Summaries of Arkansas Cotton Research 2017

The intensity of Verticillium wilt at Judd Hill in 2017 demonstrates the importance of evaluating cotton lines at this location for tolerance to the disease

Edited by Fred Bourland

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

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Cover Photo: Judd Hill cotton test site showing the intense severity of Verticillium wilt and variations in symptoms between adjacent plots as plants approached maturity in 2017. Fred Bourland, Arkansas Agricultural Experiment Station, University of Arkansas System, Division of Agriculture.

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Summaries of Arkansas Cotton Research 2017

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Cotton Incorporated and the Arkansas State Support Committee

The *Summaries of Arkansas Cotton Research 2017* 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, Tennessee, administers the act, and contracts implementation of the program with Cotton Incorporated, a private company with its world headquarters in Cary, North Carolina. 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 comprises cotton growers, while that of the Cotton Board comprises 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 2017.

	2016	2017
New Funds	$207,000	$180,000
Previous Undesignated	$99,402	$68,652
Total	$306,402	$248,652

Researcher	Short Title	2016	2017
Oosterhuis	Cotton Research In Progress	$5,000	$0
Bourland	Breeding	$26,000	$26,000
Oosterhuis	Improving Cotton Fertility	$9,800	$0
Norsworthy	Cover Crops	$32,782	$0
Reba	Increasing yield through irrigation management	$13,620	$0
Robertson	Cotton Research Verification/Applied Research	$50,000	$50,000
Lorenz	Alternative Thrips Control	$21,724	$21,724
Roberston	Potash	$11,000	$11,000
Robertson	Soil health - no till	$12,074	$12,074
Barber	New Herbicide Tech	$25,000	$25,000
Robertson	Soil health - no till	$13,000	$0
Robertson	Enhanced communication	$12,000	$0
Reba	Tillage impacts on water quality of irrigation runoff	$6,000	$0
Lorenz, Bourland, Robertson	OVT Thrips tolerance	$5,000	$0
Robertson	Leaf K and foliar disease field survey	$2,000	$0
Barber, Robertson	New varieties over top Liberty Applications	$4,000	$0
Adviento-Borbe	Tillage Practices and Water Quality	$0	$15,000
Robertson	Target Leaf Spot IPM	$0	$15,000
Robertson	Cereal Rye Termination Timing	$0	$15,000
Reba	Improving Research Capacity	$0	$17,000
Uncommitted		$57,402	$40,854
Total		**$249,000**	**$207,798**

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
— 2017 —

Review of the 2017 Arkansas Cotton Crop

Overview

Arkansas cotton producers set a new record yield of 1205 lb lint/acre in 2017. The five-year lint yield average is 1130 lb lint/acre. Each of the last five years have yields that rank historically in the top 6 of all time. The string of consecutive years with good yields is helping to drive the increase in cotton acres experienced recently. Production cost is the main factor that limits cotton acre expansion beyond what is currently being experienced.

Planting

Reports released by Agricultural Marketing Service estimated 70% of the cotton varieties planted in 2017 contained B2XF traits, up from 58% the previous year. Non-GMO cotton accounted for less than 1% of the planted acres. No commercial organic cotton production occurs in Arkansas. The remaining 30% of the cotton acres were planted to cotton with traits including but not limited to WRF, W3FE, GLB2, and GLT.

An early planting window in April moved planting progress ahead of last year and the five-year average, but wet and cool conditions caused us to fall behind by May 1 and we stayed behind the remainder of the planting season. Approximately 15% of the crop in 2017 was planted in April. Wet weather the end of April and first of May delayed planting for about 10 days during the heart of the traditional cotton planting window. Planting resumed resulting in approximately 50% of the crop being planted by 15 May. An additional 25% was planted the week of 15 May. March planting intentions of 500,000 acres were not reached as a result of uncooperative planting conditions in May. In 2017, 445,000 acres ended up being planted.

Fruiting and Harvest

While planting progress in 2017 lagged behind that of last year and the five-year average, squaring and boll set generally progressed at a rate slightly greater than last year and the five-year average. The condition of the crop was very good all season long. Reports by the United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS; available at: http://usda.mannlib.cornell.edu/usda/current/CropProdSu/CropProdSu-01-12-2018.pdf) indicated the percentage of the acres statewide receiving a rating of good to excellent ranged from 80% to 85% the entire season.

Results of the very favorable growing conditions contributed to the slowing of the occurrence of open bolls. Boll opening trailed behind that of last year and the five-year average from first open boll to the end of September when approximately 85% of fields had open bolls. The delay in boll opening likely triggered a delay in harvest aid applications and harvest initiation. Harvest progress lagged behind that of last year and the five-year average for the first few weeks of harvest in September through the middle of October. Harvest progress improved greatly the last half of October moving past that of last year and the five-year average as might be expected with an extremely dry fall. Harvest progress ended about par with last year and the five-year average. Very few fields were rutted by harvest equipment in 2017.

Inputs

In our Cotton Research Verification Sustainability Program (CRVSP), operating expenses per acre averaged $593.36 across all fields. Our greatest operating expenses were seed, herbicides, insecticides, and fertilizers. Seed and related fees averaged $116.22 and fertilizer products, $75.08 per acre. These accounted for almost one-third of our total operating expenses per acre.

Plant bugs and palmer pigweed continue to be our key pests. Fields in our Cotton Research Verification Sustainability Program (CRVSP) fields were treated an average of 4.5 times for plant bugs in 2017. Each field had an average of 1.6 burndown and 4.1 in-season herbicide applications. All fields averaged 1.6 treatments for moths/worms. Average costs per acre for herbicides and insecticides were $102.60 and $86.85, respectively. Pest control expenses accounted for an additional one-third of our operating expenses per acre.

Yield and Quality

The NASS September Crop Production report projected that Arkansas producers would harvest 1096 lb lint/acre. Their estimates increased to 1162 lb lint/acre in November and up again to 1205 lb lint/acre in their annual summary released in January of 2018 (available at: http://usda.mannlib.cornell.edu/usda/current/CropProdSu/CropProdSu-01-12-2018.pdf). A record yield of 1205 lb lint/acre broke the previous one set in 2014 by 60 lb lint/acre. Our current five-year lint yield average is 1130 lb lint/acre with each having yields that rank in the top 6 of all time. In 2004, Arkansas' lint yield of 1114 lb/acre is the 4th highest ranking for the state.

Fiber quality was very good in 2017 as 90.1% of bales classed for Arkansas were tenderable compared to 81.4% in 2016 and 60.6% in 2015. Little rainfall was received during harvest. Consequently, color grades were good with 49.5% of bales receiving color grades of 31 or better and 95.1% of bales classed received a color grade of 41 or better. Micronaire averaged 4.3, with almost 96% of Arkansas cotton classed having micronaire in our target value range of 3.5 to 4.9. Staple averaged 37.8 with 58.5% of the bales classed having a staple 38 or greater. Leaf was perhaps our greatest issue with only 38.8% of the bales classed receiving a leaf of 4 or less. Leaf values for the 2017 crop averaged 5.3 for the season. While most producers received premium over base on their 2017 crop, our 2017 CCC loan schedule lists a discount of 205 points by raising leaf from 4 to 5 on a base quality bale.

Summary

Arkansas ended the 2017 season ranked 5th nationally in harvested acres (438,000 acres), 3rd in lint yield/acre (1205 lb), and 4th in total production (1,123,871 bales). Estimates by NASS in April of 2018 indicated Arkansas acreage intentions are at 480,000 acres, up 8% from the 445,000 acres planted in 2017. This continues to push our ginning capacity of 30 gins in 2017 and on-farm picker capacity to the limit. Optimism for cotton is greater than for most other commodities, but may not be great enough to invest in more gins or pickers.

Bill Robertson
Professor, Cotton Extension Agronomist
Newport Extension Center, Newport

2017 Judd Hill Cooperative Research Station: Overview of Cotton Research

W. Barnett[1], A. Rouse[1], and F. Bourland[1]

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 University of Arkansas Division of Agriculture to conduct research on other property belonging to the Foundation (Table 1). Judd Hill is located about 5 miles south of Trumann and 8 miles northwest of Marked Tree. 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 on the entire 35-acre block.

Table 1. List of 2017 cotton research at Judd Hill Cooperative Research Station.

Project Leader(s)	Discipline	Title
Arlene Adviento-Borbe Michelle Reba Tina Teague	Multi-disciplinary	Influence of tillage practices on water quality of irrigation runoff and total N loss in a cotton production
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests: transgenic test with 41 entries and conventional test with 16 entries
Fred Bourland	Cotton Breeding	Cotton Strain Tests, 11 tests evaluating a total of 252 entries
Morteza Mozaffari	Soil Fertility	Effect of phosphorus potassium rates on seedcotton yield
Tina 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
Craig Rothrock	Plant Pathology	National cottonseed treatment test; 10 industry trials and 1 graduate student project related to control of cotton diseases

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

2017 Conditions and Observations

Excessive rainfall in April and May (Table 2) delayed planting until mid- and late May at Judd Hill. Adequate moisture and good soil temperatures resulted in excellent stands in most plots. The plants grew well and established excellent boll loads. Insect pressure was light throughout the season. High incidence of Verticillium in 2016 provided ample levels of inoculum of this soilborne fungus. With relatively cool temperatures and ample moisture in August (Fig. 1), Verticillium wilt severely affected the boll-loaded plants in 2017. Resulting wilt symptoms were as severe as ever experienced at Judd Hill. Consequently, many plants shed most of their leaves prior to application of defoliants. Just as plots were ready for harvest in late September, the engine failed on the plot picker (picker modified for harvesting and weighing plot harvests), and had to be replaced. Harvest of plots was thus delayed until November.

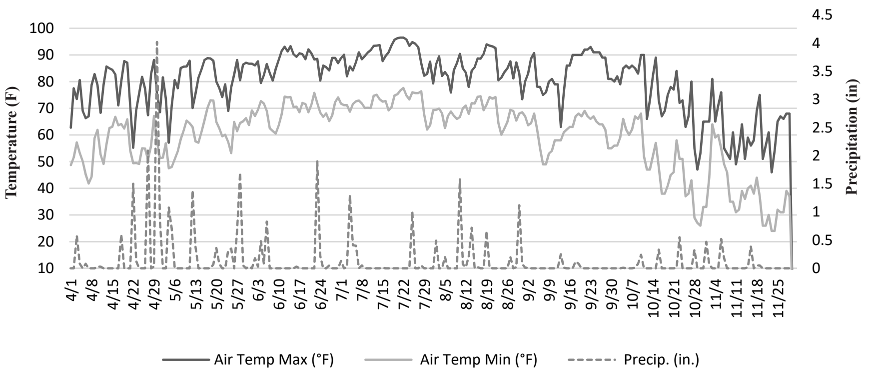

Fig. 1. 2017 Judd Hill temperature and precipitation.

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

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2017	201	329	552	664	526	387	182	2841
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2455
Rainfall (in.) 2017	9.2	8.0	3.8	3.4	5.4	0.5	1.6	31.8
Hist. avg. rainfall (in.)[b]	5.0	4.6	3.8	3.5	2.5	3.0	4.3	26.7

[a] 30-year average of data collected at the Keiser Station 1986-2015; dd60.uaex.edu
[b] 30-year average of data collected at the Jonesboro Municipal Airport 1981-2010; www.ncdc.noaa.gov/cdo-web/datatools/normals

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 is greatly appreciated. Additionally, we thank Mike Duren, Resident Director and Charles Wilson, Center Director of the Northeast Research and Extension Center; and Timothy Burcham, Dean of Agriculture and Technology, Arkansas State University. Support also provided by the University of Arkansas System Division of Agriculture.

2017 Northeast Research and Extension Center: Overview of Cotton Research

A. Rouse[1] and F. Bourland[1]

Background

The University of Arkansas System Division of Agriculture initiated cotton research at Keiser in 1957. The 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 other cotton stations in the state, 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 2017 cotton research at Northeast Research and Extension Center, Keiser.

Project leader	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (transgenic test, 41 entries and conventional test, 16 entries)
Fred Bourland	Cotton Breeding	National Cotton Variety Test (10 entries), Regional High Quality Strain Test (20 entries) and Regional Breeders' Network Test (34 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests, 7 tests evaluating a total of 124 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/Soil Testing	Evaluation of nitrogen fertilizer source, rate, and timing on seedcotton yields
Morteza Mozaffari	Soil Fertility/Soil Testing	Soil fertility and soil testing research for improving cotton phosphorus and potassium fertilization practices
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)

[1] Program Technician and Professor, respectively, University of Arkansas System Division of Agriculture, Northeast Research and Extension Center, Keiser.

2017 Conditions and Observations

Rainfall in April and May delayed land preparation at Keiser (Table 2). Planting of cotton plots was completed in a narrow window (8 May to 15 May). Adequate moisture and good soil temperatures resulted in good stands in most plots, but stands were reduced and vegetative growth was slowed by sand damage associated with a severe late May storm. Some heribicide (dicamba) injury was also observed in the cotton plots. Total Degree-Day 60 (DD60) accumulations from April 2017 through October 2107 were 40% higher than the historical average. Temperatures were much greater than average in April and October and slightly greater in June and July, but below average in August and September. Seasonal rainfall was 21% higher than normal, while August rainfall was 288% of normal. The August rainfall was evenly distributed, and was accompanied by relatively low temperatures. Both insect and disease incidences were low at Keiser in 2016. As harvest time approached, the weather was relatively dry and mild. Defoliants were applied on time using ground application. The harvest of the Keiser plots began on 27 September and was completed on 13 October, which is likely the earliest that cotton harvest has been completed at Keiser.

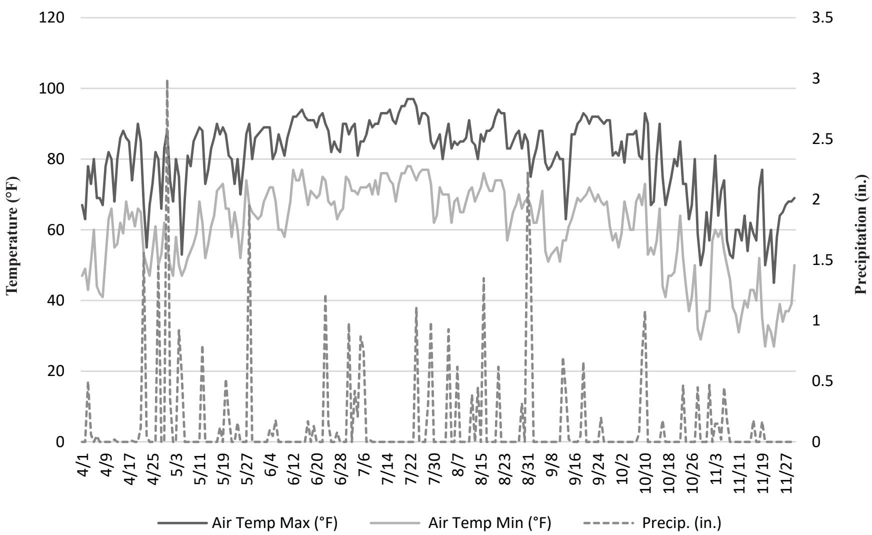

Fig. 1. 2017 Northeast Research and Extension Center, Keiser temperature and precipitation.

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

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2017	209	329	555	674	530	372	279	3426
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2455
Rainfall (in.) 2017	6.8	5.6	2.1	5.7	6.9	3.6	3.0	33.6
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 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.

2017 Manila Airport Station: Overview of Cotton Research

F. Bourland[1] and R. Benson[2]

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 2017 cotton research at Manila Airport.

Project Leader	Discipline	Title
Tina Gray Teague	Multi-disciplinary	Seeding rate, cultivar selection, cover crop and irrigation timing effects on maturity and yield of mid-South cotton
Fred Bourland	Cotton Breeding	Arkansas Transgenic Cotton Variety Test (41 entries)
Morteza Mozaffari	Soil Fertility	Cotton response to nitrogen source, rate and timing
Bill Robertson	Agronomy	Evaluation of tillage and cover crops in cotton

2017 Conditions and Observations

Wet conditions delayed planting of plots at Manila until 19 May. Adequate moisture and good soil temperatures resulted in good stands in most plots. Weather conditions in the area were wetter than normal throughout the season until fall.

[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.

Evapotranspiration (ET) gauge readings were collected weekly, and used to estimate and track field moisture status during the season. Irrigation events, however, were initiated based on the cooperating producer's standard production practices. Seven furrow irrigations were triggered during the production season. Insect pressure was generally light in 2017. Incidence of bacterial blight and target spot diseases was very light. The relatively dry conditions restricted vegetative growth. Harvest was completed by late-October. Average lint yield achieved in the 2017 Arkansas Cotton Variety Test at the Manila Airport was the highest that we have achieved since we began conducting the test at Manila Airport in 2014 and was higher than at any other 2017 location of the test.

Weather Data

Weather at Manila Airport would be similar to the weather reported for Keiser and Judd Hill Cooperative Research Stations. 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.

2017 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 2017 cotton research at Lon Mann Cotton Research Station.

Project Leader	Discipline	Title
Tom Barber	Weed Science	Control of weeds using various cotton herbicides and programs, including new Xtend and Enlist technologies
Tom Barber	Weed Science	Evaluation of cotton herbicide efficacy and weed control systems
Tom Barber	Weed Science	Evaluation of non-crop weed control systems and herbicide tolerance to specific crops
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (transgenic test, 41 entries and conventional test, 16 entries)
Fred Bourland	Cotton Breeding	Cotton strain tests, 11 tests evaluating a total of 211 entries
Fred Bourland	Cotton Breeding	Cotton breeding trial of 240 Advanced F_6 progenies
Fred Bourland	Cotton Breeding	Cotton observation plots of 960 F_5 preliminary progenies
Leo Espinoza	Soils	Varietal response to potassium rates under sub-optimal soil potassium levels
Gus Lorenz	Entomology	Thrips efficacy trials (6 trials, 48 total treatments)
Gus Lorenz	Entomology	Thrips variety trials (2 trials; Bt, 34 Entries; conventional, 20 entries
Morteza Mozaffari	Soil Fertility/Soil Testing	Fertilizer rate trails to evaluate cotton response to NPK
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
Chuck Wilson	Soil Fertility	Cotton response to P and K fertilizer rates

[1] Resident Director, University of Arkansas System Division of Agriculture, Northeast Research and Extension Center, Lon Mann Cotton Research Station, Marianna.

2017 Conditions and Observations

Frequent rains and relatively mild temperatures characterized the 2017 growing season at LMCRS. Weather conditions delayed some pre-plant and planting operations, but most cotton plots were planted on a timely basis. 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. Growth and development of cotton planted into cereal rye was delayed by excessive plant residue and competition for nutrients. Weather conditions were generally good throughout the season (Fig.1, Table 2). Heat units (DD60s) accumulated in April and October were almost three times higher than normal. Rainfall from April through September was 67% higher than normal, but was 34% lower than normal in October. Due to the wet summer months, irrigation costs and plant stress was low in 2017. The dry October facilitated good harvest. Plots were furrow-irrigated as needed. Mepiquat chloride (Pix) to control internode elongation and plant height was required at normal rates. Insect pressure was relatively light with the primary insect pest being plant bugs. Harvest was completed in mid-November.

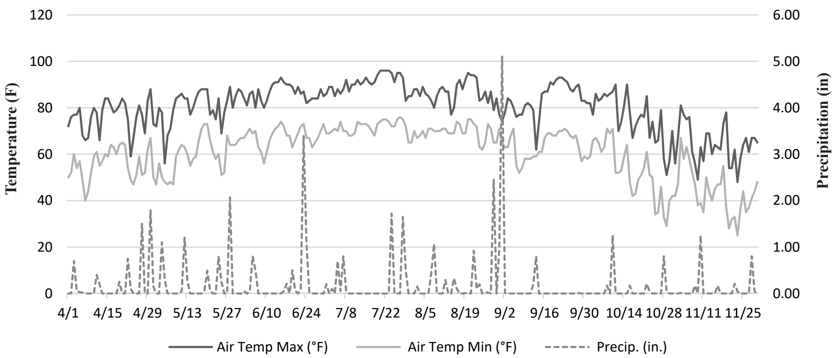

Fig. 1. 2017 Marianna temperature and precipitation.

Table 2. Weather conditions at Marianna.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2017	208	331	513	651	558	384	295	2938
Historical avg. DD60s[a]	87	339	548	650	594	398	98	2714
Rainfall (in.) 2017	5.8	6.8	6.8	5.8	7.1	6.1	2.7	41.0
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/normals

Acknowledgments

The author would like to thank Charles Wilson, Center Director of the Northeast Research and Extension Center (NEREC), Keiser. (LMCRS is administratively associated with NEREC.) Support was also provided by the University of Arkansas System Division of Agriculture.

2017 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 2017 cotton research at Rohwer Research Station.

Project Leader	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (Transgenic, 41 entries and Conventional 16 entries
Fred Bourland	Cotton Breeding	Cotton Strain Tests, 6 tests evaluating a total of 120 entries
Fred Bourland	Cotton Breeding	Cotton breeding trial of 240 Advanced F6 progenies
Fred Bourland	Cotton Breeding	Cotton observationplots of 960 F5 preliminary progenies
Morteza Mozaffari	Soil Fertility	Phosphorus & Potassium Fertility for Cotton
Tom Barber	Weed Science	Rye Cover Crop Followed by Cotton, 2 trials
Tom Barber	Weed Science	Loyant, Liberty, Brake, and Xtend Flex Systems, 4 trials
Tom Barber	Weed Science	Industry Trials
Nick Seiter	Entomology	Extend and Dow Tests, 3 trials
Nick Seiter	Entomology	Tarnished Plant Bug, BT Overspray, and Seed Treatment Tests, 5 total trials
Terry Spurlock	Plant Pathology	Cotton Seed Treatment – Q2, 1 trial

2017 Conditions and Observations

Research trials at Rohwer were planted during the last week of April and continued until late May. Excessive moisture and cooler soil temperatures resulted in stands with low seedling vigor and slight cool weather damage in most trials

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(Fig. 1, Table 2). Seedling diseases were minor and seed treatments for insect pests were effective for control. Weed control programs for most trials were successful at controlling early season grass and broadleaf species. Post-emergence applications were effective at controlling both grass and broadleaf species including Palmer amaranth. Slight hand weeding was needed to control escaped Palmer amaranth in some trials. Four irrigations were required to maintain adequate moisture (2 inch allowable deficient) for the crop with the last irrigation applied on the first of August. Insect pests were low and never met threshold for applying insecticides. Termination timings for plant bugs, worms, and irrigation were mid to late August. Harvest was dry and proceeded in a timely manner.

