**	-03.78	-34.30**	00.90	41.84**	D
plant (g)	C_1	17.87**	22.67**	-28.06	-26.34	11.91	01.89	D
branc (8)	C_2	17.65**	-02.53*	-04.97	-46.71**	01.01	59.34**	D
	C ₃	20.74**	06.15**	-06.01	64.77**	00.39	89.64**	c
Biological yield/	C1	34.29**	04.72**	-10.07	-20.97**	00.76	27.26**	D
	C_1	43.50**	11.57	-38.09**	-37.46	11.04	57.87	D
plant (g)	C_2	44.99**	-03.92*	-28.16	-05.83	-02.09	47.20**	D
	C 2	38.91**	-03.92	-10.28	01.08	-02.09	71.40	

^{*, **} Significant at 5 and 1% levels, respectively.

C1 = A 206 × Raj 1555; C2 = JWJ 2914 × HI 1077; C3 = HUW 201 × GW 190; C4 = JWJ 866 × GW 190.

m = Mean; d = Additive gene effects; h = Dominance gene effects; i = Additive × additive gene interactions: j = Additive × dominance gene interactions: I = Dominance × dominance gene interactions.

D = Duplicate type of epistatic interactions; C = Complementary type of epistatic interactions.

number of tillers/plant, number of grains/spike, 1000-grain weight, grain yield/plant, and biological yield/plant in HUW 201 \times GW 190; for days to heading, number of tillers/plant, spike length, number of spikelets/spike, number of grains/spike, 1000-grain weight, grain yield/plant, and biological yield/plant in JWJ 866 \times GW 190.

A dominant type of gene action was significant for 1000-grain weight in A 206 \times Raj 1555; for plant height, spike length, number of spikelets/spike, and biological yield/plant in JWJ 2914 \times HI 1077; for spike length and number of spikelets/spike in HUW 201 \times GW 190; for number of tillers/plant, number of spikelets/spike, and number of grains/spike in JWJ 866 \times GW 190.

Among the epistatic interactions, additive × additive type of interactions were found to be significant for number of tillers/plant, number of spikelets/spike, 1000-grain weight, and grain yield/plant in A 206 × Raj 1555 and HUW 201 × GW 190. Similarly, the cross JWJ 866 × GW 190 for number of spikelets/spike, 1000-grain weight, and grain yield/plant; and JWJ 2914 × H1 1077 for number of spikelets/spike. Additive × dominance gene interaction were significant for number of grains/spike in A 206 × Raj 1555; for number of spikelets/spike in HUW 201 × GW 190; and for 1000-grain weight in JWJ 866 × GW 190. Dominance × dominance type of gene interaction were significant for number of tillers/plant, number of spikelets/spike, and grain yield/plant in A206 × Raj 1555, HUW 201 × GW 190, and JWJ 866 × GW 190.

Discussion

Most of the yield components in the crosses of wheat had predominance of additive gene effects which would be useful in exploiting transgressive variation for those traits among the progenies. Similar findings were also reported for plant height and grain weight (Amawate and Behl 1995); for number of tillers/plant and grain yield/plant (Shrivastava et al. 1981); for number of spikelets/spike (Walia et al. 1995); for number of tillers/plant, 1000-grain weight and grain yield/plant (Mishra 1989). Dominant gene effects are invariably exploited in developing hybrid varieties. Bhatiya et al. (1986) and Mishra (1989) reported earlier dominant gene action for number of tillers/plant, grain yield/plant and 1000-grain weight. Among the interaction effects, additive × additive type of interaction effects are more useful for the plant breeder. Additive × additive type of interactions were in conformity with the findings of Jafari Shabastari (1980). Singh and Singh (1992), Verma and Yunus (1986), Walia et al. (1995), Chatrath et al. (1986) for number of tillers/plant,

number of spikelets/spike, 1000-grain weight, and grain yield/plant in wheat.

A duplicate type of epistasis played a significant role in the expression of all the characters such as number of tillers/plant, number of spikelets/spike, number of grains/spike, 1000-grain weight, grain yield/plant, and biological yield/plant in almost all the crosses of wheat. Characters with complementary type of epistasis indicate the possibility of improvement and crosses showing this type of gene interaction would be beneficial in selection programs. Cross JWJ 866 × GW 190 exhibited complementary type of epistasis for spike length and grain yield/plant in wheat.

