Breeding for High Quality Rice: Challenges and Prospective

Xueyan Sha
Rice Breeder and Associate Professor
Rice Research and Extension Center

Jazzman Jasmine
85
Della-2

Della Dellrose Della-2

Della  Deltrose  Della-2
Variety/Line | Seedling Vigor | Days to 50% Heading | Height (cm) | Yield (lbs/A) | Milling (%) | Chilli & Total
---|---|---|---|---|---|---
Cheniere | 4.3 | 77 | 91 | 6232 | 60.0 | 71.7
Catahoula | 3.9 | 75 | 95 | 6821 | 55.4 | 70.7
Mermentau | 4.3 | 75 | 92 | 6458 | 57.0 | 69.3
Jazzman | 4.0 | 80 | 100 | 6324 | 57.2 | 68.4
Jazzman-2 | 4.2 | 75 | 85 | 5877 | 61.8 | 70.1
Celia-2 | 4.0 | 79 | 97 | 6278 | 56.8 | 67.9

Lesson Learned from Breeding Aromatic Rice
- Only a small program with a limited number of breeding populations is afforded.
- Well-planned cross combinations to minimize the simultaneous selection for multiple specialty traits by:
  - development of pre-breeding lines,
  - intracross among improved aromatic lines, and
  - cross between parents that only differ in one or two specialty attributes.
- Rigorous selection for specialty traits (aroma, grain appearance, etc.) in the early-mid generations.
- Backcross or three-way cross aided by marker-assisted selection.

Rationales
- Arkansas ranks 1st among the six U.S. major rice-producing states, accounting for approximately 48 percent of the U.S. rice production.
- Rice ranks 2nd in cash value and 1st in export among the state’s agricultural commodities.
- The annual Arkansas rice crop contributes more than $1 billion to the state’s economy and accounts for thousands of jobs.
- The public rice breeding program funded by both state and the Check-off program has played and will continue to play an important role in improving rice production in Arkansas and mid-south United States.

What is “High-Quality Rice”?
- Good and stable milling recovery
- Acceptable grain appearance
  - Dimension: length, width, and L/W ratio
  - Translucency or chalkiness
  - Coloration
  - Grain uniformity
- Standard cooking and processing characteristics
  - Physicochemical characteristics indicative of each corresponding market class
  - Texture, flavor, and/or aroma
  - Characteristics of steam-cooked rice: flavor, chewiness, cohesiveness, glossiness, whiteness, etc.
Findings of US Rice Federation Taskforce

- There is a wide range among US cultivars for quality traits.
- Some US cultivars are as good as high quality imported and commercially milled rice samples.
- Production in different southern US locations can have a major impact on quality, regardless of cultivar.
- Assessment of chalk is more variable and less repeatable, regardless of how it is measured.
- Although there are some US cultivars with excellent quality, comparable to imports, the cultivars that account for the majority of the southern US acreage also have the highest level of chalk and lowest assessment scores by Mills.

Breeding for High-Quality Rice

- Balanced approach: future rice cultivars have to have the superior yield potential while maintain the high quality of traditional U.S. rice.
- Minimize or avoid the variation of standard quality attributes such as grain dimension, cooking and processing characteristics in the breeding population, meanwhile focus on the improvement of milling and translucency.
- Understand the GxE interaction among the important quality attributes and select for most stable genotypes which perform across different environmental conditions.

Narrow-sense Heritability of Grain Appearance and Uniformity, Crowley, LA, 2003

(Parent-Offspring regression of F_2 and F_4 families of four populations)

<table>
<thead>
<tr>
<th>Population</th>
<th>Heritability Appearance</th>
<th>Heritability Uniformity</th>
<th>No. families</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLMT/3/NAVBT/4AFF/5/202</td>
<td>0.10</td>
<td>0.14</td>
<td>44</td>
</tr>
<tr>
<td>DURS/AR1142/LA2011</td>
<td>0.53*</td>
<td>0.02</td>
<td>39</td>
</tr>
<tr>
<td>DLMT8462.../4/DMS1/5/RSM</td>
<td>0.45*</td>
<td>0.27</td>
<td>25</td>
</tr>
<tr>
<td>JSMN/TORD-2/DLMT</td>
<td>0.31*</td>
<td>0.00</td>
<td>14</td>
</tr>
</tbody>
</table>
Compact Batch Mills and Separator

2012 Research Summary
- 9 experimental lines tested in advanced trials (ARPT and/or URRN).
- 26 breeding lines tested in SIT and 2 in PYT trials.
- 1,109 P panicle rows, 18 bulked for yield trials and 116 for re-selection in 2013.
- 15 MG and 139 semi-dwarf LG F2 populations were space-planted and selected.
- 125 new crosses: 64 MGxMG, 33 LGxMG or MGxLG, and 28 MGxClearfield.

Performance of Selected Medium-grain Experimental Lines in 2012 ARPT Trial

<table>
<thead>
<tr>
<th>Variety/Line</th>
<th>Days to 50% Heading</th>
<th>Plant Height (in)</th>
<th>Yield (bu/A)</th>
<th>Head Rice (%)</th>
<th>Total Rice (%)</th>
<th>Lodging (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST00PR-80-062</td>
<td>82</td>
<td>36</td>
<td>210</td>
<td>63</td>
<td>70</td>
<td>31</td>
</tr>
<tr>
<td>13AR1021</td>
<td>82</td>
<td>40</td>
<td>224</td>
<td>54</td>
<td>68</td>
<td>40</td>
</tr>
<tr>
<td>13AR1030</td>
<td>82</td>
<td>36</td>
<td>222</td>
<td>56</td>
<td>69</td>
<td>18</td>
</tr>
<tr>
<td>Caffey</td>
<td>87</td>
<td>38</td>
<td>203</td>
<td>60</td>
<td>69</td>
<td>33</td>
</tr>
<tr>
<td>Jupiter</td>
<td>88</td>
<td>37</td>
<td>205</td>
<td>61</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>CL261</td>
<td>83</td>
<td>30</td>
<td>179</td>
<td>59</td>
<td>69</td>
<td>31</td>
</tr>
</tbody>
</table>

UA Medium-grain Rice Breeding Program
- To develop improved conventional and Clearfield medium-grain rice varieties.
- To develop superior conventional and Clearfield semi-dwarf long-grain rice varieties.
- To develop adapted male sterile, maintainer, and restorer lines by the introgression of hybrid traits of various sources into elite semi-dwarf Arkansas long-grain genotypes.
- To maintain high quality and pure head row and breeder seed for foundation seed production at the RREC.
Rice breeding is both an art and science, very competitive by nature, and still remains to be a number’s game.

- Being able to greatly expand breeding populations with the aid of new technologies (machinery, computer, and molecular markers), genetic gain of US rice still increases while most of the world is stagnant.
- Today’s public rice breeders have to deal with multiple tasks/objectives, such as Clearfield and non-Clearfield.
- Can we get what we want with the advance of rice genomics?

Increase Breeding Populations

A total of 682 F1 populations were germinated in greenhouse and transplanted or to be transplanted into the field to produce F2 seeds.
A total of 290 new crosses were made to create recombination among the most recent elite breeding lines developed by public breeding programs in the southern U.S.

- Team approach.
- Stay focused.
- Work with passion and closely with rice growers and industry.

Questions?