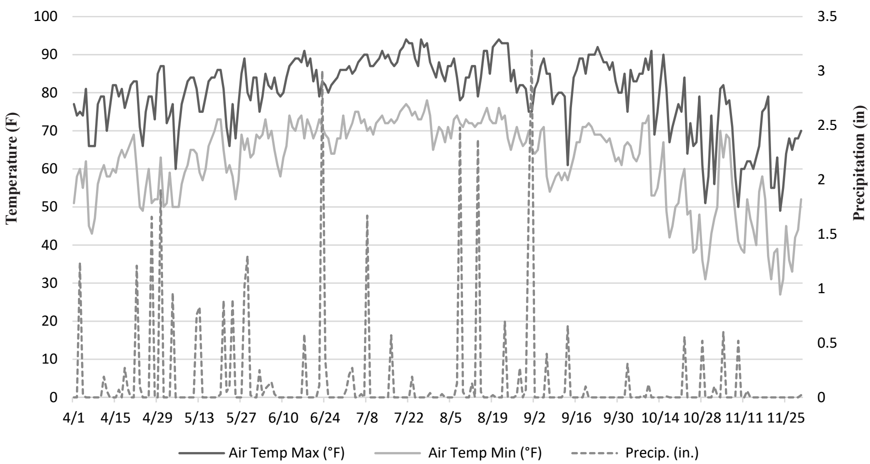

Fig. 1. 2017 Rohwer temperature and precipitation.

Table 2. Weather conditions at Rohwer.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2017	100	307	488	648	571	426	223	2763
Historical avg. DD60s[a]	100	354	551	661	618	415	167	2866
Rainfall (in.) 2017	6.8	6.9	4.7	3.1	8.1	4.4	1.5	35.5
Hist. avg. rainfall (in.)[b]	4.8	4.9	3.6	3.7	2.6	3.0	3.4	26.1

[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

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Cotton Research Verification Sustainability Program: 2017 Economic Report

A. Free[1], B. Robertson[1], and B. Watkins[2]

Abstract

Producers continually focus on adjustments that can be made to increase efficiency in an effort to improve profitability. One strategy to improve profitability is increasing input efficiency. As producers improve efficiency, a positive impact is often observed in regard to sustainability. As producers reduce tillage, or convert to a no-till production system with an established cover crop, both sustainability and profitability are impacted. The objective of this study is to evaluate the impact that improving soil health has on profitability and sustainability of cotton. The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability Program conducted research in 6 of the 12 fields in the Discovery Farms program in 2017. A unique situation occurred at Discovery Farms in Southeast Arkansas which allowed for observation of farmer standard tillage (stale seedbed) versus no-till cover as fields are composed of two irrigation sets. Wellcot and Homeplace fields in Desha County were also watered in two irrigation sets, however the entire field was farmer standard tillage with no cover. The remaining fields were located in Mississippi and St. Francis Counties. Fields at these locations were unable to be watered in two sets; however, the field was split in half for a comparison of farmer standard tillage versus no-till with cover. Mississippi County farmer standard is reduced tillage, and St. Francis farmer standard is conventional tillage. All fields were monitored for inputs, providing the information needed to calculate both fixed and variable costs. In Arkansas, it is unlikely to be able to farm in a completely no-till situation, so each of the no-till fields were almost no-till as a FurrowRunner was used to make a very narrow trench leaving the cover crop residue as undisturbed as possible. The average yield across all fields was 1249 lint lb/acre, and the average operating expense was $0.51/lb. Total expense per pound was $0.64, but does not include land cost, management, or other expenses and fees not associated with production.

Introduction

The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability Program (CRVSP) works with producers to produce

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

cotton more efficiently with the objective of improving profitability. As cost of production continues to increase, the producers are searching for ways in which modifications can be made to their practices in an effort to improve both efficiency and profitability. For cotton to continue being a viable commodity, profitability must be improved. The Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980. This is an interdisciplinary effort in which recommended 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 295 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 expanded beyond that of the traditional verification program by measuring a producer's environmental footprint for each field and evaluating the connection between profitability and sustainability.

Procedures

The 2017 CRVSP was composed of 12 fields, at three locations, with 8 fields being in Desha County, 2 fields in Mississippi County, and 2 fields in St. Francis County. Each field was entered into the Field to Market Fieldprint Calculator. Two fields entered their third year of research regarding farmer standard tillage with a stale seedbed compared to that of a modified no-till with cover production system.

The CRVSP worked alongside the University of Arkansas System Division of Agriculture's Discovery Farms Program in Southeast Arkansas on 6 of the 12 fields in the program. Discovery Farms' main focus was to monitor edge-of-field water quality. Fields were watered in two sets. The split-field arrangement provided the opportunity to compare two production strategies. The farmer standard tillage and cover crop usage were compared to a no-till system with a cereal rye cover crop. The fields at Mississippi and St. Francis Counties did not have the opportunity to be watered in two sets. In fall 2016, all no-till with cover fields had either Elbon or Wrenz albrunzi cereal rye broadcasted, with a targeted seeding rate of 56 lb/acre. Irrigation methods were composed of either furrow or pivot irrigation at all locations. The diversity of the fields in the program reflect cotton production in Arkansas. Field records were maintained and economic analyses were conducted at season's end to determine net return/acre for each field in the program.

Results and Discussion

The majority of cotton in Arkansas was planted from mid-April to late May. Plant bug numbers increased compared to 2016; fields in the CRVSP were treated an average of 4.5 times for plant bugs. Plant bug pressure was similar across all locations as all fields were sprayed 4–5 times during the growing season. Each field had an average of 1.5 burndowns and 4 herbicide applications for the 2017 season. Average number of treatments for moths/worms was 1.67. Average costs/acre for herbicides and insecticides were $103.52 and $87.75, respectively. Pest control represents a big expense and can impact yields greatly.

Records of field operations on each field provided the basis for estimating expenses. Production data from the 12 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 cost type. Costs in this report do not include land costs, return to management, or other expenses and fees not directly associated with production. Price received for cotton of $0.72/lb is the estimated Arkansas annual average for the 2017 production year, and includes a $0.05/lb premium for cottonseed value after deducting all post-harvest expenses (Table 1). Average cotton yield for these verification fields was 1249 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 Table 1 were $602.32 per acre. Chemical costs averaged $233.05/acre and were 39% of operating expenses (Table 1). Seed and associated technology fees averaged $118.23/acre, or 20% of operating expenses and included 6 fields with a cover crop. Fertilizer and nutrient costs averaged 12.81% of operating expenses and were $77.16/acre. With average yield of 1249 lb/acre, average operating costs were $0.51/lb. Operating costs ranged from a low of $551.71in the Conder's Farmer Standard (FS) No Cover (NC) Field to a high of $663.92 in the Grain Bin No Till Cover Field. Returns to operating costs averaged $296.66 per acre. The range was from a low of $-126.83 in the Wellcot Field to a high of $662.99 in the Manila Farmer Standard Cover Field. Average fixed cost was $154.03 which led to average total cost of $756.36 per acre. The average returns to total specified costs are $142.62 per acre. The low was $-290.73 in the Wellcot Field and the high was $502.65 in the Manila Farmer Standard Cover Field. Total specified costs averaged $0.64/lb. The reason for such a low yield in the Wellcot Field is believed to be caused by Verticillium wilt.

Practical Applications

The CRVSP 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 meet 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. Summary of revenue and expenses per acre for 2017 fields comparing farmer standard tillage (FS) with or without

Revenue	Shop NT/C	Shop FS/ NC	Weaver NT/C	Weaver FS/NC	Grain Bin NT/C
Yield (lb)	1391.00	1228.00	1305.00	1225.00	1202.00
Price ($/lb)	0.72	0.72	0.72	0.72	0.72
Total Crop Revenue	**1001.52**	**884.16**	**939.60**	**882.00**	**865.44**
Cottonseed Value[a]	208.65	184.20	195.75	183.75	180.30
Expenses					
Seed	115.75	96.50	119.01	99.76	144.50
Fertilizer & Nutrients	85.18	85.18	85.18	85.18	85.18
Herbicides	101.58	80.10	78.02	87.94	124.86
Insecticides	96.80	93.50	96.80	96.81	88.68
Other Chemicals	26.86	36.75	47.66	35.81	36.46
Custom Applications	63.00	56.00	63.00	49.00	60.20
Other Inputs	3.88	3.88	3.88	24.29	3.88
Diesel Fuel	19.73	23.62	20.12	10.94	19.73
Irrigation Energy Costs	15.75	13.66	10.49	14.29	8.92
Input Costs	**528.53**	**489.18**	**524.15**	**504.00**	**572.40**
Fees	22.41	22.41	22.41	22.41	22.41
Repairs and Maintenance[b]	28.34	30.47	28.03	26.12	27.77
Labor, Field Activities	27.82	30.54	28.11	8.64	27.69
Production Expenses	**607.10**	**572.61**	**602.69**	**561.17**	**650.27**
Interest	12.75	12.02	12.66	11.78	13.66
Post-harvest Expenses	208.65	184.20	195.75	183.75	180.30
Operating Expenses	**619.85**	**584.63**	**615.35**	**572.95**	**663.92**
Returns to Op. Expenses	**381.67**	**299.53**	**324.25**	**309.05**	**201.52**
Cap. Recovery and Fixed Costs	146.65	160.21	145.75	132.39	146.09
Total Specified Expenses[c]	**766.50**	**744.85**	**761.10**	**705.35**	**810.02**
Returns to Spec. Expenses	**235.02**	**139.31**	**178.50**	**176.65**	**55.42**
Operating Expenses/lb	0.45	0.48	0.47	0.47	0.55
Total Expenses/lb	0.55	0.61	0.58	0.58	0.67

[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.

Cotton Research Verification Sustainability Program cover crop to no-till (NT) with cover crop.

Grain Bin FS/NC	Home-place FS/NC	Wellcot FS/NC	Manila NT/C	Manila FS/C	Conder NT/C	Conder FS/NC	Average
1253.00	1026.00	725.00	1021.00	1717.00	1335.00	1555.00	1248.60
0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
902.16	**738.72**	**522.00**	**735.12**	**1236.24**	**961.20**	**1119.60**	**898.98**
187.95	153.90	108.75	213.90	257.55	200.25	233.25	192.35
123.50	99.61	93.76	137.46	124.86	141.80	122.20	118.23
85.18	85.18	85.18	47.72	47.72	74.53	74.53	77.16
115.58	114.43	116.55	119.32	119.32	98.36	86.18	103.52
93.50	93.50	125.70	81.14	81.14	52.71	52.71	87.75
36.46	36.46	28.49	46.80	46.80	63.78	58.98	41.78
49.00	42.00	49.00	10.92	7.00	42.00	42.00	44.43
3.88	3.88	3.88	27.64	32.49	22.24	25.91	13.31
23.85	20.87	22.00	11.38	13.77	10.95	13.77	17.56
11.89	12.37	27.88	26.77	26.77	3.21	3.21	14.60
542.83	**508.29**	**552.44**	**509.14**	**499.85**	**509.58**	**479.49**	**518.32**
22.41	22.41	22.41	22.41	22.41	22.41	22.41	22.41
30.62	28.53	31.09	28.50	30.11	27.95	29.70	28.94
30.61	28.42	29.55	7.35	9.09	6.63	8.77	20.27
626.46	**587.65**	**635.49**	**567.40**	**561.46**	**566.56**	**540.37**	**589.94**
13.16	12.34	13.35	11.92	11.79	11.90	11.35	12.39
187.95	153.90	108.75	213.90	257.55	200.25	233.25	192.35
639.62	**599.99**	**648.83**	**579.32**	**573.25**	**578.46**	**551.71**	**602.32**
262.54	**138.73**	**-126.83**	**155.80**	**662.99**	**382.74**	**567.89**	**296.66**
163.81	149.01	163.90	150.01	160.33	162.17	168.09	154.03
803.43	**749.00**	**812.73**	**729.33**	**733.59**	**740.63**	**719.80**	**756.36**
98.73	**-10.28**	**-290.73**	**5.79**	**502.65**	**220.57**	**399.80**	**142.62**
0.51	0.58	0.89	0.57	0.33	0.43	0.35	0.51
0.64	0.73	1.12	0.71	0.43	0.55	0.46	0.64

University of Arkansas Cotton Breeding Program: 2017 Progress Report

F. M. Bourland[1]

Abstract

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. The current program has released almost 100 germplasm lines and cultivars. 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.

Introduction

Cotton breeding programs have existed at the University of Arkansas System Division of Agriculture for over a century (Bourland, 2018). 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 has led the program since 1988, and has been responsible for almost 100 germplasm and cultivar releases. He has established methods for evaluating and selecting several cotton traits. The current program primarily focuses on the development of improved breeding methods and the release of conventional genotypes (Bourland, 2004; 2013). 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.

Procedures

Breeding lines and strains are annually evaluated at multiple locations in the University of Arkansas System Division of Agriculture's Cotton Breeding Pro-

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gram. During early generations, breeding lines are evaluated in non-replicated tests because seed number is limited. Breeding line tests include initial crossing of parents, generation advance in early generations, individual plant selections 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 promoted to strains, which are evaluated in replicated strain tests at multiple Arkansas locations to determine traits associated with yield, yield component, 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 2012 through 2017 (F_1 through F_6 generations evaluated in 2017) 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 (Bourland and Jones, 2012a) into higher yielding lines. Breeding line development exclusively focuses on conventional cotton lines.

The primary focus of the 24 crosses made in 2017 was to combine lines having specific morphological traits, enhanced yield components and improved fiber characteristics. Eighteen of the 24 crosses were made between advanced Arkansas lines, and 6 were made between an Arkansas line and a line from another public program. The 2017 breeding effort also included field evaluation of 12 F_2 populations, 17 F_3 populations, 16 F_4 populations, 896 first year progeny, and 216 advanced progeny. Bolls were harvested from superior plants in F_2 and F_3 populations and bulked by population. Individual plants (800) were selected from the F_4 populations. An additional 250 second-cycle selections were made from advanced lines with particular attention to nectariless and high-glanding traits. After discarding individual plants for fiber traits, 880 progenies from the individual plant selections will be evaluated in 2018. From the first year progenies, 216 were advanced, and 72 F_6 advanced progenies were promoted to strain status. Most of these selected 72 F_6 advanced progeny have either UA48 (Bourland and Jones, 2012a), or UA222 (Bourland and Jones, 2012b) in their pedigrees.

Strain Evaluation

In 2017, 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 29 derived from crosses with UA48 and 26 crosses with UA222.

Germplasm Releases

Germplasm releases are a major function of public breeding programs. Since 2004, a total of 60 cotton germplasm lines and 5 cotton cultivars have been released by the University of Arkansas System Division of Agriculture's Arkansas Agricultural Experiment Station. Lines released in 2017 included two germplasm lines, Arkot 0705 and Arkot 0711 (Bourland and Jones, 2018a), and two cultivars UA107 (Bourland and Jones, 2018b) and UA114 (Bourland and Jones, 2018c). These germplasm lines provide new genetic material to public and private cotton breeders with documented adaptation to the mid-South cotton region. Cultivar UA107 will replace previously released UA103 (Bourland and Jones, 2013), while UA114 is expected to supplement UA222.

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 2017

F. Bourland[1], W. Barnett[1], C. Kennedy[2], L. Martin[3], A. Rouse[1] and B. Robertson[4]

Abstract

Other than variation in transgenic technologies and seed treatment, 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. Varieties that are now available or may soon be available to producers are annually evaluated in small and large plot tests in Arkansas. Results from the small plot tests, which usually include 40 to 60 lines and are mostly conducted at experiment stations, provide information on which lines are best adapted to Arkansas environments. Based on these results, varieties are chosen and evaluated in large plot on-farm tests. These large plot tests represent various growing conditions, growers' management, and environments of Arkansas cotton producers. Results from the large plot tests are used to supplement and verify results of small plots. Results from both tests help producers to choose the best varieties for their specific field and farm situations.

Introduction

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. In our testing system, results from small plot variety testing (coordinated by Bourland) are supplemented by

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subsequent evaluation in large plot extension plots (coordinated by Robertson). A much greater number of varieties can be evaluated in our small plot tests than in our large plot tests. Results from small plot tests are used to select varieties that are subsequently evaluated in on-farm strip tests.

Procedures

Small Plot Tests

Entries in the 2017 Arkansas Cotton Variety Test were separated into transgenic and conventional lines (Bourland et al., 2018). The small plot tests were conducted on experiment stations that span about 180 miles north to south and include contrasting soil types, weather, pests, and management. The 41 entries in the 2017 transgenic test included 18 entries (13 B2XF, 2 WRF, 2 GLT, and 1 GLB2) returning from the 2016 test and 23 first-year entries (6 B2XF, 3 B3XF, 1 GLT, 13 W3FE). The transgenic test was replicated 6 times at Manila Airport, 5 times at Judd Hill Cooperative Research Station and 4 times at the Keiser Research Station, the Lon Mann Cotton Research Station (Marianna) and the Rohwer Research Station. The conventional test included 16 entries and was evaluated using 5 replications at Keiser, Judd Hill, Marianna, and Rohwer.

Originators of seed supplied seed of their entries treated with their standard fungicides. Prior to planting, all seed were uniformly 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's Cooperative Extension Service recommendations for cotton production, including COTMAN rules for insecticide termination. Cereal rye was planted in the test plot areas at both Marianna and Keiser as a cover crop. 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.

Large Plot Tests

From 7 to 12 transgenic varieties were evaluated at 11 locations from Ashley County to Clay County. Two varieties from five seed companies (Bayer, Americot, Monsanto, Dow, and Crop Production Services) were entered in this study. In addition, one test in Lee County compared conventional varieties with popular transgenic varieties. Replicated strips were planted the length of the field and managed according to the remainder of the field in which the study was located in all locations with the exception of Clay county. Clay county location was not replicated. A full sized module of each variety was harvested, ginned, and marketed separately for each variety in Clay county. The test plots were harvested with the producer's equipment. Grab samples were collected for lint fraction and fiber quality with the exception of Clay county where samples were ginned in a commercial gin.

Results and Discussion

Results of the Arkansas Cotton Variety Test (small and large plot tests) are published annually and made available online at https://arkansas-variety-testing.uark.edu/.

Small Plot Tests

Wet conditions delayed planting at all sites except Rohwer. Rainfall was unusually high through much of the summer at all locations. The cereal rye cover crop supplied valuable supplemental control of weeds, particularly pigweed, but interferred with cotton planting at Keiser and with plant growth at Marianna. Delays in killing the cover crop caused planting problems and likely reduced nitrogen availability to the cotton. 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, percentage of open bolls, and fiber strength in both the transgenic and conventional tests, and lint percentage, seed per acre, fibers per seed, and fiber elongation in the transgenic test. However, several of the top yielding varieties were similar at each site. Variety by location interaction is often found for micronaire, but was not present in either the transgenic or conventional tests in 2017. 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 were found in both the transgenic and conventional variety tests.

Large Plot Tests

On-farm plots were established with a wide range of planting and harvest dates. Acceptable plant stands were achieved at each location. COTMAN curves indicated no unexpected stress throughout the season at any location. Nodes above white flower data were recorded for all varieties to calculate days to cutout. Plant height, canopy closure and a visual rating were recorded at or just prior to defoliation. Lint yield was summarized across locations containing all technologies and across all locations comparing only B2XF varieties. Discounts associated with excessive leaf grades is a major concern. Leaf grades from commercially ginned plots in Clay county were compared to leaf and stem pubescence ratings and marginal trichome density data collected by Bourland in the small plot Arkansas Cotton Variety Test. Harvest preparation in this study did an excellent job of defoliation and boll opening with no desiccated leaves present for any variety. All bales from the module harvested for each variety and ginned in a commercial gin of some varieties received a leaf grade of 1 or 2, while other varieties had no bales that received a leaf grade of 1 or 2. The potential to receive leaf discounts especially when less than ideal defoliation has occurred appears to be much greater for some varieties. One conventional variety (UA222) yielded more than all other conventional and transgenic varieties in the one conventional variety test.

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. Results from large plot tests provide more information on specific adaptation of varieties. When choosing a variety, producers should first examine results (yield and fiber quality) of a large plot test that most closely matches their geographic and cultural conditions. Second, they should examine results from multiple years of small plots for consistency of performance. Third, variety selection can be fine-tuned by examining pest and morphological features from small plot tests. Finally, results from the small plot tests can identify new lines that may be considered.

Acknowledgments

We appreciate the assistance of the Directors, Program Technicians and staffs at the stations of the University of Arkansas System Division of Agriculture. We are also grateful to the cotton producers who cooperate with us to perform the large plot tests. Finally, we acknowledge the contributions of seed companies that participate in our Arkansas Cotton Variety Testing

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Chlorophyll Fluorescence as an Indicator of Temperature Tolerance in Cotton Genotypes

M.M. van der Westhuizen[1], D.M. Oosterhuis[1] and J. Berner[2]

Abstract

Cotton (*Gossypium hirsutum* L.) is sensitive to high temperatures during reproductive development, but information is lacking on genotypic tolerance to heat stress (HS). To evaluate tolerance to heat stress in cotton, chlorophyll *a* fluorescence (ChlF) induction kinetics were investigated in four diverse cotton genotypes (Arkot 9704, VH260, DP393 and DP 210 B2RF) in a 30 °C control and a 40 °C heat stress at Rustenburg, South Africa, during 2017. Heat stress measurements of functions of the fluorescence response to heat stress were evaluated through fluorescence intensity. Plants at the pinhead square stage were subjected for 6 hours to 2 temperature treatments, a 30 °C control and 40 °C HS treatment. The transient profile of chlorophyll *a* fluorescence (ChlF) intensities with time after start of the measurement showed clear genotypic differences with DP393 being the least affected by HS of the four genotypes. The genotype DP393 had the lowest change in fluorescence intensities, indicating heat tolerance and Arkot 9704 had the biggest changes and showed heat sensitivity. Measurement of chlorophyll *a* fluorescence proved to be a precise method of quantifying heat stress responses in cotton genotypes.

Introduction

Chlorophyll fluorescence intensity is an indication of absorbed photons that are not used for photosynthesis. Light energy absorbed by chlorophyll molecules in a leaf can undergo one of three fates, namely a) drive photosynthesis, b) dissipate excess energy as heat, or c) it can be re-emitted as light (ChlF). These three processes are in competition with each other, such that the increase in efficiency of one will lead to a decrease in the yield of the other two (Misra et al., 2012; Strasser et al., 2004). The ChlF technique was developed by Kitajima and Butler (1975), and is one of the most widely and popular stress tests in crop production (Baker and Oxborough, 2004; Resco et al., 2008; Wu et al., 2011) because of the ease of gaining detailed information on the effects of stress on photosystem II.

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Florescence measurements provide an understanding of the fundamental mechanisms of photosynthesis and the responses of plants to environmental change (Murchie and Lawson, 2013). Chlorophyll fluorescence takes place in the chlorophyll, where light energy is absorbed by pigments present in the photosynthetic antenna molecules in the thylakoid membranes (Misra et al., 2009). The objective of the study was to evaluate a procedure for measuring the fluorescence response of cotton genotypes to heat stress derived from the fast chlorophyll *a* fluorescence kinetics to evaluate heat stress responses of cotton and identify heat tolerance among four diverse genotypes.

