7-2021

Summaries of Arkansas Cotton Research 2020

Fred Bourland

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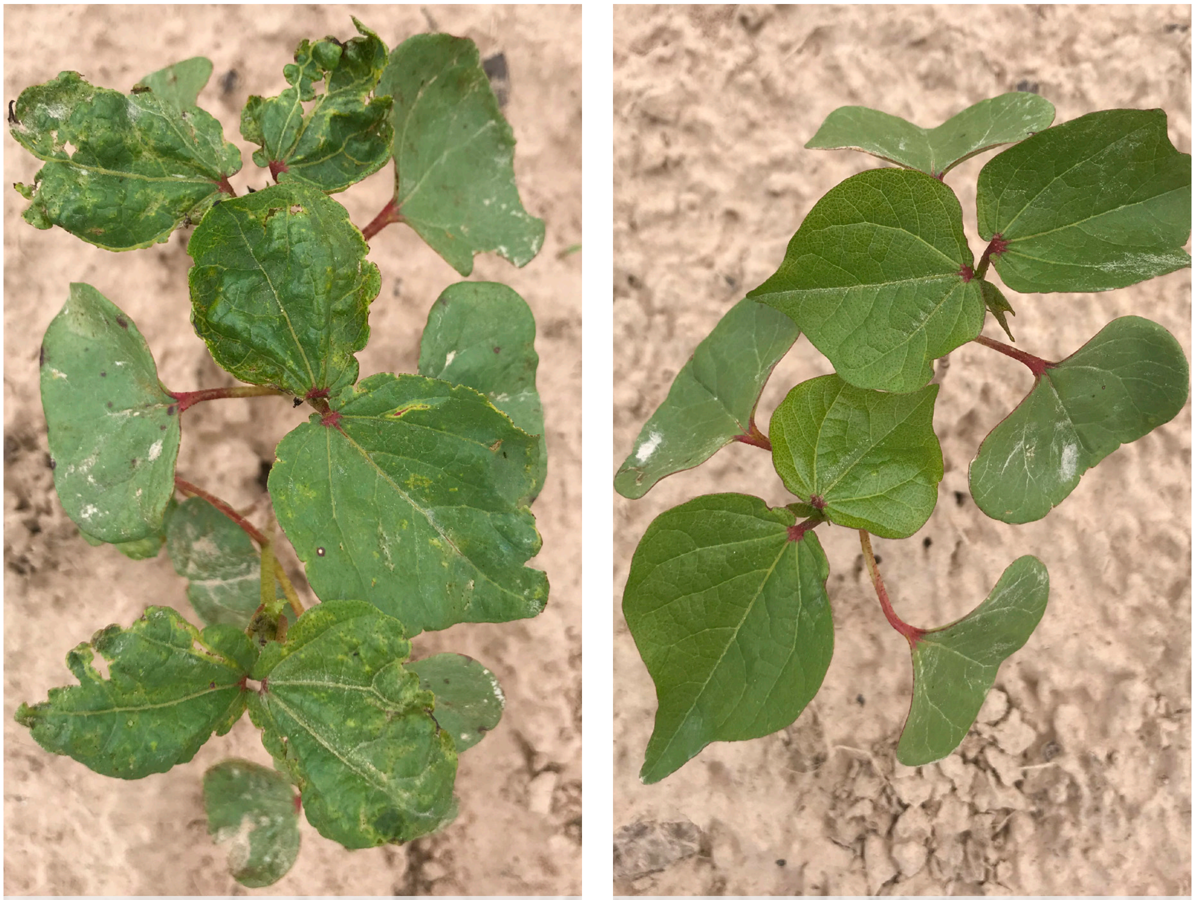

Non-Thryvon cotton plants (heavy thrips damage)

Thryvon cotton plants (no thrips damage)

Edited by Fred Bourland

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Cover Photo: (left) Non-Thryvon (heavy thrips damage) vs. (right) Thryvon (no thrips damage) cotton plants. These pictures relate to the article, Large Block Evaluation of Thryvon Cotton Against Tobacco Thrips and Tarnished Plant Bug, on pages 58-60. Thryvon is a new transgene that was developed to control tarnished plant bugs, but has been found to provide even better control of thrips.
Photograph by Ben Thrash, University of Arkansas System Division of Agriculture Cooperative Extension Service.

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

Arkansas Agricultural Experiment Station (AAES), University of Arkansas System Division of Agriculture, Fayetteville. Mark J. Cochran, Vice President for Agriculture. Jean-François Meullenet, AAES Director and Senior Associate Vice-President for Agriculture–Research. WWW/CC2021.

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Summaries of Arkansas Cotton Research 2020

Fred Bourland, Editor

University of Arkansas System
Division of Agriculture
Arkansas Agricultural Experiment Station
Fayetteville, Arkansas 72704

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Agronomy

Cotton Incorporated and the Arkansas State Support Committee

The *Summaries of Arkansas Cotton Research 2020* is 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 composed 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 is allocated to the State Support Committees of cotton-producing states. The sum given 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 is composed of cotton growers, while that of the Cotton Board is composed of both cotton importers and growers. The budgets of both organizations are reviewed annually by the U.S. Secretary of Agriculture.

