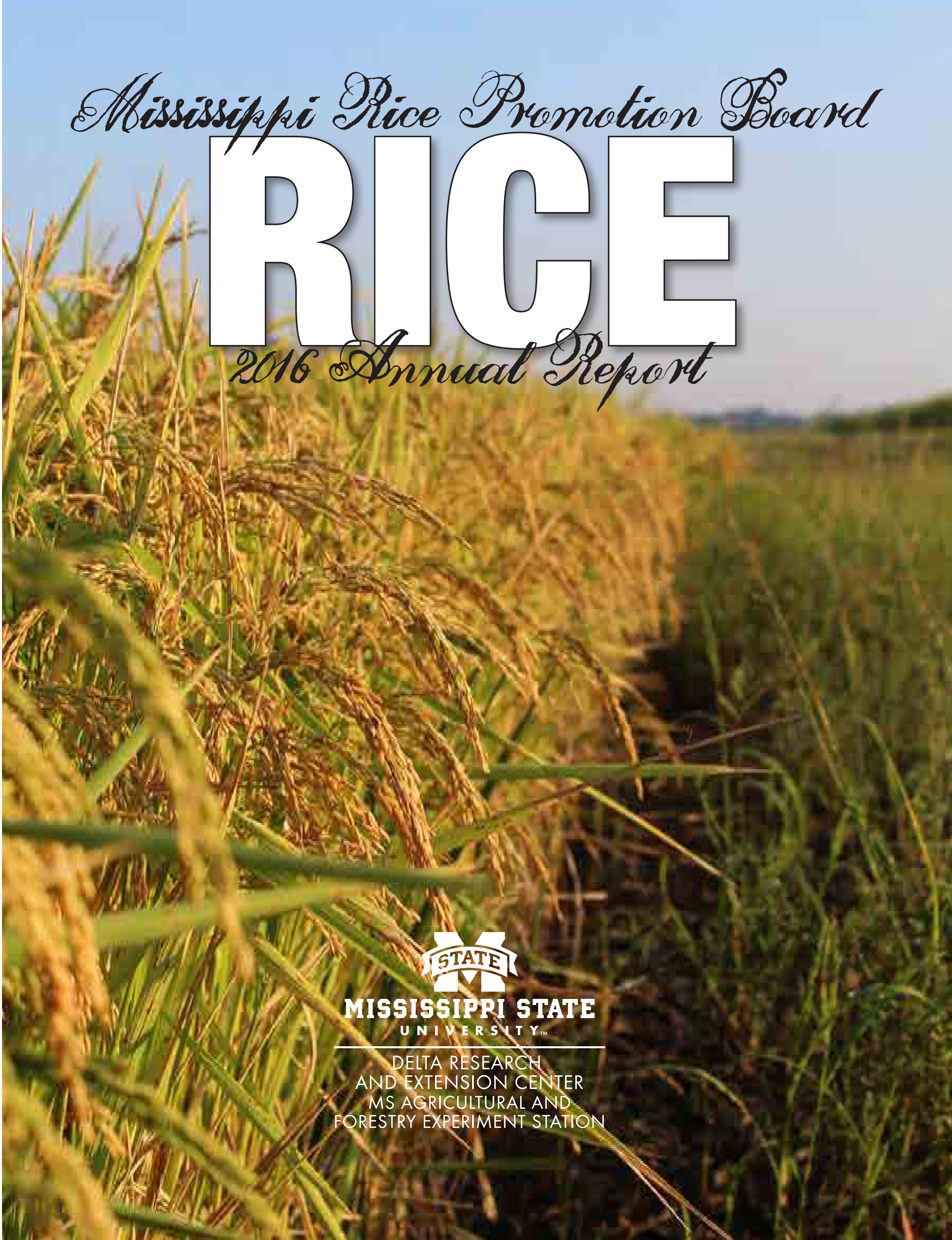

Mississippi Rice Promotion Board

RICE

2016 Annual Report

MISSISSIPPI STATE
UNIVERSITY™

DELTA RESEARCH
AND EXTENSION CENTER
MS AGRICULTURAL AND
FORESTRY EXPERIMENT STATION

Promotion Board

The Mississippi Rice Promotion Board is a group of 12 individuals appointed by the Mississippi Governor's Office to oversee the expenditure of research and promotion funds generated by the state's rice farmers. Each year, research and extension scientists submit proposals to address key issues pertaining to rice production. The board strives to fund proposals that advance rice production in a holistic, programmatic manner, with a major emphasis on applied research.

This report highlights projects funded during the 2015–2016 funding cycle. We hope you find it enlightening and informative. Anytime issues arise on your farm that you believe should be addressed, please speak with one of the board members or contact any of the scientists who contributed to this report.

We appreciate your support of the Mississippi Rice Check-Off Program and wish you much success in 2017.

Mississippi Rice Promotion Board

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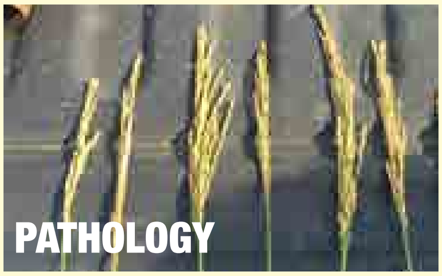

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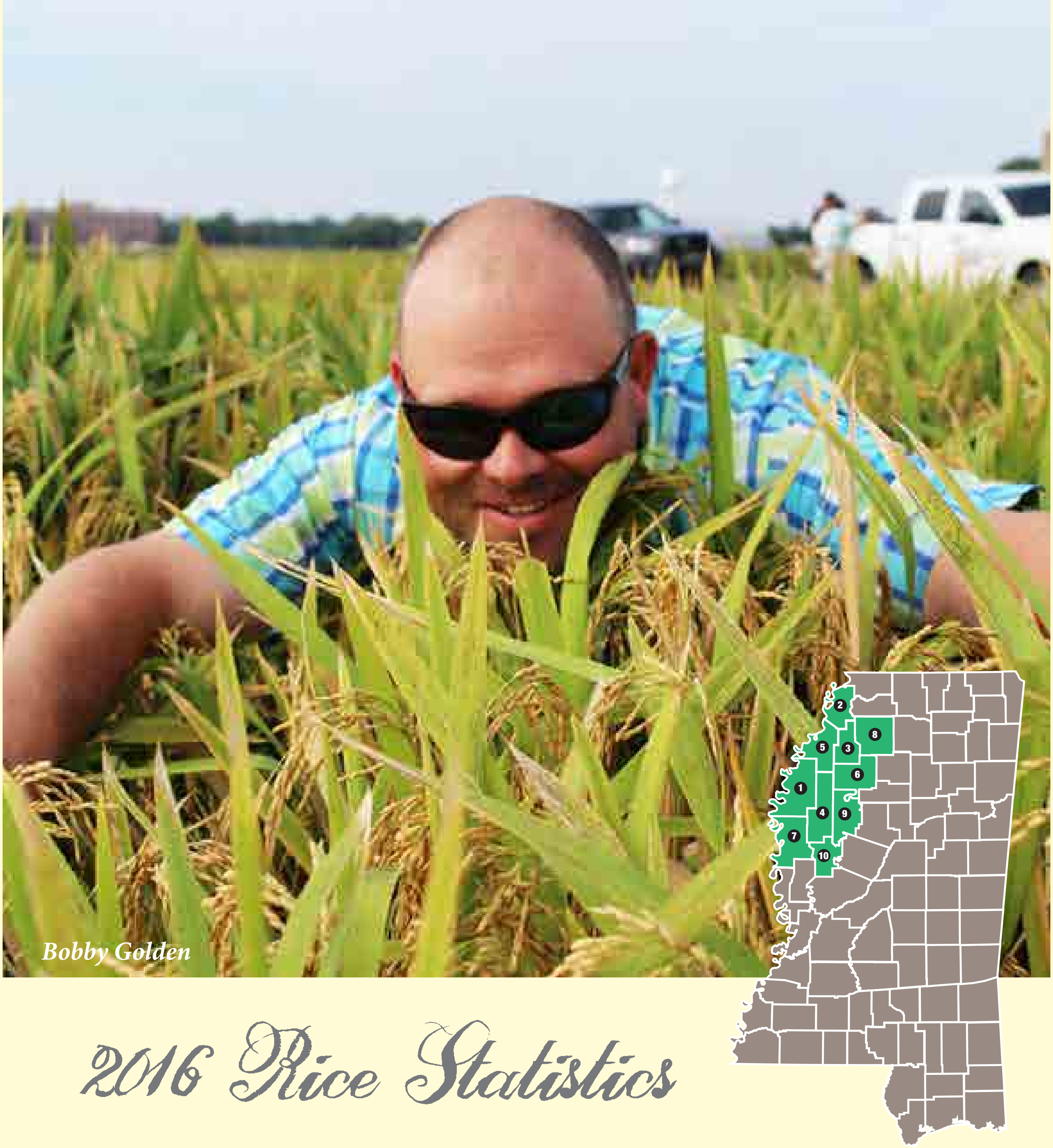


Bobby Golden

2016 Rice Statistics

13,800,000 hundredweight was produced on **259 Mississippi farms** for a **$139 million** value of production.

County	MS Co. Rank	Rice Acreage	% of Cropland in Rice
Bolivar	1	47,839	13.4
Tunica	2	34,802	19.6
Quitman	3	20,515	17.7
Sunflower	4	19,994	7.14
Coahoma	5	12,885	4.9
Tallahatchie	6	12,330	6.9
Washington	7	12,135	3.5
Panola	8	9,668	12.4
Leflore	9	7,734	3.6
Humphreys	10	4,440	6.0

2016 Overview

Bobby Golden

The USDA-FSA certified approximately 189,826 acres of rice in Mississippi for the 2016 growing season. Certified acres increased by approximately 27 % compared to 2015 acreage. During 2013-2016 the three year average acreage for MS is 171,000 and well above the previous 3-year cycle. Once again Bolivar Co. led with the most acreage dedicated to rice in the state, with Tunica Co. coming in second and Quitman Co. supplanting Sunflower Co. for third greatest rice acreage in MS. Again, in 2016, most of the rice acreage was cultivated north of highway 82 with rice seeded in approximately 17 of the 19 Delta counties. Yield estimates are lower than the previous three years with USDA suggesting a yield of 6,975 lb/ac. I feel like yields will be off by at least 10% when all the bushels are finally counted.

The year started off with a bang, with planting progress occurring at almost record pace. By May 5th, approximately 70% of the state's total acreage was in the ground, with 95% planted by May 19th. This pace eclipsed the 2015 pace as well as the three, five and ten year average. Therefore, most of the states acreage was planted on time and we got off to a great start to set up the year for success. Unfortunately, soon after rice emerged, off-target herbicide drift calls began to come in. Much like the last two years most of the off-target drift complaints centered on paraquat and soybean residual herbicide tank mix partners. Most of the acreage affected by paraquat drift recovered and rice was harvested, in some cases adequate with yield. However, much of the affected rice needed additional time to recover and mature delaying timely management for many aspects associated with production. Again similar to last year glyphosate drift events were isolated, but the few events that did occur, occurred at the most inopportune time and seriously reduced grain yield.

Pest pressures related to insects was relatively minor, except for a few weeks where army worms moved in and affected some later planted rice fields. Most of the army worm situation was handled with border sprays with only a few full fields sprayed. In many areas, producers had to deal with escapes of barnyardgrass and sprangletop. We observed and I had more than one consultant suggest that this was the grassiest crop that they had in some time. Most of the escapes were adequately controlled post-flood, but in some areas the critical weed free period had passed and yield reductions occurred. On the disease side, unlike 2014 and 2015, rice blast occurrence was relatively minor, with a few isolated cases reported. On the other hand, the late August environment that was met with at least 0.10" rain for a duration greater than 7 days allowed sheath blight to escalate. In many fields, sheath blight had blown out the top and was visible from the turn row

The greatest concern in 2016 and one that definitely contributed to a portion of the reduced yield in the state was the environment from July and August. The combination of heat, wind, and rain at unfortunate times surrounding rice flowering held rice yield back in many areas of the state. The portion of the crop that flowered and matured in July met daily maximum air temperatures greater than 92 degrees for the first 27 days of the month. Daily air temperatures cooled into August, but wind and rain damage to flowering rice was just as detrimental as the early heat. I feel environment played the largest role in the roller coaster yields observed in many cases across the turn row during the 2016 growing season. 2016 shaped up to be what I would consider an average year overall.

Agronomy

Nitrogen Fertilizer Programs Following Rice Exposure to Gramoxone SL

Benjamin Lawrence, Jason Bond, Bobby Golden, Tyler Hydrick, and Matthew Edwards

In Mississippi, rice is produced within the Mississippi and Yazoo River Delta located in the northwestern portion of the state. Rice accounts for about 5% of the total row crop acreage in Mississippi; therefore, it is commonly grown adjacent to corn, cotton, and/or soybean. Row-crop producers in Mississippi have primarily chosen to continue the use of Roundup Ready cropping systems in the presence of glyphosate-resistant weeds. In these production systems, Gramoxone SL is often applied prior to planting at 3 pints per acre for glyphosate-resistant weed control.

Nitrogen (N) fertilizer is applied to rice in the greatest quantity and frequency of any nutrient, and a single preflood N application prior to rice tillering is the most efficient N delivery method for rice in Mississippi. However, split applications are also recommended under challenging rice management scenarios. Starter N fertilizers applied to two-leaf rice and during stressful environmental conditions have been shown to increase yields as much as 10 bu/ac. Due to Mississippi's diverse cropping landscape, incidents of off-target movement of Gramoxone SL to rice from adjacent fields have increased in recent years. Nitrogen fertilizer is a cornerstone input for rice production; therefore, altering fertilizer management strategies or adding starter fertilizer may improve rice performance following exposure to a sub-lethal rate of Gramoxone SL.

Two studies were conducted at the Delta Research and Extension Center to determine the impact of starter N fertilizer (AMS 21-0-0) and altering urea (46-0-0) applications to rice exposed to sub-lethal rates of Gramoxone SL. Gramoxone SL was applied at the two- to three-

Different urea nitrongen management strategies applied before (indicated area below, left) and after (indicated area below, right) rice exposure to Gramoxone SL.

Table 1. Urea (46-0-0) application timings and rate following rice exposure to Gramoxone SL applied at 10% the recommended use rate in Mississippi.

	Urea Application Timing	
Urea Application Splits	Urea (N) Units lb/A	Timing
None	150	LPOST
Two	100:50	LPOST:PD
Three	75:37.5:37.5	LPOST:14DPF:PD
Four (1)	37.5:37.5:37.5:37.5	MPOST:LPOST:14DPF:PD
Four (2)	37.5:37.5:37.5:37.5	LPOST:14DPF:PD: 5% Head

*EPOST (2- to 3-leaf); MPOST (3- to 4-leaf); LPOST (4-leaf to 1-tiller); PD (panicle differentiation); 14 DPF (14 d postflood); 5% HD (panicle emergence)

leaf (EPOST) rice growth stage in both studies at 10% of the suggested use rate of 3 pints per acre to simulate a worst-case scenario drift event. Starter N fertilizer treatments were applied at 21 units 7 days before, the same day as, or 7 days after Gramoxone SL applications. In the study evaluating N fertilizer management strategies, urea treatments are shown in Table 1.

