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.
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.

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Arabic abstracts
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Nuha Sadek

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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) and ICARDA.

The Workshop was officially opened by Prof. Dr. A. El-Beltagi, 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 Joumaih (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.
2. 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.
4. 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. Lurfi, 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 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:

1. 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.
3. 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.
5. 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.

7. 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.

8. Indigenous knowledge and traditional rights should be considered and engaged as the core of any partnership between researchers and farmers on equal basis.

9. 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-Bhousini 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 spontaneum. 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, Eritrea, 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.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>4.20</td>
<td>4.33</td>
<td>4.36</td>
<td>4.85</td>
<td>4.93</td>
<td>5.29</td>
<td>5.18</td>
</tr>
<tr>
<td>Asia</td>
<td>14.85</td>
<td>12.99</td>
<td>11.72</td>
<td>10.86</td>
<td>11.64</td>
<td>12.48</td>
<td>12.51</td>
</tr>
<tr>
<td>N. America</td>
<td>7.04</td>
<td>7.70</td>
<td>8.96</td>
<td>8.07</td>
<td>9.22</td>
<td>8.58</td>
<td>7.23</td>
</tr>
<tr>
<td>S. America</td>
<td>1.14</td>
<td>1.04</td>
<td>1.03</td>
<td>0.84</td>
<td>0.56</td>
<td>0.63</td>
<td>0.66</td>
</tr>
<tr>
<td>Europe</td>
<td>12.90</td>
<td>15.58</td>
<td>17.79</td>
<td>19.95</td>
<td>19.36</td>
<td>18.15</td>
<td>15.77</td>
</tr>
<tr>
<td>Russia + CAS</td>
<td>18.30</td>
<td>20.33</td>
<td>28.37</td>
<td>34.00</td>
<td>30.52</td>
<td>28.50</td>
<td>28.70</td>
</tr>
<tr>
<td>Oceania</td>
<td>0.87</td>
<td>1.39</td>
<td>2.15</td>
<td>2.57</td>
<td>3.00</td>
<td>2.31</td>
<td>2.94</td>
</tr>
<tr>
<td>World</td>
<td>59.40</td>
<td>63.40</td>
<td>74.47</td>
<td>81.21</td>
<td>79.33</td>
<td>76.04</td>
<td>73.06</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>17.296</td>
<td>15.445</td>
<td>14.675</td>
<td>16.080</td>
<td>17.272</td>
<td>18.651</td>
<td>20.244</td>
</tr>
<tr>
<td>S. America</td>
<td>1.264</td>
<td>1.063</td>
<td>1.194</td>
<td>1.039</td>
<td>0.695</td>
<td>1.004</td>
<td>1.136</td>
</tr>
<tr>
<td>Europe</td>
<td>33.777</td>
<td>44.817</td>
<td>57.167</td>
<td>66.800</td>
<td>70.904</td>
<td>71.198</td>
<td>60.567</td>
</tr>
<tr>
<td>Russia + CAS</td>
<td>18.693</td>
<td>28.018</td>
<td>39.819</td>
<td>50.77</td>
<td>40.545</td>
<td>48.154</td>
<td>47.213</td>
</tr>
<tr>
<td>Oceania</td>
<td>0.978</td>
<td>1.586</td>
<td>2.5766</td>
<td>3.124</td>
<td>4.127</td>
<td>3.672</td>
<td>4.975</td>
</tr>
<tr>
<td>World</td>
<td>87.852</td>
<td>110.810</td>
<td>139.037</td>
<td>162.043</td>
<td>162.487</td>
<td>171.541</td>
<td>161.019</td>
</tr>
</tbody>
</table>

Source: Agrostat 1997

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

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>0.72</td>
<td>0.78</td>
<td>0.87</td>
<td>0.86</td>
<td>0.84</td>
<td>1.03</td>
<td>0.96</td>
</tr>
<tr>
<td>Asia</td>
<td>1.16</td>
<td>1.19</td>
<td>1.25</td>
<td>1.48</td>
<td>1.48</td>
<td>1.50</td>
<td>1.62</td>
</tr>
<tr>
<td>N. America</td>
<td>1.82</td>
<td>2.11</td>
<td>2.17</td>
<td>2.45</td>
<td>2.64</td>
<td>2.67</td>
<td>2.98</td>
</tr>
<tr>
<td>S. America</td>
<td>1.10</td>
<td>1.02</td>
<td>1.15</td>
<td>1.23</td>
<td>1.25</td>
<td>1.58</td>
<td>1.72</td>
</tr>
<tr>
<td>Europe</td>
<td>2.60</td>
<td>2.87</td>
<td>3.21</td>
<td>3.34</td>
<td>3.67</td>
<td>3.93</td>
<td>3.84</td>
</tr>
<tr>
<td>Russia + CAS</td>
<td>1.02</td>
<td>1.37</td>
<td>1.41</td>
<td>1.51</td>
<td>1.33</td>
<td>1.70</td>
<td>1.64</td>
</tr>
<tr>
<td>Oceania</td>
<td>1.13</td>
<td>1.14</td>
<td>1.20</td>
<td>1.22</td>
<td>1.34</td>
<td>1.58</td>
<td>1.66</td>
</tr>
<tr>
<td>World</td>
<td>1.48</td>
<td>1.74</td>
<td>1.87</td>
<td>1.99</td>
<td>2.05</td>
<td>2.26</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Source: Agrostat 1997

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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All wheat</td>
<td>559</td>
<td>593</td>
<td>625</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>29</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>Coarse grains</td>
<td>813</td>
<td>842</td>
<td>910</td>
</tr>
<tr>
<td>Barley</td>
<td>169</td>
<td>177</td>
<td>186</td>
</tr>
<tr>
<td>Total</td>
<td>1570</td>
<td>1639</td>
<td>1750</td>
</tr>
</tbody>
</table>

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 homileari, 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, stressfull 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 agroecological 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 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 machi-ca 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 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).

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

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

<table>
<thead>
<tr>
<th></th>
<th>1989-93 Average base period</th>
<th>Projections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>1448</td>
<td>650</td>
</tr>
<tr>
<td>Former USSR</td>
<td>4940</td>
<td>1130</td>
</tr>
<tr>
<td>Middle East</td>
<td>6469</td>
<td>7440</td>
</tr>
<tr>
<td>Africa</td>
<td>1275</td>
<td>1570</td>
</tr>
<tr>
<td>Pacific Asia</td>
<td>2757</td>
<td>4050</td>
</tr>
<tr>
<td>Latin America</td>
<td>580</td>
<td>790</td>
</tr>
<tr>
<td>Total</td>
<td>14.132</td>
<td>10.790</td>
</tr>
</tbody>
</table>
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:

1. To collaborate with national programs in germplasm development.
2. To strengthen national barley breeding programs.
3. 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 x 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 Simmons (1984) and defined as selection in the target environments. Decentralized selection has been also termed in situ or on-site selection. In the case of self-pollinated crops, it consists in selection of early segregating populations (such as F₂) 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 ICARDA/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 G × E 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, bunt) is entirely conducted in Tunisia and Morocco, while the screening for resistance to barley stem gall midge (Mayetiola destructor) 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>
<thead>
<tr>
<th>Country/Region</th>
<th>Countries/Area</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Africa</td>
<td>Egypt, Libya, Tunisia, Algeria, Morocco</td>
<td>Fully implemented</td>
</tr>
<tr>
<td>Iraq (Baghdad)</td>
<td>Central Iraq</td>
<td>Fully implemented</td>
</tr>
<tr>
<td>Iraq (Mosul)</td>
<td>Northern Iraq</td>
<td>Fully implemented</td>
</tr>
<tr>
<td>EARS (East Africa/</td>
<td>Yemen, Eritrea, Tigray</td>
<td>First crosses made in 1998</td>
</tr>
<tr>
<td>Red Sea)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Ethiopia (except Tigray)</td>
<td>Use of local landraces fully implemented</td>
</tr>
<tr>
<td>CAC (Central Asia</td>
<td></td>
<td>First special nursery in 1997</td>
</tr>
<tr>
<td>&amp; Caucasus)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>Cyprus</td>
<td>First nursery planned for 1999</td>
</tr>
<tr>
<td>Cyprus</td>
<td>India, Thailand, Vietnam, China</td>
<td>First special nursery in 1995, first crosses in 1998</td>
</tr>
<tr>
<td>Far East</td>
<td>Pakistan</td>
<td>First special nursery in 1996, first crosses in 1997</td>
</tr>
<tr>
<td>Pakistan</td>
<td>S. Arabia, Qatar, Oman</td>
<td>First special nursery in 1997</td>
</tr>
<tr>
<td>Gulf Countries</td>
<td>Ecuador</td>
<td>First crosses made in 1992</td>
</tr>
<tr>
<td>Ecuador</td>
<td></td>
<td>First nursery planned for 1999</td>
</tr>
</tbody>
</table>
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).

![The Barley Breeding Program at ICARDA](image)

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 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).

![Chart: 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:
1. Training of technical staff should become a responsibility of NARS (the long-term residential course has been discontinued).
2. Individual training and degree training will be emphasized and should become a component of special projects.
3. 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 F2 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 headquarters' 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 (W1291/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).

<table>
<thead>
<tr>
<th>Country</th>
<th>kg/person/year</th>
<th>Country</th>
<th>kg/person/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>64.1</td>
<td>Libya</td>
<td>11.5</td>
</tr>
<tr>
<td>Iraq</td>
<td>22.4</td>
<td>Afghanistan</td>
<td>10.9</td>
</tr>
<tr>
<td>Algeria</td>
<td>19.3</td>
<td>Tunisia</td>
<td>10.2</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>14.1</td>
<td>Peru</td>
<td>2.8</td>
</tr>
</tbody>
</table>

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 challenges 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


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 self-pollinated 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:
1. Matching the yield components to achieve yield maximization in hybrids.
2. Diversity in parental lines.
3. Hybrid x 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% (Borghii et al. 1986) to as high as 41% (Zehr et al. 1997). Fabrizio 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 (Borghii et al. 1989; Bents 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 (Paterson 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 (Borghii et al. 1988). Kernel weight tends to be higher in hybrids but this does not contribute significantly to increase yields (Borghii 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.

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

**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 × 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 × 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 sedi-
mentation) 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
generically diverse high yielding superior ideotype, may
result in hybrid combinations which may be superior in eco-
nomic 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 hetero-
sis in wheat can be achieved by matching yield components,
quality and disease resistance from genetically diverse par-
ents. 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 understand-
ing 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 pro-
gram 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 attrac-
tive reality.

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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 Kahramanmaras, 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 عوامل القمح الحبيبة (Triticum aestivum L.)

المتخصصة
نفت هذا البحث على 22 صنفاً من القمح الشائع باتباع تصميم القطاعات الكاملة العشوائية بأربعة مكررات في الفترة ما بين 1996 و 1998 في كل من مزارع بتركيا. وقد تم في التجربة بحث
المتغيرات التالية: عدد الصوب/م²، عدد الأعوام/الصوب، وزن الحبة/الصوبة، وزن الحبة/السليمة، الوزن عند الاختبار، الفئة الحبيبة، وحسب
الارتباط البسيط ومعاملات المسار لتحديد التأثيرات المباشرة
وغير المباشرة لهذه الصنافات في الفئة الحبيبة.

وقد وجدت ارتباطات إيجابية ومعنوية بين الفئة الحبيبة
وبين كل من عدد الصوب/م²، عدد الأعوام/السليمة، وزن
الحبة/السليمة، الوزن عند الاختبار، كما دلت معاملات
المسار على تأثيرات مباشرة لكل من عدد الصوب/م²، وزن
الحبة/السليمة، تأثير غير مباشر إيجابي ومعنوي لحصول
ضرر عدد الأعوام/السليمة، وزن الحبة/السليمة في الفئة
الحبيبة. وعلى ينكن استخدام عدد الصوب/م²، وزن
الحبة/السليمة، عدد الأعوام/السليمة كمعايير انتخابية في
برامج التربية لاستنبات أصناف مغلالة من القمح الحبيبة.

simple correlation coefficient. Although correlation coeffi-
cient 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 situ-
ations 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
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 quantitative 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; Gebeiyou et al. 1982a, 1982b; Borjovic and Williams 1982; Mou 1990), barley (Pury et al. 1982; Kirtok and Çölkesen 1985; García et al. 1991), bean (Duarte and Adams 1972) and cowpea (Altinbas and Sepetoglu 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 Kahramanmaras, was to use path coefficient analysis to determine direct and indirect effects of yield components, 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 Kahramanmaras, 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 P₂O₅ 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 MSTAT-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 (Gebeiyou et al. 1982a; García 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>
<thead>
<tr>
<th>Registration No.</th>
<th>Cultivars/line</th>
<th>Registration No.</th>
<th>Cultivars/line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1001</td>
<td>Genç-88</td>
<td>1015</td>
<td>Bow/Buc/Bul</td>
</tr>
<tr>
<td>1002</td>
<td>Ka’s/NAC (Genç-99)</td>
<td>1016</td>
<td>Bow’s/Crow’s’</td>
</tr>
<tr>
<td>1003</td>
<td>Panda</td>
<td>1018</td>
<td>(477/2)/Fkn/Gb</td>
</tr>
<tr>
<td>1004</td>
<td>84ÇZT04</td>
<td>1020</td>
<td>Van’s’/Bb/KA</td>
</tr>
<tr>
<td>1005</td>
<td>84ÇZT04(S)</td>
<td>1021</td>
<td>Pr’s’/Pew’s’</td>
</tr>
<tr>
<td>1006</td>
<td>Seri-82</td>
<td>1023</td>
<td>Tow’s’/Pew’s’</td>
</tr>
<tr>
<td>1007</td>
<td>CHIL’s’</td>
<td>1024</td>
<td>Peg’s’/HD206/Horb’s’</td>
</tr>
<tr>
<td>1009</td>
<td>Ures/Bow’s’</td>
<td>1025</td>
<td>Van’s’/3/Cndr’s’/Anq</td>
</tr>
<tr>
<td>1011</td>
<td>KAUZ</td>
<td>1027</td>
<td>Cettia</td>
</tr>
<tr>
<td>1013</td>
<td>BR12×4/BH146*6/ALD</td>
<td>1028</td>
<td>Kasyon/Pvn’s’/spruv’s’</td>
</tr>
<tr>
<td>1014</td>
<td>Attila</td>
<td>1029</td>
<td>Car422/ANA/Ures</td>
</tr>
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</table>
Table 2. Correlation between all pairs of variables.