Cotton production research in Arkansas is supported partly by Cotton Incorporated directly from its national research budget and 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 are supported wholly or partly by these means.

Table 1. Arkansas Cotton State Support Committee Cotton Incorporated Funding 2020.

Researcher	Short Title	2019	2020
Robertson	Cotton Research Verification/Applied Research	$50,000	$50,000
Bourland	Breeding	$26,000	$26,000
Robertson	Soil Health - No Till	$20,000	$0
Faske	BMP for Root-Knot Nematodes and Target Spot	$0	$13,598
Adviento-Borbe	Tillage Practices and Water Quality	$5,000	$0
Robertson	Target Leaf Spot Integrated Pest Management	$15,000	$0
Robertson	Cereal Rye Termination Timing	$27,000	$0
Lorenz	2 and 3 gene *Bt* and Non-*Bt* for Arkansas	$0	$20,000
Barber	Integrated Pest Management for Weeds	$20,000	$31,351
Total		**$154,000**	**$140,949**

Acknowledgments

The organizing committee would like to express appreciation to Christina Jamieson for help in formatting this research series for publication.

Disclaimer

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture, an equal opportunity provider and employer.

Summaries of
Arkansas Cotton Research
— 2020 —

Review of the 2020 Arkansas Cotton Crop

Overview

In the five years before 2020, cotton acreage in Arkansas had steadily increased from an all-time low of 210,000 acres in 2015 to 610,000 planted acres in 2019. One reason for the increase can be attributed to a downturn in prices received by producers for commodities such as corn and soybean, which compete for acres with cotton. With the worldwide COVID-19 pandemic, cotton mill use dropped significantly during the first half of 2020 https://www.cottongrower.com/market-analysis/ncc-cotton-demand-returning-as-u-s-and-world-economies-rebound/. This disruption of the cotton supply chain was felt across the entire cotton industry. The resulting downturn of cotton prices prior to planting impacted producers planting decisions.

Arkansas producers planted 525,000 acres, down from the intentions of 590,000 released in March by USDA-NASS https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Prospective_Plantings/2020/arplant20.pdf. Producers harvested 520,000 acres in 2020, down 15 percent from 2019. The yield averaged 1,200 pounds per harvested acre, a new Arkansas yield record and up 15 pounds from last year. Production was approximately 1.30 million bales https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Annual_Summary/2020/arannsum20.pdf. The 2020 crop brings our five-year average to 1,154 lb lint/ac. Arkansas currently ranks third in cotton production behind Texas and Georgia https://downloads.usda.library.cornell.edu/usda-esmis/files/k3569432s/w3764081j/5712n018r/cropan21.pdf.

Planting

Virtually 100% of cotton varieties planted in 2020 contained traits for enhanced insect and weed control. Reports released by Agricultural Marketing Service (https://www.ams.usda.gov/mnreports/cnavar.pdf) estimated 85% of the cotton varieties planted in 2020 contained XtendFlex® herbicide-tolerant traits (XF). Plantings of varieties containing the Enlist™ weed control system traits (FE) were estimated at 10% in 2020. The remaining 5% of the cotton acres were planted to cotton with traits for herbicide tolerance to only glyphosate and glufosinate.

Varieties containing two-gene *Bt* traits accounted for 75% of the acres statewide. The remaining 25% of the acres were planted to three-gene *Bt* traited varieties (B3-10%, TP-5%, and W3 10%). The three most widely planted varieties DP 1646 B2XF, DP 1518 B2XF, and DP 1725 B2XF, accounted for 49%, 12%, and 10% of planted acres, respectively.

The early planting window, which we generally have in April, never materialized. Subsequently, we only planted about 10% of our crop in April compared to our five-year average of just over 20% for this timeframe (https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Progress_&_Condition/2020/index.php). Conditions did not become favorable for cotton planting until the last few days of April. Planting progressed slowly and trailed behind the five-year average to the very end of planting due to numerous rainfall events. We were only 47% planted mid-May at the end of our optimum planting window compared to the five-year average of 71% for the same period. It was surprising that we exceeded 500,000 planted acres. While not planned, some producers' planting windows extended into June.

Fruiting and Harvest

The condition of most of the crop was good to excellent all season long. Reports by the United States Department of Agriculture National Agricultural Statistics Service (https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Progress_&_Condition/2020/index.php) indicate the percentage of the acres statewide receiving a rating of excellent never dropped to less than 27% once the crop started flowering. The percent of the crop rated good and excellent was greater than 80% essentially the entire season. The absence of extremely high temperature and the occurrence of relatively high rainfall provided excellent growing conditions throughout the season.

Progress of squaring was similar to last year and was slightly behind the five-year average, as was our planting progress. As expected, squaring started slowly, but by the time half of our crop was squaring, we were only slightly behind the five-year average. Flowering followed the same trend. However, flowering was on track with our five-year average by two to three weeks into the flowering period. This rapid progress of the 2020 crop reflects the favorable season with timely rainfall. Consequently, nodes above white flower (NAWF) was near our goal of 9 to 10 NAWF at first flower.

