DELTA RESEARCH AND EXTENSION CENTER

2015 ANNUAL REPORT

MISSISSIPPI STATE UNIVERSITY™
DELTA RESEARCH AND EXTENSION CENTER

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Delta Research and Extension Center would like to extend a special note to appreciation to Mr. John Oglesby of Oglesby Farms in Chatham, MS, for providing the location for the photography featured on the cover of this report.

FROM THE HEAD

The Delta Research and Extension Center (DREC) is a unique place. Its unique factors include size, location, mission, but most importantly it's the people. The faculty are among the best in the world in their disciplines; the research and support staff are highly trained, innovative, and professional; and our stakeholders are interested and actively engaged in the research activities and results at DREC.

In my capacity as Head of Delta Research and Extension Center, I am constantly humbled by the amount of effort that goes into supporting our Delta agricultural industry. It doesn't matter if you are a local grower, an industry representative, or a gardener just trying to grow the biggest tomatoes in the county.

And many times I have thought that the casual passerby might think that DREC appears to be sleepy little research station. That assumption couldn't be farther from the truth. And here are some numbers to back me up.

DREC was founded in 1904 so that gives us 112 proud years of history as research leaders in the Mississippi Delta. Our campus is one of the largest ag research facilities in the world and encompasses more that 4,800 acres including test plots, catfish research ponds, hardwood research facilities, and numerous buildings. Currently, we have 22 full-time Ph.D.'s on staff. That's right, 22! That's more than many small colleges across the country. If you include our support staff and the additional folks we hire during our peak summer season, we boast more than 160 employees.

Our primary emphasis lies in corn, rice, soybean, cotton, and catfish but we have interests in milo, peanuts, sesame, ag economics, irrigation, conservation, and weather research to name a few.

DREC is also the headquarters for the Delta Region of the MSU Extension Service. We have agents located in 19 counties as we serve the Delta. These Extension responsibilities comprise an additional 90 folks to our staff.

And we all know that money talks. DREC is responsible for helping contribute almost $17 million that are created by agricultural economic impact across Mississippi. And this figure doesn't include the decades of innovation and savings that we have contributed to the Delta's ag economy over the last 112 years.

So if you get a chance, please stop by for a visit. We'll help you in any way we can, give you a tour, or even serve you a cup of coffee.

Dr. Jeff Johnson
Head, Delta Research and Extension Center

Dr. Jeff Johnson

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AG ECONOMICS

IMPACTS OF "GENERIC BASE" ACRES ON FARM PROGRAM SUPPORT

Larry Falconer

In 2013, federal farm support payments to Mississippi totaled over $112 million, an important risk management component for the state's agricultural community. The 2014 Agricultural Act cut support levels and made major changes to the programs Mississippi crop producers have utilized to help manage financial risk in the agricultural production sector.

One of the largest changes made in the 2014 Agricultural Act was to remove cotton as a Title I commodity, making it ineligible for price and income support programs over the life of the 2014 Agricultural Act. This impacts over 1.6 million acres on over 14,000 farms in Mississippi. However, the 1.6 million acres of historic cotton base was converted to "generic base" in the 2014 Agricultural Act. These "generic base" acres would receive price and income support payments if another covered commodity was planted on those base acres within a crop year. The calculation of how the "generic base" acres would be allocated depends on the ratio of the covered commodity planted for a crop year. This is a major change from historic methods used to calculate base acres for farm program support programs, as this effectively links potential farm program payments to planting patterns for a particular crop year.

Agricultural economists at the Delta Research and Extension Center and Mississippi State University's main campus have developed a decision support aid to help producers estimate the impact of "generic base" acres for different planting patterns on a particular farm for a specified crop year.

Farm ID: FSN XXX / Projected 2016-17 Example

The values in this column should be the payment rate per acre you expect for the program you selected for that crop. It should not be the full rate, not adjusted by 85%.

The values in this column when based on your numbers should be added as income for the crop when budgeting, as this revenue is now coupled to planting that crop.

Base Acres		Planted Acres for Crop Year	Distributed Generic	Expected ARC-CO or PLC Rate ($/Acre)	Generic Base Credit ($/Planted Acre)	Base Acres	Expected ARC-CO or PLC Payment (Total $)
Wheat	236.2	Wheat	0.0	0.0 $ 22.00	$ -	236.2	$ 4,416.94
Corn	282.4	Corn	300.0	103.5 $ 71.21	$ 20.88	385.9	$ 23,357.95
Grain Sorghum	1.7	Grain Sorghum	0.0	0.0 $ 36.00	$ -	1.7	$ 52.02
Barley	0	Barley	0.0	0.0 $ -	$ -	0.0	$ -
Oats	0	Oats	0.0	0.0 $ -	$ -	0.0	$ -
Long Grain Rice	4	Long Grain Rice	300.0	103.5 $ 97.65	$ 28.64	107.5	$ 8,922.77
Medium Grain Rice	0	Medium Grain Rice	0.0	0.0 $ -	$ -	0.0	$ -
Soybeans	3	Soybeans	300.0	103.5 $ 49.05	$ 14.38	106.5	$ 4,440.25
Other Oilseeds	0	Other Oilseeds	0.0	0.0 $ -	$ -	0.0	$ -
Peanuts	0	Peanuts	0.0	0.0 $ -	$ -	0.0	$ -
Dry Peas	0	Dry Peas	0.0	0.0 $ -	$ -	0.0	$ -
Dry Beans	0	Dry Beans	0.0	0.0 $ -	$ -	0.0	$ -
Lentils	0	Lentils	0.0	0.0 $ -	$ -	0.0	$ -
Chickpeas	0	Chickpeas	0.0	0.0 $ -	$ -	0.0	$ -
Generic	310.4	**Cotton**	0.0			837.8	$ 41,189.93
		Non-Program Crop	0.0				
	837.7		900.0	310.5			

Generic Base Acreage Payment Credit Calculator

PROPERLY UTILIZING AND INTERPRETING RESULTS FROM THE DECISION SUPPORT AID WILL ASSIST PRODUCERS IN MAKING SOUND DECISIONS TO PARTIALLY OFFSET THIS LOSS OF COTTON AS A TITLE I COMMODITY.

AG ENGINEERING

FURROW IRRIGATION INITIATION IN CORN ON A DUNDEE/FORESTDALE SILTY CLAY LOAM SOIL

Lyle Pringle

INITIATING IRRIGATIONS THREE TO FIVE DAYS AHEAD OF TASSELING WHEN AVERAGE SOIL WATER POTENTIAL IS –50 TO –100 KPA WILL RECHARGE THE SOIL PROFILE JUST AHEAD OF THE TASSELING AND POLLINATION GROWTH STAGES WHICH IS THE MOST SENSITIVE TO DROUGHT STRESS AND WILL MAXIMIZE YIELD AND APPARENT WATER-USE EFFICIENCIES.

Ground water supplies are decreasing in the Mississippi Delta and at the same time irrigated acreage is increasing and development of efficient use of water pumped, new surface water supplies and/or government regulation are the tools available to bring our agricultural water needs into balance. In the Mississippi Delta, furrow irrigation is the most popular method of irrigating, yet generally one of the least efficient methods. Continuation of furrow irrigation in our area will depend on improving furrow irrigation efficiencies with proper irrigation scheduling and management. Changing the common philosophy of "irrigating to avoid stress and/or maximize yield" to "irrigating to maximizing yield economically with the least amount of water" is a step in the right direction to help conserve our water resources while reducing fuel consumption.

Initiation of irrigations is one of the most critical decisions a producer has to make when scheduling irrigations in corn to maximize yield economically with the least amount of water. In irrigation initiation research in Mississippi, it has been found that there is an "Initiation Window" that lasts maybe 5 to 10 days and sometimes longer if rainfall occurs. Initiating irrigations anytime within this window will produce yields that are not statistically different. The location of this "Window" usually occurs during late vegetative stages and closes 3 to 5 days ahead of VT or at V15 – V17. Initiations at this time will recharge the soil profile just ahead of the tasseling and pollination period which is the most sensitive to drought. Generally, the closer the actual irrigation initiation is to the back side of this "Initiation Window" the more efficient and cost effective.

Irrometer Watermark soil water potential sensors were installed in a furrow irrigation initiation study on a Dundee/Forestdale silty clay loam soil to monitor moisture tension and root activity. These sensors indirectly measure the negative pressure (kPa) the plant has to put on the soil to remove water. The sensors have a limited range of 0 to -250 kPa, but more than 50% of the readily available soil moisture can be removed within this range. "Field Capacity" is when the moisture content of the soil cannot hold any more moisture after all free water has drained away and is generally said to occur at -10 kPa for sandy soils and -30 kPa for clayey soils. The "Wilting Point" refers to the situation when there is no more available moisture in the soil. This generally occurs at -1500 kPa for most crops. Thus, the closer the values are to zero the wetter the soil and the easier it is to remove moisture. The more negative the values the drier the

Typical poly pipe watering configuration in corn.

soil and the more difficult it is to remove less moisture. The sensors were installed at depths of 9, 18, and 27 inches which approximated the depth of the effective rooting zone of this soil/crop for most years. Since the sensors are site specific and only measure a small volume of soil, there is some inherent variability in the readings. The "Trigger Values" to initiate irrigations to maximize yield and apparent water-use efficiencies in this research study occurred while initiating irrigations when the average sensor readings of all three depths over all replications reached -50 kPa in a hot, dry year and -65 to -100 kPa in cooler, wet years. Variations in the negative pressures to trigger initiations indicates that there may be more total available moisture in the rooting zone on these relatively deep but low infiltration rate soils. Initiating irrigations prior to any root activity at the deeper 27 inch depth was less efficient and did not increase yield statistically. Allowing the roots to start utilizing moisture stored in the lower portion of the effective zone from winter rainfall before initiating irrigations will help reduce water use in corn. Soil moisture sensor systems are useful tools that can be used to aid in irrigation scheduling decisions.

AGRONOMY

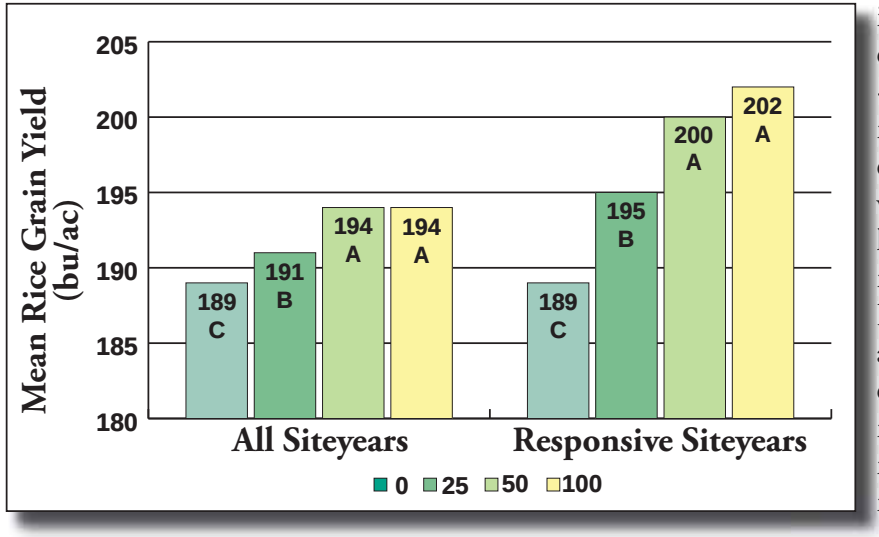
REVIEW OF RICE PHOSPHORUS RESEARCH IN MISSISSIPPI

Bobby Golden

PHOSPHORUS NUTRITION IS EXTREMELY IMPORTANT TO PRODUCING HIGH-YIELDING RICE ON OUR HIGH PH CLAY SOILS IN THE MISSISSIPPI DELTA.

Phosphorus (P) deficiency of rice seems to be a continual issue that sneaks up on us in the Mississippi Delta from year to year. In 2015, we experienced an above average amount of P deficiency-related issues. Many of these issues were brought to our attention as potential herbicide issues, however at the end of the day it was phosphorus. P deficiency in rice can be characterized by stunting and appear very dark green to almost bluish in color. The most distinctive characteristic of P deficient rice is erect spindly leaves with minimal tillers on the plant. Younger tissue may appear healthy while older tissue can turn brown and become necrotic in severe cases.

P research to correlate and calibrate soil tests to describe the relationship between rice grain yield and P was first conducted in 2002 and the program has been maintained with multiple trials placed across the Delta annually. These trials carry a small footprint but are very powerful in helping establish proper P fertilization practices for rice grown in Mississippi.



Currently with 34 siteyears of data in the model, we still have some difficulties explaining rice grain yield response with soil test P data on low P testing soils. What we have observed over the last ten years is when P is needed, the timing of the P application is almost as important as the rate applied. In general, optimum P fertilization timing is somewhere between preplant and the 1-2 leaf stage of rice growth and development. Soil test data suggest that when Lancaster P is below 30 lb P/ac we have a greater chance of observing a yield response. When applying P, however, in many instances even when soil test P < 10 lb P/ac, we have not observed responses. Coupling pH with soil test P data has helped, but more research evaluating P fertilization and alternative soil test extractants for rice is needed to produce more precise recommendations.

AGRONOMY

NITROGEN FERTILIZER RESPONSE PROFILES FOR NEW AND EMERGING RICE VARIETIES

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

As rice varieties are brought to market it is necessary to know how the variety will perform in response to differing management strategies. Nitrogen (N) can influence rice grain yield more than any other nutrient 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.

In general for each variety as nitrogen rate increased yield potential increased before reaching a plateau at 200 lb N/ac on clay soils and 150 lbs N/ac on the silt loam soils. On both clay and silt loam soils the greatest numerical yield was achieved with XP760 the only hybrid rice variety entered into the 2015 trials. The newly released MSU bred CL163 required 200 lb N/ac to maximize yield on clay soils and 150 lb N/ac on silt loams. LaKast yields on clay soils continued to increase across the N application range, but for the silt loam were maximized at 180 lb N/ac. Dissimilar to LaKast and CL163, CL172 maximized yield on clay soils with 160 lb N/ac, while on the silt loams 150 lb N/ac was needed to produce top yields. RU1104077 an experimental line from MSU produced the numerical least grain yield at each nitrogen rate when compared to other varieties in 2015. The nitrogen response profile for RU1104077 was similar to that of CL172 on both the clay and silt loam soils. 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.

NITROGEN REPRESENTS X% OF THE TOTAL PRODUCTION BUDGET FOR RICE. IT'S IMPERITIVE THAT THE PROPER NITROGEN RATE IS APPLIED TO MINIMIZE COSTS ASSOCIATED WITH FERTILIZATION.

N Rate	Mean Rice Grain Yield by Variety (bu/ac)				
(lb N/ac)	LaKast	CL163	CL172	XP760	RU1104077
0	85	111	74	104	85
80	117	143	122	170	112
120	141	170	134	186	130
160	171	172	164	218	150
200	185	183	165	219	157
220	195	189	167	230	165

Mean grain yield response of new rice cultivars to nitrogen rate on clay soils in Mississippi during 2015.

N Rate	Mean Rice Grain Yield by Variety (bu/ac)				
(lb N/ac)	LaKast	CL163	CL172	XP760	RU1104077
0	80	117	101	121	95
60	146	155	145	177	123
90	154	185	154	191	136
120	166	177	160	209	149
150	187	196	181	208	159
180	193	197	177	197	173

Mean grain yield response of new rice cultivars to nitrogen rate on silt loam soils in Mississippi during 2015.

AGRONOMY

MANAGING CORN PRODUCTION WITH PRE-TASSEL NITROGEN APPLICATIONS– NECESSITY OR ANOTHER TOOL IN THE PRODUCTION TOOL BOX?

Wayne Ebelhar

NITROGEN MANAGEMENT IS CRITICAL FOR OPTIMUM CROP PRODUCTION.... USE THE TOOLS IN YOUR TOOL BOX TO ACHIEVE MAXIMUM ECONOMIC POTENTIAL.

One of the biggest decisions producers make each year concerns nitrogen (N) fertility management. Environmental issues such as rainfall can directly impact the availability of both fertilizer N and soil available N (made available through biological transformations). The closer N applications are made to the time that plants can efficiently utilize the nutrient the better for overall crop production efficiency. In most cases, fertilizer N applications are made as a split application with the first portion applied at or near planting and the remainder applied at the V5 to V6 growth stage. However, recent research has shown that N applications, delayed until just before tassel emergence, have been effective in significantly increasing corn yields. The greatest response has been at lower standard N rates (less than 200 lb N/ac) with less response or no response at levels above 200 lb N/ac. Over the years, producers have gone in to fields with airplanes to "touch up" yellow areas that have apparent N deficiency due to numerous reasons but generally as a result of N loss (usually denitrification) where water has stood. Whether this practice led to increased yield was debatable and never really documented. However, producers felt that the practice was important enough to continue making the applications. After several years of replicated field studies, it is well documented that the N is making its way into plants and there is a yield advantage when N levels are not sufficient early in the season.

Research was initiated at the DREC to evaluate pre-tassel N management for corn in a corn/soybean rotation system. Standard N rates were established at 120, 160, 200, 240, and 280 lb N/ac with 120 lb N/ac applied prior to planting as urea-ammonium nitrate solution (32% N) and the remainder applied as a sidedress application (0 to 160 lb N/ac). Pre-tassel nitrogen (PTN) as urea was then hand-applied at rates from 0 to 60 lb N/ac as a broadcast (to simulate aerial application) followed by irrigation or rainfall to incorporate. Grain yields have varied from year to year (Table 1) but yields have been consistently increased with the PTN applications up to 20 lb N/ac (Table 2) applied as urea (46-0-0). Grain yield response to N rates from 2011 through 2014 are summarized in Table 1 (averaged across the pre-tassel N rates) and Table 2 (averaged across N rates). Additional PTN did not significantly increase yields above the 20 lb N/ac rate in any of the four years. In most years, the biggest gain has come with only 20 lb N/ac even though the minimum aerial application is 100 lb product/ac. Along with grain yields, bushel test weight and seed weight were both significantly impacted by the standard N

Nitrogen Management with Pre-tassel Urea Applications 4-Year Summary of Main Effects DREC– Silt Loam Site				
Nitrogen Rate	**2011 Yield**	**2012 Yield**	**2013 Yield**	**2014 Yield**
(lb N/A)	--Grain Yield @15.5%Moisture (BU/ac)--			
0	140 b	187 b	202 b	185
20	156 a	196 a	216 a	185
40	160 a	206 a	222 a	188
60	165 a	202 a	217 a	193
LSD (0.05)	11	6	12	11 ns
Means averaged across standard N rates (120 to 280 lb N/ac)				

Nitrogen Management with Pre-tassel Urea Applications 4-Year Summary of Main Effects (2011-2014) DREC– Silt Loam Site				
Nitrogen Rate	**2011 Yield**	**2012 Yield**	**2013 Yield**	**2014 Yield**
(lb N/A)	--Grain Yield @15.5%Moisture (BU/ac)--			
120	109 d	173 d	171 d	161 d
160	139 c	187 c	204 c	178 c
200	159 b	204 b	221 b	194 b
240	181 a	212 a	235 a	200 a
280	189 a	213 a	241 a	207 a
LSD (0.05)	12	7	14	12
Means averaged across Pre-tassel N rates (O, 20, 40, and 60 lb N/ac)				

Table 1, far left: *Four-year summary of corn grain yield (@ 15.5% moisture) response to pre-tassel nitrogen (PTN) rates averaged across standard nitrogen application rates. Delta Research and Extension Center, Stoneville, MS. 2011 – 2014.*

Table 2, left: *Four-year summary of corn grain yields (@ 15.5% moisture) with varying nitrogen (N) management averaged across pre-tassel nitrogen (PTN) rates. Delta Research and Extension center, Stoneville, MS. 2011-2014*

rates and PTN rates.

This research was originally supported in part by the Mississippi Corn Promotion Board. The current evaluations are being conducted without additional funding. An effort has been underway to try to refine the pre-tassel N management by looking at additional cultivars and soil types. Also under investigation is the possible timing of the PTN application based on growth stage or growing degree days in an effort to identify the "best" time for pre-tassel N applications. Further research in producer fields has shown that the yield response may be related to cultivars as some cultivars did not respond to PTN applications.

Many producers are inquiring as to whether the PTN application should become a standard procedure when growing corn. While the research data over the last several years has shown that the plants are responding to the PTN application, the response is greatest when adequate N is not available prior to tassel emergence. However, the PTN application is the most expensive N and does require a water source (rainfall or irrigation) to incorporate the added N. Data also indicated that there was no response when the standard N rate was applied at recommended levels early in the growing season. Delaying N applications could lead to complications and N deficiencies if environmental conditions are not favorable. To address some of these questions, two studies were initiated in 2015 to evaluate the interaction of cultivars and PTN applications. The two studies involve 1) a lower than normal standard N rate (180 lb N/ac: 120 lb N/ac applied prior to planting + 60 lb N/ac as a sidedress at V5-V6), and 2) a high standard N rate (240 lb N/ac: 120 lb N/ac prior to planting + 120 lb N/ac as a sidedress at V5-V6). While there were responses to PTN in the low standard system, there was no response to PTN in the other. These studies are planned to continue in 2016.

