

ON-FARM VARIETY TRIALS

On-farm varietal evaluation is a vital step in the variety development process for many crops, including rice.

Conducting variety trials under producers' field conditions helps identify the released varieties or hybrids as well as elite experimental breeding lines that are best suited to specific growing environments, including niche markets. It also helps determine which specific entries are widely adapted to and/or have consistent performance across varying growing conditions. This information not only helps in future breeding, but also is important for proper deployment of released varieties.

It is typical in on-farm variety trials for standard varieties, hybrids, new releases, and elite experimental lines to be evaluated in their target growing environments. In the case of elite breeding lines, based on their performance in these multi-environment tests, the most promising are selected for possible release as new varieties. The information collected on these lines include yield and milling performance, insect and disease susceptibility, tolerance to environmental stresses, vigor, and lodging scores. However, apart from using the data generated for line advancement decisions, they could also be used to recycle yet-imperfect lines back into the hybridization program.

With the inclusion of released varieties from Mississippi and the U.S. Midsouth as entries in the on-farm trials, the testing process also helps local rice producers to determine the most suitable released variety to plant on their respective farms based on the test locations. By placing these trials at multiple key locations throughout the Mississippi Delta, varieties, hybrids, and elite lines are exposed to the prevalent growing conditions and practices that are commonly

used in commercial production in Mississippi. Many of these growing conditions and management practices cannot be reproduced at the MSU Delta Research and Extension Center in Stoneville, thus there is a great value to on-farm evaluations from a research and development perspective. In return, growers are afforded the opportunity to evaluate the current varieties and hybrids in commercial circulation, side by side under their own management conditions. Ultimately, this process helps them in deciding which variety or hybrid to use on their farms the following year and in placing advanced seed orders for their chosen varieties or hybrids accordingly.

Variety selection is one of the most important decisions a grower makes in crop production planning. Growers should attempt to select varieties that offer the best combination of yield and quality factors while also considering the variety's tolerance or susceptibility to both biological and environmental factors that could limit yield potential. As grain quality is becoming more important for improving U.S. rice global competitiveness, producers will benefit from having grain quality data for the commercial varieties evaluated in the variety trials. Millers, consolidators, and traders may also use this grain quality data for implementing "identity preserved" strategies that are gaining importance for improving overall rice grain quality. Rice research and extension specialists can use variety trials as an educational platform for demonstrating the merits of on-farm evaluation to other scientific or technical staff, growers, private consultants, rice industry personnel, students, policy makers, and the general public. Through these trials, interested parties are afforded a first look at new or potential releases from Mississippi State and other participating rice breeding programs, including from the private industry.

TEST PROCEDURES

For 2020, the rice On-Farm Variety Trials consisted of 36 entries including five hybrids/FullPage® herbicide technology-based materials, 16 Clearfield® or Provisia® purelines (seven released varieties and nine elite experimental lines), and 15 conventional purelines (seven released varieties and eight elite experimental lines). All hybrids/Full Page® materials were provided by RiceTec, HorizonAg provided all the Clearfield® and Provisia® herbicide-technology-based purelines, and the conventional pureline released varieties came from the public

breeding programs of Mississippi (two), Arkansas (two), Louisiana (two), and Texas (one). The trials were conducted in seven locations from north to south of the Mississippi Delta: Tunica, Clarksdale, Pace, Shaw, Choctaw, Stoneville, and Hollandale (**Figure 1**). Individual plots consisted of eight drilled rows that were 15 feet in length and spaced 8 inches apart. Varieties and experimental lines were planted at a seeding rate of 85 pounds of seed per acre, while the hybrids were planted at 25 pounds of seed per acre. Seeds were mechanically

drilled approximately 1.25 inches deep into stale seedbeds at all locations. All entries were replicated three times at each location using a randomized complete block experimental design. Crop management practices for each location, as well as the stresses encountered, are presented in **Tables 3-9**.

For more information on pesticide formulations and application rates, please refer to the pesticide product label information available on the internet or to MSU Extension Service Pub. 1532, *2020 Weed Control Guidelines for Mississippi* (http://extension.msstate.edu/sites/default/files/publications/publications/P1532_web.pdf).

