Genotypic variation for frost tolerance in winter wheat

Ram Sharma, Amir Amanov, Zafar Ziyaev, Esbosin Sadikov, Jozef Turok, Michael Baum

1ICARDA, 2Uzbek Res. Inst. of Plant Industry, 3Karakalpakstan Res. Inst. of Crop Husbandry

2nd International Plant Breeding Congress, 1-5 November, Antalya, Turkey
Scope of presentation

- Frost as a constraint to winter wheat production
- Germplasm evaluation
- Frost management
- Successes – tolerant lines and varieties
Research Site

CGIAR Research Program on Dryland Systems (CRP1.1) Action Site: Aral Sea Region

Temperatures: -20 to -30°C, without snow cover
Frost as a problem to winter wheat

Turkmenistan, 2013
-29°C, end February
Loss up to 100%

Tajikistan, 2014
-25°C, early March
Loss up to 100%

Uzbekistan, 2013
-15°C, end March
Loss up to 70%
Frost kill – 16 February 2015
Wheat crop without snow cover
Frost Damage: 31 March – 2 April 2015
Fergana, Uzbekistan
Wheat growing options for Aral Sea frost-prone zone

• Frost tolerant winter wheat varieties
• Heat tolerant spring wheat varieties (>40°C, 80 days maturity)
• Alternative crops
Methodology

• Annually evaluate 150 – 200 advanced breeding lines (since 2013)
  • Frost tolerance
  • Agronomic performance
  • Yield and quality

• Frost management through agronomic practices
  • Deeper than normal seeding depth for autumn and winter frost
  • Additional fertilization and irrigation for early spring frost
Genotypic variation for frost tolerance
Genotypic variation for frost tolerance
7 March 2014, Urgench, Uzbekistan

Tolerant

Moderately Tolerant
Genotypic variation for frost tolerance
2013, Urgench, Uzbekistan

17 of 150 lines were tolerant
### Variation for frost tolerance at two planting depths

150 genotypes evaluated

<table>
<thead>
<tr>
<th>Frost kill</th>
<th>Seedling depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-cm</td>
</tr>
<tr>
<td>Number of lines with ≤20% frost kill</td>
<td>97</td>
</tr>
<tr>
<td>Number of lines with ≤10% frost kill</td>
<td>75</td>
</tr>
</tbody>
</table>

4-cm seeding depth: 4 cm depth, 71% survived

2-cm seeding depth: 2 cm depth, 41% survived
## Variation for frost tolerance

21FAWWON-IRR

Aral Sea Region

Uzbekistan

2014

19 of 157 selected

<table>
<thead>
<tr>
<th>Entry number</th>
<th>Variety name</th>
<th>Frost kill (%)</th>
<th>Grain yield (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bezostaya 1 (check)</td>
<td>0</td>
<td>393</td>
</tr>
<tr>
<td>2</td>
<td>Seri (check)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sultan 95 (check)</td>
<td>0</td>
<td>197</td>
</tr>
<tr>
<td>4</td>
<td>Katia 1 (check)</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Konya (check)</td>
<td>0</td>
<td>435</td>
</tr>
<tr>
<td>6</td>
<td>Krasnodar 99</td>
<td>0</td>
<td>345</td>
</tr>
<tr>
<td>98</td>
<td>OK07214</td>
<td>0</td>
<td>645</td>
</tr>
<tr>
<td>96</td>
<td>F07098G1</td>
<td>0</td>
<td>521</td>
</tr>
<tr>
<td>99</td>
<td>OK07218</td>
<td>0</td>
<td>477</td>
</tr>
<tr>
<td>97</td>
<td>F07270G2</td>
<td>0</td>
<td>450</td>
</tr>
<tr>
<td>23</td>
<td>Jcam/Emu/Dove/3/Jgr/4/Thk/5/Boema</td>
<td>0</td>
<td>448</td>
</tr>
<tr>
<td>18</td>
<td>Polovchanka/Pehlivian</td>
<td>0</td>
<td>447</td>
</tr>
<tr>
<td>109</td>
<td>Grom</td>
<td>0</td>
<td>444</td>
</tr>
<tr>
<td>100</td>
<td>OK09634</td>
<td>0</td>
<td>428</td>
</tr>
</tbody>
</table>
Genotypic variation for frost tolerance
16 February 2015, Nukus, Uzbekistan