<table>
<thead>
<tr>
<th></th>
<th>No. grains/head</th>
<th>Grain weight/head</th>
<th>1000-grain weight</th>
<th>Test weight</th>
<th>Grain yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. heads/m²</td>
<td>-0.06</td>
<td>-0.48**</td>
<td>-0.28**</td>
<td>-0.12</td>
<td>0.57**</td>
</tr>
<tr>
<td>No. grains/head</td>
<td>-</td>
<td>0.79**</td>
<td>-0.29*</td>
<td>0.12</td>
<td>0.45**</td>
</tr>
<tr>
<td>Grain weight/head</td>
<td>-</td>
<td>-</td>
<td>0.19**</td>
<td>0.25**</td>
<td>0.27**</td>
</tr>
<tr>
<td>1000-grain weight</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.26**</td>
<td>-0.14</td>
</tr>
<tr>
<td>Test weight</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>0.18*</td>
</tr>
</tbody>
</table>

*, ** 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).

![Path diagram representing cause and effect relationships among yield components and grain yield.](image-url)
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.

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Path Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of heads/m²</strong></td>
<td></td>
</tr>
<tr>
<td>Direct effect on grain yield, P₁₆</td>
<td>1.09</td>
</tr>
<tr>
<td>Indirect effects via;</td>
<td></td>
</tr>
<tr>
<td>- Grain number/head, r₁₂P₁₆</td>
<td>-0.04</td>
</tr>
<tr>
<td>- Grain weight/head, r₁₃P₃₆</td>
<td>-0.62</td>
</tr>
<tr>
<td>- 1000-grain weight, r₁₄P₄₆</td>
<td>-0.08</td>
</tr>
<tr>
<td>- Test weight, r₁₅P₅₆</td>
<td>-0.02</td>
</tr>
<tr>
<td>- Correlation r₁₆</td>
<td>0.57**</td>
</tr>
<tr>
<td><strong>Number of grains/head</strong></td>
<td></td>
</tr>
<tr>
<td>Direct effect, P₂₆</td>
<td>-0.62</td>
</tr>
<tr>
<td>Indirect effects via;</td>
<td></td>
</tr>
<tr>
<td>- Head number/m², r₁₃P₁₆</td>
<td>-0.07</td>
</tr>
<tr>
<td>- Grain weight/head, r₂₃P₃₆</td>
<td>1.04</td>
</tr>
<tr>
<td>- 1000-grain weight, r₂₄P₄₆</td>
<td>-0.08</td>
</tr>
<tr>
<td>- Test weight, r₂₅P₅₆</td>
<td>0.02</td>
</tr>
<tr>
<td>- Correlation r₂₆</td>
<td>0.45**</td>
</tr>
<tr>
<td><strong>Grain weight/head</strong></td>
<td></td>
</tr>
<tr>
<td>Direct effect, P₂₆</td>
<td>1.31</td>
</tr>
<tr>
<td>Indirect effects via;</td>
<td></td>
</tr>
<tr>
<td>- Head number/m², r₁₅P₁₆</td>
<td>-0.52</td>
</tr>
<tr>
<td>- Grain number/head, r₂₃P₂₆</td>
<td>-0.50</td>
</tr>
<tr>
<td>- 1000-grain weight, r₂₄P₄₆</td>
<td>-0.06</td>
</tr>
<tr>
<td>- Test weight, r₃₅P₅₆</td>
<td>0.03</td>
</tr>
<tr>
<td>- Correlation r₇</td>
<td>0.27**</td>
</tr>
<tr>
<td><strong>1000-grain weight</strong></td>
<td></td>
</tr>
<tr>
<td>Direct effect, P₂₆</td>
<td>-0.29</td>
</tr>
<tr>
<td>Indirect effects via;</td>
<td></td>
</tr>
<tr>
<td>- Head number/m², r₁₄P₁₆</td>
<td>-0.31</td>
</tr>
<tr>
<td>- Grain number/head, r₂₄P₂₆</td>
<td>0.18</td>
</tr>
<tr>
<td>- Grain weight/head, r₃₃P₃₆</td>
<td>0.25</td>
</tr>
<tr>
<td>- Test weight, r₄₃P₅₆</td>
<td>0.03</td>
</tr>
<tr>
<td>- Correlation r₄₆</td>
<td>-0.14</td>
</tr>
<tr>
<td><strong>Test weight</strong></td>
<td></td>
</tr>
<tr>
<td>Direct effect, P₅₆</td>
<td>0.13</td>
</tr>
<tr>
<td>Indirect effects via;</td>
<td></td>
</tr>
<tr>
<td>- Head number/m², r₁₂P₁₆</td>
<td>0.13</td>
</tr>
<tr>
<td>- Grain number/head, r₂₅P₂₆</td>
<td>-0.07</td>
</tr>
<tr>
<td>- Grain weight/head, r₃₅P₃₆</td>
<td>0.33</td>
</tr>
<tr>
<td>- 1000-grain weight, r₄₅P₄₆</td>
<td>-0.07</td>
</tr>
<tr>
<td>- Correlation r₅₆</td>
<td>0.18**</td>
</tr>
</tbody>
</table>

* ** Significant at P <0.05 and 0.01, respectively.

References


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

S.C. Vimal and S.R. Vishwakarma
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. P1, F1, F2, B1 and B2 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

\[ \text{Tأثرات المورثة التي تتحكم بمكونات الغلة في نبات (Hordeum vulgare L.)} \]

تملخص

أجريت أربع تجربة نباتات NDB 901 × Jagrati, NDB940 × RD2516 و NDB 206 × BL-2 و NDB940 × Ranta. وراثة متجانسة اللون ونباتات وراثية حيث زرعت نباتات P1, F1, F2, B1, BC1, BC2 للقطاعات العائلية المتواقعة. وسجل البيانات يوميا عن عدد الأيام حتى انبثاق النبتة، وطول النبتة، وعدد السنجابات/النباتات الرئيسية، وعدد الحبوب/النباتات الرئيسية، وزارع الحبوب/النباتات الرئيسية. وقد دل التحليل الوراثي الذي أجري باستخدام نموذج المعاملات المستقلة 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 المعدقة للوراثة. وعليه قد يكون من المفيد بشري القيام بالتحسين الوراثي من خلال الانتقاء 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 \textit{rabi} 1995/96. During the same year, the F1 generations of cross combinations obtained from these projects were sown to raise hybrid populations (B1, B2 and F2). All F1 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,
B₂ and F₂) 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 B₁ and Parent-2 for B₂ to obtain back crosses, and F₂ generations were raised by selfing the F₁ 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 F₁ generations, and 20 each from back crosses and F₂ 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 2. Scaling test, gene effects, and type of epistasis for five metric traits.

<table>
<thead>
<tr>
<th>Character</th>
<th>m</th>
<th>d</th>
<th>h</th>
<th>i</th>
<th>Gene effects</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Type of epistasis</th>
<th>Scale test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to ear emergence</td>
<td>87.00**</td>
<td>-3.67**</td>
<td>11.17**</td>
<td>10.00**</td>
<td>2.83*</td>
<td>-46.33**</td>
<td>D</td>
<td>21.00**</td>
<td>15.33**</td>
<td>26.33**</td>
<td>-5.00**</td>
</tr>
<tr>
<td>Plant height</td>
<td>95.60**</td>
<td>-3.54**</td>
<td>3.15</td>
<td>-6.95</td>
<td>5.36**</td>
<td>-18.03**</td>
<td>D</td>
<td>17.85**</td>
<td>7.13**</td>
<td>31.93**</td>
<td>3.48</td>
</tr>
<tr>
<td>No. of spikelets/ main spike</td>
<td>27.53**</td>
<td>1.36</td>
<td>0.55</td>
<td>-1.11</td>
<td>2.09</td>
<td>-1.64</td>
<td>D</td>
<td>5.07**</td>
<td>0.89</td>
<td>10.27**</td>
<td>2.16</td>
</tr>
<tr>
<td>Weight of grains/ main spike</td>
<td>2.66**</td>
<td>0.13</td>
<td>0.68*</td>
<td>0.47</td>
<td>0.22*</td>
<td>-1.44**</td>
<td>D</td>
<td>0.71**</td>
<td>0.26</td>
<td>0.50*</td>
<td>-0.23</td>
</tr>
<tr>
<td>No. of grains/ main spike</td>
<td>64.88**</td>
<td>-0.84</td>
<td>6.46</td>
<td>0.53</td>
<td>0.50</td>
<td>-21.25</td>
<td>D</td>
<td>10.86</td>
<td>9.87**</td>
<td>20.20</td>
<td>-0.26</td>
</tr>
<tr>
<td>NDB 901 x Jagruti (Cross II)</td>
<td>77.33**</td>
<td>-1.33</td>
<td>9.67*</td>
<td>6.67</td>
<td>0.67</td>
<td>-22.00**</td>
<td>D</td>
<td>8.33**</td>
<td>7.00**</td>
<td>8.67**</td>
<td>-3.33</td>
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<td>Plant height</td>
<td>85.13</td>
<td>3.62</td>
<td>4.88</td>
<td>-5.07</td>
<td>9.24*</td>
<td>11.03</td>
<td>C</td>
<td>6.25</td>
<td>-12.22</td>
<td>-0.90</td>
<td>2.53</td>
</tr>
<tr>
<td>No. of spikelets/ main spike</td>
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<td>0.25</td>
<td>13.13**</td>
<td>7.39**</td>
<td>1.85</td>
<td>-24.50**</td>
<td>D</td>
<td>10.45**</td>
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<td>9.80**</td>
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<td>0.16**</td>
<td>0.74*</td>
<td>0.39</td>
<td>0.22*</td>
<td>-1.40**</td>
<td>D</td>
<td>0.73**</td>
<td>0.28**</td>
<td>0.62**</td>
<td>-0.20*</td>
</tr>
<tr>
<td>No. of grains/ main spike</td>
<td>64.15**</td>
<td>-2.63</td>
<td>8.50</td>
<td>0.27</td>
<td>-2.27</td>
<td>-32.80</td>
<td>D</td>
<td>14.00</td>
<td>18.53**</td>
<td>32.27**</td>
<td>-0.13</td>
</tr>
<tr>
<td>NDB 940 x RD 2516 (Cross III)</td>
<td>77.67**</td>
<td>1.00</td>
<td>12.67**</td>
<td>12.67**</td>
<td>8.09**</td>
<td>-13.33**</td>
<td>D</td>
<td>8.33**</td>
<td>-7.67**</td>
<td>-12.00**</td>
<td>-6.33**</td>
</tr>
<tr>
<td>Plant height</td>
<td>84.47**</td>
<td>4.04</td>
<td>19.83</td>
<td>10.39</td>
<td>6.10</td>
<td>-20.88</td>
<td>D</td>
<td>11.35*</td>
<td>-0.86</td>
<td>0.09</td>
<td>-5.20</td>
</tr>
<tr>
<td>No. of spikelets/ main spike</td>
<td>24.11**</td>
<td>0.58</td>
<td>17.88**</td>
<td>13.85**</td>
<td>1.01</td>
<td>-25.55**</td>
<td>D</td>
<td>6.86**</td>
<td>4.84**</td>
<td>-2.15</td>
<td>-6.92**</td>
</tr>
<tr>
<td>Weight of grains/ main spike</td>
<td>2.65**</td>
<td>0.11</td>
<td>0.77*</td>
<td>0.43</td>
<td>0.04</td>
<td>-1.26**</td>
<td>D</td>
<td>0.46**</td>
<td>0.38</td>
<td>0.41</td>
<td>-0.21</td>
</tr>
<tr>
<td>No. of grains/ main spike</td>
<td>61.12**</td>
<td>3.51</td>
<td>28.85**</td>
<td>22.29**</td>
<td>3.08</td>
<td>-55.51**</td>
<td>D</td>
<td>19.69**</td>
<td>13.53**</td>
<td>10.93**</td>
<td>-11.14**</td>
</tr>
<tr>
<td>NDB 206 x BI-2 (Cross IV)</td>
<td>78.00**</td>
<td>0.67</td>
<td>48.50**</td>
<td>41.33**</td>
<td>-0.50</td>
<td>-61.00**</td>
<td>D</td>
<td>9.33**</td>
<td>10.33**</td>
<td>21.67**</td>
<td>-20.67**</td>
</tr>
<tr>
<td>Plant height</td>
<td>89.02**</td>
<td>2.89</td>
<td>-9.67</td>
<td>-19.34**</td>
<td>0.36</td>
<td>-46.48**</td>
<td>D</td>
<td>-13.21**</td>
<td>-13.93**</td>
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<td>5.85**</td>
<td>-3.92**</td>
<td>-8.96</td>
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<td>0.08</td>
<td>-0.11</td>
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<td>0.03</td>
<td>-0.02</td>
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<tr>
<td>No. of grains/ main spike</td>
<td>61.97**</td>
<td>-0.79</td>
<td>23.71*</td>
<td>18.65</td>
<td>-4.12</td>
<td>-46.23**</td>
<td>D</td>
<td>9.67*</td>
<td>17.91**</td>
<td>8.93</td>
<td>-9.32</td>
</tr>
<tr>
<td>NDB 901 x Ratna (Cross I)</td>
<td>87.00**</td>
<td>-3.67**</td>
<td>11.17**</td>
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<td>2.83*</td>
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<td>-0.26</td>
</tr>
</tbody>
</table>

