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Summaries of Arkansas Cotton Research 2016

Fred Bourland

University of Arkansas, Fayetteville

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Bourland, F. (2017). Summaries of Arkansas Cotton Research 2016. *Arkansas Agricultural Experiment Station Research Series*. Retrieved from <https://scholarworks.uark.edu/aaesser/10>

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Summaries of Arkansas Cotton Research 2016



Cotton in cereal rye cover crop

Summaries of Arkansas Cotton Research 2016

Bourland

AAES



Edited by Fred Bourland



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Layout and editing by Christina Jamieson
Technical editing and cover design by Gail Halleck

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ISSN: 1941-1618 CODEN:AKAMA6

**Summaries of
Arkansas Cotton
Research 2016**

Fred Bourland, Editor

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Cotton Incorporated and the Arkansas State Support Committee

The *Summaries of Arkansas Cotton Research 2016* was published with funds supplied by the Arkansas State Support Committee through Cotton Incorporated.

Cotton Incorporated's mission is to increase the demand for cotton and improve the profitability of cotton production through promotion and research. The Arkansas State Support Committee is comprised of the Arkansas directors and alternates of the Cotton Board and the Cotton Incorporated Board, and others whom they invite, including representatives of certified producer organizations in Arkansas. Advisors to the committee include staff members of the University of Arkansas System Division of Agriculture, the Cotton Board, and Cotton Incorporated. Seven and one-half percent of the grower contributions to the Cotton Incorporated budget are allocated to the State Support Committees of cotton-producing states. The sum allocated to Arkansas is proportional to the states' contribution to the total U.S. production and value of cotton fiber over the past five years.

The Cotton Research and Promotion Act is a federal marketing law. The Cotton Board, based in Memphis, Tenn., administers the act, and contracts implementation of the program with Cotton Incorporated, a private company with its world headquarters in Cary, N.C. Cotton Incorporated also maintains offices in New York City, Mexico City, Osaka, Hong Kong, and Shanghai. Both the Cotton Board and Cotton Incorporated are not-for-profit companies with elected boards. Cotton Incorporated's board is comprised of cotton growers, while that of the Cotton Board is comprised of both cotton importers and growers. The budgets of both organizations are reviewed annually by the U.S. Secretary of Agriculture.

Cotton production research in Arkansas is supported in part by Cotton Incorporated directly from its national research budget and also by funding from the Arkansas State Support Committee from its formula funds (Table 1). Several of the projects described in this series of research publications, including publication costs, are supported wholly or partly by these means.

**Table 1. Arkansas Cotton State Support Committee
Cotton Incorporated Funding 2016.**

		2015	2016
New Funds		\$218,000	\$207,000
Previous Undesignated		\$91,012	\$99,402
Total		\$309,012	\$306,402
Researcher	Short Title	2015	2016
Oosterhuis	Cotton Research In Progress	\$5,000	\$5,000
Bourland	Breeding	\$26,000	\$26,000
Oosterhuis	Improving Cotton Fertility	\$9,800	\$9,800
Norsworthy	Cover Crops	\$32,782	\$32,782
Reba	Increasing yield through irrigation management	\$13,620	\$13,620
Robertson	Verification 2015	\$50,000	\$50,000
Lorenz	Alternative Thrips Control	\$32,000	\$21,724
Roberston	Potash	\$11,500	\$11,000
Robertson	Soil health - no till	\$0	\$12,074
Barber	New Herbicide Tech	\$0	\$25,000
Robertson	Soil health - no till	\$0	\$13,000
Robertson	Enhanced communication	\$0	\$12,000
Reba	Tillage impacts on water quality of irrigation runoff	\$0	\$6,000
Lorenz, Bourland, Robertson	OVT Thrips tolerance	\$0	\$5,000
Robertson	Leaf K and foliar disease field survey	\$0	\$2,000
Barber, Robertson	New varieties over top Liberty Applications	\$0	\$4,000
Henry	Irrigation	\$31,500	\$0
Burgos	Palmer amaranth Herbicide Resistance	\$13,500	\$0
Uncommitted		\$83,310	\$57,402
Total		\$225,702	\$249,000

Acknowledgments

The organizing committee would like to express appreciation to Christina Jamieson for help in typing this special report and formatting it for publication.

**Summaries of
Arkansas Cotton Research
— 2016 —**

OVERVIEW AND VERIFICATION

Review of the 2016 Arkansas Cotton Crop

The 2016 cotton planting season began with a limited amount of cotton planted in March. Percentage of cotton planted prior to the first half of April was close to the five-year average (8%). Favorable conditions through the end of April resulted in 36% of our acres being planted compared to our five-year average of 19%. Plantings during the month of May were generally a week ahead of the five-year average as published by the United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS; available at: https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Progress_&_Condition/index.php). Cotton planting intentions were estimated to be 380,000 acres by the USDA-Farm Service Agency (available at: https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Prospective_Plantings/2016/arplant16.pdf).

The month of May presented challenges for our crop especially north of Interstate 40. Wet and cool conditions resulted in significant levels of black root rot (*Thielaviopsis basicola*). Above-ground plant growth was slowed as the plants recovered. Very favorable conditions in June helped cotton statewide to recover. It was not unusual for fields to have a new node developing every 2.5 days for much of the month. Vegetative and reproductive development of the plant was rapid. Consequently, optimum timing of applications of plant growth regulator to manage the balance between vegetative and reproductive growth was often hindered. Plant heights became excessive for some and led to problems that occurred later in the season. Flowering rates of fields statewide were roughly one week ahead of the five-year average through the flowering period.

Plant bugs and palmer pigweed continue to be key pests. Plant bug numbers in Cotton Research Verification Sustainability Program (CRVSP) fields decreased this year compared to 2015; fields in the CRVSP were treated an average of 2.3 times for plant bugs in 2016. A slightly higher plant bug pressure was seen in St. Francis County in 2016 compared to other fields in this study. Each field had an average of 1.3 burndowns and 1.9 herbicide applications for the 2016 season. All fields with the exception of the Manila location had an average of 1.7 treatments for moths/worms. Average costs for herbicides and insecticides (excluding technology fees) were \$82.56 and \$38.60, respectively. Pest control represents a significant expense and can impact yield greatly.

Positive visual impressions of a crop sometimes do not translate into realized harvest. This was particularly true after nine days of significantly cloudy weather and wet conditions beginning 13 August and ending on 23 August 2016. At the start of this period, plants had a very heavy boll load and were maturing normally. Target

leaf spot after the nine days of wet and cloudy weather resulted in some fields in northeast Arkansas exhibiting 60% to 70% of the leaves defoliated, when a week earlier these same fields were at 350 heat units (HU) beyond cutout and had less than 10% defoliation. Almost full-sized bolls were also shedding from plants. Research conducted by Derrick Oosterhuis and his students have indicated that four consecutive days of cloudy weather has the potential to affect lint yield during late boll fill. Significant carbon stress from the cloudy weather was thought to be the primary driver for this event and was enhanced by the occurrence of target leaf spot. Some speculated that as much as 500 lb lint/acre were lost as a result of target leaf spot. However, at harvest the anticipated loss of yield compared to areas of fields treated with fungicides for target leaf spot was not observed. Thus, the yield loss was likely more associated with cloudy conditions than to target spot.

The National Agricultural Statistics Service September Crop Production report projected that Arkansas producers would harvest 1088 lbs lint/acre, up 36 lbs from the August report but down 4 lbs from 2015 (available at: https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Crop_Production_Monthly/2016/arcropseptember16.pdf). The majority of people acquainted with Arkansas cotton felt that the status of the 2016 crop at that time was the same or slightly better than the 2015 crop. The year ended at 1075 lbs lint/acre. This exceeded the five-year average of 1073 lbs lint/acre by only 2 pounds, but less than the 2015 average of 1092 lbs lint/acre.

Fiber quality was a mixed bag. Little rainfall was received during harvest for the second consecutive year. As a result, our color grades were good with almost 67% of Arkansas cotton classed at Dumas having a color grade of 31 or better. Micronaire averaged 4.67, with over 76% of Arkansas cotton classed at Dumas having micronaire in our target value range of 3.5 to 4.9. In 2015, greater than 60% was in the discount range with a value of 5.0 or greater and was discounted. Staple was slightly less in 2016 compared to 2015, 36.46 and 36.72 (1/32 of an inch), respectively. Leaf trash values greater than 4 were received on almost 18% of bales classed at Dumas in 2016. Discounts related to high micronaire and leaf values greatly decreased the value of the lint even though other fiber quality parameters were good.

Arkansas ended the 2016 season ranked nationally at 4th in harvested acres, 6th in lint yield/acre, and 4th in total production. Estimates by USDA-NASS in April of 2017 indicated Arkansas would experience a 32% increase in cotton acres for the 2017 season projecting planted acres to increase from 380,000 to 500,000 acres (available at: https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Prospective_Plantings/2017/arplant17.pdf). This projection will push our picker capacity to the limit as optimism for cotton is greater than for most other commodities, but may not be great enough to invest in more pickers.

Bill Robertson
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OVERVIEW AND VERIFICATION

2016 Judd Hill Cooperative Research Station: Overview of Cotton Research

W. Barnett¹ and A. Rouse¹

Background

The University of Arkansas System Division of Agriculture and Arkansas State University initiated a cooperative research agreement with the Judd Hill Foundation in 2005 to conduct small-plot cotton research on a 35-acre block of land on the Judd Hill Plantation. In addition, the Judd Hill Foundation generously permits scientists from Arkansas State University and the the Division of Agriculture to conduct research on other property belonging to the Foundation (Table 1). Research at the Judd Hill site has been conducted annually since 2005. The primary soil type at the Judd Hill station is a Dundee silt loam (fine-silty, mixed, active, thermic Typic Endoaqualfs). Furrow irrigation is available for all plots.

Table 1. List of 2016 cotton research at Judd Hill Cooperative Research Station.

Project leader(s)	Discipline	Title
Michele Reba and Tina Gray Teague	Multi-disciplinary	Impacts and benefits of polyacrylamide (PAM) on irrigation efficiency, soil conservation, and water quality in mid-South cotton production
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Test: transgenic test with 35 entries and conventional test with 10 entries
Fred Bourland	Cotton Breeding	Cotton Strains Test, 9 tests evaluating a total of 228 entries
Tina Gray Teague	Multi-disciplinary	On-farm water, soil, and plant monitoring—irrigation, nitrogen fertilizer, and cultivar effects in no-till, cover crop, and conventional tillage systems
Morteza Mozaffari	Soil Fertility	Cotton fertility studies
Craig Rothrock	Plant Pathology	National Cottonseed Treatment Test and cotton disease related industry trials

2016 Conditions and Observations

Favorable weather conditions during planting led to all plots being planted in a timely manner between 28 April and 9 May (Fig. 1 and Table 2). Adequate

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moisture and good soil temperatures resulted in good stands in most plots. The first application of mepiquat chloride was delayed due to equipment issues and led to a longer internode length than is normally desired on most plots. All plots were irrigated 6-7 times during the growing season using polytube pipe.

Insect pressure was light except for a period in mid-August when bollworms and tarnished plant bugs were at threshold levels in some plots, but persistent rainfall prevented timely treatment. Cooler-than-average temperatures accompanied the weeklong rainy period and contributed to an outbreak of Verticillium wilt in many plots—resulting in noticeable yield loss. This disease is naturally occurring in the soil at the Judd Hill Station. September and October brought dry conditions and warm temperatures that allowed for timely, effective defoliation and the harvesting of all plots between 29 September and 12 October.

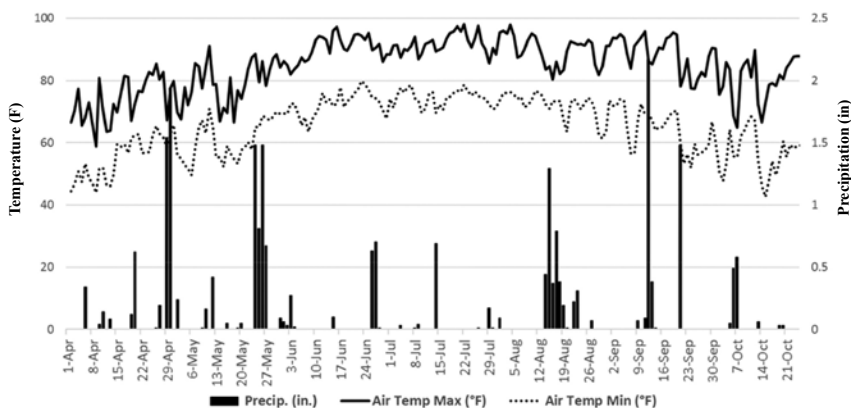


Fig. 1. 2016 Judd Hill temperature and precipitation.

Table 2. Weather conditions at Judd Hill Cooperative Research Station.

Weather factor ^a	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2016	309	642	716	649	496	281	3093
Historical avg. DD60s	354	551	661	618	415	167	2766
Rainfall (in.) 2016	5.5	1.8	0.9	4.2	4.2	1.3	17.9
Hist. avg. rainfall (in.)	4.9	3.6	3.7	2.6	3.0	3.4	21.3

^a DD60 (growing degree days based on 60 °F) and rainfall from 2016 and historical (1960-2007) data. Historical data are from Keiser, approximately 35 miles east of Judd Hill.

Acknowledgments

We are indebted to Mike Gibson and the Judd Hill Foundation for their generous support and assistance. Cooperation of Marty White, Jessie Flye, Billy Baker, and Jim Baker on many of these research projects is greatly appreciated. Additionally, we would like to thank Mike Duren, Resident Director and Charles Wilson, Center Director of the Northeast Research and Extension Center. Support also provided by the University of Arkansas System Division of Agriculture.

OVERVIEW AND VERIFICATION

2016 Northeast Research and Extension Center: Overview of Cotton Research

A. Rouse¹ and W. Barnett¹

Background

The University of Arkansas System Division of Agriculture initiated cotton research at Keiser in 1957. The University of Arkansas System Division of Agriculture's Keiser station includes 750 acres (about 650 in research plots) and is located between the city of Keiser and Interstate 55. Through the years, cotton research has spanned all disciplines with particular focus on breeding; variety testing; control of insects; diseases, and weeds; soil fertility; irrigation, and agricultural engineering (Table 1). Innovative practices evaluated at Keiser have included narrow row culture, mechanical harvest (pickers, strippers and the cotton combine), and the cotton caddy (forerunner to cotton module system). The Sharkey clay soil at Keiser is not a dominant cotton soil type in Arkansas, but it provides an environment with a soil type that contrasts our other cotton stations, and one that has very low incidence of Verticillium wilt. Since cotton normally does not require application of mepiquat chloride on this soil type, plants develop unaltered heights at this station.

Table 1. List of 2016 cotton research at Northeast Research and Extension Center, Keiser.

Project leader(s)	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Test (transgenic test, 35 entries and conventional test, 10 entries) and the National Cotton Variety Test (10 entries)
Fred Bourland	Cotton Breeding	Cotton Strains Test, 9 tests evaluating a total of 200 entries
Fred Bourland	Cotton Breeding	Cotton breeding trials including crosses, F ₂ , F ₃ , F ₄ populations, F ₅ and F ₆ progenies, and seed increases, plus greenhouse and laboratory tests
Morteza Mozaffari	Soil Fertility	Evaluation of magnesium and nitrogen fertilizer source, rate, and timing on seedcotton yields
Jason Norsworthy	Weed Science	Evaluation of Long-term Programs for Sustaining the Use of HPPD Herbicides in Agronomic Crops
Craig Rothrock	Plant Pathology	National cottonseed treatment test
Glenn Studebaker	Entomology	TPB in Cotton: Resistance, Insecticide Termination, Experimental Insecticides, Rate Efficacy, and Tank Mix Evaluation (5 tests)
Glenn Studebaker	Entomology	Bollworm in Cotton: Evaluation of Damage Threshold
Glenn Studebaker Gus Lorenz	Entomology	Thrips in Cotton: Neonicotinoid Alternatives, Seed Treatment Combinations, and Experimental Seed Treatments (3 tests)

¹Program Technicians, University of Arkansas System Division of Agriculture, Northeast Research and Extension Center, Keiser.

2016 Conditions and Observations

Rainfall in April delayed land preparation, but plots at Keiser were planted on timely basis (5-11 May). Adequate moisture and good soil temperatures resulted in good stands in most plots. Temperatures in May were near normal, but Degree-Day 60 accumulations from June through October were 19% higher than the historical average. Rainfall in July and October was much lower than normal, while April and August rainfall was much higher than normal. Most of the August rainfall occurred in the third week of August, and was accompanied by relatively low temperatures. Monthly rainfall for September was high, but most was associated with one rain event. Both insect and disease incidences were low at Keiser in 2016. As harvest time approached, the weather was very dry and mild. Defoliantes were applied on time using ground application. The harvest of the Keiser plots began on 27 September and were completed on 13 October, which is likely the earliest that cotton harvest has been completed at Keiser.

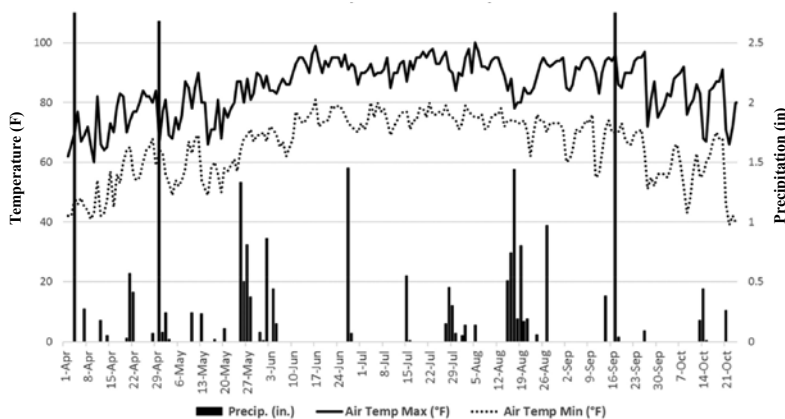


Fig. 1. 2016 Northeast Research and Extension Center, Keiser temperature and precipitation.

Table 2. Weather conditions at Northeast Research and Extension Center, Keiser.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2016	149	299	653	735	680	536	286	3338
Historical avg. DD60s ^a	49	293	522	634	552	348	57	2455
Rainfall (in.) 2016	8.3	4.0	3.0	1.5	5.4	3.8	1.0	27.0
Hist. avg. rainfall (in.) ^b	4.8	5.4	4.0	4.0	2.4	3.2	4.0	27.8

^a 30-year average of data collected in Mississippi County 1986-2015; dd60.uaex.edu

^b 30-year average of data collected at the Northeast Research and Extension Center, Keiser 1981-2010; www.ncdc.noaa.gov/cdo-web/datatools/normals

Acknowledgments

The authors would to thank Mike Duren, Resident Director and Charles Wilson, Center Director of the Northeast Research and Extension Center, Keiser. Support also provided by the University of Arkansas System Division of Agriculture.

OVERVIEW AND VERIFICATION

2016 Manila Airport Station: Overview of Cotton Research

F. Bourland¹ and R. Benson²

Background

A Memorandum of Agreement (MOA) was initiated in 2014 between the City of Manila, Costner and Sons Farm, and the University of Arkansas System Division of Agriculture to conduct cotton research on a 30-acre block of land at the Manila Airport. This research was initiated in response to local demand for cotton research on a dominant cotton soil (Routon-Dundee-Crevasse complex) in northeast Arkansas. The MOA was amended in 2016 by substituting Wildy Farms for Costner and Sons Farm. Fields in this area of the state often exhibit soil texture variations ranging from coarse sand to areas of silt loam and clay. Soil textural variations within individual fields confound management decisions, especially with regard to irrigation and fertility. Infiltration of irrigation water to the rooting zone is a major concern in the area, and varies across the different soil textures. Consequently, timing the frequency of irrigation events is challenging, and warrants dedicated research activities. One long-term research objective at this location is to determine ways to improve irrigation water use (Table 1).

Table 1. List of 2016 cotton research at Manila Airport.

Project Leader	Discipline	Title
Tina Gray Teague	Multi-disciplinary	Seeding rate, cultivar selection and irrigation timing effects on maturity and yield of mid-South cotton
Fred Bourland	Cotton Breeding	Arkansas Transgenic Cotton Variety Test (35 entries)
Morteza Mozaffari	Soil Fertility	Cotton response to nitrogen source, rate and timing
Bill Robertson	Agronomy	Evaluation of tillage and cover crops in cotton

2016 Conditions and Observations

Plots at Manila were planted around 9 May. Adequate moisture and good soil temperatures resulted in good stands in most plots. Weather in the area during the summer and fall was warmer and drier than normal. Evapotranspiration (ET)

¹ Professor, University of Arkansas System Division of Agriculture, Northeast Research and Extension Center, Keiser.

² County Cooperative Extension Agent, University of Arkansas System Division of Agriculture, Cooperative Extension Service, Blytheville.

gauge readings were collected weekly, and used to initiate irrigation events once a soil moisture deficit of 1.5 inches had been reached. As a result of evapotranspiration measurements, seven furrow irrigations were triggered during the production season. Insect pressure was generally light in 2016. Incidence of bacterial blight was much less than in 2015. Target spot was present, but occurred too late in the season to result in yield loss. The relatively dry conditions restricted vegetative growth. Harvest was completed by mid-October. Lint yields at Manila Airport in 2016 were lower than in 2015, but higher than on most other Arkansas cotton stations.

Weather Data

Weather at Manila Airport would be similar to the weather reported for the Northeast Research and Extension Center, Keiser and Judd Hill Cooperative Research Station. Manila Airport is located about 15 miles northwest of Keiser and about 28 miles northeast of Judd Hill.

Acknowledgments

We wish to thank the City of Manila, Mayor Wayne Wagner, Wildy Farms (David Wildy and professional staff), and Mississippi County Cooperative Extension Service (Ray Benson) for their support of this work. Additionally, we would like to thank Mike Duren, Resident Director and Charles Wilson, Center Director of the Northeast Research and Extension Center. Support was also provided by the University of Arkansas System Division of Agriculture.

OVERVIEW AND VERIFICATION

2016 Lon Mann Cotton Research Station: Overview of Cotton Research

*C. Kennedy*¹

Background

The Lon Mann Cotton Research Station (LMCRS) had its beginning in 1927 as one of the first three off-campus research stations established by the University of Arkansas System Division of Agriculture, and was known as the Cotton Branch Experiment Station until 2005. Cotton research has always been a primary focus of the station (Table 1). The station includes 655 acres (about 640 in research) and is located in Lee County on Arkansas Highway 1 just south of Marianna with its eastern edge bordering Crowley's Ridge and the Mississippi River. The primary soil types at LMCRS are Loring silty loam (fine-silty, mixed, thermic Typic Fragiudalfs) and Calloway silt loam (fine-silty, mixed, thermic Glossaquic Fragiudalfs). The silt loam soils at Marianna have long been associated with cotton production in eastern Arkansas. Cotton research at the station has included work on breeding, variety testing, pest control (insects, diseases, and weeds), soil fertility, plant physiology, and irrigation.

Table 1. List of 2016 cotton research at Lon Mann Cotton Research Station.