Agronomic and crop phenology data were collected at appropriate times during the growing season. Lodging ratings were obtained on a plot-by-plot basis. The entire plot was harvested with a Wintersteiger Delta plot combine equipped with a computerized weighing system and a moisture meter. Due to differences in maturity, most of the entries at each location were required to have achieved the appropriate harvest moisture level before the test was harvested. Average harvest grain moisture levels for each entry are reported in **Tables 3-9**. Subsamples of each entry were collected at harvest and these were used for measuring milling-related traits, chalkiness, bushel weight, and 1,000-seed weight parameters.

For yield, previous replicated research has shown that the border effect common in small-plot research could result in increases in grain yield estimates of 10% for inbred varieties and 15% for hybrids. Therefore, the plot yields reported for the test entries should be compared in a relative manner rather than just through the absolute values for the reported yield potential.

Analysis of variance procedure was conducted for all relevant data gathered from the trials using SAS version 9.4 statistical software. The Least Significant Difference (LSD) test at the 5% significance level may be used to determine significant differences between entries. If the value of the yield difference between any two trial entries at a location, as computed from the yields reported in **Tables 3-9**, is greater than the LSD value for that particular location, the entries are deemed to be statistically different from each other. In addition, a coefficient of variation (CV) was calculated for each test. This measure is an indication of the variability or “noise” in the trial, thus the level of precision of each test. Lower CV values indicate greater reliability of the test. Coefficient of variation values of 10% or less are generally considered to be optimum for plant-breeding trials, and CV values above 25% are considered unacceptable. The LSD and CV values for yield in these tests are reported in the footnotes of **Tables 3-9** and are included for the other measured variables in **Table 11**.

RESULTS

To assist Mississippi rice producers in their variety selection process for 2021, preliminary results of the 2020 rice variety trials were immediately processed and made available online in late October 2020 via the Mississippi Agricultural and Forestry Experiment Station Variety Trials website (<http://mafes.msstate.edu/variety-trials/includes/crops/rice.asp>). Traditionally, hard copies of the preliminary results would also have been distributed to rice producers attending the annual Delta Rice Producers Meeting in Cleveland, Mississippi, in mid-November. However, due to the COVID-19 pandemic, this yearly growers’ meeting was not held in 2020.

Complete details on the performance of each entry at each of the seven test locations are presented in **Tables 3-9**. As with the 2019 trials, the 2020 yield evaluations were planted in a narrow time span of about 4 weeks (April 6 to May 6). The Stoneville trial was the only trial planted on an experiment station. In general, plant stands were excellent, with uniform emergence and optimum plant density for all the locations. Among the diseases reported

to have occurred at some point in the growing season were leaf blast and sheath blight. However, none of these factors occurred to a level that was economically damaging or that completely wiped out any test entry. Lodging was reported in six of the seven locations (except for Stoneville) because of rainfall and strong hurricane-induced winds late in the season. The most severe lodging occurred in Hollandale, where 60% of the entries lodged by up to 90%. Lodging occurred in the hybrids/FullPage®, Clearfield, Provisia®, and conventional pureline groups at six of the seven locations. However, nine breeding lines (five Clearfield® and four conventional types) and four commercial varieties (one Provisia® and three conventional types) showed superior standability and did not exhibit any lodging in all the seven locations. There was no significant black bird damage in Stoneville unlike previous years.

The average rice yield across entries and locations for the 2020 trials was 259 bushels per acre, up 34 bushels (15%) from the 2019 average of 225 bushels, and 39

bushels (17%) more than the 220-bushel running 5-year variety trial overall yield average (2015–2019). Moreover, the 2020 overall yield average of 259 bushels per acre surpasses, by 17 bushels (7%), the formerly highest recorded average trial yield of 242 bushels in 2014. This yield trend in the trials closely mirrors the Mississippi statewide yield trends from USDA NASS data, where an uptick in yield was also recorded for 2020. Location yield averages ranged from 225 bushels per acre for Stoneville to 284 bushels for Choctaw. Tunica (281 bushels) and Hollandale (269 bushels) were the second and third highest yielding sites, respectively. Hollandale was the highest yielding location in these trials the previous year. On the other hand, the Stoneville location has consistently been the lowest yielding during the last 5 years (2016–2020) with an average of 175 bushels per acre across entries primarily due to moderate to heavy black bird damage. With minimal black bird damage in 2020, the Stoneville location average yield exceeded 200 bushels for the first time.