References

- Amawate, J.S. and P.N. Behl. 1995. Genetic analysis of some quantitative components of yield in bread wheat. *Indian Journal of Genetics and Plant Breeding* 55(2): 120-125.
- Bhatiya, V.G., B.S. Tondon, and M.S. Pithio. 1986. Genetics of quantitative characters in macaroni wheat. *Indian Journal of Agricultural Sciences* 56: 878-880.
- Chatrath, R., D.R. Satiya, and V.P. Gupta. 1986. Genetic analysis of grain yield in wheat. *Indian Journal of Genetics* 46(3): 466-471.
- Haymann, B.I. 1958. The separation of epistatic from additive and dominance variation in generation means. *Heredity* 12:37-40.
- Jafari Shabastari, J. 1980. Detection of epistatic gene action two populations of winter wheat. *Dissertion Abstracts International Bureau* 41 (6): 2013.
- Mishra, P.K. 1989. Gene action and response to selection in wheat (*T. aestivum* L.). PhD Thesis. Jawaharlal Nehru Kirishi Vishwa Vidyalaya Jabalpur (M.P.), India.
- Singh, R.P. and S. Singh. 1992. Estimation of genetic parameters through generation means analysis in bread wheat. *Indian Journal of Genetics and Plant Breeding* 52(4): 469-375.
- Shrivastava, R.B., O.P. Luthra, D. Singh, and K.C. Goyal. 1981. Genetic architecture of yield, harvest index and related traits in wheat. *Cereal Research Communication* 9(1): 31-37.
- Verma, S.S. and M. Yunus. 1986. Role of epistasis in the analysis of variance in bread wheat. *Indian Journal of Agricultural Sciences* 56:687-698.
- Walia, D.D., Tashi Dawa, P. Plaha, and H.K. Choudhary. 1995. Gene effects controlling grain yield and its components in bread wheat. Agricultural Science Digest 15(3): 129-131.

Allelopathic Effect of *Lantana camara* L. on Wheat var. Sujata

P. Oudhia and R.S. Tripathi

Department of Agronomy, College of Agriculture, IGAU, Raipur-492012, INDIA

Abstract

An experiment under controlled conditions was carried out to explore the allelopathic potential of different parts of Lantana camara L. on germination and seedling vigor of the wheat variety Sujata. Root, stem, leaf, and stem + leaf of Lantana camara were allowed to decay for periods of 5, 7, 9, and 11 days corresponding to 120, 168, 216, and 264 hours, respectively in normal water in a ratio of 1:10 w/v of plant material and water, respectively. Initially, at 3 and 5 days after sowing (DAS), different treatment combinations delayed germination. At 7, 9, and 11 DAS, stem extract of 264 hours produced significantly higher germination as compared to control (water). At 3 and 5 DAS, stem + leaf extract of 120 hours, at 7 DAS, leaf extract of 120, and at 9 and 11 DAS, root extract of 168 hours resulted in the lowest germination. Leaf extract of 216 hours and leaf extract of 120 hours produced maximum root and shoot length, respectively. The behavior of Lantana camara is difficult to understand since its allelopathy has not been well documented. Therefore, repeating this work under field conditions would give a better understanding of the allelopathic phenomenon of this weed on a test crop.

Key words: allelopathic; *Lantana camara* L.; allelopathic potential; germination; seedling vigor; decay; weeds; India.

Introduction

Allelopathy is a relatively a new branch of science. The term allelopathy includes biochemical interactions (both inhibitory and stimulatory) among the organisms, including microorganisms. Positive (inhibitory) allelopathic effects of any weed on other weeds can be utilized to develop ecofriendly, cheap and effective 'green herbicides'. Similarly, negative (stimulatory) allelopathic effects of any weed on crops can be exploited to develop 'green growth promoters' to hasten early germination, seedling vigor, and high dry matter accumulation (Oudhia et al. 1998). Lantana camara L. is a serious weed in 14 different crops in 47 countries (Narwal 1994). It is one of the problematic and common weeds in the Chhattisgarh region (Madhya Pradesh) of India (Oudhia and Dixit 1994). Allelopathic