AGRONOMY

AGRONOMIC EVALUATION OF SOYBEAN/CORN ROTATION WITH TWIN-ROW PRODUCTION AND INCREASED NUTRIENT MANAGEMENT

Wayne Ebelhar

THIS RESEARCH, SPONSORED IN PART BY THE MISSISSIPPI SOYBEAN PROMOTION BOARD, LOOKS TO DEMONSTRATE THE NEED FOR FOLLOWING SOIL TEST RECOMMENDATIONS AND THE BENEFITS OF CROP ROTATION WITH TWIN-ROW PLANTING SYSTEMS.

Rotations involving corn and soybean have been occurring around the country especially in the Midwest and much of the Corn Belt. The literature has been filled with documentation of the "rotation effect" with many potential explanations as to why the effect occurs. Many fields have been continuously cropped to cotton for decades in the Mid-south. In recent times, corn has replaced cotton, irrigation has replaced dryland or rain-fed production, and soybean has moved from the last crop planted to the early soybean production system with planting in March and April rather than May and June. Raised beds remain the choice for most producers in the Delta on the lighter textured soils. Large-tired equipment and the presence of cotton still push producers toward wide-row planting systems while many variations in planting patterns continue to be developed and evaluated. Twin-row planting systems help to combine the wide-row and narrower-row technology into a viable alternative for Mid-south production systems. Twin-row production (two rows on a single bed) allows for more rapid ground cover and yet maintains adequate waterways for surface drainage and irrigation.

As grain yields increase, nutrient uptake and subsequent nutrient removal is increased. With higher yields and no supplemental fertilizer nutrients, soil levels continue to decline. Nutrient removal is generally higher for corn and soybean compared to cotton (as much as 2 to 3 times). Should the stover be removed for energy generation the decline in soil-available nutrients is even greater. The purpose of this research is to combine the technologies into a management system that can optimize yields and increase profitability.

The overall objectives of the study were 1) determine the agronomic implications of soybean/corn rotations in twin-row planting systems under standard and high management with irrigation, and 2) evaluate the economic impact of the above systems on whole-farm enterprise profitability.

Six-year field studies were established at two locations in 2012. Two rotation system were included: 1/1 soybean/corn (SB/CR) rotation (one year SB followed by one year CR) and a 2/1 system (SB/SB/CR, two years of SB followed by one year CR). Planting seed selection has been based on the latest technology with seed price as a component of the economic analysis. Standard fertility practices have been defined as those based on soil test recommendation for the crop being grown. The high fertility has then been defined as

20-25% above recommended levels for each fertilizer nutrient. Plots have been maintained uniformly across all treatments when possible.The 2015 corn and soybean production on the sandy loam site is summarized in Table 1 with grain yield corrected for moisture. There was no significant difference between the soybean yields as affected by the previous crop or fertility regime. Corn yields following soybean at the high fertility level were significantly higher (Table 1) but were not significantly different. At the standard fertility level, corn following two years of soybean were 40 bu/acre higher (28.8%). Soybean and corn yields on the sandy loam site were lower than those observed in earlier years. The site was planted later than planned due to errors at planting.

The results from the clay site had similar corn and soybean yields compared to the sand site. The corn crop on the clay soil site was adversely affected by wet soil conditions early in the season but held up better with irrigation and dry weather later into the growing season. The results are summarized in Table 2.

Soybean yields were higher than the yields from the sandy loam site with no response to increased fertility. Soil tests show the area to be above levels expected to respond to additional fertilizer. Stands were acceptable for the field even after planting into the old stubble from the previous year. Fall and spring tillage can be delayed due to wet soils. Corn yields on the clay averaged about the same as the sand but the range in yields was much narrower. There was no difference observed in either corn or soybean on the clay site with respect to rotation or fertility level.

Soil samples were again collected after harvest from each plot. These samples were dried, ground, and then analyzed for nutrient content and other soil test components by the Soil Testing and Plant Analysis Laboratory at MSU. These results are used to determine fertility recommendations for the study. This was the fourth year of a six-year study and will be continued in 2016. This project has been supported in part by the Mississippi Soybean Promotion Board and their support is greatly appreciated.

TRT	Crop Sequence	2015 Crop	Fertility (lb/acre)			Soybean Yield (bu/acre) @ 13.0%		Corn Yield (bu/acre) @ 15.5%	
			N	P	K				
1	CR-SB	SB	0	0	0	49.3			
2	SB-CR	CR	220	0	0			139.0	b
3	CR-SB-SB	CR	220	0	0			179.0	a
4	SB-CR-SB	SB	0	0	0	48.6			
5	SB-SB-CR	SB	0	0	0	47.5			
6	CR-SB	SB	0	26.2	50	49.9			
7	SB-CR	CR	260	26.2	50			184.1	a
8	CR-SB-SB	CR	260	26.2	50			197.1	a
9	SB-CR-SB	SB	0	26.2	50	49.0			
10	SB-SB-CR	SB	0	26.2	50	49.3			
	LSD (0.05)					4.3		35.0	
	Prob > F					0.8877	ns	0.0232	

TRT	Crop Sequence	2015 Crop	Fertility (lb/acre)			Soybean Yield (bu/acre) @ 13.0%		Corn Yield (bu/acre) @ 15.5%	
			N	P	K				
1	CR-SB	SB	0	0	0	50.7			
2	SB-CR	CR	220	0	0			173.9	
3	CR-SB-SB	CR	220	0	0			166.4	
4	SB-CR-SB	SB	0	0	0	53.4			
5	SB-SB-CR	SB	0	0	0	52.2			
6	CR-SB	SB	0	26.2	50	53.2			
7	SB-CR	CR	260	26.2	50			184.8	
8	CR-SB-SB	CR	260	26.2	50			175.1	
9	SB-CR-SB	SB	0	26.2	50	53.5			
10	SB-SB-CR	SB	0	26.2	50	52.6			
	LSD (0.05)					3.3		13.4	
	Prob > F					0.4836	ns	0.0741	ns

Table 1, far left: *Summary of grain yields corrected for moisture for evaluation of soybean/corn rotation in twin-row production on a sandy loam soil.*
Table 2, left: *Summary of grain yields corrected for moisture for evaluation of soybean/corn rotation in twin-row production on a clay soil.*

AGRONOMY

INTERACTION OF NITROGEN RATES AND CULTIVARS FOR CORN PRODUCTION– COMPARING SINGLE-ROW TO TWIN-ROW SYSTEMS

Wayne Ebelhar

MANY PRODUCERS CONTINUE TO QUESTION WHETHER TWIN-ROW PRODUCTION IS BETTER THAN SINGLE-ROW PRODUCTION FOR CORN. THE OBJECTIVE OF THIS RESEARCH IS DESIGNED TO EXAMINE CULTIVAR EFFECTS WITH SINGLE-ROW VERSUS TWIN-ROW PRODUCTION SYSTEMS.

Cultural practices are quite important for optimum corn production in the Mississippi Delta and are the focus of several research projects. Plant population (seeding rates), nitrogen (N) fertilization, and irrigation are key components of Mid-south corn production within the wide-row planting systems. While yields may not be as high for some areas in the non-Delta region due to lack of natural fertility and irrigation potential, the profitability of corn compared to other crops has led to increased acreage. Twin-row planters and drills are being utilized to optimize soybean yield with conventional wide-row spacing common to the cotton production area. Producers want to use the same planter for corn and soybean. As fertilizer prices continue to fluctuate, increases in seeding rates, especially in twin-row planting patterns, have been more cost effective than increased N rates. Previous research has shown that the seeding rates could be increased by at least 5000 seed/ac ($3.75/1000 seed based on $300/80K bag of planting seed). Another key factor that producers must evaluate is the cost of planting seed related to the technology

Figure 1: *Summary of 2015 interaction effects for cultivars and planting pattern.*

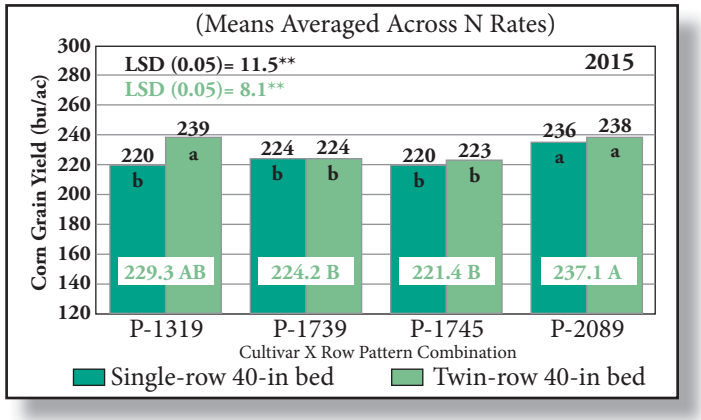
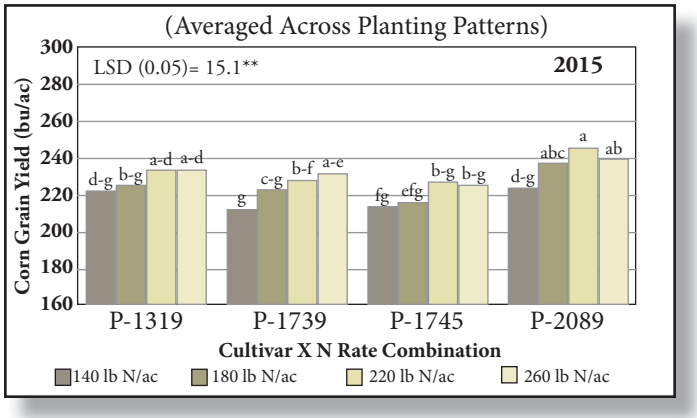


Figure 2: *Interaction effects for cultivars and nitrogen rates averaged across planting patterns.*



fees being assessed. An evaluation of these two components could lead to increased yields and reduced unit cost of production.

Multi-year research was initiated in 2013 to evaluate single-row (SR) vs twin-row (TR) production systems for corn on wide rows following soybean. The study included N rates of 140, 180, 220, and 260 lb N/ac with 100 lb N/ac applied pre-plant (PPN) and the remaining N (40, 80, 120, or 160 lb N/ac) applied as a sidedress. Based on previous research, seeding rates were planned at 32,500 seeds per acre for SR production and 37,500 seeds per acre for the TR system. Four Pioneer hybrids (ranging in maturity from 113 to 120 days) were chosen for the study and included 1319 HR, 1739 HR, 1745 BVT, and 2089 YHR. The hybrids were planted with a Monosem TR planter and John Deere SR planter. At maturity, the two center rows of each 4-row plot (for TR system, four rows of eight) were harvested with a commercial combine adapted for plot harvest. Samples were collected at harvest and used to measure harvest moisture and determine both bushel test weight and seed index (100 seed weight).

Grain yields have been summarized in Table 1. Yields ranged in the SR planting system from 211.0 bu/ac (Pioneer 1319 HR, 140 lb N/ac) to 245.5 bu/ac (Pioneer 2089 YHR, 220 lb N/ac). A similar range was observed in the TR planting system where yields ranged from 211.7 bu/ac (Pioneer 1739 HR, 140 lb N/ac) to 247.0 bu/ac (Pioneer 2089 YHR, 220 lb N/ac). Interestingly, there were differences between cultivars again in 2015. The earliest maturing cultivar, Pioneer 1319 HR (113 days) averaged 19.4 bu/ac greater yields for TR compared to SR production (Table 1). The interaction effects of cultivars and planting patterns averaged across N rates is shown in Figure 1 along with the main effects for cultivar averaged across N rates and planting patterns. Pioneer 2089 YHR produced higher yields in 2015 compared to the other cultivars when averaged across planting pattern and N rate (Figure 1). The effects of N rate are shown in Figure 2. For most of the cultivars, grain yields were increased with increasing N rates up to 220 lb N/ac with no additional yield with the last 40-lb increment of N. This study did follow soybean in rotation and some N credit is given for soybean in rotation (usually 30 lb N/ac). Yields results have differed from year to year with different cultivars coming out on top in different years. The overall yield for the research area was 228 bu/ac.

Trt	Cultivar	N Rate	Single-Row System		Trt	Twin-row System		Differ
		(lb/A)	(bu/acre)			(bu/acre)		(bu/A)
1	1319 HR	140	211.0	i	17	233.4	a-g	22.4
2	1319 HR	180	219.8	e-i	18	232.7	a-h	12.9
3	1319 HR	220	224.9	b-i	19	244.0	abc	19.1
4	1319 HR	260	222.8	c-i	20	245.8	ab	23.0
5	1739 HR	140	214.3	ghi	21	211.7	hi	- 2.6
6	1739 HR	180	223.3	c-i	22	224.1	c-i	0.8
7	1739 HR	220	228.1	a-i	23	228.8	a-i	0.7
8	1739 HR	260	231.3	a-i	24	231.7	a-i	0.4
9	1745 BVT	140	211.2	i	25	217.5	f-i	6.3
10	1745 BVT	180	219.2	e-i	26	214.5	ghi	- 4.7
11	1745 BVT	220	224.6	b-i	27	230.6	a-i	6.0
12	1745 BVT	260	223.8	c-i	28	228.5	a-i	4.7
13	2089 YHR	140	221.0	d-i	29	227.7	a-i	6.7
14	2089 YHR	180	237.6	a-f	30	237.5	a-f	- 0.1
15	2089 YHR	220	245.5	ab	31	247.0	a	1.5
16	2089 YHR	260	239.4	a-e	32	241.5	a-d	2.1
	Fisher's LSD (0.05) = 21.3 bu/acre [Prob > F = 0.0067]							
	C.V. (%) = 7.5%							

Table 1: *Corn grain yield from an evaluation of cultivars and N rates in SR and TR production systems.*

AGRONOMY

EVALUATION OF SURGE IRRIGATION AS A FUNGICIDE DELIVERY SYSTEM IN FURROW IRRIGATED PEANUT

Stephen Leininger, Jason Krutz, Jason Sarver, Alan Henn, and Jeff Gore

NO ONE HAS STUDIED FURROW IRRIGATION IN PEANUT. THE ACCEPTED THOUGHT IS OVERWATERING PEANUT WILL REDUCE YIELD. OUR TEAM IS EVALUATING TECHNIQUES TO OPTIMIZE PEANUT PRODUCTION IN A FURROW IRRIGATED ENVIRONMENT.

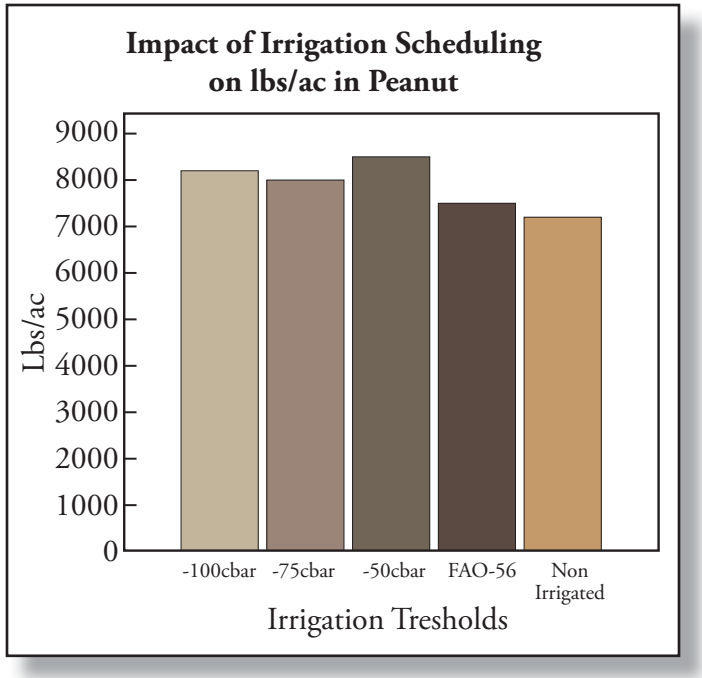
Multiple experiments were conducted at the Delta Research and Extension Center to determine the effect of furrow irrigation on peanut yield. In experiment 1, peanut yield as a function of three soil moisture sensor thresholds, i.e., -50, -75, -100 cbar, was compared to FAO-56 and a non-irrigated control. For experiment 2, we evaluated the effect of irrigation and fungicide on Southern Blight *(Sclerotium rolfsii)* infestation in peanut. In experiment 3, we evaluated the control of Southern Blight in furrow irrigated peanuts as a function of fungicide application timing (day vs night spray) and delivery system, i.e., conventional vs fertigation. Peanuts were planted May 5 and uniform stands were established. Water deficits were tracked using MSU climatic data, and irrigation was applied when a 2-inch deficit occurred or when soil moisture sensor thresholds were achieved. First generation *Sclerotium rolfsii* were raised on millet and research plots were inoculated uniformly. Disease ratings were completed to compare pressure between treatments. A preventative foliar fungicide regiment was established on a 14 day interval beginning 30 days after emergence to isolate any yield loss to Southern blight. At 60 and 90 days after emergence, plots were treated with Abound fungicide either as a day spray, night spray, 1x rate via surge irrigation, or a no spray control. Irrigation events did not increase the spread/growth of Southern blight, even with dense vegetative canopies and hot, humid weather.

In the first experiment, peanut yield was higher in sensor based treatments as compared to FAO-56 and the non-irrigated control. These data indicate that sensor based irrigation scheduling is superior to FAO-56, and that the optimum yield and water use efficiency for peanuts in a furrow irrigated environments occurs at an irrigation threshold of -100 cbar in silt loam texture soils (Figure 1).

In experiment 2, irrigated peanut yield was 49% greater than that of the non-irrigated control. For both irrigated and non-irrigated environments, the presence or absence of fungicide did not significantly affect yield or disease hits on the limbs and crown of the plants. Under conditions of this experiment, therefore, irrigation did not increase the occurrence of Southern Blight.

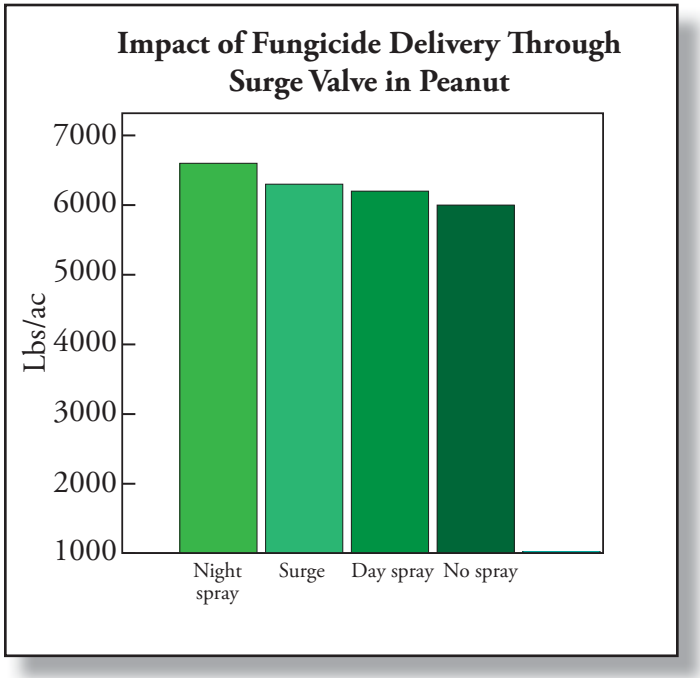
In experiment 3, peanut yield was not significantly different among fungicide timing or delivery method (Figure 2). Mean yield for treatments decreased in the order of night spray (6552 lbs/ac), surge (6323 lbs/ac), day spray (6153 lbs/ac), non-treated (6019 lbs/ac).

Figure 1: *Impact of irrigation scheduling on peanuts yield in 2015.*



Results of these experiments will improve peanut yield and water use efficiency by developing sensor-based thresholds for producers in furrow irrigated peanut environments. Preliminary data indicate potential to improve management recommendations for Southern blight disease in Mississippi.

Figure 2: *Impact of fungicide application method on peanuts yield in 2015.*



AGRONOMY

GROWTH REGULATION WITH LACTOFEN DOES NOT AFFECT YIELD OF IRRIGATED SOYBEANS IN MISSISSIPPI

John Orlowski, Jason Bond, Bobby Golden, and Paul Mangialardi

THE RESULTS OF THIS STUDY SUGGEST THAT FOR HIGH-YIELDING, IRRIGATED SOYBEAN IN MISSISSIPPI, APPLICATION OF LACTOFEN FOR GROWTH REGULATION IS NOT NECESSARY.