Procedure

Four diverse cotton genotypes namely Arkot 9704, VH260, DP393 and DP 210 B2RF (Table 1), were planted in 2 litre PVC pots in two greenhouse studies at Rustenburg, South Africa (S 26° 41' 20", E27° 05' 25"), in August 2016. 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 one week after emergence. Plants were watered daily with half-strength Hoagland's solution (Hoagland and Arnon, 1950). 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, Northwest) to create the temperature treatments. Fluorescence intensities were taken on intact cotton 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 µmol m^{-2} s^{-1}, 650 nm peak wavelength) for 1 s provided by an array of 6 light-emitting diodes focused on a circle of 5 mm diameter of the sample surface. Six plants per genotype were evaluated from the control (30 °C) and HS (40 °C) and measurements were taken at three different spots on the adaxial surface of the fourth mainstem leaf from the terminal.

Results and Discussion

The transient profile of ChlF intensities with time after start of the measurement of four cotton genotypes at two different temperature regimes in two growth room studies are presented in Fig. 1. At 30 °C control there were differences in ChlF intensity between genotypes indicating innate differences in photosynthetic efficiency. DP393 (33208) and DP210 (32008) had significantly higher intensities than Arkot (28865) and VH260 (28726). The 40 °C HS resulted in a significant decline of the transient response of all four genotypes (Fig. 1). These decreases in fluorescence intensities are associated with the restriction in the flow of electrons between the two photosystems (PSII and PSI) in photosynthesis as well as a decrease in the plants ability to reduce NADP + to NADPH (Oukarroum et al., 2013). There was a significant interaction between genotype responses to heat stress. The genotype DP393 had the least change in fluorescence intensity compared to the 30 °C control showing that it was more tolerant to heat stress. The other three genotypes, Arkot 9704, VH260 and DP 210 B2RF showed higher changes in fluorescence intensity indicating larger responses to heat stress. The transient profile of ChlF intensities with time after start of the measurement showed clear genotypic differences with DP393 being the least affected by heat stress of the four genotypes. As indicated by analysis of the functions within the chlorophyll transient, a decrease in fluorescence intensity of cotton plants was observed when subjected to 40 °C, indicating the adverse effects of heat stress on the efficiency of Photosystem II. Arkot 9704 had the biggest changes and showed heat sensitivity.

Practical Applications

Damage caused by heat stress can be quantified using ChlF measurements. Measurement of ChlF transients proved to be a precise method of quantifying heat stress responses in cotton genotypes. Cotton cultivars should be evaluated for temperature tolerance and identified for yield performance at specific localities for recommendations to producers.

Acknowledgments

Support for this research was provided by Cotton Incorporated, University of Arkansas System Division of Agriculture, Agricultural Research Council, South Africa, and Potchefstroom University, South Africa.

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Table 1. Pedigree information for the genotypes used in the greenhouse study in 2017.

Genotypes	Area of origin	Parent lines
VH260	A Pakistan genotype that grows at temperatures of 45 °C (Zhang *et al.*, 2016)	S12 x H1692 (VH55 XLRA5166)
Arkot 9704	Arkansas Agricultural Experiment Station (Bourland and Jones, 2009)	Ark 9108 x 8 M331RKN
DP393	USA, Delta & Pine Land Co.	PVP 200400266
DP 210 B2RF	South Africa, Monsanto	DP560BGIIx2[B1][B2]/ COKER312[R2]

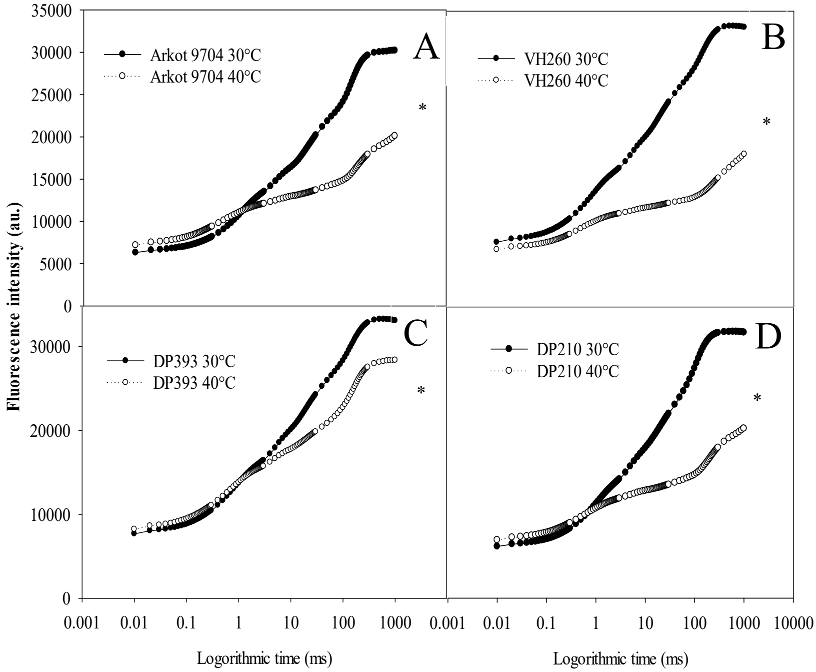

Fig. 1. Chlorophyll fluorescence intensity (arbitrary units) transient exhibited by intact leaves of four cotton genotypes (A) Arkot 9704, (B) VH260, (C) DP393 and (D) DP 210 B2RF subjected to a 30 °C treatment and a 40 °C temperature regime. * = significant difference.

Monitoring for Varietal Resistance to Tarnished Plant Bug in Mid-South Conventional Cotton

G.E. Studebaker[1], F.M. Bourland[1], and C. Jackson[1]

Abstract

A small plot field trial was planted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center at Keiser to validate tarnished plant bug (TPB) resistance in conventional cotton cultivars. Four conventional cotton lines were evaluated. One TPB susceptible cultivar (UA48) was planted as a check to validate TPB populations within the test, and was compared to the other three conventional lines. At least one line reached economic threshold at each sampling date, but TPB pressure was relatively low overall. Cultivar Ark 0812-87ne had the lowest yield loss, while UA114 had the highest yield loss. No significant differences in yield were noted among the other cultivars. Tarnished plant bug pressure and environmental conditions may have some influence on the utility of resistance in some conventional lines. Results from this test indicate the need to continue to verify resistance identified by damaged anthers in dirty flower examinations.

Introduction

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), is a key pest of cotton in the mid-South (Scott et al., 1985). Increasing levels of insecticide resistance as well as loss of key insecticides has limited grower options to control this pest. Host-plant resistance in an important component of integrated pest management (IPM) and should not be overlooked. As prices of cotton fluctuate, so does the growers' demand for alternative varietal choices. In some cases, growers may need to utilize conventional cultivars that can be purchased at a much lower price than the insect resistant transgenic varieties. It is important that the level of resistance to TPB in these conventional cultivars is evaluated.

Procedures

Small plot trials were conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keiser,

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Ark. Plots (4 rows wide by 27 meters long) of conventional cotton lines were planted in randomized complete block design with replications. Each cotton line was managed under two regimes: 1) an untreated check and 2) treated as needed with 0.75 lb/acre of acephate. Two shake sheet samples from the center of each plot were taken to monitor TPB on a weekly basis throughout the growing season until cotton reached cutout (nodes above white flower = 5) plus 250 accumulated heat units. Plots were taken to yield by harvesting all four rows in each plot with a cotton picker modified to harvest and weigh cotton from small plots. Yield loss was determined by subtracting yields from the untreated plots from those that were treated. All data were analyzed using Agriculture Research Manager (ARM) version 2016 software (Gylling Data Management, Inc., Brookings, South Dakota).

Results and Discussion

Lines were chosen based on damaged flower data from ultra-small plot TPB testing (Bourland et al., 2014). The 4 lines included UA48 (relatively susceptible), UA114, UA222 (relatively resistant) and Ark 0812-87ne (nectariless advanced line). Tarnished plant bug populations were low to moderate and only reached a peak of 7 per 10 row feet in UA48 (Fig. 1). Tarnished plant bug numbers are reported in levels per 10 row-ft, therefore the economic threshold in the figure would be six. Cultivar UA48 reached threshold in each of the 3 weeks that data were collected. Cultivar UA114 was the only other line to reach threshold, and that occurred week 3 of the test. As expected, the nectariless line had the lowest density of tarnished plant bug. Yield loss was determined by subtracting yields from the untreated plots from those that were treated at threshold and is reported in Fig. 2. Cultivar Ark 0812-87ne numerically had the lowest yield loss, while UA48 and UA222 had a significantly higher yield loss compared to the other lines. Lower yield losses would indicate there is some level of resistance or perhaps tolerance in Ark 0812-87ne. Results from the last two years have been variable with some lines exhibiting resistance in small plots not translating into resistance in large plots. Tarnished plant bug pressure and environmental conditions may have some influence on the utility of resistance in some lines. This study should be repeated in both small plots and incorporated into a large plot study as well to better understand the ability of these conventional lines to tolerate TPB and protect yield.

Practical Applications

Results from this conventional test indicate the need to continue to verify resistance found in ultra-small dirty bloom examinations. Data from these studies could be used by breeders to discard very susceptible lines, and to incorporate more resistant lines into production practices. The use of resistant cultivars could potentially result in fewer insecticide treatments, which is economically and environmentally beneficial.

Acknowledgments

The authors would like to extend our appreciation to Cotton Incorporated for partial funding for this project. Support also provided by the University of Arkansas System Division of Agriculture.

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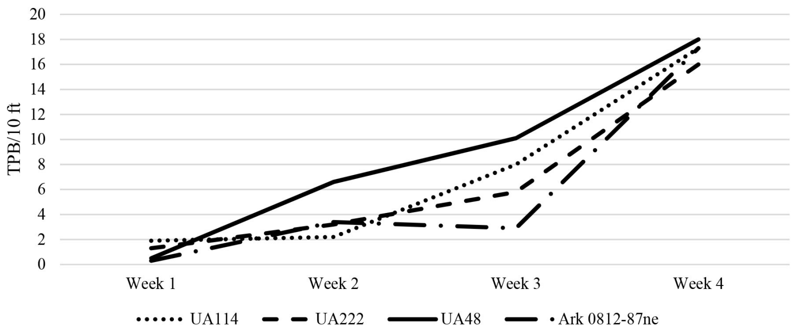

Fig. 1. Tarnished plant bug (TPB) densities in untreated plots (number per 10 row foot) for four conventional cotton lines.

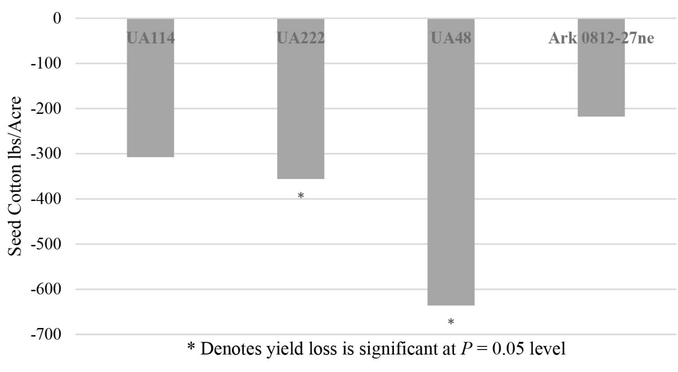

Fig. 2. Yield loss caused by tarnished plant bug in conventional cotton lines.

Monitoring for Varietal Resistance to Tarnished Plant Bug in Mid-South Cotton

C. Jackson[1], G. Studebaker[1], and F.M. Bourland[1]

Abstract

A large plot field trial was planted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center at Keiser to validate tarnished plant bug (TPB) resistance previously established in ultra-small plot studies. Four supposed TPB resistant and two TPB susceptible cultivars were evaluated. The two TPB susceptible cultivars were used to validate TPB populations within the test. All cultivars reached economic threshold only once. Cultivars PHY 312WRF, DP 1725 B2XF and ST 4946 GLT had the lowest yield loss, while DP 1518 B2XF and DP 1522 B2XF had the highest yield losses. Cultivar DP 1518 B2XF was determined to have some resistance in small plots, but has shown the highest yield loss in large plots the last two years, indicating that its resistance did not carry over at the field level. Cultivar PHY 312 WRF had significant yield loss two years ago, but had very low yield loss last year and this season. Tarnished plant bug pressure and environmental conditions may have some influence on the utility of resistance in some cultivars. Results from this cultivar test indicate the need to continue to verify resistance found in ultra- small plots.

Introduction

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois), is a key pest of cotton in the mid-South (Scott et al., 1985). Increasing levels of insecticide resistance as well as loss of key insecticides has limited grower options to control this pest. Host-plant resistance in an important component of integrated pest management (IPM) and should not be overlooked. As new cultivars become available, it is important that their level of resistance or susceptibility to tarnished plant bug be known.

Procedures

Large plot trials were conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keis-

[1] Program Associate, Extension Entomologist and Professor, respectively, University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser.

er, Arkansas. Large plots (24 rows wide by 88 feet long) of 2 cotton cultivars assumed to be susceptible and 4 cultivars assumed to be resistant were planted in randomized complete block design with 4 replications. Cultivars were chosen based on damaged flower data from small plot testing (Bourland et al., 2014). Each cultivar was managed under two regimes: 1) an untreated check and 2) treated with 0.75 lb/acre of acephate. Two shake sheet samples from the center of each plot were taken to monitor TPB on a weekly basis throughout the growing season until cotton reached cutout (nodes above white flower = 5) plus 250 accumulated heat units. Plots were taken to yield by harvesting the center rows in each plot with a small plot cotton picker. Yield loss was determined by subtracting yields from the untreated plots from those that were treated. All data were analyzed using Agriculture Research Manager (ARM) version 2016 software (Gylling Data Management, Inc., Brookings, South Dakota).

Results and Discussion

Tarnished plant bug populations were low to moderate and only reached a peak of just over 19 per 10 row feet in DP 1518 B2XF (Fig. 1). Tarnished plant bug numbers are reported in levels per 10 row-ft, therefore the economic threshold in the figure would be six. All cultivars reached economic threshold only once (DP 5115 GLT, ST 4946 GLT and PHY 312 WRF in week 2; DP 1518 B2XF, DP 1522 B2XF and DP1725 B2XF in week 3). Yield loss was determined by subtracting yields from the untreated plots from those that were treated at threshold. Cultivars PHY 312 WRF, DP 1725 B2XF and ST 4946 GLT had the lowest yield loss, while DP 1518 B2XF and DP 1522 B2XF had the highest yield losses (Fig. 2). Cultivar DP 1518 B2XF was determined to have some resistance in small plots, but has shown the highest yield loss in large plots the last two years. This may indicate that resistance does not carry over at the field level. Lower yield losses would indicate there is some level of resistance or perhaps tolerance in ST 4946 GLT, PHY 312 WRF and DP 1725 B2XF. Results from the last two years have been variable with some cultivars exhibiting resistance in small plots not translating into resistance in large plots. Cultivar PHY 312 WRF had significant yield loss two years ago, but had very low yield loss last year and this season. Tarnished plant bug pressure and environmental conditions may have some influence on the utility of resistance in some cultivars.

Practical Applications

Results from this cultivar test indicate the need to continue to verify resistance found in ultra-small plots. Data from cultivar trials such as this could be used by breeders to discard very susceptible lines, and to incorporate more resistant lines into production practices. The use of resistant cultivars could result in fewer insecticide treatments, which is economically and environmentally beneficial.

Acknowledgments

The authors would like to extend our appreciation to Cotton Incorporated for partial funding for this project. Support also provided by the University of Arkansas System Division of Agriculture.

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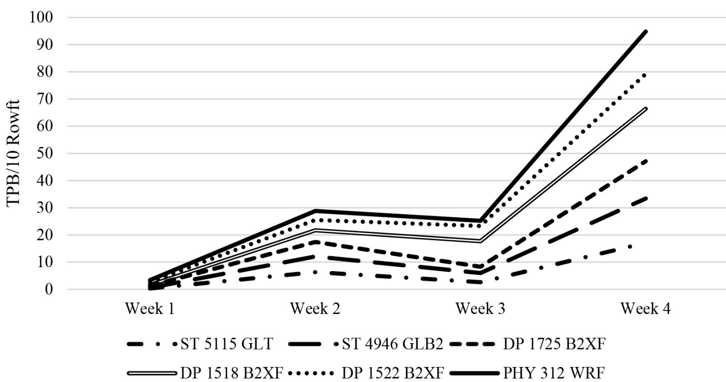

Fig. 1. Tarnished plant bug (TPB) densities in untreated plots across four weeks of data collection.

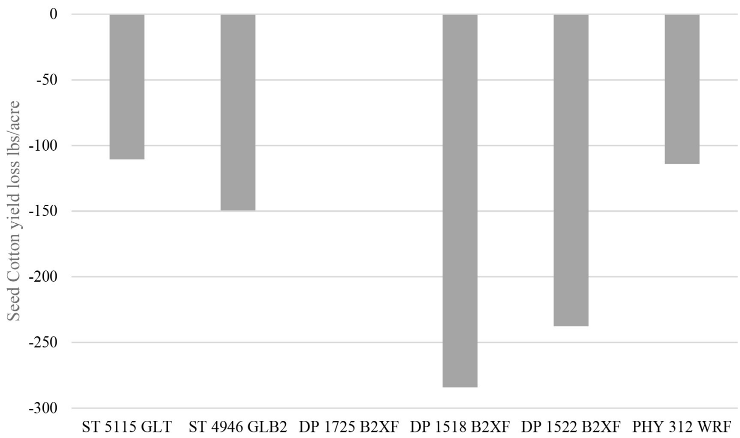

Fig. 2. Yield loss associated with tarnished plant bug damage to six cotton cultivars.

Comparison of *Bacillus thuringiensis* Cultivars for Control of Cotton Bollworm With and Without a Foliar Application in Arkansas, 2017

N. Taillon[1], G. Lorenz[1], A. Plummer[1], N. Bateman[1], B. Thrash[1], K. McPherson[1], A. Cato[2], J. Black[1], and J. Pace[1]

Abstract

The bollworm is a very important pest of cotton in Arkansas and can cause significant yield losses if not controlled. An increasing amount of fruit damage has been observed in dual gene cotton cultivars in the last several years. The objective of this study was to evaluate the efficacy of dual gene and triple gene Bacillus *thuringiensis* (Bt) cotton cultivars in sprayed and unsprayed conditions. Results indicated that dual gene cultivars benefited from supplemental foliar applications for control of bollworms but no benefits were seen in triple gene cultivars.

Introduction

Cotton is a high input crop for growers and many are struggling to make a profit due to increasing costs of technology fees, insecticide applications, weed control, and field maintenance making it imperative to find ways to save money for growers. Each year, the cotton bollworm (*Helicoverpa zea*, Bodie), infests 100% of all cotton planted in Arkansas. It remains a major pest of post-bloom cotton in the mid-South despite widespread use of transgenic *Bacillus thuringiensis* (*Bt*) cotton cultivars. In recent years 98%–100% of the cotton acreage in Arkansas was planted with dual gene *Bt* cultivars (Williams, 2016). A recent meta-analysis of mid-South cotton data since 2007 indicated that there has been increasing amounts of square damage in dual gene cotton. This suggests that there may be some tolerance developing to dual gene technologies used for control of cotton bollworm (pers. comm., G. Lorenz). Studies in 2017 indicated there is widespread resistance to Cry1Ac, the major gene associated with *Bt* cotton (Kerns et al., 2017). Estimated economic loss in 2015 from bollworm based on cost of treatment and reduction in yield has added up to more than $1.7 million, averaging $9.41 per acre (Williams, 2016).

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The objective of this study was to evaluate the efficacy of dual-gene and triple gene *Bt* cottons, specifically Bollgard II, WideStrike, WideStrike III, TwinLink, and TwinLink Plus for control of cotton bollworm in sprayed and unsprayed conditions. This study monitors current and emerging technology to help growers make informed decisions.

Procedures

A trial was conducted on a 2017 grower field in Jefferson County, Arkansas. Plot size was 12.5 ft. (4 rows) by 40 ft., in a randomized complete block design with 4 replications. Cotton used consisted of: one Non-*Bt* cultivar (DP 1441 RF); three dual gene cultivars, WideStrike (PHY 333 WRF), Bollgard 2 (ST 4946 GLB2), and TwinLink (ST 4949 GLT); and two triple gene cultivars, TwinLink Plus (ST 5517 GLTP), and WideStrike 3 (PHY 330 W3FE). Each cultivar had a treated and untreated control. Sprayed plots were treated with a foliar application of Prevathon at 20 oz/acre on 24 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/acre and 40 psi. Damage ratings were taken 2, 9, 17, and 23 days after application (DAA) by sampling 25 squares, 25 blooms, and 25 bolls per plot. Plots were harvested using a John Deere two row plot picker. The data were processed using Agriculture Research Manager 2017 (Gylling Data Management, Inc., Brookings, South Dakota) and Duncan's New Multiple Range Test ($P = 0.10$) to separate means. Means followed by same letter do not significantly differ. Mean comparisons were performed only when analysis of variance Treatment P (F) were significant at mean comparison observed significance level.

Results and Discussion

All plots had less damage than the untreated non-*Bt* control for each sampling date (Figs. 1–4). All of the *Bt* cultivars had less damage than the sprayed non-*Bt* cultivar 2 DAA and were below the threshold (Fig. 1). At 9 DAA, the unsprayed WideStrike cultivar had more damage than all other plots (Fig. 2). The unsprayed WideStrike, BGII, and TwinLink cultivars had damage near or above the 6% damage threshold. There was also a trend for the dual gene *Bt* cultivars to have more damage than the triple gene *Bt* cultivars, although this was not significant. Similar results were observed 17 days after application (Fig. 3). At 23 DAA, the unsprayed WideStrike cultivar had more damage than all other transgenic plots (Fig. 4). The unsprayed dual gene cultivars, though not always significant, had damage levels exceeding the threshold of 6% damaged fruit.

Non-*Bt* and Widestrike cultivars had higher yields when foliar applications were made for control of bollworms (Fig. 5). No difference in yield was observed for BG II, Widestrike III and TwinLink Plus cultivars between sprayed and unsprayed treatments. 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 cultivars varies from year to year. In 2012, foliar applications increased yield in Bollgard II and WideStrike cultivars, but in 2013 and 2014 yields did not increase with foliar applications. This would indicate that bollworm numbers from year to year are the determining factor regarding the need for supplemental foliar applications.

Practical Applications

This study indicates that dual gene *Bt* cultivars may not provide the protection needed to prevent fruit damage from bollworms and may require foliar applications in years when populations of bollworm are high. In this study, the newer triple gene *Bt* cultivars are currently providing the control needed to maximize yield without requiring foliar applications. Studies should be continued to monitor these trends and keep growers informed of their choices.