Gramoxone SL injured rice ≥48%, reduced rice height 56%, delayed rice maturity 8 days, and reduced rice yield 56% regardless of starter N fertilizer treatment. Results from the starter N fertilizer study indicated that AMS did not aide in rice recovery following exposure to sub-lethal rates of Gramoxone SL. Regardless of urea application timing, Gramoxone SL injured rice ≥50%, reduced rice height 16%, and delayed rice maturity 5 days. Differences in rice yield were observed due to urea applied at different application timings, but yield loss due to Gramoxone SL was at least 58% regardless of urea management.

Both studies indicate severe rice growth and development issues can occur from off-target movement of Gramoxone SL. In either fertilizer study, rice was unable to overcome early-season exposure to Gramoxone SL. Extreme caution should be exercised if Gramoxone SL is applied adjacent to rice.

Ammonium sulfate (AMS) applied as a starter fertilizer before (indicated area below, left) and after (indicated area below, right) rice exposure to Gramoxone SL.

Broadcast Seeding Rate Revisited

Bobby Golden, Lindsey Bell, Justin McCoy, Richard Turner, and Brian Pieralisi

Timely seeding is imperative to produce high yielding rice. Due to weather events in 2015, interest in broadcast seeding was generated in an effort to cover ground quickly due to time constraints and drill or planter availability. Research evaluating the yield costs associated with broadcast seeding is outdated and many production practices has changed since research was last conducted to determine optimum broadcast seeding rates. Past data suggest that increasing the seeding rate by 30% would produce similar yield as drill planted rice. However, when the current recommendation was generated the drill seeded rice recommendation was around 90 lb seed ac^{-1}, today most non hybrid cultivars are seeded at 65 lbs seed acre^{-1}. Therefore research is needed to revisit the broadcast seeding recommendations.

In 2016 two trials (silt loam and clay soil) were established to begin to determine the optimum broadcast seeding rate for rice. Treatments included two drill seeded rates (65 and 115 lb seed ac^{-1}) and five broadcast rates ranging from 75-115 lb seed ac^{-1}. The drill seeded rates represent the current industry standard for varieties and a 2x seeding rate. Broadcast seeding rates increase as a percentage of the current standard drill seeding rate. Broadcast seeded rice was shallow incorporated with a triple K harrow implement and drilled rice treatments were seeded approximately ¾" deep.

For silt loam soils, the greatest grain yield (200 bu/ac^{-1}) was achieved with rice drilled at 65 lb seed ac^{-1} (Fig 1). Rice grain yield across the range of broadcast seeding rates did not differ from one another and averaged 175 bu ac^{-1}. A differing response was observed on Sharkey clay soils. Drill seeded rice regardless of seeding rate yielded similar and greater than any broadcast seeding rate (Fig 2.). In general, for the clay soils as broadcast seeding rate increased, rice grain yield increased. Overall, preliminary work suggests that broadcast seeding rate recommendations need to be revised, and economic analysis is required to determine if broadcast seeding is a viable alternative to drill seeding.

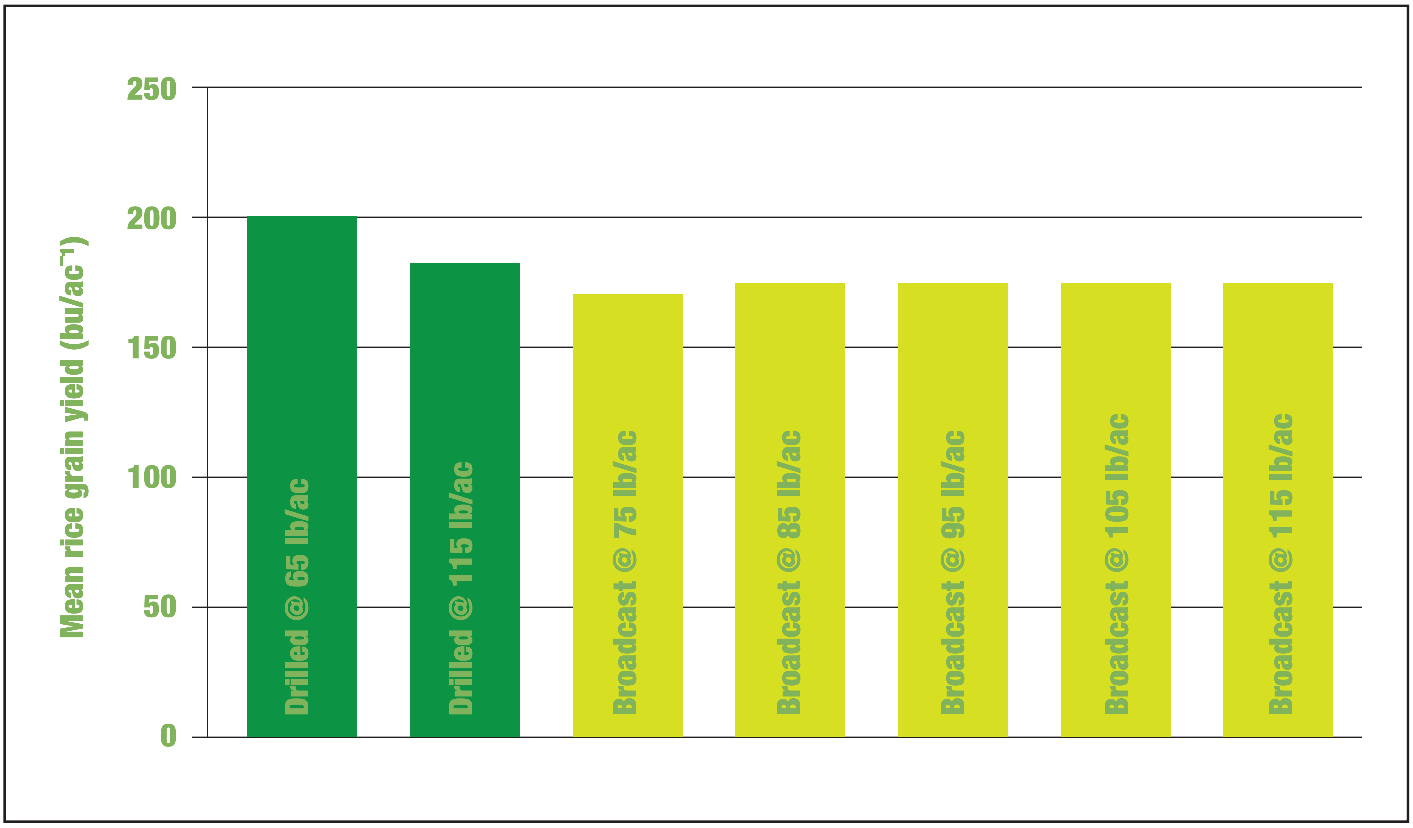


Figure 1. Differences between drill and broadcast seeding rates on silt loam soils in Mississippi.

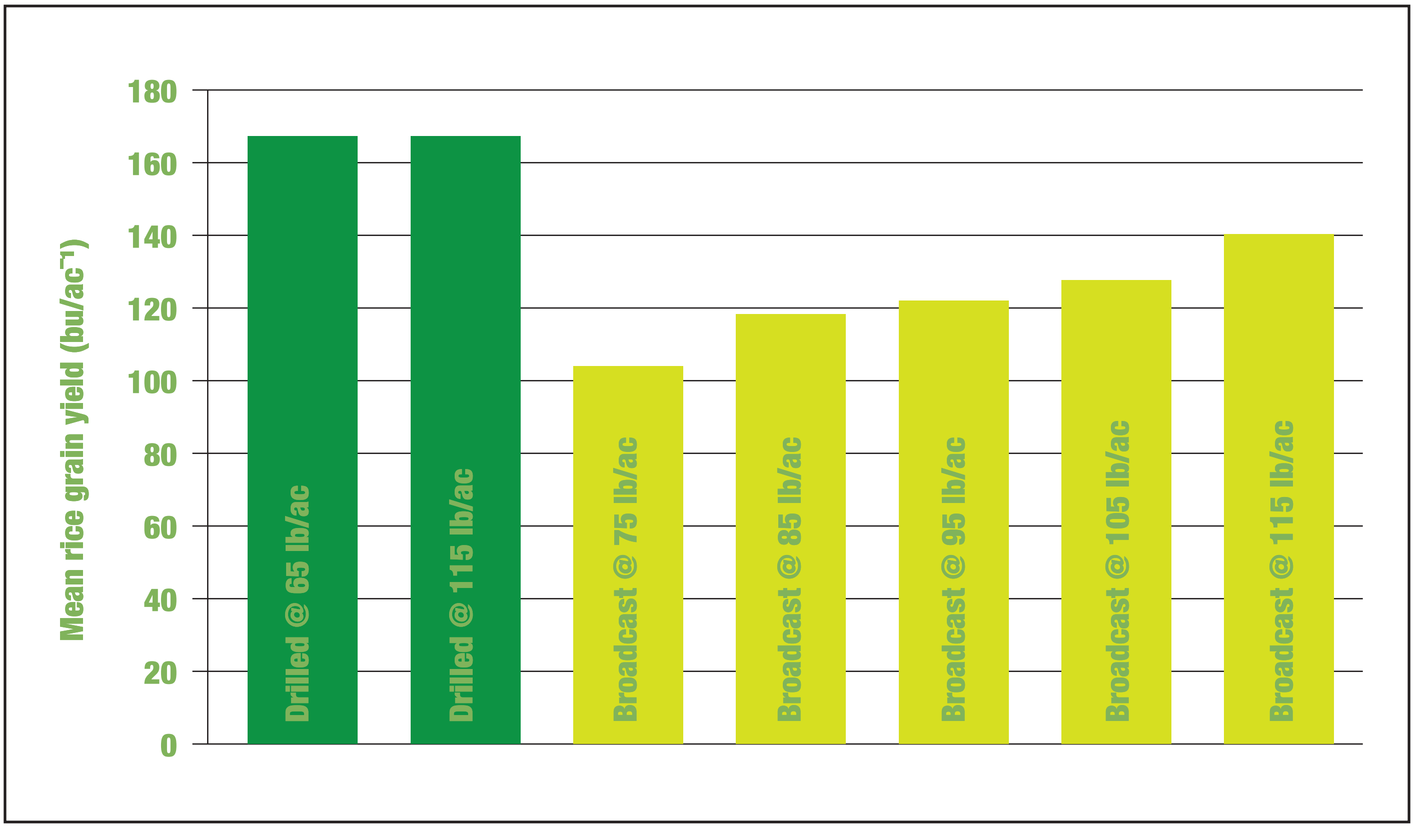


Figure 2. Differences between drill and broadcast seeding rates on clay soils in Mississippi.

Agronomy

Nitrogen Fertilizer Response Profiles for New and Emerging Rice Varieties

Bobby Golden, Justin McCoy, Richard Turner, Lindsey Bell, Robert Sullivan, and Willie Clark

As new rice varieties are brought to market, it is a necessity to have an agronomic package in hand to know how the variety will perform in response to differing management strategies. Nitrogen is by far the nutrient that producers spend the most money on and can influence rice grain yield more so than any other under normal production practices. Trials are conducted annually across the Delta to determine the appropriate nitrogen rate for new varieties across a range of soil textures.

Varieties for 2015 testing were CL163,CL172, LaKast, XP760, and Thad. New for varieties for 2016 testing included CL153 and Diamond. At each testing location 5 total nitrogen rates were evaluated and compared to an untreated control that received no nitrogen. Nitrogen rates ranged from 0-210 lb N/ac for both clay and silty clay soils. Each trial was arranged as a factorial and replicated 4 times. All nitrogen was applied in a 2 way split method with 75% of total N applied preflood and the remainder applied at Midseason.

In general for each variety as nitrogen rate increased yield potential increased before reaching a plateau around 200 lb N/ac. The greatest numerical yield was achieved with XL760 the only hybrid rice variety entered into the 2016 trials. The newly released MSU bred 'CL163' required 180 lb N/acre to maximize and the newly released conventional 'Thad' responded to nitrogen similarly (Table 1). The greatest yielding non-hybrid was CL153, a Horizon Ag offering that will be available for limited acreage in 2016. Diamond a new release from Arkansas also performed well in trial and had similar yields to Lakast and is less prone to lodging. These data are preliminary in the sense that we would like to have three to four years of N management data for a variety before a full N recommendation can be made.

Table 1. Mean grain yield response of new rice cultivars to nitrogen rate in Mississippi during 2016.

N Rate	Variety							
lb N/ac	CL163	CL153	CL172	Diamond	Lakast	Thad	XL760	CL272
	- - - - - - - - - - - - -Mean rice grain yield (bu/ac)- - - - - - - - - - - - -							
0	127	111	111	110	120	121	180	104
90	161	194	152	164	163	162	243	158
120	179	189	168	171	184	177	258	167
150	179	201	171	196	199	176	256	194
180	191	201	180	203	195	188	273	200
210	186	214	180	201	201	191	271	192

Agronomy

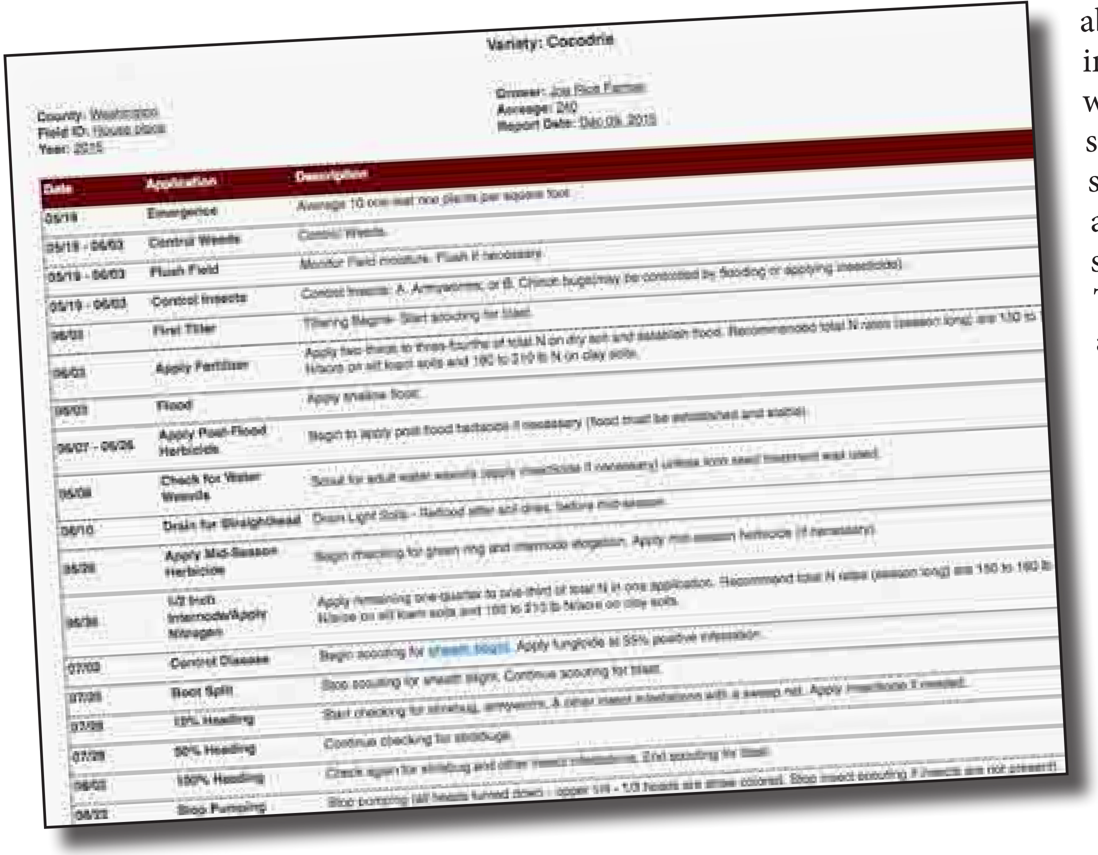
Rice DD 50 App Makes the Program Easy for Smart Phone Use

Mark Silva

Producers and researchers in the intensive agricultural region of the Mississippi Delta have a tremendous need for weather information to develop critical research and management strategies for planting, to fertilize, and to harvest as well as the timing of other key production practices on rice planted in the Delta. This project's goals are to continue data collection and dissemination of pertinent agriculture weather data and products that are required by researchers and farmers and to increase the availability and quality of the data and products available.