التأثير الضار لنبات أم كلثوم Lantana camara في صنف القمح سوجاتا Sujata

الملخص

نفذت تجرية تحت ظروف متحكم بها لاختبار التأثير الضار لنبات أم كلثوم Lantana camara في إنبات بذور القمح وقوة بادراته من الصنف Sujata. وسمح لكل من جذور، وساق، وأوراق، وساق + أوراق نيات أم كلتو م Lantana camara بالتعفن لفترات تراوحت بين 5، و7، و9، و11 يوماً، أي ما بكافئ 120، 168، 216، 264، ساعة في ماء عادي بنسبة 1:10 وزن/حجم لكل من المادة النباتية والماء على الترتيب. في البداية، وفي اليوم الثالث والخامس من بعد النقع، أدت توليفات مختلفة من المعاملة إلى تأخير عملية الإنبات. وفي اليوم السابع، والتاسع، والحادي عشر بعد النقع أعطى مستخلص الساق معدل إنبات أعلى من معاملة الشاهد (الماء). و كانت أقل نسبة إنبات في اليوم الثالث والخامس بعد النقع لمستخلص الساق والأوراق بعمر 120 ساعة، وفي اليوم السابع لمستخلص الأوراق بعمر 120 ساعة، وفي اليوم التاسع والحادي عشر لمستخلص الجذر بعمر 168 ساعة.أعطى مستخلص الأوراق بعمر 216 ساعة ومستخلص الأوراق بعمر 120 ساعة طولاً أعظمياً للجذور والفروع على التوالي. ويعد سلوك نبات أم كلثوم Lantana camara صعب الفهم، لأن أضراره لم توثق بشكل جيد. وعليه، فإن تكرار هذا العمل تحت الظروف الحقلية سيعطى فهمأ أفضل للظاهرة المرضية لهذا العشب على المحصول المختبر.

effects of *Lantana camara* on many agricultural crops have been reported (Narwal 1994). The present study is an attempt to explore the allelopathic effects of different parts of *Lantana camara* L. on germination and seedling vigor of wheat var. Sujata.

Material and Methods

Root, stem. leaf and stem + leaf of Lantana camara L. were allowed to decay for periods of 5, 7, 9, and 11 days corresponding to 120, 168, 216 and 264 hours as per treatment in normal water in the ratio of 1:10 w/v of plant material and water, respectively. The weed parts were decayed at $28\pm2^{\circ}$ C. The treatment was replicated three times and the experiment twice. The experiment was carried out in petri

dishes with sterile sand as substrate. In each petri dish, 50 representative seeds were placed in sand, 15 ml of extract was applied, and water was used as control. The petri dishes were kept at a constant temperature (21±2°C) for germination. The wheat variety Sujata was used as a test crop. Germination of plants at 3, 5, 7, 9 and 11, DAS was recorded. At 11 DAS, root and shoot length of plants were noted.

Results and Discussion

The aqueous extract of *Lantana camara* L. produced a significant effect on germination and seedling vigour of wheat.

Initially at 3 DAS, different treatment combinations delayed germination of wheat. Root extract of 168 and 216 hours, stem and stem + leaf extract of 168 hours were at par with control (water). At 7, 9 and 11 DAS, stem extract of 264 hours resulted in maximum germination. At 11 DAS, root and stem extract of 216 hours produced comparable germination to that of stem extract of 264 hours. At 3 and 5 DAS, stem + leaf extract of 120 hours; at 7 DAS, leaf extract of 120 hours; and at 9 and 11 DAS, root extract of 168 hours, lowered the germination to the minimum (Table 1).

Significantly higher shoot length was noted under leaf extract of 216 hours compared to the rest of the treatment

Table 1. Allelopathic effect of Lantana camara L. on germination (%) of wheat.

		Decaying Period		
	120 hours	168 hours	216 hours	264 hours
Source				
		3 DAS		
Root	1,40(6.80)	30.60(33.58)	31.90(34.33)	7.70(16.11)
Stem	0.68(4.73)	30.00(33.21)	20.60(26.99)	19.80(26.42)
Leaf	0.22(2.69)	9.20(17.66)	25.10(30.07)	17.50(24.73)
Stem+Leaf	0.00(0.00)	25.20(30.13)	19.80(26.42)	15.90(23.50)
Control (water)	32,400	30.13)		
CD at 5%	4,30			
		5 DAS		
Root	50.00(45.00)	51.30(45.75)	62.00(51.94)	54.00(47.29)
Stem	58.70(50.01)	49.30(44.60)	28.50(32.27)	65.30(53.91)
Leaf	08.50(16.95)	44.60(41.90)	62.00(51.94)	56.00(48.45)
Stem+Leaf	06.60(14.89)	57.30(49.20)	42.60(40.74)	55.40(48.10)
Control (water)	65.80(54.21)		
CD at 5%	4.30			
		7 DAS		
Root	64.00(53.13)	51.30(45.75)	84.10(66.50)	69.30(56.35)
Stem	71.40(57.67)	62.00(51.94)	78.80(62.58)	90.70(72.24)
Leaf	30.60(33.58)	52.00(46.15)	74.10(59.41)	56.00(48.45)
Stem+Leaf	31.90(34.39)	60.00(50.77)	50.60(45.34)	74.10(59.41)
Control (water)	69.800	56.66)		
CD at 5%	4.89			
		9 DAS		
Root	69.30(56.35)	51.30(45.75)	84.10(66.50)	71.40(57.67)
Stem	71.40(57.67)	62.00(51.94)	78.80(62.58)	90.70(72.24)
Leaf	63.30(52.71)	61.30(51.53)	76.90(61.27)	74.00(59.34)
Stem+Leaf	62.20(52.71)	63.40(52.77)	75.40(60.27)	80.10(63.44)
Control (water)	78.00(62.03)		
CD at 5%	4.99			
		11 DAS		
Root	72.80(58.56)	60,00(50,77)	90.50(72.05)	71.40(57.67)
Stem	77,40(61.62)	68.00(55.55)	85.70(67.78)	94.20(76.06)
Leaf	64.70(53.55)	68.80(56.04)	75.30(60.20)	84.90(67.13)
Stem+Leaf	64.00(53.13)	70.70(57.23)	84.10(66.50)	80.80(64.01)
Control (water)		65.27)		
CD at 5%	8.35			