The 2020 Atlantic Hurricane Season was the top season for most landfalling tropical systems in the United States. Louisiana was one of the hardest-hit states during this season. Along with Delta, four other tropical systems hit the coast:

Tropical Storm Cristobal, Hurricane Laura, Tropical Storm Marco and Hurricane Delta (https://www.kark.com/weather/weather-headlines/2020-atlantic-hurricane-season-breaks-record-for-most-landfalling-tropical-systems-in-u-s-history/). These systems directly impacted the development of our top crop with cloudy conditions and loss of lint as the crop matured. It was felt by some that our statewide yield average would have exceeded 1300 lb lint/ac had we missed the hurricanes.

Harvest progress trailed behind that of last year and the five-year average during the entire harvest window. Rainfall during harvest impacted this trend. Approximately 25% of the crop was not harvested as we reached our target harvest completion date of 1 November. Harvest for some fields was not completed until mid- to late-November.

Inputs

In our 2020 Cotton Research Verification Sustainability Program (CRVSP), the average operating cost for cotton was $537.46/acre. Protection chemicals averaged $183.27 per acre and were 34% of operating expenses. Seed and associated technology fees averaged $117.34 per acre, or 22% of operating expenses, and included 5 fields with a cover crop. Fertilizer and nutrient costs averaged 15% of operating expenses and were $82.36 per acre. Tarnished plant bug (TPB) numbers were slightly lower in the 2020 CRVSP fields, which were treated an average of 3.33 times compared to 3.57 times in 2019. Each field had an average of 1.58 burndowns and 1.83 herbicide applications for the 2020 season. The average number of treatments for moth/worms was 0.83. The average costs for herbicides and insecticides were $71.97 and $63.23, respectively. Pest control represents a big expense and can impact yields greatly.

Costs do not include land costs, management, or other expenses and fees not associated with production. Price received for cotton of $0.62/lb is the estimated Arkansas annual average for the 2020 production year. The average cotton yield for these verification fields was 1,302 lb lint/ac, 102 lb lint/ac greater than the state average. The average operating costs were $0.42/lb lint, while total expenses averaged $0.53/lb lint.

Yield and Quality

The NASS Annual Summary report projected that Arkansas producers would harvest 1200 lb lint/ac. Their estimate remained unchanged through much of the harvest season despite repeated hurricanes and weather events (https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Annual_Summary/2020/arannsum20.pdf). Fiber quality was outstanding. In 2020, 95% of bales classed for Arkansas was tenderable, exceeding all other cotton-producing states for quality (https://www.ams.usda.gov/mnreports/cnwwqs.pdf). Even with rain delays, color grades were good, with 22.5% of bales receiving color grades of 31 or better, and 75.3% of bales classed received a color grade of 41 or better. Micronaire averaged 4.4, with 97.7% of Arkansas cotton classed having micronaire in our target value range of 3.5 to 4.9. Staple averaged 38.45, with 74.2% of the bales classed having a staple 38 or greater. Leaf was not a big issue in 2020, with 87.4% of the bales classed receiving a leaf of 4 or less compared to 82.4% in 2019. Leaf values for the 2020 crop averaged 3.72 for the season.

Summary

Arkansas ended the 2020 season ranked 4th nationally in harvested acres (520,000 acres), 4th in lint yield on an acre basis (1200 lb/ac), and 3rd in total production (1,300,000 bales). The string of consecutive years with record-breaking or near-record yields is helping to sustain cotton acres. Harvest and ginning capacity are other limiting factors for acre expansion. Our current production continues to push our ginning capacity of 29 gins in 2020 and on-farm picker capacity to the limit. Cotton planting intentions for 2021 reflect a slight decrease of 7% compared to 2020 (https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Prospective_Plantings/2021/arplant21.pdf).

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

2020 Northeast Research and Extension Center: Overview of Cotton Research

A. Beach,[1] E. Brown,[1] and F.M. 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 multiple disciplines, including breeding, variety testing, control of insects, diseases, and weeds, soil fertility, irrigation, and agricultural engineering (Table 1). Innovative practices evaluated at Keiser have included narrow row culture, mechanical harvest (pickers, strippers, and the cotton combine), and the cotton caddy (forerunner to cotton module system). The Sharkey clay soil at Keiser is not a dominant cotton soil type in Arkansas, but it provides an environment with a soil type that contrasts our other cotton stations and one that has a very low incidence of Verticillium wilt. Since cotton normally does not require an application of mepiquat chloride on this soil type, plants develop unaltered heights at this station.

Table 1. List of 2020 cotton research at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser.