This data is used for our research to indicate various weather patterns that a rice crop receives throughout the growing season. This info is beneficial in making management decisions. With the Rice DD 50 management program supplied by the Delta Agricultural Weather Center monitors, plant growth, and quality of rice entries in various variety demonstrations across the State as well as for rice growers. Also, it can be helpful in justifying, insect and disease timing applications as well as harvest dates that might be later than the norm. This information should be especially valuable for the years of extreme drought and high temperatures that were experienced in areas throughout the years.

The information available, primarily on the interactive Internet website www.deltaweather.msstate.edu, has contributed significantly to the actual and potential annual savings for rice producers. The Rice DD50 program allows farmers to reduce their risks and thus avoid possible losses due to untimely applications and management decisions. The program recently as provide a Web App for the DD 50 Program for Smart Phone use. The App can be found and downloaded at http://webapps.msucares.com/



Variety: Cocodrie

County: Washington
Field ID: House place
Year: 2015

Grower: Joe Rice Farmer
Acreage: 240
Report Date: Dec 09, 2015

Date	Application	Description
05/19	Emergence	Average 10 one-leaf rice plants per square foot
05/19 - 06/03	Control Weeds	Control Weeds.
05/19 - 06/03	Flush Field	Monitor Field moisture. Flush if necessary.
05/19 - 06/03	Control Insects	Control Insects: A. Armyworms, or B. Chinch bugs(may be controlled by flooding or applying insecticide)
06/03	First Tiller	Tillering Begins- Start scouting for blast.
06/03	Apply Fertilizer	Apply two-thirds to three-fourths of total N on dry soil and establish flood. Recommended total N rates (season long) are [illegible] N/acre on silt loam soils and 180 to 210 lb N on clay soils.
06/03	Flood	Apply shallow flood.
06/07 - 06/26	Apply Post-Flood Herbicide	Begin to apply post flood herbicide if necessary (flood must be established and stable)
06/08	Check for Water Weevils	Scout for adult water weevils (apply insecticide if necessary) unless [illegible] seed treatment was used.
06/10	Drain for Straighthead	Drain Light Soils - Reflood after soil dries, before mid-season
06/26	Apply Mid-Season Herbicide	Begin checking for green ring and internode elongation. Apply mid-season herbicide (if necessary)
06/26	1/2 Inch Internode/Apply Nitrogen	Apply remaining one-quarter to one-third of total N in one application. Recommend total N rates (season long) are 150 to 180 lb N/acre on silt loam soils and 180 to 210 lb N/acre on clay soils.
07/02	Control Disease	Begin scouting for sheath blight. Apply fungicide at 35% positive infestation.
07/20	Boot Split	Stop scouting for sheath blight. Continue scouting for blast.
07/28	10% Heading	Start checking for stinkbug, armyworm, & other insect infestations with a sweep net. Apply insecticide if needed.
07/28	50% Heading	Continue checking for stinkbugs.
08/02	100% Heading	Check again for stinkbug and other insect infestations. 2nd scouting for blast. Stop insect scouting if insects are not present!
08/22	Stop Pumping	Stop pumping (all heads turned down - upper 1/4 - 1/3 floors are straw colored).

Agronomy

The Delta Agricultural Weather Center provides onsite Weather Data for MSU Rice Variety Trials

Mark Silva

Agricultural weather data are needed by rice producers, researchers, and policy makers to make decisions daily. Farmers utilize the data for critical management decisions about tillage, planting, crop protection applications, flooding, fertilization, and harvesting. Researchers require agriculture weather data to analyze test products, verify field data and compare different data sets to each other.

Mobile weather stations were installed at three sites that are being used by the breeding program for conducting yield trials, including on-farm testing. The weather data collected will help in understanding rice yield potential as affected by climatic factors under MS conditions. Moreover, the setup may be expanded to cover all on-farm test locations to gain a deeper understanding of genotype X environment interaction effects for yield and key traits for use in both breedings widely adapted cultivars and location-specific variety deployment.

Agronomy

On-farm Verification of Intermittent Flood Techniques in the Mississippi Delta

Richard Atwill, Jason Krutz, and Dan Roach

The alluvial aquifer serves as the major source of irrigation water for rice production in Mississippi; however, it is declining at a rate of 300,000 acre feet per year and has done so for approximately 25 years. On average, rice uses approximately 3.0 acre feet per year, which based on average acreage equates to approximately 600,000 acre feet per year. Research in Mississippi has shown that rice can be produced with up to 50% less water than the regional average using multiple-side inlet, alternate wetting and drying (AWD) flooding strategies. The objective of this research, therefore, is to develop safe and efficient intermittent flood strategies while maintaining yield and improving overall farm profitability and to establish best management practices (BMPs) for Mississippi rice growers, state and federal agencies (including county extension agents), and private industry (field reps/consultants) for an AWD irrigation production system including: cultivar selection, N management, weed control, disease, and physiological disorder control.

An experiment was conducted on 18 grower fields throughout the delta region of Mississippi from 2014-2016 to evaluate yield response of rice grown using multiple side-inlet (MSI) irrigation, and MSI coupled with AWD irrigation as compared to rice grown using conventional continuous water management. Three adjacent fields were chosen on each farm, one for each irrigation treatment. Continuously flooded rice was managed by the grower, while MSI and MSI + AWD was managed by MSU. A custom pipe made from 6” PVC was installed in AWD fields to monitor water level below the soil surface. Irrigation of AWD treatments was initiated when water level reached 4″ below the soil surface. Rice water use was determined using a flow meter in each treatment, and yield was recorded at harvest.

Results from grower fields from 2014-2016 suggest that rice grown using AWD irrigation reduced water use by 27% compared to conventional irrigation. Rice grain yield was maintained in AWD irrigation compared to MSI

Table 1. Yield, water use, water use efficiency (WUI), and profitability for conventional rice irrigation, multiple side inlet, and multiple side inlet + alternate wetting/drying (AWD) for grower field experiments from 2014 – 2016.

	Yield	Water Use	WUI	Profitability
	--- bu/ac---	--- ac-in ---	--- bu/ac-in ---	--- $/acre ---
Conventional	165 a*	34.3 a	4.8 a	604 b
MSI**	168 a	28.7 b	5.8 a	629 a
MSI + AWD	166 a	23.4 c	7.1 b	633 a

* Means followed by the same letter are not significantly different at $P \leq 0.05$.

** MSI- Multiple side inlet

Figure 1. Example of water level measurement below the soil surface using a modified "pani-pipe."

and continuous irrigation. Water use efficiency (WUI, bu/ac-in) increased 29% for AWD irrigation compared to continuous flood irrigation. Averaged over 18 sites, 45% of growers exceeded the permitted 36 ac-in for a conventional continuous flood, 26% over using MSI, and 6% exceeded the permit using AWD. Economic analysis results indicate that rice grown using AWD and MSI averaged $29 and $25 per acre greater than continuous flood irrigation, respectively. Rice growers that currently practice intensive water management (n=8) exceeded the permit 5% of time for conventional rice irrigation, however did not exceed the permit using MSI or AWD. On-farm locations that are not currently practicing intensive water management (n=10) exceeded irrigation pumping permitted values 86%, 46%, and 16% of the time with conventional, MSI, and AWD irrigation, respectively. Compared to continuously flooded rice, MSI alone increased farm profitability $56 per acre, and MSI with AWD averaged $74 per acre greater than continuous flooded irrigation practice. Irrigation water applied was reduced by 11 ac-in, on average using AWD irrigation compared to conventional irrigation, and maintained equivalent grain yield. These data suggest that rice grown using AWD irrigation can improve WUI compared to using continuous flooded rice, reduce irrigation pumping amounts, and improve overall farm profitability for Mississippi rice producers.

Agronomy

Development of Intermittent Flood Management System in the Mississippi Delta

Richard Atwill and Jason Krutz

Rice irrigation currently accounts for the greatest amount of irrigation water applied per acre over corn, soybeans, and cotton in the mid-south. The alluvial aquifer serves as the major source of irrigation water for rice production in Mississippi; however, it is declining at a rate of 300,000 acre feet per year and has done so for approximately 25 years. Permitted irrigation withdrawals for fields in rice production in Mississippi are limited to 36 ac-in per year. Recent data suggests that rice producers often exceed this permitted value, and water saving irrigation practices must be validated prior to wide adoption. This study was conducted to determine whether safe and efficient alternate wetting and drying (AWD) water management can be achieved while maintaining yield and improving overall farm profitability.

Figure 1. Water delivery in rice using poly-pipe allows for simultaneous irrigation of individual paddies, resulting in reduced pumping times and increased irrigation efficiency for rice production.

An experiment was conducted at the Delta Research and Extension Center in Stoneville, MS in 2015 and 2016 to evaluate the yield and physiological response of rice to several alternate wetting and drying (AWD) irrigation regimes. Three rice cultivars, CL151, Rex, and XL745 (RiceTec®) were evaluated in six different rice irrigation treatments. Irrigation treatments included: a continuous flood, allowing the flood to recede to the soil surface, 4″ below the soil surface, 8″ below the soil surface, 12″ below the soil surface, and 16″ below the soil surface. Water level in each paddy was monitored and irrigation events were triggered at each respective threshold back to a 4″ flood, then allowed to subside until threshold was reached. Urea (150 lbs N/ac) was applied at first tiller, and a 4″ flood was established and maintained for 14 days on all treatments. Irrigation treatments were then initiated until flowering, at which time a 4″ depth flood was maintained in all treatments. Water treatments resumed after rice plots reached 100% heading until two weeks prior to harvest. Rice plots were harvested at 18-20% moisture and yields were calculated for rice at 12% moisture content. A conventional herbicide program and Clearfield® herbicide program were also evaluated in AWD irrigation and compared to a continuous flood. Experimental plots were over-seeded with barnyardgrass and were evaluated for barnyardgrass control.

Figure 2. Weed control plots overseeded with barnyardgrass to evaluate herbicide control for AWD irrigation as compared to continuous rice irrigation.

Rice grain yield response of two AWD treatments were equal to rice grown with a continuous flood. A ten bushel grain yield increase was observed when the flood within a paddy was allowed to recede to the soil surface compared to a continuous flood. Grain yield for continuous flood was equal to rice grown with flood receding to 4″ below soil surface. Reduction of grain yield was observed when the flood receded past 8″ below the soil surface as compared to continuous flood. Control of barnyardgrass in experimental plots was not different for rice grown under continuous flood compared to AWD (8″ below soil surface). Barnyardgrass control for Clearfield® rice herbicide program in AWD and continuously flooded rice was 95% pooled over all herbicide treatments. For conventional rice, barnyardgrass control (pooled over all herbicide treatments) for continuous irrigation averaged 79% control, while AWD irrigation averaged 82% control.

Data from this experiment in 2015 and 2016 suggest that allowing flood to subside to 4 inches below the soil surface does not result in yield loss compared to a continuous flooded system. Water management practices that reduce groundwater withdrawals are a viable option for rice producers in the mid-south. Weed control for AWD irrigation is maintained using current herbicide programs for conventional and Clearfield® rice production systems. Rice water management using AWD irrigation reduces cost of fuel for pumping while maintaining yield potential thus improving overall profitability.

Mississippi Rice Breeding Program

Ed Redoña, Whitney Smith, Zach Dickey, Justin Glenn, Steve Felston, and Scott Lanford

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, the Mississippi State University (MSU) established a rice breeding program at the Delta Research and Extension Center (DREC) in Stoneville 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 Mississippi Rice Promotion Board has very strongly supported the MSU rice breeding program since its inception 30 years ago.

Figure 2. During the 2016 Rice Field Day, Dr. Ed Redoña discusses elite breeding lines being generated by the MSU rice breeding program for potential release as new Mississippi rice varieties.

To date, the MSU rice breeding program has developed and released eight rice varieties. Six of these were conventional types: 'Litton' (1996), 'Priscilla' (1997), 'Pace' (2005), 'Bowman' (2007), 'Rex' (2010), and 'Thad' (2016) while two were Clearfield® types: 'CL 162' (2011) and 'CL 163' (2015). On average, variety development from hybridization to release has taken 15.6 years, with one new variety being released every 3.75 years. The adoption of these new varieties by Mississippi rice producers has made an impact on the state's economy. In 2014, for example, DREC estimated the regional economic impact of the variety 'Rex' alone to be $1.38 million annually. The latest variety release 'Thad', on the other hand, is one of the very few high-amylose content US rice varieties and is comparable to 'Rex' yield-wise. This unique trait makes 'Thad' highly suitable for use in the parboiling, canning, packaged rice, and noodle processing industry as well as for export to Central American markets where consumers prefer this trait for table rice. 'Thad' thus widens the options available to Mississippi producers on the varieties they can plant to maximize farm profitability, while also increasing the global competiveness of the Mississippi rice industry.

For 2016, breeding activities designed to achieve the breeding goal of developing high-yielding varieties that are adapted to Mississippi, with tolerance to major biological/environmental stresses and grain/milling/cooking qualities desired by domestic and foreign markets were continued. Among these activities were: (1) importation of new donors possessing genes for key desired traits such from the International Rice Research Institute via the USDA; (2) use of new genetic donors in crosses to enrich and broaden the genetic base of future Mississippi rice varieties; (3) piloting of new methods for rapid generation advance and selection; (4) streamlined multi-stage sequential rice varietal evaluation, including via the Uniform Rice Research Nurseries and U.S. mid-South breeding collaborations; (5)

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 preflood followed by a mid-season treatment of 45 pounds of nitrogen per acre.

