Breeding and Evaluation for Improved Rice Varieties - The Arkansas Rice Breeding and Development Program


ABSTRACT

The Arkansas rice breeding program has as ongoing goals the development of new long-grain cultivars as well as specialty cultivars like Japanese quality short-grains and aromatics. Cultivars are evaluated and selected for desirable characteristics. Those which require further improvement are utilized as parents in future crosses. Important components of this program include: pest and disease resistance, high-yield potential, excellent milling yields, improved plant type (i.e. short stature, earliness, erect leaves), and superior grain quality (i.e. cooking, processing and eating). New varieties are continually being released to rice producers for the traditional Southern U.S. long-grain markets as well as for the emerging specialty markets.

INTRODUCTION

The rice breeding and genetics program at the University of Arkansas Rice Research and Extension Center (RREC) is by nature a continuing project with the goal of producing new, improved rice cultivars for rice producers in Arkansas and the southern U.S. rice growing region. Breeding objectives for improved long-grain cultivars include standard cooking quality, excellent milling and grain yields, improved plant type, disease resistance, and pest resistance. Through the years, improved disease resistance for rice blast and sheath blight has been a major goal. Blast resistance has
been addressed through research by visiting scholars, graduate students, and by the development and release of ‘Katy’, ‘Kaybonnet’, ‘Drew’, and ‘Ahrent’. These cultivars include the first to have resistance to all of the common southern U.S. rice blast races. Sheath blight tolerance has been an ongoing concern and the cultivars from this program have also had the best sheath blight tolerance of any in the U.S. A recurrent selection program for increased sheath blight tolerance was implemented in 1983 as a long-term approach to increasing resistance (Moldenhauer et al., 1994). The cultivar Ahrent was released from this program. With increased interest in specialty rice, the program has been developing agronomically-acceptable cultivars with Japanese seed quality or that are aromatic (Jasmine or Basmati types). Significant yield increases have been realized with the release of the long-grain cultivars ‘LaGrue’, ‘Wells’, and ‘Francis’.

**PROCEDURES**

The rice breeding program continues to utilize the best available parental material of U.S. breeding programs, the USDA World Collection, and the International Centers, CIAT, IRRI, and WARDA. Crosses are made each year to incorporate genes for broad-based disease resistance, improved plant type (i.e. short-stature, earliness, erect leaves), superior quality (i.e. cooking, processing, and eating), and N-fertilizer use efficiency into highly productive, well-adapted lines. The winter nursery in Puerto Rico is utilized to accelerate breeders seed increases of promising lines and to advance early generation selections each year. As outstanding lines are selected and advanced they are evaluated extensively for yield, milling and cooking characteristics, insect tolerance (entomologist), and disease resistance (pathology group). Advanced lines are evaluated for proper timing and rate of nitrogen fertilizer (soil fertility group), and for weed control practices (weed scientists).

The rice breeding program utilizes all feasible breeding techniques and methods including hybridization, backcrossing, mutation breeding, and biotechnology to produce breeding material and new cultivars. Segregating populations and advanced lines are evaluated for grain and milling yields, quality traits, maturity, plant height and type, and disease and insect resistance. The state-wide rice performance testing program, which includes rice varieties and promising new lines developed in the Arkansas program and from cooperating programs in the other rice producing states, is carried out each year to select the best materials for future release and to provide producers with current information on rice variety performance. Disease data are collected from ongoing inoculated disease plots, including inoculated sheath blight, blast, stem rot and black sheath rot nurseries, general observation tests planted in problem disease fields, and general observations made during the agronomic testing of entries.
RESULTS AND DISCUSSION

The new variety Ahrent, a high-yielding long-grain line released in 2001, was
grown on 2.5% of the acreage in 2002. Ahrent compared favorably in yield with Cocodrie
and Drew, in the Arkansas Rice Performance Trials (ARPT) from 1999 to 2001 with the
three cultivars producing mean grain yields of 171,169, and 162 bu/acre, respectively
(Table 1). Ahrent has blast resistance, some sheath blight tolerance and is approxi-
mately 8 to 10 cm shorter and is 4 to 5 days earlier than Drew. Data were presented on
Ahrent in the B.R. Wells Rice Research Studies 2000 (Moldenhauer et al., 2001). PVP
and a Plant Utility Patent have been applied for, for the rice cultivar Ahrent. The Attor-
ney docket number N 1375-003 has been assigned for the patent.

Francis, a high-yielding long-grain rice variety, was released to qualified seed
growers for the 2002 season. Data were presented on Francis in the B.R. Wells Rice
Research Studies 2001 (Moldenhauer et al., 2002). The average yield of Francis was 194
bu/acre for the three years 2000 to 2002 in the ARPT compared to Wells, LaGrue, and
Cocodrie at 191, 183, and 176 bu/acre, respectively (Table 1). In the Uniform Regional
Rice Nursery (URRN) 1999 to 2001, Francis had extremely high yields across all four
locations with a three year average of 221 bu/acre compared to LaGrue, Wells, and
Cocodrie at 204, 200, and 193 bu/acre, respectively.