*,**, 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 (i) interaction. The opposite signs of h and l 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-allellic 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. Lone (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 (i) 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 (l) 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).
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, Aristotlean 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 F₁ hybrids were evaluated in single row plots in nil-competition, and differences in yield performance were not significant. The F₂ to F₅ generations were evaluated in a honeycomb design in nil-competition. Additionally, the F₅ lines were evaluated in solid stand at two locations. From F₂, the three highest-yielding crosses and one low-yielding cross were selected for further evaluation.

References


selected for a more detailed evaluation. In the F₂ to F₄ 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 F₃, F₄, and F₅ generations. In nil-competition, 25 to 31% of the F₄ 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 F₂ could constitute the criteria 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 F₂ progeny tests. On the other hand, Nass (1979) found that lines of crosses identified as high yielding in F₁ had significantly greater mean yield in F₄ than lines of crosses that were low yielding in F₁. 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 F₁ and F₂ agreed very well with those made in F₃, less so in F₄ and that the F₁ and F₂ 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 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 F₁ generations with a relative small inbreeding depression in the F₂ are promising populations from which to select. However, the plant density under which the breeder should evaluate the F₁ and F₂ generations is open to question. The results of Roupakias et al. (1997) indicate that evaluating F₁ and F₂ 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 F₁ to F₅ 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 (F₃) 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 honeycomb 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 F₁ 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 inter-row 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 1A to 1G; i.e. 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 × Satellite) 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 low-yielding cross in F₃ to F₅ generations**

The F₃, F₄ and F₅ lines of four crosses were evaluated in an R-49 honeycomb design. The variety Myconos was sown as a check. In addition, the F₅ 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 F₁ and F₂ generations, mass honeycomb selection for high grain yield/plant was applied using the principle of

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**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 F3 and F4 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 F1 to the F5 generation are shown in Table 1.

Statistical analysis

The 2-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 equivalent in the F5, F4, and F3 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:

\[ H_{ILP} = \frac{100(F_{ILP} - ILP)}{ILP} \]

Results and Discussion

The thirteen F1 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 × Satelite (Table 2). Considerable changes occurred in the yield rank between the F1 and F2 generations (r = 0.21). In F2, 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 × Ciano differed significantly from only two crosses. Heterosis ranged from -31 to 11.6% and positive values were observed only for the crosses Myconos × Chios (11.6%) and Myconos × Sk-7 (5.8%). A high level of inbreeding depression was observed for Myconos × Ciano (Table 2).

Because F2 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 F2 crosses and one low-yielding F2 cross were selected for a more detailed evaluation. A

![Table 1. Number of lines and plants per cross from F3 to F5.](image)

<table>
<thead>
<tr>
<th>Cross</th>
<th>F3 Lines</th>
<th>F3 Plants</th>
<th>F4 Lines</th>
<th>F4 Plants</th>
<th>F5 Lines</th>
<th>F5 Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myconos × Chios</td>
<td>11</td>
<td>376</td>
<td>19</td>
<td>525</td>
<td>8</td>
<td>271</td>
</tr>
<tr>
<td>Myconos × Sk-7</td>
<td>11</td>
<td>365</td>
<td>16</td>
<td>421</td>
<td>16</td>
<td>800</td>
</tr>
<tr>
<td>Myconos × Satelite</td>
<td>11</td>
<td>363</td>
<td>5</td>
<td>173</td>
<td>5</td>
<td>139</td>
</tr>
<tr>
<td>Myconos × Ciano</td>
<td>11</td>
<td>362</td>
<td>5</td>
<td>126</td>
<td>4</td>
<td>129</td>
</tr>
<tr>
<td>Myconos (check)</td>
<td>5</td>
<td>167</td>
<td>4</td>
<td>106</td>
<td>5</td>
<td>126</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>49</td>
<td>1633</td>
<td>91</td>
<td>1351</td>
<td>38</td>
<td>1465</td>
</tr>
</tbody>
</table>

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

![Table 2. Mean yield (g plant⁻¹) and heterosis (H₁LP) in F₁ and F₂.](image)

<table>
<thead>
<tr>
<th>Crosses</th>
<th>Yield</th>
<th>F₁ Mean</th>
<th>H₁LP</th>
<th>Rank</th>
<th>Yield</th>
<th>F₂ Mean</th>
<th>H₁LP</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myconos × Satelite</td>
<td>179</td>
<td>-4.07</td>
<td>1</td>
<td></td>
<td>101</td>
<td>-1.9</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Myconos × (Check)</td>
<td>172</td>
<td>100</td>
<td>2</td>
<td></td>
<td>103</td>
<td>100.0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Myconos × Ciano</td>
<td>167</td>
<td>-2.9</td>
<td>3</td>
<td></td>
<td>86.7</td>
<td>-16.5</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Myconos × NTK “S”</td>
<td>176</td>
<td>-2.9</td>
<td>4</td>
<td></td>
<td>96.9</td>
<td>-6.7</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Myconos × Pavon “S”</td>
<td>158</td>
<td>-8.0</td>
<td>5</td>
<td></td>
<td>78.7</td>
<td>-24.2</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Myconos × CGS 10480</td>
<td>158</td>
<td>-8.0</td>
<td>6</td>
<td></td>
<td>75.3</td>
<td>-27.0</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Myconos × Vee S</td>
<td>155</td>
<td>-9.8</td>
<td>7</td>
<td></td>
<td>81.3</td>
<td>-24.0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Myconos × Sk-7</td>
<td>148</td>
<td>-13.9</td>
<td>8</td>
<td></td>
<td>109</td>
<td>+5.8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Myconos × Cerros 66</td>
<td>148</td>
<td>-13.9</td>
<td>9</td>
<td></td>
<td>99.7</td>
<td>-3.8</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Myconos × Lesvos</td>
<td>146</td>
<td>-15.1</td>
<td>10</td>
<td></td>
<td>63.9</td>
<td>-3.8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Myconos × Chios</td>
<td>146</td>
<td>-15.1</td>
<td>11</td>
<td></td>
<td>115</td>
<td>+11.6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Myconos × Banks</td>
<td>146</td>
<td>-15.1</td>
<td>12</td>
<td></td>
<td>96.9</td>
<td>-6.7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Myconos × Mexipak 65</td>
<td>146</td>
<td>-15.1</td>
<td>13</td>
<td></td>
<td>91.9</td>
<td>-11.6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Myconos × Pavon 76</td>
<td>142</td>
<td>-17.4</td>
<td>14</td>
<td></td>
<td>71.9</td>
<td>-31.0</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

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 F3 for all crosses and in F4 and F5 for the crosses of Myconos with Chios and Sk-7. The cross Myconos × Chios had the highest percentage (78.9 to 100%) of F3, F4 and F5 lines outyielding the highest-yielding line from Myconos × Ciano. On the other hand, for Myconos × Satellite this percentage ranged from 20 to 80% (Table 4). In these two crosses, 25% of the F3 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 F3 to F5 of four crosses classified as high- or low-yielding in F2.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F3</td>
</tr>
<tr>
<td><strong>High-yielding</strong></td>
<td></td>
</tr>
<tr>
<td>Myconos × Chios</td>
<td>152.4⁻ᵃ</td>
</tr>
<tr>
<td>Myconos × Sk-7</td>
<td>137.3ᵇ</td>
</tr>
<tr>
<td>Myconos × Satellite</td>
<td>136.4ᵇ</td>
</tr>
<tr>
<td><strong>Low-yielding</strong></td>
<td></td>
</tr>
<tr>
<td>Myconos × Ciano</td>
<td>110.2ᶜ</td>
</tr>
<tr>
<td>Myconos (check)</td>
<td>138.6ᵃᵇ</td>
</tr>
</tbody>
</table>

* 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).

<table>
<thead>
<tr>
<th>Cross</th>
<th>Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F3</td>
</tr>
<tr>
<td>Myconos × Chios</td>
<td>10 90.9(7)ᵃ</td>
</tr>
<tr>
<td>Myconos × Sk-7</td>
<td>7 63.6(3)</td>
</tr>
<tr>
<td>Myconos × Satellite</td>
<td>5 45.4(1)</td>
</tr>
</tbody>
</table>

* 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 F3 lines from Myconos × Sk-7 and 25% of those from Myconos × Satellite 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⁻ILP) of F5 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.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Yield</th>
<th>H⁻ILP (%)</th>
<th>Number of lines(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-yielding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myconos × Sk-7</td>
<td>1722.8ᵃ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myconos × Chios</td>
<td>1528.2ᵇ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myconos (Check)</td>
<td>1436.0ᵇ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myconos × Satellite</td>
<td>1393.6ᵇ</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low-yielding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myconos × Ciano</td>
<td>1181.5ᵇ</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LSD = ± 472.34; CV = 19%

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

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 F2 (Table 2), and the F3 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 Abualef (1979), who studied the heritability of heterosis in various crosses. He found that, if in F2 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 F2 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.
Figure 2. Heterosis for grain yield in each generation and cross (honeycomb selection).

References


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

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

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 hundreds of millions who live in less favored parts of the earth (Frankel et al. 1995). There are two main reasons for giving special attention 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 Ehdie 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 multtrait combinations that are useful for durum wheat to survive under semiarid 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 (NCART-TT) 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 semi-arid 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 +curies). Fertilizer was applied prior to seeding at a rate of 100 kg diammonium phosphate (DAP) per hectare. Then, the field

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Owned saved</td>
<td>30</td>
<td>25</td>
<td>43</td>
<td>9</td>
<td>10</td>
<td>7</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>145</td>
</tr>
<tr>
<td>Other farmer</td>
<td>2</td>
<td>0</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>25</td>
<td>58</td>
<td>11</td>
<td>10</td>
<td>7</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>164</td>
</tr>
<tr>
<td>Percentage (%)</td>
<td>19.5</td>
<td>15.3</td>
<td>35.3</td>
<td>6.7</td>
<td>6.1</td>
<td>4.3</td>
<td>9.2</td>
<td>2.4</td>
<td>1.2</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2. Geographical data for Maru location, date of sowing and harvesting during the 1995/1996 cropping season.

<table>
<thead>
<tr>
<th>Location</th>
<th>Maru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>35° 55'N</td>
</tr>
<tr>
<td>Longitude</td>
<td>32° 55'N</td>
</tr>
<tr>
<td>Altitude (m)</td>
<td>500</td>
</tr>
<tr>
<td>Seasonal (mm) precipitation</td>
<td>333.7 mm</td>
</tr>
<tr>
<td>Date of sowing</td>
<td>4 December</td>
</tr>
<tr>
<td>Date of harvesting</td>
<td>25 May</td>
</tr>
</tbody>
</table>

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’, ‘Ascad 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 Villarreal 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:

\[ \text{flag leaf area} = \text{leaf width}^1 \times \text{leaf length} \times 0.67. \]

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 \(\bar{x} + s\)
- Group 3: equal to or greater than \(\bar{x} + s\)

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):

\[ \text{hs.j} = - \sum_{i=1}^{n} P_i \ln P_i, \text{for } i = 1, 2, \ldots, n \]

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 taken on individual plant basis.