Note: Figures in parentheses indicate angular value.

combinations, except for leaf extract of 264 hours which was at par. The leaf extract of 120 hours produced the lowest shoot length. Significantly superior root length was noted under leaf extract of 120 hours. The lowest root length was produced under the root extract of 168 hours. Leaf extract of 216 and 120 hours resulted in maximum and minimum shoot:root ratio, respectively (Table 2).

A positive allelopathic effect of whole plant extract of

28±2°C. These interactions might have produced some water soluble allelochemicals which have altered the allelopathic effects. As the allelopathy of *Lantana* on wheat has not been well documented before and allelochemicals were not isolated in these studies, it is difficult to understand the behavior of *Lantana* allelochemicals under different periods of decay. Furthermore, duplicating this work under field conditions would provide better understanding of allelopathic phenomenon of this weed on a test crop.

Table 2. Allelopathic effect of Lantana camara L. on seedling vigor of wheat.

		Decaying perio	od .		
	120 hours	168 hours	216 hours	264 hours	
Source					
	·-	Shoot length (cm/p	olant)		
Root	17.23	11.51	8.25	15.09	
Stem	17.69	13.75	16.29	17.58	
Leaf	5.08	15.19	20.73	19.00	
Stem+Leaf	10.58	16.66	17.33	17.43	
Control (water)	16	5.83			
CD at 5%	2	2.76			
		Root length (cm/pl	ant)		
Root	9.93	9.74	14.75	10.85	
Stem	12.06	10.44	2.30	11.71	
Leaf	16.90	12.73	12.30	10.93	
Stem+Leaf	13.74	12.39	10.13	9.88	
Control (water)	11	.79			
CD at 5%	1	.86			
		Shoot:Root ratio (length wise)		
Root	1.73	1.18	0.56	1.39	
Stem	1.47	1.31	1.35	1.50	
Leaf	0.29	1.19	1.82	1.74	
Stem+Leaf	0.77	1.34	1.68	1.76	
Control (water)	1	.42			
CD at 5%	C	.24			

Lantana camara L. on wheat has been reported (Narwal 1994). The present study revealed that different parts of the weed have different allelopathic potential and that different periods of decaying can alter the allelopathic effects. Decay of weed material in natural ecosystems is a common phenomenon. This observation is in line with the findings that Oudhia et al. (1997) reported earlier. In the present study, isolation of allelochemicals from extracts was not carried out. At 7, 9 and 11 DAS, stem extract of 264 hours can be used for the seed soaking treatment of wheat seeds prior to sowing to hasten the germination. No peculiar relationship was observed in relation to decay period and wheat germination at different days after sowing. This may be due to biochemical interactions between the weed part and micro organisms active at a specific temperature, i.e.,

References

Narwal, S.S. 1994. Allelopathy in Crop Production. Scientific Publishers, Jodhpur, India. 288 pp.

Oudhia, P. and A. Dixit 1994. Weeds in Ambikapur (Madhya Pradesh) region and their traditional use. *Weed News* (1): 19-21.

Oudhia, P., S.S. Kolhe, and R.S. Tripathi. 1997. Allelopathic effect of *Blumea lacera* L. on wheat. Page 109 *in* Abstracts seventh Biennial Conference. *Indian* Society of Weed Sciences, Ludhiana, India.

Oudhia, P., S.S. Kolhe, and R.S. Tripathi. 1998. Allelopathic effect of *Blumea lacera* L. on rice and common kharif weeds. *Oryza* 35(2): 175-177.