Silt loam soils – 120 pounds of nitrogen per acre preflood 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

Figure 1. A conventional variety, Thad is the latest product to be developed by the MSU-DREC Rice Breeding Program. Released in 2016, certified seeds of Thad will be available to Mississippi rice growers beginning in the 2017 cropping year.

use of molecular markers to incorporate blast resistance genes into popular Mississippi varieties; (6) shuttle breeding to Puerto Rico for selection and seed increase; (7) on-farm rice variety testing across the Mississippi Delta; and (8) nucleus seed production of elite breeding lines for potential release. In all, the program handled over 30,000 unique breeding materials in 2016, including 2,500 lines under sequential yield testing in its three main breeding pipelines – conventional, Clearfield®, and dual purpose type varieties- where both producer- and end-user-desired traits are being emphasized. New genes for key traits currently and/or likely to be important under future farming scenarios are being incorporated in the variety development pipelines to ensure that future varieties will continue to satisfy the needs of Mississippi rice industry stakeholders.

Breeding and Physiology

Morpho-physiological Characterization of 100 Elite Rice Lines for Drought Tolerance During Early-growth Stage

Salah Jumaa, Ajaz Lone, Shasthree Taduri, Ed Redoña, and Raja Reddy

Drought stress is a major abiotic stress factor that affects growth and development of plants at all stages. Developing a screening tool to identify drought stress tolerance during seedling establishment is key to identifying stress tolerant lines for breeding. An experiment was conducted to evaluate 100 rice experimental breeding lines for tolerance to drought stress under pot-culture in a mini-greenhouse condition (Fig. 1). The rice seedlings were subjected to two different soil moisture regimes, 100 and 50% field capacity, from 10 to 30 days after sowing (DAS). Several morpho-physiological parameters including root traits were measured at the end of the experiment, 25-30 DAS. Significant moisture stress X cultivar interactions were found for most of the parameters measured. A cumulative drought response index (CDRI) was developed by summing the individual response indices of all cultivars. The CDRI varied between 14.7 and 27.9 among the cultivars tested. Based on CDRI and standard deviation values, five and 28 lines were identified as most sensitive and sensitive to drought, respectively, 45 as moderately sensitive, and 16 and six as most tolerant and highly tolerant, respectively (Fig. 2). Cheniere and RU1402174 were identified as the least and most tolerant to drought among 100 lines tested. Even though significant linear correlations were obtained between CDRI and root ($R^2 = 0.91$) and shoot (R^2, 0.48) parameters, root traits are important in studying and identifying drought tolerant lines during the seedling establishment stages in rice. The identified rice lines will be a valuable resource for rice breeders to develop new genotypes best suited for drought conditions.

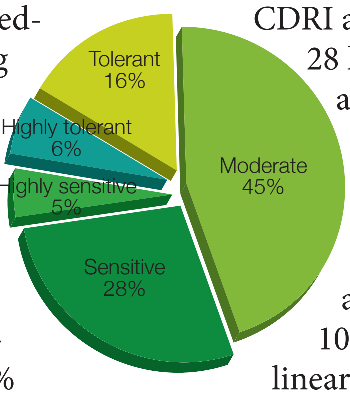


Figure 2.

Figure 1. Monitoring physiological traits under drought conditions.

Breeding and Physiology

Unlocking the Mysteries of Rice Root Systems

Raja Reddy, Salah Jumaa, Naqeebullah, Ed Redoña, and Bobby Golden

Root growth and dynamics are integral parts of the crop growing system and quantitative data in response to abiotic stresses and management practices are often limited because of lack of equipment and analytical techniques. Root system architecture has been implicated as an integrative result of lateral root initiation, morphogenesis, emergence, and growth and thus provides key traits that could be used to screen cultivars for survival under stress conditions.

Theefore, a thorough understanding of the complex genetic mechanisms associated with abiotic stresses (temperature, nitrogen, salinity, and water) under variable weather conditions is essential to design crop varieties with improved water- and nitrogen-use efficiencies, thereby improving crop yield while mitigating environmental damage.

Over the last three years, we have been developing methodologies and tools to quantify genetic variation in plant root systems and their responses to stress conditions. Several hundreds of root system images were acquired and analyzed in rice lines acquired from across the world and their responses to stress conditions using variety of facilities, greenhouses, sunlit plant growth chambers, outdoor pot-culture facilities. Processing root images (Fig. 1), from washing to scanning to further analysis, are labor intensive and involves thousands of man-hours.

Figure 1. WinRhizo optical scanner system for root studies.

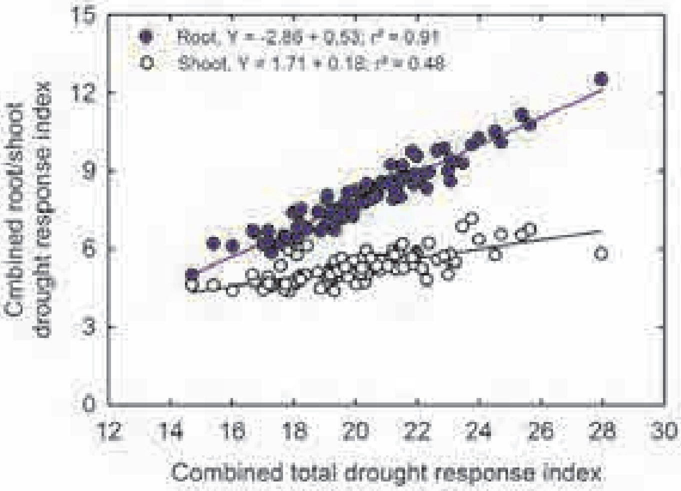


Figure 2. Relationship between total drought response index and combined soot or root drought response indices.

Root traits include cumulative root length, root surface area, average root diameter, root length per volume, root volume, number of roots, number of roots having laterals, number of tips, number of forks, and number of crossings using WinRHIZO system (Fig. 2). Both root and shoot parameters varied among the treatments and rice lines/cultivars. Preliminary results show that understanding plant responses to environmental stresses, root systems are needed in the analysis. Even though significant linear correlations were obtained between total combined drought response index (shoot and root) and root CDRI (R2 = 0.91) and shoot (R2 = 0.48) parameters, root traits are important in studying and identifying drought tolerant lines during the seedling establishment stages in rice (Fig. 2).

Breeding and Physiology

Molecular Marker Assisted Fast Breeding of Blast and Panicle Blight Resistant Cultivars in Rice (*Oryza sativa*)

Perez LM, Ed Redoña, and Zhaohua Peng

Blast and bacterial panicle blight (BPB), caused by *Magnaporthe oryzae* and *Burkholderia glumae,* respectively, are two diseases of rice that pose serious production losses in Mississippi and southern U.S. Blast, despite being a well-studied pathosystem in rice, remained elusive to control both in terms of chemical, cultural, and host plant resistance due to high degree of variation of the pathogen as a result of changing weather patterns. Similarly, BPB in rice is a serious threat because of the warm temperature and high humidity during rice growing season. Due to the requirement for weather conditions at specific developmental stages and the difficulty of field inoculation, phenotype based selection for resistance breeding is highly challenging. Even under ideal weather condition, it will take many years to stack the resistant genes for two major diseases together in the same cultivar. Use of molecular markers to fast track the resistant traits is an ideal approach to achieve host plant resistance in rice disease management.

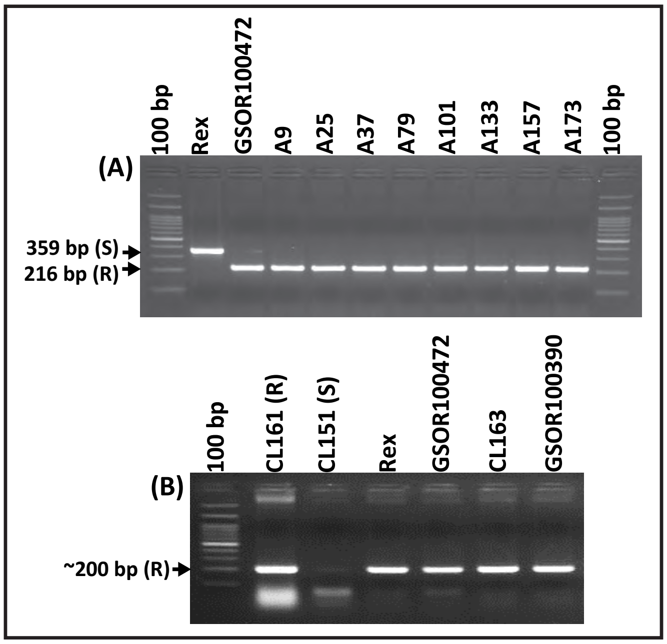


Figure 1. (A) DNA fingerprints of selected F2 plants of Rex/GSOR 100472 with Pi54 (homozygous) for blast resistance, and (B) NBS-LRR genotypes (BPB resistance) of varieties used as parents in developing breeding populations.

To breed for rice cultivars with resistance to blast, seven rice blast resistance markers, including Pita, Pib, Pi54, Pi-km, Pi-ks, Piz, and Pik, were used in DNA fingerprinting analysis of 162 F2 plants from the cross of Rex/GSOR 100472 and 187 F2 plants from the cross of CL163/GSOR100390. The crosses were selected according to our prior survey of the resistance molecular markers in the germplasm collection, about 100 lines, frequently used for breeding in Mississippi and southern U.S. Ten F2 plants of Rex/GSOR 100472 cross contained at least 5 blast R genes including Pita, Pi54, Pi-km, Pik, and Pi-ks. All the plants were homozygous for Pi54 (Figure 1A). Two F2 plants, B41 and B90, from the cross of CL163/GSOR100390 were identified to contain at least 5 blast R genes including Pita, Piz, Pi-km, Pik, and Pi-ks.

Our findings revealed the identification of rice germplasm with desired combinations of blast resistance genes can be used to develop breeding populations for blast resistant rice varieties in Mississippi. We used DNA marker technologies to precisely identify specific progenies of REX/GSOR100472 and

CL163/GSOR100390 containing at least 5 blast resistance genes. The selected F2 plants were approximately 3% of the segregating population, thus effectively narrowing down the pool of genetic materials for further selection and breeding of blast resistant cultivars.

Recently, several spots of BPB disease were observed in Mississippi rice fields. There is no approved chemicals to control BPB in the US and the pathogen have reportedly caused significant yield loss in rice producing regions, including Louisiana, Texas, and Arkansas. Survey and analysis of BPB resistance genes or QTLs is a significant step towards identification of possible rice germplasm to develop BPB resistance rice cultivars in Mississippi. Three markers for resistance to BPB were used in our studies, including NBS-LRR2 for LOC_Os11g12300 in chromosome 11 and 2 rice microsatellites, RM1216 and RM11727 flanking RBG2, a quantitative trait locus (QTL) in chromosome 1. The resistance transcript of Os11g12300 is highly expressed in the resistant cultivar CL161 but not in susceptible cultivar CL151 (Figure 1B).

Results have found that 67% of Mississippi rice breeding germplasm contains RBG2 QTL and a NBS-LRR candidate gene for resistance against B. glumae in rice. These included 12 released varieties, 6 clearfield varieties, 3 donor parents, and 45 breeding lines. Three of the parents used to develop rice blast F2 populations including Rex, CL163, and GSOR100472 contains both RBG2 and Os11g12300. This information is significant because this will contribute to improving disease resistance by combining blast and BPB resistance genes in the selected F2 plants. However, GSOR100390 has Os11g12300 only but no RBG2 QTL. Thus, the use of DNA marker technology for precise selection of plants with blast and BPB resistance has efficiently reduced breeding populations and fast track the development of resistant lines against two major rice diseases in Mississippi rice production.

2016 Foundation Seed Stocks Project Report Summary

Brad Burgess

In 2016, MSU's Foundation Seed Stocks program increased seed of both "Rex" and "Thad" varieties.

Rex was produced on MSU's north farm on the main campus while seed of Thad was increased at the North MS Research and Extension Center at Verona.

Field productions of both varieties progressed normally and numerous rogueings to remove any non-typical plants were conducted throughout the growing season, (see attached photo of roguing of non-typical plants from Thad). Plant uniformity at harvest appeared excellent for both varieties.

Following harvest, preliminary seed testing yielded results consistent with an expectation of high quality seed products. Seed conditioning, treating, and packaging are scheduled to take place in January, 2017.

A sufficient seed supply of the "Mermentau" variety remaining from the 2015 production is currently being held in cold storage to fill 2017 seed orders.

Breeding and Physiology

Puerto Rico Rice Nursery Facilitates Development of Rice Varieties for Mississippi

Ed Redoña, Whitney Smith, Zach Dickey, and Justin Glenn

The Puerto Rico (PR) fall and winter rice research nursery program, established by Louisiana State University, has operated since 1970, with Mississippi joining in 1998. Practically all rice varieties released in the southern United States were at some point advanced, selected or increased in the nursery. In 2013, the agricultural experiment stations of Arkansas, Louisiana, Mississippi, Puerto Rico, and Texas, along with the USDA rice center in Stuttgart AR, agreed to continue the PR nursery program for at least until September 2018. The nursery is on approximately 70 acres within the PR Experiment Station in Lajas, PR (latitude 18°01′03″, longitude 67°04′25″, elevation 45 feet asl).

RU1104077, an MSU developed elite breeding line entered in the on-farm variety trial that is in the final stages of the variety release process.

Each year, the PR nursery is used by the U.S. mid-South rice breeding programs and USDA for generation advancement, selection work, seed purification, seed increase, germplasm propagation, rejuvenation of the USDA world rice collection, and/or breeder seed production. The Mississippi rice breeding program has used the PR nursery for generation advancement, selection work, seed increase, and producing breeder seeds of upcoming variety releases. Since 2013, for example, close to 50,000 early generation breeding lines for selection and advancement as well as panicle selections for breeder seed production have been shuttled between Stoneville and Lajas (Table 1). The dedicated nursery management provided by PR research station personnel ensures breeding program pipeline continuity each year. With a tropical climate, PR allows rice can be planted for one to two extra generations each year, thus reducing the total time required to develop a new rice variety by 1-2 years (Fig. 1).

Table 1. Breeding materials shuttled to and from the Puerto Rico Rice Winter Nursery in Lajas, PR.

Winter Nursery Activity	Cropping Year			Average	Total
	2013-2014	2014-2015	2015-2016		
Clearfield® Variety Rows Planted	5,192	5,627	2,513	4,444	13,332
Conventional Variety Rows Planted	1,983	2,727	1,523	2,078	6,233
Conventional Variety Panicles Selected	4,565	4,929	2,951	4,148	12,445
Clearfield® Variety Panicles Selected	1,943	2,699	2,134	2,259	6,776
Breeder Seed Production Rows	4,000		3,888	3,944	7,888
Total	**17,683**	**15,982**	**13,009**	**15,558**	**46,674**

Figure 1. Panicle rows planted at the designated field for the Mississippi rice breeding program in the PR rice nursery, Lajas, PR, April 2016.