Project leader	Discipline	Title
Tom Barber	Weed Science	Effect of 5 Group 4 auxin herbicide families on Xtend and Enlist cotton
Tom Barber	Weed Science	Evaluation of Engenia programs in XtendFlex cotton
Tom Barber	Weed Science	XtendFlex and Enlist cotton tolerance to high rates and multiple applications of Liberty herbicide
Tom Barber	Weed Science	Determining optimum preemerge programs and application sequence of Engenia herbicide without tankmix options in Cotton
Tom Barber	Weed Science	Evaluation of new pre-mix dicamba formulations in cotton
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (transgenic test, 35 entries and conventional test, 10 entries)
Fred Bourland	Cotton Breeding	Cotton strain tests, 9 tests evaluating a total of 214 entries
Fred Bourland	Cotton Breeding	Cotton breeding trials including F ₅ and F ₆ progenies.
Leo Espinoza	Soils	Varietal response to potassium rates under sub-optimal soil potassium levels
Gus Lorenz	Entomology	Thrips efficacy trials (10 trials, 80 total treatments)
Gus Lorenz	Entomology	Thrips variety trials (3 trials; Bt, 36 Entries; conventional, 20 entries; regional study 7 entries)
Gus Lorenz	Entomology	Plant bug efficacy trials (7 trials, 65 treatments)
Morteza Mozaffari	Soil Fertility/Soil Testing	Cotton response to source, timing, and rate of nitrogen fertilization.
Jason Norsworthy	Weed Science	Evaluation of Brake FX formulation in cotton
Jason Norsworthy	Weed Science	Evaluation of weed control programs in Enlist cotton
Jason Norsworthy	Weed Science	Comparison of weed control programs in cereal rye and winter wheat versus no cover crop

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2016 Conditions and Observations

Frequent rains in April and early May delayed some pre-plant and planting operations, but most cotton plots on the LMCRS were planted on a timely basis during the first half of May. Adequate moisture, good soil temperatures and low degree of soil crusting resulted in good stands in most plots. In some fields (including the variety test), cereal rye was used as a cover crop. Cotton planted into cereal rye seemed to better tolerate dry conditions due to conserving of moisture in rye straw cover. Weather conditions were generally good throughout the season (Fig. 1 and Table 2), but heat units (Degree-Day 60) in June through October were 19% higher than normal (2789 vs. 2336). Rainfall during the same period was 22% lower than normal (13.5 in. vs. 17.3 in.) with the largest deviation occurring in October. The relatively dry October facilitated good harvest. Plots were furrow-irrigated as needed. Mepiquat chloride (Pix) to control internode elongation and plant height was required at higher rates than usual. Insect pressure was relatively light with the primary insect pest being plant bugs. Harvest was completed in October, which permitted fall land preparation.

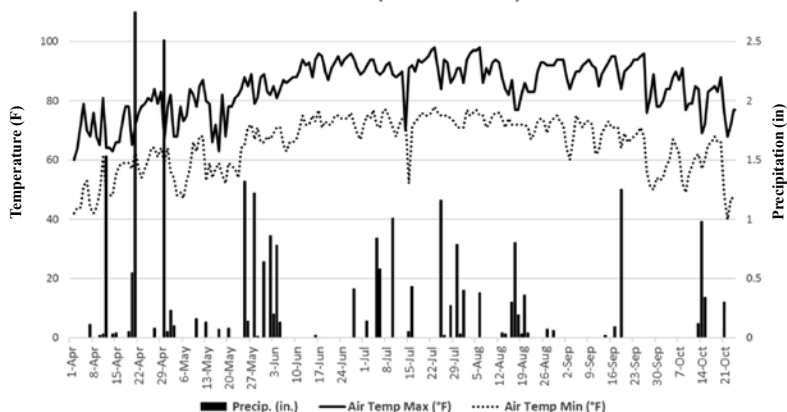


Fig. 1. 2016 Marianna temperature and precipitation.

Table 2. Weather conditions at Marianna.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2016	131	293	616	680	645	548	301	3214
Historical avg. DD60s ^a	87	339	548	650	594	398	98	2714
Rainfall (in.) 2016	8.6	4.2	2.4	5.3	2.7	1.4	1.7	26.3
Hist. avg. rainfall (in.) ^b	5.0	5.1	3.9	3.8	2.6	2.5	4.1	27.0

^a 30-year average of data collected in Lee County 1986-2015; dd60.uaex.edu

^b 30-year average of data collected at the Lon Mann Cotton Research Station 1981-2010; www.ncdc.noaa.gov/cdo-web/datatools/normal

Acknowledgments

The author would to thank Mike Duren, Resident Director and Charles Wilson, Center Director of the Northeast Research and Extension Center, Keiser. Support also provided by the University of Arkansas System Division of Agriculture.

OVERVIEW AND VERIFICATION

2016 Rohwer Research Station: Overview of Cotton Research

*L. Martin*¹

Background

Cotton research has always been a primary focus at the Rohwer Research Station that began operations in 1958. The station includes 826 acres (about 630 in research plots) and is located on Arkansas Highway 1 in Desha County, 15 miles northeast of McGehee. Soil types at the Rohwer Research Station include Perry clay (very-fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts), Desha silty clay (very-fine, smectitic, thermic Vertic Hapludolls), and Hebert silt loam (fine-silty, mixed, active, thermic Aeric Epiaqualfs) with cotton grown primarily on the latter. Cotton research at the station has primarily focused on breeding, variety testing, pest control (insects, diseases, and weeds), soil fertility, plant physiology, and irrigation (Table 1).

Table 1. List of 2016 cotton research at Rohwer Research Station.

Project Leader	Discipline	Title
Tom Barber	Weed Science	Dicamba Tests, 3 trials totaling 41 treatments
Tom Barber	Weed Science	Liberty Tests, 3 trials totaling 45 treatments
Tom Barber	Weed Science	Brake and Enlist Tests, 3 trials total
Tom Barber	Weed Science	Engenia and Xtend Tests, 2 trials total
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (transgenic test, 35 entries and conventional test, 10 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests, 6 tests evaluating a total of 120 entries
Fred Bourland	Cotton Breeding	Cotton breeding trials of F ₆ progenies
Terry Kirkpatrick	Plant Pathology	Cotton Seed Treatment Seedling Disease Test, 1 trial
Nick Seiter	Entomology	Thrips Tests, 4 trials
Nick Seiter	Entomology	Plant Bug, Foliar BT, Neonic and Seed Treatment Tests, 3 total trials

2016 Conditions and Observations

Research trials at Rohwer were planted during the first week of May. Adequate moisture and good soil temperatures resulted in good stands in most trials. Seedling diseases were minor and seed treatments for early-season insect pests were

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effective for pest control. Weed control programs for most trials were adequate at controlling early season grasses and broadleaf species. Post emerge applications were effective at controlling both grass and broadleaf species other than palmer amaranth. Hand weeding was needed to control palmer amaranth in most trials. Four irrigations were required to maintain adequate moisture (2-inch allowable deficient) for the crop with the last irrigation around first of August. Insect pests were low and threshold levels for cotton pests (plant bugs and worms) reached marginal levels only once for plant bugs during the season. Termination timings for plant bugs, worms, and irrigation were mid-August. Significant rainfall occurred in August that persisted 21 days which resulted in 14 days of measurable rainfall for a total of 7.99 inches. This caused significant boll rots and boll shed that reduced lint yield and quality. Harvest was dry and proceeded on time.

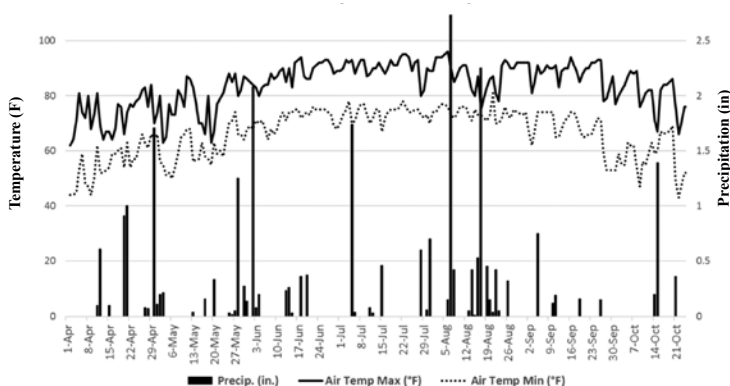


Fig. 1. 2016 Rohwer temperature and precipitation.

Table 2. Weather conditions at Rohwer.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2016	156	297	594	685	652	546	287	3217
Historical avg. DD60s ^a	100	329	537	647	589	399	123	2724
Rainfall (in.) 2016	4.6	3.3	3.6	3.7	8.0	1.4	2.0	26.6
Hist. avg. rainfall (in.) ^b	4.8	5.1	3.8	3.7	2.5	2.6	4.2	26.7

^a 30-year average of data collected in Desha County 1986-2015; dd60.uaex.edu

^b 30-year average of data collected at the Rohwer Station 1981-2010; www.ncdc.noaa.gov/cdo-web/datatools/normals

Acknowledgments

The author would to thank Larry Earnest, Director and Kelly Bryant, Center Director of the Southeast Research and Extension Center. Support also provided by the University of Arkansas System Division of Agriculture.

OVERVIEW AND VERIFICATION

Cotton Research Verification Sustainability Program: 2016 Economic Report

A. Free¹, B. Robertson¹, and A. Flanders²

Research Problem

The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability Program (CRVSP) works with producers to produce cotton more efficiently with the objective of improving profitability. A continuing increase in the cost of production, and decreasing cotton prices have resulted in a decrease in cotton acres over the last 10 years. For cotton to continue being a viable commodity, profitability must be improved.

Background Information

The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980. This is an interdisciplinary effort in which recommended best management practices and production technologies are applied in a timely manner to a specific farm field. Since the inception of the CRVP in 1980, there have been 283 irrigated fields entered into the program. The success of the cotton program spawned verification programs in rice, soybean, wheat, and corn in Arkansas and in other mid-South states. In 2014, the CRVP became known as the CRVSP. The CRVSP expands beyond that of the traditional verification program by measuring the producers' environmental footprint for each field and evaluating the connection between profitability and sustainability.

Research Description

The 2016 CRVSP was composed of 14 fields at three locations, with 8 fields being in Desha County, 2 fields in Mississippi County, and 4 fields in St. Francis County. Each field was entered into the Field to Market Fieldprint Calculator. Two fields entered a second year of research regarding farmer standard tillage with stale seedbed compared to that of a modified no-till with cover production system.

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² Associate Professor, University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser.

Increasing both efficiency and profitability will continue to be a major part of the program in 2017.

The CRVSP has worked along with the University of Arkansas System Division of Agriculture's Discovery Farms Program in Southeast Arkansas on 6 of the 14 fields in the program. Discovery Farms' main focus is to monitor edge-of-field water quality. Fields are watered in two sets. The split-field arrangement provides the opportunity to compare two production strategies. The farmer standard tillage and cover crop usage was compared to a no-till system with a cereal rye cover crop. The fields at the Mississippi and St. Francis County locations did not have the opportunity to be watered in two sets. In fall 2015, all no-till with cover fields had Elbon cereal rye broadcasted, with a targeted seeding rate of 56 lb/acre. The remaining two fields had no established cover crops in 2016. Irrigation methods were composed of either furrow or pivot irrigation at all locations. This program was conducted under various farmer standard tillage treatments, irrigation regimes, soil types and environmental conditions. The diversity of the fields in the program reflect cotton production in Arkansas. Field records were maintained and economic analyses were conducted at seasons end to determine net return/acre for each field in the program.

Results and Discussion

The majority of the cotton in Arkansas was planted from late April to mid May. Plant bug numbers decreased this year compared to 2015; fields in the CRVSP were treated an average of 2.3 times for plant bugs. A slightly higher plant bug pressure occurred in St. Francis County in 2016 compared to other fields in this study. Each field had an average of 1.3 burndowns, and 1.9 herbicide applications for the 2016 season. All fields except for Manila had an average of 1.7 treatments for moths/worms. Average costs for herbicides and insecticides were \$82.56 and \$38.60, respectively. Pest control represents a significant expense and can impact yield greatly.

Records of field operations on each field provided the basis for estimating expenses. Production data from the 14 fields were applied to determine costs and returns above operating costs, as well as total specified costs. Operating costs and total costs per pound indicate the commodity price needed to meet each costs type. Operating costs, total costs, costs per pound, and returns are presented in Table 1. Costs in this report do not include land costs, management, or other expenses and fees not associated with production. Budget summaries for cotton are presented in Table 2. Price received for cotton of \$0.74/lb is the estimated Arkansas annual average for the 2016 production year and includes a \$0.05/lb premium for cottonseed value after deducting all post-harvest expenses. Average cotton yield for all verification fields was 1159 lb/acre. Value of cottonseed was set equal to total post-harvest expenses for each field with a \$0.05/lb net premium.

Average operating costs for cotton in Tables 1 and 2 were \$512.31 per acre. Table 2 indicates that chemicals averaged \$151.16/acre and were 30% of operating

expenses. Seed and associated technology fees averaged \$127.00/acre, or 25% of operating expenses and included six fields planted with a cover crop. Fertilizer and nutrient costs averaged 17% of operating expenses and were \$86.08/acre.

With average yield of 1159 lb/acre, average operating costs were \$0.45/lb in Table 1. Operating costs ranged from a low of \$450.96 in the Manila North field to a high of \$551.01 in the Grain Bin West field. Returns to operating costs averaged \$345.51 per acre. The range was from a low of \$200.90 in the Wellcot field to a high of \$456.64 in the St. Francis South field. Average fixed costs were \$150.12 which led to average total costs of \$662.43 per acre. The average returns to total specified costs are \$195.39 per acre. The low was \$42.11 in the Shop North field, and the high was \$307.56 in the Conders South field. Total specified costs averaged \$0.58/lb.

Practical Applications

This program has become a vital tool in the educational efforts of the University of Arkansas System Division of Agriculture. It continues to serve a broad base of clientele including cotton growers, consultants, researchers, and county extension agents. The program strives to obtain its goals and provide timely information to the Arkansas cotton community.

Acknowledgments

Support provided by the University of Arkansas System Division of Agriculture.

Table 1. Operating costs, total costs, and returns for 2016 Cotton Research Verification Program fields.

Field	Operating Costs	Operating Costs per Pound	Returns to Operating Costs^a	Total Fixed Costs	Total Costs	Returns to Total Costs^a	Total Costs per Pound
Shop North	523.95	0.53	201.99	159.88	683.83	42.11	0.70
Shop South	538.26	0.50	257.98	141.70	679.96	116.28	0.63
Weaver North	506.57	0.40	431.75	158.70	665.27	273.05	0.52
Weaver South	524.67	0.41	417.35	136.49	661.17	280.85	0.52
Homeplace	531.53	0.49	278.77	160.63	692.17	118.13	0.63
Grain Bin East	527.58	0.43	372.26	136.51	664.10	235.74	0.55
Grain Bin West	551.01	0.42	409.51	154.05	705.06	255.46	0.54
Wellcot	459.92	0.52	200.90	147.65	607.57	53.25	0.68
Manila South	466.40	0.42	349.82	154.96	621.36	194.86	0.56
Manila North	450.96	0.40	392.64	170.29	621.25	222.35	0.54
Conders North	529.64	0.44	370.94	138.02	667.66	232.92	0.55
Conders South	512.76	0.39	456.64	149.07	661.83	307.56	0.51
Causey West	538.23	0.45	340.89	151.66	689.89	189.23	0.58
Causey East	510.80	0.44	355.74	142.11	652.91	213.63	0.56
Average	512.31	0.45	345.51	150.12	662.43	195.39	0.58

^aReturns include cottonseed value equal to post-harvest expenses with a \$0.05/lb premium added to lint price. All values in U.S. dollars.

Table 2. Summary of revenue and expenses per acre for 2016 Cotton Research without cover crop (CC) to no-till (NT) with

Revenue	Field					
	Shop North	Shop South	Weaver North	Weaver South	Homeplace	Grain Bin East
Yield (lb)	981	1076	1268	1273	1095	1216
Price ^a (\$/lb)	0.74	0.74	0.74	0.74	0.74	0.74
Total Crop Revenue	725.94	796.24	938.32	942.02	810.30	899.84
Cottonseed Value ^a	128.17	140.58	165.66	166.32	143.06	158.87
Expenses						
Seed	116.22	137.22	115.21	127.78	118.02	130.59
Fertilizers & Nutrients	82.84	82.84	74.29	82.84	82.84	82.84
Herbicides	112.29	112.29	106.29	106.29	92.82	106.28
Insecticides	38.06	38.06	38.06	38.06	52.71	38.06
Other Chemicals	27.34	27.34	27.34	27.34	29.60	27.34
Custom Applications	35.00	35.00	35.00	42.00	42.00	42.00
Other Inputs	3.50	3.50	3.50	3.50	3.50	3.50
Diesel Fuel	14.38	12.08	14.58	11.52	14.90	11.52
Irrigation Energy Costs	8.76	8.05	7.28	5.43	8.84	5.46
Input Costs	438.37	456.37	421.54	444.75	445.23	447.58
Fees	22.00	22.00	22.00	22.00	22.00	22.00
Repairs & Maintenance ^b	29.03	26.95	28.76	26.06	29.28	26.06
Labor, Field Activities	22.40	20.44	22.52	19.69	22.70	19.70
Production Expenses	511.80	525.77	494.82	512.50	519.20	515.34
Interest	12.16	12.49	11.75	12.17	12.33	12.24
Post-harvest Expenses	128.17	140.58	165.66	166.32	143.06	158.87
Operating Expenses	523.95	538.26	506.57	524.67	531.53	527.58
Returns to Operating Expenses	201.99	257.98	431.75	417.35	278.77	372.26
Capital Recovery & Fixed Costs	159.88	141.70	158.70	136.49	160.63	136.51
Total Specified Expenses^c	683.83	679.96	665.27	661.17	692.17	664.10
Returns to Specified Expenses	42.11	116.28	273.05	280.85	118.13	235.74
Operating Expenses/lb	0.53	0.50	0.40	0.41	0.49	0.43
Total Expenses/lb	0.70	0.63	0.52	0.52	0.63	0.55

^a Price includes cottonseed value equal to post-harvest expenses with a \$0.05/lb premium added to lint price.

^b Includes employee labor allocated to repairs and maintenance.

^c Does not include land costs, management, or other expenses and fees not associated with production.

Verification Program fields comparing farmer standard tillage (FS) with or without cover crop (CC).

Grain Bin	Field							
	West	Wellcot	Manila South	Manila North	Conders North	Conders South	Causey West	Causey East
1298	893	1103	1140	1217	1310	1188	1171	1159
0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
960.52	660.82	816.22	843.60	900.58	969.40	879.12	866.54	857.82
169.58	116.67	144.11	148.94	159.00	171.15	155.21	152.99	151.45
109.59	109.59	123.33	108.98	155.88	134.88	155.88	134.88	127.00
82.84	82.84	103.74	103.74	85.86	85.86	85.86	85.86	86.08
118.66	58.73	41.74	41.74	64.68	64.68	64.68	64.68	82.56
61.84	32.30	26.14	26.14	37.73	37.73	37.73	37.73	38.60
27.34	28.08	30.70	30.70	34.24	34.24	34.24	34.24	30.00
42.00	42.00	25.00	18.00	41.00	34.00	34.00	34.00	35.79
3.50	3.50	3.50	3.50	24.53	32.16	29.49	29.12	10.74
14.25	13.61	10.98	13.43	8.79	10.53	11.89	10.79	12.38
6.57	7.34	20.01	20.01	7.22	7.22	7.18	7.38	9.05
466.58	377.99	385.15	366.24	459.93	441.30	460.95	438.69	432.19
22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
27.80	27.69	28.89	30.68	26.70	27.77	29.69	27.74	28.08
21.84	21.58	19.54	21.58	8.72	9.79	13.10	10.52	18.15
538.22	449.25	455.58	440.50	517.35	500.87	525.74	498.95	500.42
12.78	10.67	10.82	10.46	12.29	11.90	12.49	11.85	11.89
169.58	116.67	144.11	148.94	159.00	171.15	155.21	152.99	151.45
551.01	459.92	466.40	450.96	529.64	512.76	538.23	510.80	512.31
409.51	200.90	349.82	392.64	370.94	456.64	340.89	355.74	345.51
154.05	147.65	154.96	170.29	138.02	149.07	151.66	142.11	150.12
705.06	607.57	621.36	621.25	667.66	661.83	689.89	652.91	662.43
255.46	53.25	194.86	222.35	232.92	307.56	189.23	213.63	195.39
0.42	0.52	0.42	0.40	0.44	0.39	0.45	0.44	0.45
0.54	0.68	0.56	0.54	0.55	0.51	0.58	0.56	0.58

OVERVIEW AND VERIFICATION

Cotton Research Verification Sustainability Program: 2016 Sustainability Report

*A. Free¹, B. Robertson¹, A. Flanders², M. Daniels³, C. Henry⁴, S. Stevens⁵,
J. Whittenton⁶, and D. Wildy⁷*

Research Problem

As costs of production continue to increase, producers are searching for ways to increase efficiency in hopes of becoming more profitable. Practices that lead to becoming more efficient often improve sustainability and soil health, having a direct impact on the fields' environmental footprint as measured by the Fieldprint Calculator by Field to Market. Two practices to increase sustainability in the Fieldprint calculator include reducing tillage (no-till) and using cover crop. Initial concerns with converting to a no-till cover crop system are the ability or inability to furrow irrigate efficiently as well as the costs associated with adopting a new technology. No single practice will work for all producers; cotton producers utilize many different production practices in order to increase efficiency in hopes of becoming more profitable and sustainable.

Background Information

The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980. In 2014, the CRVP became known as the CRVSP. The CRVSP expands beyond that of the traditional verification program by measuring the producers' environmental footprint for each field and evaluating the connection between profitability and sustainability. The Cotton Research Verification/Sustainability Program (CRVSP) conducted research in three counties in 2016: Desha, Mississippi and St. Francis counties. In Desha County, the CRVSP conducted research along with the Univer-

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⁶ Producer, University of Arkansas System Division of Agriculture, Southeast Arkansas Discovery Farms, St. Francis County.

⁷ Producer, University of Arkansas System Division of Agriculture, Southeast Arkansas Discovery Farms, Mississippi County.

sity of Arkansas System Division of Agriculture's Discovery Farms in Southeast Arkansas for two fields. All fields in Desha County were composed of two irrigation sets allowing for evaluation of farmer standard practice to that of a modified production system. Fields located in Mississippi and St. Francis counties were not composed of two irrigation sets, fields still remained split in half for observation of farmer standard tillage to that of a modified production system no-till with cover.

All fields were monitored for inputs and were entered into The Fieldprint Calculator. The Fieldprint Calculator is a relatively new tool developed by Field to Market: The Alliance for Sustainable Agriculture. The Fieldprint Calculator was designed in an effort to help educate producers on how adjustments in management could affect environmental factors. Utilization of the calculator assists producers by making estimates over seven sustainability factors: land use, soil conservation, soil carbon, irrigation water use, water quality, energy use, and greenhouse gas emissions. Fieldprint Calculator estimates a fields' performance and compares results to national and state averages. Calculated summaries give producers insight and the ability to identify areas for improved management on their farm.

Research Description

The 2016 CRVSP was composed of five fields which allowed for observation of two systems (farmer standard tillage and no-till with cover) in an effort to improve sustainability and soil health. Each system studied composed half of the field. Throughout the study, all producers' inputs were recorded which provided the information needed to enter fields into Fieldprint Calculator. Field data were collected through utilization of soil moisture sensors, rain gauges, evapotranspiration gauges, flow meters, and trapezoidal flumes. A set of three soil moisture sensors were placed in both no-till with cover and farmer standard tillage at 6, 12, and 18 inches. Evapotranspiration gauges were used to trigger irrigation. Flow meter readings allowed documentation for how much water was applied across all fields. Runoff data were collected at the two fields that were alongside Discovery Farms after irrigations and rainfall events through the use of trapezoidal flumes.

Results and Discussion

Soil moisture was consistently higher in no-till with cover fields, and irrigation water flow rates down the row were slower in no-till with cover fields. After large rain events, we observed that water infiltrated quicker in the no-till with cover fields, which allowed for decreased runoff when compared to that of a stale seedbed rehipped with a cover crop. Established cover crops allowed for other benefits. Visual observations of improved soil structure and increased earthworm appearances were noted. Earthworms are a great soil health indicator. Across all field locations, no-till with cover had one tillage operation (FurrowRunner) vs.

multiple tillage operations in farmer standard tillage. The FurrowRunner allowed us to make a very narrow trench in the furrow to help with water movement while leaving all cover crop residue on the sides of the furrow and on top of the row, creating only minimal disturbance. Water movement slowed as water worked its way through stubble allowing for better water infiltration and less runoff. The fields in Desha County which had multiple years of established cover crops had an increased yield in no-till cover producing 1175 lb lint/acre across both years when compared to farmer standard tillage producing only 1125 lb lint/acre. All the fields in their first year of an established cover crop produced a lower yield using no-till with cover when compared to farmer standard tillage (no till averaged 1179 lb lint/acre and farmer standard tillage averaged 1249 lb lint/acre). Excess irrigation of the no-till with cover fields is thought to be the reason for this yield difference as this was a new practice for these producers.