Short Communication

First Steps in Barley Improvement in Armenia

A. Petrosyan¹, R. Kazaryan¹, E. Melikyan¹, D. Epremyan¹, and V. Shevtsov²

- ¹ Department of Science, Information and New Technology Introduction, Ministry of Agriculture, ARMENIA
- ² ICARDA-CAC Regional Program, Tashkent, UZBEKISTAN

In Armenia, spring barley is grown in foothill and mountainous zones at the altitudes 1200-2400 m above sea level. After winter wheat, barley is the second most important crop with an acreage of 75,000-100,000 ha. Average grain yield varies from 1.1 to 1.5 t/ha. Barley grain is used for feed and malt production and has a good market demand.

Research activities on barley improvement and seed production are concentrated at Gumriyskaya Breeding Station. The main source of new germplasm includes locally developed varieties and promising lines, a collection of barley accessions from different republics of the former Soviet Union, and new germplasm coming from the International Center for Agricultural Research in the Dry Areas (ICAR-DA).

Taking into consideration limited technical facilities and financial limitations, the Armenian Barley Improvement Project follows two strategies. The first one is to develop new varieties following a complete breeding scheme, and starting from making targeted crosses. The second strategy consists of collecting the most promising lines developed by other breeding centers, testing them, and using the best for commercial production. This second strategy is implemented in collaboration with ICARDA. The current situation in agriculture makes it urgent to fill the gap created during the last decade as a consequence of the collapse of the former system. At present, the private sector, lease holders, farmers, and the remaining state farms urgently need new varieties, suitable for agronomic environments, which in turn are conditioned by the economic situation.

Regular breeding activities were interrupted many times because of economic and political reasons and the first task now is to restore a gene pool and to test it in different agroclimatic zones. The evaluation of ICARDA barley nurseries started in 1996. In total, 185 accessions of spring barley were tested and some of them were identified as a source of valuable traits and issued in crosses. Three lines were included into advanced trials. The purpose of the paper is to document these activities and to give an example of the potential of collaboration with ICARDA.

The experiment was carried out in a randomized complete block design with three replications under both rainfed and supplementary irrigation, with fertilizers (N 60, P 80, K 40) and without them. The experimental field has chestnut color soil with 3.4% humus content in the 0-20 cm soil layer and pH of 7.1-7.2. Precipitation was 392 mm in 1997 and 410 mm in 1998.

Previous work resulted in identification of the locallydeveloped variety Gyumri, Nutans115 (now released), and the spring barley varieties Mamluk, Vicont, and Rubicon, developed under a joint program between ICARDA and Krasnodar Research Institute of Agriculture.

Data from three years of testing show a significant advantage for the spring barley variety Mamluk especially in rainfed conditions. Its yield increase above the best check variety (Nutans 115) was 18.5 and 27.2% without and with fertilizers, respectively (Table 1). Under supplementary irrigation, the superiority of Mamluk over the best check (Nutans 115) was 11 and 15% without and with fertilizer, respectively.

Mamluk is an early maturing variety ripening 5-7 days earlier than the check. Its grain is plumped and well shaped, with 1000-kernel weight of 40-55 g. It has a very fast initial growth vigor, rather strong straw, and good response to fertilizers and irrigation. The new variety ranked the first in grain yield at yield levels between 1500 kg/ha and more than 4000 kg/ha. The adaptation of Mamluk to a wide spectrum of agro-climatic conditions will facilitate establishment of seed production in many zones and farms.

In conclusion and on the basis of the results of the yield trials, the spring barley variety Mamluk is recommended for release and cultivation in foothill and mountainous zones of Armenia for both rainfed conditions and supplementary irrigation. For prompt introduction of the new variety into practice, it is necessary to introduce 50 tonnes of original seeds to start seed multiplication in specialized, elite seed-producing farms. Collaboration with ICARDA is encouraging and promises new achievements in the future.

Table 1. Results of spring barley yield trials (means 1997-1999).

Variety		Grain yie	ld (kg/ha)		Aver	age
	Check	%	NPK	%	kg/ha	%
	· •		Rainfed			
Nutans 115	1670	100	2240	100	1955	100
Gyumri	1330	80	1820	81	1575	81
Vicont	1420	85	2180	97	1800	92
Rubicon	1320	79	1710	76	1515	77
Mamluk	1980	118	2850	127	2415	123
LSD 0.5	160-190		210-230			
		Supple	mentary irrigation			
Nutans115	2800	100	3890	100	3345	100
Gyumri	2590	92	3870	99	3230	97
Vicont	2590	92	3720	95	3155	94
Rubicon	2420	86	3430	88	2925	87
Mamluk	3110	111	4470	115	3790	113
LSD 0.5	230-240		290-330			

Cereal News

Forthcoming Events

2000

Use of Molecular Markers in Plant Breeding, Cabrils, Spain, 7-18 February.