Project leader	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (transgenic test, 51 entries and conventional test, 10 entries)
Fred Bourland	Cotton Breeding	National Cotton Variety Test (8 entries), Regional High Quality Strain Test (18 entries) and Regional Breeders' Network Test (16 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests (6 tests evaluating a total of 120 entries)
Fred Bourland	Cotton Breeding	Cotton Industry Strain Test (evaluating 48 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)
Glenn Studebaker	Entomology	Tarnished Plant Bug (TPB) in Cotton: Verification of TPB Resistance in Cultivars and TPB Standardized Efficacy Study
Glenn Studebaker	Entomology	Bollworm in Cotton: Efficacy of Various *Bt* Cultivar Technologies and Standardized Efficacy Study with Foliar Insecticides
Glenn Studebaker	Entomology	Efficacy of Seed Treatments and In-Furrow Insecticides on Control of Thrips
Glenn Studebaker	Entomology	Cotton Aphid Standardized Efficacy Study
Glenn Studebaker	Entomology	Spider Mite Standardized Efficacy Study

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

2020 Conditions and Observations

Similar to conditions in both 2018 and 2019, rainfall in April delayed land preparation at Keiser (Fig. 1). Planting of cotton plots was completed in late May. Adequate moisture and good soil temperatures resulted in good stands in most plots. Except for late July and early August, frequent rains caused fields to be relatively wet throughout the season. Total seasonal rainfall (May through October) was similar to normal (Table 2). Total Degree-Day 60 (DD60s) accumulated from May through October in 2020 were equal to the historical average (Table 2). The DD60 accumulations were similar to historical averages for each month from May through October. Despite the high heat unit accumulations for the season, temperatures never exceeded 100 °F and exceeded 95 °F on only two days. Both insect and disease incidences were low at Keiser in 2020. Defoliants were applied on time using ground application. Harvest was completed prior to a major rainfall event on 28 October.

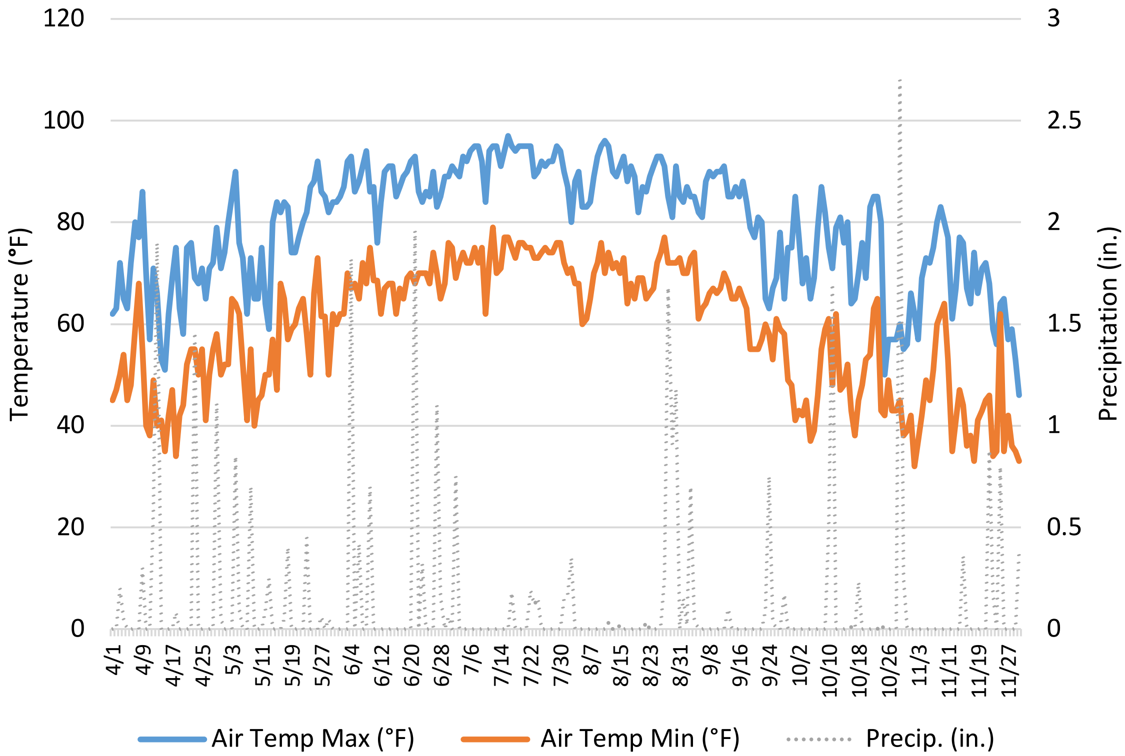

Fig. 1. 2020 temperature and precipitation at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser.

Table 2. Weather conditions at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2020	61	263	539	718	592	351	100	2623
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2612
2020 rainfall (in.)	5.7	3.0	6.5	1.5	4.6	2.1	5.4	28.9
Hist. avg. rainfall (in.)[b]	4.8	5.4	4.0	4.0	2.4	3.2	4.0	27.4

[a] 30-year average of data collected in Mississippi County 1986–2015; DD60 = Degree-Day 60.

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

Acknowledgments

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

2020 Manila Airport Cotton Research Station: Overview of Cotton Research

F.M. Bourland,[1] A. Beach,[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 (see Table 1 for list of 2020 research at Manila).

Table 1. List of 2020 cotton research at Manila Airport.