<table>
<thead>
<tr>
<th>No.</th>
<th>Trait</th>
<th>Unit of measurement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plant height (PH)</td>
<td>cm</td>
<td>Measured from ground to the peak of the spike, excluding awns</td>
</tr>
<tr>
<td>2</td>
<td>Peduncle length (PL)</td>
<td>cm</td>
<td>From base of spike to the top of ligule</td>
</tr>
<tr>
<td>3</td>
<td>Tillering capacity (TC)</td>
<td>number</td>
<td>Number of tillers/plant</td>
</tr>
<tr>
<td>4</td>
<td>Spikelets/spike (S/S)</td>
<td>number</td>
<td>Counting number of spikelets/spike</td>
</tr>
<tr>
<td>5</td>
<td>Average awns length (SL)</td>
<td>cm</td>
<td>From the top to the base of the spike</td>
</tr>
<tr>
<td>6</td>
<td>Average spike length</td>
<td>cm</td>
<td>Length from the base of spike to the top of the awns B spike length</td>
</tr>
<tr>
<td>7</td>
<td>Spike density (SD)</td>
<td>ratio</td>
<td>Ratio between number of spikelets/spike over spike length</td>
</tr>
<tr>
<td>8</td>
<td>Kernel/spike (K/S)</td>
<td>number</td>
<td>Counting number of seeds/spike</td>
</tr>
<tr>
<td>9</td>
<td>Spike weight (SW)</td>
<td>grams</td>
<td>Weighing the main spike</td>
</tr>
<tr>
<td>10</td>
<td>Yield/plant (Y/P)</td>
<td>grams</td>
<td>Weighing the total kernels/plant</td>
</tr>
</tbody>
</table>

1. 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 taken on plot basis.

<table>
<thead>
<tr>
<th>Number</th>
<th>Trait</th>
<th>Unit of measurement</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Days to heading (DH)</td>
<td>day</td>
<td>Counted from the first day of rainfall which is sufficient for germination to 50% of plants in flowering</td>
</tr>
<tr>
<td>2</td>
<td>Days to maturity (DM)</td>
<td>day</td>
<td>Recorded when 95% of the spikes in plot had lost their green coloration from first effective rain for germination</td>
</tr>
<tr>
<td>3</td>
<td>Filling period (FP)</td>
<td>day</td>
<td>Days to maturity (DM)/Days to heading (DH)</td>
</tr>
<tr>
<td>4</td>
<td>Number of spikes per meter square (S/m²)</td>
<td>number</td>
<td>Counting number of spikes in 1 m²</td>
</tr>
<tr>
<td>5</td>
<td>Biological Yield (BY)</td>
<td>tonne/hectare</td>
<td>Weighing total dry matter above soil surface</td>
</tr>
<tr>
<td>6</td>
<td>Grain yield (GY)</td>
<td>tonne/hectare</td>
<td>Weighing a total kernel weight in unit area</td>
</tr>
<tr>
<td>7</td>
<td>Harvest Index (HI)</td>
<td>ratio</td>
<td>Grain yield/Biological yield</td>
</tr>
<tr>
<td>8</td>
<td>Straw yield (SY)</td>
<td>tonne/hectare</td>
<td>Biological yield/Grain yield</td>
</tr>
<tr>
<td>9</td>
<td>1000-weight (TKW)</td>
<td>grams</td>
<td>Weighing 1000 seeds</td>
</tr>
<tr>
<td>10</td>
<td>Growth habit (GH)</td>
<td>score</td>
<td>1 = erect juvenile growth habit (spring type)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 = semierect (facultative)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 = prostrate juvenile growth habit (winter type)</td>
</tr>
<tr>
<td>11</td>
<td>Early vigor (EV)</td>
<td>score</td>
<td>1 = excellent early vigor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 = intermediate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 = poor early vigor</td>
</tr>
<tr>
<td>12</td>
<td>Canopy color (CC)</td>
<td>score</td>
<td>1 = dark green</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 = green</td>
</tr>
<tr>
<td>13</td>
<td>Glaucousness (GL)</td>
<td>score</td>
<td>1 = show glaucousness</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9 = show nonglaucousness</td>
</tr>
</tbody>
</table>

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 cvv. 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 accessions 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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Ploidy level</th>
<th>Percentage</th>
<th>Landrace</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durum</td>
<td>162</td>
<td>4X</td>
<td>98.8%</td>
<td>Hourani</td>
<td>136</td>
<td>85.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Safra Ma’an</td>
<td>25</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Unknown</td>
<td>15,5</td>
<td>0.6%</td>
</tr>
<tr>
<td>Bread</td>
<td>2</td>
<td>6X</td>
<td>1.2%</td>
<td>Unknown</td>
<td>2</td>
<td>1.2%</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
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 undesirable 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 kernel 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 germlasm (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.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Landraces</th>
<th>Hoorani F8</th>
<th>Acsad 65</th>
<th>Amra</th>
<th>Shami</th>
<th>Max.</th>
<th>Min.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to heading</td>
<td>120.7-130.7</td>
<td>123.7-125.3</td>
<td>116.3-120.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days to maturity</td>
<td>166.8-167.2</td>
<td>161.7-163.0</td>
<td>161.7-163.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filling period</td>
<td>45.13-53.42</td>
<td>38.0-37.7</td>
<td>45.3-42.7</td>
<td>40.0</td>
<td>37.7</td>
<td>40.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant height</td>
<td>129.3-109.5</td>
<td>112.3-112.7</td>
<td>86.3-83.9</td>
<td>81.6</td>
<td>95.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peduncle length</td>
<td>30.8-15.15</td>
<td>27.8-25.8</td>
<td>18.4-13.8</td>
<td>14.2</td>
<td>13.8</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spike length</td>
<td>9.39-5.36</td>
<td>7.0-6.30</td>
<td>7.5-7.3</td>
<td>7.4</td>
<td>7.5</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spike weight</td>
<td>3.0-1.5</td>
<td>2.5-2.5</td>
<td>2.8-2.9</td>
<td>2.6</td>
<td>2.9</td>
<td>3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awns length</td>
<td>14.73-6.61</td>
<td>9.5-9.7</td>
<td>11.2-12.3</td>
<td>14.3</td>
<td>14.3</td>
<td>9.5</td>
<td>11.4</td>
<td></td>
</tr>
<tr>
<td>No. of fertile tillers</td>
<td>4.33-1.2</td>
<td>2.5-2.4</td>
<td>3.5-3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>2.4</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Flag leaf area</td>
<td>42.0-20.0</td>
<td>27.6-26.6</td>
<td>25.4-21.2</td>
<td>27.6</td>
<td>27.6</td>
<td>25.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of spikelets/m²</td>
<td>499.2-320.4</td>
<td>388-306</td>
<td>360.6-409.4</td>
<td>409.4</td>
<td>409.4</td>
<td>453.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000-kernel weight</td>
<td>48.3-25.3</td>
<td>30.18-31.27</td>
<td>32.47-30.98</td>
<td>32.47</td>
<td>32.47</td>
<td>30.6</td>
<td>30.6</td>
<td></td>
</tr>
<tr>
<td>No. of kernels/spike</td>
<td>49.7-28.8</td>
<td>46.3-39.1</td>
<td>47.5-47</td>
<td>48.7</td>
<td>48.7</td>
<td>44.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spike density</td>
<td>36.9-21.8</td>
<td>3.2-3.2</td>
<td>2.6-3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of spikelets/spike</td>
<td>24.5-18.1</td>
<td>22.3-20.3</td>
<td>19.5-19.5</td>
<td>19.5</td>
<td>19.5</td>
<td>20.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield/plant</td>
<td>6.5-1.9</td>
<td>3.7-3.2</td>
<td>4.6-3.7</td>
<td>4.6</td>
<td>4.6</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological yield</td>
<td>15748-3969</td>
<td>11067-8833</td>
<td>10700-10700</td>
<td>9567</td>
<td>11067</td>
<td>8833</td>
<td>10460</td>
<td></td>
</tr>
<tr>
<td>Grain yield</td>
<td>2940-663</td>
<td>2213-1690</td>
<td>2245-2245</td>
<td>2117</td>
<td>2780</td>
<td>2009</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Straw yield</td>
<td>13500-3245</td>
<td>9034-8366</td>
<td>8714-9310</td>
<td>8714</td>
<td>845.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest index</td>
<td>0.47-0.11</td>
<td>0.199-0.1781</td>
<td>0.211-0.233</td>
<td>0.116</td>
<td>0.233</td>
<td>0.17</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>
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. Glaucousness 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 accessions 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 non-desirable traits recorded in the field for 164 collected landraces from Jordan during the 1990 cropping season.

<table>
<thead>
<tr>
<th>No</th>
<th>Trait</th>
<th>Desirable trait</th>
<th>Number of populations</th>
<th>Percentage (%)</th>
<th>Non-desirable trait</th>
<th>Number of populations</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Spike length</td>
<td>long</td>
<td>22</td>
<td>13.4</td>
<td>short</td>
<td>26</td>
<td>16.8</td>
</tr>
<tr>
<td>2</td>
<td>No. of spikelets/spike</td>
<td>high</td>
<td>25</td>
<td>15.3</td>
<td>low</td>
<td>29</td>
<td>17.7</td>
</tr>
<tr>
<td>3</td>
<td>1000- kernel weight</td>
<td>heavy</td>
<td>12</td>
<td>7.3</td>
<td>low</td>
<td>15</td>
<td>9.2</td>
</tr>
<tr>
<td>4</td>
<td>No. of kernels/spike</td>
<td>high</td>
<td>20</td>
<td>12.2</td>
<td>light</td>
<td>30</td>
<td>18.3</td>
</tr>
<tr>
<td>5</td>
<td>Spike weight</td>
<td>heavy</td>
<td>25</td>
<td>15.3</td>
<td>light</td>
<td>23</td>
<td>14.0</td>
</tr>
<tr>
<td>6</td>
<td>Spike density</td>
<td>dense</td>
<td>27</td>
<td>16.5</td>
<td>lax</td>
<td>10</td>
<td>6.1</td>
</tr>
<tr>
<td>7</td>
<td>Days to heading</td>
<td>early</td>
<td>18</td>
<td>11.0</td>
<td>late</td>
<td>24</td>
<td>14.6</td>
</tr>
<tr>
<td>8</td>
<td>Days to maturity</td>
<td>medium</td>
<td>115</td>
<td>70.0</td>
<td>late</td>
<td>45</td>
<td>27.4</td>
</tr>
<tr>
<td>9</td>
<td>Filling period</td>
<td>long</td>
<td>25</td>
<td>15.2</td>
<td>short</td>
<td>21</td>
<td>12.8</td>
</tr>
<tr>
<td>10</td>
<td>Awnedness</td>
<td>awned</td>
<td>162</td>
<td>98.8</td>
<td>awnless</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>11</td>
<td>Awns length</td>
<td>long</td>
<td>9</td>
<td>5.5</td>
<td>short</td>
<td>29</td>
<td>17.7</td>
</tr>
<tr>
<td>2</td>
<td>Glaucousness</td>
<td>strong</td>
<td>139</td>
<td>84.8</td>
<td>absence</td>
<td>25</td>
<td>15.2</td>
</tr>
<tr>
<td>3</td>
<td>Flag leaf area</td>
<td>large</td>
<td>23</td>
<td>14.0</td>
<td>small</td>
<td>26</td>
<td>15.9</td>
</tr>
<tr>
<td>14</td>
<td>Early vigor</td>
<td>excellent</td>
<td>145</td>
<td>88.4</td>
<td>poor</td>
<td>2</td>
<td>1.2</td>
</tr>
<tr>
<td>15</td>
<td>Growth habit</td>
<td>erect</td>
<td>164</td>
<td>100</td>
<td>prostrate</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>16</td>
<td>No. of spikes/m²</td>
<td>high</td>
<td>26</td>
<td>15.9</td>
<td>low</td>
<td>24</td>
<td>14.6</td>
</tr>
<tr>
<td>17</td>
<td>No. of tillers/plant</td>
<td>high</td>
<td>22</td>
<td>13.4</td>
<td>low</td>
<td>19</td>
<td>11.6</td>
</tr>
<tr>
<td>18</td>
<td>Plant height</td>
<td>tall</td>
<td>15</td>
<td>9.2</td>
<td>short</td>
<td>14</td>
<td>8.5</td>
</tr>
<tr>
<td>19</td>
<td>Peduncle length</td>
<td>long</td>
<td>26</td>
<td>15.9</td>
<td>short</td>
<td>19</td>
<td>11.6</td>
</tr>
</tbody>
</table>
Table 8. Phenotypic diversity index (H') of 25 characters for 164 collected landrace populations from Jordan.