The environmental footprint calculated by the Fieldprint Calculator showed a smaller or more sustainable footprint with the no-till with cover fields. Sustainability metrics improved in several of the five calculated Fieldprint Sustainability metrics: land use, soil conservation, irrigation water use, energy use, and greenhouse gas emissions (Table 1). Improvements in sustainability were seen in 80% of the metrics in fields with multiple years of an established cover crop. More water was applied during irrigation events in no-till with cover fields as water infiltrated better into the soil with little runoff, leading to a negative impact on irrigation water use sustainability metric for fields with multiple years of an established cover crop. A total of 10.86 inches of water was applied on the farmer standard tillage side, where 12.13 inches was applied on no-till with cover. In fields with first year of an established cover crop, improvements were seen in 60% of the metrics.

Practical Applications

A higher yield was seen in no-till with cover on those fields with multiple years of an established cover crop; cotton was produced approximately \$0.01/lb cheaper in those no-till with cover fields when compared to farmer standard tillage. In fields which entered their first year of an established cover crop, cotton was produced approximately \$0.03/lb cheaper in the farmer standard tillage. Going forward, the CRVSP will focus on improving irrigation practices between farmer standard tillage and no-till with cover fields in efforts to improve yield, irrigation water use efficiency, and to avoid the potential of over watering. Additional research is needed to further evaluate how profitability, irrigation water use efficiency, size of environmental footprint, soil health, and continuous improvement are related.

Acknowledgments

Support provided by the University of Arkansas System Division of Agriculture.

Table 1. Sustainability metrics: Improvements with no-till cover crops (CC) vs. farmer standard tillage.

Metrics	Cover Crop Multiple Years (2 fields)	Cover Crop First Year (3 fields)
Land Use	5.43%	-5.48%
Soil Conservation	68.58%	71.09%
Irrigation Water Use	-10.47%	1.45%
Energy Use	6.42%	1.33%
Greenhouse Gas Emissions	5.20%	-1.05%

**University of Arkansas Cotton Breeding Program:
2016 Progress Report**

F.M. Bourland¹

Research Problem

The University of Arkansas System Division of Agriculture's Cotton Breeding Program attempts to develop cotton genotypes that are improved with respect to yield, yield components, host-plant resistance, fiber quality, and adaptation to Arkansas environments. Such genotypes would be expected to provide higher, more consistent yields with fewer inputs. To maintain a strong breeding program, continued research is needed to develop techniques, which will identify genotypes with favorable genes, combine those genes into adapted lines, then select and test derived lines.

Background Information

Cotton breeding programs have existed at the University of Arkansas System Division of Agriculture since the 1920s (Bourland and Waddle, 1988). Throughout this time, the primary emphases of the programs have been to identify and develop lines, which are highly adapted to Arkansas environments and possess good host-plant resistance traits. Bourland (2004, 2013) described the methods and output from the current program, which primarily focuses on the development of improved breeding methods and the release of conventional genotypes. Conventional genotypes continue to be important to the cotton industry, as a germplasm source and alternative to transgenic cultivars. Transgenic cultivars are usually developed by backcrossing transgenes into advanced conventional genotypes.

Research Description

Breeding lines and strains are annually evaluated at multiple locations in the University of Arkansas System Division of Agriculture's Cotton Breeding Program. Breeding lines are developed and evaluated in non-replicated tests because seed number in early generations is limited. Breeding line tests include initial crossing of parents, generation advance in early generations, individual plant se-

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lections from segregating populations, and evaluation of the progenies derived from individual plant selections. Once segregating populations are established, each sequential test provides screening of genotypes to identify ones with specific host-plant resistance and agronomic performance capabilities. Selected progeny are carried forward and evaluated in replicated strain tests at multiple Arkansas locations to determine yield, yield components, fiber quality, host-plant resistance and adaptation properties. Superior strains are subsequently evaluated over multiple years and in regional tests. Improved strains are used as parents in the breeding program and/or released as germplasm lines or cultivars.

Results and Discussion

Breeding Lines

The primary objectives of crosses made in 2008 through 2016 (F_1 through F_6 generations evaluated in 2016) included development of enhanced nectariless lines (with the goal of improving resistance to tarnished plant bug), improvement of yield components (how lines achieve yield), and improvement of fiber quality (with specific use of Q-score). Particular attention has been given to combine the fiber quality of UA48 cotton into higher yielding lines. Breeding line development focused on conventional cotton lines.

The primary focus of the 24 crosses made in 2016 was to combine lines having specific morphological traits, enhanced yield components and improved fiber characteristics. Six of the 24 crosses were made between advanced Arkansas lines, and 18 were made between an Arkansas line and a line from another public program. The 2015 breeding effort also included field evaluation of 16 F_2 populations, 16 F_3 populations, 24 F_4 populations, 840 first-year progeny, and 192 advanced progeny. Bolls were harvested from superior plants in F_2 and F_3 populations and bulked by population. Individual plants (1200) were selected from the F_4 populations. After discarding individual plants for fiber traits, progenies from the individual plant selections will be evaluated in 2017. From the first-year progenies, 216 were advanced, and 72 F_6 advanced progenies were promoted to strain status. These selected 72 F_6 advanced progeny included 28 progenies derived from crosses with UA48 cotton (Bourland and Jones, 2012a) and 25 derived from crosses with UA222 cotton (Bourland and Jones, 2012b).

Strain Evaluation

In 2016, 108 strains (Preliminary, New, and Advanced) were evaluated at multiple locations. Screening for host-plant resistance included evaluation for resistance to seed deterioration, seedling disease, bacterial blight, Verticillium wilt, and tarnished plant bug. Work continued in order to improve yield stability by focusing on yield components and to improve fiber quality by reducing bract trichomes. The 72 Preliminary Strains included 40 derived from crosses with UA48 cotton and 8 crosses with UA222, and 13 from a cross of UA48 by UA222.

Germplasm Releases

Germplasm releases are a major function of public breeding programs. Since 2004, a total of 56 cotton germplasm lines and 3 cotton cultivars have been released by the University of Arkansas System Division of Agriculture's Arkansas Agricultural Experiment Station. Lines released in 2016 included Arkot 0502ne, Arkot 0504ne, Arkot 0506ne, and Arkot 0517HG. These four lines possess either the nectariless or high glanding characteristic, which are important for tarnished plant bug and worm resistance, respectively. The lines provide new genetic material to public and private cotton breeders with documented adaptation to the mid-South cotton region. Additional lines are now being considered for release.

Practical Applications

Genotypes that possess enhanced host-plant resistance, improved yield and yield stability, and excellent fiber quality are being developed. Improved host-plant resistance should decrease production costs and risks. Selection based on yield components may help to identify and develop lines having improved and more stable yield. Released germplasm lines should be valuable as breeding material to commercial and other public cotton breeders or released as cultivars. In either case, Arkansas cotton producers should benefit from having cultivars that are specifically adapted to their growing conditions.

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Arkansas Cotton Variety Test 2016

F. Bourland¹, W. Barnett¹, C. Kennedy², L. Martin³, and A. Rouse¹

Research Problem

Other than variation in transgenic technologies and seed treatments, costs of cotton planting seed are relatively constant. However, choosing the best cotton variety to plant can often determine whether the producer experiences a successful production year. The producer must assume that past performance of varieties is a good predictor of future performance. Generally, the best cotton variety to plant in the forthcoming year is the one that performed best over a wide range of environments. However, specific adaptation to certain soil and pest situations may exist.

Background Information

Variety testing is one of the most visible activities of the University of Arkansas System Division of Agriculture's Arkansas Agricultural Experiment Station. Data generated by cotton variety testing provide unbiased comparisons of cotton varieties and advanced breeding lines over a range of environments. The continuing release of varieties that possess new technologies has contributed to a rapid turnover of cotton varieties. In the past, we often evaluated a new line for at least three years before it was widely grown in the state. This degree of testing provided good insight into the specific adaptation and best management associated with the line. Only 5 of the 35 transgenic lines in the 2016 Arkansas Cotton Variety Test have been in our test for at least three years (Bourland et al., 2017). The limited available testing of these lines intensifies the importance of each test site and the importance of comparing results over locations. The locations of the Arkansas Cotton Variety Test span about 200 miles north to south and include contrasting soil types, weather, pests, and management.

Research Description

The 35 entries in the 2016 transgenic test included 18 entries (12 B2XF, 3 WRF, 2 GLT, and 1 GLB2) returning from the 2015 test and 17 first-year entries

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(11 B2XF, 3 GLT, 2 GLTP, and 1 B2RF). The transgenic test was replicated 8 times at Manila Airport, 5 times at Judd Hill Cooperative Research Station and the Northeast Research and Extension Center, Keiser and 6 times at Lon Mann Cotton Research Station (Marianna) and the Rohwer Research Station. The conventional test included 10 entries and was evaluated using 5 replications at Keiser and 6 replications at Judd Hill, Marianna, and Rohwer. Originators of seed supplied double-treated (two fungicides) seed for all entries. Prior to planting, all seed were treated with imidacloprid (Gaucho[®]) at a rate of 6 oz/100 lb seed. Plots were planted with a constant number of seed (about 4 seed/row ft). All varieties were planted in two-row plots on 38-inch centers and ranged from 40 to 50 feet in length. Experiments were arranged in a randomized complete block. Although exact inputs varied across locations, cultural inputs at each location were generally based on University of Arkansas System Division of Agriculture Cooperative Extension Service recommendations for cotton production, including COTMAN rules for insecticide termination. Cereal rye was planted in the test plot area at Marianna as a cover crop on 28 October 2015. Urea (45 lb N/a) was applied on 28 March to push growth of the cover crop. Gramoxone (40 oz/a) and Brake (42 oz/a) were applied to the cereal rye on 25 April, and cotton was planted into the standing dead cereal rye on 9 May. Conventional tillage was employed at all other locations. All plots were machine-harvested with 2-row or 4-row cotton pickers modified with load cells for harvesting small plots.

Results and Discussion

Results of the Arkansas Cotton Variety Test are published annually and made available in hard copy (Bourland et al., 2017) and online at www.ArkansasVarietyTesting.com. Excellent stands and early growth were attained at each site in 2016. The cereal rye cover crop supplied valuable supplemental control of weeds, particularly pigweed. Parameters reported for each location included lint yield, lint percentage, plant height, percentage open bolls, seed index, lint index, seed per acre, fibers per seed, fiber density, and fiber properties (quality score, micronaire, length, uniformity index, strength and elongation). Variety by location interactions were significant for lint yield, lint fraction, plant height, percentage of open bolls, and number of seed per acre in both the transgenic and conventional tests and for fibers per seed, fiber density and micronaire in the transgenic test. However, several of the top yielding varieties were similar at each site. Other than micronaire, fiber quality parameters of the varieties were relatively similar across environments. Parameters measured at only one location included leaf pubescence, stem pubescence, bract trichome density, tarnished plant bug damage, and bacterial blight response. Significant variety effects for each of the parameters measured across locations and at one location were found in both the transgenic and conventional variety tests.

Practical Applications

Varieties that perform well over all locations of the Arkansas Cotton Variety Test possess wide adaptation. Specific adaptation may be found for varieties that do particularly well at Keiser (clay soil adapted), Judd Hill (*Verticillium*-wilt tolerant), Manila (sandy soil adapted), Marianna (applicable to most Arkansas environments), and Rohwer (more southern location may favor late-maturing lines). The multiple reported parameters provide information on each variety regarding their specific yield adaptation, how their yields were attained (i.e. yield components), maturity, relative need for growth regulators, fiber quality, plant hairiness, and fiber quality.

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Chlorophyll Fluorescence as an Indicator of Temperature Stress in Cotton (*Gossypium hirsutum* L.) Genotypes

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Research Problem

Elevated CO₂-induced climate change will affect cotton production practices due to more frequent occurrence of heat waves, and these warmer temperatures will have a negative effect on sustainable crop production (Bange et al., 2016). To evaluate the effect of heat stress (40 °C) on photosystem II efficiency via chlorophyll fluorescence measurements, two greenhouse studies were planted in Rustenburg 2016/2017 with four diverse cultivars namely Arkot 9704, VH260, DP393 and DP210,

Background Information

With the current change in climate, heat stress has become a major factor impacting crop yields and food security (Bange et al., 2016). In cotton, high temperature has been shown to adversely affect crop growth and yield (Oosterhuis, 1999; Bange et al., 2016). Heat stress is defined as the rise in temperature beyond a threshold level for a sufficient period of time to cause irreversible damage to plant growth and development (Wahid et al., 2007). The impacts of plant stress depend on the crops tolerance towards the timing (developmental stage), duration and severity of stress (Snider and Oosterhuis, 2011). To ensure future crop productivity and food security, it is of vital importance to identify crops and genotypes, which can tolerate drought and heat stress. The ideal temperature range for cotton is between 20 °C and 30 °C (Reddy et al., 1991). In cotton, the most sensitive stage to heat stress is during flowering with elevated temperatures (above 30 °C) resulting in fruit abscission (Reddy et al., 1992). Different screening methods for heat tolerance in cotton have been investigated including membrane leakage (Bibi et al., 2008) and chlorophyll fluorescence (Bibi et al., 2008; Wu et al., 2014).

Photosynthesis is the process in plant cells that is the most sensitive to heat stress (Sharkey and Schrader, 2006). Heat stress causes changes in the reduction-oxidation properties of PSII acceptors and reduces the efficiency of electron transport in the photosystems (Mathur et al., 2014). Chlorophyll fluorescence (ChlF) is a non-destructive method used in crop research to assess genotype re-

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sponse to stress (Wu et al., 2014) because of the ease of gaining detailed information on the effects of stress on the photosynthetic process (Murchie and Lawson, 2013). The objective of the study was to evaluate a procedure for measuring the ChlF response of cotton genotypes to heat stress and to investigate the applicability of various functional processes in the photosynthetic system to investigate heat tolerance among four diverse genotypes.

Research Description

Four diverse cotton (*Gossypium hirsutum* L.) genotypes namely Arkot 9704 (Bourland and Jones, 2009), VH260, 'DP 393' (PVP 200400266) and DP210, were planted in PVC pots in two greenhouse studies at Rustenburg, South Africa (S 26° 41' 20", E27° 05' 25") in August 2016 (Study 1) and January 2017 (Study 2). The selected genotypes represent a diverse set representative of the major germplasm pools in cotton production. The pots (14 cm in diameter and 13 cm in height) were filled with soil, which was composed of a 50/50% mixture of coarse sand and black clay and planted with four cotton seeds which were thinned to one cotton plant per pot a week after emergence. Plants were watered daily with a dissolved solution of multigrow fertilizer. Air temperature was kept at 30/20 °C (day/night). Cotton plants were grown for 5 weeks up to the pinhead square stage and then subjected to two temperature regimes, namely a 30 °C control and a 40 °C heat stress for 6 hours using two converted laboratory ovens (Scientific 2000, Potchefstroom, North-West) to create the temperature treatments.

Fluorescence measurements including fluorescence intensities, maximum efficiency of PSII photochemistry (Fv/Fm) and performance index on absorption basis of chlorophylls (PIABS) were measured on intact leaves using a MPEA fluorometer (Hansatech Instruments, King's Lynn, Norfolk, UK). Cotton plants were dark adapted for 6 hours (while subjected to heat stress) before the measurements and then illuminated with continuous light (2400 $\mu\text{mol m}^{-2} \text{s}^{-1}$, 650 nm peak wavelength) for 1 s provided by an array of six light-emitting diodes focused on a circle of 5 mm diameter of the sample surface. Measurements were taken at three different spots on the adaxial surface of fully developed canopy leaves of three plants per treatment.

Results and Discussion

Fluorescence intensities of four cotton genotypes at two different temperature regimes in two studies are presented in Table 1. At 30 °C control, there were differences in ChlF intensity between genotypes indicating innate differences in photosynthetic efficiency. These decreases in fluorescence intensities are associated to the restriction in the flow of electrons between the photosystems in photosynthesis (PSII and PSI) as well as a decrease in the plants ability to reduce nicotinamide adenine dinucleotide phosphate (NADP) + to NADPH (Oukarroum et al., 2013). There was an interaction between genotype responses to heat stress

in the two studies (Table 1). Decreases of fluorescence intensities after heat stress is an indication of the decrease in efficiency of photosystem II. Cultivar DP 393 was the least affected by heat stress showing that it was more tolerant to high temperature. The other three genotypes showed higher changes in fluorescence intensities indicating larger responses to high temperature.

Maximum efficiency of PSII (Fv/Fm) is the most widely used parameter in ChlF research (Kalaji et al., 2016). Changes in maximum efficiency of PSII are presented in Table 2 and revealed differences in the response of the four different genotypes to heat stress. Maximum efficiency was high and then decreased after heat stress treatment. In study 1, DP393 had the lowest percentage change (9%) compared to Arkot 9704 (23%), VH260 (28%) and DP210 (22%). In Study 2, DP210 had the lowest percentage change of 4% compared to DP 393 (6%), VH260 (8%) and Arkot 9704 (11%). In Study 1, after heat stress, DP393 had significantly higher Fv/Fm ratios than DP210, Arkot 9704, and VH260. In Study 2 after heat stress, DP210 had the highest Fv/Fm, but not significantly higher than DP 393 and VH260, suggesting a greater tolerance of DP210, DP393 and VH260 to heat stress compared to Arkot 9704.

Performance index on absorption basis of chlorophylls is a measurement of the accumulation of all PSII's responses to energy capture and use in chlorophylls (Oukarroum et al., 2013), and is used to quantify the effect of stress. In both studies (Table 3) heat stress plants had lower values for all four genotypes compared to the control temperature, thus indicating the negative effect of heat stress on PSII function. In Study 1 (Table 3), the lowest reduction (46%) in PIABS was obtained by DP393, exhibiting heat tolerance. In study 2 (Table 3), both DP210 (45%) and DP393 (48%) resulted in the lowest reductions of PIABS indicating heat tolerance. In Study 1, after heat stress, genotypes differed significantly with DP393 having the highest PIABS, compared to Arkot 9704, VH260 and DP210. Although genotypes did not differ significantly in Study 2, the same tendency was found, with DP 393 and DP210 with higher values compared to Arkot 9704 and VH260.

Practical Applications

Quantification of the detrimental effects of high temperature stresses is possible by using various parameters of chlorophyll fluorescence (ChlF) to screen genotypes for heat tolerance. Chlorophyll fluorescence is a fast and non-invasive method of obtaining masses of data regarding the structure and function of photosystem II. This is an ongoing project to evaluate cotton genotypes for high temperature tolerance for selection in screening cotton germplasm.

Acknowledgments

Support for this research was provided by Cotton Incorporated and also the University of Arkansas System Division of Agriculture.

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Table 1. Chlorophyll fluorescence intensity (ChIF) at 300 μ s of four cotton genotypes at two temperature regimes. Studies 1 and 2, Potchefstroom, 2016/2017.

Study	Treatment	Fluorescence Intensity (au)			
		Arkot 9704	VH260	DP393	DP210
1	30°C	28,865 b [†]	28,726 b	33208 a	32,008 a
	40°C	18,781 c	14252 d	27,521 b	18,147 c
	Difference	35 %	50 %	17 %	43 %
2	30°C	29,941 a	28,464 ab	27,938 ab	29,596 a
	40°C	20997 d	24073 c	26,482 bc	26,531 bc
	Difference	29 %	15 %	5 %	10 %

[†]The same letters in a row indicates no significant difference between genotypes ($P < 0.05$).

Table 2. Maximum fluorescence efficiency of PSII (Fv/Fm) of four cotton genotypes at two temperature regimes. Studies 1 and 2, Potchefstroom, 2016/2017.

Study	Treatment	Maximum fluorescence efficiency (F _v /F _m)			
		Arkot 9704	VH260	DP393	DP210
1	30°C	0.787 a [†]	0.808 a	0.765 a	0.803 a
	40°C	0.606 c	0.585 c	0.696 b	0.629 c
	Difference	23 %	28 %	9 %	22 %
2	30°C	0.825 a	0.813 ab	0.798 b	0.796 b
	40°C	0.737 d	0.748 cd	0.750 cd	0.767 c
	Difference	11 %	8 %	6 %	41 %

[†]The same letter in a row indicates no significant difference between genotypes ($P < 0.05$).

Table 3. Performance index on absorption basis of chlorophylls (PIABS) of four cotton genotypes at two temperature regimes. Studies 1 and 2, Potchefstroom, 2016/2017.

Study	Treatment	Performance index on absorption basis (PIABS)			
		Arkot 9704	VH260	DP393	DP210
1	30°C	8.3 b [†]	12.3 a	5.7 c	9.8 b
	40°C	2.4 a	1.5 d	3.1 d	2.4 d
	Difference	71 %	88 %	46 %	76 %
2	30°C	16.4 a	13.0 b	9.8 c	9.2 c
	40°C	4.8 d	4.6 d	5.0 d	5.0 d
	Difference	71 %	64 %	48 %	45 %

[†]The same letters for each genotype in a row indicates no significant difference between genotypes ($P < 0.05$).

Verification of Varietal Resistance to Tarnished Plant Bug Large Plots

G.E. Stuebaker¹, F. M. Bourland¹ and C. Jackson¹

Research Problem

Insecticides are by far the most commonly used option for managing tarnished plant bug (TPB) when they reach treatment threshold in cotton in Arkansas (Stuebaker, 2016). However, increasing levels of resistance to insecticides are beginning to make some chemistries less effective. Therefore, it is important to evaluate other options for TPB management, particularly host-plant resistance. Host-plant resistance can delay insecticide resistance, reduce environmental effects, and is a more cost-effective option for managing insect pests.

Background Information

Tarnished plant bug (TPB) is one of the most important pests of cotton in Arkansas. From 2003 to 2016 it caused more yield losses than any other pest averaging an annual loss of over 50,000 bales most years in Arkansas (Williams, 2016). Ongoing small-plot studies have indicated that some commercially grown varieties are less attractive or exhibit some level of resistance to tarnished plant bug. A large block study was conducted in 2016 to verify the resistance of several varieties that exhibited low damage from TPB in small-plot studies in previous years (Bourland et al., 2016).

Research Description

Trials were conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keiser, Ark. Plots were 24 rows wide by 100 ft long, arranged in a split-plot design with 4 replications. Varieties showing lower damage in small plots (DP 1522 B2XF, DG 3385 B2XF, ST 5289 GLT, DP 1518 B2XF, PHY 312 WRF) as well as one variety showing high damage in small plots (ST 5115 GLT) were used to conduct the study (Table 1). Each variety had two TPB treatment regimes; an untreated control and treated when TPB numbers reached the recommended threshold of 3

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bugs/5 row-ft. Plots were sampled weekly with a drop cloth. When TPB reached the treatment level of 3 bugs per 5-row feet, treatments were applied with a high clearance sprayer calibrated to deliver 10 gal/acre through two hollow cone nozzles per row. Acephate at 0.75 lbs ai/acre was applied when threshold was reached. Plots did not reach treatment level until after flowering. Yields were taken from the center 4 rows of each plot at the end of the season. All data were analyzed using ARM version 2016 software (Gylling Data Management, Inc., Brookings, S.D.). Treatment means were separated at the $P = 0.05$ alpha level.