Sensitive   Tolerant   Moderately Tolerant

31 of 102 selected
Frost tolerant new winter wheat varieties, 2014 - 2015

Davlatle
Turkmenistan

Amudarya
Uzbekistan

Aral
Uzbekistan

VORONA/HD2402/6/VEE/TSI//GRK/3/NS55.03/5/C126.15/COFN/3/N10B/P14///P101/4/KRC67;
TCI 001482: -030YE-030YE-2E -0E-3AP-0AP

135U 6.1/5/CNDO/R143/
ENTE/MEXI75/3/AE.SQ/4/2*OCI,
CMSW01WM00832S: -030YE-30E-1E-0E-4E-0E

OK82282//BOW/NKT/3/F4105/4/KS97P0630-4-5
TCI 001557: -030YE-030YE-1E-0E -3E-0E
Tolerance to multiple abiotic stresses

- Frost tolerance
- Tolerance to medium level salinity (6 to 10 dS/m)
- Heat tolerance (temperature during grain filling >40°C)
- (Drought tolerance)
Salinity tolerant winter wheat (Davlatle)
Also tolerant to drought, heat and frost
Dashoguz, Turkmenistan

135U 6.1/5/CNDO/R143//ENTE/MEXI75/3/AE.SQ/4/2*OCI,
CMSW01WM00832S: -030YE-30E-1E-0E-4E-0E
Performance of frost tolerant new varieties

• Grain yield: 3 – 7 t/ha (30 to 100% higher than checks)
• Maturity: earlier than or similar to checks
• Quality related traits: Comparable to or better than checks
## Performance of frost tolerant new varieties

<table>
<thead>
<tr>
<th>Variety name</th>
<th>Grain yield (t/ha)</th>
<th>1000-kernel weight (g)</th>
<th>Plant height (cm)</th>
<th>Days to heading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davlatle</td>
<td>3.00</td>
<td>45</td>
<td>66</td>
<td>206</td>
</tr>
<tr>
<td>Krasnodar-99 (Improved Check)</td>
<td>2.00</td>
<td>47</td>
<td>56</td>
<td>212</td>
</tr>
<tr>
<td>Sahraýy (Old Local Check)</td>
<td>1.15</td>
<td>50</td>
<td>53</td>
<td>209</td>
</tr>
<tr>
<td>LSD_{0.05}</td>
<td>0.59</td>
<td>4</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>CV (%)</td>
<td>12.1</td>
<td>4.2</td>
<td>7</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Two new winter wheat varieties in Uzbekistan- 2015

<table>
<thead>
<tr>
<th>Entry name</th>
<th>Grain yield (t/ha)</th>
<th>1000-kernel weight (g)</th>
<th>Test weight (g/l)</th>
<th>Grain hardness (%)</th>
<th>Flour protein (%)</th>
<th>Flour gluten (%)</th>
<th>Days to heading</th>
<th>Plant height (cm)</th>
<th>Agronomic score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chimby 2014</td>
<td>Chimba y 2015</td>
<td>Urgench 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krasnodar-99</td>
<td>2.58</td>
<td>4.18</td>
<td>4.41</td>
<td>48.0</td>
<td>788</td>
<td>85</td>
<td>12.1</td>
<td>28.4</td>
<td>219</td>
</tr>
<tr>
<td>(check)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amudarya</td>
<td>4.20</td>
<td>5.58</td>
<td>5.66</td>
<td>50.2</td>
<td>806</td>
<td>86</td>
<td>13.0</td>
<td>26.4</td>
<td>220</td>
</tr>
<tr>
<td>Aral</td>
<td>2.99</td>
<td>6.30</td>
<td>5.68</td>
<td>50.5</td>
<td>792</td>
<td>81</td>
<td>11.7</td>
<td>28.6</td>
<td>218</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>1.53</td>
<td>0.86</td>
<td>0.97</td>
<td>5.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary

- Arrays of genotypic variation occurred among the winter wheat genotypes adapted to Central Asia and the advanced breeding lines introduced from IWWIP in Central Asia.

- Many frost tolerant genotypes also possessed superior agronomic and grain characteristics, which were advanced to further evaluations.

- Seeding depth significantly influenced frost survival.

- Three frost tolerant varieties (2 in Uzbekistan and 1 in Turkmenistan) have been identified.
Acknowledgements

• National wheat improvement programs in Uzbekistan, Turkmenistan and Tajikistan
• ICARDA
• CRP Dryland Systems
• CRP WHEAT
• International Winter Wheat Improvement Program (IWWIP)
Thank you for your attention!