Project Leader	Discipline	Title
Tina Gray Teague	Multi-disciplinary	Seeding Rate, Cover Crop, and Cover Crop Termination Timing Effects on Maturity and Yield of Mid-South Cotton
Fred Bourland	Cotton Breeding	Arkansas Transgenic Cotton Variety Test (51 entries)
Bill Robertson	Agronomy	Impact of Cover Crop Termination on Soil Health and Lint Yield of Cotton
Bill Robertson	Agronomy	Integrated Management of Target Leaf Spot in Cotton
Bill Robertson	Agronomy	Evaluation of Cotton in Large-Plot On-Farm Variety Testing

2020 Conditions and Observations

Wet conditions delayed the planting of plots at Manila until 25 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. Soil moisture sensors were installed at depths of 6, 12, 18, and 30 inches and were monitored to evaluate irrigation efficiency. Irrigation events, however, were initiated based on the cooperating producer's standard production practices.

Insect pressure was generally light in 2020. Incidences of bacterial blight and target spot diseases were very light. Harvest was completed by early November. Despite the late planting date, the average lint yield obtained in the 2020 Arkansas Cotton Variety Test at the Manila Airport was the second-highest achieved since we began conducting the test at this location in 2014 and was the highest of all 2020 locations.

[1] Professor and Program Technician, respectively, 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.

Weather Data

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

Acknowledgments

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

2020 Judd Hill Cooperative Research Station: Overview of Cotton Research

E. Brown,[1] A. Beach,[1] and F.M. Bourland[1]

Background

The University of Arkansas System Division of Agriculture (UADA) 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 (Table 1). In addition, the Judd Hill Foundation generously permits scientists from Arkansas State University and UADA to conduct research on other property belonging to the Foundation. 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 2020 cotton research at the 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 51 entries and conventional test with 10 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests (6 tests evaluating a total of 120 entries)
Fred Bourland	Cotton Breeding	Cotton Industry Strain Tests, (9 tests with a total of 440 plots)
Alejandro Rojas	Plant Pathology	2020 National Cottonseed Treatment (NCST) Test

2020 Conditions and Observations

Accumulative Degree-Day 60 (DD60s) and rainfall during the 2020 growing season at Judd Hill were similar to historical averages (Table 2). Due to excessive rainfall in April and May, some tests were not planted until June. With adequate moisture and good soil temperatures, most plots at Judd Hill achieved excellent stands. Daily high temperatures were relatively mild throughout the season, with no days exceeding 96 °F (Fig. 1). The plants grew well and established excellent boll loads. Insect pressure was light throughout the season. Verticillium wilt at Judd Hill in 2020 was moderate to high but occurred late in the season. Late-maturing cultivars did not achieve full maturity in June-planted tests. Accumulative Degree-Day 60 (DD60s) over the season were 10% higher than the historical average and were consistently higher each month. Total rainfall from April through October was similar to the historical average rainfall (Table 2). The excessive late-season rainfall in October hampered harvest. Harvest was completed in November.

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

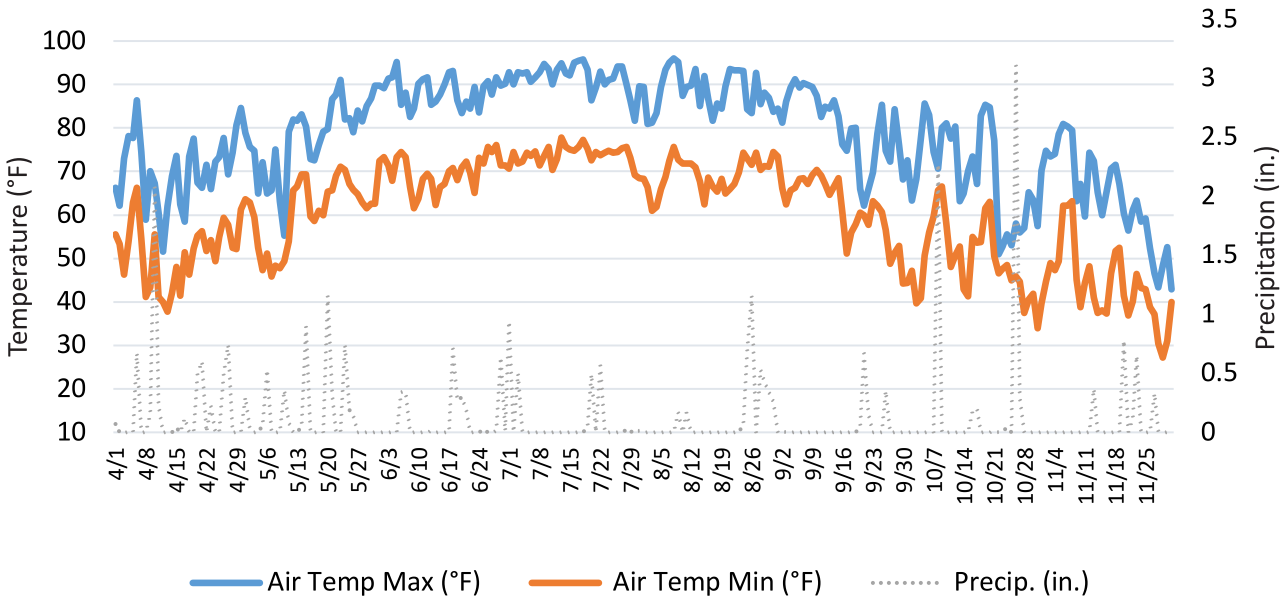

Fig. 1. 2020 Judd Hill temperature and precipitation.