Soybean producers in Mississippi have the ability to produce very high yields (>80 bu/ac) under the Early Soybean Production System largely due to a warm growing season and the availability of ample supplies of irrigation water. The growing conditions and irrigation associated with high-yielding ESPS soybean results in soybean that have the ability to grow very tall lodge, potentially decreasing yield. That is why some soybean producers have considered using the herbicide Cobra (lactofen) to regulate soybean growth. Although lactofen is registered for use in soybean, application results in damage to the leaves and stems which can limit vegetative growth and lodging. It has also been suggested that lactofen can increase total node numbers in soybean by damaging the growing point, stimulating increased lateral branching and potentially increasing soybean yield. The purpose of this study was to determine the effect of lactofen on soybean growth characteristics and yield for furrow irrigated soybean in Mississippi.

Field studies were conducted during the 2013 and 2014 growing seasons at the Mississippi State University Delta Research and Extension Center in Stoneville, MS. Soybean were planted on April 15, May 1, May 15, and June 1, in order to determine if growth regulation with lactofen varied by planting date. Planting dates were split between nontreated soybean, soybean that were sprayed with crop oil concentrate, and soybean that were treated with a 12 ounce per acre rate of lactofen plus 1% v/v COC. Visual estimates of soybean injury were documented 7 and 14 d after treatment (DAT) and stunting was evaluated at 21 and 28 DAT. Light interception measurements were also taken at 21 and 28 DAT. Plant height, total node number, lodging and yield were measured at harvest.

Lactofen application caused yellowing, bronzing, and necrosis on the soybean leaves and stems. Injury was visible 7 day after application but the soybean plants recovered by 14 DAT. Slight stunting was observed for lactofen treated soybean at 28 DAT and plant height was reduced by 11%. Soybean planted June 1 were significantly taller than the earlier planting dates. However, lodging was not observed for any treatments or planting dates meaning that plant height did not affect yield in this study. There were no differences in light interception or node number at 28 DAT, but the May 15 and June 1 planting dates did

Foliar soybean injury from lactofen

have approximately 2 more nodes per plant than the earlier planting dates.

Despite some differences in plant characteristics between nontreated and soybean treated with lactofen, no yield differences were observed. Averaged across the two years of the study soybean yield averaged approximately 100 bu/ac. The results of this study suggest that for high-yielding, irrigated soybean in Mississippi, application of lactofen for growth regulation is not necessary.

AGRONOMY

ZINC SOURCE AND RATE AFFECT INJURY AND TISSUE CONCENTRATION, BUT NOT YIELD, IN MISSISSIPPI CORN

Bobby Golden, Jason Bond, and John Orlowski

DESPITE THE HIGH LEVEL OF VISUAL INJURY, CITRATE-ZN IS LIKELY THE MOST COST-EFFECTIVE OPTION FOR CORN PRODUCERS CONSIDERING A FOLIAR ZINC APPLICATION.

Cotton in the Mississippi Delta has historically been planted in light textured, high-pH soils that typically have low organic matter levels. These soils are also generally low in certain micronutrients, including zinc. Cotton acreage in Mississippi has dramatically declined and the majority of former cotton acreage is currently being planted to corn. Corn planted on these light-textured, former cotton soils often exhibit zinc deficiency and numerous corn fields in the Mississippi Delta are positively identified as being zinc deficient during the growing season.

Zinc deficiency in corn generally occurs early in the growing season and is characterized by interveinal chlorosis and/or white mid-leaf streaking. Current Mississippi Extension recommendations call for 2-3 pounds of zinc/ac for soils that are deficient in zinc. However, corn producers in the Mississippi Delta are reluctant to use soil-applied zinc due to the cost and uncertainty of economic return. Producers are generally more interested in applying zinc as a foliar spray if zinc deficiency symptoms are observed in the corn crop.

Multiple formulations of zinc are available for foliar application and producers have reported varying levels of foliar injury from different foliar zinc sources. However, it is unclear whether foliar injury observed from foliar applications of zinc results in yield loss. Furthermore, little information exists regarding the ability of different zinc formulations to increase the level of zinc in the corn plant and on the appropriate application rates for various zinc products used to correct zinc deficiencies in corn. Therefore, the objectives of this study were to (i) determine the level of corn injury caused by multiple foliar zinc sources, (ii) determine if injury caused by foliar zinc application affected corn grain yield, and (iii) determine plant tissue zinc content of corn treated with various foliar zinc sources at multiple rates.

Studies were established at the Mississippi State University Delta Research and Extension Center during the 2012, 2013 and 2014 growing seasons. Since an objective of this study was to determine if injury from foliar zinc application affected yield, study sites were chosen that had sufficient levels of zinc to support a high yielding corn crop (>200 bu/ac) and were unlikely to respond to foliar zinc application.

Treatments consisted of three zinc sources that are

Zinc deficient corn plant

labeled for foliar application on corn. One source was EDTA chelated zinc (EDTA-Zn). Another source was citric acid chelated zinc (Citrate-Zn). The final source was zinc sulfate (ZnSO4). All three zinc sources were applied at rates of 0.5 lbs Zn/ac, 1.0 lb Zn/ac, and 2.0 lb Zn/ac at the four leaf growth stage (V4). Foliar injury was evaluated 3, 6, and 9 days after zinc application and yield were determined at harvest. Tissue samples were taken after zinc application to access plant zinc status.

Differences in corn injury were observed among zinc sources and rates. In general Citrate-Zn resulted in the greatest foliar injury while ZnSO4 resulted in the least foliar injury after application. Despite the differences in injury, corn grain yield was not affected. Although there were no yield differences between zinc sources, producers may still want to avoid the high levels of visual injury associated with Citrate-Zn. At the 0.5 and 1.0 pound Zn/ac rates ZnSO4 application resulted in similar levels of tissue zinc concentration as Citrate-Zn with much lower levels of foliar injury, indicating that ZnSO4 may be the ideal zinc source for growers averse to foliar zinc injury. For growers less concerned with foliar injury, the lack of yield differences suggests that growers should chose a foliar zinc product based on price. At current market prices a Citrate-Zn product similar to the one used in this study would cost 39% less than the EDTA-Zn and ZnSO4 products. Despite the high level of visual injury, Citrate-Zn is likely the most cost-effective option for corn producers considering a foliar zinc application.

AGRONOMY

MISSISSIPPI'S CENTENNIAL ROTATION TWELVE YEAR CYCLE COMPLETE

Wayne Ebelhar

AFTER YEARS OF BEING PLANTED IN THE SAME CROPS, FIELDS BECOME DEFICIENT IN MANY WAYS. THIS ROTATION STUDY HELPS US LOOK AT CHEMISTRIES FOR DISEASES AND INSECTS, DIFFERENT ROOT STRUCTURE BENEFITS, AND DIFFERENT LEVELS OF NUTRIENT REMOVAL. COLLECTIVELY THAT MEANS PROFIT AND THAT'S WHAT WE TRY TO DELIVER TO THE LOCAL PRODUCERS.

Long-term crop rotation studies can be useful tools in studying the effects of various practices over an extended period of time. Crop rotation has been used in farming systems for hundreds of years with modern rotations (green manures) begun as early as 1730 in England. Benefits from crop rotation can be divided into three major areas. These include: a) maintenance of crop yields; b) control of diseases, insects, weeds, and other pests; and c) prevention of soil erosion. Before the widespread use of chemical fertilizers, maintenance and/or improvement of crop yields were best accomplished by improving the base fertility of the soil where the crop was to be grown. This usually required growing a legume crop to promote nitrogen (N) fixation or applying manure to provide additional organic nutrients. For some of the old studies, time is the only replication and allows for evaluating trends. In 2004, the Centennial Rotation was initiated to commemorate the 100-year anniversary of the experiment station. Early research at DREC revolved around crop rotation. The station continues to meet the original objective of the experiment station and land-grant institution – that is to make agriculture a profitable enterprise. Early research included simple rotations and the use of manure on fields that had been used for cotton production. Mechanization shifted the agricultural industry from hand labor to machines and chemicals. That shift continues with the introduction and acceptance of biotechnology.

The shift from rotation to mono-cultural and gradually back to rotation brings us to the 21st century. New technologies are rapidly being introduced and adopted and could also be evaluated in these long-term rotations. As production in the Mid-south moved into the 21st century, cotton was still the main crop for sandy soils. However, with the emphasis on bio-energy and bio-fuels, corn and soybean gained in prominence and prices increased. With increased grain prices, corn production in the Mid-south became more profitable. This influence, along with with a shift in infrastructure, corn began replacing cotton on many farms. Cotton, corn, and soybean were included in the various rotational schemes in the Centennial Rotation. The systems included 2-year, 3-year, and 4-year rotations all compared to continuous cotton. At the initiation of the study a corn/soybean system was also included. All crops within a rotation system are grown each year allowing for direct comparisons of crops for a given year. In certain years with high corn prices, there could be an advantage to growing corn but the field was scheduled to be planted to cotton in the rotational scheme. The fifteen "treatments" are replicated four times with each one consisting of four 4-row subplots. The center rows are

harvested to avoid border effects and samples taken at harvest in order to determine harvest moisture, bushel test weigh, and seed index of the grain crops and lint percentage and lint yield of the cotton plots. Once yields are calculated, total plant nutrient uptake and removal can be estimated based on standards. As would be expected the highest nutrient removal has been observed in the grain systems. For cotton over time, the lint yields have been much lower than the yield of cotton following corn. Nutrient removal for the continuous cotton system of N and phosphorus (P) was 25 to 40% of the grain crop systems. Soil samples taken following harvest are used to monitor soil nutrient levels and the basis for P and potassium (K) applications. The corn crop returns far greater levels of residue to the soil than continuous cotton and should aid in the buildup of organic matter. In the 13th season, all system will be back to the same starting point as the first season and will start over. The cropping sequences are shown in Table 1 for the first 12 years.

The first 12 years of the Centennial Rotation program was completed in 2015. The project was setup as a cotton-based system due the historic significance of cotton to this region of the US. Treatments 7 and 8 do not contain cotton and are included to document the long standing advantages of corn/soybean rotation. With recent shifts to grain production, this system has become quite important. The yield summary from the first 12 years are shown in Table 2. Cotton yields in the continuous cotton area have the overall lowest yields for cotton compared to the other systems.

The lint yields in continuous systems have ranged from 718 to 1452 lb lint/ac over the last 12 years with much of the variation related to environmental conditions. Weather problems such as hurricanes have caused some problems (lodging) but the yields have still been harvestable. Timely irrigation is a key to successful and consistent corn production as evident in 2011. Timing of the first irrigation is critical. Corn yields continued to climb through 2014 but were off some in 2015. Lint and grain yields are used to estimate nutrient uptake and nutrient removal based on the yields and crop being grown within the cycle.

CENTENNIAL ROTATION STUDY												
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
System	1	2	3	4	5	6	7	8	9	10	11	12
1	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT
2	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR
3	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT	CR	CT
4	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT
5	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT
6	CT	CT	CR	CT	CT	CR	CT	CT	CR	CT	CT	CR
7	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB
8	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR	SB	CR
9	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT
10	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR
11	CR	CT	SB	CR	CT	SB	CR	CT	SB	CR	CT	SB
12	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT
13	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT
14	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB	CR
15	CR	CT	CT	SB	CR	CT	CT	SB	CR	CT	CT	SB
CT = Cotton		CR = Corn		SB = Soybean								

Table 1: *Cropping sequence for long-term cotton-based rotation cropping system. All crops in each sequence to be grown each year.*

Soil samples are taken following the crop harvest and then used to determine fertilizer needs for the upcoming year. Following the 2015 harvests, soil samples were taken from all subplots within the study area and will be used for future nutrient additions. Economic analysis of the results from the first 12 years will examine the overall impact of the rotations systems over time.

A key area of interest in the long-term rotation study deals with nutrient uptake and removal. Nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) uptake and removal are being calculated for each of the systems. Only the grain portion of corn and soybean are removed and the seed and lint portion of cotton along with some vegetative materials. Soybean removes the largest percentage of N and K while corn removes the largest percentage of P. Standard values have been used to estimate nutrient uptake and removal for the crop sequences that have been grown to date. The continuous cotton system has resulted in the lowest nutrient removal for N, P, K, and S. After ten years, the greatest N uptake and removal has occurred in the corn/soybean rotation system (Treatments 7 and 8) where each crop has been grown five times. The two treatments are different because yields have been different from year to year. Much of the N that is removed in the CR/SB system comes from symbiotic N fixation when soybean is grown, Also, higher N fertilizer rates are used for corn compared to cotton. Producers should take extra steps to insure adequate fertility when shifting from cotton production to rotations with grain crops. Nutrient removal, especially N, can be 3 to 4 times higher than continuous cotton. The P and K removal rates are also highest for the CR/SB system. When examining uptake and removal, N uptake can be as much as 300 lb N/ac depending on the crop and yield. As long as the residue is returned to the soil and not burned, most of the nutrients not removed in the grain or seed can be recycled and thus reused for future crops. If residue is removed for feed stocks related to bio-energy, the available nutrient pool in the soil and organic matter can be further reduced as well.

CENTENNIAL ROTATION STUDY - SUMMARY OF CROP YIELDS (LB or BU/ACRE)

Rotation System	Rotation Sequence	2004 Crop Yield	2005 Crop Yield	2006 Crop Yield	2007 Crop Yield	2008 Crop Yield	2009 Crop Yield	2010 Crop Yield	2011 Crop Yield	2012 Crop Yield	2013 Crop Yield	2014 Crop Crop	2015 Crop Yield
1	Continuous CT	1430.5	1101.8	978.9	718.5	927.6	877.6	1039.4	843.2	1076.4	1452.1	1122.1	948.7
2	CT-CR	1470.9	204.6	1185.4	200.8	1218.9	182.4	1185.6	61.6	1237.4	216.8	1221.2	217.3
3	CR-CT	201.2	1334.3	185.1	942.2	194.9	961.3	194.7	965.4	242.6	1952.1	236.1	1323.0
4	CR-CT-CT	197.2	1298.4	988.0	219.4	1314.9	975.3	201.8	982.2	1098.1	228.8	1184.0	1048.0
5	CT-CR-CT	1509.4	213.3	1202.1	866.7	206.8	984.7	1148.2	73.8	1194.3	1691.6	259.5	1421.0
6	CT-CT-CR	1525.1	1148.8	191.1	909.3	982.5	194.8	1234.7	841.9	244.7	1803.8	1192.5	221.2
7	CR-SB	193.9	57.8	199.3	78.4	205.8	73.3	207.2	52.6	241.3	58.3	241.3	42.2
8	SB-CR	60.3	212.3	62.5	208.8	56.1	205.1	65.7	101.8	42.9	232.5	56.6	221.5
9	SB-CR-CT	61.4	212.6	1206.2	75.5	197.6	994.5	70.6	113.7	1105.0	72.1	250.0	1365.2
10	CT-SB-CR	1447.5	61.5	194.6	1019.2	60.4	209.4	1199.0	47.9	244.0	1902.2	57.3	230.2
11	CR-CT-SB	195.9	1268.2	64.4	207.6	1222.3	66.3	209.0	963.0	46.6	234.2	1285.6	41.1
12	SB-CR-CT-CT	60.4	199.0	1152.6	852.2	57.5	195.9	1239.2	849.3	45.6	229.2	1255.9	1095.4
13	CT-SB-CR-CT	1402.7	52.3	191.2	929.5	978.7	69.8	208.0	1059.2	1052.8	66.9	252.8	1292.9
14	CT-CT-SB-CR	1446.6	1148.2	58.1	223.4	1240.5	929.3	66.8	105.0	1194.0	1529.9	59.5	235.9
15	CR-CT-CT-SB	200.5	1359.4	947.2	81.5	199.9	992.6	1026.1	50.4	242.3	1857.7	1069.4	46.2

NOTE: Cotton Yield reported in lb lint/acre, Corn Yield reported in bu/acre @15.5%, Soybean Yield reported in bu/acre @ 13%

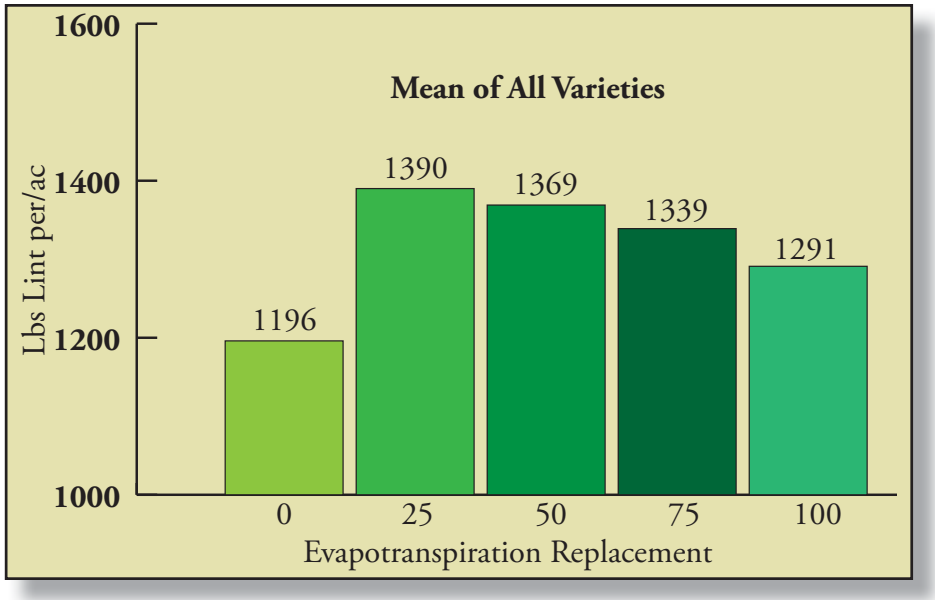
Table 2: *Summary of crop yields from the Centennial Rotation Study (2004-2015).*

AGRONOMY

RESPONSE OF COTTON VARIETIES TO IRRIGATION EVAPOTRANSPIRATION REPLACEMENT

Dustin Pickelmann, Jason Krutz, Darrin Dodds, Jeff Gore, and Bobby Golden

With increasing concerns about declining levels of the aquifer in the Mississippi Delta, there is much interest in improving water management techniques to improve overall water use efficiency. An experiment was conducted in Stoneville, MS to provide insight into the actual crop demand for supplemental irrigation in cotton. Irrigations in cotton were scheduled using FAO-56, a standard that takes into consideration crop water demands based on growth stage and climatic data to alleviate drought stress. The experiment was conducted as a split-split-plot arrangement in a randomized complete block design. The main-plot factor was irrigation based on five evapotranspiration levels. The sub-plot factor was variety and included five commercial varieties commonly planted in Mississippi. The sub-sub-plot factor was PGR use and included an untreated control or a split application of PGR at pin-head square and first bloom. The PGR treatment showed no significant yield response across all varieties. Each variety was unique in its response to varying levels of supplemental irrigations. For example, one variety reached maximum yield potential at 50% Et replacement. Whereas another variety would increase yield as the amount of water increased. When all varieties were pooled together maximum yield potential was achieved at 25% Et replacement (Figure 1). This research suggests that each cotton variety may need to be pre-commercially screened for maximum yield potential based on Et replacement.



DEPENDING ON VARIETY, SUPPLEMENTAL IRRIGATION AMOUNTS COULD VARY GREATLY IN ORDER TO ACHIEVE MAXIMUM YIELD POTENTIAL.

AQUACULTURE

NUTRIENT DIGESTIBILITY OF ALTERNATIVE FEED INGREDIENTS BY CHANNEL CATFISH

Menghe Li, Danny Oberle, and Penny Lucas

KNOWING NUTRIENT DIGESTIBILITY/ AVAILABILITY OF VARIOUS FEED INGREDIENTS IS ESSENTIAL IN FORMULATING COST-EFFECTIVE CATFISH FEEDS TO ENSURE ALL NUTRIENT AND ENERGY REQUIREMENTS ARE MET FOR OPTIMUM FISH PERFORMANCE.

Traditional catfish feeds are typically comprised of soybean meal, cottonseed meal, corn, wheat middlings, and small amounts of animal proteins and fats, as well as vitamin and mineral supplements. Nutrient and energy digestibility for these ingredients have been determined for channel catfish, and values have been widely used in commercial feed formulations. Recently, with the dramatic increase in prices of traditional feed ingredients, such as soybean meal and corn, alternative feedstuffs, such as corn gluten feed, and corn germ meal, are being used to partially replace traditional ingredients in catfish feeds. Research has shown these alternative feedstuffs are good sources of protein and energy that can be used, up to a certain level, without affecting catfish performance.