Results and Discussion

Tarnished plant bug numbers were highest at the end of the season in susceptible varieties (Fig. 1). Tarnished plant bug populations were variable in the resistant varieties. Two varieties with consistently low TPB populations through the season were ST 5289 GLT and DG 3385 B2XF. Variety ST 5289 GLT also required the fewest number of insecticide applications, while PHY 312 WRF and ST 1518 B2XF required the highest number of applications (Fig. 2). Average yield losses to TPB are shown in Fig. 3. Variety DP 1518 B2XF exhibited more dramatic yield loss compared to the other varieties tested. Variety PHY 312 WRF had the lowest yield loss even though it required a high number of insecticide applications. The resistant varieties tended to have lower populations of TPB and less yield loss indicating a tolerance to TPB, but not complete resistance. Variety DP 1518 B2XF was the exception, showing moderate resistance in small plots. However, this did not translate into our large-plot study, indicating a need for large plot studies or a mistaken assessment of the resistance of this variety in the small-plot study.

Practical Applications

Utilizing resistant varieties to manage TPB in cotton is a viable option for growers in Arkansas. While these varieties are not completely immune to TPB damage, they did tend to require fewer insecticide applications and also suffered less yield loss from this pest than susceptible varieties. By utilizing these varieties, growers should be able to reduce insecticide applications for TPB, avoid secondary pest outbreaks, and delay the development of insecticide resistance in this pest.

Acknowledgments

The authors would like to thank Cotton Incorporated and the University of Arkansas System Division of Agriculture's Agricultural Experiment Station for their support of this project.

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Table 1. Tarnished plant bug damage to flowers in selected varieties.

Variety	Leaf pubescence	% damaged flowers
DP 1522 B2XF	6.4	61
DG 3385 B2XF	1.7	63
DP 1612 B2XF	4.9	63
DP 1614 B2XF	6.4	63
ST 5289GLT	7	64
DP 1518 B2XF	6.9	68
DG 2285 B2RF	3.6	70
PHY 312 WRF	6.6	72
DG CT15426	4.5	73
NG 3405 B2XF	1	74
NG 3406 B2XF	3.1	74
ST 5032GLT	6.8	74
PHY 427 WRF	4.5	74
PHY 487 WRF	3.4	74
PHY 499 WRF	5.2	74
ST 4946GLB2	5.7	75
DP0912 B2RF	4	75
AMDG-7824	1.1	76
PHY 444 WRF	1.2	76
ST 4747GLB2	5.1	77
DP 1639 B2XF	3.9	77
PHY 333 WRF	6.3	78
MON 15R513B2XF	6.6	79
DP 1646 B2XF	1.1	79
PHY 222 WRF	6.1	79
ST 6182GLT	1.6	80
PHY 495 W3RF	3.8	81
PHY 496 W3RF	4.8	81
FM 1944GLB2	1.7	84
ST 5115GLT	2.6	84
PHY 339 WRF	3.6	85
DG CT14515	3.3	91

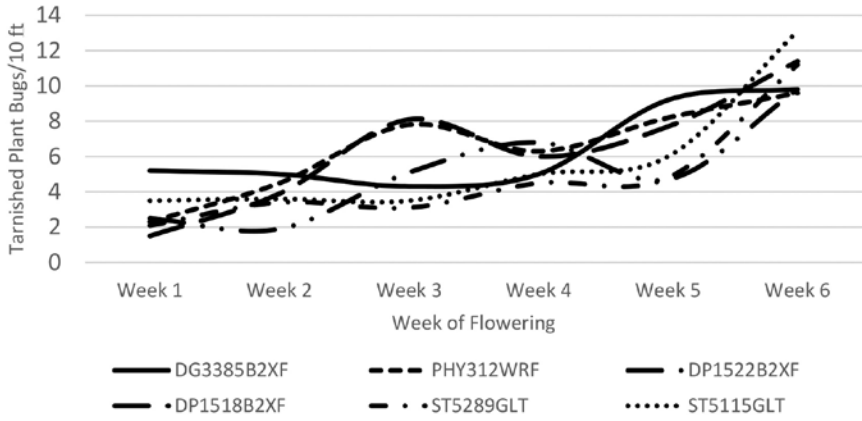


Fig. 1. Tarnished plant bug levels by variety in untreated plots.

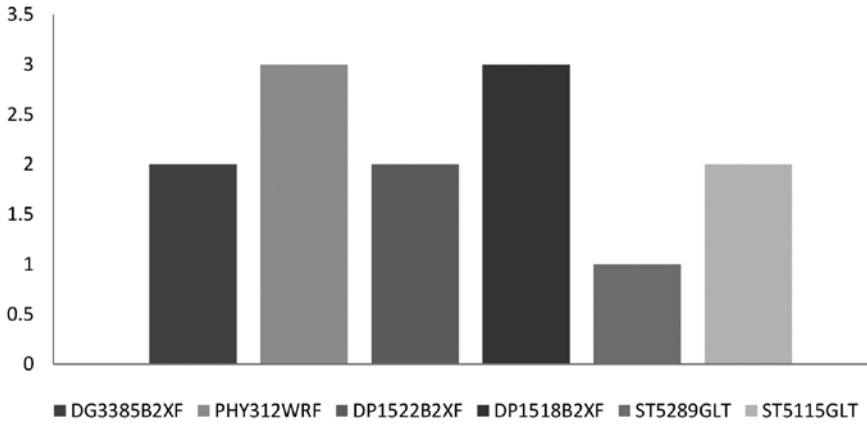


Fig. 2. Number of tarnished plant bug insecticide applications by variety.

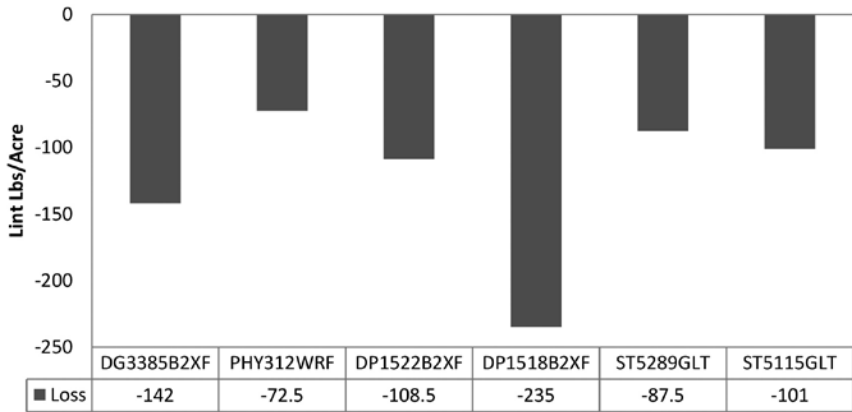


Fig. 3. Yield loss by variety due to tarnished plant bugs in large plots.

Evaluating Thrips Tolerance in Selected Cotton Cultivars

*G. Lorenz¹, F. Bourland², N. Taillon¹, A. Plummer¹, M. Chaney¹,
J. Black¹, and A. Cato³*

Research Problem

The purpose of this study was to investigate cultivars for tolerance to thrips, to determine the value of insecticide seed treatments and the interaction between cultivars that may have tolerance to thrips, and ultimately to determine the effects of thrips tolerance and insecticide seed treatments for control of thrips and impact on subsequent yield.

Background Information

Thrips are the second most damaging and costly insect to cotton production in Arkansas. Recent observations indicate that some cultivars appear to tolerate thrips better than other cultivars. If some cultivars tolerate thrips better than other ones, growers may use the tolerant cultivars to avoid thrips and reduce their reliance on thrips insecticides.

Insecticide seed treatments have been applied to 99% of all cotton seed planted in Arkansas for the last several years. The shift to neonicotinoid insecticide seed treatments from aldicarb (Temik) began in 2006 due to convenience and because data indicated that they provided similar thrips control as aldicarb. However the last several seasons (2011-2014), a reduction in thrips efficacy has been documented on the farm level and multiple post-emergence applications have been needed to control thrips populations. Previous studies have shown that pre-emergence and post-emergence herbicides can exacerbate thrips control issues; the overriding problem has been the development of insecticide resistance by tobacco thrips to neonicotinoids, particularly Cruiser. However, studies in 2014 also indicated tolerance is developing to imidacloprid (Gaucho-based treatments).

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Research Description

Small-plot studies were conducted to evaluate cotton cultivars for thrips tolerance with and without an insecticide seed treatment and the impact of thrips on cotton growth and yield. Studies were conducted at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station. We used a randomized complete split plot design with 4 replications. Each plot was 4 rows by 30 ft long with 2 rows treated and 2 rows untreated. The study included 18 *Bacillus thuringiensis* (Bt) cultivars and 10 conventional cultivars with and without Gaucho seed treatment applied at 0.375 mg ai/seed, the standard rate used for thrips control on cotton for a total of 224 plots. All of the cultivar entries were evaluated in both the 2015 and 2016 Arkansas Cotton Variety Tests. Seed used in the 2016 thrips tests were from boll samples taken from the 2015 cultivar tests. Boll samples were ginned and seed were acid-delinted prior to being treated with standard fungicides and with or without Gaucho. Thrips samples were collected on 23 May and 3 June. Five plants from each plot, treated and untreated, were randomly sampled by placing them in jars with alcohol and brought back to the lab at Lonoke for counting. Damage ratings were taken 26 May and 3 June on a scale of 0-5 with 0 representing no damage and 5 being a dead plant. After samples were taken and injury ratings were conducted, the entire test was treated identically for all pests for the remainder of the season. Seed cotton yield was measured at the end of the season by mechanically harvesting each plot. Data are currently being analyzed as this is an extraordinarily large trial with a lot of data.

Results and Discussion

The addition of the seed treatment increased yields an average of 173 lb/a for conventional cultivars and 201 lb/a in *Bt* cultivars. However in both conventional and *Bt* cultivars, some cultivars actually had higher yields or negligible increases with the addition of the insecticide seed treatment. The *Bt* cultivars: NG3406 B2XF (-251.6 lb/a), Dyna-Gro 3526 (-175 lb/a), Dyna-Gro 3385 B2XF (-21.3 lb/a), DP 1639 B2XF (-297.5 lb/a), and DP1612 B2XF (21.3 lb/a) all had negative or little response to the seed treatment. Conventional cultivars that had little or no response to the insecticide seed treatment included: DP 393 (75.6 lb/a), UA 48 (-13.8 lb/a), and UA114 (48.1 lb/a) shown in Fig. 1.

Conventional Cultivars

Thrips counts were extremely high on the second sample date and may have overwhelmed any tolerance to thrips (Fig. 2). Although the seed treatment consistently lowered thrips numbers in all cultivars, there were considerable differences in the response to control with the seed treatment.

***Bacillus thuringiensis* Cultivars**

As seen in conventional cultivars, extremely high thrips counts on the second sample date may have overwhelmed any tolerance to thrips (Fig. 3). Although the seed treatment consistently lowered thrips numbers in most cultivars, there were considerable differences in the response to control with the seed treatment. Yield data were not significantly different (Fig. 4).

More analysis of data is forthcoming. However, we think that the extremely high thrips numbers we experienced this year may have masked any tolerance that some of these cultivars may have. We look forward to continuing the study in 2017.

Practical Applications

Studies such as these allow us to evaluate cultivars that may be more susceptible to thrips which can help growers prepare and budget additional insecticide applications to achieve adequate thrips control to prevent yield loss or to avoid those cultivars and plant cultivars with better tolerance. Also, this study helps us to evaluate the control of thrips with a seed treatment and quantify the value of the seed treatment for growers.

Acknowledgements

We appreciate the support of the staff at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station.

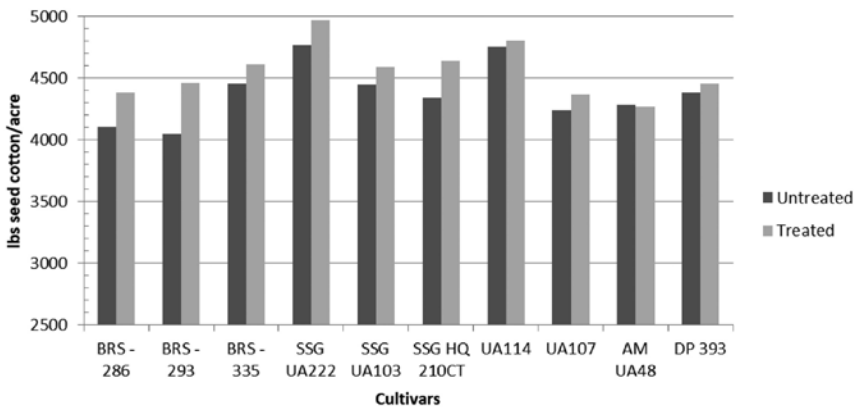


Fig. 1. Yield of selected conventional cultivars with and without a seed treatment at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station.

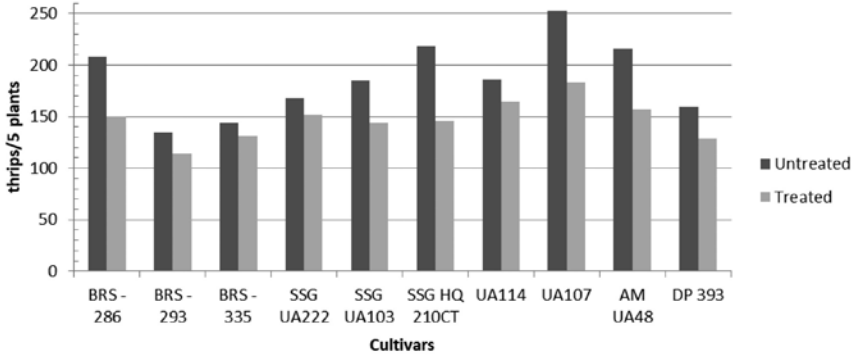


Fig. 2. Number of thrips per 5 plants in second thrips sample, Conventional Cultivars (3 June) at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station.

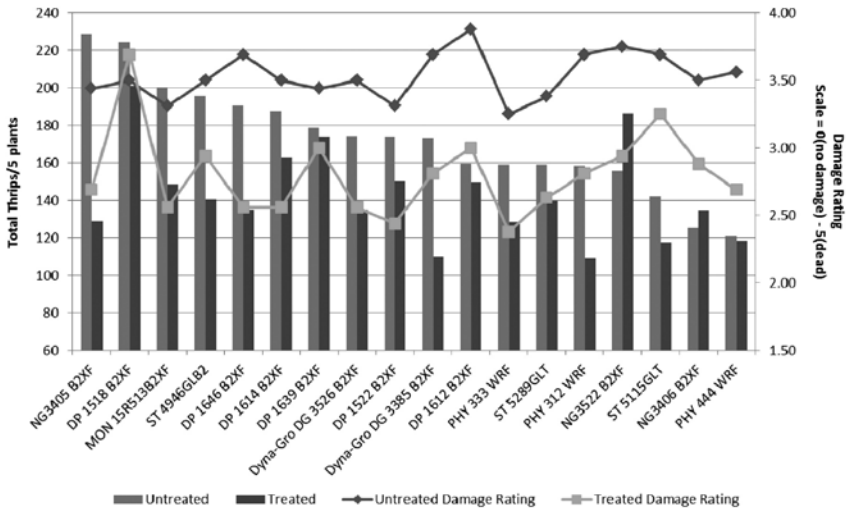


Fig. 3. Second thrips sample and damage rating for *Bacillus thuringiensis* (Bt) cultivars at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station.

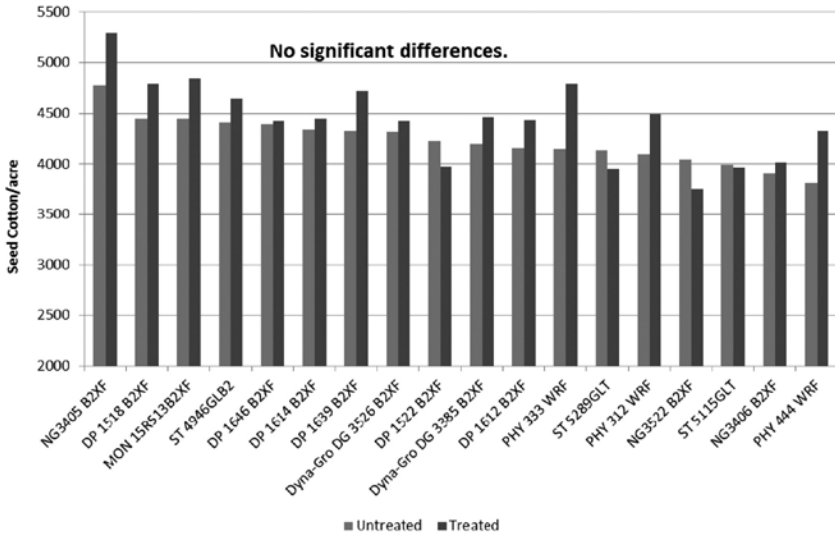


Fig. 4. Yield for selected *Bacillus thuringiensis* (Bt) cultivars at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station.

**Evaluate the Sensitivity of Enlist™ and Roundup Ready®
Bollgard II® XtendFlex® Cotton to Post-Emergence
Applications of Auxinic Herbicides**

J.S. Rose¹, L.T. Barber², J.K. Norsworthy¹, and H.D. Bowman¹

Research Problem

Roundup Ready® Bollgard II® XtendFlex®, dicamba-tolerant cotton was released commercially in 2015. Another cotton variety trait, Enlist™, which provides tolerance to 2,4-D, glyphosate, and glufosinate, was released on limited acres in 2016. Since the release of these new traits, there have been many questions surrounding these varieties. One main area of discussion is how these varieties will respond to a post-emergence application of chemicals within various synthetic auxin [Weed Science Society of America (WSSA) Group 4] families.

Background Information

New technologies are being released to help combat the ever-growing problem of weed resistance, especially with the *Amaranthus* spp. In Arkansas, Palmer amaranth, the most threatening weed in the state's row-crop production, has developed resistance to six sites of action (SOA) (Heap, 2017). The herbicides 2,4-D and dicamba belong to WSSA Group 4, which is divided into five families, these families are based on the location of the carboxylic acid moiety and the type of aromatic group (Epp et al., 2015; Zheng and Hall 2001). It has been proposed that the same transgene that provides tolerance to 2,4-D will also provide tolerance to other auxinic herbicides (Wright et al., 2010).

Research Description

Tests were conducted in the summer of 2015 and 2016 at the University of Arkansas System Division of Agriculture's Rohwer Research Station in Rohwer, Ark., and in 2016 at the Lon Mann Cotton Research Station in Marianna, Ark. The experiment was arranged as a split-split plot design where the main plot factor was technology (3), the split plot factor was herbicide (9 different auxin herbi-

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cides and an untreated plot), and the split-split plot factor was rate (2), with four replications.

Treatments (Table 1) were made in a single post-emergence application to 7-leaf cotton at two rates, $1/16 \times$ and $1 \times$. Ratings for visual injury were taken each week for 1 and 3 weeks after application using a rating scale of 0% to 100%, with 0% being no injury and 100% meaning plant death. At 3 weeks after application (WAA), terminal heights from 5 plants in each plot were taken to the nearest centimeter and averaged, immediately prior to biomass collection. Biomass was collected from one meter of row from each plot, number of plants in the meter row counted, and placed in a forage dryer, until a constant weight was reached, which was then recorded (data not shown). The untreated plots once again served as the basis for any injury or biomass/height reductions.

Results and Discussion

No injury was observed where dicamba was applied to Xtend[®] cotton or where 2,4-D was applied to Enlist[™] cotton. Xtend[®] cotton was injured by all other herbicide treatments at the 1 week after application (WAA) timing regardless of rate. This injury was sustained and consistent for 3 WAA rating at the $1 \times$ rate (Figs. 1 and 2). Enlist[™] cotton showed increased tolerance to triclopyr and fluroxypyr at both rates and rating timings (Figs. 1 and 2). This was further quantified with the height data where taller plants resulted in less overall injury observed (Fig. 3).

Practical Applications

This research indicates that there is potential for the trait associated with Enlist[™] cotton to exhibit increased tolerance to applications of other auxinic herbicides from different families within Group 4. This could allow for the use of other Group 4 herbicides for potential improvements in weed control and thus affect other sites within a plant, since it has been noted that resistance to one auxinic herbicide does not necessarily confer resistance to all auxinic herbicides (Peniuk et al., 1993).

Acknowledgments

Special thanks is given to my major professors Tom Barber and Jason Norworthy, Aaron Ross, Ryan Doherty, Zach Hill, graduate colleagues, student workers, and the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station and Rohwer Research Station farm crews for help in conducting this research.

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Table 1. Post-emergence herbicides applied to Enlist™, Xtend®, and Glytol cotton.

Treatment	Herbicide	1X	1/16X
CHK	Check	-	-
1	2,4-D	1,120 g ae ha ⁻¹	70 g ae ha ⁻¹
2	Dicamba	560 g ae ha ⁻¹	35 g ae ha ⁻¹
2	Triclopyr	420 g ae ha ⁻¹	26.25 g ae ha ⁻¹
4	Clopyralid	140 g ae ha ⁻¹	8.75 g ae ha ⁻¹
5	Aminopyralid	122 g ae ha ⁻¹	7.625 g ae ha ⁻¹
6	Fluroxypyr	157 g ae ha ⁻¹	9.813 g ae ha ⁻¹
7	Quinclorac	420 g ai ha ⁻¹	26.25 g ai ha ⁻¹
8	Halauxifen-methyl	5 g ae ha ⁻¹	0.313 g ae ha ⁻¹
9	Florpyrauxifen-benzyl	30 g ae ha ⁻¹	1.875 g ae ha ⁻¹

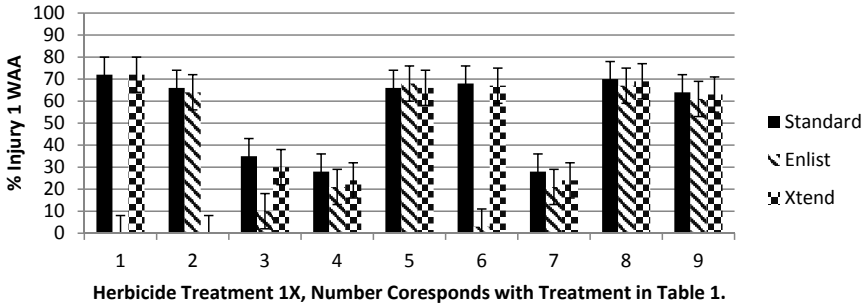


Fig. 1. Means of percent visual crop injury observed 1 week after application (WAA). Least significant difference (LSD) bars ($\alpha = 0.05$) are for comparisons between varieties within a treatment, for comparisons across treatments $LSD = 9$ ($\alpha = 0.05$).

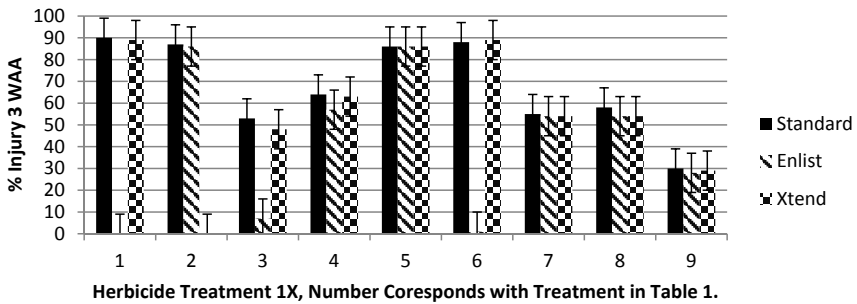


Fig. 2. Means of percent visual crop injury observed 3 weeks after application (WAA). Least significant difference (LSD) bars ($\alpha = 0.05$) are for comparisons between varieties within a treatment, for comparisons across treatments $LSD = 10$ ($\alpha = 0.05$).