The 2016 Mississippi Rice Variety Trials

Ed Redoña, Whitney Smith, Zachary Dickey, S. Lanford, Justin Glenn, and Bobby Golden

The 2016 rice variety trials were conducted on-farm in seven locations from north to south of the Mississippi Delta: Tunica, Clarksdale, Ruleville, Shaw, Choctaw, Stoneville, and Hollandale. The average yield across sites was 205 bushels per bu/ac which was 7% lower than the 220 bu/a obtained in 2015. Shaw was the highest yielding site (241 bu/ac) while Stoneville was the lowest yielding (140 bu/ac), primarily due to heavy bird damage (Table 1). There were 34 test entries including 5 hybrids, 10 Clearfield® types, and 19 conventional varieties/breeding lines. XL753 was the highest-yielding hybrid while CL272, a new medium-grain release, and Diamond, a new long-grain release from Arkansas, gave the highest yields for the Clearfield® and conventional variety entries, respectively. The newly released Mississippi variety Thad was the second-highest yielding conventional variety entry (209 bu/ac) after Diamond but significantly surpassed Diamond in terms of whole milled or head rice recovery (Table 2). Thad also outperformed the popular Mississippi variety Rex, which was the fourth highest-yielding conventional variety entry, by 7 bu/ac.

To assist Mississippi rice producers in their

2017 variety selection and seed ordering processes, preliminary results of the 2016 variety trials were made available online as early as mid-October 2016 via the MAFES Varietal Trials website (http://www.mafes.msstate.edu/variety-trials/includes/crops/rice.asp). Printed copies of the preliminary results were also distributed to rice growers at the Annual Delta Rice Producers meeting in mid-November 2016. The regular MAFES Information Bulletin detailing the complete results of the variety trials will be published in early 2017. *(continued on p. 26)*

Table 1. Average rough rice yields of varieties, hybrids, and advanced breeding lines evaluated in the 2016 on-farm trials at seven Mississippi locations.

Entry	Choctaw	Clarksdale	Hollandale	Ruleville	Shaw	Stoneville	Tunica	Average	Stability[1]
	bu/A	*bu/A*	*bu/A*	*bu/A*	*bu/A*	*bu/A*	*bu/A*	*bu/A*	
					Hybrids				
XL753	308	261	291	292	304	142	321	274	22
Gemini 214 CL	286	264	270	310	324	146	309	273	22
XL760	320	264	262	272	331	150	309	273	22
CLXL766	307	251	264	318	308	110	305	266	28
CLXL745	280	261	222	267	294	108	282	245	26
					Clearfield				
CL272	227	214	216	220	256	164	183	212	14
RU1504083	228	213	213	197	244	168	196	209	12
RU1504197	213	194	197	198	223	147	209	197	12
CL163	176	214	174	239	208	163	199	196	14
CL153	200	212	176	213	233	105	234	196	23
RU1504122	220	186	179	200	232	96	222	191	24
CL172	181	181	187	184	227	159	184	186	11
RU1504154	158	219	150	233	242	79	208	184	32
CL151	176	189	151	185	222	103	246	182	26
CL111	189	211	141	175	221	82	219	177	29
					Conventional				
Diamond	226	219	216	251	269	188	235	229	11
Thad	254	207	194	235	230	212	212	220	9
Taggart	235	216	200	216	262	175	230	219	13
Rex	228	212	217	218	231	178	207	213	8
LaKast	214	195	209	207	239	168	233	209	11
RU1404122	207	192	207	218	250	163	211	207	13
Titan	230	228	202	207	232	110	208	203	21
Bowman	204	185	173	223	245	180	185	199	13
RU1504114	186	201	161	227	210	165	223	196	14
RU1604191	188	190	162	199	246	121	244	193	23
RU1504198	215	198	184	157	229	134	216	190	18
RU1404156	186	183	169	188	231	145	218	189	15
RoyJ	200	164	180	200	224	161	188	188	12
RU1404154	227	187	191	157	205	139	203	187	16
Cheniere	207	166	185	172	212	152	185	183	12
Mermentau	202	167	180	181	217	144	184	182	13
Sabine	201	159	148	175	214	111	194	172	21
Antonio	212	155	172	162	209	97	181	170	23
Cocodrie	189	136	172	131	173	88	175	152	23
Mean	220	203	195	213	241	140	222	205	
LSD	34	23	26	34	29	28	24		
CV	9%	7%	8%	10%	8%	12%	7%		
Planting Date	April 7	April 8	April 25	April 5	April 7	April 5	April 8		

[1] Stability is calculated by dividing the standard deviation by the mean and multiplying by 100. The lower the number, the more stable it is across multiple locations.

Table 2. Average agronomic and milling performance of varieties, hybrids, and lines grown at seven Mississippi locations, 2016.

Entry	Origin[1]	Yield[2]	Whole Milled Rice	Total Milled Rice	Harvest Moisture	Bushel weight	Plant Height	50% Heading[3]	Lodging[4]	Lodging[5]
		bu/A	*%*	*%*	*%*	*lb*	*in*	*days*	*%*	*(1-5)*
					Hybrids					
XL753	RT	274	54.3	71.2	13.8	39.7	44	83	1	1
Gemini 214 CL	RT	273	56.2	69.8	14.4	38.6	48	86	16	1
XL760	RT	273	56.1	69.6	14.4	38.4	48	87	8	1
CLXL766	RT	266	53.4	70.5	13.9	38.3	44	81	4	1
CLXL745	RT	245	55.3	71.1	13.7	38.1	44	82	23	2
					Clearfield					
CL272	LA-HA	212	57.5	68.8	15.3	43.4	41	86	0	1
RU1504083	MS	209	55.3	69.7	14.5	41.8	37	83	0	1
RU1504197	MS	197	58.9	70.0	15.3	44.0	37	84	1	1
CL163	MS-HA	196	58.1	69.2	15.0	39.8	42	89	27	2
CL153	LA-HA	196	61.2	70.5	14.8	40.6	41	86	15	2
RU1504122	MS	191	59.7	71.1	15.4	41.3	40	83	3	1
CL172	AR-HA	186	60.1	70.4	14.9	42.3	39	86	3	1
RU1504154	MS	184	56.6	69.4	14.4	38.6	45	83	27	2
CL151	LA-HA	182	58.3	70.5	14.9	40.8	39	83	21	2
CL111	LA-HA	177	58.0	70.7	14.7	40.8	40	84	27	2
					Conventional					
Diamond	AR	229	52.1	69.4	15.0	42.0	42	86	0	1
Thad	MS	220	59.1	69.7	15.3	44.5	40	88	0	1
Taggart	AR	219	53.3	70.1	15.0	43.4	47	90	2	1
Rex	MS	213	57.7	68.5	14.7	42.0	43	85	2	1
LaKast	AR	209	49.6	69.5	14.5	42.1	44	86	0	1
RU1404122	MS	207	59.9	71.7	14.9	41.9	41	87	0	1
Titan	AR	203	58.2	68.8	15.1	44.9	40	82	3	1
Bowman	MS	199	60.4	70.1	15.6	43.5	40	90	5	1
RU1504114	MS	196	60.7	71.9	15.4	42.3	46	88	20	2
RU1604191	MS	193	57.1	72.0	14.7	40.7	44	86	17	2
RU1504198	MS	190	57.5	69.9	14.4	40.3	47	85	16	2
RU1404156	MS	189	53.3	71.0	14.3	40.5	41	86	6	1
RoyJ	AR	188	56.7	71.5	16.2	41.7	43	90	0	1
RU1404154	MS	187	59.0	67.7	15.9	42.1	40	93	0	1
Cheniere	LA	183	63.1	72.9	14.4	41.2	38	87	1	1
Mermentau	LA	182	61.4	70.2	16.0	40.6	42	87	0	1
Sabine	TX	172	62.0	70.5	15.3	42.3	40	87	0	1
Antonio	TX	170	62.9	71.4	16.1	42.2	41	85	0	1
Cocodrie	LA	152	63.4	71.4	16.6	41.8	41	88	0	1
Mean		205	58	70	15	41	42	86	7	1
LSD		24.5	3.4	1.4	0.9	1.4	1.7	5.2	14.0	0.5
CV		19.7	7.9	2.7	9.5	4.4	5.5	8.1		

Pathology

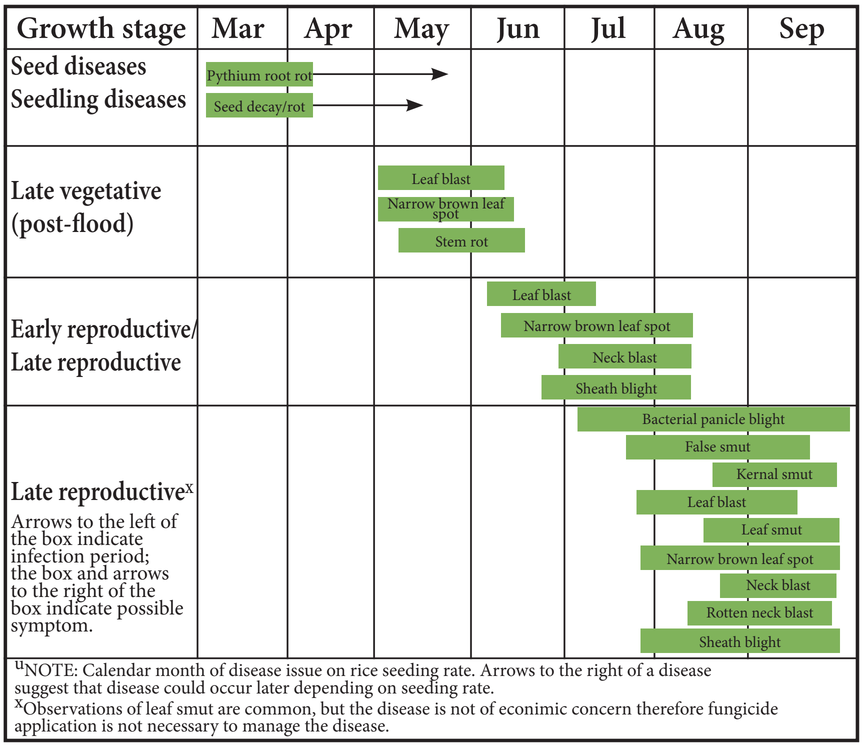
Rice Disease Calendar

Tom Allen, Bobby Golden, Jason Bond, Jeff Gore, and Don Cook

One of the biggest questions each year is whether or not a specific disease is present at a specific growth stage. Most, and I say most, since this statement differs from year-to-year or location-to-location, rice diseases, much like the diseases observed in other crops, occur at particular times of the year or a specific growth stage. For example, bacterial panicle blight is observed prior to harvest while blast can be observed at several different growth stages throughout the season. Generally, the presence of a specific disease will depend on planting date, especially since over the past few years leaf blast has been observed earlier in the season. In other cases, and regardless of planting date, the environment exerts the greatest impact as to whether or not a particular disease occurs. For example, bacterial panicle blight generally occurs when high temperatures occur at the time of flowering.

The second most important factor as related to disease has to do with the previous crop. Fields with no history of rice will not be as likely to have diseases that occur as a result of inoculum present in the field (e.g., leaf blast, false smut, kernel smut). In fact, most of the diseases in the disease calendar (Table 1) are caused by inoculum present as a result of residue remaining in the field from previous seasons. The only real exceptions are the seedling diseases and sheath blight because the organisms that cause these specific diseases are considered to be ubiquitous and occur almost everywhere the plants are grown. However, the specific anastomosis group that causes sheath blight may not be present in every field.

Table 1. Rice disease scouting calendar[u] (TWA—updated 4/16/2016)



[u] NOTE: Calendar month of disease issue on rice seeding rate. Arrows to the right of a disease suggest that disease could occur later depending on seeding rate.

[x] Observations of leaf smut are common, but the disease is not of econimic concern therefore fungicide application is not necessary to manage the disease.

By no means is the attached calendar an exhaustive list of ALL of the rice diseases encountered in Mississippi. The diseases included should be considered to be some of the more common and recognizable diseases regardless of location.

The arrows to the right of the diseases indicate the likely period of infection that is generally required for symptoms to be expressed as well as the period whereby the disease could continue to be an issue. However, the presence of seedling diseases will ultimately depend on the seeding date and environment that occurs subsequent to rice seeding.

Pathology

Scouting and Managing Rice Blast

Bobby Golden, Tom Allen, Jason Bond, Jeff Gore, and Don Cook

Throughout the past several seasons, numerous fields of blast-susceptible rice varieties have been observed to contain leaf blast throughout the Delta. Once again in 2016, disease incidence was relatively mild. In general, most fields where leaf blast occurrence was observed, producers managed the complex well using field techniques such as maintaining adequate flood depth and reducing the midseason N rate, without the need for a fungicide application. However, in certain areas the blast progressed past the leaf phase and infected necks. But, just because leaf blast was observed in a field did not mean that neck blast occured in the same field. In 2015, several fields south of Highway 82 progressed from having leaf blast on younger tillers to no observable leaf blast in a period of 4 weeks in the upper canopy. As of July 16, 2015, the particular fields were observed to contain observable neck blast in several fields of an extremely susceptible rice variety.

Blast symptoms

Leaf blast initially appears as maroon to brownish, diamond-shaped lesions that generally range in size from 1/8 to 1/4 of an inch. As lesions mature, and oftentimes when observed in the morning, they contain a brown to grayish center where fungal growth may occur if the environmental conditions persist and sporulation occurs. When blast progresses to the neck blast phase, portions of the neck appear brown. As lesions on the neck mature the panicle itself can become discolored and bleached, particularly when sterile as a result of neck blast. When sterility results as a consequence of neck blast, a reduction of the transport of nutrients resulting in a lack of grain formation follows, hence the blank, white kernels.

Scouting for blast

Scout areas of fields where the flood may not be as deep first (< 4 inches) before scouting areas of the field where the flood may be the deepest (4+ inches). Scout fields where a high seeding rate may have occurred or fields where the soil class tends to be closer to a silt loam rather than a clay. Pay particular attention to fields with tree lines and shaded areas on the eastern edge of the field that will act to increase prolonged periods of leaf wetness from early morning dew.

Table 1. Fungicide products for blast

Chemical	Rate	Application Timing
Aframe/Quadris	12.5 fl oz/ac	pre-harvest interval = 28 days
Afame Plus/Quilt Xcel	21 to 27 fl oz/ac	pre-harvest interval = 35 days
Equation	12.5 fl oz/ac	pre-harvest interval = 28 days
Gem	3.1 to 4.7 fl oz/ac	pre-harvest interval = 35 days
Quilt	28 to 34 fl oz/ac	pre-harvest interval = 35 days
Satori	12.5 fl oz/ac	pre-harvest interval = 28 days
Stratego 250EC	19 fl oz/ac	pre-harvest interval = 35 days

Managing blast

Maintaining a flood and not allowing the water level to drop to a depth below 4 inches will ultimately reduce the likelihood of infection as well as decrease disease severity. In addition, mid-season nitrogen management may need to be altered in fields where leaf blast has been observed prior to panicle initiation (PI).

Fungicides, while effective management tools, should be used to manage neck blast, rather than applied to reduce leaf blast symptoms. Keep in mind that fungicides will not completely eliminate the disease. Sporulation will continue to occur as the season progresses, especially at the time of heading. Fungicides act to limit yield losses as a result of the disease. But, with that in mind, product selection changes drastically once the head emerges. Triazole (or DMI) fungicides typically have a pre-harvest interval that negates their use if closer than 45 days until harvest. However, stand-alone quinone outside inhibitor (QoI; strobilurin) fungicides that contain azoxystrobin can still be applied to reduce potential yield loss associated with neck blast.