Rice blast (Pyricularia grisea) can be a devastating disease in Arkansas. Races
IB-49 and IC-17 are currently the major races in Arkansas. RU0001188 is a high-yielding
long-grain rice line that is blast-resistant and is being considered for increase in a
foundation seed field for 2003. It was developed through a backcrossing program
using LaGrue as the recurrent parent. It had resistance to the major blast races in
Arkansas and was in the ARPT and URRN in 2001 and 2002. RU0001188 had an average
yield of 190 bu/acre in the ARPT in 2000-2002 which compared favorably with Francis,
Wells, and LaGrue at 193, 191, and 183 bu/acre, respectively (Table1.)

Several extremely early lines are currently in preliminary trials and are being
evaluated by the systems agronomist at the RREC. These lines have maturities of
about 100 to 110 days as well as blast resistance. One of these lines RU0101093 will be
grown in head rows in 2003. This line has yielded 162 bu/acre in the URRN for 2001 and
2002 compared to ‘Jefferson’, and ‘Maybelle’ at 158, and 133 bu/acre, respectively. In
the ARPT for 2001 and 2002, RU0101093 yielded 163 bu/acre compared to Jefferson and
Maybelle at 151 and 130 bu/acre, respectively. In the ARPT for these years it headed in
77 days compared to Jefferson, and Maybelle at 82 and 77 days, respectively. This line
also yielded very well in Dr. Anders very-short-season test (190 bu/acre).

‘Koshihikari’ and ‘Mars' have been crossed to develop high-yielding, agronomi-
cally-adapted short-grain rice acceptable to the Japanese markets. One line RU9601099
(seed not for sale - experimental line) has good yields and stiffer straw than Koshihikari.
It will be released as a germplasm line in 2003. In an independent test in Japan, RU9601099
rated a 76 on a Japanese taste testing machine compared to Atitakomachi in the same
test which rated a 74 (Koshihikari was not included in their test). The higher the number
the better the taste. They rated the sample lower in other areas and were surprised by
their good ratings on the machine. A backcross program with RU9601099 and RU9601096
(seed not for sale - experimental line) as the donor parents and Koshihikari as the recurrent parent has also been implemented. Backcrosses have also been made with other selected lines from the Koshihikari by Mars crosses for the past 3 years, in an attempt to capture the elusive Koshihikari quality. Several lines from these crosses will be in the Stuttgart Initial Test in 2003.

Other crosses are also being made to further improve the blast resistance in Arkansas varieties. Another source of blast resistance, Raminad Stain 3, is an international rice blast differential which has resistance to all of the southern U.S. races. A backcrossing program is underway to incorporate the genes for blast resistance from Raminad Strain #3. Lines have been selected with blast resistance and no photoperiod sensitivity and used as parents in the breeding program. Tolerance to sheath blight, caused by the organism Rhizoctonia solani Kuhn, is also a very important aspect of the breeding program in Arkansas. A recurrent selection program for sheath blight tolerance has been successful in selecting lines, and potential parents, with more sheath blight tolerance. The populations derived from this approach have more tolerance to sheath blight and good plant height and type. In general, lines from the Arkansas breeding program have more tolerance to sheath blight than those from the other southern states.

Data from the ARPT conducted in Arkansas (Stuttgart, Colt, Keiser, Rohwer, and Cross County) in 2002 are available in the University of Arkansas Cooperative Extension Service Information Sheet "Arkansas Rice Performance Trials, 2000-2002", and online at: www.uaex.edu Agriculture; Agronomy; Rice.

Lines were selected from Dr. Tim Croughan's IMI mutation lines which had a 10-fold increase in resistance to the herbicides. Eight of these lines will be included in a yield test in both Louisiana and Arkansas this summer. Dr. Croughan will continue to screen these lines and others for tolerance to the IMI herbicides again this year. We will be working with Dr. Croughan on more lines and crosses in the future.

Studies continued with Dr. Thomas Tai, USDA-ARS molecular geneticist who is Acting Research Leader/Location Coordinator of the USDA-ARS Crops Pathology and Genetics Research at the Department of Agronomy and Range Science University of California Davis. He is utilizing molecular techniques to discover the yield genes associated with extremely high yield in LaGrue, and on milling quality genes with the LaGrue/Cypress and Cypress/LaGrue crosses.

Marker-assisted selection has been utilized in this program to select the lines which have the pi-ta gene for blast resistance and the CT classes to predict cooking quality (see V. A. Johnson et al., pages 60-66). Anther culture has also been used to speed up the development of pure lines for further crossing and improving plant type.