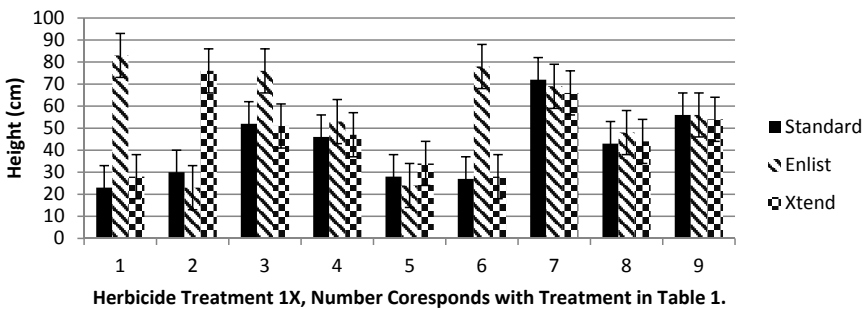


Fig. 3. Means of plants heights (cm) at biomass 3 weeks after application (WAA). Least significant difference (LSD) bars ($\alpha = 0.05$) are for comparisons between varieties within a treatment, for comparisons across treatments $LSD = 11$ ($\alpha = 0.05$).

XtendFlex Management in the Absence of Dicamba Tank-Mix Partners

R.C. Doherty¹, L.T. Barber², Z.T. Hill², and A.W. Ross³

Research Problem

Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*), remains a major concern for cotton (*Gossypium hirsutum* L.) growers in Arkansas. Palmer amaranth herbicide resistance to protoporphyrinogen oxidase inhibitor (PPO) herbicides has increased the need for new technology, such as dicamba-tolerant crops, and the use of multiple modes of action in-season. These herbicide systems must be applied timely and may need to contain multiple tank-mix partners in a single application, to control this evasive weed. The objective was to evaluate weed control in the absence of dicamba tank-mix partners.

Background Information

Palmer amaranth populations resistant to glyphosate, Acetolactate synthase (ALS) and to protoporphyrinogen oxidase inhibitor (PPO) herbicides continue to force evolution in Arkansas cotton weed control programs. At the present time, restrictions on dicamba applications in the state will not allow dicamba to be tank-mixed with other herbicides. Presently, no single herbicide will provide adequate control of Palmer amaranth; herbicide systems that contain tank mixes must be used (Scott et al., 2017). More information is needed on weed control provided by dicamba applied alone in a season-long herbicide system.

Research Description

A trial was established in 2016 at the University of Arkansas System Division of Agriculture's Rohwer Research Station in Rohwer, Ark. to evaluate herbicide systems in XtendFlex[®] cotton in scenarios where tank mixtures were not included with dicamba applications. The soil type was a Desha silt loam. Trials were designed in a factorial arrangement of treatments with four replications. Pre-emer-

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gence (PRE) herbicide comparisons were provided in addition to post-emergence (POST) options. Herbicides compared pre-emergence included Brake FX (fluometuron 0.75 lb ai/acre + fluridone 0.15 lb ai/acre), Cotoran (fluometuron), Direx (diuron) and Warrant (acetochlor). Post-emergence herbicides evaluated included combinations of Liberty (glufosinate), Clarity (dicamba) and Roundup PowerMax (glyphosate) and were applied to 2–4 inch weeds. Visual weed control ratings of Palmer amaranth, barnyardgrass, and Southwestern cupgrass were recorded at 21 days after final treatment (DAT).

Results and Discussion

Brake FX systems, 21 DAT, provided more consistent weed control across all weed species (Fig. 1). Cotoran at 1.0 lb ai/acre followed by (fb) Clarity at 0.5 lb ai/acre, Roundup at 0.95 lb ai/acre, or Liberty at 0.53 lb ai/acre fb Clarity provided 94%, 92%, and 90% control of Palmer amaranth, respectively. All other weed control was 83% or less with Cotoran systems (Fig. 2). Grass control was not adequate with Warrant PRE, except when followed by Clarity at 0.5 lb ai/acre fb Roundup at 0.95 lb ai/acre. Warrant at 1.13 lb ai/acre fb two applications of Clarity at 0.5 lb ai/acre provided 97% control of Palmer amaranth, while Warrant at 1.13 lb ai/acre fb Liberty at 0.53 lb ai/acre fb Clarity at 0.5 lb ai/acre provided 94% (Fig. 3). Direx at 0.75 lb ai/acre fb Clarity at 0.5 lb ai/acre and Roundup at 0.95 lb ai/acre, or Liberty at 0.53 lb ai/acre fb Clarity provided 95%, 94%, and 91% control of Palmer amaranth, respectively. Grass control was 90% or less with all Direx systems (Fig. 4.). Brake FX at 0.9 lb ai/acre fb Roundup at 0.95 lb ai/acre fb Clarity at 0.5 lb ai/acre provided the greatest control (95%, 85%, 85%) of Palmer amaranth, barnyardgrass, and Southwestern cupgrass, respectively (Fig. 1).

XtendFlex herbicide systems that were established with Brake FX applied PRE provided better overall weed control across all systems, while systems utilizing Warrant PRE provided the least control. All systems that contained two post-emergence applications provided greater weed control over systems that contained one. The addition of Liberty or Roundup in the herbicide system improved grass control over two applications of Clarity, but did not improve Palmer amaranth control.

Practical Applications

The in-season use of dicamba in Arkansas cotton provides growers with an additional mode of action to aid in the control of glyphosate-, ALS-, and PPO-resistant Palmer amaranth in addition to other broadleaf weeds. The establishment of early-season residual weed control is essential, when dicamba must be applied alone. These data will be used to make weed control recommendations across the state.

Acknowledgments

Support provided by the University of Arkansas System Division of Agriculture.

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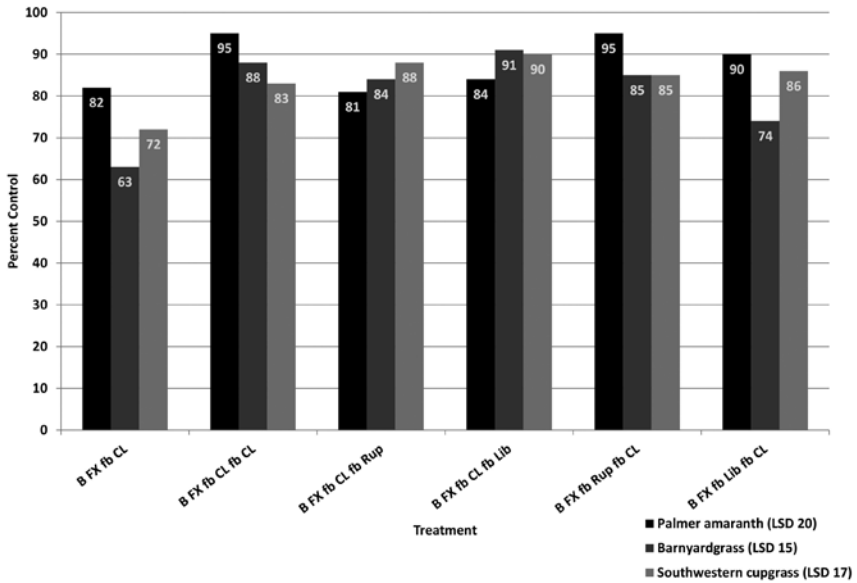


Fig. 1. 2016 Brake FX Systems Weed Control 21 days after treatment (DAT) at the University of Arkansas System Division of Agriculture’s Rohwer Research Station, in Rohwer, Ark. B-Brake FX 0.9 lb ai/acre, CL-Clarity 0.5 lb ai/acre, L-Liberty 0.53 lb ai/acre, Rup-Roundup PowerMax 0.95 lb ai/acre, LSD-least significant difference.

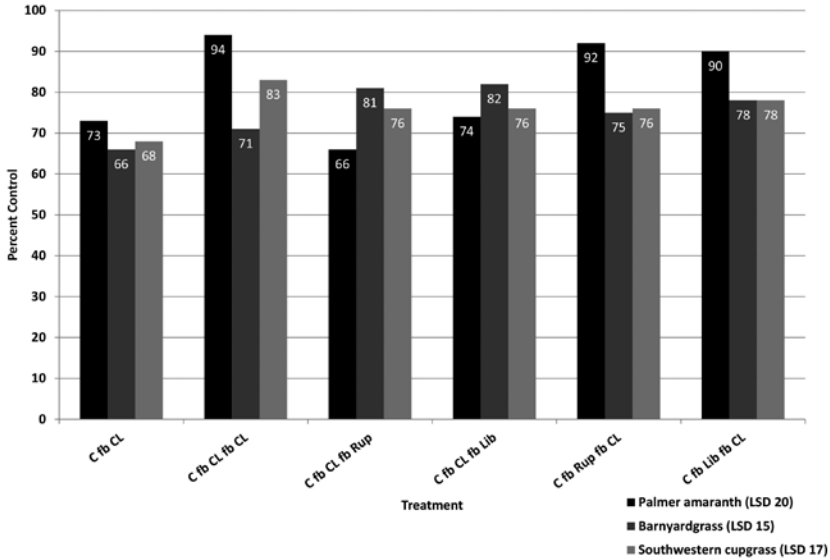


Fig. 2. 2016 Cotoran Systems Weed Control 21 days after treatment (DAT) at the University of Arkansas System Division of Agriculture's Rohwer Research Station, in Rohwer, Ark. C-Cotoran 1.0 lb ai/acre, CL-Clarity 0.5 lb ai/acre, L-Liberty 0.53 lb ai/acre, Rup-Roundup PowerMax 0.95 lb ai/acre, LSD-least significant difference.

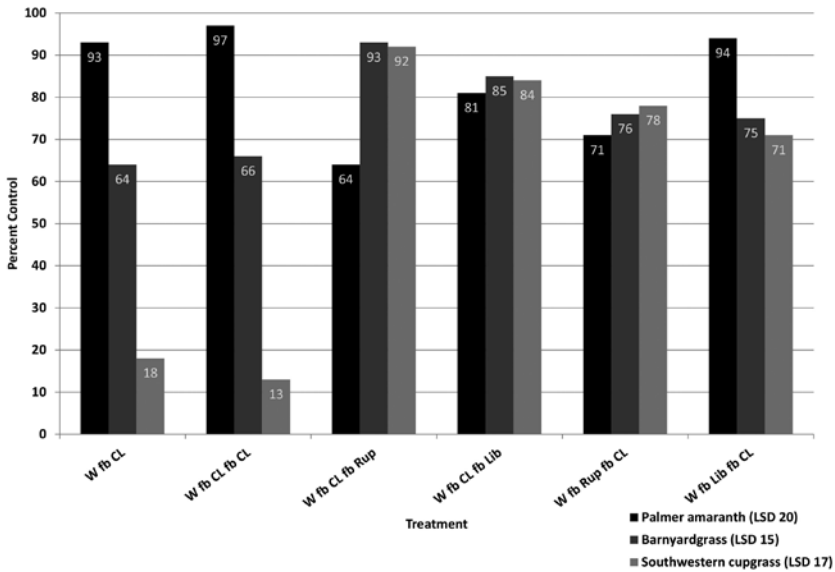


Fig. 3. 2016 Warrant Systems Weed Control 21 days after treatment (DAT) at the University of Arkansas System Division of Agriculture's Rohwer Research Station, in Rohwer, Ark. CL-Clarity 0.5 lb ai/acre, L-Liberty 0.53 lb ai/acre, Rup-Roundup PowerMax 0.95 lb ai/acre, W-Warrant 1.13 lb ai/acre, LSD-least significant difference.

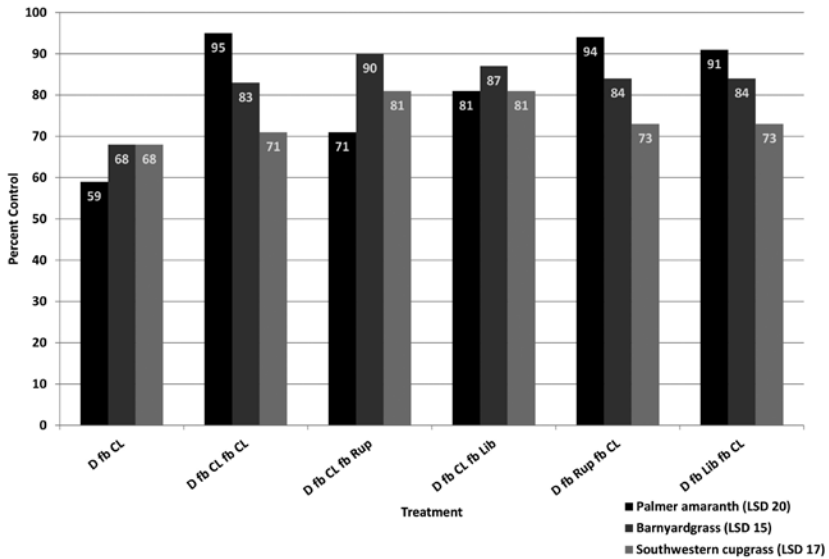


Fig. 4. 2016 Direx Systems Weed Control 21 days after treatment (DAT) at the University of Arkansas System Division of Agriculture’s Rohwer Research Station, in Rohwer, Ark. CL-Clarity 0.5 lb ai/acre, D-Direx 0.75 lb ai/acre, L-Liberty 0.53 lb ai/acre, Rup-Roundup PowerMax 0.95 lb ai/acre, LSD-least significant difference.

Evaluating Efficacy of Herbicide Programs for Use in Enlist™ Cotton

N.R. Steppig¹, J.K. Norsworthy¹, L.T. Barber², and C.J. Meyer¹

Research Problem

Dow AgroSciences recently commercialized Enlist™ cotton, which is resistant to applications of the herbicides 2,4-D, glyphosate, and glufosinate. Use of this technology allows for applications of tank-mixed combinations of all three herbicides. The objective of this research was to determine the efficacy of herbicide programs utilizing combinations of the three herbicides for control of troublesome weeds in cotton production systems.

Background Information

Weeds, specifically annual grasses and glyphosate-resistant (GR) Palmer amaranth, present major issues to cotton growers in the Midsouth (Van Wychen, 2016). Herbicides available for use in Enlist™ crops have shown high levels of control of these problematic weeds in soybean (Miller and Norsworthy, 2015); however, limited studies exist in cotton. As such, research is needed to assess the efficacy of these herbicides in Arkansas cotton production systems.

Research Description

A field experiment was conducted in 2016 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, in Marianna, Ark. Eight herbicide treatment programs (Table 1), plus an untreated check were evaluated. All programs, except the untreated plot, received an application of Cotoran at planting, followed by an application when weeds reached 2–4 inches (early post-emergence, EPOST) and a subsequent application two weeks after EPOST (mid post-emergence, MPOST). Visual estimates of weed control were collected weekly following herbicide application and assessed on a 0-100 scale (0 = no injury, 100 = complete plant death), in addition seedcotton yield was collected at the end of the season. Data were subjected to analysis of variance and significant means separated using Fisher's protected least significant difference

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test ($\alpha = 0.05$). Additionally, orthogonal contrasts were run to determine whether the addition of a soil-residual herbicide (Dual II Magnum[®]) increased weed control/yield.

Results and Discussion

At 6 weeks after MPOST, Palmer amaranth control was $\geq 88\%$ in all treatments that included a non-glyphosate post-emergence (POST) herbicide and annual grass control was $\geq 88\%$ in all programs that included a POST herbicide (Figs. 1 and 2). Seedcotton yield was significantly greater in programs that included a non-glyphosate POST herbicide compared to those that did not (Fig. 3). The inclusion of one or more effective modes of action for control of GR Palmer amaranth, applied post-emergence, provided increased weed control and a subsequent increase in seedcotton yield, compared to glyphosate-only programs. Additionally, although including Dual II Magnum did not statistically increase weed control, the use of residual herbicides is commonly recommended to combat the spread of herbicide resistance.

Practical Applications

Results from this research indicate that tank-mixing the herbicides associated with Enlist[™] cotton (2,4-D choline, glyphosate, and glufosinate), plus including a herbicide with residual weed control, will result in high levels of weed control and ultimately increased cotton yield.

Acknowledgments

The authors wish to offer thanks to Cotton Incorporated and the University of Arkansas System Division of Agriculture for support of this research.

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Table 1. Herbicide programs, including treatment number, pre-emergence (PRE), early post-emergence (EPOST), and midseason post-emergence (MPOST) herbicide applications.

Treatment	PRE	EPOST	MPOST
1	-	-	-
2	Cotoran ^a	-	-
3	Cotoran	Roundup ^b	Roundup
4	Cotoran	Liberty ^c	Liberty
5	Cotoran	Enlist Duo ^d	Enlist Duo
6	Cotoran	Enlist Duo	Liberty
7	Cotoran	Enlist Duo + Dual Magnum ^e	Enlist Duo
8	Cotoran	Liberty + Dual Magnum	Liberty + Roundup
9	Cotoran	Liberty + Dual Magnum	Enlist Duo

^a Cotoran = fluometuron; 1000 g ae ha⁻¹.

^b Roundup = glyphosate; 1120 g ae ha⁻¹.

^c Liberty = glufosinate; 595 g ai ha⁻¹.

^d Enlist Duo = 2,4-D plus glyphosate; 1120 + 1065 g ae ha⁻¹.

^e Dual Magnum = S-metolachlor 1071 g ai ha⁻¹.

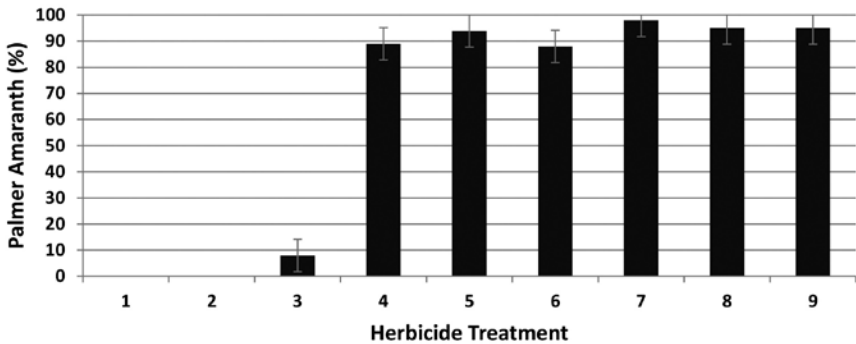


Fig. 1. Palmer amaranth control 6 weeks after mid post-emergence application. Where error bars overlap, mean control is not significantly different ($\alpha = 0.05$). Herbicide treatments are listed in Table 1.

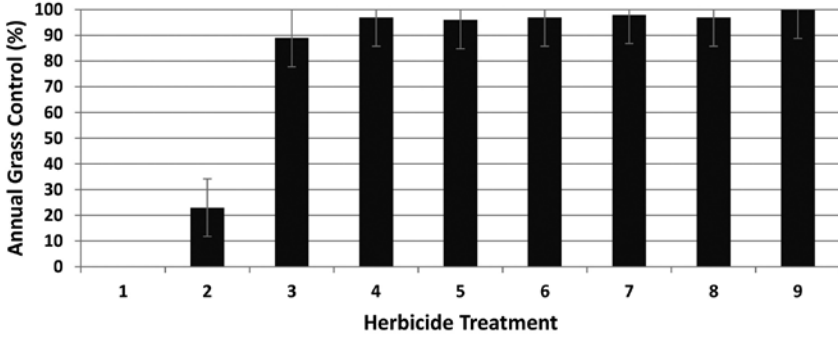


Fig. 2. Broadleaf signalgrass control, used to represent similar levels of control in barnyardgrass, large crabgrass, and goosegrass, 6 weeks after mid post-emergence application. Where error bars overlap, mean control is not significantly different ($\alpha = 0.05$). Herbicide treatments are listed in Table 1.

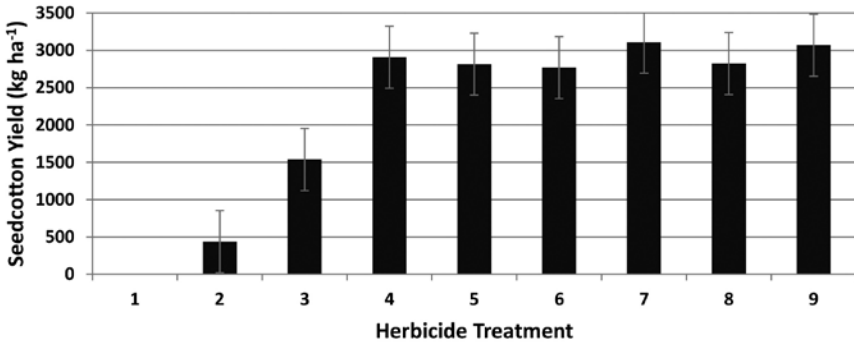


Fig. 3. Seedcotton yield data. Where error bars overlap, mean yield is not significantly different ($\alpha = 0.05$). Herbicide treatments are listed in Table 1.

Alternatives to Neonicotinoids for Control of Thrips in Cotton

M. Chaney¹, G. Lorenz¹, N. Taillon¹, A. Plummer¹, J. Black¹, and A. Cato²

Research Problem

Thrips are early-season pests in cotton that can delay maturity and cause yield loss. With the future of neonicotinoid products uncertain and thrips tolerance/resistance to thiamethoxam (Cruiser/Avicta) being found in Arkansas, there is a need to evaluate alternative products for thrips control. The objective of this study, conducted at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Ark, was to evaluate other insecticide classes as a seed treatment or in-furrow treatment for control of thrips.

Background Information

Symptoms of thrips damage on young cotton are crinkled leaves, burnt edges, and a silvery appearance. Thrips are considered to be the second most costly insect pest of cotton in Arkansas. In 2014, thrips infested 83% of cotton acreage causing a loss of 1281 bales of cotton in Arkansas (Williams, 2015). In the last several years, insecticide resistance in tobacco thrips, the predominant species found in cotton in the mid-South, has made this a difficult pest to control. Recent studies have indicated that tolerance/resistance has developed to thiamethoxam (Cruiser/Avicta) in the mid-South (Herbert and Kennedy, 2015). Studies conducted by Plummer et al. (2015) in Arkansas support these findings. Insecticide seed treatments and additional foliar insecticide application(s) are often necessary to effectively control thrips, creating high input costs for growers. In recent years, neonicotinoids have come under scrutiny for their impact on pollinators (Krupke et al., 2012). With the threat of losing this class of insecticides, there is a need to find alternative modes of action to control thrips.

Research Description

Plot size was 12.5 ft by 40 ft in a randomized complete block design with 4 replications. Treatments consisted of 3 insecticide seed treatments (IST): Veri-

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mark (cyantraniliprole) 13 oz/cwt; Orthene (acephate) 15 oz/cwt; and Aeris Seed Applied System (imidacloprid + thiodicarb) 33.27 oz/cwt. Aeris was used as the neonicotinoid commercial standard. Five in-furrow treatments (IF) treatments included: Verimark at 13 oz/acre, Orthene at 1 lb/acre, Sivanto (flupyradifurone) at 7 oz/acre, and Aldicarb at 3.5 and 5 lb/acre. All treatments, including the untreated check (UTC), were treated with a base fungicide package of Trilex Advanced at 1.6 oz/cwt. Insecticide seed treatments were applied using a small batch treater. In-furrow applications were applied with an in-furrow mounted sprayer system at 10 gal/acre set at 40 psi using Tee Jet 9001 VS flat fan nozzles for Sivanto, Orthene, and Verimark, while a planter-mounted granular applicator was used for Aldicarb treatments. Plots were planted on 6 May. Thrips samples were taken 18 and 26 days after planting (DAP) by collecting 5 plants per plot and placing in jars with 70/30 alcohol solution. Samples were washed and filtered in the lab at the University of Arkansas System Division of Agriculture's Lonoke Extension Center, Lonoke, Ark., and thrips were counted using a dissection scope. Thrips damage ratings were taken at 20 and 28 DAP using the scale 0–5 where 0 = no damage, and 5 = plant loss. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

At 18 DAP all treatments had fewer thrips than the UTC except Sivanto IF and Verimark IST; Aldicarb IF 5 lb/acre had fewer thrips than Verimark IF, Aeris Seed Applied System IST, and Orthene IF (Fig. 1). Thrips damage ratings taken at 20 DAP show all treatments had less damage than the UTC except Sivanto IF and Verimark IST; Aldicarb IF at both rates had less damage than Verimark IF and Orthene IF (Fig. 2). Thrips counts 26 DAP show all treatments to be lower than the UTC except Sivanto IF and Verimark IST; Aldicarb IF 5 lb/acre had fewer thrips than all other treatments; Aldicarb IF 3.5 lb/acre had fewer thrips than both Verimark IF and Aeris Seed Applied System IST (Fig. 3). At 28 DAP thrips damage ratings showed all treatments except Sivanto IF to have less damage than the UTC; Aldicarb at both rates and Aeris Seed Applied System IST had a less damage than all other treatments; Orthene IF and IST, Aeris Seed Applied System IST, and Aldicarb 3.5 lb/acre had less damage than Verimark IF and IST, and Sivanto IF (Fig. 4). Harvest showed Orthene IF and IST, Aeris Seed Applied System IST, Aldicarb IF 5 lb/acre, and Verimark IF had higher yield than the UTC (Fig. 5).