The CV values for yield were all acceptable and ranged from 5.8% (for both Choctaw and Shaw) to 14.4% (Hollandale). Total milling yields across locations tended to be normal across entries (clustered around the average of 70.8%), but substantial entry differences were observed for whole milled rice, ranging from 55.4% to 65.6% and averaging a high 61%.

The grain yield summary data for all entries at each location are provided in **Table 10**. Moreover, summary data for all other measured parameters averaged over the seven locations are provided in **Table 11**.

Among hybrid/FullPage® entries, the non-herbicide tolerant RT7301 gave the highest yield of 322 bushels per acre, which was also the highest average yield among all entries in the trial. Another non-herbicide tolerant entry, RT7501, came in second with an average yield of 312 bushels per acre. Both RT7301 and RT7501 outyielded the high-yielding conventional hybrid XP753 (previously designated in Mississippi variety trial reports as XL753), which was the third top-yielding entry in both the 2000 (306 bushels) and 2019 (261 bushels) evaluations. XP753 had been the highest yielding hybrid in these trials in 6 of the last 7 years with an average yield across locations of 297 bushels per acre in 2018, 296 bushels in 2017, 274 bushels in 2016, 275 bushels in 2015, 306 bushels in 2014, and 278 bushels in 2013 or an average yield of 284 bushels for this entire 7-year period. Its yield superiority over other hybrids and conventional pureline entries has been consistent over the years. The herbicide-tolerant FullPage® entry RT7521FP, which surpassed XP753 in yield for 2019,

came it fourth in this group in 2020 with a yield of 271 bushels per acre. Historically, hybrids have yielded, on average, about 21% (46 bushels) higher than pureline varieties, both for Clearfield® and conventional types, in Mississippi rice variety trials. For 2020, this hybrid/FullPage® yield advantage was, on average, 19% over Clearfield® and 14% over conventional variety types. However, since the plot border effect is greater on hybrids than in purelines, the actual yield differences may be expected to be closer when comparing the highest yielding hybrid to the highest yielding purelines.

Among the 16 Clearfield®/Provisia® type pureline entries, the six highest yield entries were all experimental breeding lines. RU2004191 was the highest yielding in this group with an average yield of 274 bushels per acre across locations followed by RU2004071 (269 bushels) and then RU1804147 and RU1704055 (both 264 bushels). RU1804147 was the highest among 16 Clearfield®/ Provisia® type pureline entries in 2019, while RU1704055 was the highest yielding among all Clearfield® entries in 2017, among the top five entries for yield in 2018, and the seventh highest yielding entry in 2019. Following these six breeding materials that are still under development were the newly released Clearfield® variety CLL16 with 262 bushels per acre and the Mississippi-bred long-grain Clearfield® potential release CLX54197 with 257 bushels. CLX54197 has the unique Cheniere-type cereal chemistry and was also among the top five entries for yield in both the 2018 and 2019 on-farm yield evaluations. The released Clearfield® varieties CL163 and CL153, which were the highest yielding in 2019, did not perform as well in 2020. CL153 had been the highest yielding Clearfield® released long-grain variety entry in these trials both in 2017 (223 bushels per acre) and 2018 (220 bushels). The newly released Provisia® pureline variety PVL02 was ranked last for yield in the group, as it was the entry most affected by plot lodging (average of 73%) in six of the seven locations with lodging occurrence.