Info: Instituto Agronómico Mediterráneo de Zaragoza

Apartado 202, E-50080 Zaragoza, Spain

Tel.: +34 976 57 60 13 Fax: +34 976 57 63 77

E-mail: iamz@ iamz.ciheam.org

International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century, New Delhi, India, 14-18 February.

E-mail: icmnr@bic-iari.ren.nic.in

World Congress of Young Farmers, Coronado Springs Resort, Orlando, FL, USA, 20-24 February.

E-mail: bhmgt@aol.com

Mendel Centenary Congress, Brno, Czech Republic, 7-9 March.

Info: Mendel University, c/o O. Chloupek, Zemedelska I,

CZ-61300 Brno, Czech Republic

Fax. 420545133302

Seminar on Durum Wheat Improvement in the Mediterranean Region: New Challenges,

Zaragoza, Spain, 12-14 April.

Info: Instituto Agronómico Mediterraneo de Zaragoza,

Apartado 202, E-50080 Zaragoza, Spain

Tel.: +34976576013 Fax.: +34976576377

E-mail: iamz@iamz.ciheam.org

International Symposium on Iron Nutrition and Interaction in Plants, Texas Medical Center, Houston, USA, 14-19 May.

E-mail: mgrusak@bcm.tmc.edu

Sixth International Wheat Conference, Budapest, Hungary, 4-9 June.

Info: Dr L. Láng - Conference Secretary
Sixth International Wheat Conference Office

Agricultural Research Institute of the Hungarian Academy

of Sciences, Brunszvik u.2

H-2462 Martonvásár, Hungary

Fax: + 63 22 460213

E-mail: 6iwc@buza.mgki.hu

Third Agricultural Biotechnology International Conference, Toronto, Ontario, Canada, 5-8 June.

E-mail: sig-group@sk.sympatico.ca

Web page: www.abic.net

International Conference on Science and Technology for Managing Plant Genetic Diversity in the 21st Century (SAT 21), Kuala Lumpur, Malaysia, 12-16 June.

Sixth International Congress of Plant Molecular Biology Ouébec, Canada, 18-24 June.

Info: Congress Secretariat, ISPMB.

c/o Agora Communocation Inc.

2600, boulevard Laurier (Suite 2680)

Saint-Fove, OC G1V 4M6 Canada

Tel.: +1 418 658 6755

Fax. +1 418 658 8850

E-mail: ispmb@agroacom.qc.ca

AgriFood 2000 Conference, Winnipeg, MB, Canada, 15-19 July.

Crop Production under Cool Long Days, Edinburgh, Scotland (satellite workshop of the International Crop Science Congress, Hamburg), 11-15 August.

E-mail: hay@sasa.gov.uk

International Crop Science Congress, Hamburg, Germany, 17-22 August.

Web page: www.cch.de/CROPSCIENCE/

Quantitative Genetics and Breeding Methods: The way Ahead. 11th Meeting of the Eucarpia Section. Biometrics in Plant Breeding, Paris, France,

30 August-1 September.

Info: EUCARPIA Congress Secretariat, Station de Génétique Végétale, INRA-UPS-INAPG, Ferme du Moulon, F-91190 Gif/Yyette, France

Fax.: +33169332340

E-mail: eucarpia@moulon.inra.fra

International Symposium on Animal, Agricultural, and Food Processing Waste, Marriott Hotel, Des Moines, IA, USA, 7-11 October.

E-mail: moore@asae.org

The Eighth International Barley Genetics Symposium, Adelaide Convention Centre, Adelaide, South Australia, 22-27 October.

Hosted by the University of Adelaide, Department of Plant Science. Sponsored by the Grains Research and Development Corporation (GRDC).

Web page: www.ibgs2000.waite.adelaide.edu.au

Major themes

- Disease and pest resistance
- Germplasm and genetic resources
- Malting, brewing, and distilling
- Nutrition, feed and food quality
- · Breeding methodologies
- Genome structure and mapping
- · Functional genomics and bio-informatics
- · Genetics and cytogenetics
- Abiotic stress
- Innovation and new technologies
- Breeding and genetics success stories

Scientific program

- The program will include oral presentations by invited speakers, poster papers, workshops, and field tours. A special end-user day with sessions on malting, brewing and distilling, feed and food quality will be offered for specialist industry groups.
- Workshop sessions will be held on Sunday and Monday evenings and Tucsday, if necessary. Individuals wishing to conduct a workshop must register their interest with the Secretariat by forwarding details about the proposed speakers and content.
- Pre-conference technical tours will also be arranged for special interest groups if there is sufficient demand. A tour for plant pathologists has already been arranged; those wishing to participate should indicate their interest on the registration of interest form.