Practical Applications

Results indicated that Orthene insecticide seed treatment and in-furrow, Verimark IF and Aldicarb IF applications were very effective for thrips control. Yield shows these treatments have comparable yield to Aeris Seed Applied System, the

standard neonicotinoid. Use of these products will be determined by price of application, planting system, and market prices. More research is needed to help find new alternative insecticides for control of thrips in cotton.

Acknowledgements

The authors acknowledge the University of Arkansas System Division of Agriculture. Appreciation is expressed to the Lon Mann Cotton Research Station.

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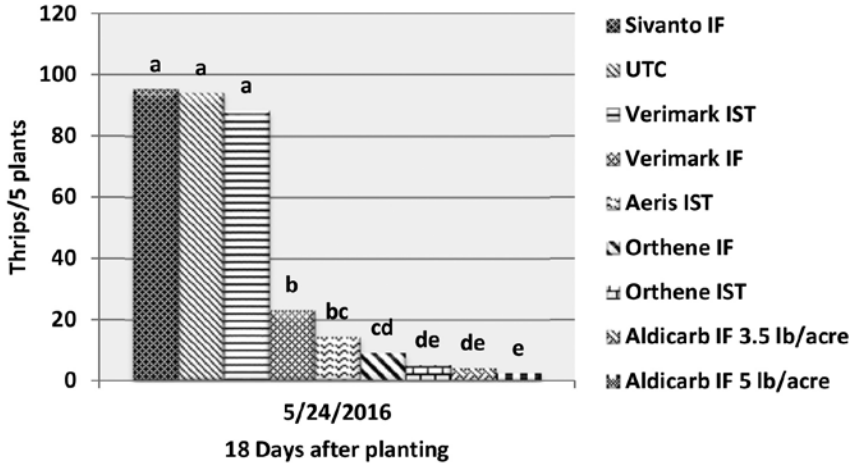


Fig. 1. Thrips counts at 18 days after planting at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station, Marianna, Ark. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan’s New Multiple Range Test ($P = 0.10$) to separate means.

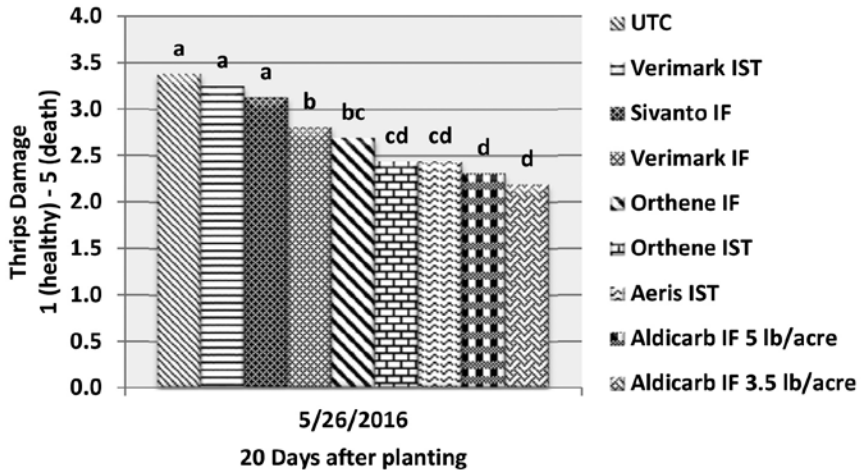


Fig. 2. Thrips damage ratings at 20 days after planting at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station, Marianna, Ark. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan’s New Multiple Range Test ($P = 0.10$) to separate means.

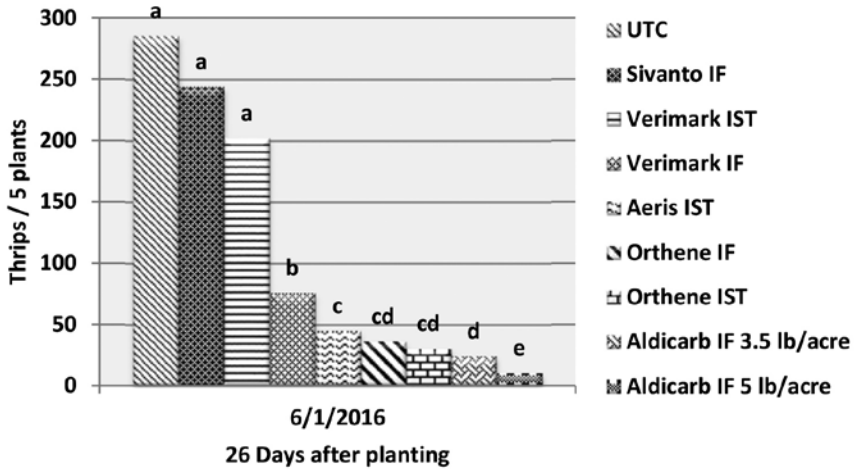


Fig. 3. Thrips counts at 26 days after planting at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station, Marianna, Ark. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan’s New Multiple Range Test ($P = 0.10$) to separate means.

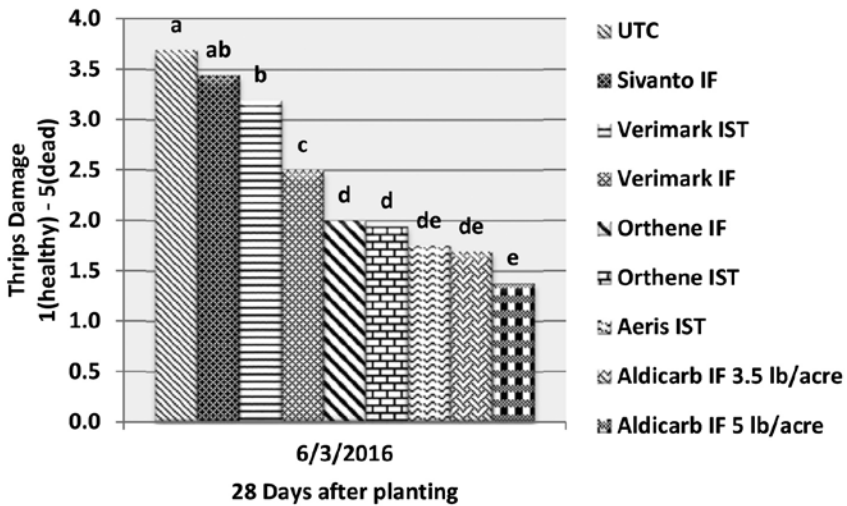


Fig. 4. Thrips damage ratings at 28 days after planting at the University of Arkansas System Division of Agriculture’s Lon Mann Cotton Research Station, Marianna, Ark. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan’s New Multiple Range Test ($P = 0.10$) to separate means.

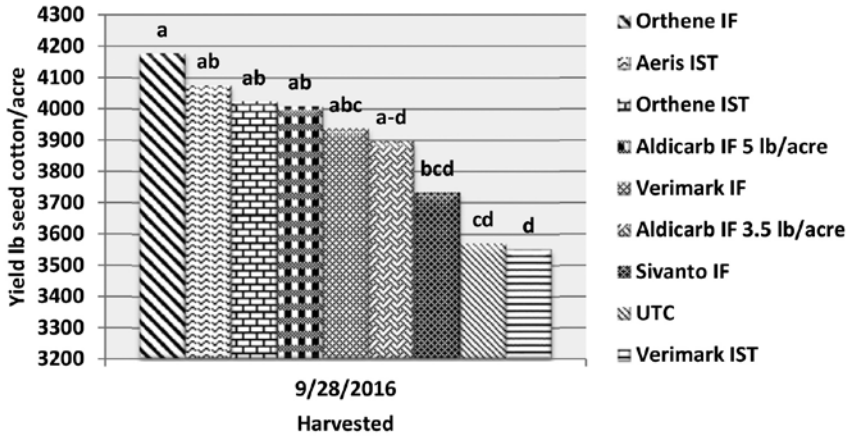


Fig. 5. Seed cotton yield in response to thrips treatments at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Ark. in 2016. Data were processed using Agriculture Research Manager, V. 9 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Comparison of Control of Heliothines in Non-*Bacillus thuringiensis* (*Bt*) and Dual Transgenic *Bt* Cotton

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Research Problem

The bollworm (*Helicoverpa zea*, Boddie) is a major pest of cotton in Arkansas. In most cases, dual-*Bacillus thuringiensis* (*Bt*) gene technology (Bollgard II or Widestrike) provides adequate control of this pest; however when bollworm populations are high, the control may not be adequate to prevent damage. This study was conducted to determine the impact and efficacy of a foliar overspray of Prevathon (chlorantaniliprole) on dual transgene *Bt* cotton cultivars and a non-*Bt* cultivar to determine the efficacy of an overspray and the value for non-*Bt* and dual gene cotton.

Background Information

Each year, the bollworm infests 100% of cotton planted in Arkansas. It remains a major pest of flowering cotton in the mid-South despite widespread use of transgenic *Bt* cultivars. Dual-*Bt* gene cotton does not always provide adequate protection from lepidopteran pests to maintain potentially high yields. In years when bollworm populations are high, foliar insecticides are commonly used to supplement control of cotton bollworm. In 2015, 98% of the cotton acreage in Arkansas was planted with dual-*Bt* gene cultivars (Williams et al., 2015). A recent analysis of data since 2007 indicates that there has been an increase in damage to squares which may mean some tolerance could be developing to dual-*Bt* gene technologies (pers. comm., G. Lorenz). In Arkansas, economic loss to the grower based on cost of treatment and reduction in yield due to this pest totaled more than \$1.7 million or \$9.41 per acre. The objective of this study was to evaluate the impact and efficacy of foliar oversprays on non-*Bt* and dual-*Bt* gene cottons, specifically Bollgard II and WideStrike, for control of cotton bollworm and to determine a threshold level based on percent damage.

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Research Description

A trial was conducted on a grower field in Jefferson County, Ark. 2016. Plot size was 12.5 ft. (4 rows) by 40 ft. in a randomized complete split-block with 4 replications. Treatments included a non-*Bt* cultivar (DP 1441 RF); a WideStrike cultivar (PHY 499 WRF); and a Bollgard II cultivar (ST 4946 B2RF); and a sprayed and unsprayed regime. For sprayed plots, a foliar application of Prevathon at 20 oz/ acre was made on 19 July. Application was made using a Mudmaster high clearance sprayer fitted with 80-02 dual flat fan nozzles at 19.5-inch spacing with a spray volume of 10 gal/a at 40 psi. Damage ratings were taken pre-application, and 3, 8, 15, and 27 days after application by sampling 25 squares, flowers, and bolls per plot. Plots were harvested using a John Deere two-row plot picker. The data were processed using Agriculture Research Manager V. 9 (Gylling Data Management, Inc., Brookings, S.D.) and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

Prior to the application of Prevathon, percent fruit damage in the non-*Bt* cultivar was high, 15%, compared to WideStrike at 4% and Bollgard II with 0.3% damage (Fig. 1). At 3 days after application, non-*Bt* sprayed, WideStrike sprayed and unsprayed, and Bollgard II sprayed and unsprayed had less damage than the non-*Bt* unsprayed (Fig. 2). Bollgard II had less damaged fruit than WideStrike; however, no differences were observed for either of the dual-*Bt* cultivars when comparing sprayed and unsprayed. At 8 days after application, all treatments had less damaged fruit than the unsprayed non-*Bt* treatment (Fig. 3). Bollgard II sprayed, Bollgard II unsprayed and WideStrike sprayed had less damage than WideStrike unsprayed and the non-*Bt* sprayed treatment. At 15 days after application, all treatments had less fruit damage than non-*Bt* unsprayed (Fig. 4). All other treatments had less fruit damage than WideStrike unsprayed. Similar differences were observed 22 days after application (Fig. 5).

Yield indicated that non-*Bt* sprayed, WideStrike sprayed and unsprayed, and Bollgard II sprayed and unsprayed had higher yield than non-*Bt* unsprayed (Fig. 6). Non-*Bt* sprayed, WideStrike sprayed, and Bollgard II sprayed and unsprayed had higher yield than WideStrike unsprayed. There is a clear indication that there was not enough damage in the Bollgard II to affect yield.

In 2016, we observed extremely high levels of fruit damage indicating control without foliar applications could result in severe yield loss with WideStrike technology; however, the Bollgard II cultivar maintained control without foliar application of insecticide. Yield results from previous studies, (Lorenz et al., 2012; Taillon et al., 2014; Orellana et al., 2014), show the impact of foliar applications on transgenic *Bt* cultivars varies from year to year. Foliar applications increased yield in Bollgard II and WideStrike cultivars in 2012, but not in 2013 and 2014.

Practical Applications

Our results indicated that a non-*Bt* cultivar sprayed with Prevathon can yield similarly to current *Bt* cultivars, and some cultivars of *Bt* cotton can benefit from an insecticide application in years when bollworm pressure is high. These studies suggest that in some years when a non-*Bt* cultivar is sprayed with insecticides, it can yield similarly to current *Bt* cultivars and some cultivars of *Bt* cotton can benefit from an insecticide application in years when cotton fields are under high bollworm pressure. Further studies will be conducted to determine the impact of supplemental foliar applications on second and third generation *Bt* cottons as well as to monitor for tolerance and determine a threshold level based on the percentage of damage to the fruit.

Acknowledgments

Appreciation is expressed to Chuck Hooker. We would also like to thank Cotton Incorporated, Dow, Monsanto, and the University of Arkansas System Division of Agriculture for their support.

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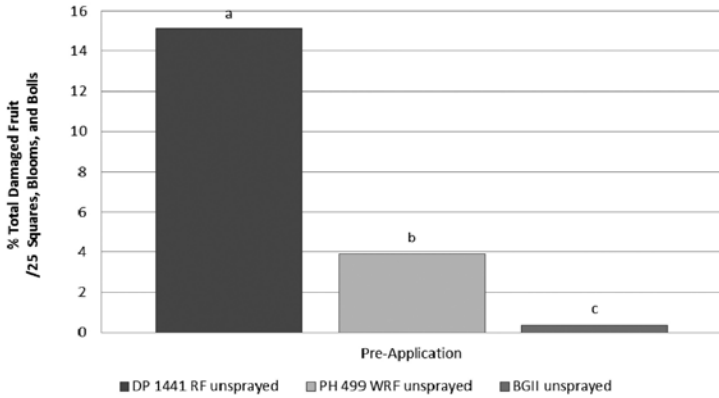


Fig. 1. Percent total bollworm damage of fruit in the trial before application of Prevathon 20 oz/acre to determine infestation levels, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

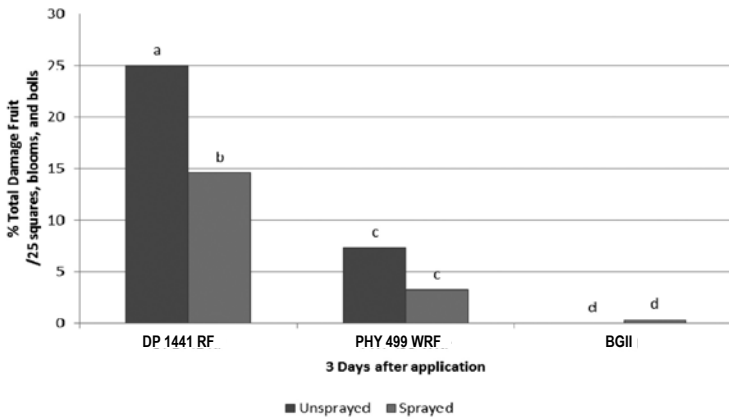


Fig. 2. Percent total damage of fruit 3 days after application of Prevathon 20 oz/acre, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

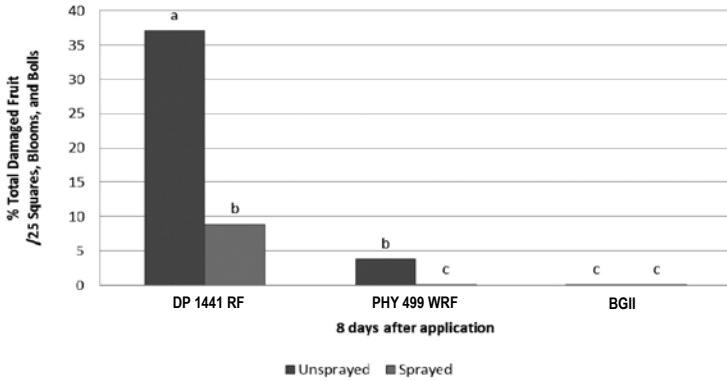


Fig. 3. Percent total damage of fruit 8 days after application of Prevathon 20 oz/acre, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

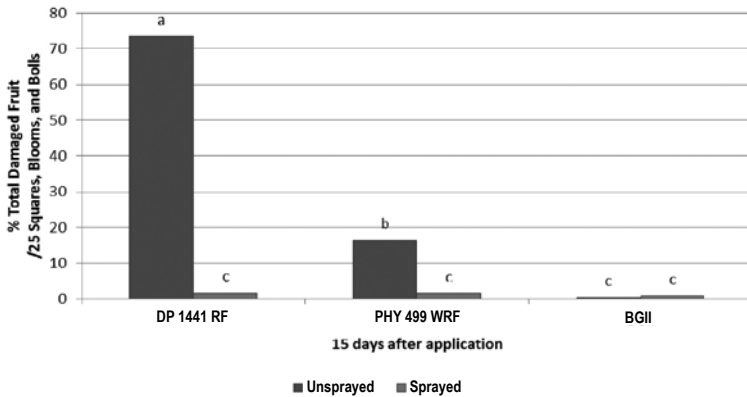


Fig. 4. Percent total damage of fruit 15 days after application of Prevathon 20 oz/acre, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

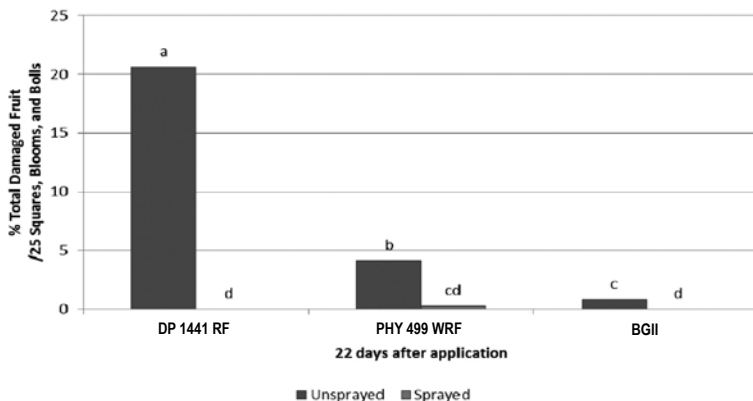


Fig. 5. Percent total damage of fruit 22 days after application of Prevathon 20 oz/acre, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

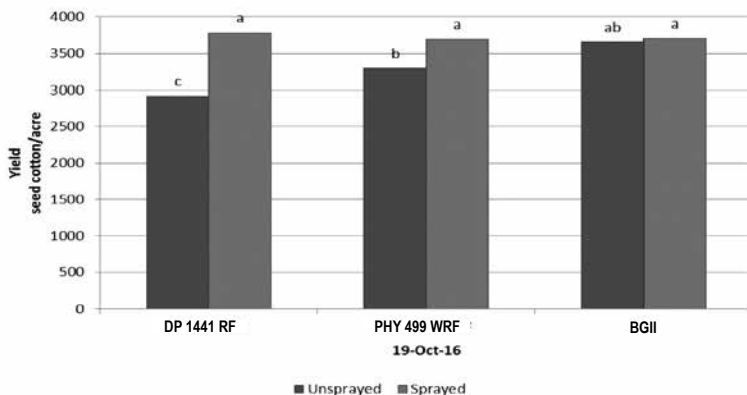


Fig. 6. Yield, lbs seed cotton/acre, grower field in Jefferson County, Ark. Means followed by same letter or symbol do not significantly differ ($P = 0.10$, Duncan's New Multiple Range Test).

Integrating Cereal Rye Cover Crop and Reduced Tillage to Improve Soil Health and Sustainability

B. Robertson¹, A. Free¹, M. Daniels², C. Henry³, and S. Stevens⁴

Research Problem

Producers are continuously focusing on adjustments that can be made to increase efficiency in an effort to improve profitability. As producers improve efficiency, a positive impact is often observed with regard to sustainability. Those in the supply chain are very interested in becoming more sustainable all through their process and desire to source responsibly produced commodities for their products. The Fieldprint Calculator[®] is an online tool developed by Field to Market[®] that is available for use by producers to measure their environmental footprint and is one of the tools those in the supply chain have invested in and are using to document improvements in sustainability. The results of this tool across an area where commodities for use in their products are produced will be the basis for improvement claims by those in the supply chain in the future. Reducing tillage and employing the use of cover crops are two practices that have perhaps the greatest impact on reducing the environmental footprint and improving sustainability of cotton.

Background Information

The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980. In 2014, the CRVP became known as the Cotton Research Verification/ Sustainability Program CRVSP. The CRVSP expands beyond that of the traditional verification program by measuring the producers' environmental footprint for each field and evaluating the connection between profitability and sustainability. The CRVSP conducted research in three counties in 2015 and 2016: Desha, Mississippi and St. Francis counties. In Desha County, the CRVSP conducted research along with the Arkansas Discovery Farms Program in Southeast Arkansas for two fields: Shopcot and Weaver fields. Discovery Farms' main focus is on edge-of-field water quality,

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which traces irrigation efficiency and nutrient and sediment losses. All fields in Desha County were composed of two irrigation sets allowing for comparison of farmer standard practice to that of a modified production system. The split-field design facilitates comparisons of how each practice impacted edge-of-field water quality and ultimately profitability of each system.

All fields were monitored for inputs and were entered into the Fieldprint Calculator. The Fieldprint Calculator® is a relatively new tool developed by Field to Market®: The Alliance for Sustainable Agriculture. The Fieldprint Calculator was designed in an effort to help educate producers on how adjustments in management could affect environmental factors. Utilization of the calculator assists producers by making estimates over seven sustainability factors: land use, soil conservation, soil carbon, irrigation water use, water quality, energy use and greenhouse gas emissions. Fieldprint Calculator estimates a fields' performance and compares results to national and state averages. Calculated summaries give producers insight into the ability to identify areas for improved management on their farm.

Research Description

The two-year evaluation was comprised of two fields in Desha county in 2015 and 2016 which allowed for observation of two systems. A farmer standard tillage was compared to a no-till field with cover in an effort to improve sustainability, profitability and soil health. Each system studied composed half of the field. Throughout the study, all producers' inputs were recorded providing the information needed to calculate both fixed and variable costs. Field data were collected through utilization of soil penetrometers, soil moisture sensors, rain gauges, evapotranspiration (ET) gages, flow meters, and trapezoidal flumes. Soil penetrometers were used to measure soil compaction at both 3 and 6 inches throughout the season in both no-till with cover and farmer standard tillage. A set of three soil moisture sensors were placed in both no-till with cover and farmer standard tillage at 6, 12, and 18 inches. Evapotranspiration gauges were used to trigger irrigation. Flow meter readings allowed documentation for how much water was applied across all fields, and runoff data were collected at the two Discovery farm fields after irrigations and rainfall events through the use of trapezoidal flumes.

