Wheat Quality Improvement using Advanced Technology

Chris L. Miller, PhD
Director of Wheat Quality Research
Heartland Plant Innovations

Advanced Breeding Tools
- Doubled Haploid
- Marker Assisted Breeding
- Genomic Selection Modeling
- CRISPR-Cas9 Gene Editing
- Complex Trait Identification

Traditional Breeding Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Parent Cross</th>
<th>Create large and genetically diverse plant populations</th>
<th>Plant in field and select for traits of interest, Eliminate undesirable progeny</th>
<th>Test for yield and quality traits</th>
<th>Release for commercial production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F₀ Parent A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>F₁, Parent B</td>
<td>Pollen Donor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>F₁ Seed (AxB Cross)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Screen and eliminate ~90% of lines each year from 20,000-30,000 initial lines to 2-3 candidate lines for commercial release

Traditional Breeding: Parent Cross F₀
- Beginning Year 1
- Identify Parent Cross
- Emasculate Parent A
- Pollinate with Parent B
- ~200 F₀ Parent crosses per year

Generate F₂ Seed
- Each Cross yields ~20 F₁ Seeds
- When Planted Each F₁ Seed will produce ~ 5 heads with ~20 seeds per head yielding ~100 F₂ Seeds.
- Each parent cross yields ~2000 F₂ Seeds with a range of genetic diversity
Importance of Genetic Variation

• Small differences in the genetic sequence occur naturally.
• This natural variation leads to the observed differences between plants (or phenotypes)
• Visual phenotypes can be selected in the field.
• Quality phenotypes must be tested in the laboratory.

Identifying Agronomic Traits

• Drought Tolerance
• Disease Resistance
• Plant Height
• Heading Date
• Bushel Yield
• Milling Yield
• Flour Quality

Traditional Breeding with Doubled Haploid

Create genetically diverse population of genetically pure progeny

Traditional Breeding with Doubled Haploid and Marker Assisted Selection

Screen doubled haploids for presence or absence of genetic markers for value added traits. Eliminate undesirable lines

Complex Quality Trait Identification

• Traits with no biological relevance
• Coincidentally under genetic control
• Examples: Loaf Volume, Extensibility, Mix Stability...

Plants did not evolve for loaf volume!
The Future of Breeding for Quality

• Milling and Baking companies will be involved in wheat variety development
• Varieties will be developed with consumer focused traits.
• Human Health and Nutrition—resistant starch, complete proteins?
• Celiac Safe Wheat
• Product differentiation with flavor, texture and appearance.
• Varieties with superior processing traits. Higher extraction, improved mix stability, absorption, consistency

Summary

• Modern wheat breeding uses sophisticated tools to advance the traditional breeding process.
• Big data helps manage the size and complexity in a breeding program.
• Identifying novel, value-added traits will drive innovation in the milling and baking industry.