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Appreciation is expressed to Chuck Hooker for providing the land where this research was conducted. Support also provided by the University of Arkansas System Division of Agriculture.

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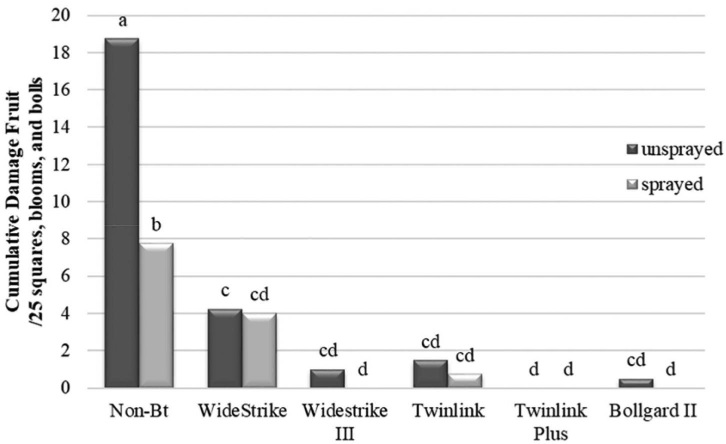

Fig. 1. Cumulative damage of 25 squares, 25 blooms, and 25 bolls on 26 July (2 days after application of Prevathon 20 oz) in *Bacillus thuringiensis* Cultivar Comparison Test in Jefferson County, Ark. Bars with the same letter do not differ significantly (*P* = 0.10).

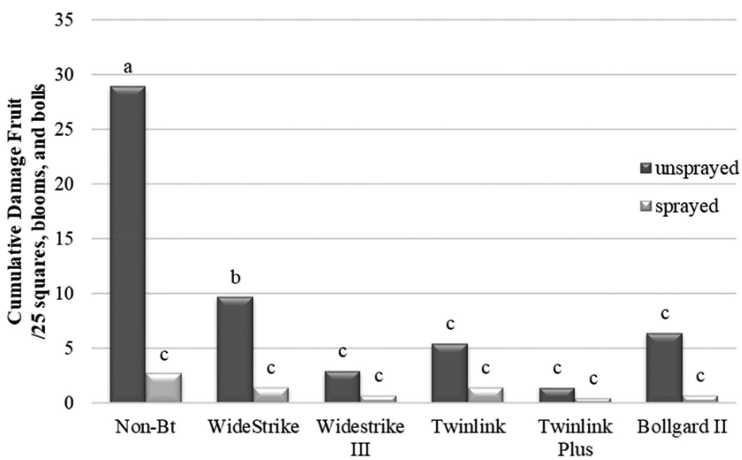

Fig. 2. Cumulative damage of 25 squares, 25 blooms, and 25 bolls on 2 Aug (9 days after application of Prevathon 20 oz) in *Bacillus thuringiensis* Culitvar Comparison Test in Jefferson County, Ark. Bars with the same letter do not differ significantly (*P* = 0.10).

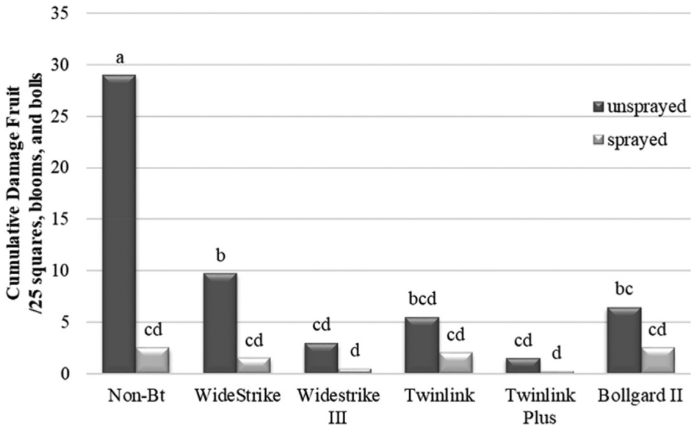

Fig. 3. Cumulative damage of 25 squares, 25 blooms, and 25 bolls on 10 Aug (17 days after application of Prevathon 20 oz) in *Bacillus thuringiensis* Cultivar Comparison Test in Jefferson County, Ark. Bars with the same letter do not differ significantly (*P* = 0.10).

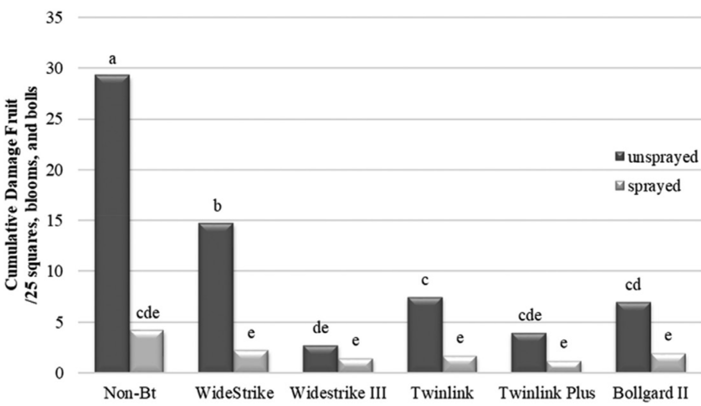

Fig. 4. Cumulative damage of 25 squares, 25 blooms, and 25 bolls on 16 Aug (23 days after application of Prevathon 20 oz) in *Bacillus thuringiensis* Cultivar Comparison Test in Jefferson County, Ark. Bars with the same letter do not differ significantly (*P* = 0.10).

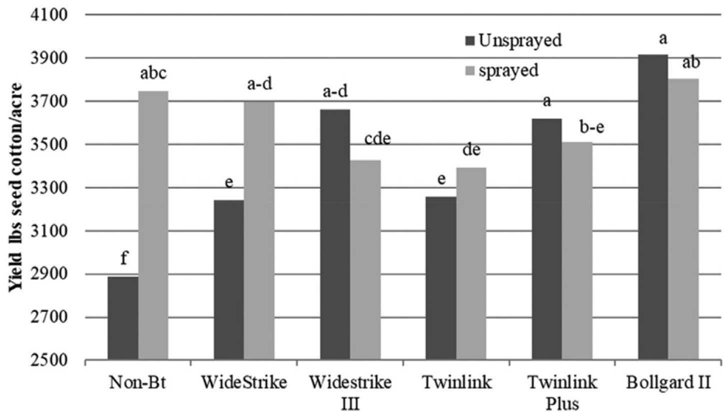

Fig. 5. Yield (seed cotton/acre) in *Bacillus thuringiensis* Cultivar Comparison Test in Jefferson County, Ark. Bars with the same letter do not differ significantly (*P* = 0.10).

Efficacy of Select Insecticides for Control of Cotton Bollworm, *Helicoverpa zea* (Boddie), in Conventional Cotton

A. Plummer[1], G. Lorenz[1], N. Taillon[1], N. Bateman[1], B. Thrash[1], K. McPherson[1], J. Black[1], A. Cato[2], L. McCullars[2], and J. Pace[1]

Abstract

A test was conducted on a grower field in Jefferson County, Arkansas, to evaluate the efficacy and residual control of selected foliar insecticides and rates on bollworm in conventional cotton. Selected insecticides included bifenthrin, Prevathon, Besiege, and Intrepid Edge. At 9 days after application (DAA) all treatments had less fruit damage than the untreated check (UTC). At 17 DAA, Besiege, Prevathon, and Intrepid Edge had less fruit damage than bifenthrin and the UTC. At 23 DAA, Prevathon (20 oz/acre) had the least amount of fruit damage of all treatments but was no different than Besiege (10 oz/acre). Results indicate that higher labeled rates of Prevathon provide an increase in residual control when compared to the lower labeled rate (14 oz/acre).

Introduction

Bollworm, *Helicoverpa zea* (Boddie), has historically been the most damaging insect pest of cotton in Arkansas and has only recently been surpassed by the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois). In 2016, 100% of Arkansas cotton acres were infested with bollworm, and 81% of these acres required supplemental insecticide treatments (Williams, 2017). Although *Bacillus thuringiensis* (*Bt*) cotton is still very effective for control of tobacco budworm, *Heliothis virescens* (F.), the amount of *Bt* cotton acreage requiring treatment for bollworms has been increasing in recent years. High costs associated with technology fees for bollworm control has encouraged growers and consultants to look for ways to reduce costs. Planting conventional cotton and using foliar insecticides for bollworm control may be a more cost effective way to grow cotton in the mid-South.

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Procedures

This test was conducted on a grower field in Jefferson County, Arkansas in 2017. Cotton cultivar DP 399 was planted on 17 May. Plot size was 12.5 ft (4 rows) by 40 ft, with a 2 row buffer between plots. Treatments were arranged in a randomized complete block design with 4 replications. Treatments consisted of an untreated control (UTC), bifenthrin 5.12 oz/acre, Prevathon (chlorantraniliprole) 14 and 20 oz/acre, Besiege (chlorantraniliprole + lambda-cyhalothrin) 7 and 10 oz/acre, Intrepid Edge (methoxyfenozide + spinetoram) 6 and 8 oz/acre. Insecticides were applied on 24 July with a Mud Master fitted with 80-02 dual flat fan nozzles with 19.5 inch spacing. Spray volume was 10 gal/acre, at 40 psi. Damage ratings were taken 9, 17, and 23 by sampling 25 squares, 25 blooms, and 25 bolls per plot. Plots were harvested using a John Deere two-row plot picker on 20 Oct. Data were processed using Agriculture Research Manager Version 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 9 days after application (DAA), all treatments had less fruit damage than the UTC (Fig. 1). Prevathon 20 oz/acre had less fruit damage than bifenthrin, Prevathon 14 oz/acre, and Intrepid Edge 6 oz/acre. At 17 DAA, all treatments had less fruit damage than the UTC (Fig. 2). All rates of Prevathon, Besiege, and Intrepid Edge had less damage than bifenthrin. Besiege 10 oz/acre was the only treatment with less damage than Intrepid Edge 6 oz/acre. At 23 DAA, all treatments had less fruit damage than the UTC except bifenthrin (Fig. 3). Prevathon 20 oz/acre had less damage than both rates of Intrepid Edge, Besiege 7 oz/acre, and Prevathon 14 oz/acre. Foliar insecticide application increased yield 100–560 lb seed cotton/acre above the UTC (Fig. 4).

Practical Applications

In this experiment bifenthrin did not provide adequate control of bollworms at any sample date. At 23 DAA, Prevathon 20 oz/acre provided the greatest control of bollworms but was no different than Besiege 10 oz/acre.

Acknowledgments

We would like to thank Chuck Hooker for allowing us to conduct research on his land and DuPont, Syngenta, and Dow for funding this research. Support also provided by the University of Arkansas System Division of Agriculture.

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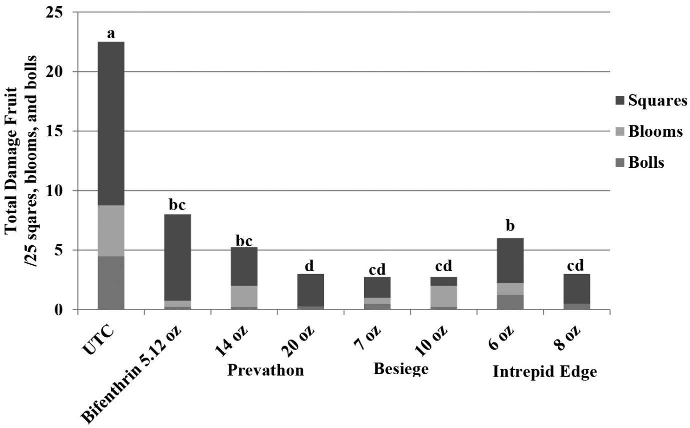

Fig. 1. Assessment of damaged fruit 9 days after application of foliar insecticides. UTC = untreated check. Bars with the same letter do not differ significantly (*P* = 0.10).

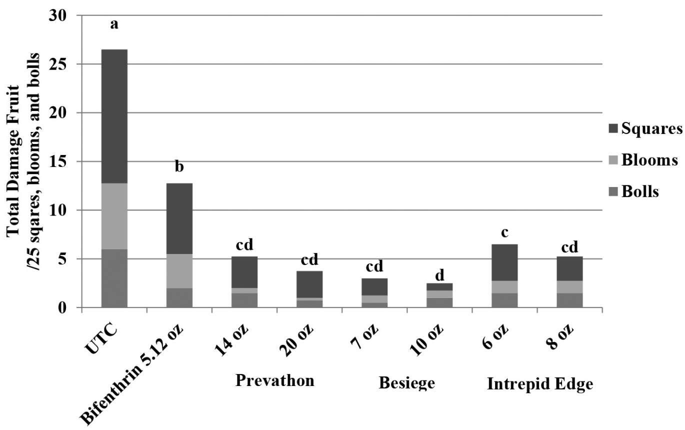

Fig. 2. Assessment of damaged fruit 17 days after application of foliar insecticides. UTC = untreated check. Bars with the same letter do not differ significantly (*P* = 0.10).

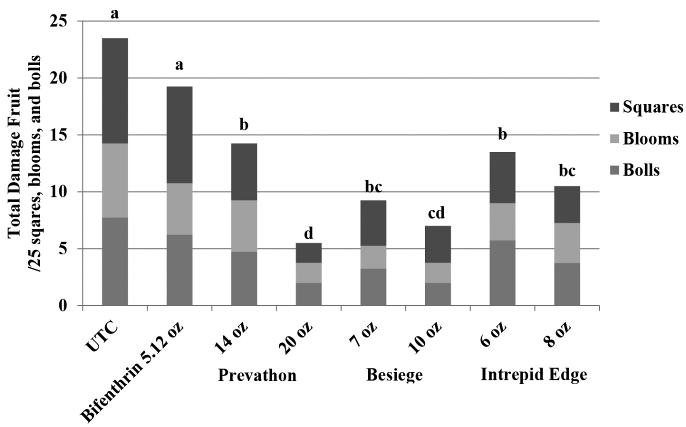

Fig. 3. Assessment of damaged fruit 23 days after application of foliar insecticides. UTC = untreated check. Bars with the same letter do not differ significantly (*P* = 0.10).

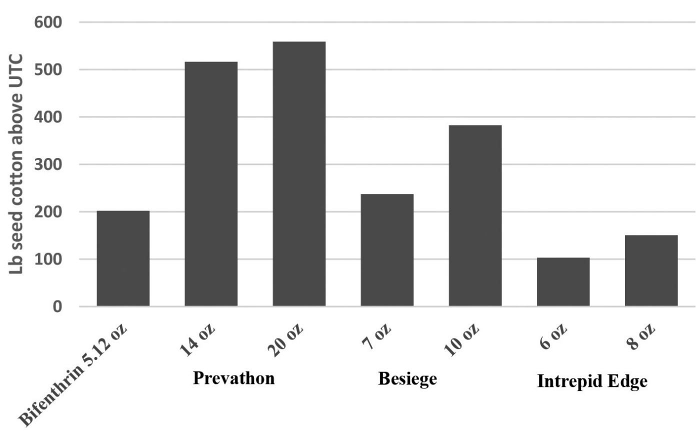

Fig. 4. Seed cotton yield (lb/acre) above the untreated control. UTC = untreated check.

Comparison of Bollgard II and Bollgard II Xtend Cotton Cultivars for Control of Cotton Bollworm, *Helicoverpa zea* (Boddie), in the Mid-South

K. McPherson[1], G. Lorenz[1], N. Taillon[1], A. Plummer[1], N. Bateman[1], B. Thrash[1], J. Black[1], A. Cato[2], L. McCullars[2], and J. Pace[1]

Abstract

A study was conducted on a grower field in Pine Bluff, Arkansas to compare the efficacy of *Bacillus thuringiensis* (*Bt*) toxins in three non-dicamba-tolerant Bollgard II cultivars and three dicamba-tolerant Bollgard II Xtend cultivars. When grouped by technology, Bollgard II Xtend cultivars had greater bollworm damage than Bollgard II cultivars. Cultivars within technologies did not differ, implying no varietal effect.

Introduction

The cotton bollworm (*Helicoverpa zea*, Boddie) is a major pest of post-flower cotton in the mid-South. Cotton cultivars containing the *Bacillus thuringiensis* (*Bt*) genes have been planted on 98–100% of Arkansas' cotton acreage since 1996 (Bryant et al., 2001, Williams 2017). In 2002, Bollgard II, a new dual gene *Bt* cotton cultivar was introduced to improve caterpillar management (Jackson et al., 2007). In 2016, the cotton bollworm infested 100% of the cotton acreage in Arkansas (Williams, 2017). Another major concern for cotton producers across the mid-South is the development of herbicide resistant weeds. To combat this problem, multiple transgenic cultivars of cotton have been developed in recent years allowing growers to spray herbicides that would normally damage cotton plants. Which cotton cultivar a grower chooses will dictate the insect and weed control programs that will or can be used (Bryant, et. al., 2003). Growers invest in transgenic cotton cultivars to increase control of herbicide-resistant weeds and lepidopteran pests, but ultimately use them to maximize profit.

Recently, dicamba-tolerant cultivars were introduced in combination with dual gene *Bt* cultivars in order to help control herbicide-resistant weeds and cotton bollworm. Anecdotal observations were made that dicamba-tolerant *Bt* cotton

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cultivars appear to have lower efficacy on bollworm than non-dicamba-tolerant *Bt* cultivars. The objective of this study was to evaluate these observations by comparing the efficacy of Bollgard II and Bollgard II Xtend cultivars for control of cotton bollworms.

Procedures

A trial was conducted during the 2017 growing season on a grower field in Jefferson County, Arkansas. Plot size was 12.5 ft. (4 rows) by 40 ft., with treatments arranged in a randomized complete block design with 4 replications. Eight cultivars were planted on 17 May consisting of two non-*Bt*, three Bollgard II, and three Bollgard II Xtend cultivars (Table 1). Damage ratings were taken at 66, 70, 76, 83, and 93 days after planting (DAP) by sampling 25 random squares, 25 flowers, and 25 bolls per plot. Plots were harvested using a John Deere two row picker. All data were analyzed using Agriculture Research Manager 2017 (Gylling Data Management, Inc., Brookings, South Dakota) and Duncan's New Multiple Range Test (P = 0.10) for mean separation means.

Results and Discussion

All *Bt* cultivars sustained less damage than the non-*Bt* cultivars across sample dates (Table 2). No differences were observed among the *Bt* cultivars at any of the sampling dates.

Xtend cultivars generally had no more damage than the Bollgard II cultivars within any sampling date (Table 2). Because the objective of this study was to determine if Bollgard II and Bollgard II Xtend cultivars provided equal control of cotton bollworm, another analysis was conducted with cotton cultivars grouped as non-*Bt*, Bollgard II, or Bollgard II Xtend. This analysis indicated there was a greater overall amount of damage in Xtend cultivars compared to Bollgard II cultivars (Table 3).

Practical Applications

If there are differences between the new Bollgard II Xtend cultivars and the non-Xtend Bollgard II cultivars in the expression of *Bt* toxins, growers need to know in order to adjust sampling and control of cotton bollworm. However, more work is needed to see if this trend is correct.

Acknowledgments

Appreciation is expressed to Chuck Hooker for providing the land where this research was conducted. Support also provided by the University of Arkansas System Division of Agriculture.

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Table 1. List of cotton cultivars used in cotton bollworm efficacy studies in 2017.

Non-*Bt*†	Bollgard II	Bollgard II Xtend
DP 399	ST 4946 B2RF	DP 1646 B2XF
DP 1441 RF	DP 1555 B2RF	DP 1518 B2XF
	DP 1321 B2RF	DP 1522 B2XF

† *Bt = Bacillus thuringiensis.*

Table 2. Cumulative damaged squares, flowers, and bolls for eight cultivars by five sample dates.

	Sample Date				
Cultivar	July 22	July 26	Aug 1	Aug 8	Aug 18
DP 399 (Non-*Bt*)	11.50a†	16.25a	26.50a	26.00b	27.50a
DP 1441 RF (Non-*Bt*)	13.50a	14.25a	20.25b	31.25a	17.75b
DP 1646 B2XF	0.50b	0.00b	0.75c	3.75c	7.50c
DP 1518 B2XF	1.25b	0.75b	0.50c	6.00c	10.00c
DP 1522 B2XF	0.25b	0.50b	0.50c	6.50c	6.75c
ST 4946 B2RF	1.75b	0.50b	2.75c	5.25c	4.25c
DP 1555 B2RF	0.00b	0.00b	1.75c	4.00c	8.75c
DP 1321 B2RF	0.75b	0.75b	1.75c	4.00c	4.75c

† Means within a column followed by the same letter do not differ significantly.

Table 3. Cumulative damaged squares, flowers, and bolls by cultivar group over five sample dates.

Technology	Damage
Non-*Bt*	19.5a†
BG2 XTEND	9.3b
BG2	4.9c

† Means within a column followed by the same letter do not differ significantly.

Crop Tolerance and Weed Control Programs in Enlist™ Cotton

J.R. Richburg[1], J.K. Norsworthy[1], G.L. Priess[1], and L.T. Barber[2]

Abstract

Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri* S. Wats.) has forced southern cotton growers to seek herbicides other than glyphosate for adequate control of this devastating weed. The herbicide 2,4-D, a synthetic auxin (Group 4) herbicide available in a variety of salt and ester formulations, has been noted for its control of some glyphosate-resistant weeds such as Palmer amaranth. Recently, Dow AgroSciences released a choline formulation known as Enlist One. This product is less likely to volatize than other forms of 2,4-D such as ester formulations and has an additive to reduce physical drift. A study was conducted on-farm in 2017 in Crawfordsville, Ark., to evaluate the tolerance of cotton to Enlist One (2,4-D choline) when applied with other common cotton herbicides such as Interline (glufosinate) and Moccasin (S-metolachlor). This test also measured control from these different herbicides and herbicide combinations. At 7 days after application to 2-leaf cotton, treatments containing Enlist One, Interline, and Moccasin showed increased injury when compared to treatments only containing Enlist One mixed with Interline or Moccasin. No 8-leaf cotton application caused injury over 10%. Palmer amaranth control never fell below 96% for any treatment. This research shows that Enlist cotton weed control programs containing Enlist One provide growers with an additional effective option for controlling glyphosate-resistant Palmer amaranth. The ability to apply multiple modes of action to Enlist cotton reduces selection pressure on any one particular herbicide thus slowing resistance development.

Introduction

Enlist™ cotton is resistant to glyphosate, glufosinate, and 2,4-D. The herbicide 2,4-D is currently registered in a variety of salt and ester formulations for use on cotton, soybean, and other crops (Anonymous, 2015). The herbicide 2,4-D controls some glyphosate-resistant weeds when applied post-emergence (Ford et al., 2014). Enlist One (2,4-D choline) is less likely to volatize than other forms of 2,4-D (e.g., ester) (Li et al., 2013).