Results and Discussion

Soil compaction was consistently lower in no-till with cover fields, soil moisture was consistently higher in no-till with cover fields, and irrigation water flow rates down the row were slower in no-till with cover fields. After large rainfall events, we observed that no-till fields with cover practices infiltrate water quicker which allowed for decreased runoff when compared to that of a stale seeded rehipped field with a cover crop. Established cover crops allow for other benefits noticed this year in all no-till with cover fields, including increased observation

of earthworms. Earthworms are a great soil health indicator. Across all field locations, no-till with cover fields had only one tillage operation (FurrowRunner) vs. multiple tillage operations in farmer standard tillage. The FurrowRunner provided a very narrow trench in the furrow to help with water movement while leaving all cover crop residue on the sides of the furrow and on top of the row, thus having only minimal disturbance. Water movement slowed as water worked its way through stubble allowing for better water infiltration and less runoff. Irrigation water use efficiency ranged from a low of 88% on Weaver field to as high as 100% on Shopcot field throughout the season. On the date that Weaver field had an irrigation efficiency of 88%, the field also received a 1.1 inch rain. The fields that had two or more years of established cover crops had an increased yield, with the no-till with cover fields producing 1175 lb lint/acre across both years when compared to farmer standard tillage practices producing only 1125 lb lint/acre. Total variable costs were 46 cents/lb of lint, compared to the 52 cents/lb of lint produced for the farmer standard. The environmental footprint calculated by the Fieldprint Calculator, showed a smaller or more sustainable footprint with the no-till cover field. Sustainability measure improved in the five quantitative Fieldprint Sustainability metrics: land use, soil conservation, irrigation water use, energy, and greenhouse gas emissions (Table 1).

Practical Applications

Changes in production practices toward no-till with a cover crop had the greatest impact on improving soil conservation by reducing total soil erosion losses by 68%, improving irrigation water use by over 18%, and reducing greenhouse gas emissions and improving land use or yield by over 11%. This practice also resulted in decreasing total variable costs by \$0.06/lb of lint produced. Additional research is needed to further evaluate how profitability, irrigation water use efficiency, size of environmental footprint, soil health, and continuous improvement are related.

Acknowledgments

Support provided by the University of Arkansas System Division of Agriculture.

Table 1. Two-year sustainability metrics: improvements with no-till with cereal rye cover vs. farmer standard tillage practices.

Sustainability Metrics	Two-year Averages
Land Use	11.17%
Soil Conservation	68.01%
Irrigation Water Use	18.58%
Energy Use	12.06%
Greenhouse Gas Emissions	11.33%

Procedures to Analyze Cotton Yields from Three Seeding Rate Densities in Northeast Arkansas

R. Benson¹, A.M. Mann², D.K. Morris³, and T.G. Teague²

Research Problem

Yield monitors and variable-rate planter controllers have become standard technologies on many Arkansas cotton farms. Researchers and cooperating producers can exploit this equipment capacity in on-farm studies to evaluate new practices and products, which may improve production efficiency. Cotton seeding density studies represent a research area that may provide information to help producers reduce production costs and maintain production levels. The objectives of this study were to develop and refine guidelines for cotton seeding densities specific to fields in northeast Arkansas, and to identify appropriate procedures for managing and analyzing georeferenced yield monitor data.

Background Information

Results from previous research have suggested that reducing seeding densities to approximately 1.0 seed/row ft had a minimal impact on cotton lint yield (Bednarz et al., 2005). In those experiments, emerged seedlings were hand-thinned to achieve the desired plant stand density. From a practical standpoint, questions remain regarding the impact of reducing seeding rates using large-scale production planters. In addition to seed cost savings, reduced stand densities and plant biomass have been shown to be less attractive to immigrating adults of *Lygus* spp. (Heteroptera: Miridae) (Leigh et al., 1974; Willers et al., 1999), and may result in a reduction of pesticide applications during the production season. With availability of variable-rate planter controllers capable of planting multiple seed types (e.g. cultivars, seed treatments, etc.) at different rates within the same planter pass, field scale research is needed to evaluate variable seeding rates on production efficiency. Data management and geospatial analysis of GPS-referenced yield monitor data from such studies represent a departure from traditional data management/analysis methods. Preparing yield maps for analysis is often confounded due to erroneous yield points in the data (Blackmore and Marshall, 1996). Studies have shown that 10–31% of yield monitor data points contain significant errors

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and should be removed (Blackmore, 1999). Sudduth and Drummond (2007) indicated that removing data points containing error improved the spatial structure of the data and improved the quality of data for testing research hypotheses. Georeferenced yield monitor points often display patterns of yield estimates that vary due to location, and may suggest heterogeneity and dependence in the data. Tobler's first law of geography states that all things are related, but nearer things are more related than those separated by distance (Tobler, 1970). As such, spatial data likely violate several assumptions required for traditional statistical analysis and require different procedures to account for spatial error (Anselin, 1989; Griffin et al., 2006).

Research Description

A large-plot study was established during the 2016 production season in a commercial field on Wildy Family Farms in Mississippi County in northeastern Ark. The study was conducted to evaluate the effects of seeding rate on cotton yield. Soils in the field were classified as a Routon Dundee-Crevasse Complex and ranged from coarse sand to areas of heavy clay. The experiment was designed as a randomized complete block with six replications. Seeding rate treatments were programmed into the producer's John Deere 1720 12-row vacuum planter equipped with a hydrolytic variable-rate driver. Seeding rates evaluated in the study were 1.5, 3.0 and 4.5 seed/ row foot and included cultivar Deltapine 1518 B2XF planted 8 May. Each seeding rate plot was 12 rows wide and planted the entire length of the field (approximately 1200 ft). Cultural practices including furrow irrigation followed the cooperating farmer's standard and were consistent across all plots. Plots were harvested on 28 October using the producer's 6 row John Deere cotton picker, and yield data were recorded on the GPS-referenced on-board yield monitor. Yield files were filtered for errors using USDA's Yield Editor version 2.0.7 (Sudduth and Drummond, 2007), and mapped using ArcMap version 10.3 (ESRI, Redlands, Calif). Average yield for each 12 row plot was analyzed using PROC GLM (SAS Institute, Inc., Cary, N.C.) with treatment means separated using Fisher's protected least significant difference at $P < 0.05$, methods commonly used in small-plot experiments. Those findings were compared to results obtained using spatial statistical methods. The data were evaluated for spatial autocorrelation, which was assumed not to be present for the traditional analysis, and analyzed using the spatial error statistical model available in GeoDa 1.8.16.4 (GeoDa Center for Geospatial Analysis and Computation, Arizona St. Univ., Tempe, Ariz.). To account for spatial effects, a distance-based weights matrix was imposed on the data and set to the minimum distance required to ensure each yield observation had at least one neighbor. Using the weights matrix, maximum likelihood estimation was used to determine the effects of seeding rate on cotton yield while accounting for autocorrelation in the data.

Results and Discussion

Data filtering with Yield Editor removed approximately 17% of the total yield data points (Table 1). The yield map of filtered yield monitor data provided visual evidence of spatial difference in yield across the field (Fig. 1). Results from traditional analysis techniques using PROC GLM indicated no significant treatment effects ($P = 0.86$). Moran's I test statistic for spatial autocorrelation (Anselin, 1995) in the data (0.65; $P < 0.001$) indicated significant spatial dependence of yield observations (Table 2) and suggested that aspatial (i.e. traditional statistics) analysis may be inappropriate for identifying treatment effects. Ordinary least squares (OLS) and spatial error analyses were conducted using all yield data points (10,199) remaining after filtering for errors (Table 3). The difference is that OLS does not account for spatial autocorrelation in the data. Results of analysis using the spatial error model provided a highly significant spatial autoregressive coefficient (SAC), λ , of 0.916 supporting the use of spatial models for data analysis. While differences between the yield estimates obtained from the spatial and aspatial analysis results were generally small, there were differences observed between the two methods in terms of their respective probability values. Using the spatial error model, yields obtained from the 4.5 seed/ft density resulted in a significantly lower yield than either the 1.5 or 3.0 seed/ft density treatment. There were no statistical differences observed between yields obtained from 1.5 or 3.0 seed/ft densities. These results suggest that reduced seeding rates may represent a cost reduction strategy in cotton production. Additionally, these data indicate that georeferenced yield monitor data may be used to test treatment effects of on-farm studies; however, spatial statistical procedures may be required to ensure accurate inferences are drawn from study results.

Practical Applications

The results of this study suggest that the use of georeferenced yield monitor data, and software to manage spatial data can be used to effectively analyze large block on-farm research. The application of statistical models that account for spatial autocorrelation (often associated with dense yield monitor data) may help ensure more accurate interpretation of test results. Combining spatial analysis techniques with the ability of producers to accumulate "on the go" harvest data should help facilitate experiments that will ultimately improve crop production efficiency in the region. Spatial analysis of seeding rate studies in 2016 indicated that yield was not increased as a result of higher planting densities. These data suggest that reducing seeding rates may improve overall farm efficiency and increase profits. Updated guidelines for variable-rate planting should be one eventual result of this research.

Acknowledgments

The authors appreciate continued cooperation and support of Wildy Family Farms. This project was supported through Cotton Incorporated Core and the University of Arkansas System Division of Agriculture's Arkansas Agricultural Experiment Station. This work was also supported, at least in part, by the USDA National Institute of Food and Agriculture project ARK02355.

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Table 1. Parameters and settings used for yield monitor data filtering, Manila, Ark. 2016.

Filtering parameter	Parameter value	Number of points cleaned (deleted)
Flow delay (s)	2	136
Start pass delay (s)	2	136
End pass delay (s)	3	204
Max speed (mph)	5.1	486
Min speed (mph)	3.5	770
Max yield (lb/A)	1750	25
Min yield (lb/A)	0	0

Table 2. Results of regression analysis (dependent variable = lint yield per acre) using georeferenced yield monitor data from the 2016 seeding rate study, Manila, Ark.

Seeding rate (seed/row ft)	Ordinary Least Squares (aspatial)			Spatial Error		
	Yield estimate (lb A ⁻¹)	Standard error	P-value	Yield estimate (lb A ⁻¹)	Standard error	P-value
1.5	1001	7.19	<0.003	1019	7.18	0.139
3.0	1031	7.16	<0.001	1018	7.90	0.230
4.5	1021	7.24	<0.001	984	8.00	0.003
λ^a				0.916	0.005	< 0.001
Degrees of freedom		10,199			10,199	
spatial weights matrix threshold distance, ft					21.7	
Diagnostics tests		Value			P	
Moran's I (error)		0.647			< 0.001	
Likelihood ratio test		783			< 0.001	

^a λ = spatial autoregressive coefficient; P-value of <0.001 indicates significant autocorrelation in the data.

Table 3. Results from aspatial analysis using PROC GLM (SAS), 2016 seeding rate study, Manila, Ark.

Source of variation	SS ^a	df	MS	F	P-value ^b
Replication	31309.61	5	6261.92	0.74	0.608
Seeding rate treatment	2668.44	2	1334.22	0.16	0.856
Error	84142.22	10	8414.22		
Total	118120.28	17			

^a SS = Sum of Squares; df = degrees of freedom; MS = Mean Square; F = F statistic.

^b Seeding rate treatments were not significantly different.

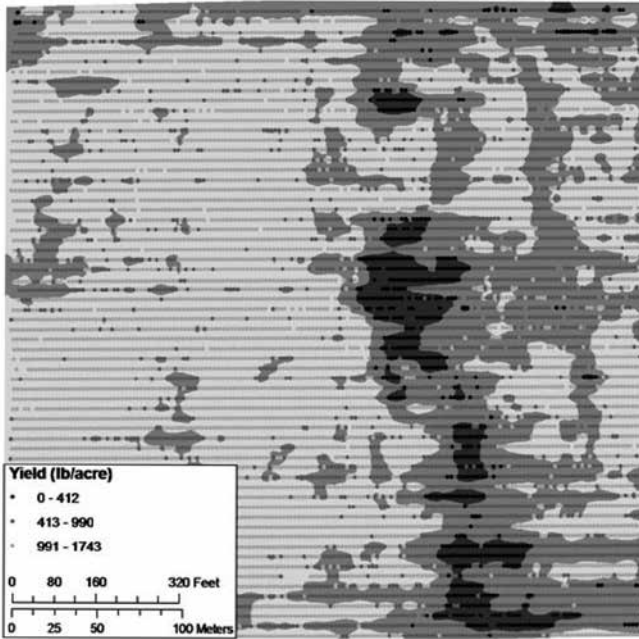


Fig. 1. Yield monitor map from 2016 seeding rate study; dark areas indicate low yield recordings, Manila, Ark.

Cultivar Selection, Seeding Rate, and Irrigation Timing Effects on Yield of Northeast Arkansas Cotton

N.R. Benson¹, A.M. Mann² and T.G. Teague²

Research Problem

To improve profitability, mid-South cotton producers must seek ways to reduce input costs and increase production efficiency. They can reduce losses to pests and lower their costs for crop protection when they select and grow cultivars that have been shown to exhibit host-plant resistance (HPR) to key insect pests and diseases. Given that the cost for treated, transgenic seed planted at current recommended seeding rates is nearly \$100/acre, adjustments in plant population densities through reduced seeding rates represent an opportunity for producers to reduce production costs if seeding rates can be lowered without yield penalties. Producers also are concerned with sustainability of groundwater resources, and they understand the need to increase irrigation water use efficiency. In this report, we summarize results from year 3 of a 3-year study focused on finding optimal management combinations of cultivar, seeding rate, and irrigation timing to improve cotton profitability.

Background Information

Cultural control tactics are agronomic practices that reduce pest abundance and damage below that which would have occurred if the practice had not been used. Host-plant resistance (HPR) is an important component of cultural control within integrated pest management (IPM) systems. Assessments of HPR characteristics of new cultivars of cotton are made annually in the University of Arkansas System Division of Agriculture's Cotton Variety Testing Program (<http://arkansasvarietytesting.com/home/cotton/>). In addition to cultivar selection, plant stand density can also impact pest interactions. For example, reduced stand densities and plant biomass have been shown to be less attractive to immigrating adults of *Lygus* spp. (Heteroptera: Miridae) (Leigh et al., 1974; Willers et al., 1999). Producers can significantly lower stand density and input costs by reducing rates of costly transgenic seed. In previous small-plot research where plant stand density was varied by hand-thinning, researchers showed that moderate reductions

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in plant stand densities have a minimal impact on cotton lint yield (Bednarz et al., 2005; Wrather et al., 2008). At the field scale, crop managers question impact of reduced seeding rates using production planters. Better timing of irrigation will help producers conserve precious groundwater resources, reduce production costs, as well as improve yields. Previous research in Arizona and Arkansas has shown yield advantages associated with early initiation of the first irrigation (Steger et al., 1998; Barber and Francis 2011; Bauer et al., 2012). These findings correspond with work done in Northeast Arkansas that showed earlier irrigation start times allowed avoidance of pre-flower water-deficit stress and increased both yields and earliness compared to irrigation initiation after flowering (Teague and Shumway, 2013).

Research Description

The objective of this 2016 on-farm study was to evaluate impacts of cultivar, seeding rate, and irrigation initiation timing on maturity and yield of cotton. The field trial was conducted in Mississippi County in Northeast Arkansas at the Manila Airport research field. Soils in the field are classified as Routon-Dundee-Crevasse complex (Typic Endoqualfs). The experiment was designed a $3 \times 3 \times 2$ factorial arranged in a split-plot arrangement with three irrigation treatments considered main plots. Three seeding rate and two cultivar treatments were randomized within main plots. Furrow irrigation treatments were 1) early start (initiation timing in 2nd week of squaring), 2) late start (initiation after first flower) and 3) rainfed (no irrigation). Seeding rates were 1.5, 3.0 and 4.5 seed per foot of row (38-inch row spacing). Cultivars were ST 5115 GLT (moderately susceptible to plant bugs) and ST 5288 B2RF (relatively resistant) based on rankings by Bourland et al. (2013, 2016).

A John Deere 12-row vacuum planter was used to establish the 12-row wide plots, 100 ft long with 10-ft alleys separating plots within the field. Weekly stand counts beginning at 8 days after planting (DAP) were made using line-transect sampling with counts of plants per 3 ft. in two transects across 12 rows in each plot (Willers et al., 1992). Plant monitoring included weekly counts of main-stem sympodia and assessments of first position square retention and plant height using standard COTMAN Squaremap sampling protocols (Oosterhuis and Bourland, 2008). Tarnished plant bug abundance was monitored with drop cloths in weekly samples starting in the first week of squaring and extending through nodes above white flower (NAWF) = 5. Cultural practices, with the exception of irrigation timing, were based on the producer's standard management criteria and were consistent across all plots within the study (Table 1). Irrigation timing was based on in-field monitoring of evapotranspiration and soil moisture assessments with Watermark sensors set at depths of 6 and 12 inches in the top of beds in 12 sensing stations distributed in irrigation main plots across the field. Plots were harvested using the cooperating producer's cotton picker, and lint yields determined from

the center 6 rows of each subplot. Yields were extracted from yield monitor data with data post-calibrated. Data were analyzed using PROC MIXED (SAS Institute, Inc., Cary, N.C.).

Results and Discussion

Weather conditions were cool and wet after planting presenting challenges for stand establishment. Results from plant stand count results, presented as a percentage of the target seeding rate planted, showed that ST 5288 B2RF had a lower percentage of emerged plants compared to ST 5115 GLT for each seeding rate over each sample period (Fig. 1). There were no significant interactions between seeding rate and cultivar. Precipitation information is shown in Table 2 and with COTMAN growth curves in Fig. 2. Pace of plant nodal development prior to first flowers (60 DAP) among cultivars in relation to the target development curve showed effects of early cool temperatures (Fig. 2). Plants in the lowest seeding rate treatment produced slightly more squaring nodes by first flowers compared to the higher seeding rates; there were no differences among irrigation treatments (data not shown). Mean number of days to physiological cutout (NAWF = 5) was significantly ($P < 0.001$) affected by seeding rate with earlier maturity with highest seeding rate (Fig. 2). Irrigation effects did not affect days to cutout, and there were no significant interactions. Soil moisture measurement data showed great variability among soil textures within the same irrigation treatment; these data summaries are not included in this report due to space limitations. Insecticide applications maintained plant bug numbers below Cooperative Extension recommended action levels (i.e., 3 bugs per drop cloth sample prior to cutout and 6 bugs per sample after cutout) throughout the season (Fig. 2). Mean first position square shed was maintained below 10% for the season through physiological cutout (data not shown). With overall low population densities coupled with aggressive control measures, we failed to observe differences in plant bug numbers among treatments that we had measured in previous seasons.

There were significant yield differences between cultivars ($P < 0.001$) and among irrigation treatments ($P = 0.03$), but there were no differences associated with seeding rates ($P = 0.22$). The cultivar with highest resistance rating produced higher yields (Fig. 3). Yield-limiting pest effects in 2016 were not insect related. There were likely disease-related problems. Weather conditions in 2016 were conducive for plant disease, and atypically high levels of *Verticillium* wilt, target spot, and other foliar diseases were noted throughout northeast Arkansas. Regrettably, we failed to make disease assessments among treatments in this test. For irrigation main effects, highest yield monitor measured yields were associated with the rainfed compared to irrigated treatments (Fig. 4). It is worth mentioning that negative impacts of irrigation also were noted in surrounding production fields (e.g., yield monitor measured yields comparing production in rain-fed corners of center pivot fields to irrigated circles) (Ray Benson, unpublished).

Practical Applications

Published results from cultivar performance testing that include assessments for host-plant resistance to pests (both insect and disease) provide important information to assist producers in reducing crop protection costs without yield penalty. To save money on crop protection costs, to produce higher yields, and to reduce off-target environmental risks from foliar applications of costly protectants, managers should select recommended cultivars that have been shown to exhibit host-plant resistance traits.

Reducing seeding rate from 4.5 down to 1.5 seeds per ft of row had no significant effect on yield. We observed similar results in the first two years of this study (Benson et al., 2015, 2016). These data support the use of reduced seeding rates as a viable cost-saving tactic for mid-South producers using treated, genetically enhanced seed. Until further data are available, we suggest that producers adjust rates to the specific field conditions at planting time and select seeding rates that ensure a final plant population density that lies within the range tested in this study.

Acknowledgments

The authors are grateful for support from Wildy Family Farms and the Manila Airport Committee. This project was funded by Cotton Incorporated Core and the University of Arkansas System Division of Agriculture's Agricultural Experiment Station. This work was also supported, at least in part, by the USDA National Institute of Food and Agriculture project ARK02355.

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Table 1. Production details for 2016 cultivar × seeding rate × irrigation trial including dates of planting, irrigation, insecticide application, defoliation timing and harvest date, Manila Airport, 2016.

Operation	Date	Days after planting
Planting	9 May	
Insecticide ^a	25 May, 16 June, 8, 30 July	16, 38, 60, 82
Irrigation	18 June (early only) & 2, 8 July, 4 August	40, 54, 60, 87
Defoliation	16, 29 September	130, 143
Harvest	11 October	155

^aInsecticide applications were made by the cooperating producers using their high clearance sprayer; timing and product selection was based on recommendations by their crop advisor.

Table 2. Monthly precipitation (inches) measured at the study site for the 2016 season compared with 30-year average for the county, Manila Airport, 2016.

Month	30-year Average	2016 Rainfall	Departure
	-----inches-----		
May	5.37	5.7	0.33
June	3.99	2.55	-1.44
July	4.04	3.88	-0.16
August	2.36	4.16	1.8
Total Season	20.51	16.29	-4.22

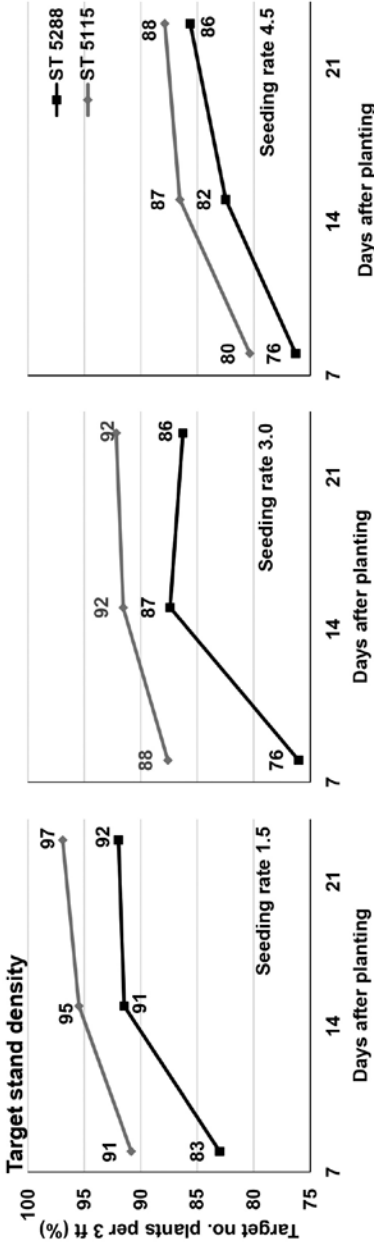


Fig. 1. Stand counts for cultivars and seeding rates (1.5, 3.0 and 4.5 seeds/ft row) expressed as a percentage of the target seeding rate determined at 8, 16, and 27 days after planting, Manila Airport, 2016.