Since feed cost currently accounts for nearly 60% of the total variable cost in catfish production, knowing the nutrient and energy digestibility/availability of these emerging alternative feedstuffs is essential to more precisely formulate cost-effective feeds that not only meet catfish nutrient requirements, but also maximizes feed utilization and improves profit. A study was conducted to determine apparent digestibility coefficients of protein, fat, and energy, and apparent availability coefficients of essential amino acids for corn gluten feed, corn germ meal, distillers grains, and canola meal for channel catfish. Soybean meal was included as a test ingredient for the comparison purpose.

	Corn gluten feed	Corn germ meal	Distillers grains	Canola meal	Soybean meal
Crude protein	74.6 c	83.7 b	86.9 b	76.9 c	94.2 a
Crude fat	92.8	91.9	93.8	92.4	96.8
Energy	52.3 b	57.0 b	58.5 b	52.2 b	79.2 a
Lysine	67.1 c	77.6 b	72.1 bc	78.9 b	93.8 a
Methionine	69.1 c	80.0 b	84.8 ab	82.6 b	89.2 a
Cystine	72.9 c	78.4 b	81.7 b	79.7 b	91.1 a

*Means in a row followed by different letters are significantly different at a 5% probability level.

Table 1: *Apparent digestibility coefficients* (%) of protein, fat, and energy, and apparent availability coefficients (%) of the most limiting essential amino acids lysine, methionine, and cystine of test ingredients for channel catfish.*

Catfish during a typical feeding regimen.

Channel catfish averaging 0.32 pound per fish were stocked in 30-gallon cylindro-conical digestibility tanks and reared at optimum temperature (86ºF). Fish were fed test diets containing chromium oxide as a marker. Fecal samples were collected by sediment method. Results show the apparent digestibility/availability coefficients of protein, essential amino acids, and energy in the alternative protein feedstuffs tested were generally lower than those in soybean meal by channel catfish (Table 1). Apparent digestibility coefficients of protein ranged 75–87% and those of energy ranged 52–59% for alternative feedstuffs. Lysine in alternative feedstuffs was 67–79%, methionine was 69–85%, and cystine was 73–82% available to channel catfish. Apparent digestibility/availability coefficients determined in this study can be useful in formulating cost-effective catfish feeds using these alternative feedstuffs to ensure that all nutrient and energy requirements are met for optimum fish performance.

AQUACULTURE

FEEDING MANAGEMENT FOR MARKET-SIZE HYBRID CATFISH

Menghe Li, David Wise, Brian Bosworth, Penny Lucas, and Kyle Kingery

HARVEST DELAYS OFTEN OCCUR WHEN THERE IS OFF-FLAVOR, OVER-SUPPLY OF FISH IN THE MARKET, OR LOW FISH PRICES. HARVEST DELAYS CAN BECOME A SERIOUS ISSUE FOR HYBRID CATFISH, SINCE THEY FEED MORE AGGRESSIVELY AND GROW FASTER THAN CHANNEL CATFISH.

Circumstances such as off-flavor, oversupply of fish in the market, or low fish prices, can cause delays in harvesting market-size fish in catfish production. Harvest delays increase the risk of fish losses and restricts cash flow resulting in diminished production efficiency. In addition, large fish exceeding optimal harvest size begin to convert feed less efficiently and, more importantly will decrease in value if they exceed a specified size limit. Harvest delays can become a serious issue, especially for hybrid catfish, since they feed more aggressively and grow faster than channel catfish. Proper feeding management to maintain fish size is needed to minimize economic losses associated with harvest delays. A preliminary study conducted at DREC/NWAC shows the weight of market-size hybrid catfish can be held relatively constant by feeding to satiation once weekly. However, the effects of complete feed restriction and the effects of re-feeding after feed restriction on hybrid production and processing characteristics are not known. As a continuation of this work, a pond study was conducted to evaluate effects of no feeding, maintenance feeding, and refeeding on weight gain and processing yield of market-size hybrid catfish.

Market-size hybrid catfish (average weight = 1.42 lb) were stocked into 20 experimental ponds (0.1 ac) at 8,520 lb/ac (approximately 6,000 fish per ac). Fish were not fed or fed once weekly to satiation to simulate a long-term harvest delay, which were compared with fish fed daily to satiation. A commercial 28% protein feed was used. After two months, half the ponds in each feed restriction treatment were harvested, and fish in the remaining ponds were fed daily for one month and then harvested. After two months, weight gain, percent visceral fat, carcass yield and fillet yield were compared. Fish not fed for two months lost 14.3% body weight, compared to a 6.7% weight gain for fish fed weekly. Fish not fed or fed once weekly had reduced visceral fat and fillet yield compared with fish fed daily. There were no statistical differences in percent visceral fat and fillet yield between fish not fed or fed once weekly. The unfed fish had statistically higher carcass yield than fish fed daily or once a week. This is likely caused by the metabolism of energy reserves during starvation which initially results in a loss of visceral fat and liver followed by a loss in muscle. Since head, bones, and skin remain relatively constant during the initial stages of starvation, there is little change in carcass yield.

At the end of three months (after all fish were fed daily for one month), the average fish size in each

Feeding regimen	Feed fed (lb/ac)	Net yield (lb/ac)	Weight gain (%)	Feed conversion	Carcass yield (%)	Fillet yield (%)	Visceral fat (%)
Not fed for 2 mos	–	-1,297 b	-14.3 b	–	67.9 a	31.8 b	3.3 b
1×/wk for 2 mos	1,433 b	439 a	6.7 a	2.70	66.6 b	31.1 b	3.6 b
7×/wk for 2 mos	8,455 a	NH[2]	NH	–	67.1 b	33.3 a	6.1 a
Not fed for 2 mos + 7×/wk for 1 mo	8,194 z	3,215 z	38.9 z	2.51 yz	67.2	33.3	4.6 z
1×/wk for 2 mos + 7×/wk for 1 mo	9,230 z	3,253 z	40.0 z	2.71 y	66.7	33.1	4.6 z
7×/wk for 3 mos	14,296 y	5,811 y	70.4 y	2.38 z	66.9	33.8	6.2 y

[1]Initial weight was 1.42 lb/fish; carcass yield, fillet yield, and visceral fat of initial samples were 68.5%, 33.4%, and 3.8%, respectively.
[2]Not harvested.

Table 1: *Production and processing characteristics of hybrid catfish[1] on various feeding schedules. Means in each column and each section followed by different letter were significantly differerent. ($P \leq 0.05$)*

treatment was 2.42 lb for fish fed daily, 1.99 lb for fish fed once weekly, and 1.97 lb for fish withheld from feed for the first two months. There were no statistical differences in weight gain, net yield, carcass yield, fillet yield, or percent visceral fat whether fish were previously not fed or fed once weekly. Fish fed daily for three months had statistically higher weight gain, visceral fat, and marginally higher fillet yield ($P = 0.08$). Feeding once weekly for two months followed by one-month full feeding resulted in statistically higher feed conversion ratio (FCR) than fish fed daily for three months. No feeding for two months followed by one-month full feeding led to an intermediate FCR, which was not significantly different from the other two feeding regimens. The higher FCR observed may be due to a relatively higher proportion of the ingested feed being used for maintenance during the first two months and for tissue recovery during refeeding. There were no statistical differences in observed mortalities among feeding regimens.

Results from this study show feeding once weekly can generally maintain fish body weight. No feeding or feeding once weekly for two months does not affect survival but significantly reduces fillet yield. After one month of full feeding there were no differences in production and processing characteristics whether fish were previously not fed or fed once weekly. One month of full feeding following no feeding or maintenance feeding improves fillet yield relative to values before refeeding.

AQUACULTURE

REDUCING FEED COST FOR HYBRID CATFISH FINGERLING PRODUCTION

Menghe Li, David Wise, Charles Mischke, and Penny Lucas

CATFISH FINGERLING FEED PRICES HAVE INCREASED TO $600–700 PER TON IN THE PAST FEW YEARS. THERE IS INTEREST AMONG CATFISH FINGERLING PRODUCERS IN REDUCING FEED COST. FEED COST CAN BE REDUCED BY LOWERING PROTEIN LEVELS AND USING LESS EXPENSIVE ALTERNATIVE FEEDSTUFFS, BUT THIS SHOULD BE DONE WITHOUT COMPROMISING FISH PERFORMANCE.

In commercial catfish fingerling production, nursery ponds are typically fertilized with inorganic fertilizers before stocking with catfish fry to ensure adequate desirable zooplankton are available. The newly stocked fry are also fed with powdered feeds as supplemental nutrients. Once the fry reach about 1–2 inches and come up to the pond surface, they are generally fed small floating pellets containing 35% protein, part of which is supplied by fish meal. As fish grow they may be switched to slightly larger pellets containing 35% or 32% protein. Prices of commercial 35% protein fingerling feeds have increased to $600–700 per ton in the past few years, so there has been interest among catfish fingerling producers in reducing feed cost. Feed cost can be reduced by lowering protein levels, using less expensive alternative feed ingredients, or both, provided fish performance is adequately maintained.

A feeding trial was conducted to evaluate diets containing 35% or 32% protein with 7.5% fish meal or pork meat, bone, and blood meal (PMBB) for pond-raised hybrid catfish fingerlings. The 35% protein diet with fish meal was similar to commercial catfish fingerling feeds in diet composition and was used as the control. All diets were formulated to meet or exceed all known nutrient requirements for channel catfish.

Three weeks before stocking, the ponds were fertilized with urea according to recommended dose and schedule to ensure natural foods were available. Small hybrid catfish fingerlings with an average weight of 4.5 pounds per 1,000 (2.4 inches) were stocked into twenty

0.1-acre ponds at a density of approximately 70,000 fish per acre based on sample weight and count of 1,000 fish. Each diet had five replicated ponds. The fish were fed once a day to apparent satiation from July to October for 113 days. Ponds were managed according to typical industry practices.

At the end of the study, there were no significant differences in total amount of feed fed, gross yield, feed conversion ratio, or observed mortality in fish fed 35% or 32% protein diets containing fish meal or PMBB (Table 1). There were also no significant differences in the number of desirable zooplankton or ammonia and nitrite levels in the pond water among dietary treatments.

At the time of feed purchase (June 2015), the control diet (35% protein with fish meal) cost $614 per ton. The 32% protein diet with fish meal, 35% protein diet with PMBB, and 32% protein diet with PMBB cost $20, $69, and $89 per ton less than the control, respectively, which are equivalent to annual savings of $120, $414, $534 per acre, if a total of 6 tons of feed per acre were fed in a growing season. Although feed prices often fluctuate, there will be some savings using the 32% protein diet with PMBB, because fish meal is much more expensive. An additional trial is planned for 2016 to further evaluate catfish fingerling diets including all-plant diets and lower protein diets.

Dietary protein (%)	Animal protein	Total feed fed (lb/ac)	Gross yield (lb/ac)	Final weight[1] (lb/1,000)	Feed conversion ratio	Observed mortality (#/pond)
35	fish meal	13,532	11,202	148	1.24	14
35	PMBB	13,727	11,135	162	1.27	4
32	fish meal	12,944	10,707	152	1.24	21
32	PMBB	13,986	11,724	166	1.23	25

[1]Estimated based on sample weight of 1,000 fish per pond.

Table 1. *Production characteristics of hybrid catfish fingerlings fed diets containing 35% or 32% protein with 7.5% fish meal or pork meat, bone, and blood meal (PMBB) for 113 days.*

AQUACULTURE

POTASSIUM PERMANGANATE IS NOT AN EFFECTIVE POND DISINFECTANT TO CONTROL DERO DIGITATA

Charles Mischke, David Wise, Matt Griffin, and Terry Greenway

PRE-TREATING PONDS WITH POTASSIUM PERMANGANATE, EVEN UP TO 20 MG/L, IS NOT AN EFFECTIVE PREVENTATIVE OF HAMBURGER GILL DISEASE. DERO WORMS, INTERMEDIATE HOSTS IN THE LIFE CYCLE OF THE PARASITE CAUSING HAMBURGER GILL, APPARENTLY ARE ABLE TO BURROW INTO THE MUD AND BE PROTECTED FROM POTASSIUM PERMANGANATE TOXICITY.

Proliferative gill disease (PGD), commonly referred to as hamburger gill disease, is a major problem in farm-raised channel catfish. PGD represents the most commonly diagnosed parasitic disease and approximately 17% of the total cases submitted to the Thad Cochran National Warmwater Aquaculture Center fish diagnostic laboratory.

The parasite requires the intermediate host, *Dero digitata*, to complete its life cycle. One commonly used method to reduce disease caused by parasites requiring multiple hosts is to disrupt the life cycle. Catfish farmers have tried several chemical treatments to disinfect ponds, thus disrupting the PGD life cycle through elimination or reduction of *Dero* populations. Some treatments are believed to reduce PGD incidence, but have not been experimentally validated.

Dero digitata

Disinfection with various chemicals in the hatchery is a routine part of good hatchery practice. However, pond disinfection is considerably more difficult to achieve. Lime, potassium permanganate, and niclosamide (Bayluscide®) have all been used in attempts to eliminate pathogens and disease vectors from ponds before stocking, but their effectiveness is unknown.

Potassium permanganate is an oxidizing agent that has been used to treat several fish diseases, especially crustacean and protozoan parasites (20 mg/L for 1 hour), and has been used as an equipment disinfectant at 10 mg/L for 30 minutes. It is particularly effective for treating *Trichodina*

or *Ambiphrya* infestations and external columnaris infections. Potassium permanganate is believed to be an effective disinfectant at high rates in ponds before stocking. It is believed potassium permanganate disinfects ponds and reduces *Dero* populations, but this practice has not been verified experimentally.

We evaluated potassium permanganate as a pond disinfectant to reduce *Dero* populations before stocking fish. In the first study, 2 liters of catfish pond mud and 18 liters of pond water were placed in each of 16 20-liter microcosms. Four microcosms were dosed at each of four treatment levels (0, 10, 20, and 30 mg/L) of potassium permanganate. After treatment, all *Dero* present in the sample were counted. In the microcosm study, all treatment levels significantly ($P<0.05$) reduced *Dero* populations relative to controls (Table 1).

In a second study, benthic populations were compared from 10 0.1 acre ponds before and after treatment with 20 mg/L potassium permanganate. However, in the field trial, there were no significant ($P<0.05$) differences pre- and post-treatment with potassium permanganate at 20 mg/L in *Dero* populations or total benthic organism populations (Table 2).

Treatment with potassium permanganate at 20 mg/L is not an effective pond disinfectant. This treatment level did not eliminate or even significantly reduce *D. digitata* populations. Although it was believed such high levels of potassium permanganate should 'sterilize' the pond, and previous toxicity studies (and the current microcosm study) of potassium permanganate to *Dero* indicated much lower levels of toxicity, it is clear this treatment is not effective. The 15-min potassium permanganate demand was less than 1 mg/L, so organic matter in the ponds should not have influenced the effectiveness of potassium permanganate. Apparently, in a commercial pond environment, *D. digitata* are able to burrow in the mud below the chemical-sediment interface and be protected from potassium permanganate toxicity.

Treatment	Mean	Standard Error
Control	60a	29.6
10 mg/L	1b	0.7
20 mg/L	0b	0.2
30 mg/L	0b	0.0

Table 1: *Comparison of mean and standard error of* Dero digitata *numbers in microcosms after treatment with potassium permanganate. ANOVA followed by Fisher's PLSD was used to detect treatment differences. Mean values sharing the same letter were not significantly different (P<0.05).*

	Before Treatment	After Treatment	Mean Difference	P-value
Dero	561 (256.0)	115 (48.8)	447 (264.3)	0.1253
Non-Dero	878 (246.2)	1055 (141.8)	-177 (238.5)	0.4769

Table 2: *Comparison of mean (+/- SEM)* Dero digitata *numbers and all* non-Dero *benthic macroinvertebrate numbers before and after treatment with 20 mg/L potassium permanganate. A paired t-test was used to determine if the difference between pre- and post-treatment was different from zero.*

AQUACULTURE

DEET TOXICITY TO CHANNEL CATFISH SAC FRY

Charles Mischke, David Wise, Craig Tucker, and Travis Brown

MOSQUITOES CAN BE A BIG NUISANCE IN CATFISH HATCHERIES IN THE SPRING. FORTUNATELY, DEET APPEARS TO HAVE A LOW TOXICITY TO CATFISH FRY AND SHOULD BE SAFE TO USE AROUND THE HATCHERY.

Larval and juvenile channel catfish are produced in numerous private hatcheries throughout the southeastern United States. The combination of open facilities, moisture, and warm weather during the catfish spawning season causes mosquito-infestation problems. Mosquitoes make working in the hatchery unpleasant for farm workers. Besides causing unpleasant working conditions, mosquito bites can cause blistering, bruising, or inflammatory reactions, and mosquitoes are vectors for viruses that can be transmitted to humans, including West Nile Virus.

The most common solution to mosquito problems in catfish hatcheries is widespread use of mosquito repellents applied to exposed skin and clothing. DEET (N,N-diethyl-m-toluamide) is the active ingredient in most personal insect repellents.

DEET was developed in the 1940's by the U.S. Department of Agriculture for the U. S. Army for protection against biting insects and control of disease transmission. In the U.S., DEET is contained in 225 registered products with over 1.8 million kg used annually.

Oddly, the toxicity of DEET to channel catfish—the most widely cultured fish in the United States—is unknown. Further, the early life stages of fish are particularly sensitive to environmental pollutants and the toxicity of this widely used chemical should be established to ensure it is safe to use around the sensitive sac-fry developmental stage present in hatcheries.

Researchers at the NWAC conducted toxicity tests of DEET to catfish fry (2-3 d post-hatch). Test solutions were made by dissolving the appropriate amount of DEET (Ben's 100 Max Formula, Tender Corporation, Littleton, New Hampshire, 98.11% DEET) in well water. The 24-h LC10 and LC50 values (the concentration of DEET lethal to 10 or 50% of the test fish in 24 hours, respectively) were determined.

In addition to the toxicity testing, a trial was conducted to determine the amount of active ingredient dispensed from two different applicators: a pump sprayer (Ben's 100 Max Formula, 1.25 fl. oz., Tender Corpora-

tion, Littleton, New Hampshire, 98.11% DEET) and an aerosol can (Ben's 30% DEET Wilderness Formula, 6 fl. oz. aerosol, Tender Corporation, Littleton, New Hampshire, 30% DEET). For the pump sprayer, one pump (from a full bottle) was sprayed onto a pre-weighed paper towel in a plastic weigh boat, and the amount dispensed was weighed. Five replicate trials were conducted to determine the mean and standard error active ingredient dispensed. For the aerosol can (from a full can), the product was dispensed into a pre-weighed paper towel in a plastic weigh boat for 5 sec, and the amount dispensed was weighed. Five replicate trials were conducted to determine the mean and standard error active ingredient dispensed.

LC test	LC value (95% CI)
24-h LC_{10}	274 (246.9 – 293.2)
24-h LC_{50}	345 (327.0 – 365.9)

Acute toxicity, expressed as lethal concentration (24-h LC10 and LC50 values and 95% confidence interval), of DEET to 2- to 3-d-old channel catfish sac fry. All results are given in ppm active ingredient.

The 24-h LC10 was 274 ppm, and the 24-h LC50 was 345 ppm. When discussing chemical toxicity to aquatic organisms, it is convention to categorize chemicals from super toxic (96-h LC50 <0.01 ppm) to practically non-toxic (96-h LC50 >100 ppm). Although this test was 24-h and not 96-h, the concentration required to kill 50% of the organisms was well above the 100 ppm threshold to be considered practically non-toxic.

The pump sprayer (98.11% active ingredient) dispensed 113.3 +/- 0.57 mg (mean +/- SEM) active ingredient per pump. This would require 2.4 pumps directly into the hatchery trough for every liter of water to achieve the 24-h LC_{10}. The aerosol can (30% active ingredient) dispensed 526.8 +/- 6.71 mg (mean +/- SEM) active ingredient per second. Although the aerosol can was only 30% DEET, it dispensed large amounts of product compared to the pump bottle. Nonetheless, to reach 24-h LC_{10} concentrations, it would require spraying the aerosol can directly into the hatchery trough for 0.5 sec for each liter of water. Typical hatchery troughs hold 380-450 L of water, which would require spraying directly into the trough for 190-225 seconds, not accounting for exchange rate from fresh water flowing through the tanks.

In hatcheries where air movement by fans is not sufficient to control mosquitoes, using insect repellent products containing DEET as an active ingredient should be safe. However, this study only determined acute toxicity of a single exposure; repeated exposures may increase mortalities. As with the use of any chemicals, follow label directions and take care to avoid drift into hatchery troughs. As a general precaution, one should not spray the parts of the hands and arms that will be submersed in hatchery trough water; but because DEET falls into the practically non-toxic category, there should be no problem spraying the repellent around worker's head, body and legs.