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[2] Associate Professor, Department of Crop, Soil, and Environmental Sciences, University of Arkansas System Division of Agriculture, Little Rock.

Residual herbicides are necessary for adequate weed control. S-metolachlor is an effective residual herbicide for Palmer amaranth when applied post-emergence in cotton (Whitaker et al., 2011). In-season applications of multiple herbicides are not uncommon. When applying multiple herbicides, adjuvant induced injury may occur (Cobb and Reade, 2017). This study was conducted to determine if treatments containing Interline (glufosinate) and Moccasin (S-metolachlor) would result in higher injury to cotton when mixed with Enlist One. Palmer amaranth control was also assessed to determine if the addition of Moccasin would increase efficacy of common Enlist™ cotton weed control programs.

Procedures

The study was conducted on-farm in Crawfordsville, Arkansas, in 2017. Enlist cotton (PHY 490 W3FE) was planted into conventionally tilled soil with raised beds on 9 May. The study was designed as a randomized complete block with four replications. Each treatment received a standard pre-emergence application of Cotoran at 1 qt/acre. Treatments were then applied to 2-leaf and 8-leaf cotton (Table 1). All treatments then received a layby application consisting of Direx at 1 pt/acre and MSMA at 2.5 pt/acre. Applications were made using a CO_2-pressurized backpack sprayer delivering 15 gallons per acre. All treatments received 1 qt/acre Cotoran pre-emergence (PRE) and 1 pt/acre Direx + 2.4 pt/acre MSMA at Layby. Weed control by species and crop injury was rated on a 0 to 100 scale, with 0 being no control or injury and 100 being complete control or crop death.

Results and Discussion

Treatments containing Interline and Moccasin (treatments 4, 5, and 7) exhibited the highest amounts of injury 7 days after the 2-leaf cotton application (Fig. 1). All treatments displayed transient injury at the 8-leaf cotton rating (< 6%). By layby (64 days after planting), cotton exhibited no injury from the herbicide treatments (data not shown). Weed control never fell below 96% for any treatment (Fig. 2). Therefore, it is concluded that due to injury to small cotton, Moccasin plus Interline is a better option applied to 8-leaf than to 2-leaf cotton. The addition of Moccasin to Interline did not significantly increase weed control when applications were timely.

Practical Applications

When applied to 2-leaf cotton, Moccasin plus Interline may contribute to crop injury, but when applied to 8-leaf cotton, injury is transient. Also, Enlist™ cotton provides growers options for controlling glyphosate-resistant Palmer amaranth. Enlist™ cotton allows for multiple modes of action to control Palmer amaranth, which reduces selection pressure and slows resistance development.

Acknowledgments

The authors would like to acknowledge United Phosphorous, Inc. (UPI), as well as the University of Arkansas System Division of Agriculture for their support in this research.

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Table 1. List of herbicides, rates, and timings evaluated for cotton injury and Palmer amaranth control in Crawfordsville, Ark., in 2017.

Treatment	Herbicide	MOA[a]	Rate	Timing
			qt/acre	
1	Enlist One	1	1	2-leaf cotton
	Durango DMA		1	
	Enlist One		1	8-leaf cotton
	Durango DMA		1	
2	Enlist One	2	1	2-leaf cotton
	Interline		1	
	Enlist One		1	8-leaf cotton
	Interline		1	
3	Enlist One	3	1	2-leaf cotton
	Interline		1	
	Enlist One		1	8-leaf cotton
	Interline		1	
	Moccasin		1.25	
4	Enlist One	3	1	2-leaf cotton
	Interline		1	
	Moccasin		1.25	
	Enlist One		1	8-leaf cotton
	Interline		1	
5	Enlist One	3	1	2-leaf cotton
	Interline		1	
	Moccasin		1.25	
	Enlist One		1	8-leaf cotton
	Interline		1	
	Moccasin		1.25	
6	Enlist One	2	1	2-leaf cotton
	Interline		1	
	Durango DMA		1	
	Enlist One		1	8-leaf cotton
	Interline		1	
	Durango DMA		1	
7	Interline	2	1	2-leaf cotton
	Durango DMA		1	
	Moccasin		1.25	
	Interline		1	8-leaf cotton
	Durango DMA		1	
	Moccasin		1.25	

[a] Number of effective modes of action for glyphosate-resistant Palmer amaranth available in the treatment.

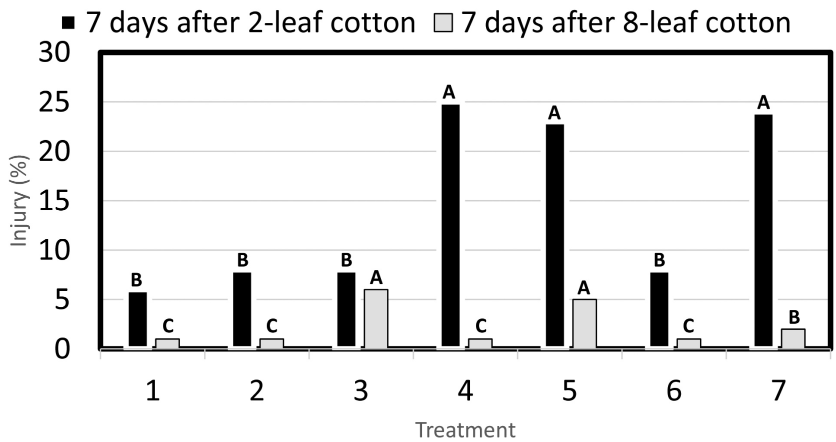

Fig. 1. Injury to cotton 7 days after 2-leaf cotton application and 8-leaf cotton application from 7 herbicide treatments. See Table 1 for specific herbicide treatments. Means with the same letter within a rating are not statistically different (α = 0.05).

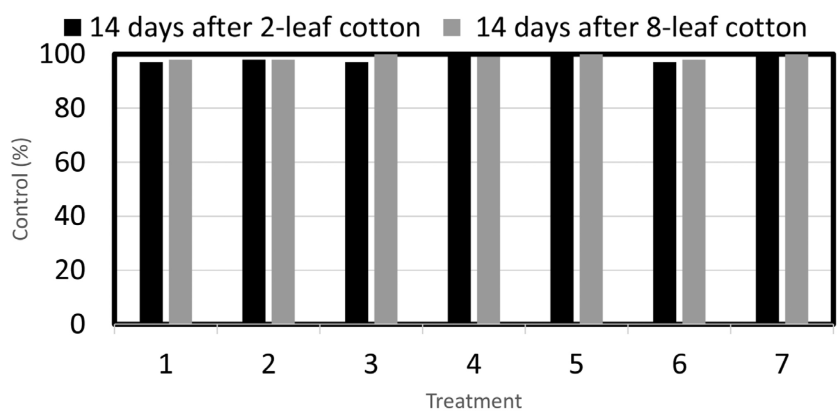

Fig. 2. Palmer amaranth control at 14 days after 2-leaf cotton application and 8-leaf cotton application by 7 herbicide treatments. See Table 1 for specific herbicide treatments. No significant differences were observed within ratings.

Evaluation of Salvage Treatment Options in XtendFlex® Cotton

W. Coffman[1], L.T. Barber[2], J.K. Norsworthy[1], Z.T. Hill[2], and H.D. Bowman[1]

Abstract

Competitive weeds like Palmer amaranth (*Amaranthus palmeri*) and barnyardgrass (*Echinochloa crus-galli*) may be difficult to control in early season due to herbicide resistance or time and weather limitations. To determine if glyphosate, glufosinate, and dicamba could be used to salvage an XtendFlex® cotton (*Gossypium hirsutum* L.) crop infested with large weeds commonly found in Arkansas, a field trial was conducted at the University of Arkansas System Division of Agriculture's Rohwer Research Station in 2017. Two factors were examined in the study; the first being herbicide combination, and the second being post-emergence (POST) timing. Glyphosate, glufosinate, and dicamba were applied alone or in combination to non-crop plots infested with 24-in tall barnyardgrass and 20-in tall Palmer amaranth, followed by (fb) a second application 7 or 14 days later. Glyphosate plus glufosinate and dicamba fb the same combination 14 days later controlled Palmer amaranth 95%. Sufficient levels of control of barnyardgrass were not attained with any treatment.

Introduction

Weeds compete with a cotton crop for water, sunlight, and nutrients, causing diminished yields if they are not controlled in a timely manner. Unfortunately, even though XtendFlex® cotton provides a new mode of action for controlling broadleaf weeds, it may not be possible to make a residual application or a post-emergence (POST) application at the optimum time for weed control. Weather, equipment malfunctions, and label restrictions can limit working days in the field. When working days are limited in areas where rapidly growing, herbicide-resistant weeds are prevalent, the only options are to abandon or attempt to salvage the emerged crop.

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Procedures

A field trial was conducted at the University of Arkansas System Division of Agriculture's Rohwer Research Station near Rohwer, Arkansas in 2017. The two factors examined were A) herbicide combination and B) length of time between applications. Treatments (Table 1) were applied to non-crop plots infested with 24-inch tall barnyardgrass and 20-inch tall Palmer amaranth at the time of the first application. The second application was applied either 7 or 14 days after the first application. Visual ratings for weed control were collected 3 weeks after the second application on a scale of 0% to 100%, with 0% being no control and 100% being complete control. Data were analyzed using JMP Pro 13 at $\alpha = 0.05$.

Results and Discussion

Applications of dicamba plus glufosinate (Treatment 8) fb the same combination 14 days later and glyphosate plus glufosinate and dicamba (Treatment 9) fb the same combination 14 days later showed 94% and 95% control of Palmer amaranth, respectively (Fig. 1). Applications of glufosinate alone (Treatment 2) offered 41% control when applied 7 days apart, and 55% control when applied 14 days apart (Fig. 1). No treatment offered an acceptable level of control of barnyardgrass. The highest level of control achieved by any treatment was 84% by dicamba plus glyphosate (Treatment 5) applied 7 days apart (Fig. 2). There is no current dicamba formulation label that allows tank mixtures of glufosinate and dicamba.

Practical Applications

Preliminary data from this research suggest that tank mixtures of dicamba plus glufosinate (Treatment 8) applied 14 days apart or glyphosate plus glufosinate and dicamba (Treatment 9) applied 14 days apart are viable options for salvaging XtendFlex® cotton infested with 20 to 24 in. Palmer amaranth. Previous research has shown that yield decreases linearly with delayed POST applications (Vann et al., 2017). Therefore, salvage applications should be made as soon as conditions permit in order to limit yield loss. In situations where barnyardgrass is also present, other methods of control should be considered.

Acknowledgments

Thank you to my graduate student colleagues, Aaron Ross, Ryan Doherty, and Dr. Barber's hourly employees for assistance in conducting this trial. Support also provided by the University of Arkansas System Division of Agriculture.

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Table 1. Post-emergence application treatments made to large Palmer amaranth and barnyardgrass plots.

	Initial Application		Second Application[a]	
Treatment	Common Name	Rate (g ae ha^{-1}) [b]	Common Name	Rate (g ae ha^{-1}) [b]
1	Untreated		Untreated	
2	Glufosinate	594[c]	Glufosinate	594[c]
3	Glyphosate + Glufosinate	867 + 594[c]	Glyphosate + Glufosinate	867 + 594[c]
4	Dicamba + NIS	561 + 0.25[d]	Dicamba + NIS	561 + 0.25[d]
5	Dicamba + Glyphosate	561 + 867	Dicamba + Glyphosate	561 + 867
6	Dicamba + Glyphosate	561 + 867	Glufosinate	594[c]
7	Glyphosate + Glufosinate	867 + 594[c]	Dicamba	561
8	Dicamba + Glufosinate	561 + 594[c]	Dicamba + Glufosinate	561 + 594[c]
9	Glyphosate + Glufosinate + Dicamba	867 + 594[c] + 561	Glyphosate + Glufosinate + Dicamba	867 + 594[c] + 561

[a] Second applications were made 1 week or 2 weeks after the first application.
[b] grams acid equivalent of herbicide salt per hectare.
[c] Rates of glufosinate listed in grams of active ingredient of herbicide per hectare.
[d] Rates of nonionic surfactant listed in % volume by volume.

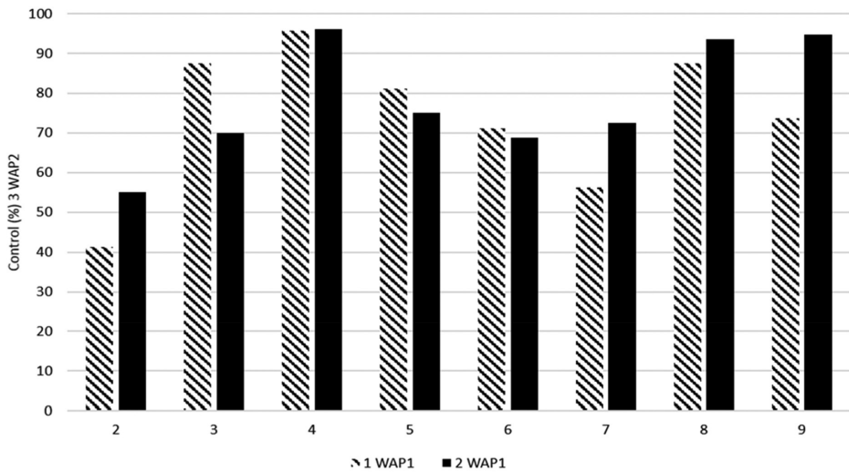

Fig. 1. Means of percent control of Palmer amaranth 3 weeks after second post-emergence application (3WAP2). Striped bars represent treatments where the second post-emergence application was made 1 week after the first post-emergence application (1 WAP1) and black bars represent treatments where the second post-emergence application was made 2 weeks after the first post-emergence application (2 WAP1). Number on x-axis corresponds with treatment in Table 1.

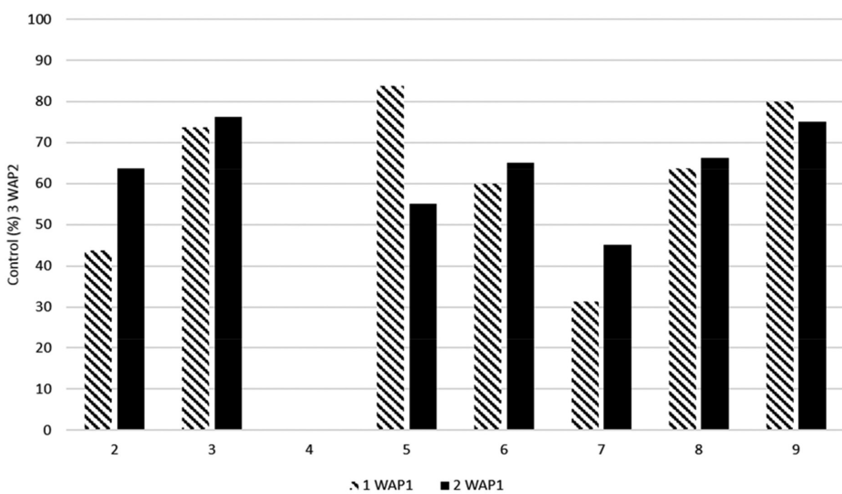

Fig. 2. Means of percent control of barnyardgrass 3 weeks after second post-emergence application (WAP2). Striped bars represent treatments where the second post-emergence application was made 1 week after the first post-emergence application (1 WAP1) and black bars represent treatments where the second post-emergence application was made 2 weeks after the first post-emergence application (2 WAP1). Number on x-axis corresponds with treatment in Table 1.

Addition of Fluridone in Bollgard II XtendFlex® Cotton Herbicide Programs

H.D. Bowman[1], T. Barber[2], J.K. Norsworthy[1] and W.D. Coffman[1]

Abstract

SePro chemical company recently labeled fluridone in cotton for pre-emergence (PRE) control of weeds. A study was conducted to determine the level of control and length of residual activity of fluridone on weeds such as Palmer amaranth. The test was designed with six PRE herbicide treatments, where fluridone was either applied alone or in combination with another cotton herbicide. At 18 days after PRE treatment, fluridone alone and fluometuron + prometryn provided 93% and 90% control of Palmer amaranth, respectively. All other treatments provided nearly complete control. An application of glufosinate was made at 18 days after the PRE to control any emerged weeds prior to fluridone activation. At 42 days after the PRE application, any treatment containing fluridone provided 93% or greater control and fluometuron + prometryn only provided 60% control. Generally, no visible injury was observed demonstrating a high level of crop tolerance to fluridone, a promising new alternative for weed control in cotton.

Introduction

SePro recently received a label for fluridone in cotton. Use of fluridone provides growers with a different site of action (SOA) for pre-emergence (PRE) control of glyphosate-resistant (GR) Palmer amaranth, which was listed as the most problematic weed in a mid-South cotton consultant survey (Riar et al., 2013). Fluridone has shown to provide high levels of residual control of GR Palmer amaranth (Hill et al., 2016). However, studies have not been conducted to determine the length of residual control. As such, research is needed to assess the length of residual control of fluridone in Arkansas cotton production systems.

Procedures

Field experiments were conducted in 2017 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station (LMCRS), in

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Marianna, Arkansas and the Rohwer Research Station (RRS) in Rohwer, Arkansas Bollgard II XtendFlex® cotton was planted at both locations in early May. Immediately following planting, six PRE herbicide treatments (Table 1), plus an untreated check were applied. Treatments were arranged as a randomized complete block with 4 replications. Visual weed control and crop injury assessments were taken 18 days after PRE. After the assessment, a post-emergence (POST) application of glufosinate was made to control any weeds that emerged prior to activation of the fluridone. In the first 18 days after planting, LMCRS and RRS received 5.7 and 11.4 cm of rainfall respectively, providing adequate soil moisture for activation of fluridone. Visual weed control and injury were assessed on a 0-100 scale (0 = no injury, 100 = complete plant mortality). At 42 days after PRE application, visual weed control and crop injury assessments were taken. Data were subjected to analysis of variance and significant means separated using Fisher's protected least significant difference test ($\alpha = 0.05$).

Results and Discussion

At 18 days after PRE, all treatments provided >99% control of GR Palmer amaranth, except fluridone alone and fluometuron + prometryn, which provided 93% and 90% control respectively (Fig. 1). At 42 days after the PRE application, any treatment containing fluridone provided 93% or greater control with the only difference in control being observed with the standard of fluometuron + prometryn, which only provided 60% control (Fig. 2).

Practical Applications

Generally, no visible injury was observed demonstrating that cotton's tolerance to fluridone could offer a promising new alternative for weed control in cotton. Results indicate fluridone can provide high levels of weed control up to 42 days, which may reduce the number of herbicide applications in cotton.

Acknowledgments

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

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Riar, D.S., J.K. Norsworthy, L.E. Steckel, D.O. Stephenson, T.W. Eubank, J. Bond, and R.C. Scott. 2013. Adoption of best management practices for herbicide-resistant weeds in midsouthern United States cotton, rice, and soybean. Weed Technol. 27:788-797.

Table 1. Herbicide treatments, including treatment number, pre-emergence (PRE) and post-emergence (POST) herbicide applications.

Treatment	PRE	Rate	POST[a]
1	-	-	-
2	Fluridone	231 g ai ha^{-1}	Glufosinate
3	Fluridone Fluometuron	231 g ai ha^{-1} 841 g ae ha^{-1}	Glufosinate
4	Fluridone Fomesafen	231 g ai ha^{-1} 231 g ai ha^{-1}	Glufosinate
5	Fluridone Diuron	231 g ai ha^{-1} 561 g ai ha^{-1}	Glufosinate
6	Fluridone Dicamba	231 g ai ha^{-1} 561 g ae ha^{-1}	Glufosinate
7	Fluometuron Prometuryn	561 g ae ha^{-1} 561 g ae ha^{-1}	Glufosinate

[a] Glufosinate was applied at 595 g ai ha^{-1}.

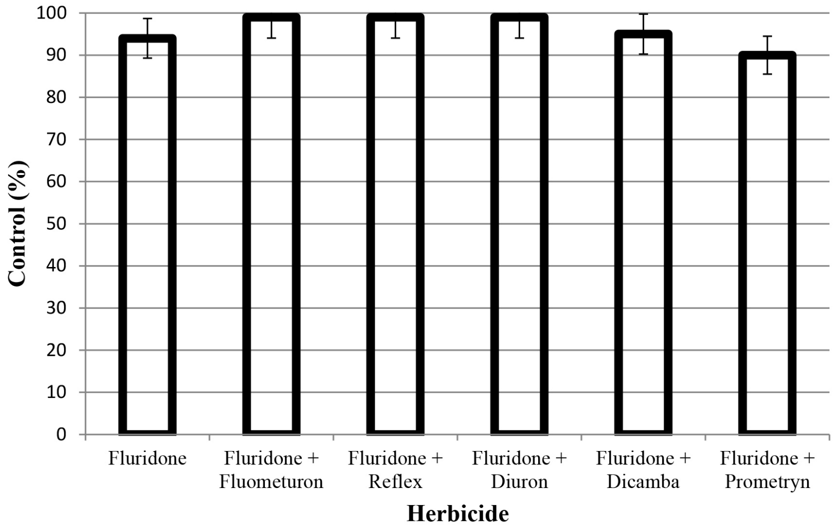

Fig. 1. Palmer amaranth control 18 Days after pre-emergence application. Where error bars overlap, mean control is not different (α = 0.05).

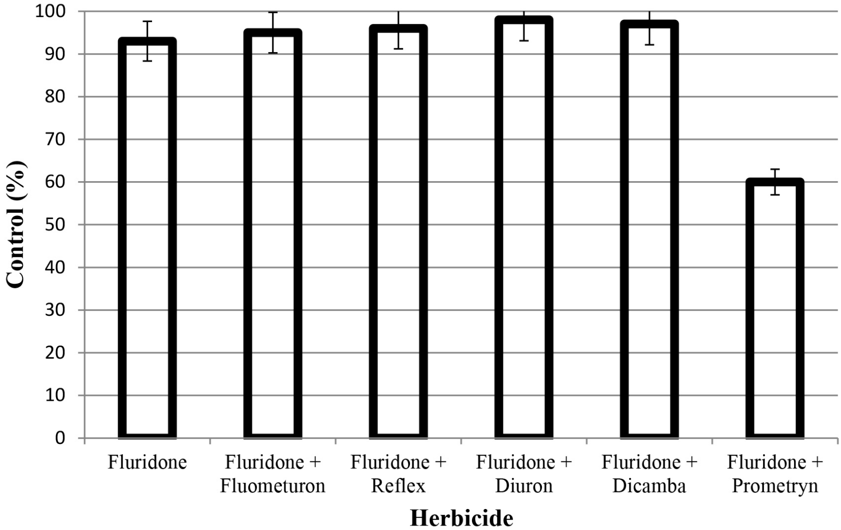

Fig. 2. Palmer amaranth control 42 days after pre-emergence application. Where error bars overlap, mean control is not different (α = 0.05).