Fungicide application timings

First applications for blast should be made when 50% of the rice plants in a given field are in late boot to panicle exertion. Ideally, the fungicide application timing structure we are accustomed to in MS may be misleading for blast management. In field situations where a fungicide has been applied to manage sheath blight, such as at the PD-timing, a second application may be necessary if blast progresses from the leaf phase to the neck. Be mindful, that multiple fungicide applications for blast (either leaf or neck) are likely not practical nor economical.

Figure 1 (right, top). Typical symptomology of rice leaf blast.
Figure 2 (right, middle). Initial phases of neck blast.
Figure 3 (right). Neck blast present on a susceptible rice variety.

Figure 1

Figure 2

Figure 3

Pathology

Bacterial Panicle Blight of Rice Observed in Multiple Delta Fields

Tom Allen, Bobby Golden, and Jason Bond

Bacterial panicle blight has been a rare disease in Mississippi rice. Over the past several years, bacterial panicle blight has only been observed in years when high temperatures occurred for extended periods of time during flowering. The specific environment for disease development is generally considered to be hot, dry weather. But, high daytime temperatures are not the only requirement for the disease to occur. Nighttime temperatures in the high 70s to low 80s during grain filling periods can increase the risk associated with bacterial panicle blight.

The organism that causes bacterial panicle blight can be both seedborne and soilborne. A survey conducted several years ago in Mississippi rice production systems determined the organism to be present in soil and water in several rice producing counties. Even though the organism may be seedborne, a conducive environment would be necessary for the disease to develop. In addition, most seedborne organisms, including the bacterial panicle blight organism, are present on or in the seed coat in extremely low concentrations.

The symptoms associated with bacterial panicle blight are generally first observed on the bottom of developing kernels. In advanced stages of the disease, bacterial panicle blight can result in panicles that remain upright in the field as a result of sterility. However, several other disorders can result in rice plants exhibiting sterility. The absence of parrot-beaking, which can result from such things as glyphosate injury is one key diagnostic feature associated with the disease. The upright panicles can be the result of sterile grain. However, upright panicles in a rice field as a result of bacterial panicle blight will not contain parrot-beaking which can be commonly asso-

Figure 1. Panicles exhibiting symptoms of bacterial panicle blight can oftentimes appear with straighthead.

Figure 2. Light and dark banding patterns are commonly observed with bacterial panicle blight.

Figure 3. Field symptoms can be confused with other issues that cause sterility.

ciated with herbicide injury or the straighthead disorder attributed to arsenic. The grain discoloration associated with bacterial panicle blight is fairly unique. Banding across the kernel can be observed whereby alternating bands of light and brown coloration commonly occur (figure 2). In addition, the banding pattern on kernels can be associated with stems that remain green. Panicles with disease can also develop secondary infection from saprophytic fungi that can make diagnosing bacterial panicle blight difficult. Infected kernels are more commonly observed beginning at the base of the panicle and can extend through the entire length of the panicle.

In general, management practices do not reduce the presence of the disease. Fungicides are not active on the bacterial organism. As in the past, the fields affected appear to have been planted within a narrow window and were at susceptible/conducive growth stages during the hot, dry environment required for disease development.

Pathology

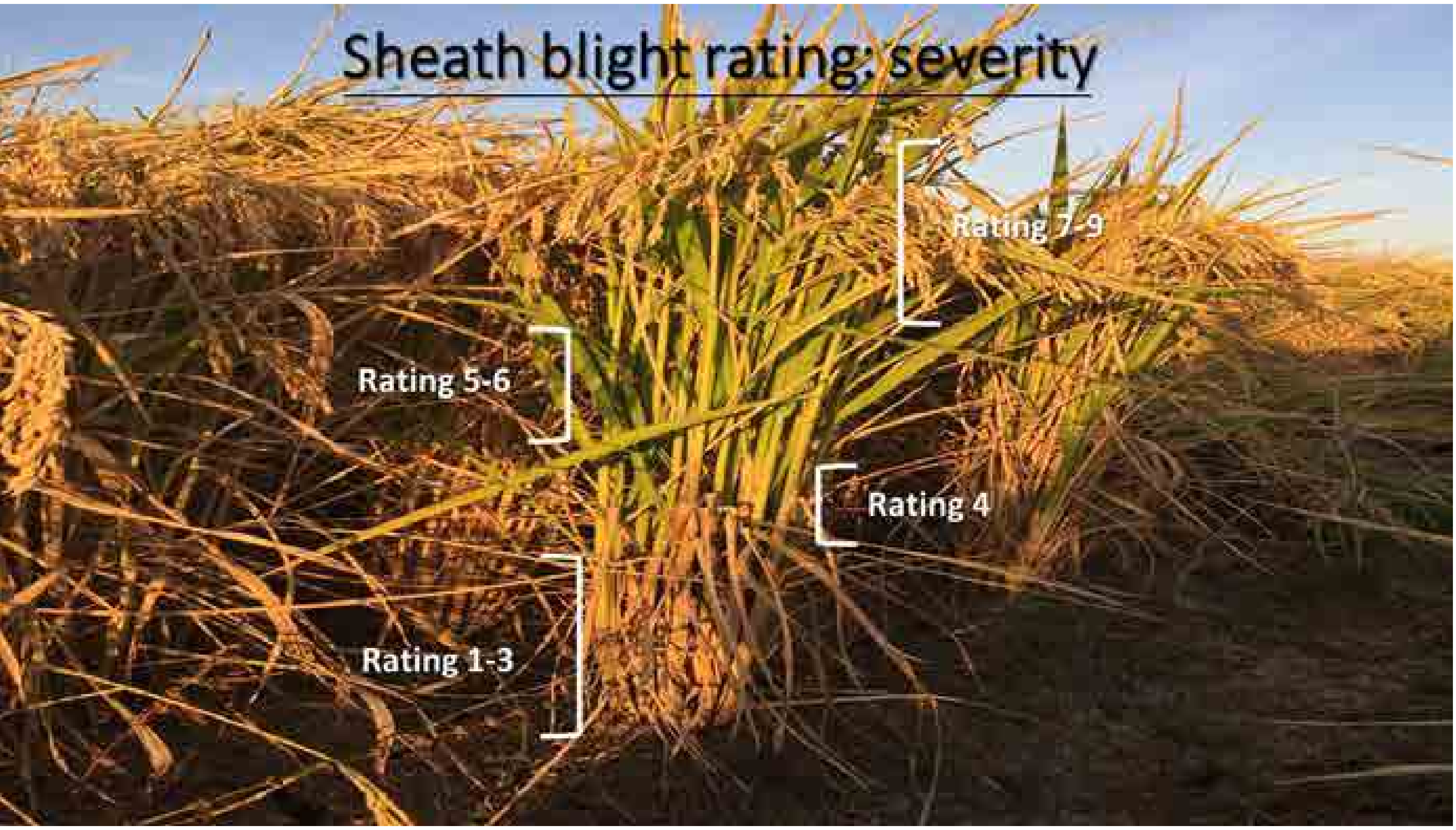
Plant Pathology Program: Sheath Blight Management

Tom Allen

Sheath blight continues to be one of the single most important rice diseases. Even though all commercially available cultivars are susceptible to the disease, breeding efforts continue. In the meantime, trials are conducted on an annual basis in Stoneville, MS to provide information to breeders on the susceptibility of rice entries contained in the Uniform Regional Rice Nursery (URRN) to the sheath blight fungus.

In general, the URRN contains approximately 200 rice entries that at some point in the future may become new rice cultivars depending on their performance across the rice growing region over multiple years. In Mississippi, the entries contained in the URRN are inoculated with Rhizoctonia solani, the sheath blight fungus, and observed for their response. Single row "plots" were planted and inoculated with a slurry of the fungus shortly after permanent flood establishment. The inoculated plots are rated towards

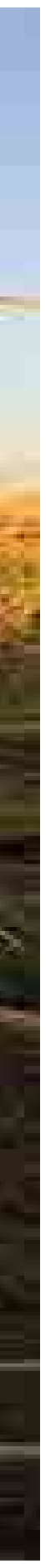
Figure 1. Modified 0 to 9 rating scale used to rate sheath blight. Sheath blight ratings are conducted from the base of the plant, or ground level, to the top of the plant.

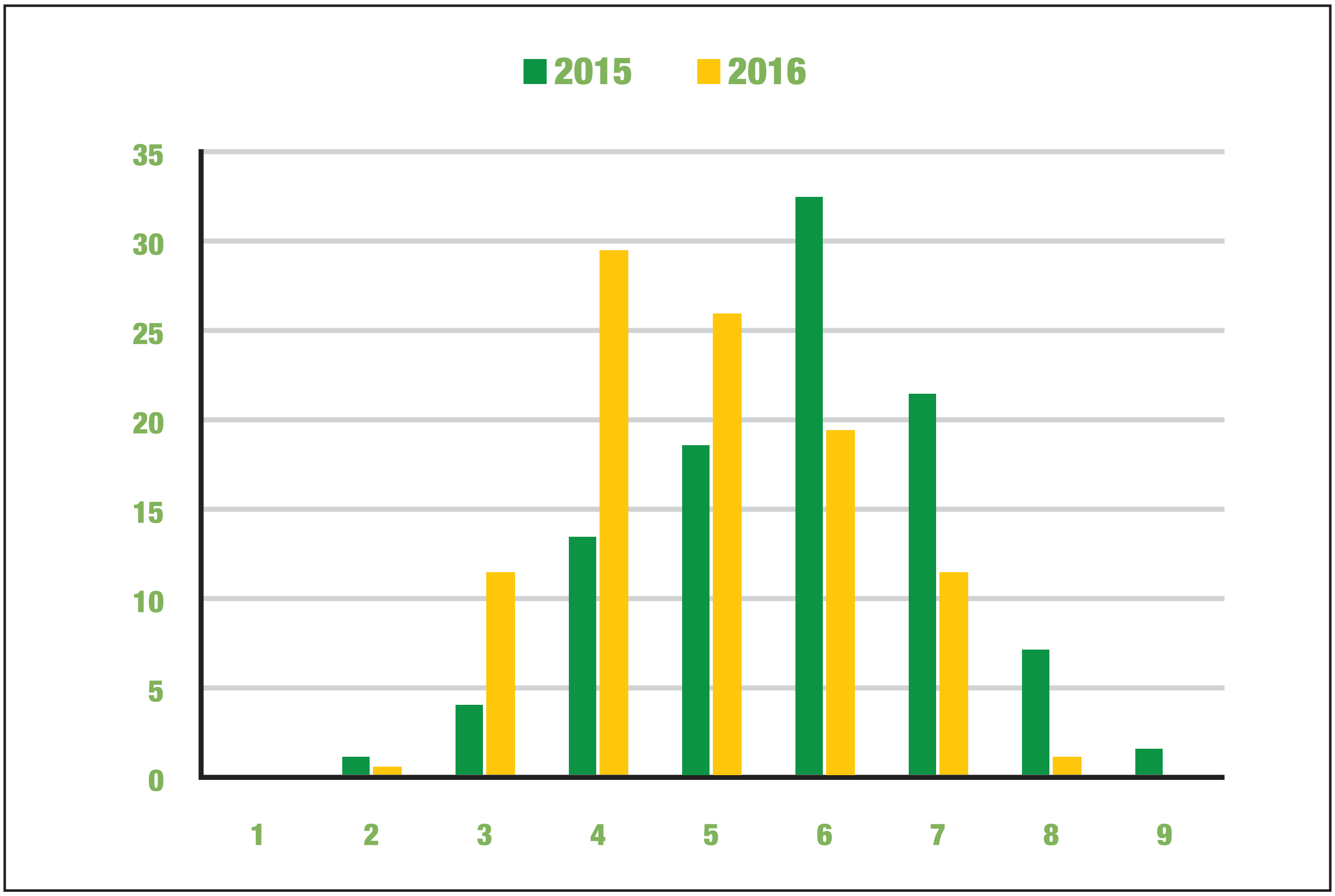


the end of the season, after heads have emerged. Sheath blight severity is rated using a modified 0 to 9 scale. Rice plants are observed for their response to sheath blight from the base of the plant at the soil line to the top of the plant using a 0 to 9 scale whereby 0=no disease and 9=a completely diseased, lodged plant. The photo included depicts the general rating scale used to determine sheath blight severity as it moves up the plant.

In general, during 2016, a range of severities were observed within the entries. The lowest severity observed was a 2 in one entry, and the greatest severity, an 8, was observed in one entry. On average, the response of the URRN entries in MS was a 4. Compared to the results from 2015 (included in the figure below) disease severity tended to be reduced in 2016. The greater temperatures that occurred throughout the season, coupled with drought-like conditions for much of the late growing season likely reduced the overall severity attributed to the inoculum applied. The observations made in the URRN will be continued on annual basis as the information is important for breeding efforts in hopes of developing a sheath blight resistant variety in the future.

Figure 2. Response of rice entries in the URRN program during 2015 and 2016 to sheath blight. Entries are grouped by the percentage of entries rated within rating scale (0 to 9).





Entomology

Quantifying the Potential Exposure of Honey Bees to Neonicotinoid Insecticides In Rice

Jeff Gore, Bobby Golden, Don Cook, Joel Moor, and Read Kelly

Numerous insecticides are commonly used in most crops grown in the Mid-South to manage various insect pests. They are an important component of managing rice water weevil, rice stink bug, and various other insects in rice. Recently, concerns have been raised about the use of insecticides in agriculture and their impact on managed honey bee colonies. In particular, the neonicotinoid class of insecticides has received the most attention. Neonicotinoids have become an important component of rice water weevil management in rice. Thiamethoxam (Cruiser) and clothianidin (Nipsit) are used as seed treatments and clothianidin (Belay) is used as a foliar spray. They consistently provide superior control of this pest compared to the only other alternative, foliar applications with pyrethroid insecticides. Rice is a self-pollinated crop and does not require pollination by insects to achieve adequate yields. However, many pollinators including honey bees harvest pollen from multiple plant hosts. Currently, little information exists about the occurrence of honey bees in flowering rice. A survey was conducted during the summers of 2015 and 2016 to determine the occurrence of honey bees in rice throughout Mississippi. A total of 12 fields were sampled 3 times per day with 3 replications per sample at 4 distances within rice fields over the two years. This resulted in 432 total observations of flowering rice. A sample consisted of slowly walking 100 ft and observing an 8ft wide area (800 ft2).

Honey bees were observed in 21 of the 432 observations (4.9%). A total of 30 bees were observed in rice fields in Mississippi over the two year period. More bees were observed at mid-day compared to morning and evening (Fig. 1). Additionally, the majority of bees were observed at one location that had a bee yard with approximately 20 hives nearby. This survey showed that honey bees will visit rice during the flowering stage and that there is a potential for exposure to insecticide residue in rice.

Bees do occasionally visit rice during the flow-

Figure 1. Occurrence of honey bees in rice at different times during the day.