AQUACULTURE

PATHOGEN SPECIFIC ANTIBODY RESPONSE IN CATFISH

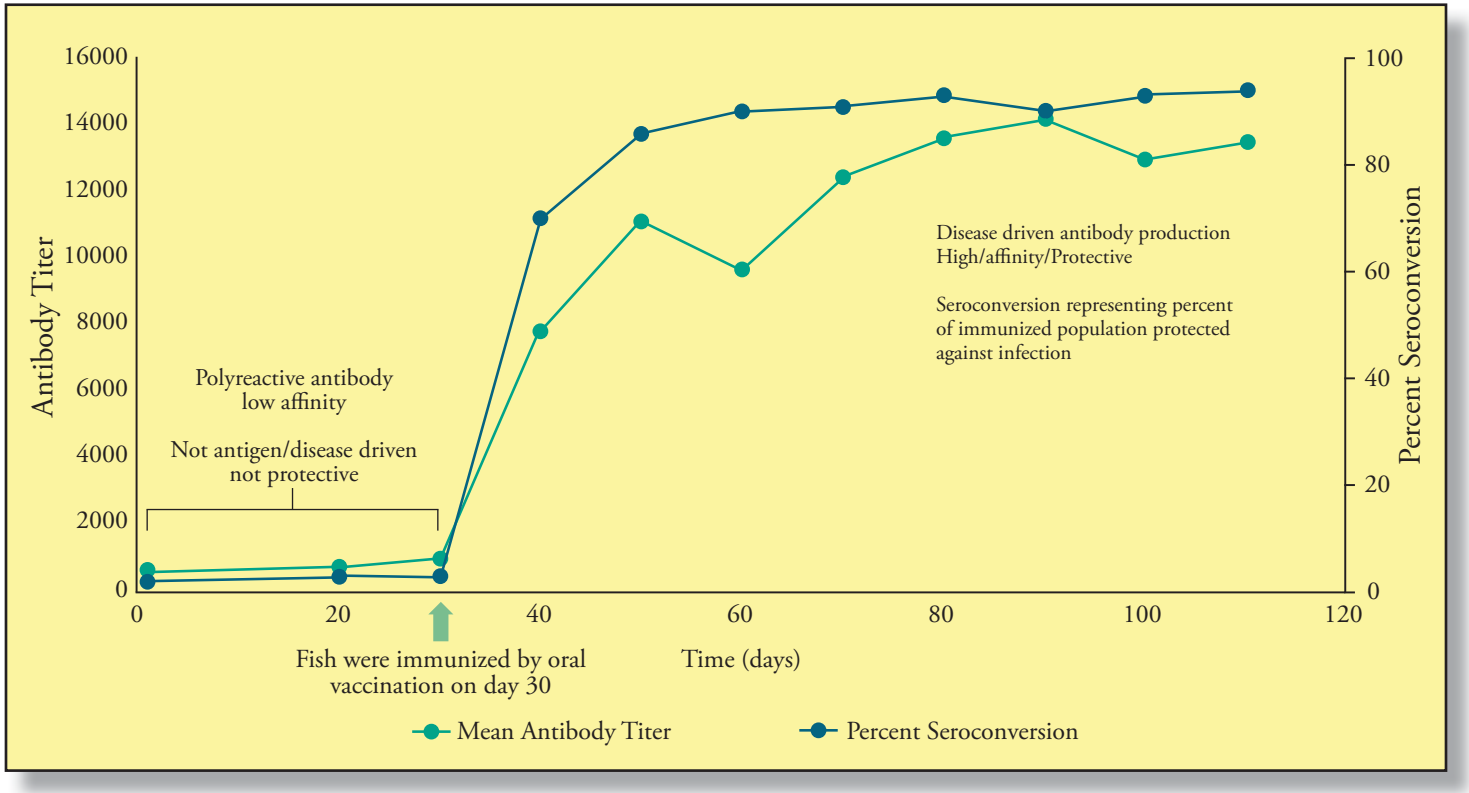
Terry Greenway, Matt Griffin, and David Wise

EVERY SUCCESSFUL ANIMAL DISEASE ERADICATION AND CONTROL PROGRAM HAS EMPLOYED TECHNIQUES ALLOWING FOR PATHOGEN SURVEILLANCE IN THE ENVIRONMENT AND MEASUREMENT OF HOST RESPONSES TO THE PATHOGEN.

Monitoring, evaluation, and surveillance are the cornerstones of any animal health program. Successful disease eradication programs have embraced disease surveillance examining morbidity and mortality patterns, pathogen detection, and antibody prevalence studies. Whether through vaccination or natural exposure to disease causing agents, protection is most often associated with antibody production. Antibodies are substances produced by the body which bind certain areas of disease causing agents. This binding protects by clearing the disease agent from the body. Antibody prevalence and antibody levels are the most commonly used indicators of clinical protection against disease and are used to assess the ongoing status of clinical disease as well as the distribution of immunity within a population-in this case a pond.

96 well ELISA plates containing duplicate catfish serum samples. Color intensity directly correlates to the concentration of pathogen specific antibody in the serum.

Enzyme-linked immunosorbent assays (ELISAs) are one of the most commonly used techniques to determine antibody levels, in part due to their sensitivity and low cost. This assay employs a colorimetric reaction where color intensity reflects antibody concentration. Routine antibody assays commonly used with fish suffer from a lack of specificity. Fish along with other animals possess a subset of antibodies called "natural antibodies" which are continually produced and require no pathogen or antigen induction. A hallmark of this type of antibody is their reactivity to a variety of substances (i.e. not pathogen specific) and a relatively low or weak binding strength (low avidity). When assayed, these samples exhibit artificially high concentrations and are not a true depiction of antibody levels capable of conferring protection from infectious disease. Chemical treatment of the serum sample in an ELISA, with either high concentrations of salt or urea, can dissociate these weakly binding antibodies which is reflected in the color change. This allows researchers to more accurately predict whether the fish has generated sufficient antibody (i.e. following vaccination) to afford protection from disease. We have developed a custom set of reagents reactive to both high and low molecular weight antibodies in blue, channel and hybrid catfish. This coupled with using species specific reference sera for generating a standard curve will allow for



*Longitudinal analysis of anti-*E. ictaluri *antibody*

greater accuracy in reporting antigen specific antibody levels in catfish. Since both innate and acquired arms of the immune system are present in the same individual animal, both low affinity polyreactive and high affinity monoreactive antibodies can be present to the same antigen. The need to discriminate between the relative contribution made by naturally occurring antibody and actively acquired antibody (in response to pathogens) is essential.

This response to vaccine or disease is often termed seroconversion indicating the animal has encountered the vaccine or disease element and has mounted a protective response (antibody). These aforementioned assays measure these responses and are being used in ongoing disease surveillance programs evaluating population responses to vaccines as well as tracking the spread of disease through populations. For example-following vaccination we routinely sample (blood sample) fish and after assay, attempt to determine the percentage of fish within a population that was exposed to the vaccine as well as the magnitude of the immune response of those which consumed the vaccine. In the future we hope to have a formula that takes into account both percentage seroconversion and magnitude of response which predicts survival chances if disease outbreaks occur.

AQUACULTURE

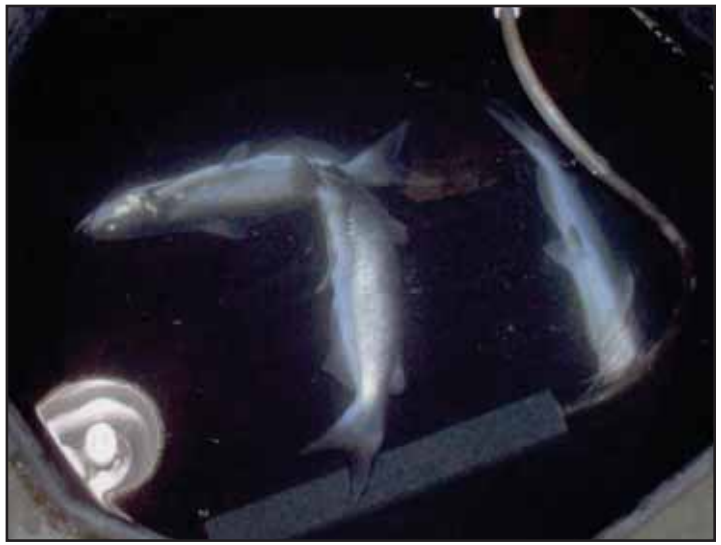
SYNERGISTIC EFFECTS OF *FLAVOBACTERIUM COLUMNARE* ON MORTALITY FROM DISEASED CATFISH

Patricia Gaunt, Dana Gao

THERE WAS AN INCREASED RISK FOR MORTALITY IN CHANNEL CATFISH THAT WERE EXPOSED TO BONT/E AND CHALLENGED WITH *F. COLUMNARE* SUGGESTING THAT COLUMNARIS DISEASE COULD SYNERGISTICALLY EFFECT CATFISH MORTALITIES WITH SUBLETHAL POND EXPOSURE TO BONT/E DURING VTC OUTBREAKS.

Visceral toxicosis of catfish (VTC) is a disease primarily of food-sized fish that causes aberrant swimming and sudden mortality in late fall and early spring when pond temperatures are between 18 and 22^{0}C. The cause of VTC was shown to be botulinum serotype E (BoNT/E), and field mortalities were associated with a neuromuscular blockade induced by the toxin.

Catfish purportedly affected by VTC were submitted by farmers to the Mississippi State University College of Veterinary Medicine Aquatic Diagnostic Laboratory (ADL), where they were bled, necropsied, and examined for characteristic lesions of VTC. The presumptive diagnosis was confirmed through a bioassay using catfish fingerlings injected with serum from the affected fish. Catfish sera that caused mortality in sentinel fingerlings within 96 hours with lesions typical of VTC-affected fish were considered positive. Sera that did not cause mortality in sentinel fingerlings within 96 hours were considered negative.



Catfish, affected by VTC, swimming in a vat on their sides (still alive) because they lost neuromuscular control to swim upright.

Because fish presented to the ADL were showing VTC clinical signs in the pond but were not causing mortalities in sentinel fingerlings, we considered that additional synergistic factors could be interacting with sublethal doses of BoNT/E to effect mortalities from VTC. One such factor was the bacteria *Flavobacterium columnare*.

Flavobacterium columnare is the most commonly diagnosed bacterial infection of catfish in the Mississippi Delta. The bacteria causes ulceration and necrosis of the skin, mouth, and gills of fish. Columnaris disease outbreaks can occur in

catfish ponds at approximately the same temperature as VTC outbreaks.

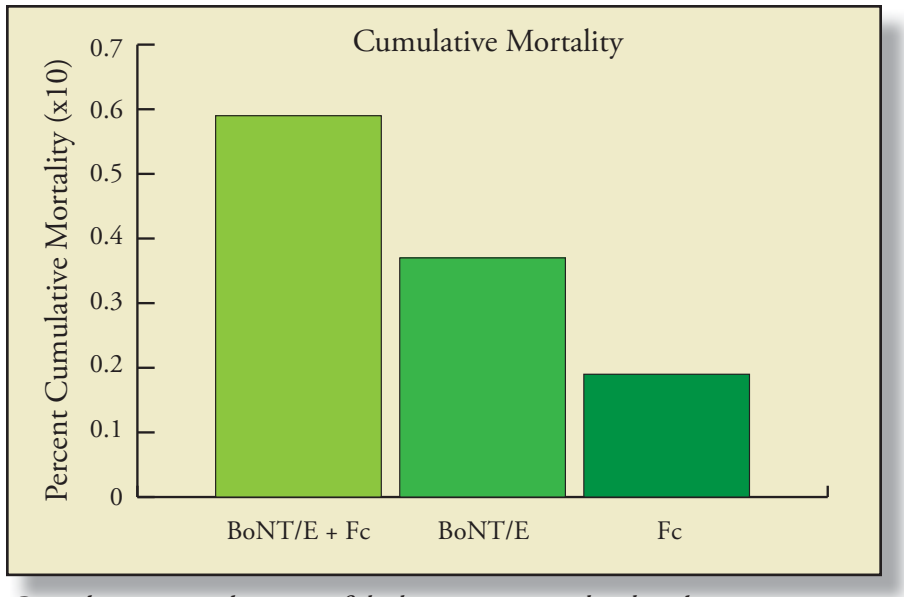
We designed a research study to determine whether there was a synergistic effect between sublethal doses of BoNT/E and *F. columnare* in catfish using 3 treatment groups:

1. Fish injected with BoNT/E and immersion-challenged with *F. columnare* (BoNT/E +Fc)

2. Fish injected with BoNT/E (BoNT/E) only

3. Fish immersion-challenged with *F. columnare* (Fc) only

Mortalities were cultured, necropsied, and examined for characteristic lesions of VTC. The cumulative mortality and relative risks for mortality were calculated post termination.



Cumulative mortality in catfish that were exposed to botulinum serotype E and Flavobacterium columnare *(BoNT/E + Fc), botulinum serotype E (BoNT/E), or* Flavobacterium columnare *(Fc).*

A significant difference was seen between the BoNT/E +Fc, and the other 2 groups. The cumulative mortality was 58%, 36%, and 18% for the BoNT/E +Fc, BoNT/E, and Fc, respectively.

In conclusion, there was an increased risk for mortality in channel catfish that were exposed to BoNT/E and challenged with *F. columnare* suggesting that columnaris disease could synergistically effect catfish mortalities with sublethal pond-exposure to BoNT/E during VTC outbreaks.

EDWARDSIELLA PISCICIDA: A NEW CATFISH PATHOGEN

Matt Griffin, Stephen Reichley, Lester Khoo, Patricia Gaunt, Terry Greenway, and David Wise

WE HAVE EVIDENCE THAT SUGGESTS EDWARDSIELLA PISCICIDA IS AN EMERGENT PATHOGEN WITHIN MISSISSIPPI AQUACULTURE. WE DON'T KNOW WHAT IS DRIVING THIS EMERGENCE, BUT WE NOW HAVE MOLECULAR ASSAYS THAT CAN DETECT AND QUANTIFY THESE BACTERIA IN THE POND ENVIRONMENT. THESE ASSAYS WILL BE VALUABLE RESEARCH TOOLS MOVING FORWARD.

A new *Edwardsiella* taxon was recently described from fishes of Europe and Asia. Phenotypically similar to *Edwardsiella tarda*, extensive genetic and phenotypic characterization determined this new strain does not belong to any established *Edwardsiella* taxa, leading to the adoption of a new taxon, *Edwardsiella piscicida*. Concurrent research also identified two genetically distinct taxa within the group of organisms traditionally classified as *E. tarda*. Comparisons of *gyrB* sequences between US isolates and *E. piscicida* from Europe and Asia identified several US isolates with >99.6% similarity to the *gyrB* sequence of the *E. piscicida* type strain (ET883) but <87% similarity to the *E. tarda* type strain from humans (ATCC #15947). A discriminatory PCR was developed for the identification of *E. tarda* and 2 genetic variants of *E. piscicida* (*E. piscicida* and *E. piscicida-like* species). Using these PCR assays, a survey was conducted of 44 archived bacterial specimens from disease case submissions to the Aquatic Research and Diagnostic Laboratory at the Thad Cochran National Warmwater Aquaculture Center between 2007 and 2012. All 44 isolates, originally identified phenotypically and biochemically as *E. tarda*, were identified as *E. piscicida* by PCR. Repetitive sequence-mediated PCR (rep-PCR) analysis of these archived specimens suggests they are largely homogenous, similar to what has been observed for *E. ictaluri*. The *gyrB* sequence data, coupled with the *E. piscicida* specific-PCR and rep-PCR data, confirms that *E. piscicida* has been isolated from fish disease cases in the southeastern USA. Moreover, our survey data suggests *E. piscicida* is likely more prevalent in catfish aquaculture than *E. tarda*, which is a zoonotic pathogen.

This work led to the development of individual real-time polymerase chain reaction (qPCR) assays for *E. tarda, E. piscicida,* and *E. piscicida–like* sp. to provide rapid quantitative confirmatory tests for these phenotypically ambiguous bacteria. The qPCR assays were shown to be repeatable and reproducible, with high degrees of sensitivity. Moreover, each assay was found specific to their respective targets with no observed amplification from non-target organisms, including the closely related *E. ictaluri* and *E. hoshinae.* Under the conditions used in this study, the 3 assays had a quantifiable limit ranging from 10^3 (*E. piscicida*) to 10^2 (*E. piscicida–like* and *E. tarda*) colony forming units (CFU) in kidney tissue biopsies (ap-

proximately 25 mg), pond water samples (35 mL), and broth culture (20 µL). In experimental disease challenges, the assays were able to detect their respective targets in both clinically and subclinically infected channel catfish (*Ictalurus punctatus*) fingerlings. This challenge work also identified significant differences in pathogenicity to channel catfish between these three enteric pathogens (Figure 1), with minimal mortality observed in fish exposed to *E. tarda* and *E. piscicida-like sp.*, even at doses >1x10^7 CFU. In addition to quantifying target bacteria from various substrates, the assays provide rapid identification, differentiation, and confirmation of the phenotypically indistinguishable *E. tarda, E. piscicida,* and *E. piscicida–like* sp., a valuable tool for diagnostic assessments.

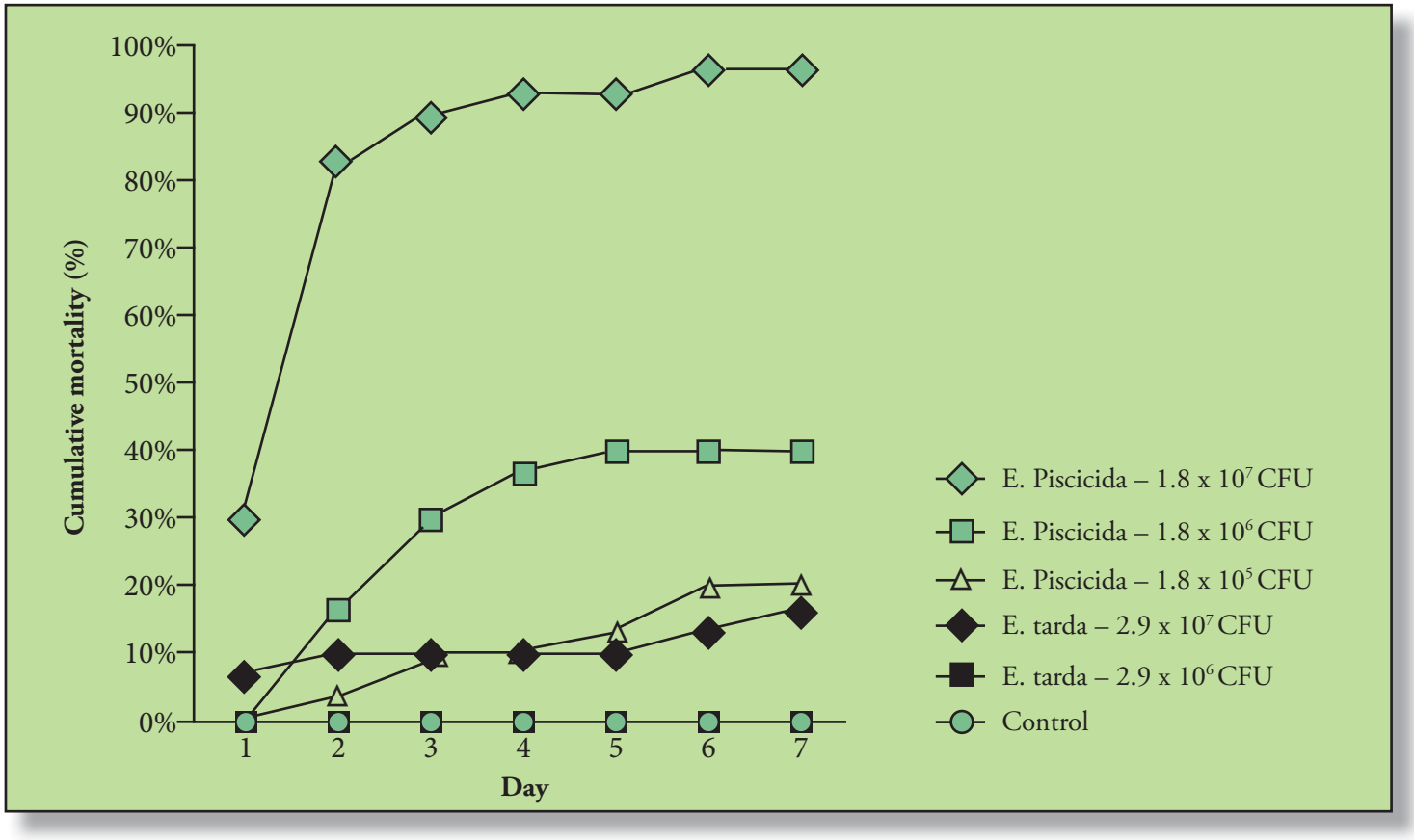


Figure 1: *Nonreplicated cumulative mortality for channel catfish challenged with 3 different doses of* Edwardsiella piscicida, Edwardsiella piscicida–like *sp., and* Edwardsiella tarda. *Thirty fish were challenged with each dose by IP injection. The cumulative percent mortality is reported.*

AQUACULTURE

BIOMPHALARIA OBSTRUCTA (SYN. B. HAVANENSIS) IS HOST TO TWO SPECIES OF TREMATODES INFECTIVE TO CATFISH

Matt Griffin, Graham Rosser, Neely Alberson, Lester Khoo, Terry Greenway, and David Wise

THE BIOMPHALARIA SP. SNAILS WERE PREVIOUSLY CONSIDERED A PEST OF MINIMAL CONCERN IN CATFISH AQUACULTURE. WE'VE FOUND THEY TRANSMIT TWO TREMATODES THAT HAVE DELETERIOUS EFFECTS ON CATFISH. THE BIOMPHALARIA SP. SNAILS ARE JUST AS MUCH OF A THREAT TO PRODUCTION AS THE RAMS-HORN SNAILS. ITS IMPORTANT PRODUCERS REMAIN DILIGENT IN MINIMIZING SNAIL POPULATIONS ON THEIR OPERATIONS.