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

References


Prevalence of Karnal Bunt in Wheat Seed Lots in Pakistan

A.R. Bhutta\textsuperscript{1}, A. Hussain\textsuperscript{1} and I. Ahmad\textsuperscript{2}

\textsuperscript{1} Federal Seed Certification and Registration Department, G-9/4, Islamabad, 44000, PAKISTAN

\textsuperscript{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\slash94 to 1996\slash97. 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\slash95 to 1996\slash97. 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 (\textit{Tilletia indica} Mitra [Syn. Neovossia indica Mitra Mundkur]), is known to be a disease of economic significance in Afghanistan, India, Iraq, Mexico, Nepal and Pakistan (Mathur and Cunfer 1993). In Pakistan, this disease 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 Ilyas 1986).

Research, carried out from 1984\slash85 to 1992\slash93 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)
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 (Bhatta 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. 1985; Warham 1990).
Table 1. Incidence of karnal bunt (*Tilletia indica*) in wheat seed lots from 1993/94 to 1996/97 in Pakistan.

<table>
<thead>
<tr>
<th>Seed production regions</th>
<th>Cultivars</th>
<th>Infection percentage range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Punjab</td>
<td>Pak. 81</td>
<td>0.0-0.30</td>
</tr>
<tr>
<td>(Lahore, Sahiwal, Khanewal,</td>
<td>Fd 83</td>
<td>0.0-0.40</td>
</tr>
<tr>
<td>Sargodha)</td>
<td>Fd 85</td>
<td>0.0-3.00</td>
</tr>
<tr>
<td></td>
<td>Pb 85</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Pirsaabak 85</td>
<td>0.0-10</td>
</tr>
<tr>
<td></td>
<td>Pashan 90</td>
<td>0.0-0.20</td>
</tr>
<tr>
<td></td>
<td>Inqlab 91</td>
<td>0.0</td>
</tr>
<tr>
<td>Southern Punjab</td>
<td>Pak. 81</td>
<td>0.0-0.10</td>
</tr>
<tr>
<td>(Multan and R.Y. Khan)</td>
<td>Fd 83</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Fd 85</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Pb 85</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Pashan 90</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Inqlab 91</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Perwaz</td>
<td>(-)</td>
</tr>
<tr>
<td>Southern Parts</td>
<td>Jauhar 78</td>
<td>0.0</td>
</tr>
<tr>
<td>Sindhi (Sukkur, Sakrand and</td>
<td>Sindh 81</td>
<td>0.03</td>
</tr>
<tr>
<td>Hyderabad)</td>
<td>T.J-83</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Mehran 89</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Anmol 90</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Soghat 90</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Sarsabz</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Kiran 96</td>
<td>(-)</td>
</tr>
<tr>
<td>North West Parts-</td>
<td>Pak. 81</td>
<td>0.0-0.20</td>
</tr>
<tr>
<td>NWF (Peshawar and D.I. Khan)</td>
<td>Pirsaabak 85</td>
<td>0.03-3.00</td>
</tr>
<tr>
<td></td>
<td>Pirsaabak 91</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td>Fd 85</td>
<td>0.0-0.10</td>
</tr>
<tr>
<td></td>
<td>Khyber 87</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td>Bakhtawar</td>
<td>(-)</td>
</tr>
</tbody>
</table>

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 0.05 and 0.2% in seed, respectively).
Southern parts of the country were found free from kar nal 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, Pirsa bak 85, Fd 83, Blue Silver, and WI 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


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 gliadins 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-Zculi 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.

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 1 (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).

<table>
<thead>
<tr>
<th>Durum wheat accessions</th>
<th>Genotype composition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Zagorka</td>
<td>0.6</td>
</tr>
<tr>
<td>Chirpa</td>
<td>0.5</td>
</tr>
<tr>
<td>43/7</td>
<td>0.9</td>
</tr>
<tr>
<td>63/1</td>
<td>0.7</td>
</tr>
<tr>
<td>87/9</td>
<td>0.5</td>
</tr>
<tr>
<td>99/8</td>
<td>0.9</td>
</tr>
<tr>
<td>110/5</td>
<td>0.5</td>
</tr>
<tr>
<td>120/5</td>
<td>0.4</td>
</tr>
<tr>
<td>142/10</td>
<td>0.7</td>
</tr>
</tbody>
</table>

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


<table>
<thead>
<tr>
<th>Durum wheat accessions</th>
<th>Biotype</th>
<th>Spike length (cm)</th>
<th>No. of spikelets/spike</th>
<th>No. of seeds/spike</th>
<th>Kernel row weight/spike (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mean</td>
<td>difference</td>
<td>mean</td>
<td>difference</td>
</tr>
<tr>
<td>Zagorka</td>
<td>A</td>
<td>7.55</td>
<td></td>
<td>20.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>7.60</td>
<td>+0.05</td>
<td>21.1</td>
<td>+0.3</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>9.20</td>
<td>+1.65***</td>
<td>21.2</td>
<td>+0.4</td>
</tr>
<tr>
<td>Chirpan</td>
<td>A</td>
<td>8.35</td>
<td></td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>7.40</td>
<td>-0.95***</td>
<td>22.5</td>
<td>-2.1**</td>
</tr>
<tr>
<td>63/1</td>
<td>A</td>
<td>6.90</td>
<td></td>
<td>22.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8.90</td>
<td>+2.00**</td>
<td>24.6</td>
<td>+2.5**</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>7.10</td>
<td>+0.20</td>
<td>21.5</td>
<td>-0.6</td>
</tr>
<tr>
<td>87/9</td>
<td>A</td>
<td>7.75</td>
<td></td>
<td>21.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8.73</td>
<td>+0.98*</td>
<td>23.3</td>
<td>+1.4*</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>7.05</td>
<td>-0.70</td>
<td>21.7</td>
<td>-0.2</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>7.75</td>
<td></td>
<td>21.6</td>
<td>-0.3</td>
</tr>
<tr>
<td>99/8</td>
<td>A</td>
<td>9.15</td>
<td></td>
<td>24.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>7.95</td>
<td>-1.20**</td>
<td>22.2</td>
<td>-2.0**</td>
</tr>
<tr>
<td>110/5</td>
<td>A</td>
<td>8.00</td>
<td></td>
<td>20.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8.10</td>
<td>+0.10</td>
<td>22.8</td>
<td>+2.3**</td>
</tr>
<tr>
<td>120/5</td>
<td>A</td>
<td>8.55</td>
<td></td>
<td>22.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8.80</td>
<td>+0.25*</td>
<td>23.9</td>
<td>+1.3*</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>6.95</td>
<td>-1.60**</td>
<td>18.4</td>
<td>-4.2**</td>
</tr>
<tr>
<td>145/10</td>
<td>A</td>
<td>8.50</td>
<td></td>
<td>22.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8.65</td>
<td>+0.15</td>
<td>24.6</td>
<td>+2.4**</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>8.05</td>
<td>-0.45*</td>
<td>20.9</td>
<td>-1.3*</td>
</tr>
</tbody>
</table>

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

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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 x 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 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 Koëbner 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:

\[
CD = \text{Standard error (SE) difference} \times t \text{ error degree of freedom (df)}
\]

\[
= SE \times \sqrt{2} X t (0.05, 0.01) \text{ error degree of freedom}
\]

Standard error difference = \(2 \times VE/r\),

where \(VE = \text{Error variance}\), \(r = \text{replication}\)

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:

\[
\text{root: shoot ratio} = \frac{\text{Length of root (cm)}}{\text{Length of shoot (cm)}}
\]

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

\[
\text{GRI} = \sum Xn (h-n)
\]

Where \(Xn = \text{number of seeds germinated in the count}\)

\(h = \text{number of counts}\)

\(n = \text{count number}\)

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\(^{-1}\).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Germination percentage</th>
<th>Germination relative index (GRI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.35 (Control)</td>
<td>0.35 (Control)</td>
</tr>
<tr>
<td>Salt concentrations (dSm(^{-1}))</td>
<td>4 8 12 16 Mean (S)</td>
<td>4 8 12 16 Mean (S)</td>
</tr>
<tr>
<td>Unsoaked Control</td>
<td>81.28 (64.36)</td>
<td>135.86 (57.16)</td>
</tr>
<tr>
<td></td>
<td>76.45 (60.95)</td>
<td>124.69 (57.16)</td>
</tr>
<tr>
<td></td>
<td>70.78 (57.12)</td>
<td>117.62 (57.16)</td>
</tr>
<tr>
<td></td>
<td>64.24 (53.18)</td>
<td>110.13 (57.16)</td>
</tr>
<tr>
<td></td>
<td>56.84 (50.20)</td>
<td>97.68 (57.16)</td>
</tr>
<tr>
<td></td>
<td>69.92 (57.16)</td>
<td>117.20 (57.16)</td>
</tr>
<tr>
<td>Pre-sown seed soaking media:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>85.41 (67.12)</td>
<td>161.08 (57.79)</td>
</tr>
<tr>
<td></td>
<td>80.14 (63.52)</td>
<td>152.54 (57.79)</td>
</tr>
<tr>
<td></td>
<td>75.27 (60.08)</td>
<td>143.88 (57.79)</td>
</tr>
<tr>
<td></td>
<td>68.72 (56.10)</td>
<td>135.92 (57.79)</td>
</tr>
<tr>
<td></td>
<td>62.33 (52.14)</td>
<td>128.75 (57.79)</td>
</tr>
<tr>
<td></td>
<td>74.37 (57.79)</td>
<td>144.43 (57.79)</td>
</tr>
<tr>
<td>Sodium benzoate (50 ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>88.29 (70.08)</td>
<td>168.61 (62.61)</td>
</tr>
<tr>
<td></td>
<td>84.62 (66.90)</td>
<td>159.84 (62.61)</td>
</tr>
<tr>
<td></td>
<td>80.18 (63.84)</td>
<td>150.23 (62.61)</td>
</tr>
<tr>
<td></td>
<td>73.68 (58.23)</td>
<td>141.64 (62.61)</td>
</tr>
<tr>
<td></td>
<td>65.47 (54.01)</td>
<td>134.98 (62.61)</td>
</tr>
<tr>
<td></td>
<td>78.45 (62.61)</td>
<td>151.06 (62.61)</td>
</tr>
<tr>
<td>Calcium chloride (100 ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>94.65 (76.91)</td>
<td>197.24 (66.76)</td>
</tr>
<tr>
<td></td>
<td>89.17 (71.02)</td>
<td>185.43 (66.76)</td>
</tr>
<tr>
<td></td>
<td>83.64 (65.90)</td>
<td>176.31 (66.76)</td>
</tr>
<tr>
<td></td>
<td>77.72 (61.34)</td>
<td>169.12 (66.76)</td>
</tr>
<tr>
<td></td>
<td>73.85 (58.61)</td>
<td>157.28 (66.76)</td>
</tr>
<tr>
<td></td>
<td>83.81 (66.76)</td>
<td>177.08 (66.76)</td>
</tr>
<tr>
<td>Ascorbic acid (50 ppm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>90.52 (72.82)</td>
<td>176.41 (64.27)</td>
</tr>
<tr>
<td></td>
<td>86.13 (68.13)</td>
<td>169.28 (64.27)</td>
</tr>
<tr>
<td></td>
<td>81.27 (64.34)</td>
<td>160.17 (64.27)</td>
</tr>
<tr>
<td></td>
<td>74.62 (59.68)</td>
<td>149.23 (64.27)</td>
</tr>
<tr>
<td></td>
<td>69.14 (56.41)</td>
<td>141.47 (64.27)</td>
</tr>
<tr>
<td></td>
<td>80.34 (64.27)</td>
<td>159.31 (64.27)</td>
</tr>
<tr>
<td>Mean (T)</td>
<td>88.03 (70.26)</td>
<td>167.84 (54.19)</td>
</tr>
<tr>
<td></td>
<td>83.30 (66.10)</td>
<td>158.36 (54.19)</td>
</tr>
<tr>
<td></td>
<td>78.23 (62.26)</td>
<td>149.52 (54.19)</td>
</tr>
<tr>
<td></td>
<td>71.80 (57.91)</td>
<td>141.21 (54.19)</td>
</tr>
<tr>
<td></td>
<td>65.53 (54.19)</td>
<td>132.21 (54.19)</td>
</tr>
<tr>
<td>Factor</td>
<td>Salt concentration (S)</td>
<td>Salt concentration (S)</td>
</tr>
<tr>
<td></td>
<td>Treatment (T)</td>
<td>Treatment (T)</td>
</tr>
<tr>
<td></td>
<td>S × T</td>
<td>S × T</td>
</tr>
<tr>
<td>CD (P = 0.01)</td>
<td>1.98 (1.37)</td>
<td>1.22 (1.37)</td>
</tr>
<tr>
<td></td>
<td>1.98 (1.37)</td>
<td>1.22 (1.37)</td>
</tr>
<tr>
<td></td>
<td>6.12 (3.48)</td>
<td>3.84 (3.48)</td>
</tr>
</tbody>
</table>