Invited speakers

Invited speakers who have accepted the Organizing Committee's invitation include:

Professor Andrew Barr, University of Adelaide, Australia Dr Salvatore Ceccarelli, ICARDA, Syria

Professor Geoff Fincher, University of Adelaide, Australia Dr Andreas Graner, Institute for Plant Genetics and Crop Plant, Germany

Professor Larry V. Gusta, Crop Development Centre, University of Saskatchewan, Canada

Professor Patrick Hayes, Oregon State University, USA

Dr Theo van Hintum, CPRO-DLO, The Netherlands Dr Steve Jefferies, University of Adelaide, Australia

Dr Andris Kleinhofs, Washington State University, USA

Professor Peter Langridge, University of Adelaide, Australia

Professor Horst Lörz, University of Hamburg, Germany Dr Lesley MacLeod, Barrett Burston Malting Co. Pty Ltd., Australia

Dr José Luis Molina Cano, Centre UDL-IRTA, Spain Dr Richard Pickering, New Zealand Institute of Crop and Food Research, New Zealand

Dr Henry T. Nguyen, Texas Tech University, USA

Professor Wayne Powell, Dupont, USA

Professor Brian Rossnagel, University of Saskatchewan, Canada

Professor Francesco Salamini, Max-Planck Institut fur Zuchtungsforschung, Germany

Professor Dr Wilhelm Schaefer, University of Hamburg, Germany

Dr Paul Schulze-Lefert, The Sainsbury Laboratory, UK Associate Professor Brian Steffenson, North Dakota State University, USA

Dr Dave Thomas, Coors Brewing Company, USA Dr Robbie Waugh, Scottish Crop Research Institute, Scotland

Abstract submission

Abstracts may be offered for presentations as posters. However, a small number of papers will also be selected for short oral presentations and the abstracts will be used by the Organizing Committee as a guide to selecting these. Please indicate your preference on the abstract form. However, please note that the final selection is at discretion of the Organizing Committee.

Subject to agreement by the authors, abstracts will be published on the Symposium web page prior to the conference. Please indicate on the form if your abstract contains any symbols that may change during electronic transfer. If this not indicated on the original abstract form, the Organizing Committee will take no responsibility for any errors in the published version.

The following instructions are offered as a guide. Refer to the web page for an example.

- The abstract must not exceed 250 words, including title and author's name and address.
- The abstract should be typed using the Microsoft Word program with the text in Times New Roman.
- Type the abstract in Title in Bold Lower Case with Initial Caps.
- If the title extends to a second line, use single spacing. Separate the name(s) of the author(s) from the title using a double space.
- Type the names in lower case surname followed by initials (e.g., Smith, B.J.).
- The author(s)' addresses should be on the line directly following the author(s)' names. Superscript 1 etc. should be used to identify the different organizations. Use lower case and left hand alignment.
- The addresses should include Department, Institute or Organization, City or Suburb, State, Postcode, and Country. Where address extends to a second line, use single spacing. Multiple addresses should be avoided, if possible. Leave a double space and proceed with the abstract, using single spacing.
- · Do not indent paragraphs.
- Please identify any symbols that may be distorted through electronic transmission of the abstract.
- You may send your abstract either:
 - by mail (five hard copies plus a copy on IBM compatible 3½" disk)
 - · by e-mail to fcceaton@ozemail.com.au
 - via the web page located at http://wwwibgs2000.waite.adelaide.edu.au/

Offers of papers must reach the Conference Secretariat, Festival City Convention, P.O. Box 949, Kent Town S.A. 5071, AUSTRALIA by 1 March 2000. Abstracts sent by fax will not be considered.

Advice of abstract acceptance will be sent out in early April 2000. Please note that if your abstract is accepted for presentation, the full paper must reach the Conference Secretariat by 29 May 2000.

- Deadline for receipt of abstracts: 1 March 2000.
- Deadline for receipt of full papers: 29 May 2000.
- Registration brochure available: February 2000.
- Early-bird registration to: 30 June 2000.