Controlling Palmer Amaranth with Mixtures of Glufosinate, Dicamba, and 2,4-D

G.L. Priess[1], J.K. Norsworthy[1], J.T. Richburg[1], Z.D. Lancaster[1], M.E. Fogleman[1], and L.T. Barber[2]

Abstract

Glufosinate, dicamba and 2,4-D are the remaining few herbicide options left for controlling emerged glyphosate and protoporphyrinogen oxidase (PPO)-resistant Palmer amaranth in cotton. Two studies were conducted to evaluate the efficacy of 2,4-D, dicamba, and glufosinate applied alone, and 2,4-D applied in combination with two rates of glufosinate on 5-inch and 16-inch tall Palmer amaranth. A sequential application of the same treatment was applied 14 days after the first application. The only acceptable level of control (100%) of Palmer amaranth was achieved in the 5-inch tall Palmer amaranth trial by the sequential application of 2,4-D + the high rate of glufosinate. It was shown that tank mixes of two effective sites of action increased efficacy and should be incorporated into weed management programs when available.

Introduction

The commercial launch of Enlist™ cotton resistant to 2,4-D and glufosinate and the wide adoption of Xtendflex™ cotton resistant to dicamba and glyphosate enables producers to use 2,4-D, dicamba, glufosinate and glyphosate in season. In the past, overreliance on a single site of action (SOA) perpetuated the evolution of herbicide resistance (Culpepper et al., 2006). Now producers are faced with problem weeds like Palmer amaranth with multiple resistance to five SOA (Heap, 2018). Prior research has shown that utilizing two effective SOA will reduce the chance for herbicide resistance to evolve in weed species (Norsworthy et al., 2012). Therefore, it is essential to evaluate the herbicide combinations that can be used in the Enlist and Roundup Ready 2 Xtend cotton systems to control glyphosate- and PPO-resistant Palmer amaranth in the mid-South.

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[2] Associate Professor, Department of Crop, Soil, and Environmental Sciences, University of Arkansas System Division of Agriculture, Little Rock.

Procedures

Two independent bare ground studies were conducted in a production field in Crawfordsville, Arkansas. These studies evaluated the efficacy of 2,4-D, dicamba and glufosinate applied alone, and 2,4-D applied in combination with two rates of glufosinate. Applications were made on 5-inch and 16-inch Palmer amaranth with CO_2 pressurized backpacks, calibrated at 3 mph, which delivered 15 gallons per acre through the AIXR 11002 nozzles when glufosinate alone was applied and a TTI11002 nozzle when dicamba or 2,4-D was applied. One study evaluated control of 5-inch Palmer amaranth and the other evaluated control of 16-inch Palmer amaranth. Two weeks after the initial application was made in each trial, a sequential application of the same treatment was applied. Palmer amaranth control ratings were taken two weeks after the first application and three weeks after the sequential application. Data collected were subjected to analysis of variance, and means were separated using Fisher's protected least significant difference ($\alpha = 0.05$).

Results and Discussion

The 5-inch Palmer amaranth study showed the highest level of control of the two studies, and the only treatment that reached an acceptable level of control (100%) was achieved by the sequential application of the high rate of glufosinate + 2,4-D (Table 1). In the 5-inch Palmer amaranth trial, two sites of action mixed together or glufosinate alone resulted in the highest level of control. In the 16-inch tall Palmer amaranth trial, there was a large reduction in efficacy (Table 2). The studies suggest that there is a decrease in efficacy as weed size increases. The mixtures of 2,4-D + glufosinate resulted in the highest level of control. Three weeks after the sequential application of the high rate of glufosinate + 2,4-D, control of Palmer amaranth was 98%.

Practical Applications

Tank mixes of two effective SOA showed increased efficacy of control and should be incorporated into weed management programs when available. Weed management programs that do not allow for tank mix options of two effective SOA should incorporate effective sites of action by multiple passes or sequential applications. This will reduce the selection pressure placed on weed populations and prolong the preservation of the technologies available.

Acknowledgments

The authors thank Mid-South AG Consulting and Chuck Farr for land use, and assistance in plot preparation and maintenance. Support also provided by the Universtiy of Arkansas System Division of Agriculture.

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Table 1. Percent control of 5-inch Palmer amaranth using single and sequential applications.

Herbicide	Rate	Active ingredient	2WAA[a]		3WAB[b]	
			Control			
	oz/acre[c]		%			
Enlist One	32	2,4-D	77	c[d]	94	b
Xtendimax	22	dicamba	78	c	93	b
Interline	29	glufosinate	86	ab	92	b
Interline	43	glufosinate	89	ab	97	ab
Interline + Enlist One	29 + 32	glufosinate + 2,4-D	88	ab	95	ab
Interline + Enlist One	43 + 32	glufosinate + 2,4-D	93	a	100	a

[a] 2WAA, Rating shown was taking 2 weeks after initial application (A).
[b] 3WAB, Rating shown was taking 3 weeks after the sequential application (B) was applied.
[c] oz/acre, ounce of herbicide per acre.
[d] Means within a column followed by the same lowercase letter are not different according to Fisher's protected least significant difference at (α = 0.05).

Table 2. Percent control of 16-inch Palmer amaranth using single and sequential applications.

Herbicide	Rate	Active ingredient	2WAA[a]		3WAB[b]	
			Control			
	oz/acre[c]		%			
Enlist One	32	2,4-D	35	a[d]	61	c
Xtendimax	22	dicamba	39	a	55	c
Interline	29	glufosinate	47	a	82	b
Interline	43	glufosinate	40	a	83	b
Interline + Enlist One	29 + 32	glufosinate + 2,4-D	45	a	95	a
Interline + Enlist One	43 + 32	glufosinate + 2,4-D	54	a	97	a

[a] 2WAA, Rating shown was taking 2 weeks after initial application (A).
[b] 3WAB, Rating shown was taking 3 weeks after the sequential application (B) was applied.
[c] oz/acre, ounce of herbicide per acre.
[d] Means within a column followed by the same lowercase letter are not different according to Fisher's protected least significant difference at (α = 0.05).

Integrated Management of Target Leaf Spot in Cotton

B. Robertson[1], J. Davis[2], and R. Benson[3]

Abstract

In Arkansas, Target Leaf Spot (TLS) was observed on cotton statewide in 2016. Although the disease developed during late boll fill when impact on yield was questionable, significant defoliation and boll drop were observed in northeast Arkansas. Additional factors that increase TLS risk include higher planting rates, excessive N rates, narrow row spacing, vigorous growth, as well as hot, humid weather. The severity of TLS appeared to be influenced by rankness. The objectives of this study are to evaluate the efficacy and efficiency of applications of the fungicide (fluxapyroxad + pyraclostrobin) on the disease damage, growth and yield of cotton infested with TLS in various types of plant structures. An on-farm study site was selected based on the occurrence of TLS and greater than 60% leaf defoliation of cotton the previous cropping year. The site is a pivot irrigated field planted to DP 1518 B2XF. Plant height ranged from 18 inches to 42 inches and plant canopy coverage ranged from 50% to 95% in late September. The occurrence of TLS in Arkansas and in this study were very light in 2017. The incidence of TLS did not exceed 5% of the total leaf area of the plant and defoliation did not exceed 15% of total leaves. Very little differences were observed across sprayer treatments for TLS. Differences in effective coverage were observed. Effective coverage for the 15 gallon per acre (gpa) treatments was double that of the 10 gpa treatment. Lint yield did not differ statistically for fungicide treatment compared to the untreated control. While the risk of TLS impacting yield is likely very low in Arkansas because of the late timing involved with the occurrence of the disease, proper techniques are necessary to achieve effective coverage if treatment is deemed necessary.

Introduction

In Arkansas, Target Leaf Spot (TLS) was observed on cotton statewide in 2016. Although the disease developed during late boll fill when impact on yield was questionable, significant defoliation and boll drop were observed in northeast Arkansas. As many as three fungicide applications were recommended by some

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[2] Application Technologist, Department of Crop, Soil, and Environmental Sciences, Batesville
[3] County Cooperative Extension Agent, Mississippi County, Blytheville.

consultants. At harvest, the estimated yield differences these consultants expected between treated and untreated strips were not observed.

The warm, wet weather the mid-South experiences could promote TLS in cotton fields. Additional factors that increase TLS include higher planting rates, excessive N rates, narrow row spacing, vigorous growth, as well as hot, humid weather. The severity of TLS appeared to be influence by rankness. Where cotton canopies did not lap, TLS was less. Managing plant structure to reduce the ability of the disease to develop in the interior canopy may be the best means to manage this disease. Interactions of rankness of canopy and the ability of a foliar treatment of fungicide have the potential to influence the efficacy of treatments.

The objectives of this study are to evaluate the efficacy and efficiency of applications of the fungicide, (fluxapyroxad + pyraclostrobin), on the disease damage, growth and yield of cotton infested with TLS in various types of plant structures.

Procedures

An on-farm study site was selected based on the occurrence of TLS and greater than 60% leaf defoliation of cotton the previous cropping year. The site is a pivot irrigated field planted to DP 1518 B2XF. Native differences in soil types in this field result in great variations in plant canopy. Manipulation of cultural practices was not required to artificially induce canopy differences. Farmer standard cultural practices were employed season long with the exception of fungicide treatments. Georeferenced data including plant height, canopy coverage, occurrence of TLS, and defoliation as a result of TLS were collected and overlaid with other imagery and data collected during the season. Fungicide applications were made with the producer's sprayer equipped with different nozzles in order to investigate the impact of droplet size and effective coverage on disease control using two different application techniques. One technique (BMP) was to apply fungicide treatments in 15 gpa spray solution at a speed of 10 mph with a 24 inch boom height. The other technique involved speeding the sprayer to deliver 10 gpa while using a boom height of 4 to 6 foot above the canopy (neighbor). Each sprayer treatment also included nozzles to deliver a medium (M), very coarse (VC), and ultra-course (UC) droplet. Spray papers were used to evaluate effective coverage. Plants were machine harvested.

Results and Discussion

Differences in plant height and canopy coverage were observed and recorded with GPS coordinates. Plant height ranged from 18 inches to 42 inches and plant canopy coverage ranged from 50% to 95% in late September. Fungicide treatments were made to and observed across the range of plant canopy types. The occurrence of TLS in Arkansas and this study was very light in 2017. The incidence of TLS did not exceed 5% of the total leaf area of the plant and defoliation did not exceed 15% of total leaves. Very little differences were observed across sprayer treatments for TLS. Differences in effective coverage were observed (Fig. 1). Effective coverage for the 15 gpa treatment was double that of the 10 gpa treatment. Lint yield did not differ statistically for fungicide treatment compared to the untreated control. Yields ranged from 1541 lb lint/acre to 1598 lb lint/acre averaged across the range of all plant canopy types.

Practical Applications

While the risk of TLS impacting yield is likely very low in Arkansas because of the late timing involved with the occurrence of the disease, proper techniques are necessary to achieve effective coverage if treatment is deemed necessary. Carrier volumes of 15 gpa with a sprayer speed of 10 to 12 mph are recommended with a spray boom height of 20 to 24 inches. Variations in this recommendation will significantly impact coverage. A coarser droplet is recommended as speed increases with ground application. As the cost of fungicide treatments per acre can be significant, any decrease in efficacy of the product as a result of poor application techniques must be avoided.

Acknowledgments

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

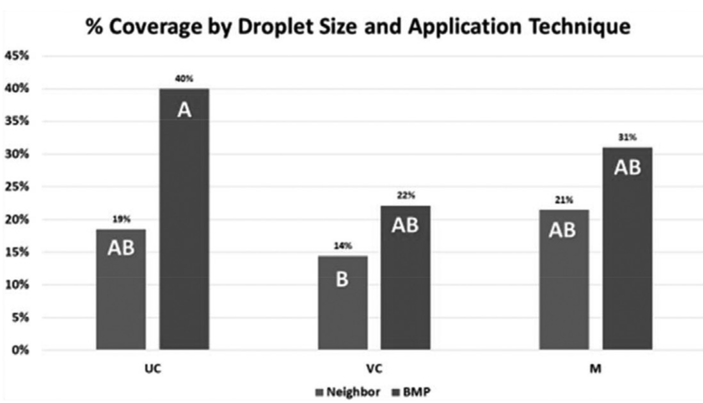

Fig. 1. Coverage of spray papers positioned one foot above the soil surface in three foot tall cotton with full canopy coverage with ultra-coarse (UC), very-coarse (VC), and medium (M) size droplets in a sprayer using best management practices (BMP) for coverage compared to the Neighbor sprayer traveling at a high rate of speed, lower carrier volumes applied in a boom positioned very high above the canopy. Bars with same letter do not differ significantly (α = 0.05)

Influence of Tillage practices on Lint Yield, Water Quality, and Soil Exchangeable N in Cotton Production

M.A.A. Adviento-Borbe[1], H. Wood[2], M.L. Reba[1], J.H. Massey[1], and T.G. Teague[3]

Abstract

Objectives of a 2017 field trial were to quantify how different tillage and N fertilization practices affect cotton productivity and nutrient management in a furrow-irrigated cotton production systems. Lint yield, soil N and runoff water quality metrics were measured after using either a conventional sweep plow or conservation tillage plow to clear water furrows combined with either broadcast urea or 32% urea ammonium nitrate (UAN) sidedressed at 90 lb acre^{-1}. Seasonal NO_3-N and P were the largest nutrient in runoff and associated with the intensity of irrigation and rainfall. Lint yields ranged from 550 to 1143 lb ac^{-1} and were unaffected by tillage and fertilizer-N treatments. There was no downward movement of soil NO_3-N in the deeper depths across tillage and N fertilizer treatments. Water quality metrics such as pH, electrical conductivity, hardness, total suspended solids (TSS) and soil sediment concentrations (SSC) were within acceptable ranges and expected to have minimal impacts on surrounding waterbodies.

Introduction

Cotton (*Gossypium hirsutum* L.) is grown on raised beds and commonly furrow-irrigated using poly-tubing. In the mid-South, cotton producers typically use tillage to clear water furrows prior to first furrow irrigation. Tillage method may affect infiltration, runoff and risk of nutrient loss especially in soil prone to surface sealing. While furrow irrigation improves delivery of water to the plants and consequently increases water use productivity, this practice may increase nutrient loss and impact field runoff. In a 2016 study on furrow-tillage practices with different fertilizer N sources (urea vs. 32% UAN), nitrogen (N) was the major nutrient that was lost (Adviento-Borbe et al., 2018). Furrow tillage and N application method had varying effects on total N loss and water quality of runoff. A follow-up investigation with these tillage and N management systems will verify their impacts on nutrient losses and water quality. This information is essential in assessing the

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potential of conservation tillage to sustain high lint yields while reducing N-fertilizer and irrigation water inputs.

The overarching goal of this research project was to improve understanding of the interactions of tillage, fertilizer use and irrigation to support recommendations for expanded adoption of soil and water conservation practices in U.S. cotton. Specific objectives were: (i) to quantify water quality of surface runoff under different tillage and fertilizer N practices, (ii) to quantify soil exchangeable N at different soil depths following irrigation events and (iii) to determine crop response under these tillage and fertilizer N practices.

Procedures

Two furrow-tillage treatments (conventional cultivator - standard sweep plow (CT) vs. conservation plow, Furrow Runner (FT)) and N-fertilizer type and placement (Broadcast urea vs. sidedressed 32% UAN each at a rate of 90 lb acre^{-1} fertilizer N) were arranged in a randomized complete block design with three replications at the University of Arkansas System Division of Agriculture's Judd Hill Cooperative Research Station, Trumann, Arkansas. Each treatment plot was 12 rows wide and 520 ft long. The cotton cultivar used was ST 4946 GLB2, planted in a Dundee silt loam soil at about 3 seeds per foot. Furrow irrigation was implemented using poly-tubing made to deliver water efficiently to all treatment plots.

Irrigation water runoff collection was made on 17, 26 July, and 3 August while runoff water samples following rain events were collected on 14, 26 and 28 July, and 9 August using automated water samplers and H-flumes (6712, Teledyne ISCO) installed in each test plot. At each sampling event, two 1-L samples were collected. The samples were stored on ice and filtered with a 0.45-µm CA syringe filter within 24-h of sample collection and stored frozen prior to chemical analyses.

Water samples were analyzed for NH_4-N, NO_3-N, NO_2-N (Doane and Horwath, 2003), PO_4- (Murphy and Riley, 1962), pH, electrical conductivity, hardness, alkalinity (APHA, 1999), total suspended solid (APHA, 1999) and suspended sediment concentration (SSC) (ASTM, 2000). All of the water samples were stored at 4 °C before physical analysis. Composite soil samples were collected after first bloom (19 July), during flowering (7 August), during boll loading (26 August), and during boll opening (13 September) at four soil depths; 0–15 cm, 15–30 cm, 30–60 cm and 60–90 cm. Yield determinations were made using a two-row cotton picker in designated harvest rows.

Results and Discussion

Lint yields of plots ranged from 550 to 1143 lb ac^{-1} (616 to 1280 kg ha^{-1}) with a mean yield of 873 lb ac^{-1} (977 kg ha^{-1}) (Fig. 1). Highest average lint yields were measured in FT-UAN treatments during the 2017 growing season. However, there were no significant lint yield differences among tillage and fertilizer-N treatments

(P = 0.149), furrow-tillage treatments (P = 0.380) or fertilizer-N treatments (P = 0.079). The 2017 yield averages were lower by 18% when compared to lint yields from 2016. Suboptimal yield was related to high incidence of Verticillium wilt which was observed at historically high levels in research plots across the Judd Hill station. Symptomology ratings made in late season did not show evidence of treatment effects on disease incidence (data not shown).

Median concentrations of soluble nutrients in runoff increased in the order NH_4-N < NO_2-N < P < NO_3-N. Soluble NO_3-N ranged from 0.23 to 5.54 mg N L^{-1} while other nutrients ranged from 0 to 0.12 mg NH_4-N L^{-1}, 0.01 to 0.36 mg NO_2-N L^{-1} and 0.07 to 0.93 mg P L^{-1} (Table 1). Median concentrations of NO_3-N and NO_2-N in the study were below the drinking water standards of 10 mg NO_3-N L^{-1} and 1 mg NO_2-N L^{-1} (USEPA, 1994). Concentrations of soluble-P were above the EPA Ecoregion X background levels for lakes (60 µg L^{-1}) or rivers (128 µg L^{-1}) (USEPA, 2001). Amounts of NH_4-N, NO_2-N and soluble-P in the runoff water were variable and were not significantly different among tillage × fertilizer N treatments (P = 0.18 to 0.97) or between tillage treatments (CT vs FT) (P = 0.43 to 0.83). These findings indicate that tillage treatments or the interaction of tillage and fertilizer N placement had no effect on runoff concentrations of NH_4-N, NO_2-N and P nutrients. On the other hand, seasonal mean NO_3-N concentrations were significantly higher in CT-UAN treatments than other treatments (P = 0.01) (Table 1). Across all sampling events, high levels of NO_3-N occurred (P < 0.0001) on 3 and 28 July following rainfall and when irrigation was applied 7 days after N-fertilizer application, respectively. In the case of P, higher amounts of runoff P occurred in all treatments in the early growth stage. High levels of runoff P also coincided with high total suspended solids and soil sediment concentrations that were measured during the growing season.

Variations in water quality characteristics such as pH, specific electrical conductivity (EC), hardness, and turbidity were generally small and were within the normal range of irrigation waters (Table 2). Differences among the water quality metrics measured were not significant across all tillage and fertilizer-N treatments (P = 0.08 to 0.67); however, water quality properties were significantly affected by sampling date (P < 0.0001) (data not shown). The pH and EC values were within the range of irrigation water quality thresholds suitable for growing cotton. Total suspended solids (TSS) were higher in Conventional tillage (170–1896 mg L^{-1}) than TSS values from Conservation tillage treatments (150–1476 mg L^{-1}). In contrast, soil sediment concentrations ranged roughly the same in both tillage treatments (Conventional: 473–1929 mg L^{-1}; Conservation: 418–1828 mg L^{-1}). Turbidity values increased during the early growing season and were highly correlated to TSS and SSC levels. Concentrations of TSS, SSC and turbidity were not significantly different among the four treatments, suggesting that tillage and fertilizer-N did not impact variability that was measured throughout the growth period.

Across all treatments, sampling depths and dates, soil exchangeable N varied with concentrations ranging from 0.07 to 19.13 NO_3-N, 0 to 1.25 NH_4-N and 0 to 0.28 NO_2-N ppm. Nitrate-N constituted the major proportion of soil N in various depths (0.46 to 176 mg kg^{-1} soil). The largest amounts occurred during boll loading at the 60-90 cm soil depth range (data not shown). Application of fertilizer N slightly increased the amount of soil exchangeable NO_3-N. However, it was not until later in the season that a substantial increase was observed. The increase in NO_3-N concentrations coincided with the increased frequency of irrigation and rain events. Although soil NO_3-N varied largely during maturity stage, overall effects of tillage and fertilizer N application on soil NO_3-N contents at different depths were not significant. However, frequency and amount of precipitation and irrigation water greatly influenced the movement of exchangeable NO_3-N to deeper soil depths (>30 cm). These results show that N-fertilizer placement had minimal influence on the levels of exchangeable NO_3-N that moved down the soil profile. To avoid substantial nitrate leaching, improved irrigation practices using soil moisture monitoring and irrigation scheduling could be implemented.

Practical Applications

Concentrations of runoff N and P were associated with the intensity and frequency of irrigation and precipitation during the growing season. Water quality metrics were within the range that have minimal risk in waterways. Lint yields were not affected by tillage and fertilizer- N placements. Also, our treatments had minor impact on the NO_3-N levels that moved down the soil profile. Movement of soil-N in deeper profiles was most affected by irrigation events during boll filling-maturity stage. Over the 2-year study, our results support the adoption of conservation practices that minimize nutrient losses in furrow irrigation systems. Improving nutrient management will lead to more sustainable cotton systems.

Acknowledgments

We gratefully acknowledge Cotton Incorporated (Project number: 17-629 and 17-632AR) CORE, and the Arkansas Cotton State Support Committee for financial support of this research. We also acknowledge research support from the University of Arkansas System Division of Agriculture (USDA National Institute of Food and Agriculture: Project ARK02355), Arkansas State University and the Judd Hill Foundation. We also thank R. Woodruff, O. Iseyemi, J. Delp, P. Deshazo, R. Lewis, A. Mann, and C. Chapdelaine for their help in chemical analysis, field management and water sampling.