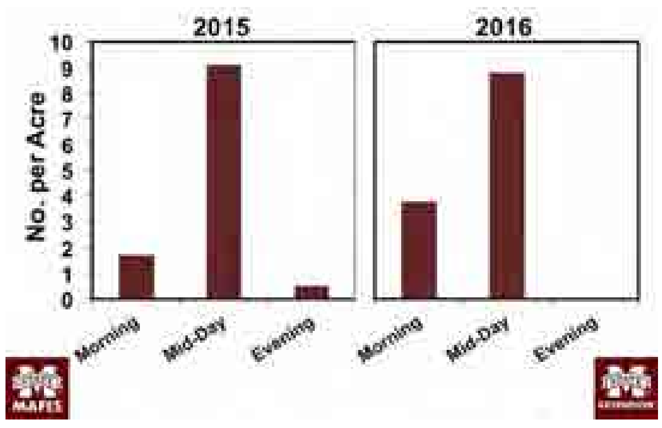
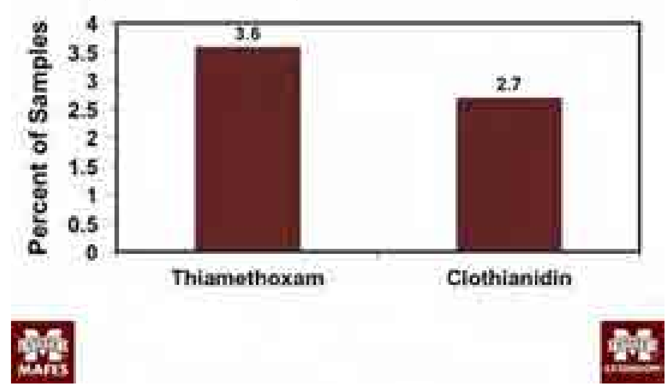


Figure 2. Detection of neonicotinoid insecticides in rice atStoneville from 2015 and 2016. Percentages are across 112 samples of all tissue types over the 2 years.



ering stage, but it is unknown whether or not they are actually exposed insecticide residues. To address this, experiments were conducted in 2015 and 2016 to measure the amount of neonicotinoid residues present in various rice tissues at the time of flowering. The treatments included both of the neonicotinoid seed treatments CruiserMaxx Rice (thiamethoxam) and Nipsit Suite (clothianidin), foliar sprays with Belay (clothianidin) pre-flood and post flood, and a pre-flood foliar application with Endigo (thiamethoxam). Samples of pollen and flag leaves were collected at peak flowering each year and grain samples were collected at the milk stage immediately after flowering. Samples were transported to the laboratory, processed, and shipped to the USDA National Science Laboratories in Gastonia, NC for chemical analysis. The analysis included measurements of the active ingredients of all neonicotinoid insecticides and their metabolites.

Out of 112 samples analyzed across all tissue types, thiamethoxam was detected in 3.6% of samples and clothianidin was detected in 2.7% of samples (Fig. 2). The greatest percentage of detections for each insecticide occurred in flag leaves (Fig. 3). Clothianidin was also detected in grain at the milk stage and no neonicotinoids were detected in the pollen.

In terms of levels detected, thiamethoxam was only detected in flag leaves following the use of CruiserMaxx seed treatment with an average level of 1.9 ppb (Table 1). The maximum level detected in any sample was 6.3 ppb. For clothianidin, the use of Belay applied pre-flood resulted in an average of 2.5 ppb in flag leaves and 1.2 ppb in milk stage grain. The maximum levels detected in each of those tissues was 10.4 ppb and 9.7 ppb, respectively. Neonicotinoid insecticides were not detected in the pollen of samples collected from any of the treatments.

These studies document that honey bees do occasionally visit rice during the flowering stages. Overall, the occurrence of honey bees in rice was not common. Bees were most often observed during the mid-day and very few bees were observed in the evening. This suggests that there is little threat to honey bees from the use of insecticides during the flowering stages. However, insecticide applications targeting rice stink bug during the late flowering stage can be made during the late afternoon to further mitigate this risk. Additionally, neonicotinoid insecticide residues were not detected in rice pollen from the use of these insecticides as seed treatments or foliar sprays to manage rice water weevil. Although very low levels were observed in flag leaves and milk stage grain, honey bees would not be exposed to those residues. Given the pest status of rice water weevil and its potential impact on yields, the benefits of neonicotinoids as seed treatments and foliar sprays greatly outweighs the risks to managed pollinators.

Figure 3. Detection of neonicotinoid insecticides in rice atStoneville, MS from 2015 and 2016. Percentages are by tissue types over the 2 years.

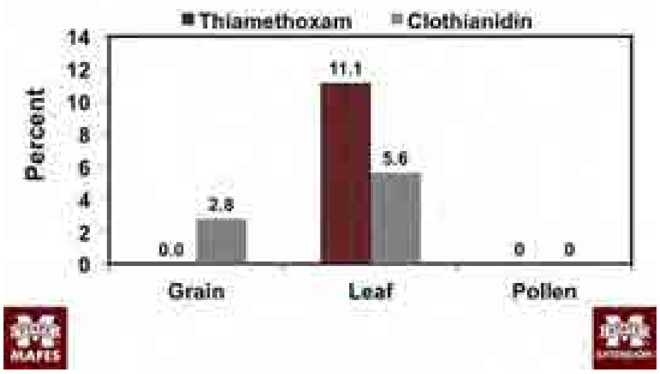
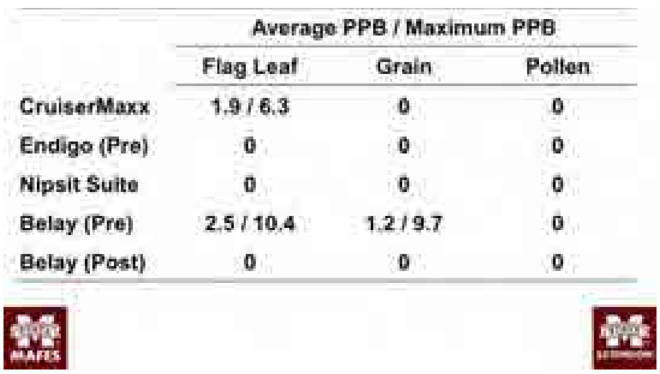


Table 1. Average and maximum concentrations of clothianidin and thiamethoxam in rice tissues in Stoneville, MS from 2015 and 2016.



	Average PPB / Maximum PPB		
	Flag Leaf	Grain	Pollen
CruiserMaxx	1.9 / 6.3	0	0
Endigo (Pre)	0	0	0
Nipsit Suite	0	0	0
Belay (Pre)	2.5 / 10.4	1.2 / 9.7	0
Belay (Post)	0	0	0

Entomology

Fall Armyworm Infestations in 2016 and Thresholds

Jeff Gore, Bobby Golden, and Don Cook

Fall armyworm has become a more consistent pest of rice in recent years. The highest populations we have experienced in many years occurred in 2014 and that year was given the name "Armywormageddon" in many press articles. During the 2016 season, populations in many areas of Mississippi exceeded the numbers experienced in 2014. Several factors have contributed to the high populations in recent years. Fall armyworm does not have a diapause mechanism which means they cannot survive during cool periods like many other insects. They require an abundance of adequate host plants throughout the year to survive in an area. As a result, populations of fall armyworm generally survive the winter only in areas outside of the U.S., typically in Central America and several tropical islands such as Puerto Rico. Occasionally, populations of fall armyworm can survive in southern Florida and southern Texas when mild winters occur. Basically, the warmer the winter, the further north fall armyworms will survive. Because they are migratory and move into Mississippi every year, the winter weather conditions influence how far they have to migrate to reach Mississippi. During mild winters when they overwinter in Florida and Texas, populations reach Mississippi earlier in the year than when they overwinter further south. When this happens, they can build up to much greater populations as the season progresses.

There are two host-strains of fall armyworm in Mississippi, the corn strain and the grass strain. The grass strain is much easier to control with foliar insecticides than the corn strain. Fortunately, the host-strain that infests rice is the grass strain and can be easily controlled with an inexpensive pyrethroid. However, even an inexpensive insecticide application can be detrimental to the economics of rice production if the target pest does not threaten yields. The current action threshold published in the 2016 Insect Control Guide for Agronomic Crops suggests spraying when scouts find an average of 5 or more worms per 10 sweeps or when considerable damage is observed. Currently, it is unknown how or where that threshold was developed. Additionally, it is reasonable to assume that the susceptibility of rice to yield losses from fall armyworm would vary throughout the growing season but the current threshold does not account for that.

Preliminary studies were initiated in 2016 to validate the current action threshold for fall armyworm in rice. Although the current action threshold may be adequate for seedling and preflood infestations of fall armyworm, the preliminary studies suggest that yield losses do not occur from late season infestations at those levels when the rice is flooded. Currently, there is little information about the impact of fall armyworm infestations on yields of rice. Based on these preliminary studies, future research will focus on determining when yield losses may occur from fall armyworm and at what levels of infestation those yield losses will occur to develop better thresholds.

Entomology

Impact of Insecticide Seed Treatments on Herbicide Injury in Rice

Chris Dobbins, Jeff Gore, Jason Bond, Bobby Golden, and Don Cook

Insecticide seed treatments provide a significant economic benefit for rice producers through their protection of the crop from rice water weevil injury. Recent reports from Arkansas suggested that these treatments may also provide some protection against herbicide injury. An experiment was conducted in Stoneville, MS during 2015 and 2016 to determine if current insecticide seed treatments can reduce plant injury from Command applied at 2.66 pints per acre as a pre-emerge. A total of 4 tests were planted in 2015 and 1 test in 2016. The treatments included:

Herbicide Treatments
1. Command 3 ME (2.66 pt/A)
2. Untreated Control

Seed Treatments
1. CruiserMaxx Rice
2. CruiserMaxx Fungicides only
3. CruiserMaxx Insecticide Only
4. Nipsit Suite
5. Nipsit Suite Fungicides only
6. Nipsit Suite Insecticide only
7. No Seed Treatment

'Rex' rice seed were planted between late-April and early-May in 2015 and late-May in 2016 due to stand loss from flooding rains and bird feeding at earlier planting dates. Command was applied to the treated plots immediately after planting with a tractor mounted boom. When rice emerged, plant density, percent herbicide injury, and percent vigor was recorded weekly. Rice water weevil densities were determined at 4 weeks after flood and rough rice yields were recorded at the end of the season.

Herbicide injury varied greatly in each year. No significant differences were observed among seed treatments or the untreated control (Fig. 1 & 2). In 2016, Nipsit Suite and the Nispsit Suite fungicides only appeared to provide some protection against Command injury, but it was not significant and was most likely a reflection of natural variability. No differences in yield were observed between Command and the Untreated Control for any of the seed treatments. All of the insecticide seed treatments had greater yields than the No Seed Treatment. Based on these results, it did not appear that the insecticide seed treatments provided significant levels of protection from Command injury. As a result, growers should base their use of insecticide seed treatments on rice water weevil history to maximize yields and profits.

Figure 1. Influence of insecticide seed treatments on injury from Command applied as a Pre-emerge. Command applied at 2.66 pt/A.

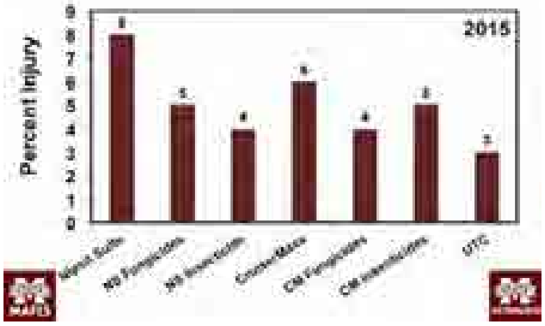
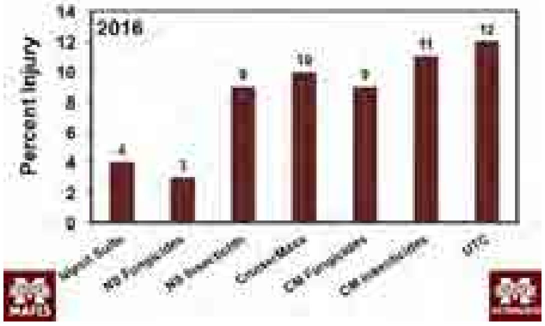


Figure 2. Influence of insecticide seed treatments on injury from Command applied as a Pre-emerge. Command applied at 2.66 pt/A.



Weed Science

Rice Yield Response as Influenced by Late-season Exposure to Off-target Herbicide Movement

Justin McCoy, Bobby Golden, and Jason Bond

In the state of Mississippi in 2016 4.2 million acres of principle crops were planted. Of this acreage 180,000 acres were planted in rice while close to 2 million of these acres were planted in soybeans. The proximity to other crops such as cotton, corn, or soybeans creates great potential for off target herbicide movement onto rice fields throughout Mississippi. Recently, the use of soybean harvest-aids has continued to gain popularity throughout the rice growing areas of the state which only furthers the risk of a rice field to encounter a late season exposure to off target herbicide movement. A study carried out to determine the effect of glyphosate drift on rice by Kurtz and Street (2002) in Stoneville, MS observed yield reductions from 30-98% when applied at the boot growth stage.

Table 1. Symptomology of plots receiving a direct application of either paraquat (left) or glyphosphate (right) at 50% heading.

In 2016 two experiments were established to evaluate rice grain yield and yield component response to late season off target herbicide movement. With these experiments we intended to identify differences in rice response across multiple late season timings, identify differences in rice response across multiple herbicide chemistries, and identify differences in rice response across multiple cultivars. In the first experiment glyphosate (3.2 oz/ac) and paraquat (1.6 oz/ac) were applied to the rice cultivar CL 163 across five timings, beginning at 50% heading with subsequent applications in one week intervals. In the second experiment glyphosate (3.2 oz/ac) and paraquat (1.6 oz/ac) were applied to five differing rice cultivars (CLXL745, XL753, CL163, Rex, and Jupiter) at the 50% heading growth stage.

In the first experiment both glyphosate and parquat applied at the 50% heading timing were observed to cause the greatest yield decrease with subsequent applications decreasing in the amount of yield reduction observed as application timings were further from the 50% heading growth stage. Applications 28 days after 50% heading were observed to exhibit no yield decrease when compared to the untreated control. In the second experiment glyphosate and paraquat were observed to cause comparable yield decreases across all cultivars. Overall late season exposure to glyphosate or paraquat were observed to exhibit substantial yield decreases across multiple cultivars and multiple timings up to the day of draining.