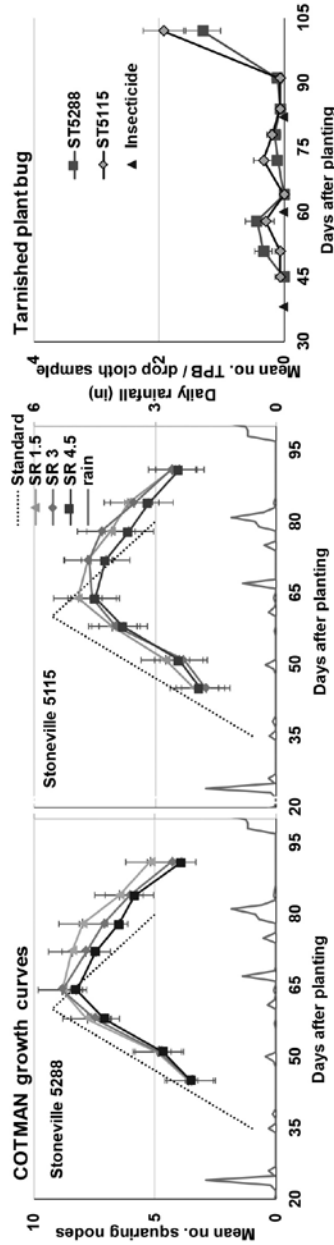


Fig. 2. COTMAN growth curves and mean number of tarnished plant bugs (\pm SEM) observed in weekly drop cloth sampling in cultivars Stoneville 5288 B2R and Stoneville 5115B2R for seeding rate \times cultivar \times irrigation study, Manila Airport, 2016.

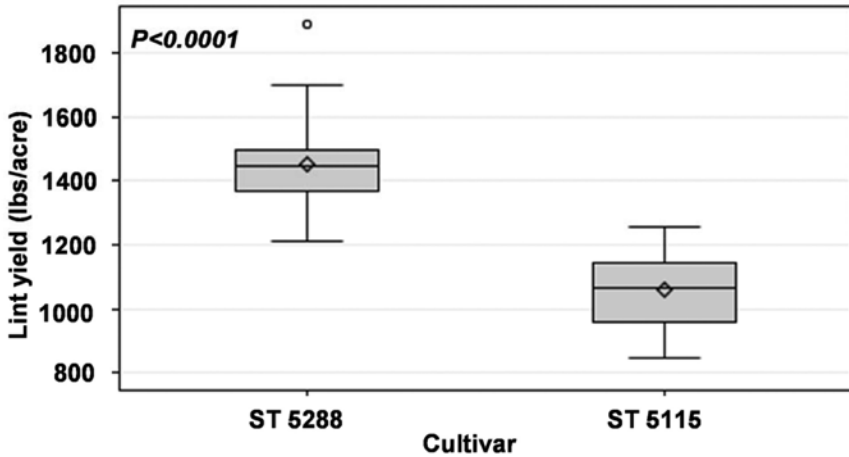


Fig. 3. Lint yield per acre for cultivar subplot effects in seeding rate \times cultivar \times irrigation study, Manila Airport, 2015. Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value. Means were significantly different ($P = 0.0001$).

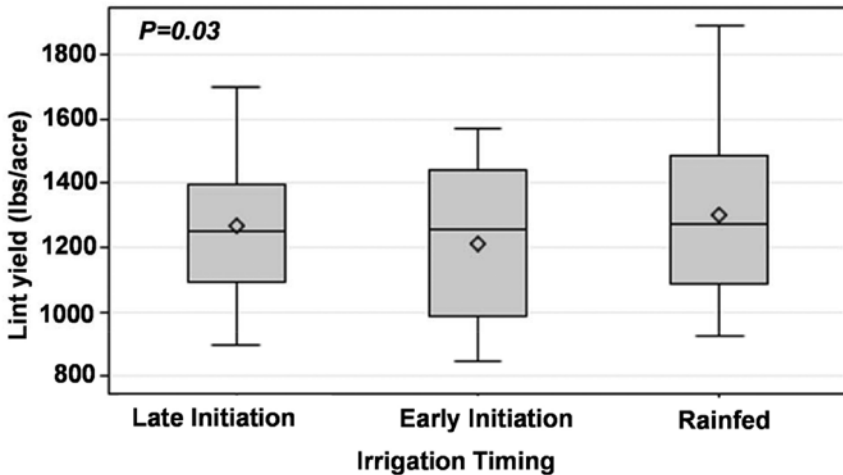


Fig. 4. Lint yield/acre for irrigation treatment main plot effects for seeding rate \times cultivar \times irrigation study, Manila Airport, 2016. Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value. Means were significantly different ($P = 0.03$).

Effect of Timing and Rate of Urea and Environmentally Smart Nitrogen on Seedcotton Yield in Arkansas

*M. Mozaffari*¹

Research Problem

In 2016, approximately 375,000 acres of cotton were harvested in Arkansas. Supplemental N fertilization is required to produce economically sustainable cotton yields. Improving N use efficiency by reducing fertilizer-N losses to the environment will increase profit margins and reduce potential environmental risks associated with N fertilization.

Background Information

Currently the University of Arkansas System Division of Agriculture recommends split application of up to 120 lb N/acre for cotton. Growers typically split the total amount of the recommended N to improve N fertilizer use efficiency. However, split application of N requires additional planning, labor, and farm equipment. In recent years, a polymer-coated urea enhanced efficiency N fertilizer (44% N, Agrium Wholesales, Denver, Colo.) has become available to Arkansas producers and is marketed under the trade name of Environmentally Smart Nitrogen[®] or ESN². The goal of this research was to evaluate seedcotton yield response to timing and rate of urea and ESN application at two locations.

Research Description

The experimental sites were located at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center at Keiser (MSG62) and Manila Airport (MSG64) at Manila. At MSG62, cotton (DP1646 B2XF) was planted on 28 April and harvested on 13 October. At MSG64, cotton (DP1518B2XF) was planted on 9 May and harvested on 11 October. Each test was implemented as a randomized complete block with seven N treatments, each replicated four times. Nitrogen treatments consisted of: a no-N (0 N) control, a two-way split application of 110 lb/acre urea-N (standard practice), a single ap-

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²Mention of a trade name is for facilitating communication only. It does not imply any endorsement of a particular product by the authors or the University of Arkansas System Division of Agriculture; or exclusion of any other product that may perform similarly.

plication of 60 lb/acre of urea-N, a two-way split application of 90 lb/acre urea-N, a single application of 60 or 90 or 100 lb/acre of ESN-N (Table 1). At MSG62, the first dose of N was applied 2 days before planting and the second dose of N (treatments 2, 4, 7, Table 1) was applied on 10 June (43 days after planting, DAP), approximately a week after the first square. At MSG64, the first split of urea-N was applied on 18 May (9 DAP) and the second split of N was applied on 22 June (45 DAP, approximately 10 days after the first square). All post-plant N treatments were applied to the top of the bed and across the row middles and incorporated into the top 2–4 inches of the soil mechanically or by a rake. At MSG62, we measured the main stem height from cotyledonary node to the terminal bud and the number of the main-stem nodes above the top white flower (NAWF) at 79 and 104 DAP. At MSG64, the same plant growth parameters were measured at 73 and 85 DAP.

Results and Discussion

The total monthly rainfall between 1 May to 30 October of 2016 at Keiser and Manila were 18.73 and 19.68 inches respectively and were below the 10-year average thus the conditions were not conducive for above normal N loss via leaching. The rainfall data for Manila was the mean rainfall for the closest weather stations located in Keiser, Blytheville, and Jonesboro, Arkansas.

Nitrogen treatment significantly influenced the plant height at 79 and 104 DAP and NAWF at 104 DAP (Table 2). At 79 DAP, cotton fertilized with split application of 110 lb/acre urea-N was significantly taller than all the other N fertilized cotton (31.7 as compared to 26.5 to 29.5 inches). At 104 DAP, cotton that received a split application of 110 lb/acre urea-N was not significantly taller than cotton fertilized with 90 lb/acre ESN-N. At 104 DAP, there was no significant difference in the NAWF between cotton that received 90 or 110 lb/acre urea-N and the cotton fertilized with 90 or 100 lb/acre ESN-N. At MSG64 (Manila), N treatments significantly influenced the plant height and NAWF 73 and 85 DAP (Table 3). Cotton fertilized with a single application of 90 lb/acre ESN-N was not significantly shorter than plants fertilized with a split application of 90 or 100 lb/acre of urea-N (Table 3). The NAWF at 73 DAP showed a trend similar to plant heights. At 85 DAP, cotton fertilized with 0 or 60 lb/acre of urea-N had significantly lower NAWF than all other N-fertilized plants. There was no significant difference in NAWF between cotton fertilized with split application of 90 or 110 lb/acre urea-N and cotton fertilized with a single application of 90 or 100 lb N/acre of ESN-N.

Nitrogen fertilizer application significantly affected seedcotton yield at both sites (Table 4). Seedcotton yield of the control (0 N) treatments were 1870 and 1800 lb/acre at MSG62 and MSG64 respectively. Seedcotton yield of the cotton that received any N ranged from 2210 to 2970 lb/acre at MSG62 and 2650 to 3260 lb/acre at MSG64. At MSG62, seedcotton yield of cotton fertilized with a split application of 110 lb/acre of urea-N was not significantly different than that of the cotton fertilized with 100 lb ESN-N.

Practical Applications

These results suggest that a single application of ESN-N might be a suitable alternative to split application of urea-N for irrigated cotton production in Arkansas. Additional research is needed to confirm reproducibility of these results under a wide range of soils.

Acknowledgments

This research was supported by Agrium Wholesales, Fertilizer Tonnage Fees and the University of Arkansas System Division of Agriculture. We thank Monsanto for donating the cotton seeds. We appreciate the assistance of the Division of Agriculture Soil Testing and Research Laboratory staff with soil analyses.

Table 1. The seven N treatments for the two experiments that evaluated cotton response to timing and rate of urea-N and Environmentally Smart Nitrogen-N application at MSG62 (Keiser) and MSG64 (Manila) research sites in Arkansas in 2016.

Treatment number	First N application †		Second N application ‡		Total N-rate lb N/acre
	N-source	N-rate (lb N/acre)	N-source	N-rate (lb N/acre)	
1	none	0	none	0	0
2	urea	60	urea	50	110
3	urea	60	none	0	60
4	urea	45	urea	45	90
5	ESN	60	none	0	60
6	ESN	90	none	0	90
7	ESN	0	ESN	100	100

†At MSG62, first split of N was applied on 26 April, 2 days before planting, and the second split was applied on 10 June.

‡At MSG64, the first split of N was applied one 18 May, 9 days after planting, and the second dose was applied on 22 June.

Table 2. Cotton plant height and nodes above the white flower (NAWF) response to timing and rate of urea-N and ESN-N fertilizer application at 79 and 104 days after planting (DAP) for the cotton N fertility trial at MSG62 site in Keiser, Arkansas during the 2016.

Treatment number	First N application		Second N application		Total N-rate	79 DAP	104 DAP	79 DAP	104 DAP	NAWF
	N-source	N-rate (lb N/acre)	N-source	N-rate (lb N/acre)						
1	none	0	none	0	0	27.0 C [†]	36.7 C	6.8	2.5 BC	
2	urea	60	urea	50	110	31.7 A	45.4 A	7.3	3.6 A	
3	urea	60	none	0	60	28.2 BC	37.8 C	6.9	2.4 C	
4	urea	45	urea	45	90	29.5 B	42.5 AB	7.1	3.7 A	
5	ESN	60	none	0	60	29.5 B	39.1 BC	6.7	2.3 C	
6	ESN	90	none	0	90	29.2 B	43.2 A	7.1	3.3 AB	
7	ESN	0	ESN	100	100	26.5 C	38.1 C	6.6	3.1 ABC	
<i>P</i> -value						0.0030	0.0057	0.7145 (NS)	0.052	

[†]Means followed by the same letter were not significantly different at $P \leq 0.1$.

Table 3. Cotton plant height and nodes above the top white flower (NAWF) response to urea and ESN at 79 and 104 days after planting (DAP) for the cotton N fertility trial at MSG64 site during the 2016.

Treatment number	First N application		Second N application		Total N-rate	73 DAP	85 DAP	73 DAP	85 DAP	NAWF
	N-source	N-rate (lb N/acre)	N-source	N-rate (lb N/acre)						
1	none	0	none	0	0	19.6 B [†]	21.2 C	4.6 D	3.6 D	
2	urea	60	urea	50	110	28.0 A	31.4 A	6.5 A	4.9 AB	
3	urea	60	none	0	60	26.5 A	29.5 A	6.0 AB	4.1 CD	
4	urea	45	urea	45	90	26.1 A	29.9 A	6.2 A	4.8 AB	
5	ESN	60	none	0	60	25.7 A	25.4 B	5.5 BC	4.4 BC	
6	ESN	90	none	0	90	26.9 A	31.0 A	6.6 A	5.3 A	
7	ESN	0	ESN	100	100	20.2 B	25.2 B	5.1 CD	5.2 A	
<i>P</i> -value						0.0041	0.0057	< 0.0001	0.0030	

[†]Means followed by the same letter were not significantly different at $P \leq 0.1$.

Table 4. Seedcotton yield response to timing and rate of urea-N and Environmentally Smart Nitrogen-N application for the two cotton N fertility trials conducted at the MSG62 (Keiser) and MSG64 sites (Manila), Arkansas during 2016.

Treatment Number	First N application		Second N application		Total N rate	MSG62	MSG64
	N source	N-rate (lb N/acre)	source	N-rate (lb N/acre)			
1	none	0	none	0	0	1870 D [†]	1800 C
2	urea	60	urea	50	110	2750 AB	3180 A
3	urea	60	none	0	60	2210 C	2745 B
4	urea	45	urea	45	90	2800 AB	3180 A
5	ESN	60	none	0	60	2750 AB	2650 B
6	ESN	90	none	0	90	2560 B	3260 A
7	ESN	0	ESN	100	100	2970 A	2855 B
	P-value					0.0009	< 0.0001

[†] Means followed by the same letter were not significantly different at $P \leq 0.1$.

Cotton Responds Positively to Urea and Environmentally Smart Nitrogen in Arkansas

M. Mozaffari¹

Research Problem

In 2016, approximately 375,000 acres of cotton were harvested in Arkansas. Organic matter content of many Arkansas agricultural soils is low (< 2.0%), thus N fertilization will increase cotton (*Gossypium hirsutum* L.) yield in many Arkansas soils. Improving N use efficiency by reducing fertilizer-N losses to the environment will increase profit margins and reduce potential environmental risks associated with N fertilization. One strategy to improve N use efficiency is to use an enhanced efficiency N fertilizer. Polymer coated controlled release (slow release, programmed release) N fertilizers may provide the growers with the opportunity to increase their N use efficiency.

Background Information

A polymer-coated urea (44% N, Agrium Wholesales, Loveland, Colo.) is currently being marketed in Arkansas under the trade name of Environmentally Smart Nitrogen[®] or ESN². Previous research in Arkansas suggested that preplant incorporated ESN is a suitable alternative to urea for cotton production in silt loam soils. The objective of this test was to evaluate cotton response to preplant application of urea (100% urea-N) and urea-ESN combination (25% urea-N, 75% ESN-N) in a common Arkansas clay soil.

Research Description

The field experiment was conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keiser, Ark. An experiment was implemented in a randomized complete block design with a factorial arrangement of preplant-applied, urea or urea-ESN combination, each applied at four rates ranging from 60 to 150 lb N/acre in 30 lb N/acre increments, and a no-N control with five replications. All N-fertilizer treatments were

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²Mention of a trade name is for facilitating communication only. It does not imply any endorsement of a particular product by the authors or the University of Arkansas System Division of Agriculture; or exclusion of any other product that may perform similarly.

hand applied onto the soil surface and mechanically incorporated immediately into the top 3–4 inches of soil. After fertilizers were incorporated, cotton (cultivar DP1646 B2XF) was planted on top of the beds on 28 April. Plant height and nodes above the white flower (NAWF) data were collected from the 0, 60, and 120 lb N/acre treatments 77 and 103 days after planting (DAP). We collected samples of the 5th leaf-blade from the top of the plant from selected treatments on 28 July. The samples were analyzed for total N by the combustion method.

Results and Discussion

Total monthly rainfall at Keiser between May to October of 2016 was 18.73 inches and was below the 10-year average for both sites. Therefore, the conditions were not conducive for above normal N loss. Seventy-seven days after planting, the main effect of N-source or N-source \times N-rate interaction did not significantly influence the cotton plant height ($P > 0.1$) (data not shown). However, averaged across the two N sources, application of 120 lb N/acre produced significantly ($P = 0.0525$) taller plants than 60 lb N/acre (36.5 vs 33.6 inches). Nodes above the white flower showed similar statistical trends where the NAWF of cotton treated with 60 and 120 lb N/acre were 5.1 and 6.2 respectively ($P = 0.0127$). The trends in plant height at 137 DAP were similar to 77 DAP and averaged across the two N sources. Cotton treated with 120 lb N/acre produced significantly taller plants than cotton fertilized with 60 lb N/acre (45.25 and 40.7 inches respectively). Nodes above the white flower at 137 DAP was not significantly influenced by the main effect of N-source, N-rate or their interaction (data not shown).

Nitrogen concentration in the leaf blade of cotton that did not receive any N fertilizer was 2.77% and that of cotton fertilized with 60 and 120 lb urea-N or urea-ESN-N was 2.57% to 2.95% and was not significantly influenced by N source or rate (data not shown). Numerically leaf-blade N in cotton fertilized with 120 lb/acre of urea-N and urea-ESN-N were 2.77% and 2.95%. Averaged across N-sources, N application rate significantly ($P = 0.0007$) increased the seedcotton yield (Table 1). However, the main effect of N source and N-source \times N-rate interaction did not significantly influence seedcotton yield, perhaps as a reflection of the below normal precipitation. Seedcotton yield for the cotton that received no N was 2305 lb/acre, which was numerically lower than the cotton that received the lowest N rate of 60 lb N/acre, averaged across N sources. Averaged across N sources, the seedcotton yield of the cotton fertilized with 150 lb N/acre was significantly greater than cotton fertilized with 60 or 90 lb N/acre. Cotton fertilized with 25%Urea-N and 75%ESN-N produced numerically higher yields than cotton fertilized with 100%-urea-N except at 90 lb N/acre. Averaged across the four N rates, cotton fertilized with 25% urea-N plus 75%-ESN-N, produced numerically higher (2875 lb/acre) seedcotton yield than cotton fertilized with 100% urea-N (2845 lb/acre).

Practical Applications

These results support our previous assertion that preplant incorporated ESN is a suitable alternative to urea for furrow-irrigated cotton grown in Arkansas. Future research should compare the effect of the timing and rate of application of urea and ESN.

Acknowledgments

This research was supported by Agrium Wholesales, Fertilizer Tonnage Fees and the University of Arkansas System Division of Agriculture. We thank Monsanto for donating the cotton seeds. We appreciate the assistance of the Division of Agriculture's Soil Testing and Research Laboratory staff with soil analyses.

Table 1. Seedcotton yield as affected by the significant N rate main effect ($P = 0.0007$), non-significant source main effect ($P = 0.5725$), and the non-significant ($P = 0.7684$) N-source \times N-rate interaction for a cotton N-fertilization experiment conducted at University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keiser, Ark. in 2016.

N-rate lb N/acre	N-fertilizer source		N rate yield mean	N-fertilizer source	N source yield mean lb/acre
	100% Urea-N	25% Urea-N 75% ESN-N ^a			
0		2305 ^b		None	2305 ^b
60	2303	2593	2481	100% Urea-N	2845
90	2768	2526	2668	25% Urea-N, 75% ESN-N	2875
120	2999	3026	3013		
150	3146	3152	3149		
LSD _{0.10}	NS ^c (interaction)		271 ^d	LSD _{0.10}	NS
<i>P</i> -value	0.5725 ^e		0.0007	<i>P</i> -value	0.7684

^a ESN, Environmentally Smart N, polymer-coated urea.

^b The no-N control is listed for reference only as it was not included in the analysis of variance.

^c NS, not significant ($P > 0.10$).

^d Least significant difference compares the yield of treatments that received N, averaged across N sources.

^e *P*-value for the N source \times N rate interaction.

Appendix I

Student Theses and Dissertations Related to Cotton Research in Progress in 2016

- Barnes, Brittany. Impacts and benefits of polyacrylamide (PAM) on irrigation efficiency, soil conservation, and water quality in mid-South cotton Production. (M.S., advisor: Reba/Teague)
- Benson, Ray. Spatial analysis methods for agronomic economic, and environmental evaluations of implementing site-specific, zone management in agricultural fields in the lower Mississippi river basin in northeastern Arkansas. (Ph.D., advisor: Teague)
- Berlangeiri, Sole. Temperature gradients in the canopy and the influence on cotton bolls growth. (M.S., advisor: Oosterhuis)
- FitzSimons, Toby. Cotton plant response to high temperature stress during reproductive development. (Ph.D., advisor: Oosterhuis)
- Greer, Amanda. Relationship between Telone II and nitrogen fertility in cotton in the presence of reniform nematodes. (M.S., advisor: Kirkpatrick)
- Hannam, Josh. Pathogens of the tarnished plant bug, *Lygus lineolaris*, in Arkansas. (M.S., advisor: Steinkraus)
- Kelly, Erin. Spatial and temporal variability of mid-south cotton grown on heterogeneous soils with cereal cover crops in Northeast Arkansas. (M.S. advisor: Teague)
- Meyer, Christopher. Understanding the risk for glufosinate resistance. (Ph.D., advisor: Norsworthy)
- Palhano, Matheus. Value of cover crop on palmer amaranth control in cotton and impact of herbicide carryover on cover crop establishment. (M.S., advisor: Norsworthy)
- Pilon, Cristiane. Effect of early water-deficit stress on reproductive development in cotton. (Ph.D., advisor: Oosterhuis)
- Rose, James. Sensitivity of Enlist™ and Roundup Ready 2 Xtend™ technologies to auxin herbicides and comparison of tolerance to susceptible cotton and soybean cultivars. (M.S., advisor: Norsworthy)
- van der Westhuizen, Mathilda. High temperature tolerance in cotton. (Ph.D., advisor: Oosterhuis)
- Wilson, Kyle. Spatial variability of seedling pathogens and diseases on cotton; influence of soil environmental factors and cultural practices. (M.S. advisor: Rothrock)

Appendix II

Research and Extension 2016 Cotton Publications

Books and Chapters

- Abidi, N., S.J. Allen, P.S. Amar, C. Armijo, B.T. Campbell, C. Chase, M.R. Chaudhry, G.A. Constable, D.M. Dodds, M.K. Dowd, S. Ferrigno, M. Giband, S. Gordon, E. Hughs, R. Hutmacher, S. Kranthi, J.M. Lacape, B. Lonnie, S. Mansoor, M. Matusiak, D. Monga, D. Munk, D.M. Oosterhuis, L.R. Pepper, D.M. Stelly, J. Stewart, T. Townsend, P.J. Wakelyn, J. Wanjura, D. Whitelock, L. Wilson, S.S. Zaidi, and M. Zimmiewska. 2016. Dictionary of Cotton. International Cotton Researchers Association and International Cotton Advisory Commission. ISBN 9780970491817.
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- Fitzsimons, T., and D.M. Oosterhuis. 2016. Temperature and Related Stress. Compendium of Cotton Diseases. C. Rothrock and T. Kirkpatrick (eds.) Publ. Phytopath Soc.
- Oosterhuis, D.M. (ed.) 2016 Summaries of Arkansas Cotton Research 2015. Arkansas Agricultural Experiment Station Research Series 635. 152 pp.
- Pilon, C., F. Bourland, and D. Bush. 2016. Chapter 3. Seeds and planting. *In*: J. Snider and D. Oosterhuis (eds.). Linking Physiology to Management. Number 9: The Cotton Foundation Reference Book Series. The Cotton Foundation, Cordova, Tenn.
- Rothrock, C.S., and T.N. Spurlock. 2016. Cultural management of plant diseases. *In*: B.H. Ownley and R.N. Trigiano (eds.) Plant Pathology Concepts and Laboratory Exercises, Third Edition. CRC Press.
- Snider, J.L and D.M. Oosterhuis. (eds.) 2016. Linking physiology to management. Number nine. The cotton foundation reference book series. Publ. Cotton Foundation, Memphis, Tenn. ISBN978-0-939809-08-0
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