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 water-soaked 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 degrade 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 different salt concentrations from 0.35 to 16 dS m⁻¹.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>(S)</th>
<th>(T)</th>
<th>S x T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>11.6</td>
<td>4.3</td>
<td>4.4</td>
<td>0.01</td>
</tr>
<tr>
<td>Sodium benzoate (50 ppm)</td>
<td>11.6</td>
<td>4.3</td>
<td>4.4</td>
<td>0.01</td>
</tr>
<tr>
<td>Calcium chloride (100 ppm)</td>
<td>11.6</td>
<td>4.3</td>
<td>4.4</td>
<td>0.01</td>
</tr>
<tr>
<td>Ascorbic acid (50 ppm)</td>
<td>11.6</td>
<td>4.3</td>
<td>4.4</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean (T)</td>
<td>11.6</td>
<td>4.3</td>
<td>4.4</td>
<td>0.01</td>
</tr>
</tbody>
</table>

CDP (P = 0.01)
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Salt concentrations (dSm⁻¹)</th>
<th>Root:Shoot ratio</th>
<th>Amylase activity (Unit mg⁻¹ fresh weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.35 (Control)</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Unsoaked Control</td>
<td></td>
<td>1.22</td>
<td>1.16</td>
</tr>
<tr>
<td>Pre-soaked seed soaking media:</td>
<td></td>
<td>1.24</td>
<td>1.20</td>
</tr>
<tr>
<td>Water</td>
<td>1.31</td>
<td>1.28</td>
<td>1.24</td>
</tr>
<tr>
<td>Sodium benzoate (50 ppm)</td>
<td>1.34</td>
<td>1.29</td>
<td>1.25</td>
</tr>
<tr>
<td>Calcium chloride (100 ppm)</td>
<td>1.32</td>
<td>1.30</td>
<td>1.24</td>
</tr>
<tr>
<td>Ascorbic acid (50 ppm)</td>
<td>1.29</td>
<td>1.25</td>
<td>1.20</td>
</tr>
<tr>
<td>Mean (T) Factor</td>
<td></td>
<td>1.40</td>
<td>1.40</td>
</tr>
</tbody>
</table>

CD (P = 0.01)

References


References

Analysis of variance showed highly significant salt concentration x treatment interaction indicating that seed soaking material required for cell growth and development. These improvements may be attributed to an increase in nutrient uptake and growth. This study also shows increased physiological activities and root proliferation increased at various physiological stages of growth through increased salt concentration and vigor and growth of seedlings. These might improve crop growth and yield as well as increase resistance to adverse effects of salt stresses.
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.


(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 possess an allelopathic potential (Worship 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 heterotoxic 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 rainfal 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 rehashed 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’.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Barley</th>
<th>Durum wheat</th>
<th>Bread wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract</td>
<td>3</td>
<td>5.8*</td>
<td>19.0*</td>
<td>3.4ns</td>
</tr>
<tr>
<td>Error</td>
<td>12</td>
<td>1.1</td>
<td>3.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

* 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’.

<table>
<thead>
<tr>
<th>Source of water-extract</th>
<th>Number of germinated seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Barley cv ‘Rihane-03’</td>
</tr>
<tr>
<td>Roots</td>
<td>23.8 a*</td>
</tr>
<tr>
<td>Control†</td>
<td>23.5 a</td>
</tr>
<tr>
<td>Stems</td>
<td>23.5 a</td>
</tr>
<tr>
<td>Leaves</td>
<td>21.8 b</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.6</td>
</tr>
</tbody>
</table>

† The treatment is only distilled water.  
* Means followed by different letters are significantly different at the 0.05 level of probability.

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.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Barley</th>
<th>Durum wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivar</td>
<td>2</td>
<td>32.2**</td>
<td>39.3**</td>
</tr>
<tr>
<td>Error</td>
<td>9</td>
<td>1.7</td>
<td>2.2</td>
</tr>
</tbody>
</table>

** 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.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Barley Number of germinated seeds</th>
<th>Durum wheat Number of germinated seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rihane-03</td>
<td>24.5 a*</td>
<td>Karim 17.0 a</td>
</tr>
<tr>
<td>Manel-92</td>
<td>24.3 a</td>
<td>Razzak 13.5 b</td>
</tr>
<tr>
<td>Roho</td>
<td>21.8 b</td>
<td>Khiar 10.8 c</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>2.1</td>
<td>LSD (0.05) 2.4</td>
</tr>
</tbody>
</table>

* 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 reduce 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
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 Aridiculture, 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-day-old 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 Bjorkman 1980; 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 (Sydny 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; Quin and Williams 1985).

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 1983; 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 35S 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 dry-crushed 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 μL 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 coomassie 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. cv 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 from 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 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 1. Autoradiogram of the total leaf proteins synthesized at control, heat shock, and four days after recovery.](image1)

![Figure 2. Autoradiogram of the thylakoid membrane proteins synthesized by leaf tissue at control, heat shock, and four days after recovery.](image2)
sent 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


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 striiformis 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 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 infecter 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 striformis* 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-defined 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 infectors and other established susceptible varieties like BHS169 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 yellow 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 moderately-resistant 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.

<table>
<thead>
<tr>
<th>Races Differential</th>
<th>24(0SO)</th>
<th>M(1SO)</th>
<th>G(4SO)</th>
<th>Q(5SO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese 166</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Heines kobew</td>
<td>R</td>
<td>S</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>T. dicocem t.</td>
<td>S</td>
<td>S</td>
<td>R</td>
<td>S</td>
</tr>
<tr>
<td>Barley local</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

S = susceptible; R = resistant

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

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Acc. No.</th>
<th>Origin‡</th>
<th>Yellow rust</th>
<th>Spot blotch</th>
<th>Net blotch</th>
<th>Stripe</th>
<th>Aphid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BCU24</td>
<td>E</td>
<td>0</td>
<td>I</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>BCU25</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>BCU26</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>BCU27</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>BCU35</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>BCU31</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>BCU127</td>
<td>E</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>BCU130</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
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<tr>
<td>9</td>
<td>BCU131</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>BCU133</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>BCU134</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>BCU135</td>
<td>I</td>
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<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>BCU167</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>BCU182</td>
<td>I</td>
<td>0</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>2</td>
</tr>
</tbody>
</table>

† 0-8 Scale = 0 = resistant, 8 = susceptible, F = free
‡ E= exotic; I= indigenous

![Weekly weather parameters during December 1995-April 1996 at Karnal (India)](image1)

![Weekly weather parameters during December 1996-April 1997 at Karnal (India)](image2)

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.

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

‡ Modified Cobb Scale
§ 0 = resistant; 8 = susceptible
t = traces; MR = moderately resistant

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

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Entry No.</th>
<th>Yellow rust</th>
<th>Aphid resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BCU21</td>
<td>tMS</td>
<td>tMS</td>
</tr>
<tr>
<td>2</td>
<td>BCU22</td>
<td>tR</td>
<td>tMR</td>
</tr>
<tr>
<td>3</td>
<td>BCU23</td>
<td>tMS</td>
<td>10MS</td>
</tr>
<tr>
<td>4</td>
<td>BCU28</td>
<td>15MS</td>
<td>15MS</td>
</tr>
<tr>
<td>5</td>
<td>BCU29</td>
<td>tMS</td>
<td>tS</td>
</tr>
<tr>
<td>6</td>
<td>BCU31</td>
<td>15MS</td>
<td>15S</td>
</tr>
<tr>
<td>7</td>
<td>BCU41</td>
<td>tMS</td>
<td>5MS</td>
</tr>
<tr>
<td>8</td>
<td>BCU53</td>
<td>MS</td>
<td>10MS</td>
</tr>
<tr>
<td>9</td>
<td>BCU79</td>
<td>tS</td>
<td>tMS</td>
</tr>
<tr>
<td>10</td>
<td>BCU125</td>
<td>tMR</td>
<td>10MS</td>
</tr>
<tr>
<td>11</td>
<td>BCU158</td>
<td>tMS</td>
<td>5MS</td>
</tr>
</tbody>
</table>

‡ Modified Cobb scale
t = traces; S = susceptible; R = resistant

Classification of accession on the basis of disease reaction.

<table>
<thead>
<tr>
<th>Accession Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod. Susceptible</td>
<td>22%</td>
</tr>
<tr>
<td>Mod. Resistant</td>
<td>8%</td>
</tr>
<tr>
<td>Immune/Resistant</td>
<td>14%</td>
</tr>
<tr>
<td>Susceptible</td>
<td>124%</td>
</tr>
</tbody>
</table>

References


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-
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).

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

* 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.

<table>
<thead>
<tr>
<th>Character</th>
<th>Range</th>
<th>Mean</th>
<th>S.E.±</th>
<th>Sign. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to heading</td>
<td>53-59</td>
<td>61</td>
<td>1</td>
<td>**</td>
</tr>
<tr>
<td>Days to maturity</td>
<td>91-105</td>
<td>100</td>
<td>2</td>
<td>**</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>70-87</td>
<td>81</td>
<td>97</td>
<td>**</td>
</tr>
<tr>
<td>No. of spikes/m²</td>
<td>301-570</td>
<td>414</td>
<td>36</td>
<td>**</td>
</tr>
<tr>
<td>No. of seeds/spikes</td>
<td>30-46</td>
<td>38</td>
<td>3</td>
<td>**</td>
</tr>
<tr>
<td>1000-kernel weight (gm)</td>
<td>37-53</td>
<td>46</td>
<td>2</td>
<td>**</td>
</tr>
<tr>
<td>Seed yield (t/ha)</td>
<td>2.1-3.1</td>
<td>2.6</td>
<td>0.3</td>
<td>*</td>
</tr>
</tbody>
</table>

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 Sln/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/ICARDA Nile Valley and Red Sea Regional Program on wheat are highly appreciated.

References


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

<table>
<thead>
<tr>
<th>Seed production locality</th>
<th>No. of samples tested</th>
<th>1993/94</th>
<th>1994/95</th>
<th>1995/96</th>
<th>1996/97</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fungi</td>
<td>Range (%)</td>
<td>No. of Samples tested</td>
<td>Fungi</td>
<td>Range (%)</td>
</tr>
<tr>
<td>Peshawar</td>
<td>5</td>
<td>Alternaria triticina 0.5-0.4</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Bipolaris sorokiniana 0.5-6.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Fusarium graminearum 0.5-2.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.5-0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>F. semiectum 0.5-4.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Islamabad</td>
<td>20</td>
<td>A. triticina 0.5-3.0</td>
<td>5</td>
<td>A.t.</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td></td>
<td>B. sorokiniana 0.0-3.0</td>
<td>B.s.</td>
<td>0.0-2.0</td>
<td>5</td>
<td>B.s.</td>
</tr>
<tr>
<td></td>
<td>F. graminearum 0.0-1.5</td>
<td>F.g.</td>
<td>0.0-2.5</td>
<td>5</td>
<td>F.g.</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.0-2.5</td>
<td>F.m.</td>
<td>0.0-1.5</td>
<td>5</td>
<td>F.m.</td>
</tr>
<tr>
<td></td>
<td>F. semiectum 0.5-2.0</td>
<td>F.s.</td>
<td>0.0-1.0</td>
<td>5</td>
<td>F.s.</td>
</tr>
<tr>
<td>Lahore</td>
<td>25</td>
<td>A. triticina 0.0-2.0</td>
<td>5</td>
<td>A.t.</td>
<td>0.0-1.5</td>
</tr>
<tr>
<td></td>
<td>B. sorokiniana 0.0-8.0</td>
<td>B.s.</td>
<td>0.5-5.0</td>
<td>5</td>
<td>B.s.</td>
</tr>
<tr>
<td></td>
<td>F. graminearum 0.0-1.5</td>
<td>F.g.</td>
<td>0.5-2.0</td>
<td>5</td>
<td>F.g.</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.0-1.5</td>
<td>F.m.</td>
<td>0.0-1.0</td>
<td>5</td>
<td>F.m.</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>25</td>
<td>A. triticina 0.0-2.0</td>
<td>5</td>
<td>A.t.</td>
<td>0.0-1.5</td>
</tr>
<tr>
<td></td>
<td>B. sorokiniana 0.0-8.0</td>
<td>B.s.</td>
<td>0.5-5.0</td>
<td>5</td>
<td>B.s.</td>
</tr>
<tr>
<td></td>
<td>F. graminearum 0.0-1.5</td>
<td>F.g.</td>
<td>0.5-2.0</td>
<td>5</td>
<td>F.g.</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.0-1.5</td>
<td>F.m.</td>
<td>0.0-1.0</td>
<td>5</td>
<td>F.m.</td>
</tr>
<tr>
<td>Sargodha</td>
<td>5</td>
<td>A. triticina 0.0-1.0</td>
<td>6</td>
<td>B.s.</td>
<td>1.0-10.0</td>
</tr>
<tr>
<td></td>
<td>B. sorokiniana 2.0-11.0</td>
<td>F.g.</td>
<td>0.5-1.0</td>
<td>5</td>
<td>B.s.</td>
</tr>
<tr>
<td></td>
<td>F. graminearum 0.5-3.0</td>
<td>F.m.</td>
<td>0.0-2.0</td>
<td>5</td>
<td>F.g.</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.0-2.0</td>
<td>F.s.</td>
<td>0.0-1.0</td>
<td>5</td>
<td>F.s.</td>
</tr>
<tr>
<td>Multan</td>
<td>30</td>
<td>B. sorokiniana 0.0-1.0</td>
<td>6</td>
<td>B.s.</td>
<td>0.0-0.5</td>
</tr>
<tr>
<td></td>
<td>F. moniliforme 0.0-0.5</td>
<td>F.m.</td>
<td>0.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>F. semiectum 0.0-1.0</td>
<td>F.s.</td>
<td>0.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sakrand</td>
<td>-</td>
<td>B. sorokiniana 0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>15</td>
<td>B. sorokiniana 0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>-</td>
<td>40</td>
<td>-</td>
<td>67</td>
</tr>
</tbody>
</table>
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


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 × 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 (Mahalanobis D² statistic) has been used in spring wheat (Bhatt 1970; Singhal and Upadhyay 1977; Jatsara 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.