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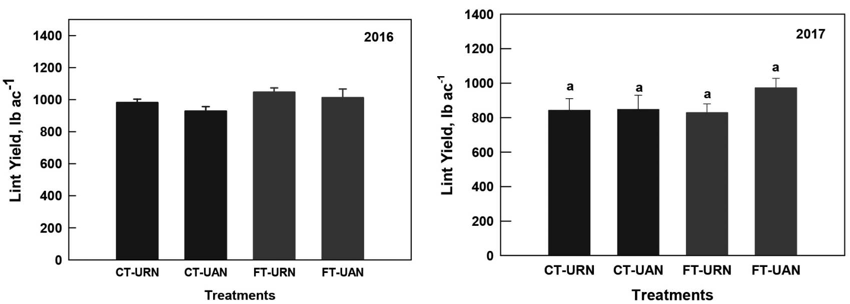

Fig. 1. Average lint yields in the different tillage and fertilizer N treatments (FT = Furrow tillage, CT = Conventional plow, URN = urea broadcasted, UAN = 32% urea ammonium nitrate injected) during 2016 and 2017 growing seasons. Lint yields followed by the same letter are not significantly different at *P* < 0.05.

Table 1. Seasonal mean (geometric) concentrations of soluble nutrients in runoff from the four tillage and fertilizer N treatments during the 2017 growing season.

Tillage treatment	Fertilizer N treatment	Soluble nutrient[a] Ammonium-N (NH_4-N)	Nitrate-N (NO_3-N)	Nitrite-N (NO_2-N)	Phosphorus (P)
		--------------------	-------------------- *mg L*[-]	--------------------	--------------------
Conventional	Urea (URN)	0.01 (0-0.10)	0.63 (0.25-3.69)*b*	0.05 (0.01-0.29)	0.16 (0.06-0.31)
(CT)	32% UAN (UAN)	0.00 (0.0-0.02)	1.05 (0.73-1.77)*a*	0.04 (0.03-0.04)	0.19 (0.08-0.35)
Conservation	Urea (URN)	0.01 (0.01-0.05)	0.84 (0.32-5.54)*b*	0.06 (0.01-0.36)	0.24 (0.13-0.62)
(FT)	32% UAN (UAN)	0.02 (0-0.12)	0.78 (0.23-4.50)*b*	0.06 (0.01-0.30)	0.29 (0.07-0.93)

[a] Values inside parentheses are computed ranges. Mean concentrations in each column with same letter were not significantly different at $P < 0.05$ level.

Table 2. Seasonal mean water quality characteristics of irrigation water during runoff or irrigation event in the four treatments.

Tillage treatment	Fertilizer N treatment	Water quality parameters[a] pH	Electrical conductivity	Hardness	Alkalinity	Turbidity	Total suspended solids	Soil sediment concentrations
			µS cm^{-1}	*mg L*$^{-1}$	*mg* $CaCO_3$ *L*$^{-1}$	NTU[b]	*mg L*$^{-1}$	*mg L*$^{-1}$
Conventional	Urea	7.7 (7.3-8.1)	431 (139-661)	158 (38-228)	72 (9-210)	931 (1-3263)	589 (170-1348)	830 (473-1929)
Tillage	32% UAN	7.6 (6.7-8.0)	458 (99-638)	170 (27-238)	27 (17-31)	1741 (2-3825)	967 (733-1896)	1245 (938-1860)
Conservation	Urea	7.8 (7.2-8.2)	404 (154-578)	146 (41-226)	43 (9-118)	1187 (2-3546)	635 (259-1476)	868 (418-1828)
Tillage	32% UAN	7.4 (6.1-8.1)	319 (66-649)	109 (13-220)	41 (1-91)	3875 (1-19273)	398 (150-723)	901 (390-1264)

[a] Values inside parentheses are computed ranges.
[b] Nephelometric Turbidity Unit.

Eddy Covariance Measurements of Carbon Dioxide and Water Fluxes in Mid-South U.S. Cotton

M.L. Reba[1], B.N. Fong[1], T.G. Teague[2], B.R.K. Runkle[3], and K. Suvočarev[4]

Abstract

An eddy covariance (EC) system was used to quantify carbon dioxide (CO_2) and water (H_2O) fluxes as net ecosystem exchange (NEE) and crop evapotranspiration (ET), respectively, in a production-sized cotton field in Northeastern Arkansas in 2016 and 2017 growing seasons. Average ET was 0.13 ± 0.01 in d^{-1} (day) during 2016 and 0.14 ± 0.01 in d^{-1} during 2017 growing season. The average ET values were similar to results from lysimeter studies conducted in the humid southeastern U.S. climates, but lower than observed in studies in arid regions; this variation was likely due to comparatively higher relative humidity and lower solar radiation in the southeastern U.S. Net ecosystem exchange decreased from emergence until the first square stage due to increasing gross primary productivity (GPP), remained constant during squaring and flowering periods, and then increased after physiological cutout during boll maturation due to decreasing GPP. These findings will contribute to research efforts to refine inventories of agricultural GHG emissions and improve water use and irrigation management for cotton in the humid mid-South.

Introduction

Land-atmosphere interaction of CO_2 and H_2O fluxes at the field scale using eddy covariance (EC) in cotton (*Gossypium hirsutum* L.) has been understudied, especially in the mid-Southern U.S. Eddy covariance is non-destructive and one of the most direct and defensible methods to measure field scale trace gas fluxes (Baldocchi, 2003). Many EC field measurements of cotton come from Texas (Alfieri et al., 2012; Chávez et al., 2009; Howell et al., 2004), which has significantly lower relative humidity compared to Arkansas, which leads to higher evaporative demand by comparison. More large-scale measurements are needed in order to make representative local and regional estimates of CO_2 and H_2O gas exchange. In addition, the measurement of CO_2 may help develop alternative crop manage-

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ment practices that increase carbon sequestration as offset credits to incentivize more sustainable agriculture practices or determine better timed crop management defined by plant behavior and growth (Mckinion et al., 2001). Measurements of crop evapotranspiration (ET) can refine irrigation scheduling, reduce plant water stress at critical growth stages, and help producers prioritize irrigation events (O'Shaughnessey and Evett, 2010).

Procedures

The objectives of the study were to 1) describe and measure CO_2 fluxes or Net Ecosystem Exchange (NEE), 2) partition NEE into component photosynthesis (gross primary productivity, GPP) and ecosystem respiration (Reco) and relate to growth stages, and 3) quantify evapotranspiration and relate to growth stages. These objectives were accomplished through EC measurements on two cotton fields near Manila, Arkansas, USA (35° 53' 14", -90° 8' 15"). Generally, EC couples high frequency (10-20 Hz, i.e., measurements per second) wind speed and direction with gas (usually CO_2 and H_2O) concentration from a spectrometer to calculate trace gas fluxes. The technique measures the exchange rate of the gas across a ground/canopy–atmosphere interface through the covariance between two consecutive vertical wind velocity and gas mixing ratio measurements. Unlike other flux measurements, these do not interfere with the canopy or surface source and therefore can be measured continuously throughout the growing season (Burba, 2013).

The fields were center pivot irrigated. Cultivar DP 1518 B2XF was planted in early May in 2016 and 2017. Eddy covariance data were collected at 20 Hz, processed, and averaged over thirty minutes using EddyPro software v 6.2.0 (LI-COR, Lincoln, Nebraska, U.S.). Plant monitoring with COTMAN (Oosterhuis and Bourland, 2008) was conducted weekly during approximately 40 to 90 days after planting (DAP) to quantify plant development.

Results and Discussion

Lint yield measured by calibrated yield monitor on the cooperating producer's cotton picker was 1480 kg ha^{-1} (1,322 lb ac^{-1}) and 2018 kg ha^{-1} (1802 lb ac^{-1}) in 2016 and 2017, respectively. Net ecosystem exchange was partitioned into its components: ecosystem respiration (Reco) and gross primary productivity (GPP), a measure of photosynthesis. The lowest observed NEE was between first week of flowering (FF) and physiological cutout (nodes above white flower equal to 5), potentially related to highest GPP. Average NEE during the growing season (planting to harvest) was -0.39 ± 0.28 µmol CO_2 m^{-2} s^{-1} during 2016 and -0.95 ± 0.28 µmol CO_2 m^{-2} s^{-1} during 2017 (Fig. 1a). The average Reco during the growing season was 7.29 ± 0.39 µmol CO_2 m^{-2} s^{-1} during 2016 and was 6.22 ± 0.25 µmol CO_2 m^{-2} s^{-1} during 2017 (Fig. 1b). Greater GPP was observed with greater leaf surface area. Average GPP during the growing season was 8.49 ± 0.52 µmol CO_2 m^{-2} s^{-1} during 2016 and 7.94 ± 0.43 µmol CO_2 m^{-2} s^{-1} during 2017 (Fig. 1c). The average ET was 0.13 ± 0.01 in d^{-1} during 2016 and 0.14 ± 0.01 in d^{-1} during 2017 growing season (planting to harvest) (Fig. 2).

Generally, ET was low in early season, with peak water use 60–90 DAP, then decreased steadily until harvest (Fig. 2). The peak water use correlated with peak plant main stem nodal development (first week of squaring to first week of flowering) indicating increased water use for vegetative and reproductive plant growth. Evapotranspiration was reduced around 140 DAP, and after harvest in October due to cooler temperatures. Due to humid conditions, peak ET values (0.22 in d^{-1}) were smaller than those measured in Texas and Arizona cotton fields. Our results were aligned with published values from the humid regions (Fisher and Udeigwe, 2013).

Practical Applications

These findings refine our understanding of plant activity (photosynthesis and plant respiration) and expand baseline data needed for improving irrigation practices in the humid mid-South.

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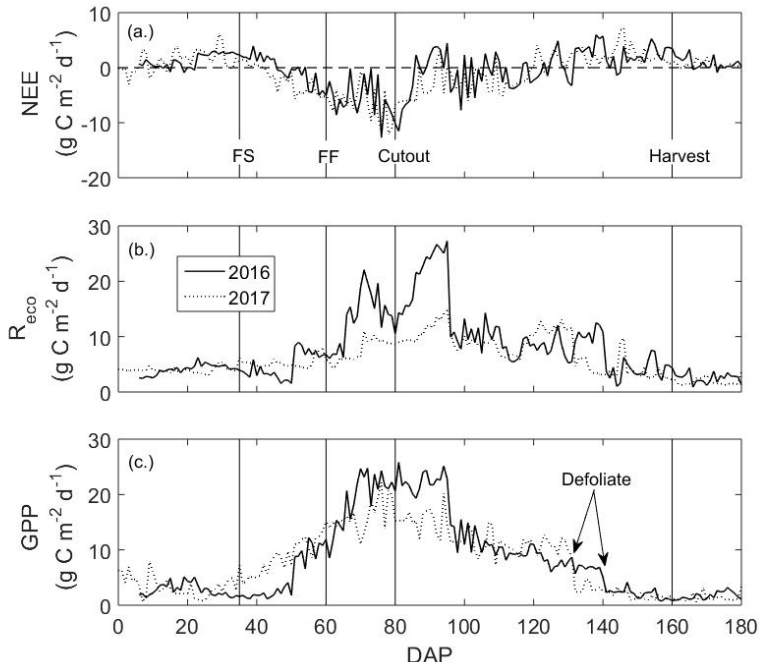

Fig. 1. Daily averaged (a) net ecosystem exchange (NEE), (b) ecosystem respiration (Reco), and (c) gross primary productivity (GPP) during the 2016 and 2017 growing season according to days after planting (DAP). FS is first week of squaring, FF is first week of flowering, and cutout is physiological cutout or nodes above white flower equal to 5.

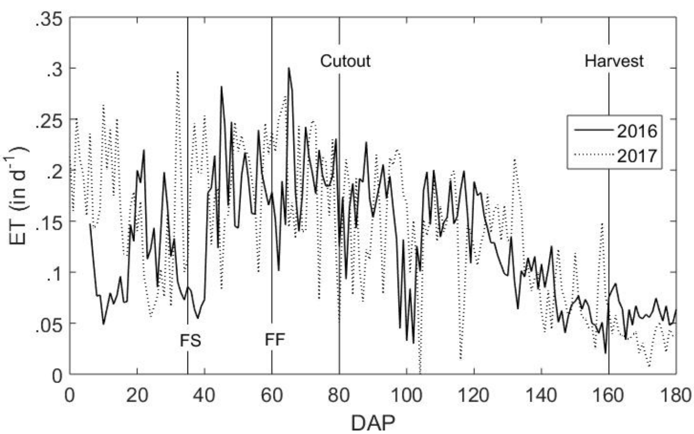

Fig. 2. Daily crop evapotranspiration (ET) during 2016 and 2017 cotton growing seasons. FS is first week of squaring, FF is first week of flowering, and cutout is physiological cutout or nodes above white flower equal to 5.

Seeding Rate, Cultivar Selection, and Winter Cover Crop Effects on Maturity and Yield of Cotton

T.G. Teague[1], N.R. Benson[2], K.D. Wilson[1], and A.M.H. Mann[1]

Abstract

Impacts of seeding rate, cultivar, and winter cereal cover crops on cotton production were evaluated in a 2017 on-farm study in Northeast Arkansas. The 4 × 2 × 3 factorial experiment included four cover crop treatments (broadcast cereal rye, banded cereal rye, banded wheat, and winter fallow), two cotton cultivars (DP1518 B2XF and DP1614 B2XF), and three seeding rates (1.5, 3, and 4.5 seeds per ft of row). Yield data were evaluated using georeferenced yield monitor measures; analysis included soil textural classes (coarse sand and loamy sand) as a co-variate. Results showed significant interactions among all factors tested. Lowest yields for both cultivars were associated with broadcast cereal rye and for field areas with coarse sand. Seeding rate response was inconsistent. Results from our previous research had showed no yield penalty for reduced seeding rates in conventional tillage systems; however, in new cover crop systems, producers should consider following standard University of Arkansas System Division of Agriculture's Extension Service recommendations (3 seeds/ft of row).

Introduction

Sustainable crop production practices that increase efficiency and reduce production input costs are needed to improve profitability of U.S. cotton. Decisions on cultivar selection, tillage practices and seeding rates each and in combination can have considerable impact on productivity and input costs. In our previous on-farm work in northeast Arkansas, reducing seeding rate from 4.5 down to 1.5 seeds per ft of row had no significant effect on cotton lint yield (Benson et al., 2015, 2016, 2017) and is a viable cost-saving tactic for mid-South producers using treated, genetically enhanced seed. Those studies were conducted in fields with conventional tillage practices or with wheat or oat cover crops planted between rows (banded in the furrow for wind and blowing sand protection). With expanded producer interest in cereal rye cover crops, practical questions have emerged regarding whether lower seeding rates are appropriate in such systems

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and also whether variable rate seeding might be appropriated for different soil textures across spatially variable fields. Improved understanding of interactions of production inputs and soil texture may provide insight into better recommendations for site-specific management to improve production efficiency.

Procedures

The experiment was conducted in a commercial field located at the Manila, Arkansas Airport Complex in cooperation with Wildy Family Farms (WFF) and the city of Manila. Our WFF cooperators supplied equipment for planting (12 row variable rate planter) and harvest (6-row cotton picker with yield monitor). The 4 × 2 × 3 factorial experiment was arranged in a split plot design with 3 replications. Winter cover crop treatments were considered main plots and were: 1) cereal rye (cv. Elbon) broadcast at 54 lb/acre; 2) cereal rye banded in-furrow at 20 lb/acre; 3) wheat banded in-furrow at 20 lb/acre; and 4) winter fallow (untreated-no cover crop). Seeding rate and cultivar treatments were sub-plots. Seeding rate treatments were 1.5, 3, and 4.5 seeds per ft of row. Cultivars were DP 1518 B2XF and DP 1614 B2XF. Sub-plots were 12 rows wide and 100 ft long. Soils in the field were classified as Routon-Dundee-Crevasse complex (Typic Endoqualfs). On 22 November 2016, the field was re-bedded (38-inch spacing), and appropriate cover crops planted using an air seeder. A broad-leaf selective herbicide application was made in early March 2017 leaving only grasses in the field. Cover crops were terminated with herbicides applied just after planting on 19 May. Timing for furrow irrigation and other production practices are shown in Table 1.

Weekly stand counts beginning at 8 days after planting (DAP) were made using line-transect sampling with counts of plants per 3 row ft. in two transects across 12 rows in each plot. Plant and insect pest monitoring included standard COTMAN Squaremap sampling protocols (Oosterhuis and Bourland 2008), thrips assessments (whole plant washes), and tarnished plant bug abundance (sweep nets and drop cloths). COTMAP was used for final, end-of-season plant mapping (Bourland and Watson, 1990). Yield data were collected from the cooperating producer's John Deere 7600 cotton picker equipped with calibrated yield monitor. Data processing included use of Yield Editor (Sudduth et al., 2012). Delineation of soil texture was established from indirect measurements using a Veris 3150 EC Surveyor instrument® (Veris Technologies, Inc., Salina, Kansas) to generate a soil EC map. Georeferenced data layers from the yield monitor and soil EC (5 m perimeter -shallow) were joined using ArcGIS©10.2 (ESRI; Redlands, California). A four-way factorial structure was used for analysis of the yield monitor measured yield with seeding rate, cultivar, cover crop, and block effect. Soil EC classifications were also included as a co-variate. Soil EC measures were initially broken into four classes (natural breaks in ArcGIS) calculated from shallow measurements of soil EC from Veris cart. For the final analysis, soil EC values were stratified into two classes: coarse sand (deep < 9 mS m^{-1}) and loamy sand (> 9 mS m^{-1}) which encompassed 40% and 60% of field study area, respectively.

Data were analyzed using PROC MIXED, SAS v. 9.4 (SAS Institute Inc., Cary, North Carolina).

Results and Discussion

Rainy weather conditions interrupted planting. Cultivar DP1518 B2XF was planted first, and before the DP 1614 B2XF could be planted, it began to rain. There was a 3-day delay, and total rainfall was 0.72 inches. Differences in stand counts at 7 DAP for each cultivar indicate greater variability for DP1518 B2XF compared to DP1614 B2XF (Fig. 1). Greatest deviation in stand was observed with DP1518 B2XF in winter fallow (no cover crop) subplots where we observed some soil crusting. By 25 DAP, practically all treatments were above 80% of target seeding rate with the exception of lower seeding rates of DP 1518 B2XF in the winter fallow treatment.

Pace of plant mainstem nodal development depicted in COTMAN growth curves was similar among cultivars prior to first flower. Plants in the lowest seeding rate treatment produced slightly more squaring nodes by first flowers (ca. 60 DAP) compared to the higher seeding rates (data not shown). Mean number days to physiological cutout (nodes above white flower = 5) were affected by seeding rate; mean number days from planting to physiological cutout (days to cutout) was 80, 77 and 76 days for the 1.5, 3 and 4.5 seeds/ft treatments, respectively. There were no significant maturity delays associated with cover crop or cultivar ($P > 0.15$), and there were no significant interactions ($P > 0.20$).

Overall insect pest pressure was low. No differences in thrips numbers among treatments from whole plant washes were noted (data not shown). The field was over-sprayed with insecticide shortly after our initial thrips assessment, and there was no subsequent sampling. Tarnished plant bug numbers were low and remained below action thresholds season-long. Any potential damaging infestations were suppressed with broadcast insecticidal sprays (Table 1).

End-of-season plant mapping results showed significant differences in plant structure and boll retention among cultivars, seeding rates, and cover crop subplot and main-plot effects, but only seeding rate effects are shown (Table 2). Seeding rate had greatest impacts on mainstem node production and boll retention. Early boll retention exceeded 70% in the lowest seeding rate compared to higher rates.

Yield monitor-measured yields were lower in coarse sand compared to loamy sand areas of the field. Main effects of cover crop and seeding rate were not significant; however, there were significant interactions (Table 3). Cultivars responded differently to cover crops and seeding rates. Highest overall yields were associated with DP 1518 B2XF grown at the lowest seeding rate in banded cereal rye (Fig. 2). For DP1614 B2XF, a smaller seeded cultivar, highest yields were observed at the highest seeding rate in the winter fallow treatment in loamy sand (Fig. 3). Yields were lower with DP1614 B2XF with cereal rye cover crop treatments. Lowest yields for both cultivars in both loamy sand and coarse sand were associated with broadcast cereal rye cover crops. Seeding rate response was inconsistent among treatment combinations. For DP 1518 B2XF grown in the broadcast cereal rye, higher seeding rates were required for higher yield. For both cultivars, highest yields in winter fallow also were associated with highest seeding rate.

Practical Applications

Based on previous results, reduced seeding rates in tillage systems with either winter fallow or banded wheat cover crop systems had no negative impact on yield (Benson et al., 2015, 2016, 2017). Findings from 2017 were mixed across different cover crop systems and soil textures. Until we have more information, Arkansas producers working with new cover crops systems should follow standard Cooperative Extension Service recommendations and plant at least 3 seeds/ft of row. Continued research to expand our understanding of interactions should provide insight into better recommendations for cover crops and site-specific management. Reduction of production costs is a priority, but our overall goal is to improve efficiency and ultimately cotton sustainability.

Acknowledgments

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Table 1. Dates of planting, irrigation, sampling, foliar insecticide application, and harvest for the 2017 cover crop × seeding rate × cultivar study, Manila Airport, 2017.

Operation	Date	Days after planting
Date of planting	19 May	
Stand counts	26 May, 30 May, 5 June, 13 June	7, 15, 21
Foliar insecticides	2 June, 28 June, 8 July, 28 July, 8, 18 Aug	11, 43, 56, 59, 83
Furrow irrigation	12, 20 July, 2, 24 Aug	54, 62, 75, 97
Machine harvest	28 Oct	171

Table 2. Results from final, end-of-season plant mapping using COTMAP for seeding rate (SR) sub-plots, Manila Airport, 2017.