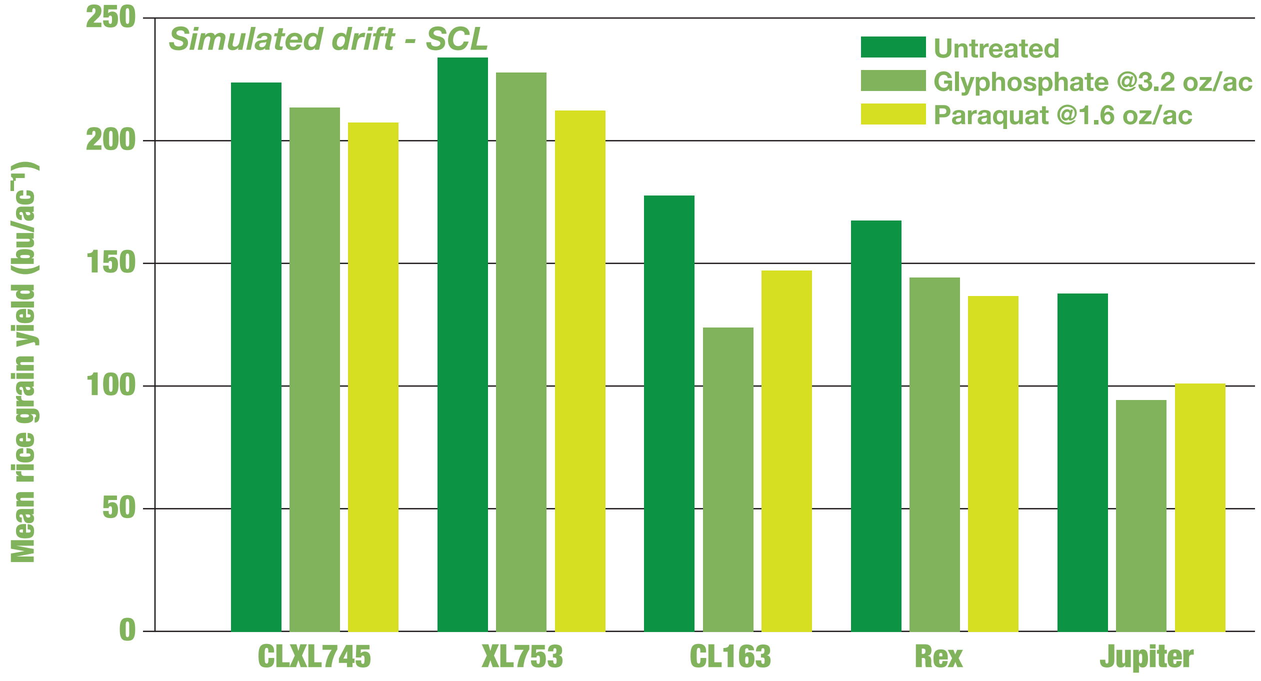


Figure 1. Varietal response to direct application of parquat and glyphosate at 50% heading.

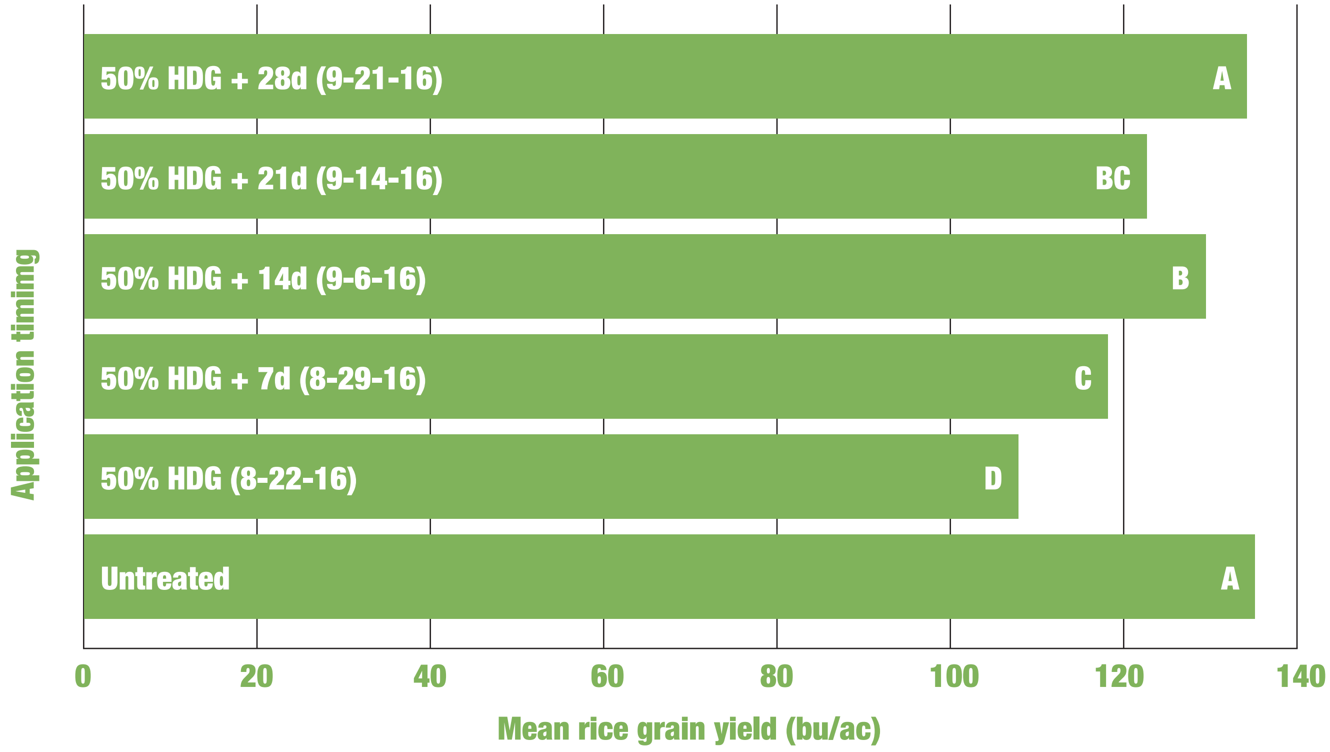


Figure 2. Rice response to direct application of either paraquat or glyphosate as influenced by application timing.

Influence of Broadleaf Herbicides on Weed Control with Provisia

Jason Bond, Matthew Edwards, Ben Lawrence, Jimmy Peeples, Tameka Phillips, and Tyler Hydrick

Provisia rice is a new non-genetically modified rice developed in a joint effort between BASF and the Louisiana State University Ag-Center. The herbicide for use in the Provisia rice production system is quizalofop, which has historically been sold as Assure II in broadleaf crops. Quizalofop will be marketed as Provisia in the Provisia rice production system. Provisia herbicide is scheduled to receive federal labeling in late 2017. The full launch of the Provisia rice production system will occur in 2018.

The Clearfield system has been useful for red rice control for 15 years. However, in recent years, populations of red rice have out-crossed with Clearfield rice, and these are now resistant to Newpath and Beyond. Also, populations of volunteer Clearfield rice are problematic in some areas. Quizalofop is effective for control of grass weeds, but its efficacy can be compromised when mixed with broadleaf herbicides. The Weed Management Program at the Delta Research and Extension Center has researched most components of the Provisia rice production system over the past three years, but one focus has been mixtures of broadleaf herbicides with Provisia.

In research to evaluate herbicide mixtures with Provisia, individual plots were eight rows and included four rows of Provisia rice and one row each of red rice, CL 151, Rex, and CL XL745. Rex, CL 151, and CL XL745 were in-

Figure 1. Nontreated control 14 days after EPOST applications.

Figure 2. Weed control with Provisia at 12.9 ounces per acre at 14 days after EPOST applications.

cluded to simulate volunteer rice. Herbicide treatments varied annually, but all included two applications of Provisia at 12.9 or 15.5 ounces per acre. These sequential applications were made early-postemergence (EPOST) to rice in the two- to three-leaf stage and late-postemergence (LPOST) just prior to flooding when rice was in the four-leaf to one-tiller stage. Broadleaf herbicides were mixed with quizalofop in the EPOST timing only.

Amazon sprangletop and the cultivars CL 151, Rex, and CL XL745 were controlled with all Provisia-based herbicide mixtures in all years. Provisia alone controlled red rice 89% 14 days after the EPOST application when applied at 12.9 ounces per acre. Red rice control was 97% with Provisia alone at 15.5 oz/ac. In years where the lower rate of Provisia was utilized, red rice control 14 d after EPOST was reduced when Facet L, RiceBeaux, or Permit Plus were added to Provisia. A concern with the reduction in red rice control with Provisia plus Facet L is that Facet L is the only herbicide currently recommended for mixture with Clincher and Ricestar HT, which have the same site of action as Provisia. Red rice control was similar among all herbicide treatments 14 d after EPOST applications in years where Provisia was applied at 15.5 oz/ac. Red rice control was similar for all treatments following the sequential applications of Provisia, so the LPOST treatments mitigated reductions in control with some herbicide mixtures.

Differences in Provisia rate from year to year were one reason for reductions in red rice control with some herbicide mixtures. Annual variation in environmental conditions also likely played a role. Solar radiation from 7 days before through 7 days following EPOST applications was lower in years where differences in red rice control were observed. Because red rice control varied with differences in Provisia rate and broadleaf herbicide mixtures, caution should be exercised when Provisia is applied in mixtures with broadleaf herbicides.

Figure 3. Control with Provisia at 12.9 ounces per acre applied in mixture with Sharpen plus Basagran 14 days after EPOST applications.

Figure 4. Weed control with Provisia at 12.9 ounces per acre applied in mixture with RiceBeaux 14 days after EPOST applications

Weed Science

Summary of Weed Control in Mississippi Rice for 2016

Jason Bond, Matthew Edwards, Bobby Golden, Ben Lawrence, Jimmy D. Peeples, and H. Tyler Hydrick

Similar to the previous 4 to 5 years, the 2016 weed control season was challenging in the Mississippi Delta. Warm temperatures and frequent rainfall throughout most of the winter of 2015-16 followed by the historic flood in March were problematic for preplant burndown herbicide applications. Many of these applications were delayed, and growers were faced with winter weeds such as Italian ryegrass and horseweed still present at planting. Rice injury from herbicides exacerbated by environment has been problematic in recent years in Mississippi due to cool, wet conditions early in the season. This was also a problem to a lesser degree in 2016; however, with some exceptions, weed control progressed smoothly after planting. The two major areas of concern in 2016 were herbicide drift and poor herbicide efficacy.

Glyphosate drift to rice was more common in 2016 than in 2014 and 2015. One major issue with the cases of glyphosate drift in 2016 was that most did not occur when rice was in the seedling stage. Previous experience and research results demonstrate that glyphosate drift is more problematic the later in the rice life cycle that it occurs. Several worst-case-scenarios were observed in Mississippi rice in 2016 where the drift occurred during reproductive growth with no symptoms until after heading.

Glyphosate drift is an annual challenge for Mississippi rice growers, but the most common problem in the area of weed science since 2013 has been drift of herbicide mixtures containing paraquat from soybean and cotton fields. Similar to glyphosate drift, more cases of paraquat drift on older rice were observed in 2016 compared

Figure 1. Seedling rice impacted by paraquat drift.

with previous years. A common belief is paraquat is strictly a contact herbicide, so if rice is not completely killed during the drift event, then the crop should recover and produce a good yield. Data generated in the Weed Management Program at the Delta Research and Extension Center in 2015 and 2016 demonstrated that rice can recover from simulated paraquat drift and produce yield similar to the nontreated control. However, this only occurred when simulated drift occurred soon after emergence. When exposed to paraquat after the beginning of the rapid growth phases, rice yield reductions were significant if not devastating. Furthermore, even when rice yield was not compromised following exposure to paraquat as was the case with simulated drift applications to one-leaf rice, rice maturity was delayed at least 7 days. Significant delays in maturity carry practical implications for crop management and ultimately harvest scheduling.

Herbicide resistance is often the cause of poor herbicide efficacy in Mississippi rice. Rice flatsedge resistant to acetolactate synthase (ALS)-inhibiting herbicides, primarily Permit, has gained prominence among troublesome weed species in recent years. With some exceptions, all rice flatsedge populations present in rice fields north of U.S. Highway 82 are considered resistant to ALS-inhibiting herbicides.

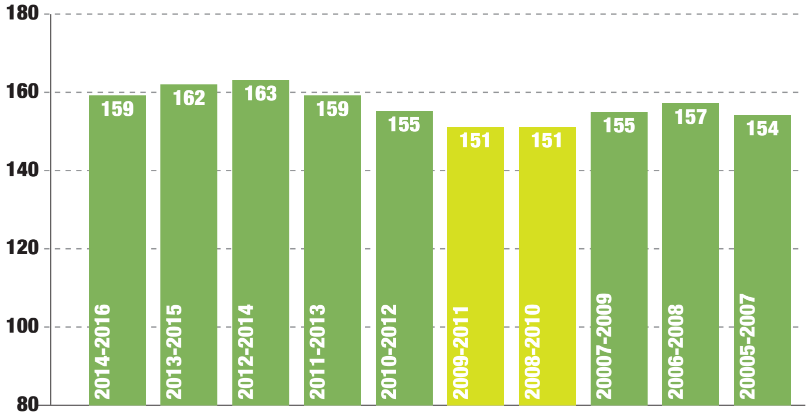
Glyphosate-resistant Italian ryegrass is a problem for all crops in the Mississippi Delta, and rice is no exception. Large populations of glyphosate-resistant Italian ryegrass jeopardize burndown herbicide programs. Fields with glyphosate-resistant Italian ryegrass not controlled during burndown will contain significant residue at planting. Residue will impede planting practices, contribute to competition between rice seedlings and glyphosate-resistant Italian ryegrass, and hinder herbicide programs due to inadequate coverage.

Barnyardgrass is the most common and troublesome weed of rice in Mississippi. Every rice-producing county likely contains barnyardgrass populations that are resistant to at least one herbicide mode of action. Barnyardgrass populations with multiple resistance to Newpath along with propanil and/or Facet have been identified in Bolivar, Leflore, Sunflower, and Washington counties.

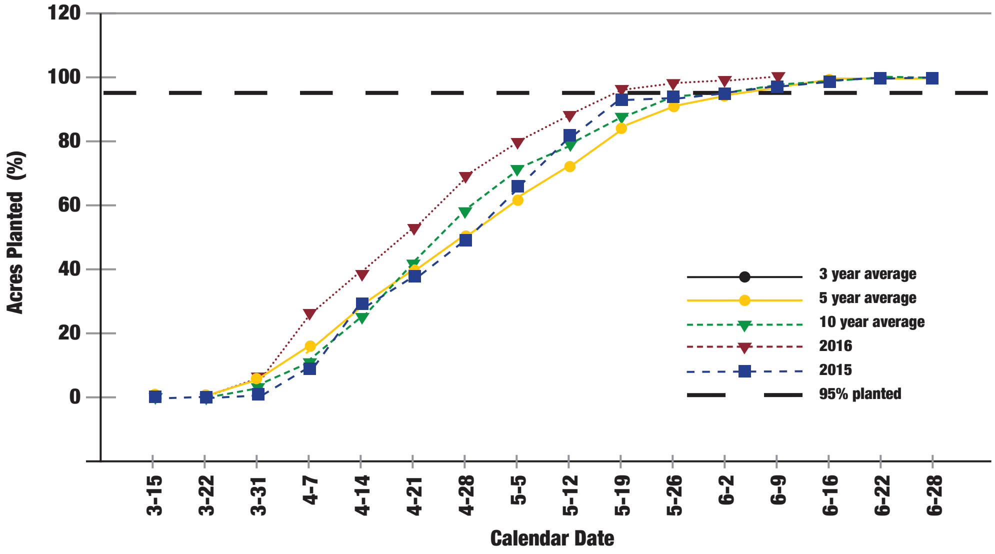
Figure 2. Italian ryegrass residue in a flooded rice field.

Mississippi Rice Statistics

3-Year Moving Average



Mississippi Planting Progress



Mississippi Rice Acreage, 1990- 2016