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 F-test 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 × VII and I × 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.

<table>
<thead>
<tr>
<th>Character</th>
<th>Mean check</th>
<th>CV</th>
<th>Mean</th>
<th>Origin</th>
<th>Value Group</th>
<th>Name</th>
<th>Value Group</th>
<th>Name</th>
<th>Origin</th>
<th>Value Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 50% heading</td>
<td>163.18</td>
<td>149.00</td>
<td>9.60</td>
<td>70 Lina</td>
<td>BOLAL</td>
<td>SYRIA-CIT</td>
<td>IV</td>
<td>BUL7-BC.P2.11</td>
<td>IV</td>
<td>BUL 554.2</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>101.68</td>
<td>103.3</td>
<td>11.96</td>
<td>YUMAL15.</td>
<td>BULGARIA</td>
<td>BULGARIA</td>
<td>II</td>
<td>BUL 1518.4.38</td>
<td>II</td>
<td>BULGARIA</td>
</tr>
<tr>
<td>Grain yield (g/plot)</td>
<td>544.37</td>
<td>609.6</td>
<td>30.36</td>
<td>MVMA</td>
<td>BULGARIA</td>
<td>BULGARIA</td>
<td>VII</td>
<td>ID13/MT371/T/</td>
<td>VII</td>
<td>BULGARIA</td>
</tr>
<tr>
<td>Test weight (g)</td>
<td>40.2</td>
<td>44.13</td>
<td>11.79</td>
<td>BUL213/BG.P2.4</td>
<td>BULGARIA</td>
<td>BULGARIA</td>
<td>IX</td>
<td>LCR/SEIKI/3/MEX</td>
<td>IX</td>
<td>BULGARIA</td>
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</table>
Table 2. Eigen root vector, eigen roots and associated variances for different components in wheat germplasm.

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

Table 3. Characters in different clusters of wheat.

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

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

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

Acknowledgement

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

References


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 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 SL/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 non-grazed 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°5' E, 995 m above sea level, 513 mm long-term annual precipitation) in 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 P₂O₅/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

---

1 SL = 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.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Treatment</th>
<th>Grain yield (kg/ha)</th>
<th>Straw yield (%)</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planting time</td>
<td>Grazing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER/Apm</td>
<td>early</td>
<td>no</td>
<td>3054</td>
<td>7622</td>
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<tr>
<td>Rihane-03</td>
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<td>6050</td>
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<td>yes</td>
<td>2794</td>
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<tr>
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<td>Rihane-03</td>
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<td>3038</td>
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<tr>
<td>LSD (5%)</td>
<td></td>
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<td>1720</td>
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</table>

Treatment mean

<table>
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<tr>
<th></th>
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<th>Grazing</th>
<th>Grain yield (kg/ha)</th>
<th>Straw yield (%)</th>
<th>Harvest index</th>
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<tr>
<td>LSD (5%)</td>
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<td>1216</td>
<td>10</td>
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</table>

Cultivar mean

<p>| | | | | | |</p>
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<th></th>
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<tbody>
<tr>
<td>ER/Apm</td>
<td></td>
<td></td>
<td>2822</td>
<td>5321</td>
<td>36</td>
</tr>
<tr>
<td>Rihane-03</td>
<td></td>
<td></td>
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<td>4734</td>
<td>46</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td></td>
<td></td>
<td>1023</td>
<td>ns</td>
<td>8</td>
</tr>
</tbody>
</table>

ns: not significant at 5% level.

**References**


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

M.A. Chowdhry, N. Mahmood, T.R. Rashad, and I. Khalid
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. Momyo and Whittington (1973) found that the flag leaf area is an indicator of potential grain yield in wheat. Therefore, 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 (Dumayrri 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 Ayenifies 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 split-plot 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 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).

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>DF</th>
<th>Flag leaf area</th>
<th>Leaf venation</th>
<th>Stomatal frequency</th>
<th>Plant height (cm)</th>
<th>Spike length (cm)</th>
<th>No. spikelets/spike</th>
<th>No. grains/spike</th>
<th>1000-grain weight (g)</th>
<th>Grain yield/plant (g)</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.12</td>
<td>0.002</td>
<td>0.417</td>
<td>0.43</td>
<td>0.509</td>
<td>1.09</td>
<td>0.34</td>
<td>3.23</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Varieties (V)</td>
<td>9</td>
<td>66.32**</td>
<td>0.368</td>
<td>0.925**</td>
<td>297.97**</td>
<td>3.882**</td>
<td>18.55**</td>
<td>407.45**</td>
<td>115.94**</td>
<td>61.44**</td>
<td>9.78**</td>
</tr>
<tr>
<td>Error</td>
<td>18</td>
<td>0.50</td>
<td>0.168</td>
<td>0.139</td>
<td>0.85</td>
<td>0.265</td>
<td>0.19</td>
<td>0.67</td>
<td>4.05</td>
<td>0.16</td>
<td>0.23</td>
</tr>
<tr>
<td>Treatments (T)</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>84.04**</td>
<td>9.576**</td>
<td>0.01</td>
<td>167.53**</td>
<td>288.42**</td>
<td>161.51**</td>
<td>23.29**</td>
</tr>
<tr>
<td>V × T</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9.58**</td>
<td>0.124</td>
<td>0.02</td>
<td>10.66**</td>
<td>22.78</td>
<td>12.29**</td>
<td>1.21**</td>
</tr>
<tr>
<td>Error</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.69</td>
<td>0.104</td>
<td>0.23</td>
<td>2.24</td>
<td>0.11</td>
<td>0.41</td>
<td></td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Varieties/lines</th>
<th>FLA (cm²)</th>
<th>Plant height (cm)</th>
<th>Spike length (cm)</th>
<th>No. spikelets/ spike</th>
<th>No. grains/ spike</th>
<th>1000-grain weight (g)</th>
<th>Grain yield/plant (g)</th>
<th>Protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU26S</td>
<td>32.8c</td>
<td>100.7</td>
<td>99.9</td>
<td>0.8*</td>
<td>11.9</td>
<td>11.1</td>
<td>0.8*</td>
<td>18.8</td>
</tr>
<tr>
<td>Pashan 90</td>
<td>27.4f</td>
<td>97.7</td>
<td>96.5</td>
<td>1.1</td>
<td>12.4</td>
<td>11.3</td>
<td>1.1*</td>
<td>22.9</td>
</tr>
<tr>
<td>Inqaal 90</td>
<td>22.7h</td>
<td>98.6</td>
<td>96.2</td>
<td>2.4*</td>
<td>11.9</td>
<td>11.1</td>
<td>0.8*</td>
<td>21.6</td>
</tr>
<tr>
<td>Pak. 81</td>
<td>20.5g</td>
<td>104.9</td>
<td>104.4</td>
<td>0.5</td>
<td>11.3</td>
<td>10.6</td>
<td>0.7*</td>
<td>23.1</td>
</tr>
<tr>
<td>4072</td>
<td>35.7ab</td>
<td>114.3</td>
<td>110.3</td>
<td>4.0*</td>
<td>12.2</td>
<td>11.8</td>
<td>0.4</td>
<td>23.5</td>
</tr>
<tr>
<td>Rohitas 90</td>
<td>29.2e</td>
<td>96.2</td>
<td>95.7</td>
<td>0.5</td>
<td>11.4</td>
<td>10.9</td>
<td>0.7*</td>
<td>23.7</td>
</tr>
<tr>
<td>Kohimoor 83</td>
<td>36.6a</td>
<td>109.4</td>
<td>101.1</td>
<td>8.2*</td>
<td>12.4</td>
<td>11.4</td>
<td>1.0*</td>
<td>21.8</td>
</tr>
<tr>
<td>5039</td>
<td>28.2ef</td>
<td>110.1</td>
<td>108.8</td>
<td>1.3</td>
<td>11.7</td>
<td>10.0</td>
<td>0.7*</td>
<td>21.6</td>
</tr>
<tr>
<td>Punjab 85</td>
<td>30.7d</td>
<td>92.2</td>
<td>91.9</td>
<td>0.4</td>
<td>11.7</td>
<td>10.4</td>
<td>1.4*</td>
<td>20.8</td>
</tr>
<tr>
<td>Faisalabad 83</td>
<td>34.6b</td>
<td>113.6</td>
<td>109.2</td>
<td>4.4*</td>
<td>14.0</td>
<td>13.4</td>
<td>0.6*</td>
<td>25.0</td>
</tr>
<tr>
<td>Mean</td>
<td>30.0</td>
<td>103.8</td>
<td>101.4</td>
<td>2.4</td>
<td>12.1</td>
<td>11.3</td>
<td>0.8</td>
<td>22.3</td>
</tr>
<tr>
<td>Overall increase (+) or decrease (-)</td>
<td>-2.3%</td>
<td>-6.1%</td>
<td>+0.1%</td>
<td>-4.8%</td>
<td>-10.4%</td>
<td>-10.8%</td>
<td>9.9%</td>
<td></td>
</tr>
</tbody>
</table>

FLA = Flag leaf area
* Significant at $P \leq 0.05$. 
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.

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

*, ** Significant at $P = \leq 0.05$ and $0.01$, respectively.

References


Gene Effects for Yield and its Components in Wheat

R.K. Yadav¹ and V.G. Narsinghani²

¹ Regional Agricultural Research Station, Boirdadar, Raigrah (M.P.) 496 001, INDIA
² Department of Plant Breeding & Genetics, J.N.K.V. College of Agriculture, Jabalpur (M.P.) 482 004, INDIA

Abstract:

Using the means of P₁, P₂, F₁, BC₁, BC₂ and F₂ 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 these traits in JWJ 866 × 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 × Raj 1555, JWJ 2914 × HI 1077, HUW 201 × GW 190 and JWJ 866 × 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, viz. both parents, F₁, F₂, BC₁ (F₁ × Parent 1) and BC₂ (F₁ × 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-centimetre long rows spaced at 20 cm and 10 cm between and within rows, respectively. The plots received 80 kg N, 60 kg P₂O₅ and 40 kg K₂O/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 × 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 × HI 1077; for days to heading, plant height,
Table 1. Gene effects for yield and its components in crosses of wheat.