Among conventional purelines, the top-yielding entry in 2020 with an average yield of 277 bushels per acre was Thad, the Mississippi-bred variety released in 2017. Following closely with a yield average of 275 bushels per acre was RU1904163, an elite experimental line still under development and entered in these trials for the first time in 2020. Rounding up the top five for yield in this group were the released varieties Rex (274 bushels), Diamond (268 bushels), and the breeding line RU1804067 (264 bushels). Rex, which remains popular among Mississippi growers, was ranked second in the 2018 trials, while Diamond, a recent release from

Arkansas, topped the 2019 and 2017 trials. The released varieties Thad, Diamond, and Rex, along with another conventional release that did not perform well this year (Lakast), have been among the top-yielding entries in these on-farm trials during the last 5 years (since 2016).

Entries that begin with RU designations are elite experimental breeding lines that have performed well in the sequential, multistage, yield evaluation conducted by the MSU rice breeding program. They have usually been entered or are about to be entered in the multistate Rice Uniform (RU) Regional Research Nursery or URRN. This URRN system is conducted by public breeding institutions in the U.S. to evaluate elite lines in other rice-growing states while sharing elite materials among U.S. breeders. The entries represent the best lines from different breeding programs and are typically at the final stages of testing. *Entries from Mississippi in the URRN have the number “4” as the first digit of the last four digits of the RU designation (e.g., RU2004191).*

Table 12 shows the agronomic, yield, and milling data for select rice varieties that have been included in on-farm tests for the last 3 years. Based on varietal performance in 21 trials conducted during the past 3 years (2018, 2019, and 2020), the yield performance of conventional varieties Diamond, Rex, Lakast, and Thad were statistically similar at 240 bushels per acre each for both Rex and Diamond, 239 bushels for Lakast, and 238 bushels for Thad. In comparison, Mermentau, a variety from Louisiana that was popular in previous years among Mississippi producers, yielded an average of 220 bushels per acre in the same trials. The Texas-bred variety Sabine, which is used in the rice-processing industry, yielded only 202 bushels per acre or about 38 bushels (18%) lower than Thad, a comparable variety.

Among the Clearfield® released varieties, the best performer during the past three years (2018, 2019, 2020) has been CL153 with an average yield of 228 bushels per acre. However, several breeding lines still under development have consistently outyielded CL153 during the period. Among these promising Clearfield® experimental lines that outyielded all other released Clearfield® varieties is CLX54197 (formerly coded as RU1504197), which had the fourth highest yield in 2019 among Clearfield® trial entries, was ranked third in 2018, and performed well also in 2017 (223 bushels per acre). Moreover, this line out-yielded all released long-grain Clearfield® varieties included in the tests in all 3 years except for CLL16 in 2020 (262 bushels vs. 257 bushels). CLX54197 is like Thad and CL163 in terms of having high amylose content but is like the formerly popular variety Cheniere in terms of having “softer-cooking”

quality. The potential release of this elite Clearfield® breeding line in 2021 is being explored in coordination with HorizonAg.

Milling traits varied substantially among the test entries, and high-yielding entries did not necessarily have the best grain-quality characteristics. Aside from these trait considerations for variety selection, performance stability over different environments and across years also needs to be considered. Certain varieties such as Cheniere have been relatively stable over many years and thus have been popular in Mississippi and the Midsouth in the past. Thad has been unanimously accepted by all major rice milling and exporting companies in the U.S. due to its excellent grain quality traits that is also favored by sectors of the rice food-processing industry. Rex, on the other hand, continues to be popular among rice growers due to its excellent yield stability over multiple locations both in Mississippi and other rice-growing states in the Midsouth.

Variety and hybrid reactions to common diseases and straighthead disorder are listed in **Table 13**. Decisions about the use of fungicides should be made considering a variety’s susceptibility to a particular disease, the potential for the disease to cause economic loss, and efficacy of fungicides that are available to combat or prevent the respective disease.

Nitrogen fertilization rate guidelines are provided in **Table 14**. These guidelines were generated from multiyear, multisite N response studies conducted for newly released varieties. A combination of current economics, individual varieties’ susceptibility to lodging, and yield potential are included in determining the rate guidelines. Annually, coarse-textured soils, commonly referred to as silt loams, require approximately 30 pounds per acre less nitrogen than fine-textured or clay soils. By applying less N on silt loam soils, disease and lodging incidence tend to decrease without sacrificing yield and quality.