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

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2020	89	307	579	706	587	336	108	2712
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2455
2020 rainfall (in.)	5.9	4.9	2.8	2.6	3.8	1.2	6.1	27.3
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 = Degree-Day 60.
[b] 30-year average of data collected at the Jonesboro Municipal Airport 1981–2010; http://www.ncdc.noaa.gov/cdo-web/datatools/normals

Acknowledgments

We are indebted to Mr. Mike Gibson and the Judd Hill Foundation for their generous support and assistance. Cooperative efforts provide by Mr. Marty White (producer) and Mike Duren (Resident Director Northeast Research and Extension Center) are greatly appreciated. Support was also provided by the University of Arkansas System Division of Agriculture.

2020 Lon Mann Cotton Research Station: Overview of Cotton Research

C. Kennedy[1] and F.M. Bourland[2]

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. 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).

Table 1. List of 2020 cotton research at University of Arkansas System Division of Agriculture's 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 Cover Crop Species and Termination Timing for Optimum Weed Control Benefit and Cotton Emergence
Tom Barber	Weed Science	Evaluating Multiple Integrated Weed Management Tactics for Optimum Control of Palmer Amaranth in Cotton
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (Transgenic, 51 entries and Conventional, 10 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests (6 tests evaluating a total of 120 entries)
Fred Bourland	Cotton Breeding	Cotton Breeding Trial of 190 Advanced F_6 Progenies
Fred Bourland	Cotton Breeding	Cotton Observation Plots of 960 F_5 Preliminary Progenies
Fred Bourland	Cotton Breeding	Miscellaneous: Cotton leaf roll dwarf virus (CLRDV) sentinel plots, 16 plots; UA48/GA230 Trait Study, 72 plots; Fiber Quality Gene Sequencing, 16 plots
Fred Bourland	Cotton Breeding	Cotton industry strain tests, total of 336 plots
Gus Lorenz	Entomology	Thrips Trials (4 trials, 29 treatments, 116 plots)
Gus Lorenz	Entomology	Thrips *Bt* Variety Trials (56 entries, 224 plots)
Gus Lorenz	Entomology	Plant bug trials (6 trials, 46 treatments, 184 plots)
Gus Lorenz	Entomology	Regulated trials (3 trials, 46 treatments, 224 plots)
Gus Lorenz	Entomology	Lepidoptera (2 trials, 19 treatments, 76 plots)
Jason Norsworthy	Weed Science	HPPD Cotton Tolerance to Herbicide
Jason Norsworthy	Weed Science	Long-Term Evaluation of Integrated Weed Management Strategies in Cotton
Jason Norsworthy	Weed Science	Residual Control of Weeds in Cotton with Isoxaflutole
Jason Norsworthy	Weed Science	Herbicides for Palmer Amaranth Management in Cotton
Jason Norsworthy	Weed Science	Importance of Cover Crop and Timely Use of Residual Herbicides for Palmer Amaranth Management in Cotton

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

2020 Conditions and Observations

Similar to 2019, LMCRS experienced frequent rains and relatively mild temperatures through most of the 2020 growing season (Fig. 1). High rainfall in April (Table 2) delayed land preparation and planting on the station, but most cotton plots were planted before mid-May. Emergence in early planted plots was slowed by low temperatures and much rainfall during early May. Adequate stands were obtained in most plots. In some fields (including the variety test), cereal rye was used as a cover crop. The cereal rye cover crop aided weed control, particularly pigweed. Weather conditions were generally good throughout the season. Heat units (DD60s) accumulated from April through October were 14% higher than normal, but were normal (within 10% of the historical averages) in June through September. Rainfall during the same period was 59% higher than the historical average, with the greatest deviations occurring in August and September. 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 early October.