Digenetic trematodes are a significant hindrance to the production of farm-raised catfish. Commercial catfish ponds are ideal environments for the propagation of digenetic trematode lifecycles as fish eating birds and the trematodes they carry are endemic to commercial catfish operations. Severe infections with the trematode *Bolbophorus damnificus* can result in death, but the real damage lies in mild to moderate infections, which can go unnoticed by producers. Research has shown that even mild infections can inhibit production to the point of operating at a net loss. Similarly *Drepanocephalus auritus* has been shown experimentally to induce mortality in channel catfish fingerlings. The ramshorn snail *Planorbella trivolvis* is the first intermediate host for *B. damnificus* and *D. auritus* and is ubiquitous in most commercial catfish ponds. Management practices aimed at controlling trematode infections primarily focus on reducing snail populations in ponds. Other aquatic snail species are also associated with commercial catfish ponds, although little is known about their contributions to trematode infections in catfish.

Figure 1: Biomphalaria *sp.*

In addition to *P. trivolvis, Biomphalaria obstructa* is also found inhabiting these ponds. Until recently they were thought to be inconsequential to catfish health.

In one study, *Biomphalaria obstructa* (syn. *B. havanensis*) snails (n=804) were collected from a commercial catfish pond and screened for trematode infections. Seven of these snails (0.81%) were actively releasing cercariae identified molecularly as *B. damnificus*. These cercariae were then used in infectivity trials with

channel catfish *Ictalurus punctatus* fingerlings (5-8 cm). Seven days post-challenge, fish were examined histologically for the presence of metacercariae, which were present in 13/15 (86.67%) surviving fish. In a second study, *B. obstructa* (syn. *B. havanensis*) (n=1740), were collected from two separate farms in Noxubee County, Mississippi and were observed for 48 hours for the presence of cercariae. Fifteen individual snails (1.01%) were actively shedding cercariae morphologically consistent with *D. auritus*. Genetic sequence analysis of cercariae was a 99%-100% match to *D. auritus* across five different gene targets. As above, these cercariae were used in infectivity trials with channel catfish fingerlings (2-3 cm). Fish were necropsied 7 days post-exposure and the presence of metacercariae was confirmed by histopathology. This is the first report of naturally occurring infections of *B. damnificus* and *D. spathans* in another snail species associated with catfish aquaculture. This work further emphasizes the importance of routine snail control on commercial catfish operations.

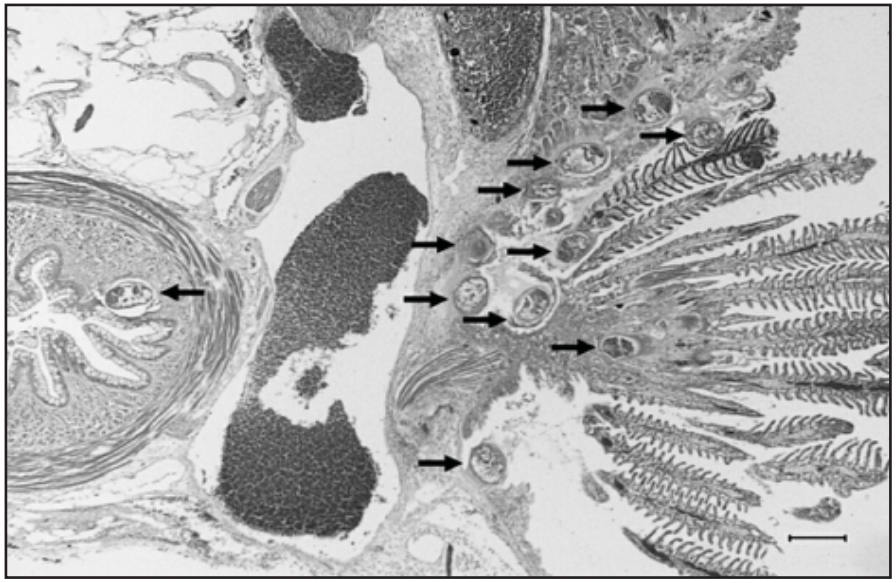


Figure 2: *Cross section of a* Drepahnocephalus spathans*–infected channel catfish fingerling at the level of the branchial chamber. Note the multiple developing metacercariae. Small arrows indicate the metacercariae at the base of the gills; larger arrow (left facing) indicates a single metacercaria in the submucosa of the esophagus. Calibration bar, approximately 200 µm (H&E).*

AQUACULTURE

CHARACTERIZATION OF MYXOZOAN ACTINOSPORE FROM A COMMERCIAL CATFISH POND IN THE MISSISSIPPI DELTA

Matt Griffin, Graham Rosser, Terry Greenway, and David Wise

THE MYXOZOA ARE AN IMPORTANT GROUP OF PARASITES THAT INFECT A WIDE VARIETY OF FISH SPECIES WORLDWIDE. WE'VE IDENTIFIED FOUR PREVIOUSLY UNDOCUMENTED MYXOZOAN LIFE CYCLES IN CATFISH PONDS, THE IMPACTS OF WHICH ARE UNKNOWN. IDENTIFICATION OF THESE PARASITE LIFE CYCLES INCREASES OUR KNOWLEDGE OF THE COMPLEX ECOSYSTEMS THAT EXIST IN AQUACULTURE PONDS AND THEIR AFFECTS ON FISH HEALTH.

The Myxozoa are an important group of metazoan spore-forming parasites. Their complex life cycles primarily involve a myxospore stage in a fish and an actinospore stage in aquatic annelids (oligochaetes and polychaetes) or bryozoans. Surveys of actinospores from aquatic oligochaetes have been conducted in both wild and commercial aquaculture settings. Catfish aquaculture in the southeastern United States is known to sustain several myxozoan life cycles, the most notable being *Henneguya ictaluri,* the causative agent of proliferative gill disease (PGD) in channel and hybrid catfish.

The oligochaete host in the *H. ictaluri* life cycle is the ubiquitous bottom-dwelling worm *Dero digitata*. Common in most catfish production ponds, *D. digitata* is a known host for the aurantiactinomyxon, echinactinomyxon, raabeia, and triactinomyxon collective groups of actinospores, 2 of which have been linked to a myxospore stage in channel catfish. The actinospore diversity of infected *D. digitata* was surveyed from a channel catfish production pond in the Mississippi Delta region for the elucidation of unknown myxozoan life cycles. In this study *D. digitata* (n= 2,592) were collected from the bottom sediment of a channel catfish production pond. After 1 week of daily observation, a total of 6 genetically different actinospore types were observed. The collective groups were classified as 2 aurantiactinomyxons, 2 helioactinomyxons, 1 raabeia, and 1 triactinomyxon (Figure 1). Overall prevalence of myxozoan infections in the isolated oligochaetes was 4.4%. Four previously undescribed actinospore types were identified and characterized molecularly and morphologically. Phylogenetic analysis revealed the raabeia and one of the helioactinomyxon (type 1) actinospores were closely related to the group of myxozoans known to parasitize ictalurids in North America. To date, no myxospores stage in fish have been linked to the newly sequenced actinospores reported in this survey. The morphological and molecular data generated from this study will assist in the identification of myxospore counterparts for these actinospore stages and aid in the elucidation of unknown myxozoan life cycles in catfish production systems.

This work generated DNA sequences for four previously undocumented parasite life cycles present in catfish aquaculture ponds in Mississippi. These sequences can be used to identify alternate life stages of these parasites in fish. Elucidation of these life cycles will help in evaluating the risk these parasites pose to catfish production and development of management practices to minimize their impact on catfish health.

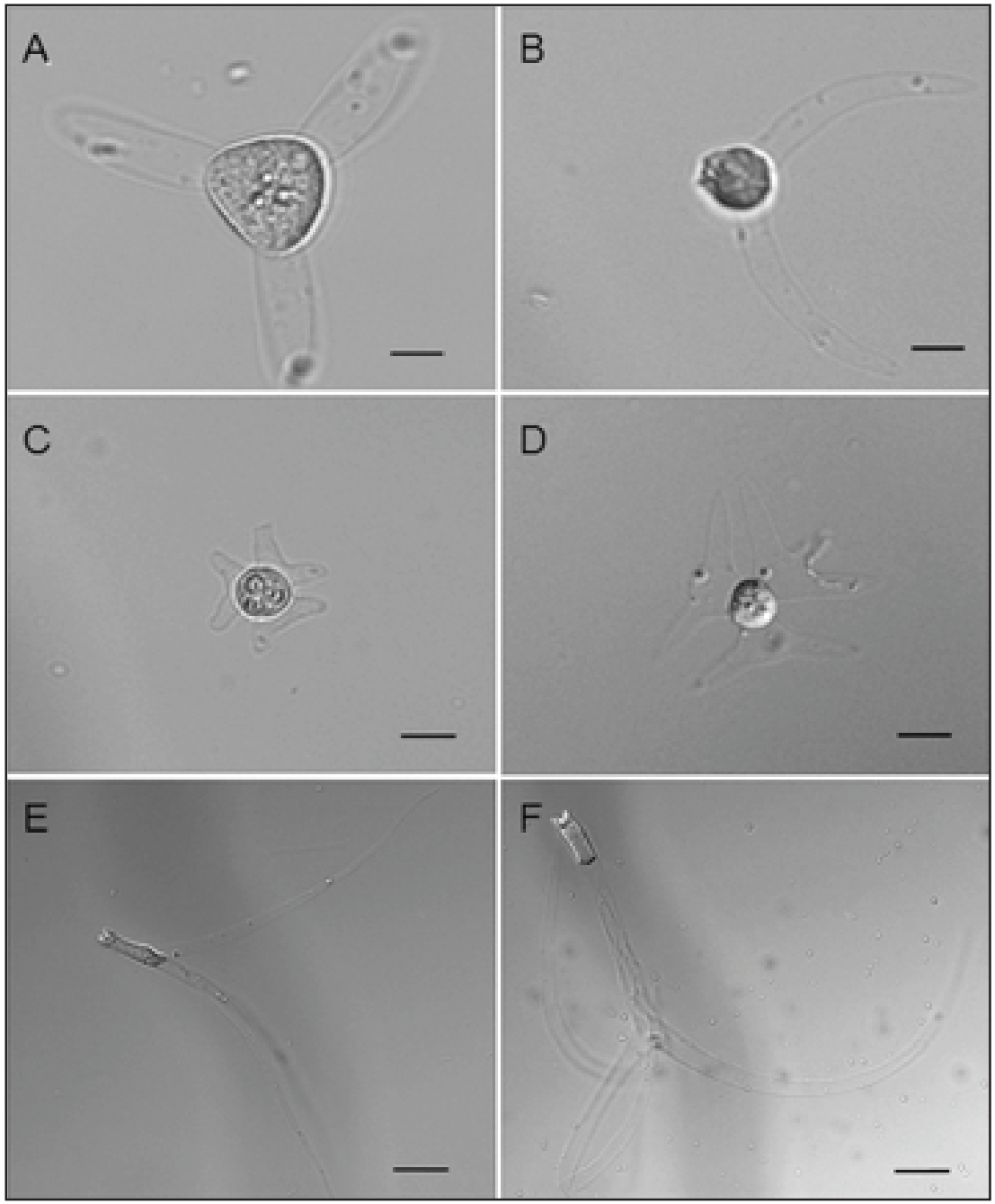


Figure 1: *Microscopic images of actinospore types: (A) Aurantiactinomyxon-type actinospore of* Henneguya ictaluri. *(B) Aurantiactinomyxon-type actinospore of* Henneguya exilis. *(C) Helioactinomyxon type 1 actinospore. (D) Helioactinomyxon type 2 actinospore. (E) Raabeia-type actinospore. (F) Triactinomyxon-type actinospore. Scale bars for A–D represent 10 µm in length. Scale bars for E–F represent 25 µm in length.*

AQUACULTURE

SUMMARY OF 2015 CASE SUBMISSIONS TO THE AQUATIC RESEARCH AND DIAGNOSTIC LABORATORY

Lester Khoo, Patricia Gaunt, and Matthew Griffin

ALTHOUGH THERE ARE INHERENT BIASES, DIAGNOSTIC LABORATORY CASE SUBMISSION DATA PROVIDES CRITICAL INSIGHT TO THE CHANGES IN PREVALENCE OF DISEASES AS WELL AS THE PATHOGENS.

The Aquatic Research and Diagnostic Laboratory (ARDL), at Delta Research and Extension Center provides diagnostic services to producers in Southeastern United States and diagnostic support to on-going disease and production research. Diagnostic records provide critical insight to changes in disease trends and emergence of new diseases affecting animal production systems, an essential component of population health management. This information provides clinicians, caregivers and researchers a good cross-section of disease occurrence across the industry and is used to prioritize the allocation of resources for the development of rapid diagnostic procedures, disease surveillance and treatment programs and implementation of biosecurity measures.

In 2015, ARDL received a total of 599 case submissions involving, bacterial, parasitic, viral and histopathological evaluations. There were also 708 water samples submitted for analysis. Bacterial diseases were the predominant diagnosis for the submissions. Columnaris disease was diagnosed in 325 submissions with no isolates exhibiting resistance to the three antibiotics tested (Terramycin, Romet and Aquaflor). *Edwardsiella ictaluri*, the causative agent of Enteric Septicemia of catfish, was isolated from 162 submissions, 158 of which were from producers. Twenty-two of these isolates demonstrated some level of antimicrobial resistance, although some of these isolates were from repeat submissions. Twenty isolates were resistant to Terramycin with intermediate resistance to Aquaflor, while 2 were resistant to Terramycin with intermediate resistance to both Romet and Aquaflor. There were 12 *E. tarda* (syn. *E. piscicida*) cases, all of which were susceptible to the 3 antibiotics. Most of these were isolated from hybrid catfish except for two, one from channel catfish and one from largemouth bass. There were 26 atypical *Aeromonas hydrophila* (VAh) cases that demonstrated lesions and biochemical profiles associated with an emergent, highly virulent strain of the pathogen. In addition to this, four *A. hydrophila* cases had lesions suggestive of the VAh but possessed a different biochemical profile. No antibiotic resistance was seen in any of these 30 isolates. There were an additional 10 *Aeromonas* isolates that could not be identified to species by routine biochemical tests. One these isolates was resistant to Terramycin. Of the parasitic diseases, there were 55 cases of

Proliferative Gill Disease, 14 cases of *Bolbophorus* trematode and 2 cases of *Ichthyophthirius multifiliis* (white spot; Ich). Lastly there were 10 channel catfish virus cases. Of the 580 total catfish cases, 320 were channel catfish, 250 were hybrid catfish and 18 were blue catfish. This information is a summary of a more comprehensive report that is archived on the Thad Cochran National Warmwater Aquaculture Center website (http://tcnwac.msstate.edu). Florfenicol was shown equally effective in controlling mortality associated with *E. ictaluri* infection in channel, hybrid and blue catfish. Research data are being used to extend the use of florfenicol in other bacterial species affecting catfish. Antimicrobial susceptibilities of catfish pathogens *E. ictaluri* and *E. piscicida* were determined by three independent laboratories. Frequency distribution of (MIC) values was used to set epidemiologic breakpoints. These values will be used to discriminate between wild-type (i.e. originally susceptible bacterial populations) from non-wild type (i.e. populations with acquired and mutational resistance mechanism) isolates and help determine susceptibility of bacteria to antimicrobials.

Information garnered from diagnostic case submissions was used to initiate research evaluating factors leading to the spread of atypical *A. hydrophila* in commercial catfish production systems. Previous ARDL work led to the approval of new antibiotic (AQUAFLOR) for treatment of *E. ictaluri* and *Flavobacterium columnare* in catfish. Current work is being conducted to extend the use of AQUAFLOR for control of *A. hydrophila* and *E. piscicida* infection in catfish. Antimicrobial susceptibility data has been submitted to the Veterinary Antimicrobial Susceptibility Testing (VAST) subcommittee for evaluation and determination of quality control ranges by the Clinical Laboratory Standards Institute (CLSI). Once the quality control ranges are accepted by the VAST, data will be published in the CLSI VET05-A2 guideline in 2016. The data will be used in clinical evaluations to determining effective recommendations for control of bacterial infections in catfish. In support of diagnostic research, multiplex quantitative polymerase chain reactions assays were developed for predominant fish pathogens affecting commercial catfish culture and are being used in disease monitoring programs.

ENTOMOLOGY

EVALUATION OF FOLIAR INSECTICIDE SPRAYS IN CURRENT BT COTTON TECHNOLOGIES

Jeff Gore, Don Cook, and Chris Dobbins

BT COTTONS ARE AN IMPORTANT COMPONENT OF IPM IN COTTON AND PRESERVATION OF THIS TECHNOLOGY IS VITAL TO THE ECONOMIC VIABILITY OF COTTON PRODUCTION IN MISSISSIPPI.

Current Bt varieties have changed the dynamic of insect pest management in cotton across the U.S. Current commercial technologies include Bollgard II® (Monsanto Company), Widestrike™ (Dow AgroSciences), TwinLink® (Bayer Cropscience), and Widestrike 3™ (Dow AgroSciences). All of these cotton technologies provide excellent control of tobacco budworm and no supplemental sprays have been needed for this pest in any of the technologies. In contrast, bollworms are much less susceptible to the proteins in Bt cotton and they can cause significant injury at moderate to high population densities. As a result, growers in Mississippi generally make 1 to 3 foliar insecticide applications to manage bollworms in Bt cottons. Research is needed to determine if these applications are economically justified in Mississippi.

An experiment was conducted at the DREC to evaluate the impact of foliar insecticide sprays for bollworm management in Bt cotton. Plots were planted as a split-plot in a randomized complete block design with 4 replications. The main-plot factor was insecticide spray and included sprayed and unsprayed. The sprayed treatments were sprayed with chlorantraniliprole (Prevathon, DuPont) at first flower at a rate of 14 fluid ounces per acre. A second application was made approximately 2 weeks later. The sub-plot factor included the Bt cotton technologies mentioned previously and a non-Bt variety. Plots were evaluated weekly beginning at first flower by counting the number of damaged terminals, squares, and bolls on 20 plants in each plot. Additionally, the numbers of live larvae were counted on each of those structures. At the end of the season, plots were harvested and lint yields were determined.

Significant injury was observed in all of the Bt technologies on multiple evaluation dates. The greatest level of injury was observed approximately the third week of flowering (July 27, 2015) in this experiment (Figure 1). For all Bt technologies and the non-Bt variety, insecticide sprays significantly reduced the percentage of damaged bolls. Additionally, all Bt technologies reduced the percentage of damaged bolls compared to the non-Bt cotton. In terms of yield, insecticide sprays preserved yield in Widestrike, Bollgard II, TwinLink, and the non-Bt cottons. No differences in yield were observed between the sprayed and unsprayed treatments for Widestrike 3.

These data demonstrate the importance of man-

aging bollworms in Bt cottons. In general, all of the Bt technologies provide good control of bollworm in Mississippi, but control is not absolute. In many cases, supplemental control with foliar insecticides may be needed to prevent yield and economic losses, especially when heavy populations persist for multiple weeks.