Table 2 shows the number of lines that were in the different phases of this breeding project for the 2002 growing season. There were 101 new cross combinations made in 2002. The 6120 panicles selected from the 15,400 space plants grown in the field in 2002 were planted in Puerto Rico for generation advance. Panicles selected from these rows will be grown as P (Puerto Rico) panicle rows in 2002/2003.
SIGNIFICANCE OF FINDINGS

The goal of the rice breeding program is to develop maximum yielding cultivars with good levels of disease resistance for release to Arkansas rice producers. The release of Wells in 1999, Ahrent in 2001, and Francis in 2002 and the future development of RU0001188 (the high-yielding blast-resistant long-grain), the germplasm release with Japanese quality, and the extremely early line RU0101093 has demonstrated that continued improvement in rice varieties for the producers of Arkansas can be realized through this program. Improved lines will continue to be released from this program in the future. They will have the characteristics of improved disease resistance, plant type, rough rice grain and milling yields, and kernel size. In the future, new rice varieties will be released not only for the traditional southern U.S. long- and medium-grain markets, but also for specialty markets as they arise.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the cooperation of the Arkansas rice producers, and the support of the Arkansas Rice Research and Promotion Board through their continued interest and funding. Thanks also go to the USDA-ARS for their cooperation, interest, and evaluation of materials, and to the other Division of Agriculture Research Stations located throughout Arkansas for their continued support.

LITERATURE CITED


Table 1. Data from the 2000 to 2002 Arkansas Rice Performance Trials for promising experimental lines and check cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Grain type</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>mean</th>
<th>Plant height</th>
<th>50% heading</th>
<th>Kernel weight</th>
<th>Milling HR:TOTx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Francis</td>
<td>L</td>
<td>187</td>
<td>190</td>
<td>203</td>
<td>194</td>
<td>40</td>
<td>86</td>
<td>16.7</td>
<td>64:71</td>
</tr>
<tr>
<td>Wells</td>
<td>L</td>
<td>185</td>
<td>190</td>
<td>197</td>
<td>191</td>
<td>42</td>
<td>87</td>
<td>19.1</td>
<td>62:73</td>
</tr>
<tr>
<td>Ahrent</td>
<td>L</td>
<td>154</td>
<td>176</td>
<td>176</td>
<td>173</td>
<td>42</td>
<td>85</td>
<td>16.2</td>
<td>64:69</td>
</tr>
<tr>
<td>Cocodrie</td>
<td>L</td>
<td>160</td>
<td>180</td>
<td>185</td>
<td>176</td>
<td>39</td>
<td>86</td>
<td>17.8</td>
<td>65:71</td>
</tr>
<tr>
<td>LaGrue</td>
<td>L</td>
<td>167</td>
<td>180</td>
<td>196</td>
<td>183</td>
<td>45</td>
<td>88</td>
<td>17.9</td>
<td>61:69</td>
</tr>
<tr>
<td>Drew</td>
<td>L</td>
<td>159</td>
<td>166</td>
<td>186</td>
<td>171</td>
<td>46</td>
<td>90</td>
<td>16.1</td>
<td>64:71</td>
</tr>
<tr>
<td>RU0001188</td>
<td>L</td>
<td>177</td>
<td>190</td>
<td>199</td>
<td>190</td>
<td>44</td>
<td>90</td>
<td>17.0</td>
<td>63:71</td>
</tr>
</tbody>
</table>

Grain type: L = long-grain, M = medium-grain, and S = short-grain.

2000 consisted of four locations: Rice Research and Extension Center (RREC), Stuttgart, AR; Pine Tree Experiment Station (PTES), Colt, AR; Southeast Branch Experiment Station (SEBES), Rowher, AR; Jackson Co. Farmer Field, Newport, AR; and Campbell, MO. 2001 consisted of RREC; PTES; SEBES; Northeast Research and Extension Center (NEREC), Keiser AR; and Phipps Farm Cross County. 2002 consisted of RREC; PTES; NEREC; SEBES; Phipps Farm Cross County, and Jackson Co. Farmer Field, Newport, AR.

x Milling figures are head rice : total milled rice.
w A bushel of rice weight 45 lb.

Table 2. Number of lines in each phase for project ARK01860 in 2002.

<table>
<thead>
<tr>
<th>Evaluation phase</th>
<th>Number of lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crosses</td>
<td>101</td>
</tr>
<tr>
<td>F₂ space plants</td>
<td>15400</td>
</tr>
<tr>
<td>F₃ panicle rows Puerto Rico</td>
<td>6120</td>
</tr>
<tr>
<td>F₄ P panicle rows</td>
<td>5520</td>
</tr>
<tr>
<td>L &amp; M panicle rows</td>
<td>6900</td>
</tr>
<tr>
<td>Preliminary trials</td>
<td>1088</td>
</tr>
<tr>
<td>Stuttgart Initial Test &amp; quality test</td>
<td>288</td>
</tr>
<tr>
<td>Uniform Regional Nursery</td>
<td>200</td>
</tr>
<tr>
<td>Arkansas Rice Performance Trials</td>
<td>104</td>
</tr>
<tr>
<td>Breeder head rows</td>
<td>6</td>
</tr>
</tbody>
</table>