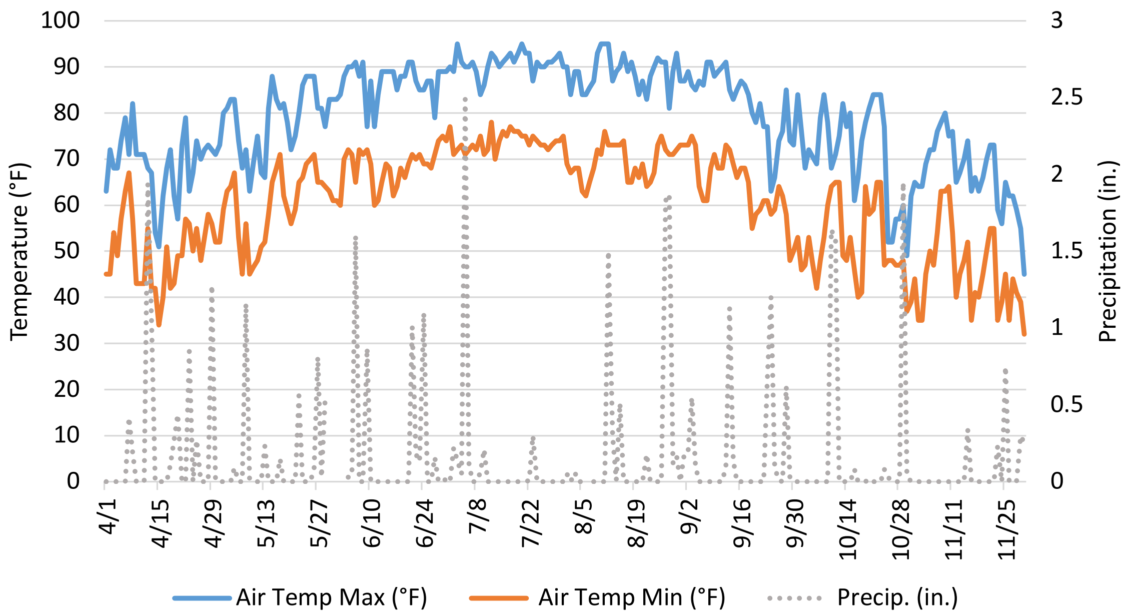

Fig. 1. 2020 temperature and precipitation at the University of Arkansas System Divison of Agriculture's Lon Mann Cotton Research Station, Marianna.

Table 2. Weather conditions at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2020	132	298	527	692	592	402	135	3081
Historical avg. DD60s[a]	65	339	548	650	594	398	98	2709
2020 rainfall (in.)	6.8	3.7	5.1	3.6	6.6	5.0	5.4	36.2
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 = Degree-Day 60.

[b] 30-year average of data collected at the Marianna Station 1981–2010; http://www.ncdc.noaa.gov/cdo-web/datatools/normals

Acknowledgments

The authors wish the staff at the LMCRS for their assistance in performing research at this station. Support was also provided by the University of Arkansas System Division of Agriculture.

2020 Rohwer Research Station: Overview of Cotton Research

L. Martin[1]

Background

Cotton research has always been a primary focus at the Rohwer Research Station, which began operations in 1958. The station includes 635 acres (about 534 acres 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. Cotton research projects conducted at Rohwer in 2020 are listed in Table 1.

Table 1. List of 2020 cotton research at the University of Arkansas System Divison of Agriculture's Rohwer Research Station.

Project Leader	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (Transgenic, 51 entries and Conventional, 10 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests (6 tests evaluating a total of 120 entries)
Fred Bourland	Cotton Breeding	Cotton breeding trial of 190 Advanced F_6 progenies
Fred Bourland	Cotton Breeding	Cotton observation plots of 960 F_5 preliminary progenies
Trent Roberts	Soil Fertility	Corteva Agriscience Cotton Research

2020 Conditions and Observations

Research trials at Rohwer were planted during the first week of May. Low temperatures and 0.77 in. rainfall occurred within a few days after planting (Fig. 1). Stands in a few plots were lost, and undesirable skips occurred in some other plots due to planting issues associated with thick cover crop debris. The lack of rainfall after planting hindered the effectiveness of weed control of early-season grass and broadleaf species. Post-emergent applications were effective in controlling grass and broadleaf species, including Palmer amaranth. Extensive hand weeding was essential to control escaped Palmer amaranth in some areas. Two irrigations were applied to maintain adequate moisture (2 inches allowable deficient), with the last irrigation occurring during the first week of August. Insect pests met threshold levels only once during the season and required the application of insecticides. Termination timings for plant bugs, worms, and irrigations were in August. Harvest was completed in multiple days due to mechanical issues and weather delays.

Except for low temperatures in May, June, and October, temperatures experienced in 2020, as indicated by monthly Degree-Day 60 (DD60s) accumulations, were very similar to historical averages (Table 2). The daily high temperature never exceeded 95 °F at Rohwer during the 2020 growing season. The absence of extremely high temperatures and the occurrence of relatively high rainfall provided excellent growing conditions through most of the season. The unusually cool temperatures during May, June, and October hindered plant development.

Acknowledgments

The authors would like to thank Larry Earnest, Director, and the staff of the Rohwer Research Station. Support was provided by the University of Arkansas System Division of Agriculture.