Based on this year’s variety-trial results and taking into consideration previous years’ performance, the conventional varieties suggested for Mississippi rice growers are Thad, Diamond, and Rex. The conventional varieties Cheniere and Mermentau have not performed as well as these varieties, though they have done well in Mississippi in the past. Sabine is often grown on limited acreage by contract, primarily due to its high amylose content and related cereal chemistry characteristics desired by the rice processing industry. The recent release of Thad and CL163, both high-amylose varieties with excellent grain qualities, provides more varietal options to the U.S. rice-processing industry as well as U.S. rice export markets requiring high-amylose rice.

For RiceTec's hybrids using the new FullPage® technology that provides growers with new generation IMI herbicide tolerance to control red rice, the best option based on 2 year's trials (2019 and 2020) is RT7521FP, which topped all entries regardless of type for yield in 2019 and was the top-yielding FP entry in 2020 (with 271 bushels per acre). For conventional hybrid rice production, XP753 remains the proven best option based on several years' yield data but the new conventional hybrid RT7301, tested for the first in 2020, promises to be a superior option along with RT7501, another first-year entry. RT7301 and RT7501 yielded 16 bushels (5%) and 6 bushels (2%) more than XP753 in 2020. Detailed additional information on production of conventional and FullPage® hybrids is available at RiceTec (<https://www.ricetec.com/products-services/seed-products/>).

Among the Clearfield® released varieties that are offered exclusively by HorizonAg (<http://www.horizonseed.com/horizon/content/varieties>), the two newly released long-grain types CLL16 and CLL15 outperformed CL153, which was the best performing long-grain Clearfield® variety type in the 2018, 2017, and 2016 trials. CLL16, CLL15, CL153, and CL163 (for those desiring high-amylose rice) are the best varietal options for long-grain Clearfield® rice. There were no medium-grain Clearfield® entries in the 2020 trials. Clearfield® rice should be used as a tool with careful attention given to stewardship so that the technology can last into the future. Stewardship should encompass minimizing the potential for outcrossing of red rice and Clearfield® rice. Stewardship should also include the addition of post-emergence and residual herbicides for grass control so that selection pressure that could break down herbicide resistance is minimized. It should be noted that incidences of ALS-resistant (Newpath®, Beyond®) barnyard-grass and sedges have increased in the last few years. Outcrossing and grass resistance jeopardize this important technology. The new Provisia® varieties PVL01 and

PVL02, which were tested in these trials for the third and first time in 2020, respectively, promise to be a useful companion technology to extend the usefulness of Clearfield® rice system for controlling red rice. However, it is important to follow the technology recommendations, such as being out of rice for a year when switching from Clearfield® to Provisia® varieties.

As is well known to rice producers, no pureline variety or hybrid is always perfect for all cropping conditions. Each cropping year may bring about recurring or new biological and/or environmental factors with the potential to negatively impact varietal performance and, ultimately, a rice producers' bottom line. Breeders must, therefore, continue to develop new strains that satisfy the needs of both producers and end users. The breeding program must cater to the needs of rice growers who are faced with an ever-changing production landscape. At the same time, it must also consider the varying needs of millers, the food industry, and consumers who continually demand higher quality rice for consumption and/or processing. The best of these new strains must perform well under farm conditions before they can be released. Each new variety release would be expected to have qualities or characteristics that add value to end-users. Ultimately, varietal performance over time and in different environments, in addition to economics, should be considered when choosing which variety to plant among the many available options. This is where the regular conduct of on-farm trials provides a great value for rice producers. For varieties with high yield potential, producers should consider risks such as lodging and disease incidence and plan to manage for those yield-limiting factors to derive maximum benefit. Planting several pureline varieties or hybrids, FullPage®, Clearfield®, Provisia®, and conventional types may help mitigate the risks associated with large production areas that are commonly found in Mississippi.