

Progress on Breeding Mississippi Rice Varieties

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Abstract

The rice area in Mississippi has averaged 209,000 acres during the past 15 years (2001-2015). In 2015, rice was grown in over 250 farms located in 17 counties, primarily via drill seeding. Yield averaged 7,200 bushels per acre (bu/a) and crop production value was \$132 million. The choice of rice variety to plant is a key management decision each grower makes yearly. To provide growers with options on varieties to grow, Mississippi State University (MSU) since 1986 has maintained the only rice breeding program in Mississippi at its Delta Research and Extension Center (DREC) in Stoneville. Supported by the Mississippi Rice Promotion Board (MSRPB), this program has developed and released eight conventional varieties using the pedigree breeding method: Litton (1996), Priscilla (1997), Pace (2005), Bowman (2007), Rex (2010), CL 162 (2011), CL 163 (2015), and Thad (2016). These varieties were bred for varying trait combinations of high yield, semidwarf stature, long grain type, earliness, disease resistance, herbicide tolerance, and dual-purpose endosperm quality for both table and industrial use. Variety development from hybridization to release averaged 15.6 years, with one new variety being released every 3.75 years. The high seed cost of hybrid and herbicide technology-based systems has recently increased demand for better but affordable conventional variety options. For example, the pureline cultivar Rex has steadily increased its market share to at least 15%, generating estimated annual cash receipts of \$1.26 million and statewide economic impact of \$2.15 million. Since Mississippi rice is primarily exported or used in the canning industry, developing varieties with grain quality traits important to end-users has been emphasized. The latest releases CL163 and Thad, for example, both possess high amylose content, a trait favored by South American consumers and the US food industry. New strategies are being implemented to achieve higher genetic gain in the coming years.

Rice Breeding in Mississippi

Rice varietal testing in Mississippi dates back to 1948, when Dr. Don Bowman began evaluating introductions for adaptation to the Mississippi Delta region. Varietal evaluation was continued by subsequent rice researchers- Dr. Ted Miller (1976-1982) and Dr. Mike Milliam (1981-1984). In 1986, MSU established a dedicated rice breeding program at DREC that has since been led by four rice breeders: Ben Jackson (1986-89), Dwight Kanter (1987-2012), Tim Walker (2009-2014), and Ed Redoña (2014-present). The breeding program is primarily supported by MSU and MSRPB.

Breeding Goal and Objectives

The current goal of the breeding program is to develop high-yielding varieties that are adapted to Mississippi, with tolerance to major biological/environmental stresses & grain/milling/cooking qualities desired by domestic & foreign markets. Specific objectives include: high yield potential & wide adaptation; lodging resistance & semi-dwarf stature; disease resistance- blast & sheath blight; environmental stress tolerance- drought, heat, salinity; herbicide resistance; superior milling; long, translucent, low-chalk grains; cooking & eating qualities desired by target markets; and cereal chemistry profiles for industry. By implementing a market-oriented & modern variety development pipeline, the program envisions to help make the Mississippi rice industry globally competitive.

Breeding Methodologies and Strategies

The breeding program follows a modified pedigree breeding method (Fig. 1). Grain quality traits are emphasized early in the variety evaluation scheme (Fig. 2). Early generations are shuttled to Puerto Rico during the winter for selection and advancement, and a seven-location on-farm variety trial along the Mississippi Delta and the multi-state Uniform Rice Research Nurseries (URRN) test promising lines both in Mississippi and other US rice-growing states, respectively (Fig. 3). Molecular markers are used for specific breeding objectives and new crossing and generation advancement techniques are being explored to accelerate genetic gain (Fig. 4).

Figure 1. The classical pedigree breeding procedure used by the program since its inception. Figure 2. Laboratory rice mill for grain quality analysis (left photo) and image analysis set-up for quantifying chalkiness (top & bottom right).



Figure 3. Early generations are shuttled to Puerto Rico during the winter for selection and generation advancement (below, left). An in-state rice variety trial conducted on-farm (below, middle) and a multi-state testing program (URRN; below right) evaluate elite materials.



Figure 4. Some breeding strategies being employed to increase/accelerate genetic gain: marker-assisted breeding (below, left), use of novel crossing schemes (below, middle); and rapid generation advancement (below, right).



Varieties Developed

The breeding program has developed and released eight (8) varieties since 1986. Six were conventional types: Litton (1996), Priscilla (1997), Pace (2005), Bowman (2007), Rex (2010), and Thad (2016; Fig. 5) while two were Clearfield® types: CL 162 (2011), CL 163 (2015). On average, variety development from hybridization to release has taken 15.6 years, with one variety released every 3.75 years.

Figure 5.

A conventional variety, Thad is the latest product to be developed by the MSU-DREC Rice Breeding Program. It was released in 2016 and named in honor of U.S. Senator William Thad Cochran. Thad resulted from a cross involving Rosemont, Mars, Newrex and Tebonnet as parents. It is one of the few high-amylose rice varieties to be released in the USA. Certified seeds of Thad will be available to Mississippi rice growers beginning in the 2017 cropping year.



The rice variety Thad is an early maturing, semidwarf variety with excellent straw strength and standability. The grain yields average 231 bushels per acre (bu/a) in small plot tests. Milling yields have averaged 54 percent whole and 69 percent total. Thad has the Newrex cooking profile that makes it superior to almost all other commercial cultivars for parboiled rice. It has the same maturity as Rex, the most popular conventional variety in Mississippi. It is rated susceptible to sheath blight, leaf blast, bacterial panicle blight, and rotten neck blast but is rated moderately resistant to the straighthead disorder. Thad should be planted with a fungicide, insecticide, and a GA3 seed treatment. With low-chalk, high milling, and unique properties, Thad has good potential for capturing value in the contract/identity preservation markets.

Seeding rate
Drill seeded ~ 75 to 90 pounds per acre

Cooking Characteristics
Apparent amylose ~ 23.6 percent
Gelatinization ~ intermediate
Cook type ~ long grain

Agronomic traits
Average yield – 231 bu/ac
Milling yield – 54/69
Bushel weight – 46
Plant height – 39
Lodging – 7%
Days to heading – 89
Days to maturity – 128
Seed weight (1000) – 25
Seeds/pound – 18,056

Fertilization
Clay soils – 120 to 135 pounds of nitrogen per acre pre-flood followed by a mid-season treatment of 45 pounds of nitrogen per acre.
Silt loam soils – 120 pounds of nitrogen per acre pre-flood followed by a mid-season treatment of 45 pounds of nitrogen per acre.

Disease Resistance
Thad is susceptible to sheath blight, leaf blast, bacterial panicle blight, and rotten neck blast.

Rice Grain Dimensions

	Paddy	Brown	Milled
Length (mm)	8.96	7.05	6.55
Width (mm)	2.75	2.39	2.31
Thickness (mm)	1.92	1.69	1.59
L/W Ratio	3.27	2.95	2.84

Impact and Future Outlook

The most successful variety developed by the program thus far has been Rex. By 2013, Rex was planted in 15% of Mississippi's rice area and yielded seven bu/a more than the most popular variety, raising grower-incomes by \$45/a. DREC estimated that by 2014, Rex increased annual cash receipts by \$1.26 million, with statewide economic impact of \$2.15 million. Breeding for better conventional varieties that are adapted to future climates has, therefore, been intensified. At the same time, to ensure that new varieties are easily accepted in domestic and foreign target markets, end user-desired traits are also being emphasized.