<table>
<thead>
<tr>
<th>Character</th>
<th>Cross</th>
<th>(m)</th>
<th>(d)</th>
<th>(h)</th>
<th>(i)</th>
<th>(j)</th>
<th>(l)</th>
<th>Type of epistasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to heading</td>
<td>C1</td>
<td>79.50**</td>
<td>-01.50</td>
<td>-44.25**</td>
<td>-45.00**</td>
<td>-72.50</td>
<td>68.50**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>80.00**</td>
<td>-12.00**</td>
<td>-08.28</td>
<td>-30.00**</td>
<td>05.25</td>
<td>42.50</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>78.00**</td>
<td>-08.50**</td>
<td>-04.50</td>
<td>-27.00**</td>
<td>-06.00**</td>
<td>31.00**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>78.00**</td>
<td>08.50**</td>
<td>-04.45</td>
<td>13.00</td>
<td>07.75*</td>
<td>01.85</td>
<td>D</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>C1</td>
<td>96.05</td>
<td>01.33**</td>
<td>15.96</td>
<td>-86.22**</td>
<td>-13.70</td>
<td>131.93*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>112.50**</td>
<td>00.16</td>
<td>-118.45**</td>
<td>-121.68**</td>
<td>01.44</td>
<td>176.91*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>117.27**</td>
<td>-17.91*</td>
<td>-50.24</td>
<td>-150.29**</td>
<td>-08.16</td>
<td>170.39**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>115.00</td>
<td>02.99</td>
<td>-25.98</td>
<td>-60.00**</td>
<td>08.97</td>
<td>65.96*</td>
<td>D</td>
</tr>
<tr>
<td>No. tillers/plant</td>
<td>C1</td>
<td>09.81**</td>
<td>-10.33**</td>
<td>-02.06</td>
<td>-25.21**</td>
<td>-01.33</td>
<td>31.92*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>10.82**</td>
<td>29.67</td>
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<td>-38.12</td>
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</tr>
<tr>
<td></td>
<td>C3</td>
<td>10.24**</td>
<td>-11.33**</td>
<td>-09.03</td>
<td>-16.97</td>
<td>-01.07</td>
<td>19.11*</td>
<td>D</td>
</tr>
<tr>
<td>Spike length (cm)</td>
<td>C1</td>
<td>11.45**</td>
<td>-11.33**</td>
<td>-14.45*</td>
<td>-16.48*</td>
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<td>28.77*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>11.45**</td>
<td>-11.33**</td>
<td>-14.45*</td>
<td>-16.48*</td>
<td>02.89</td>
<td>28.77*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>11.00**</td>
<td>-01.15</td>
<td>-09.56*</td>
<td>-09.17**</td>
<td>-00.13</td>
<td>10.83*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>11.87**</td>
<td>11.34**</td>
<td>02.63</td>
<td>01.82</td>
<td>-01.82</td>
<td>07.23*</td>
<td>C</td>
</tr>
<tr>
<td>No. spikelets/spike</td>
<td>C1</td>
<td>22.10**</td>
<td>-12.16**</td>
<td>109.31</td>
<td>-32.74**</td>
<td>-01.60</td>
<td>38.23*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>22.10**</td>
<td>-10.49**</td>
<td>-38.65**</td>
<td>-40.07**</td>
<td>-01.65</td>
<td>62.14**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>20.90**</td>
<td>-01.83</td>
<td>-02.06</td>
<td>-20.61**</td>
<td>-02.79**</td>
<td>27.72**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>21.90**</td>
<td>-12.16**</td>
<td>-11.81*</td>
<td>-20.61**</td>
<td>-01.12</td>
<td>38.02**</td>
<td>D</td>
</tr>
<tr>
<td>No. grains/spike</td>
<td>C1</td>
<td>57.69**</td>
<td>05.44**</td>
<td>14.21</td>
<td>11.17</td>
<td>06.17*</td>
<td>-31.20*</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>60.43**</td>
<td>03.79</td>
<td>-03.75</td>
<td>-05.63</td>
<td>00.29</td>
<td>19.84</td>
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<td></td>
<td>C3</td>
<td>62.42**</td>
<td>13.34**</td>
<td>-12.01</td>
<td>-13.02</td>
<td>02.79</td>
<td>06.13</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>55.18**</td>
<td>-12.10*</td>
<td>14.71*</td>
<td>11.84</td>
<td>-02.21</td>
<td>-15.64</td>
<td>D</td>
</tr>
<tr>
<td>1000-grain weight (g)</td>
<td>C1</td>
<td>32.87**</td>
<td>16.27**</td>
<td>-24.77</td>
<td>-22.00</td>
<td>-07.85</td>
<td>73.05</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>32.87**</td>
<td>16.27**</td>
<td>-24.77</td>
<td>-22.00</td>
<td>-07.85</td>
<td>73.05</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>42.50**</td>
<td>-14.25**</td>
<td>-33.93*</td>
<td>-33.85*</td>
<td>-00.37</td>
<td>53.07**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>37.50**</td>
<td>-19.95**</td>
<td>25.64</td>
<td>13.93</td>
<td>-15.66**</td>
<td>-35.28</td>
<td>D</td>
</tr>
<tr>
<td>Grain yield/plant (g)</td>
<td>C1</td>
<td>11.75**</td>
<td>-06.94**</td>
<td>-03.78</td>
<td>-34.30**</td>
<td>00.90</td>
<td>41.84**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>17.87**</td>
<td>22.67**</td>
<td>-28.06</td>
<td>-26.34</td>
<td>11.91</td>
<td>01.89</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>17.65**</td>
<td>-02.53*</td>
<td>-04.97</td>
<td>-46.71**</td>
<td>01.01</td>
<td>59.34**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>20.74**</td>
<td>06.15**</td>
<td>-06.01</td>
<td>64.77**</td>
<td>00.39</td>
<td>89.64**</td>
<td>C</td>
</tr>
<tr>
<td>Biological yield/plant (g)</td>
<td>C1</td>
<td>34.29**</td>
<td>04.72**</td>
<td>-10.07</td>
<td>-20.97**</td>
<td>00.76</td>
<td>27.26**</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>43.50**</td>
<td>11.57</td>
<td>-38.09**</td>
<td>-37.46</td>
<td>11.04</td>
<td>57.87</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>44.99**</td>
<td>-03.92*</td>
<td>-28.16</td>
<td>-05.83</td>
<td>-02.09</td>
<td>47.20**</td>
<td>D</td>
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<tr>
<td></td>
<td>C4</td>
<td>38.91**</td>
<td>-00.82</td>
<td>-10.28</td>
<td>01.08</td>
<td>-01.70</td>
<td>25.48*</td>
<td>D</td>
</tr>
</tbody>
</table>

* Significant at 5% levels, respectively.
** Significant at 1% levels, respectively.
C1 = A 206 x Raj 1555; C2 = JWJ 2914 x HI 1077; C3 = HUW 201 x GW 190; C4 = JWJ 866 x GW 190.
m = Mean; d = Additive gene effects; h = Dominance gene effects; i = Additive x additive gene interactions; j = Additive x dominance gene interactions;
I = Dominance x 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 × 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 × GW 190.

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


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

P. Oudhia and R.S. Tripathi
Department of Agronomy, College of Agriculture, IGAR, 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/w 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 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 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/w of plant material and water, respectively. The weed parts were decayed at 28±2°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>
<thead>
<tr>
<th>Source</th>
<th>120 hours</th>
<th>Decaying Period</th>
<th>216 hours</th>
<th>264 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 DAS</td>
<td>168 hours</td>
<td>216 hours</td>
<td>264 hours</td>
</tr>
<tr>
<td>Root</td>
<td>1.40(6.80)</td>
<td>30.60(33.58)</td>
<td>31.90(34.33)</td>
<td>7.70(16.11)</td>
</tr>
<tr>
<td>Stem</td>
<td>0.68(4.73)</td>
<td>30.00(33.21)</td>
<td>20.60(26.99)</td>
<td>19.80(26.42)</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.22(2.69)</td>
<td>9.20(17.66)</td>
<td>25.10(30.07)</td>
<td>17.50(24.73)</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>0.00(1.00)</td>
<td>25.20(30.13)</td>
<td>19.80(26.42)</td>
<td>15.90(23.50)</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td>32.40(30.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td>4.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>50.00(45.00)</td>
<td>51.30(45.75)</td>
<td>62.00(51.94)</td>
<td>54.00(47.29)</td>
</tr>
<tr>
<td>Stem</td>
<td>58.70(50.01)</td>
<td>49.30(44.60)</td>
<td>28.50(32.27)</td>
<td>65.30(53.91)</td>
</tr>
<tr>
<td>Leaf</td>
<td>08.50(16.95)</td>
<td>44.60(41.90)</td>
<td>62.00(51.94)</td>
<td>56.00(48.45)</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>06.60(14.89)</td>
<td>57.30(49.20)</td>
<td>42.60(40.74)</td>
<td>55.40(48.10)</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td>65.80(54.21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td>4.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>64.00(53.13)</td>
<td>51.30(45.75)</td>
<td>84.10(66.50)</td>
<td>69.30(56.35)</td>
</tr>
<tr>
<td>Stem</td>
<td>71.40(57.67)</td>
<td>62.00(51.94)</td>
<td>78.80(62.58)</td>
<td>90.70(72.24)</td>
</tr>
<tr>
<td>Leaf</td>
<td>30.60(33.58)</td>
<td>52.00(46.15)</td>
<td>74.10(59.41)</td>
<td>56.40(48.45)</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>31.90(34.39)</td>
<td>60.00(50.77)</td>
<td>50.60(45.34)</td>
<td>74.10(59.41)</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td>69.80(56.66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td>4.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>69.30(56.35)</td>
<td>51.30(45.75)</td>
<td>84.10(66.50)</td>
<td>71.40(57.67)</td>
</tr>
<tr>
<td>Stem</td>
<td>71.40(57.67)</td>
<td>62.00(51.94)</td>
<td>78.80(62.58)</td>
<td>90.70(72.24)</td>
</tr>
<tr>
<td>Leaf</td>
<td>63.30(52.71)</td>
<td>61.30(51.53)</td>
<td>76.90(61.27)</td>
<td>74.00(59.34)</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>62.20(52.71)</td>
<td>63.40(52.77)</td>
<td>75.40(60.27)</td>
<td>80.10(63.44)</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td>78.00(62.03)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td>4.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Source</th>
<th>120 hours</th>
<th>168 hours</th>
<th>216 hours</th>
<th>264 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot length (cm/plant)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>17.23</td>
<td>11.51</td>
<td>8.25</td>
<td>15.09</td>
</tr>
<tr>
<td>Stem</td>
<td>17.69</td>
<td>13.75</td>
<td>16.29</td>
<td>17.58</td>
</tr>
<tr>
<td>Leaf</td>
<td>5.08</td>
<td>15.19</td>
<td>20.73</td>
<td>19.00</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>10.58</td>
<td>16.66</td>
<td>17.33</td>
<td>17.43</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td></td>
<td>16.83</td>
<td>2.76</td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root length (cm/plant)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>9.93</td>
<td>9.74</td>
<td>14.75</td>
<td>10.85</td>
</tr>
<tr>
<td>Stem</td>
<td>12.06</td>
<td>10.44</td>
<td>2.30</td>
<td>11.71</td>
</tr>
<tr>
<td>Leaf</td>
<td>16.90</td>
<td>12.73</td>
<td>12.30</td>
<td>10.93</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>13.74</td>
<td>12.39</td>
<td>10.13</td>
<td>9.88</td>
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<tr>
<td>Control (water)</td>
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<td>11.79</td>
<td>1.86</td>
</tr>
<tr>
<td>CD at 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot:Root ratio (length wise)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root</td>
<td>1.73</td>
<td>1.18</td>
<td>0.56</td>
<td>1.39</td>
</tr>
<tr>
<td>Stem</td>
<td>1.47</td>
<td>1.31</td>
<td>1.35</td>
<td>1.50</td>
</tr>
<tr>
<td>Leaf</td>
<td>0.29</td>
<td>1.19</td>
<td>1.82</td>
<td>1.74</td>
</tr>
<tr>
<td>Stem+Leaf</td>
<td>0.77</td>
<td>1.34</td>
<td>1.68</td>
<td>1.76</td>
</tr>
<tr>
<td>Control (water)</td>
<td></td>
<td></td>
<td>1.42</td>
<td>0.24</td>
</tr>
</tbody>
</table>

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


Short Communication

First Steps in Barley Improvement in Armenia

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

¹Department of Science, Information and New Technology Introduction, Ministry of Agriculture, ARMENIA
²ICARDA-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 (ICARDA).

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 agro-climatic zones. The evaluation of ICARDA barley nursery 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 locally-developed variety Gyumri, Nutans 115 (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 plump 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).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Grain yield (kg/ha)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Check</td>
<td>%</td>
</tr>
<tr>
<td>Rainfed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutans 115</td>
<td>1670</td>
<td>100</td>
</tr>
<tr>
<td>Gyumri</td>
<td>1330</td>
<td>80</td>
</tr>
<tr>
<td>Vicont</td>
<td>1420</td>
<td>85</td>
</tr>
<tr>
<td>Rubicon</td>
<td>1320</td>
<td>79</td>
</tr>
<tr>
<td>Mamluk</td>
<td>1980</td>
<td>118</td>
</tr>
<tr>
<td>LSD 0.5</td>
<td>160-190</td>
<td></td>
</tr>
<tr>
<td>Supplementary irrigation</td>
<td></td>
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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.ciehac.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: bhngt@aol.com

Mendel Centenary Congress, Brno, Czech Republic, 7-9 March.
Info: Mendel University, c/o O. Chloupek, Zemedelska 1, CZ-61300 Brno, Czech Republic
Fax. 42054513302

Seminar on Durum Wheat Improvement in the Mediterranean Region: New Challenges, Zaragoza, Spain, 12-14 April.
Info: Instituto Agronómico Mediterráneo de Zaragoza, Apartado 202, E-50080 Zaragoza, Spain
Tel.: +34976576013
Fax: +34976576377
E-mail: iamz@iamz.ciehac.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: 6iwcz@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 Québec, Canada, 18-24 June.
Info: Congress Secretariat, ISPMB.
c/o Agora Communocation Inc.
2600, boulevard Laurier (Suite 2680)
Saint-Foy, QC G1V 4M6 Canada
Tel.: +1 418 658 6755
Fax. +1 418 658 8850
E-mail: ispbmb@agroacom.qc.ca


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/Yvette, France
Fax.: +33169332340
E-mail: eucarpia@moulon.inra.fr
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 Tuesday, 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 Granner, 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 Jefferyes, 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, Du Pont, 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 fceaton@ozemail.com.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.

- 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 to be presented at the Sixth International Wheat Conference to be held in Budapest, Hungary, 4-9 June 2000.


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.

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@cgiar.org

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.

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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 ICARDA-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
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