Figure 1: *Boll injury as a result of bollworm feeding and the impact of insecticide sprays on commercial Bt cotton technologies at Stoneville, MS on July 27, 2015*

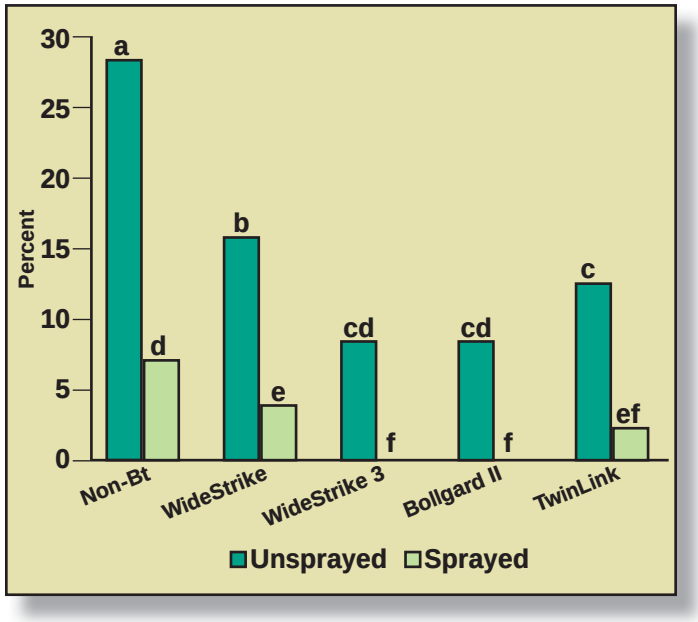
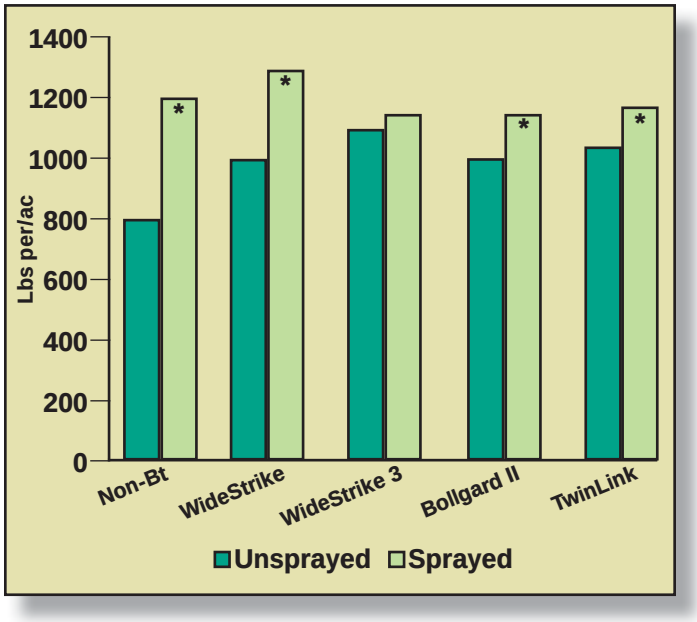


Figure 2: *Impact of insecticide sprays on lint yields of current commercial Bt cotton technologies at Stoneville, MS. Sprayed bars with an asterisk denote a significant difference compared to the unsprayed bar within a technology*



ENTOMOLOGY

VALIDATION/REFINEMENT OF CORN EARWORM ECONOMIC THRESHOLDS FOR SOYBEANS

Brian Adams, Don Cook, Angus Catchot, Jeff Gore, Fred Musser, Scott Stewart, David Kerns, Gus Lorenz, Trent Irby, Bobby Golden

THESE DATA WILL PROVIDE GROWERS TREATMENT GUIDELINES FOR CORN EARWORM INFESTING SOYBEANS THAT TAKE INTO ACCOUNT COMMODITY PRICE AND CONTROL COSTS.

In recent years, corn earworm has surpassed stink bugs and soybean loopers as the primary insect pest of soybeans in Mississippi. Current thresholds for bollworms after bloom in Mississippi are three larvae per foot of row using a drop cloth or nine larvae per 25 sweeps using a sweep net. The current thresholds used in Mississippi are based on older research that utilized varieties that are later maturing than currently planted varieties and have a determinate growth habit. The majority of the currently planted varieties are Maturity Group 4 and 5 with all of the Maturity Group 4 varieties and many of the Maturity Group 5 varieties having an indeterminate growth habit. Also, soybean yields have steadily increased over time and these thresholds were developed when soybean yield potential was substantially less than it is now. For these reasons, thresholds need to be validated or refined to reflect the current soybean production environment. These studies were conducted using Asgrow 4605 and Asgrow 4632 soybeans, with a 4.6 maturity rating and an indeterminate growth habit. Studies were conducted in 6-foot x 6-foot field cages. The treatments in this study were moth mating/oviposition duration of 5, 7, 9 and 11 days to give a range of larval densities as well as a non-infested control. Cages were infested with approximately 10 pair of corn earworm pupae. The soybean growth stage target for the infestation timing was R1-R2 stage, which most commonly represents natural bollworm infestations into soybean fields in Mississippi.

Corn earworm

Once eclosed, moths were then removed according to infestation duration treatment. Yield measurements were recorded at the end of the growing season.

A significant relationship between larval density using drop cloth sampling and yield was observed. Based on the regression equation, for every corn earworm larva per row foot, yield was reduced by 1.28 bu/ac. Economic injury levels for drop cloth sampling were calculated using these data and equation and economic thresholds for a range of commodity prices and control costs were set at 75% of the economic injury level (Table 1). Using a conversion factor to convert from drop cloth sampling to sweep net sampling, economic injury levels for sweep net sampling were calculated for the same range of commodity prices and control costs as for drop cloth sampling. Economic thresholds for sweep net sampling were also set at 75% of the economic injury level (Table 2).

Table 1. *Economic thresholds for corn earworm larvae based on drop cloth sampling.*

	Larvae/row ft				
	Control Costs ($/acre)[1]				
Crop value ($/bu)	10	15	20	25	30
6	1.0	1.5	2.0	2.4	2.9
7	0.8	1.3	1.7	2.1	2.5
8	0.7	1.1	1.5	1.8	2.2
9	0.7	1.0	1.3	1.6	2.0
10	0.6	0.9	1.2	1.5	1.8
12	0.5	0.7	1.0	1.2	1.5
13	0.5	0.7	0.9	1.1	1.4

Based on early planted Maturity Group IV soybean varieties with >50 bu/acre yield potential.
[1]Including application costs.

Table 2. *Economic thresholds for corn earworm larvae based on sweep net sampling.*

	Larvae/25 sweeps				
	Control Costs ($/acre)[1]				
Crop value ($/bu)	10	15	20	25	30
6	7.4	11.0	14.7	18.4	22.1
7	6.3	9.5	12.6	15.8	18.9
8	5.5	8.3	11.0	13.8	16.5
9	4.9	7.4	9.8	12.3	14.7
10	4.4	6.6	8.8	11.0	13.2
12	3.7	5.5	7.4	9.2	11.0
13	3.4	5.1	6.8	8.5	10.2

Based on early planted Maturity Group IV soybean varieties with >50 bu/acre yield potential.
[1]Including application costs.

PATHOLOGY

EVALUATION OF THE 2015 MISSISSIPPI SOYBEAN VARIETY TRIALS TO STEM CANKER

Walter L. Solomon, Tessie Wilkerson, Jeffrey Mansour, and Tom W. Allen

SCREENING SOYBEAN VARIETIES TO DETERMINE THEIR REACTION TO THE SOYBEAN STEM CANKER FUNGUS REMAINS AN IMPORTANT ANNUAL ENDEAVOR. EVEN THOUGH A LARGE NUMBER OF VARIETIES CONTAIN RESISTANCE TO THE STEM CANKER FUNGUS, SOME SUSCEPTIBLE VARIETIES REMAIN COMMERCIALLY AVAILABLE.

A major part of the plant pathology research program at the DREC involves determining the resistance of the soybean cultivars entered in the Mississippi State University Official Variety Trials (OVT) to yield-limiting soybean diseases. One of the more important stem diseases that annually has the potential to threaten soybean production is stem canker. Stem canker, caused by the fungus *Diaporthe aspalathi* (≡ *Diaporthe phaseolorum* var. *meridionalis*), can be one of the most dramatic and destructive soybean diseases in the Mid-South. Yield losses associated with the disease can approach 80% in susceptible soybean varieties when the environmental conditions remain favorable for disease development. Hot and generally humid conditions are the preferred environment for stem canker development. Selecting varieties with a high level of stem canker resistance may prevent serious economic loss for southern soybean producers adopting the early soybean planting system. Symptoms of stem canker first appear during the reproductive stages on leaves and stems (> R5). Leaf symptoms associated with the disease include severe interveinal chlorosis (middle photo, page 51). Lesions present on the stem can begin at the soil line and move up the stem or initiate anywhere a petiole or main stem branch occurs. Most soybean varieties have some resistance to the disease, yet every year we receive varieties that appear to be severely infected with the disease.

On an annual basis between 180 and 250 soybean varieties contained in the Maturity Group IV and V MSU OVT are evaluated. Single rows, replicated four

times, are planted containing each variety blocked by herbicide technology (conventional, LibertyLink, RoundUp Ready) as well as maturity group. The inoculation method relies on the use of a virulent fungal culture, reproduced on flat toothpicks that are then inserted into the plant approximately five weeks after planting. Inoculated plants are rated at approximately R6 and observed for foliar leaf symptoms as well as the production of a canker as a result of inoculation.

The entries in the 2015 Mississippi Soybean Variety Trials were field inoculated and the reaction of each variety was evaluated. Varieties were rated using a modified 0 to 9 scale whereby 0=no canker production and 9=severe canker and a dead plant. Greater than 90% of the entries in the 2015 OVT were observed to be either resistant (83.5%) or moderately-resistant (10%) based on no interveinal chlorosis and extremely limited canker production. The remainder of the varieties observed, 6.5%, produced a significant canker as well as interveinal chlorosis.

V5 soybean plant immediatelly after toothpick inoculation.

Stem canker leaf symptoms as observed exhibiting inveinal chlorosis-play at R6.

Toothpick inoculated plant exhibiting stem leasion at R7.

RICE BREEDING

RU1104077, A PROMISING CONVENTIONAL LINE WITH HIGH AMYLOSE CONTENT, LOW CHALK AND EXCELLENT MILLING QUALITY

Ed Redoña

GRAIN QUALITY ISSUES RAISED AGAINST U.S. RICE IN RECENT YEARS MAKE IT IMPERATIVE FOR U.S. RICE BREEDING PROGRAMS TO RE-EMPHASIZE GRAIN QUALITY TRAITS, ALONG WITH YIELD, THAT COULD HELP RESTORE LOST MARKETS AND INCREASE COMPETITIVENESS IN CAPTURING NEW OPPORTUNITIES.

Conventional pureline varieties account for about one third of the area planted in Mississippi. Certified seeds of conventional varieties cost significantly less than proprietary hybrids and herbicide technology-based varietal types. They are thus preferred by growers for reducing cost of production. The MSU breeding program has developed five pureline conventional varieties since 1986 – Litton, Priscilla, Pace, Bowman, and Rex. In 2013, Rex occupied roughly 15% of the rice area in the state and remains the

Seeding rate
Drill seeded- 75 to 90 lbs/ac

Cooking characteristics
Apparent amylose- 23.6%
Gelantinization- 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 of heading- 89
Days to maturity- 128
Seed weight (1000)- 25
Seeds/lb- 18,056

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

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

Rice grain dimensions

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

most popular conventional variety presently. A new conventional breeding line, RU1104077, has been identified as a promising candidate for release based on yield performance and other traits in multiyear, and multilocation tests. RU1104077 has the standard varieties Rosemont, Mars, Newrex and Tebonnet in its pedigree. It is an early maturing, semidwarf pureline with good yield potential, excellent straw strength, and good standability. The grain yields average 231 bu/ac in small plot tests. Milling yields have averaged 54 percent whole and 69 percent total. RU1104077 has the Newrex cooking profile that makes it superior to almost all other commercial cultivars for parboiled and canned rice. Its high amylose content of 24 percent makes it highly suited to the eating preferences of Central and South American consumers. RU1104077 is rated susceptible to sheath blight, leaf blast, bacterial panicle blight, and rotten neck blast but is moderately resistant to the straighthead disorder. In blind milling tests conducted in 2015 by USA Rice and seven major US rice mills, it was the only entry unanimously found to be acceptable based on milling and grain quality traits. With high yield, low-chalk and unique properties, this promising pureline has good potential for capturing added value in the contract/identity preservation markets and for increasing overall grain quality of rice grown in Mississippi.

RICE BREEDING

CL163: A NEW, HIGH-AMYLOSE CONTENT CLEARFIELD- RICE VARIETY

Ed Redoña

MOST SOUTHERN U.S. RICE VARIETIES ARE LONG-GRAIN TYPES WITH INTERMEDIATE AMYLOSE CONTENT. CL163 HAS HIGH AMYLOSE CONTENT, MAKING THE COOKED RICE NON-STICKY AND THUS PREFERRED BY CONSUMERS IN EXPORT MARKETS FOR MISSISSIPPI RICE.

During 2014-2015, Clearfield® pureline varieties occupied 26% of the rice acreage in Mississippi. This varietal type remains highly vigorous even with Newpath®, Clearpath® and Beyond® herbicide application due to its tolerance to imidazolinone and is thus preferred by many farmers for better weed management and red rice control. The MSU rice breeding program, through a licensing agreement with BASF®, develops Clearfield® pureline varieties in order to provide more crop management options to Mississisippi growers.

Seeding rate
Drill seeded- 75 to 90 lbs/ac

Cooking characteristics
Apparent amylose- 26.4%
Gelantinization- intermediate
Cook type-long grain

Agronomic traits
Average yield-235 bu/ac
Milling yield- 57/69
Bushel weight- 44
Plant height- 40
Lodging- 14%
Days of heading- 89
Days to maturity- 130
Seed weight (1000)- 25
Seeds/lb- 18,041

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

Disease resistance
CL163 is susceptible to sheath blight, intermediate to bacterial panicle blight, and resistant to some races of rice blast.

Rice grain dimensions

	Paddy	Brown	Milled
Length (mm)	9.40	7.26	6.70
Width (mm)	2.74	2.36	2.28
Thickness (mm)	1.92	1.73	1.60
L/W ratio	3.44	3.08	2.94

In 2011, the program released its first Clearfield® product, CL162. In 2014/15, a new imidazolinone tolerant breeding line RU1104122 was identified for release. Named CL163, this pureline was developed from a cross between CL161, a imidazolinone tolerant variety, and a breeding line derived from Rosemont, Mars, Newrex, Tebonnet, and Bellemont. CL163 is high yielding, early maturing, semidwarf, and long-grain type. It has the Newrex cooking and processing properties favored by the parboiling and canning industry. Unlike previous Clearfield® releases, it has a high level of amylose content, which makes the cooked rice non-sticky, a trait desired by consumers in Central and South America where most Mississippi rice is exported. CL163 matures two days later but has better straw strength than CL151, resulting in 20% less lodging. Grain yields average 235 bushels per acre in small plot tests. Milling yields average 57 percent whole and 69 percent total. Like CL151, it has some tolerance to rice blast but is susceptible to sheath blight. However, it is rated intermediate to bacterial panicle blight and moderately resistant to straighthead. With distinct quality traits, CL163 is a good candidate for identity preservation but can also be co-mingled with other southern varieties. This new Clearfield® release was under seed production in 2014/15 and will be widely available to growers in 2016 through Horizon Ag®.

WEED SCIENCE

GLYPHOSATE-RESISTANT PALMER AMARANTH CONTROL WITH HERBICIDE MIXTURES CONTAINING 2,4-D

Ben Lawrence, Jason Bond, Jimmy Peeples, and Matthew Edwards

THE ENLIST WEED CONTROL SYSTEM REPRESENTS THE NEXT STEP IN MANAGEMENT OF GLYPHOSATE-RESISTANT PALMER AMARANTH BECAUSE IT ALLOWS APPLICATION OF MULTIPLE HERBICIDE MODES OF ACTION THAT ARE EFFECTIVE FOR CONTROL OF THIS SPECIES.

Since the first documentation of herbicide resistance in Palmer amaranth to the dinitroaniline herbicide family (Group 3), this species has evolved resistance to multiple herbicide modes of action, including acetolactate synthesis inhibitors (Group 2), EPSP synthase inhibitors (Group 10), 4-hydroxyphenylpyruvate dioxygenase inhibitors (Group 27), photosystem II inhibitors (Group 5), and protoporphyrinogen oxidase inhibitors (Group 14). Currently, there is no documentation of Palmer amaranth resistance to 2,4-D, dicamba, or glufosinate.

Palmer amaranth

2,4-D is one of the oldest and most widely used synthetic herbicides. It controls several broadleaf weeds including Amaranthus, or pigweed, species and is applied in aquatic, lawn, and agricultural settings. Corn, cotton, and soybean varieties resistant to 2,4-D have been developed and deregulated. This technology was developed by Dow Agrosciences and will be marketed as the Enlist Weed Control System. The Enlist Weed Control System could offer soybean growers more flexibility for weed control because Enlist soybean varieties are also resistant to glyphosate and glufosinate, and herbicide applications including only one mode of action are no longer recommended. Previous research has shown that mixtures of glufosinate and 2,4-D can improve control of a variety of weeds.

Glyphosate-resistant (GR) weeds, primarily GR Palmer amaranth, are the principal weed control issue facing row crop growers in Mississippi. Understanding control of GR Palmer amaranth with 2,4-D and other herbicide modes of action is crucial for Mississippi soybean growers. Research was conducted at the Mississippi State University Delta Research and Extension Center to evaluate mixtures of glyphosate, glufosinate, and/or 2,4-D for control of different sizes of GR Palmer amaranth.

Two separate field studies were conducted to evaluate control of different sizes of GR Palmer amaranth with multiple rates of 2,4-D alone and in mixtures with glyphosate and/or glufosinate. An Early Application Study targeting 2- to 4-inch GR Palmer amaranth was conducted once in 2013 and twice in 2014. A Late Application Study targeting 6- to 8-inch GR Palmer amaranth was conducted once in 2013 and once in 2014. In both studies, glyphosate (Roundup WeatherMax) at 0 and 22 oz/ac, glufosinate (Liberty 280) at 0 and 29 oz/ac, and 2,4-D (2,4-D Amine) at 0, 1, and 2 pt/ac were applied in all possible combinations. Treatments were applied using a tractor-mounted sprayer when GR Palmer amaranth in each plot uniformly reached designated growth stages for each study. Visual estimates of GR Palmer amaranth control were recorded 7, 14, 21, and 28 days after treatment (DAT). At 28 DAT, GR Palmer amaranth density and aboveground dry weight were determined in each plot.

Based on this two-year study, treatments containing multiple herbicide modes of action provided the greatest GR Palmer amaranth control. 2,4-D was not beneficial to any mixture except glyphosate in the Late Application Study. 2,4-D alone at 2 pt/ac provided similar control to that of two- and three-way herbicide mixtures 28 DAT in the Early Application Study. At 28 DAT, glyphosate plus 2,4-D at 1 or 2 pt/ac provided GR Palmer amaranth control comparable to all other mixtures applied at early application timings; however, when applied at the later timing, mixtures of glufosinate and 2,4-D provided the greatest control of GR Palmer amaranth 28 DAT. Control was similar with glufosinate alone or all mixtures containing glufosinate in the Early Application Study, but glufosinate alone controlled less GR Palmer amaranth than glufosinate plus 2,4-D mixtures in the Late Application Study. 2,4-D alone at 2 pt/ac provided comparable control to all 2,4-D, glyphosate, and/or glufosinate mixtures 28 DAT in the Early Application Study.

Herbicide mixtures that contained glufosinate provided the greatest control of 6- to 8-inch GR Palmer amaranth; however, no mixtures provided 100% control. Optimal GR Palmer amaranth control with glyphosate plus 2,4-D is dependent upon application timing. Glufosinate and 2,4-D both provide options to be included in herbicide programs for GR Palmer amaranth control; however, 2,4-D added no benefit to any herbicide mixture except glyphosate.

WEED SCIENCE

POSTEMERGENCE CONTROL OF GLYPHOSATE-RESISTANT PALMER AMARANTH WITH CALLISTO-BASED HERBICIDE COMBINATIONS

Jason Bond, Paul Mangialardi, Ben Lawrence, Jimmy Peeples, and Matthew Edwards

ALTHOUGH THE TECHNOLOGY REQUIRES MORE IN-DEPTH STUDY, THE USE OF CALLISTO AND OTHER HPPD-INHIBITING HERBICIDES COULD ACT AS ANOTHER TOOL TO HELP MANAGE GLYPHOSATE-RESISTANT PALMER AMARANTH IN MISSISSIPPI SOYBEAN.

Continual use of herbicides with the same mode of action as the only means of weed control increases the probability of herbicide resistance. Multiple resistance, such as Palmer amaranth resistant to both glyphosate and acetolactate synthase (ALS) herbicides, is common. Populations of Palmer amaranth have evolved resistance to six different herbicide modes of action including glyphosate (Group 10), ALS inhibitors (Group 2), dinitroanilines (Group 3), triazines (Group 5), 4-hydroxyphenylpyruvate dioxygenase (HPPD; Group 27), and protoporphyrinogen oxidase inhibitors (Group 14). Herbicide resistance has allowed Palmer amaranth to become the most common and troublesome weed of soybean in Mississippi.