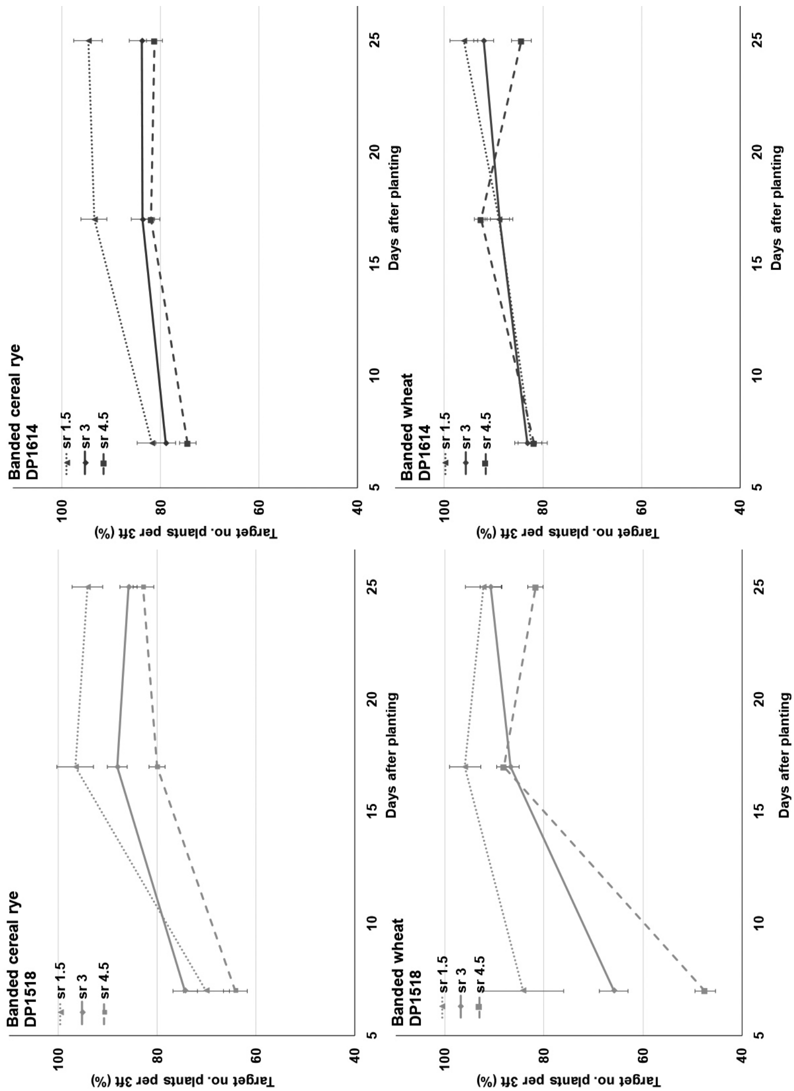
	Mean[a] per plant for seeding rate (SR)			
Category	**SR 1.5**	**SR 3**	**SR 4.5**	***Pr>F***
1st Sympodial Node	5.5	5.6	5.6	*<0.001*
No. of Monopodia	2.0	1.4	1.2	*<0.001*
Highest Sympodia with 2 Nodes	11.7	10.6	9.4	*0.06*
Plant Height (inches)	28.6	30.8	29.8	*<0.001*
No. of Effective Sympodia	10.6	9.3	8.2	*<0.001*
No. of Sympodia	14.7	13.5	12.4	*0.008*
Total Bolls/Plant	18.3	11.1	8.4	*<0.001*
% Total Bolls in 1st Position	45.5	63.0	74.8	*<0.001*
% Total Bolls in 2nd Position	26.2	24.1	18.2	*<0.001*
% Total Bolls in Outer Position	9.1	3.5	1.9	*<0.001*
% Total Bolls on Monopodia	17.8	8.5	4.4	*0.02*
% Boll Retention - 1st Position	54.6	50.3	49.5	*<0.001*
% Boll Retention - 2nd Position	41.1	25.3	16.5	*<0.001*
% Early Boll Retention	73.8	59.5	51.1	*<0.001*
Total Nodes/Plant	19.2	18.1	17.0	*<0.001*
Internode Length (inches)	1.5	1.7	1.8	*0.68*

[a] Means of 10 plants per plot.

Table 3. Type 3 tests of fixed effects (SAS 9.4, PROC MIXED) for yield monitor measure yields with 4 factors: cover crop (CC), cultivar (Cult), seeding rate (SR), and soil texture class (TEX).

Effect	Num DF[a]	Den DF[b]	F Value	Pr > F
CC	3	6	0.71	0.5809
Cult	1	769	8.6	0.0035
CC*Cult	3	769	1.55	0.2002
SR	2	769	2.21	0.1109
CC*SR	6	769	16.7	<0.0001
Cult*SR	2	769	2.02	0.1328
CC*Cult*SR	6	769	10.4	<0.0001
TEX	1	2	20.18	0.0462
CC*TEX	3	769	6.35	0.0003
Cult*TEX	1	769	0.17	0.6798
CC*Cult*TEX	3	769	0.33	0.8064
SR*TEX	2	769	0.43	0.6482
CC*SR*TEX	6	769	2.71	0.0131
Cult*SR*TEX	2	769	2.9	0.0559
CC*Cult*SR*TEX	5	769	4.38	0.0006

[a] Numerator degrees of freedom.
[b] Denominator degrees of freedom.



continued on next page

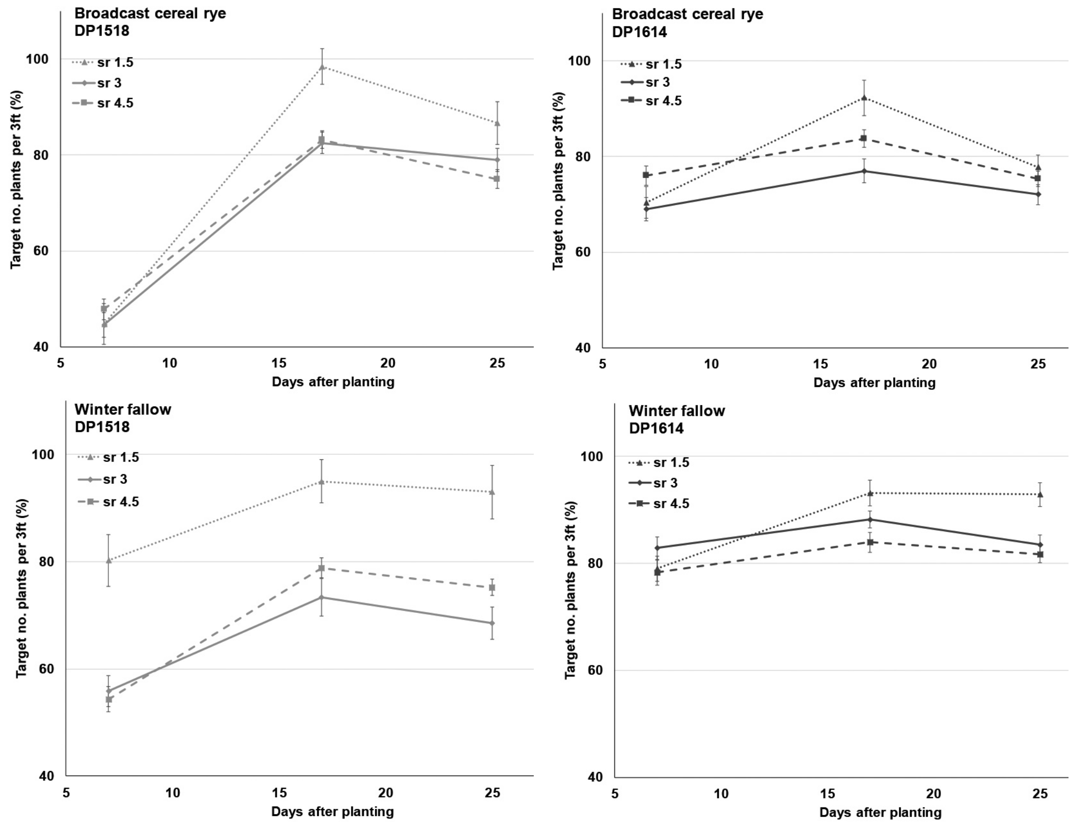


Fig. 1. Stand densities determined at 7, 17, and 25 DAP for 2 cultivars planted at 3 seeding rates into 4 different cover crop treatments, Manila Airport, 2017.

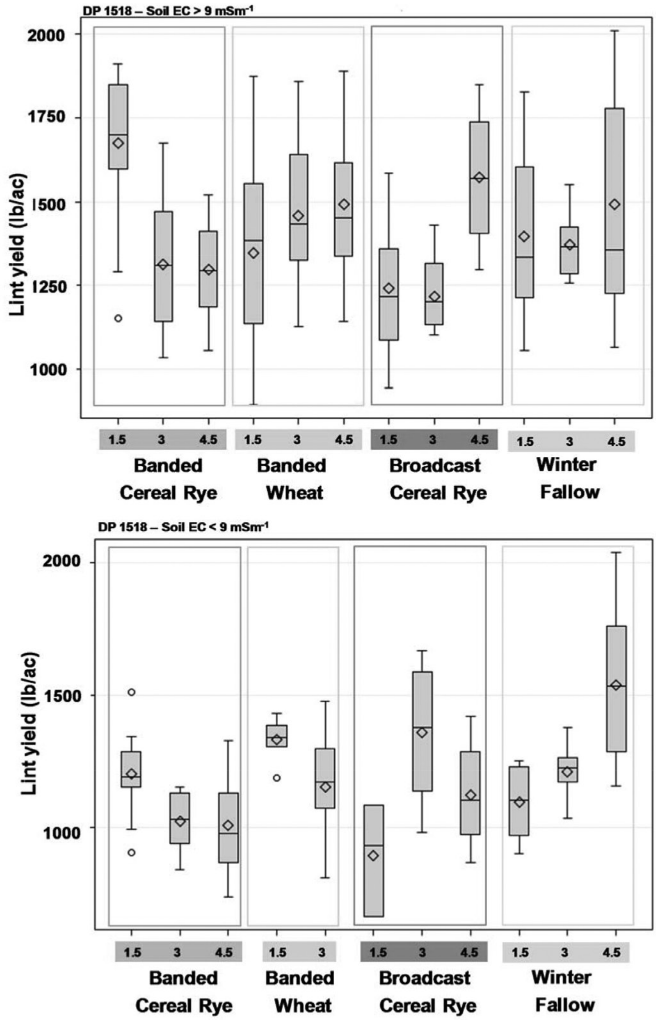


Fig. 2. Lint yield for cultivar DP 1518 f from yield monitor measures in either loamy sand (>9 mSm^{-1}) (top) or coarse sand (<9 mSm^{-1}) (bottom) in four cover crop treatments at three seeding rates (1.5, 3, or 4.5 seeds per ft of row) There were significant seeding rate*cover crop interactions (*P* = <0.01) for each soil texture. Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value, Manila Airport, 2017.

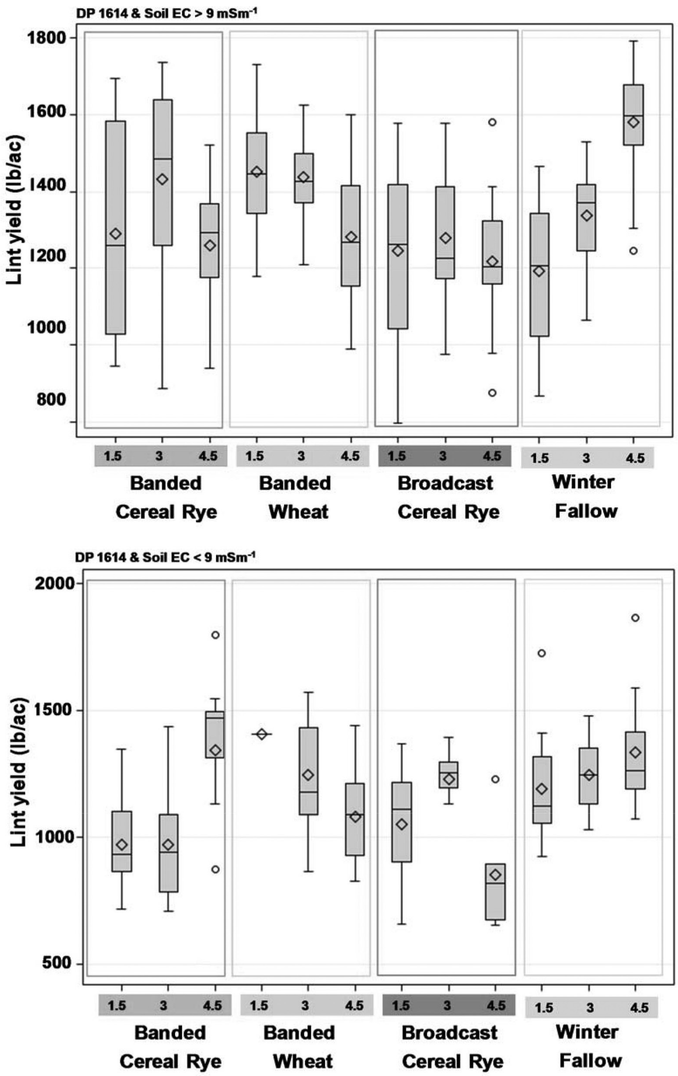


Fig. 3. Lint yield for cultivar DP 1614 from yield monitor measures in either loamy sand (>9 mSm^{-1}) (top) or coarse sand (<9 mSm^{-1}) in four cover crop treatments at three seeding rates (1.5, 3, or 4.5 seeds per ft of row) There were significant seeding rate*cover crop interactions (*P* = <0.01) for each soil texture. Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value, Manila Airport, 2017.

Cotton Responds Positively to Urea and Environmentally Smart Nitrogen in Arkansas

M. Mozaffari[1] *and H.C. Hays*[1]

Abstract

Nitrogen fertilization cost is one of the important inputs in cotton (*Gossypium hirsutumn* L.) production. A replicated field experiment was conducted to evaluate cotton response to urea and a high efficiency N fertilizer marketed under the trade name of Environmentally Smart Nitrogen (ESN). These results from 2017 support our previous findings that ESN-N is a more efficient source of N than urea when environmental conditions favor N loss.

Introduction

Cotton (*Gossypium hirsutum* L.) remains as a major crop in Arkansas. 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 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. A polymer-coated urea (44% N, Agrium Wholesales, Loveland, Colorado) is currently being marketed in Arkansas under the trade name of Environmentally Smart Nitrogen or ESN[2]. 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.

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[2] Mention 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.

Procedures

The field experiment was conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center located in Keiser, Arkansas. 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 30 to 150 lb N/acre in 30 lb N/acre increments, and a no N control with five replications. All N-fertilizer treatments were 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 30 May.

Results and Discussion

Total monthly rainfall at Keiser between May to October of 2017 was above the 10-year average. Therefore, the conditions were conducive for above normal N loss. Seedcotton yield was significantly influenced by N-sources, N-rate, and the interaction of N source × N rate ($P \leq 0.0398$, Table 1). Seedcotton yield for the cotton that received no N was 1894 lb/acre, which was lower than the cotton that received the lowest N rate of 30 lb N/acre, averaged across N sources. Averaged across the N sources, the seedcotton yield was 2529–3025 and generally increased with increasing N application rate. Seedcotton yield of plants fertilized with any urea was 2295–2999 lb/acre and seedcotton yield of plants fertilized with any ESN was 2821–3225 lb/acre, as a reflection of environmental conditions that were conducive to N loss. This supports our previous findings that ESN-N is a more efficient source of N than urea when environmental conditions favor N loss.

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 and the University of Arkansas System Division of Agriculture. We thank Monsanto for donating the cotton seeds.

Table 1. Seedcotton yield as affected by the significant N source, N rate, and N source × N rate interaction ($P \leq 0.0398$) for a cotton N-fertilization experiment conducted at Northeast Research and Extension Center in Keiser Ark. in 2017.

	N-fertilizer source				
N-rate	100% Urea-N	25% Urea-N 75% ESN-N [a]	N rate yield mean	N-fertilizer source	N source yield mean
lb N/acre	--------- Seedcotton yield (lb/acre)	----------			lb/acre
0				None	1894[b]
30	2294	2821	2529	100% Urea-N	2720
60	2692	2716	2727	25% Urea-N,75% ESN-N	2988
90	2999	2830	2924		
120	2815	3235	3013		
150	2799	3225	3025		
LSD 0.10	285[c]		204 [d]	LSD 0.10	129
P-value	0.0398 [e]		0.0018	*P*-value	0.023

[a] ESN, Environmentally Smart Nitrogen, polymer-coated urea.
[b] the no-N control is listed for reference only as it was not included in the analysis of variance.
[c] Least significant difference for the N source × N rate interaction.
[d] Least significant difference compares the yield of treatments that received N, averaged across N sources.
[e] *P*-value for the N source × N rate interaction.

Contribution of Proline to Osmotic Adjustment in Drought-Stressed Cotton

C. Pilon[1], D. Loka[2], J.L. Snider[1], and D.M. Oosterhuis[3]

Abstract

Cotton growth can be negatively affected by drought conditions. Some species make use of adaptive mechanisms, such as osmotic adjustment, to tolerate drought stress. Osmotic adjustment in roots and leaves of cotton plants has been reported in the past. However, the use of this mechanism in cotton flowers and their subtending leaves of modern, commercially available cultivars has not been fully elucidated. Therefore, the objectives of this study were to quantify osmotic adjustment in cotton plants under drought conditions and identify compatible solutes involved in this mechanism. Cotton plants were grown under field conditions. Plants were exposed to water-deficit stress at peak flowering, approximately 70 days after planting. Measurements included proline concentration and water potential components. Leaves accumulated more proline to maintain cellular turgor, whereas floral tissues appeared to be more buffered from the variation in cell turgor and solute accumulation under water-deficit conditions.

Introduction

Drought is one of the main factors affecting cotton (*Gossypium hirsutum* L.) yields. Drought stress effects in plants vary with severity and duration of the stress, growth stage and cultivar, or a combination of these factors (Kramer, 1983). Cell turgor of plants exposed to moderate to severe water-deficit stress decreases considerably, reducing growth.

Osmotic adjustment is an adaptive mechanism to stressed conditions, including drought, via accumulation of compatible solutes in the cytosol, decreasing osmotic potential, thus maintaining cell turgor (Hsiao et al., 1976). Proline is an amino acid that occurs naturally in the cells (Sharma et al., 2011). It is considered a compatible solute contributing to osmotic adjustment when accumulated at high levels in plants under stress. Research in cotton has shown that osmotic adjustment in roots was higher than in leaves of plants grown under water-deficit stress (Oosterhuis and Wullschleger, 1987).

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Identification of physiological mechanisms contributing to drought tolerance, such as osmotic adjustment, could serve as selection tools in biotechnology programs for plant improvement (Tuberosa and Salvi, 2006). The development of cotton cultivars with improved drought tolerance would support maintenance of physiological processes when the plants are exposed to drought conditions.

The relevance of osmotic adjustment in plants under drought stress has been extensively recognized (Pandey et al., 2017; Timpa et al., 1986). However, the use of this strategy in the cotton flower and its subtending leaf in drought-stressed plants has not been fully studied. Therefore, the objectives of this study were to quantify osmotic adjustment in cotton plants under drought conditions and identify compatible solutes involved in this mechanism.

Procedures

A study was conducted under field conditions at the University of Arkansas System Division of Agriculture in Fayetteville, Arkansas in 2014. The experimental design was a split-plot in randomized complete block design with four treatments and five replications. Treatments consisted of two cotton cultivars, DP0912 B2RF and PHY499 WRF, and two water regimes, well-watered control and water-deficit stress imposed at peak flowering, which was reached at approximately 70 days after planting. Approximately 10 seeds m^{-2} were sown in a Captina silt loam (fine-silty, siliceous, mesic, Typic Fragidult) soil. The entire field was irrigated with a furrow system according to the University of Arkansas System Division of Agricultures's Cooperative Extension Service recommendations until peak flowering stage. When plants reached peak flowering, water was withheld from the water-stress treatment for ten days. On the tenth day of stress, white flowers in the first sympodial branch position on the main stem and their subtending leaves were collected for determination of proline and water potential components. Proline concentration was determined according to the methodology described by Bates et al. (1973). Water and osmotic potentials were measured with screen-caged thermocouple psychrometers (model 74 series, J.R.D. Merrill Specialty Equipment, Logan, Utah) equipped with stainless steel sample chambers using the technique described by Oosterhuis (2003). Pressure potential was derived from the water and osmotic potentials. Data were subjected to analysis of variance and means were separated using least significant difference *post hoc* test ($\alpha = 0.05$). Comparison analyses were performed using JMP Pro 11 (SAS Institute Inc., Cary, North Carolina).

Results and Discussion

Metabolic processes at the cellular level in plants are generally related to cell turgor or volume (Jones, 2007). Water potential components were affected by water-deficit stress (Table 1). Leaf water and pressure potentials were unaffected by water regimes while leaf osmotic potential was approximately 37% lower in water-stressed plants compared to the control. Pistil water potential was not affected by water-deficit stress. Moreover, osmotic potential was approximately 68% lower in the pistil of water-deficit stressed plants, while pistil pressure potential was maintained at similar levels for both water regimes.

Some plant species have adaptive mechanisms, such as osmotic adjustment, to maintain cellular turgor despite reductions in water potential (Parida et al., 2007; Jones, 2007). Proline is a compatible solute that is accumulated in cells under drought stress, contributing to osmotic adjustment (Bray et al., 2000). Proline accumulation lowers cell osmotic potential, thus maintaining turgor for ongoing physiological processes. For this study, proline concentration in leaves was 2-fold higher in water-stressed plants than that in well-watered plants (Table 2). However, proline concentration in pistils was unaffected by water regimes. Higher proline accumulation and pressure potential were observed in water-stressed leaves than those in water-stressed pistils.

The mechanism assisting osmotic adjustment in cotton plants under water-deficit stress seems to be different for leaves and reproductive tissues. Leaves accumulate more proline to maintain cellular turgor, whereas floral tissues appear to be more buffered from the variation in cell turgor and solute accumulation under water-deficit conditions.

Practical Applications

Identification of osmotic adjustment in leaves and flowers of cotton plants contributing to drought tolerance could serve as selection tools in biotechnology programs for the development of cotton cultivars with improved drought tolerance. This would support ongoing physiological processes when the plants are exposed to drought conditions.

Acknowledgments

The authors would like to thank Cotton Incorporated for funding this research. Support also provided by the University of Arkansas System Divison of Agriculture.

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Table 1. Water potential (Ψw), osmotic potential (Ψs), and pressure potential (Ψp), in leaves, petals, and pistils of cotton plants grown in field conditions under two water regimes, well-watered control and water-deficit stress imposed at peak flowering. All values are means (n = 5).

Water regime	Ψ_w	Ψ_s	Ψ_p
		MPa	
		Leaf	
Well-watered control	-0.99 a†	-1.34 a	0.34 a
Water-deficit stress	-1.34 a	-1.84 b	0.50 a
		Petal	
Well-watered control	-0.29 a	-0.41 a	0.12 b
Water-deficit stress	-0.36 b	-0.58 b	0.22 a
		Pistil	
Well-watered control	-0.52 a	-0.75 a	0.23 a
Water-deficit stress	-0.98 a	-1.26 b	0.27 a

† Different letters between water regimes indicate a significant difference according to least significant difference test at a 0.05 probability level.

Table 2. Proline concentration in leaves and pistils of cotton plants grown in field conditions under two water regimes, well-watered control and water-deficit stress imposed at peak flowering. All values are means (n = 5).

Water regime	Proline (μmol g^{-1}DM) Leaf	Pistil
Well-watered control	3.95 b†	4.87 a
Water stress	8.18 a	6.71 a

† Different letters between water regimes indicate a significant difference according to least significant difference test at a 0.05 probability level.

Appendix

Student Theses and Dissertations Related to Cotton Research in Progress in 2017

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)

Meyer, Christopher. Understanding the risk for glufosinate resistance. (Ph.D., 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)

Wood, Hunter. Influence of tillage practices on water quality of irrigation runoff and total N loss in a cotton production. (M.S., advisor: Adviento-Borbe/ Teague)

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