Registration fees

Approximate registration fees (still to be finalized) are as follows:

- Full registration (including morning and afternoon teas, lunches, all social functions and the Field Trip): AUD\$ 550.
- Student registration fee (including morning and afternoon teas, lunches, some social functions and the Field Trip): AUD\$ 220.
- Accompanying persons registrations fee (including the Introductory City Tour, all social functions and the Field Trip): AUD\$ 275.

Please note that these indicative fees are inclusive of a Goods and Services Tax (GST) of 10% that will be introduced in Australia on 1 July 2000.

Recent Literature

El-Bouhssini, M. et al. Five egg parasitoids of Sunn pest (Eurygaster integriceps) in Syria and biology of Trissolcus gradis under laboratory conditions.

Paper presented at the International Symposium on Biological Control held in Aleppo, Syria, 24-28 October 1999.

Eujayl, I., M. Sorrells, P. Wolters, M. Baum, and W. Powell. Assessment of genetic variation in durum wheat—based on microsatellite markers isolated from Ests and genomic DNA libraries.

Paper to be presented at the Sixth International Wheat Conference to be held in Budapest, Hungary, 4-9 June 2000.

Pala, M. and M.K. Suleimenov. Prospects of grain production diversification in the dry areas.

Paper presented by M.K. Suleimenov at the International Conference on 'Main Directions of Grain Production Diversification in the Steppe Regions of Eurasian Continent' held in Shortandy, Kazakstan, 27-28 July 1999.

Pala, M., J. Ryan, and R. Makboul. Productivity of wheat in relation to crop sequences and nitrogen fertilizer.

Abstract to be presented at the Sixth International Wheat Conference to be held in Budapest, Hungary, 4-9 June 2000.

Ryan, J. A perspective on available soil nutrients and fertilizer use in relation to crop production in the Mediterranean area.

Paper to be published as a chapter in the book Soil Fertility and Crop Production by K. Krishna.

Suleimenov, M.K. Trends in the feed and livestock production during the transition period in three Central Asian Countries.

Paper presented at the Workshop on Food, Agriculture, and Natural Resource Policy Research-Setting the Priorities held in Tashkent, Uzbekistan, 19-21 July 1999.

Saad, N. International Symposium on Participatory Plant Breeding in Latin America and the Caribbean: An Exchange of Experiences.

Summary Report. Submitted for the Global Program on

Participatory Research and Gender Analysis, Quito, Ecuador, 31 August-3 September 1999. E-mail: N.Saad@egiar.org

Solh, M.B. and N.I. Haddad. Sustainable partnership in problem-solving regional networks in winter cereals and cool-season food legumes in Africa.

Paper presented at the International Workshop on Global Research System: Focus on Sub-Saharan Africa held in M'Bé, Côte d'Ivoire, 7-11 December 1999.

Agricultural Libraries Receiving ICARDA Publications

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

Ghana Algeria Bahamas Guatemala Guyana Bahrain Bangladesh India Iran Benin Belgium Italy Bhutan Kenya Korca (Republic) Botswana Lesotho Brazil Malawi Canada Chile Malaysia Mali China Mauritania Costa Rica Mexico Cyprus Djibouti Myanmar **Ecuador** Netherlands Nepal Ethiopia Nigeria Fiji Norway **Finland** Papua New Guinea France

Philippines
Saint Lucia
Saudi Arabia
Senegal
Somalia
Spain
Sri Lanka
Sudan
Swaziland
Syria
Taiwan
Tanzania
Thailand
Tunisia
United Kingdom

United Arab Emirates
USA
Yemen
Zambia
Zimbabwe

ICARDA Publications and Services

ICARDA Publications

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

Graduate Research Training Awards, Opportunities for Field Research at ICARDA

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

Opportunities for Training and Post-Graduate Research at ICARDA

ICARDA offers training courses on development and improvement of food legumes, cereals and forages, with the support of the Center's research scientists and trained instructors. For a complete brochure of the training opportunities at ICARDA, write to: Human Resources Development Unit, ICARDA.

Library Services

The ICARDA library conducts literature searches on ICAR-DA-mandated crops, and results are downloaded to diskette or hard copy. Photocopies of up to five articles, if available, per search can be provided to users. Researchers without adequate access to recent literature may request literature search by e-mail, fax or letter to: The Manager, Library and Information Services, ICARDA.

To obtain further information on these services, please write to the program indicated

International Center for Agricultural Research in the Dry Areas P.O. Box 5466, Aleppo, Syria

> Tel. +963-21-2213433, 2213477, 2225112, 2225012 Fax +963-21-2213490, 2225105, 5744622 E-mail: ICARDA@cgiar.org http://www.cgiar.org/icarda