Mesotrione was developed by Syngenta for the control of broadleaf and grass weeds in corn and has been marketed as Callisto. It is also a component of herbicide premixes such as Halex GT and Lexar EZ. Mesotrione inhibits the HPPD enzyme, causing the bleaching symptoms characteristic of Group 27 herbicides. Originally developed for corn, mesotrione is now labeled in a variety of agricultural, fruit, and vegetable crops. Depending on the crop, it can be applied as a preemergence or postemergence treatment for control of annual broadleaf and grass weeds.

A new herbicide-resistant crop technology is being developed in soybean that confers resistance to mesotrione. The technology is being developed by Syngenta and is currently named MGI (Mesotrione, Glufosinate, and Isoxaflutole). Isoxaflutole is the active ingredient

Photo 1

Photo 2

in Balance Flexx, which is another HPPD herbicide labeled for corn. Glufosinate is the active ingredient in Liberty 280 and is used for non-selective weed control in LibertyLink crops. Research is needed to determine how to utilize mesotrione with current soybean herbicides. Research was conducted at the Mississippi State University Delta Research and Extension Center to evaluate glyphosate plus different rates of Callisto with and without Flexstar for control of glyphosate-resistant (GR) Palmer amaranth.

A study to evaluate mixtures of glyphosate, Callisto, and Flexstar was conducted once in 2013 and twice in 2014. Callisto at 0, 1.5, 3, and 4.5 oz/ac was applied with and without Flexstar at 16 oz/ac. Glyphosate (Roundup WeatherMax) at 22 oz/ac was included in all treatments. Treatments were applied with a tractor-mounted sprayer once GR Palmer amaranth plants uniformly averaged 2 to 4 inches in height. Visual estimates of Palmer amaranth control were recorded 7, 14, 21, and 28 days after treatment (DAT). Following the final visual evaluation, GR Palmer amaranth densities and aboveground dry weight was determined in each plot.

Glyphosate alone controlled GR Palmer amaranth 35% 28 DAT. Applications of glyphosate alone and in mixtures with Callisto at 1.5 oz/ac provided similar GR Palmer amaranth control 14, 21, and 28 DAT. Palmer amaranth control was greater when glyphosate was combined with Callisto at 3 and 4.5 oz/ac compared with glyphosate alone or in mixture with Callisto at 1.5 oz/ac 14, 21, and 28 DAT. Flexstar applied in mixtures with glyphosate or glyphosate plus all rates of Callisto controlled GR Palmer amaranth ≥ 93, 92, and 90% 14, 21, and 28 DAT. No differences in plant density or dry weight were observed in plots treated with Callisto at 0 and 1.5 oz/ac. However, plant densities and dry weight were lower in plots treated with Callisto at 3 and 4.5 oz/ac compared with plots receiving no Callisto.

No differences in control were observed when Callisto, Flexstar, and glyphosate were applied in mixtures compared with Flexstar alone. Although this data indicates control was optimized with glyphosate plus Flexstar, adding Callisto to postemergence applications of glyphosate plus Flexstar may provide increased residual control of GR Palmer amaranth and slow the spread of resistance by applying multiple herbicide modes of action. Therefore, the ability to use Callisto preemergence in soybean will likely aid in maintaining GR Palmer amaranth control following postemergence applications.

Herbicide combinations targeting glyphosate-resistant Palmer amaranth
Photo 1: *nontreated.*
Photo 2: *Glyphosate + Callisto at 3 oz/ac.*
Photo 3: *Glyphosate + Flexstar at 16 oz/ac.*
Photo 4: *Glyphosate + Flexstar at 16 oz/ac + Callisto at 3 oz/ac.*

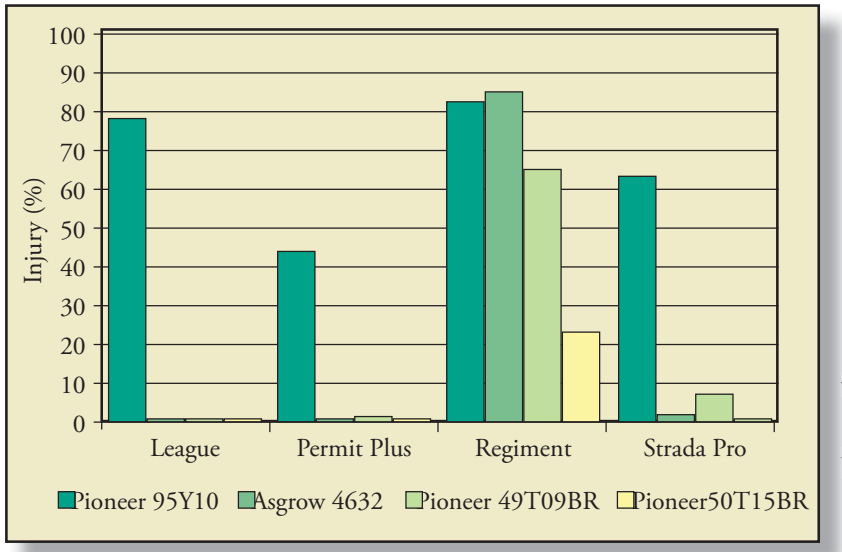
WEED SCIENCE

RESPONSE OF BOLT™ SOYBEAN CULTIVARS TO RICE HERBICIDES

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

WHILE TOOLS TO LESSEN THE NEGATIVE EFFECTS OF OFF-TARGET MOVEMENT SHOULD NOT BE USED AS AN EXCUSE TO APPLY HERBICIDES INCORRECTLY, THE BOLT™ TECHNOLOGY CAN OFFER A LEVEL OF REASSURANCE TO APPLICATORS MAKING HERBICIDE APPLICATIONS TO RICE.

Pesticide spray drift is physical movement of pesticide particles away from the target site to an unintended area. Acetolactate synthase (ALS)-inhibiting herbicides are utilized for control of annual and perennial broadleaf weeds and sedges in rice and soybean in Mississippi. Although ALS herbicide are commonly used in both soybean and rice, none of the ALS herbicides used in conventional rice are labeled for soybean. Soybean are susceptible to herbicide drift from rice because these crops are often grown in close proximity. Significant soybean yield loss due to drift can occur depending on the herbicide concentration and the soybean growth stage.

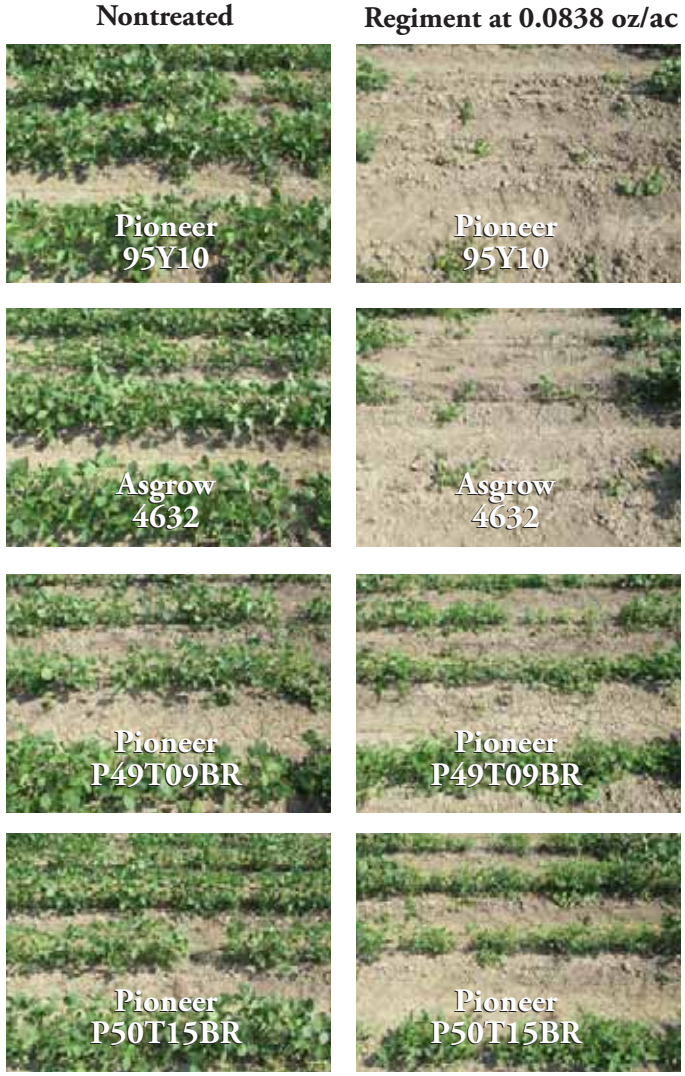


Sulfonylurea tolerant (STS) soybean, the first herbicide-resistant crop, were introduced in 1993 and were developed to tolerate higher rates of some sulfonylurea herbicides already in use in soybean. In 2015, DuPont Pioneer released a new soybean herbicide resistance trait that will be marketed as BOLT™. The BOLT™ technology enhances soybean tolerance to sulfonylurea herbicides and possibly other ALS herbicides. If injury to BOLT™ cultivars from ALS herbicides used in rice was less than that on soybean cultivars without the BOLT™ technology, the new cultivars could be utilized adjacent to rice fields to mitigate the effect of spray drift from rice herbicide applications. Research was conducted at the Mississippi State University Delta Research and Extension Center in Stoneville, MS, to compare the response of Roundup Ready, STS, and BOLT™ soybean cultivars to low rates of ALS herbicides common in southern U.S. rice production.

Four soybean cultivars were treated with low rates of common ALS rice herbicides when the majority of soybean plants in each plot had one to two fully

expanded trifoliate leaves. Soybean cultivars included 'Pioneer P49T09BR' and 'Pioneer P50T15BR' (BOLT™ cultivars), 'Asgrow AG4632' (STS cultivar) and 'Pioneer P95Y10' (Roundup Ready cultivar). Herbicide treatments were applied at 12.5% of the labeled rates of League (3.2 oz/ac), Permit Plus (0.75 oz/ac), Regiment (0.67 oz/ac), and Strada Pro (2.5 oz/ac). Soybean injury was visually estimated at 7, 14, and 28 days after treatment (DAT).

Pioneer 95Y10 was injured more than BOLT™ cultivars with each herbicide 7, 14, and 28 DAT. Although the magnitude was >40%, Permit Plus injured Pioneer 95Y10 less than other herbicides 14 and 28 DAT. Injury to Pioneer 95Y10 and Asgrow 4632 was similar with Regiment 7, 14, and 28 DAT, and the level of injury was greater than that exhibited by the BOLT™ cultivars. Regiment injured Asgrow 4632 and both BOLT™ cultivars more than other herbicides at all evaluations. Asgrow 4632 was injured more with Strada Pro 7 DAT than the BOLT™ cultivars; however, the response of Asgrow 4632 to League, Permit Plus, and Strada Pro was similar to Pioneer 50T15BR 14 and 28 DAT. Injury to Pioneer 49T09BR was greater than that for Asgrow 4632 and Pioneer 50T15BR with Strada Pro 14 DAT. Problematically, the response to some of the herbicides evaluated in the current research varied between the BOLT™ cultivars. Injury to Pioneer 49T09BR with Regiment was greater than that for Pioneer 50T15BR at all evaluations. The same trend was observed with Strada Pro 14 DAT.



Roundup Ready, STS, and BOLT™ soybean cultivars responded differently to ALS herbicides used in southern U.S. rice. The STS cultivar Asgrow 4632 was as tolerant as the BOLT™ cultivar Pioneer 50T15BR following applications League, Permit Plus, and Strada Pro applied at 12.5% of labeled rates. Among the four cultivars evaluated, response to Regiment was most variable with injury ranging from 23 to 85% 28 DAT. Although it was not completely tolerant to all herbicides evaluated, Pioneer 50T15BR could be planted adjacent to rice fields and lessen the potential negative effects from drift of ALS herbicides.

WEED SCIENCE

EFFECT OF SIMULATED HERBICIDE DRIFT ON RICE GROWTH AND YIELD

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

GLYPHOSATE-RESISTANT WEEDS, PRIMARILY GLYPHOSATE-RESISTANT PALMER AMARANTH, ARE THE PRINCIPAL WEED CONTROL ISSUE FACING GROWERS IN MISSISSIPPI. RICE IS NOT DIRECTLY AFFECTED BY GLYPHOSATE RESISTANCE, BUT IT IS IMPACTED INDIRECTLY THROUGH OFF-TARGET MOVEMENT OF HERBICIDES TARGETING GLYPHOSATE-RESISTANT WEEDS IN ADJACENT FIELDS.

Mississippi State University Extension Service recommendations are to apply the non-selective herbicide paraquat (Gramoxone SL, Parazone, Firestorm, etc.) mixed with a residual herbicide to control glyphosate-resistant weeds prior to planting corn, cotton, or soybean. Unfortunately, cases of paraquat drift to rice have increased in Mississippi in recent years, but little research has been conducted to evaluate the effect of paraquat on rice growth and yield. Previous research at the Mississippi State University Delta Research and Extension Center showed that rice yield was reduced with Reflex and metribuzin applied prior to flooding at 25% of the use rate. Gramoxone SL reduced rice yield when applied prior to flooding at 12.5 and 25% of the use rate.

A follow up study evaluated the effect on rice of low rates of Gramoxone SL and Reflex applied at different application timings. Simulated drift applications were made at 25% of the use rates of Gramoxone SL (3 pt/ac) and Reflex (1 pt/ac). These treatments were applied very early-postemergence (VEPOST) to rice in the one-leaf stage, early-postemergence (EPOST) to rice in the two- to three-leaf stage, mid-postemergence (MPOST) to rice in the three- to four-leaf stage, late-postemergence (LPOST) to rice in the four-leaf to one-tiller stage, or 21 days after flooding (21 d PTFLD).

At 14 DAT, rice injury with Gramoxone SL was greatest from EPOST applications and least from applications 21 d PTFLD. Rice injury following EPOST applications of Gramoxone SL was still 74% at 28 DAT. Gramoxone SL applications VEPOST, EPOST, MPOST, and LPOST delayed rice maturity 2 to 10 days. Rice treated with Gramoxone SL 21 d PTFLD never fully matured. All applications of Gramoxone SL reduced rice yield ≥13% with similar reductions following EPOST, MPOST, and LPOST applications. Gramoxone SL applications after flooding reduced rice yield 84%.

Rice injury 14 DAT with Reflex was <15% regardless of application timing. Reflex applications only influenced rice heading when applied 21 d PTFLD, and the delay following this application was only 1 day. Rice yield was not reduced following applications of Reflex VEPOST, EPOST, or MPOST; however, Reflex applied LPOST and 21 d PTFLD reduced rice yield 12 and 36%, respectively.

Based on visual estimates of rice injury 14 DAT and rice maturity, Gramoxone SL applications were more damaging to rice than Reflex. Effects on rice maturity and yield varied between the herbicides based on application timing. Rice recovered from

Rice response to sub-lethal rates of Gramoxone SL at different appliction timings

Nontreated

VEPOST

EPOST

MPOST

LPOST

14 d PTFLD

early-season injury following simulated drift of Reflex with no reductions in rice yield following applications VEPOST, EPOST, or MPOST. Although the magnitude varied, yield reductions were greatest with either herbicide following applications 21 d PTFLD. Yield reductions following 21 d PTFLD applications of Gramoxone SL and Reflex were 84 and 36%, respectively. Problematically, the greatest visual injury 14 DAT from these applications was 28% with Gramoxone SL. Therefore, the full extent of the consequences of drift of these herbicides occurring at midseason may not be apparent until harvest. Previous research has shown this to also be the case with drift of glyphosate and Liberty 280.

ECONOMIC IMPACT

ECONOMIC IMPACT OF THE DELTA RESEARCH AND EXTENSION CENTER

Larry Falconer

DREC GENERATED AN ESTIMATED $17.76 MILLION IN THIS FISCAL YEAR THROUGH EXPENDITURE OF APPROPRIATED FUNDS AND GRANT FUNDING FOR PAYROLL ALONG WITH EXPENDITURE OF GRANT FUNDS FOR RESEARCH ACTIVITIES. THE FACULTY AND STAFF AT DREC CARRYOUT WORK ON ECONOMICALLY IMPORTANT PROBLEMS FACING DELTA AGRICULTURE.

Delta Research and Extension Center currently employs 123 personnel, with approximately 40 additional intermittent employees engaged during the growing season. DREC's payroll for 2015/2016 was $5.53 million, comprised of $2.56 million dollars in appropriated funds and $2.97 million in grant funding, resulting in a statewide economic impact of $8.68 million. An additional $5.25 million of grant funds procured by faculty at DREC generated an estimated statewide economic impact output of $9.08 million for the year. In addition, the following selected research and extension programs are examples of the many programs at DREC that made significant positive contributions to the Mississippi economy.

Weed control research in soybean production is conducted annually at DREC in Stoneville to ensure that Mississippi growers have access to the most current weed management information. The average annual estimate of potential loss due to weed infestation in soybeans over the past 5 years is $1.09 billion. Mississippi State University Extension Service recommended weed control programs are estimated to cost producers $108 million per year, resulting in a 10 to 1 benefit to cost ratio. This translates into an annual increase in direct revenue to Mississippi producers of $985 million per year, with a statewide economic impact of $1.68 billion annually.

The Mississippi Alluvial aquifer is being mined and pumping problems are projected in the next ten years in a growing area of the Delta. Developing irrigation scheduling methods that maximize yield economically with the least amount of water will conserve water resources and reduce fuel consumption. The RISER program, a combination of MSU-ES recommendations for the use of computerized hole selection, surge irrigation and soil moisture sensors has the potential to save more than 430,000 acre-feet of water per year in soybean, corn and rice production. For every dollar invested in the RISER program, it is estimated that there will be a $2.10 return, with an economic impact of $25.4 million per year in the state of Mississippi.

Mississippi State University Research and Extension entomologists located at DREC initiated research to evaluate multiple cultural practices to improve integrated pest management plans for tarnished plant bug. The research investigated normal agronomic practices such as planting date and variety selection, and their impact on tarnished plant bug infestations and damage in cotton. Research indicated that early planting dates required 3 fewer insecticide applications compared to later planting dates, increasing producers' net returns by $40.02 per acre. Based on the average 2011-2013 treated acreage of 328,000 acres this would be an average annual increase in net returns of $13.12 million for Delta cotton producers.

The U.S. catfish industry is threatened by increasing disease losses which is considered the largest impediment to increasing production efficiencies. The most prevalent disease affecting catfish is enteric septicemia of catfish (ESC) caused by a gram negative bacterium. This disease is estimated to reduce production by 25-30% at of cost of $30-40 million annually. In efforts to develop more effective management strategies for controlling ESC, scientists at DREC developed and tested live attenuated vaccine and a mechanism for oral delivery. This oral vaccination platform will virtually eliminate ESC related losses in the catfish industry and dramatically reduce the use of medicated feeds in catfish culture.

MSU plant breeders at DREC developed the pureline rice variety 'Rex', which became available in 2013 on a wide-scale basis. Rex became Mississippi's most widely planted conventional pureline variety covering 15% of the state's total rice area. Rex supplanted Cocodrie, a Louisiana-bred pure line, which had been the most popular among Mississippi producers since 2001. On average, Rex has yielded seven bushels per acre higher than Cocodrie. Based on 2013 market share and current planted acreage of rice in Mississippi this results in annual increase of $1.26 million in cash receipts with an estimated annual statewide economic impact of $2.15 million.

Research work has shown the importance of MSU-ES soil fertility recommendations. Industry estimates indicate that 75% of the crop acres tested in Mississippi fall in the medium to very low category for levels of phosphorus and potassium. MSU-ES soil fertility research results showed that potential monetary loss due to phosphorus deficiency in corn is estimated to be $92 per acre, $67 per acre for rice and $75 per acre for soybean production. Potential monetary loss due to potassium deficiency for corn is estimated at $157 per acre, $57 per acre for rice and $70 per acre for soybeans. Based on 2015 planted acreage and plant nutrient prices, potential monetary loss due to phosphorus deficiency in the Mississippi is estimated that $120.3 million with potential monetary loss due to potassium deficiency of $129.0 annually. Estimated phosphorus costs to address medium levels of phosphorus fertility are estimated at $40.5 million, resulting in a potential net benefit of $79.8 million. Estimated potassium costs to address medium levels of potassium fertility are estimated at $41.7 million, resulting in a potential net benefit of $87.3 million.

In summary, DREC generated an estimated $17.76 million in this fiscal year through expenditure of appropriated funds and grant funding for payroll along with expenditure of grant funds for research activities. As evidenced by the selected programs listed, the faculty and staff at DREC carry out work on economically important problems facing Delta agriculture.

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