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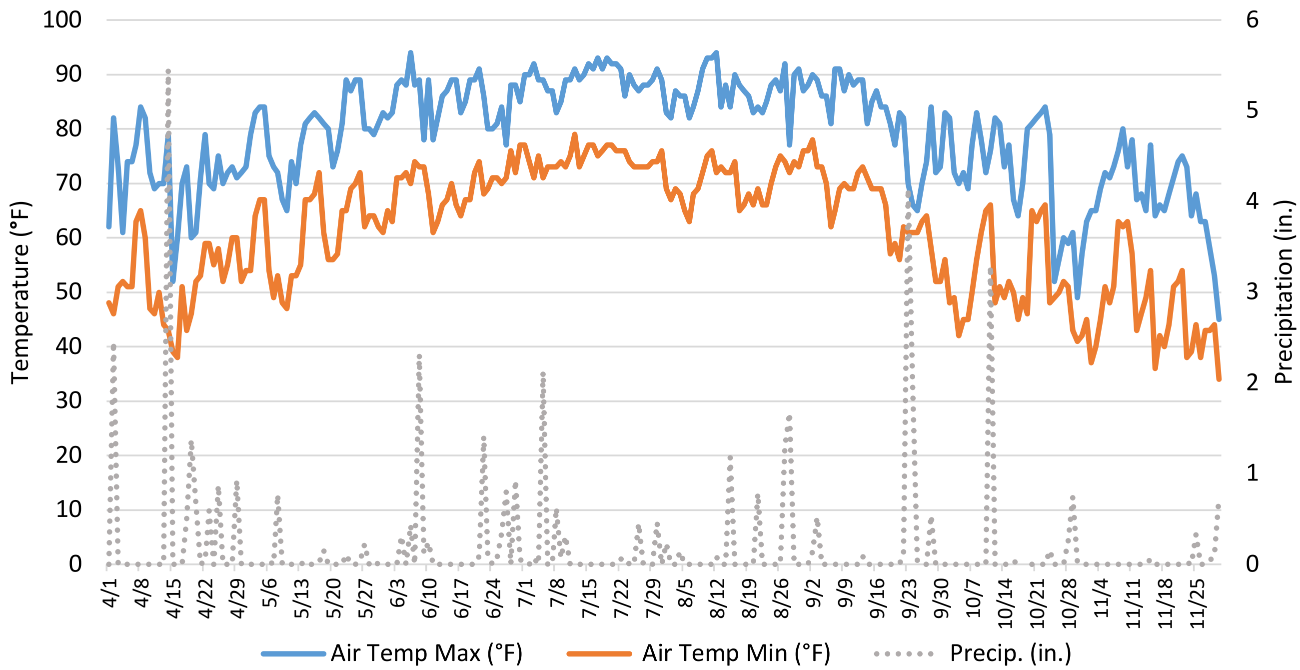

Fig. 1. 2020 temperature and precipitation at the University of Arkansas System Division of Agriculture's Rohwer Research Station.

Table 2. Weather conditions at the University of Arkansas System Division of Agriculture's Rohwer Research Station, Rohwer.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2020	91	311	524	682	618	416	135	2857
Historical avg. DD60s[a]	100	354	551	661	618	415	167	2866
2020 rainfall (in.)	12.5	1.4	7.2	4.2	5.4	7.5	4.5	43.0
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 = Degree-Day 60.

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

Cotton Research Verification Sustainability Program: 2020 Sustainability Report

A. Free,[1] B. Robertson,[1] M. Daniels,[2] and B. Watkins[3]

Abstract

Practices that lead to improved soil health often improve profitability and sustainability, having a positive impact on a field's environmental footprint. The objectives of this project were to 1) improve efficiency specifically regarding irrigation water use, 2) increase soil health, and 3) document differences in farmer standard tillage fields from that of a modified production system no-till cover through the utilization of the Fieldprint Calculator. The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability program conducted research in ten fields in 2020. Each field included different irrigation sets, which allowed for comparison of farmer standard practices (till no-cover) to that of a modified production system (no-till cover), with the exception of the USTP/BCI dryland fields and the St. Francis County pivot irrigated fields. All fields were monitored for inputs, entered in the Fieldprint Calculator, and used to calculate expenses. The yield on no-till cover increased an average of 1.59% and was $ 0.01/lb lint cheaper to produce than Farmer Standard tillage no-cover in 2020. Most of the metrics from the Fieldprint Calculator favored no-till cover with regards to improving sustainability. Soil conservation or erosion was reduced by 69.57%, and greenhouse gas emissions decreased by 3.95%. Several improvements were observed by using no-till and cover crops in this study, resulting in increased yield, decreased footprint size, and increased profitability.

Introduction

As the cost of production continues to increase, producers must be more efficient to be profitable. The key to remaining profitable is to strive for continuous improvement in all aspects of their operation. Cotton producers utilize many different production practices to improve efficiency and profitability. Producers are often hesitant to adopt new no-till with cover technology not only due to the associated costs but also concerns about irrigation efficiency. The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980 with the objective of demonstrating the profitability of University production recommendations. All field inputs are now entered into the Fieldprint Calculator. The Fieldprint Calculator, https://calculator.fieldtomarket.org/#/, is a tool developed by Field to Market: The Alliance for Sustainable Agriculture. The Fieldprint Calculator was designed in an effort to help educate producers on how adjustments in management could affect environmental factors. Utilization of the calculator assists producers by making estimates over eight sustainability factors: land use, soil conservation, soil carbon, irrigation water use, water quality, energy use, biodiversity, and greenhouse gas emissions. Fieldprint Calculator estimates fields' performance and compares results to national and state averages. Calculated summaries give producers insight into the ability areas for improved management on their farm.

Procedures

The Cotton Research Verification Sustainability Program (CRVSP) conducted research in 10 fields in four locations (Clay County (2), Desha County (4), St. Francis County (2), and Agricenter field (2)) in 2020. In Desha County, the CRVSP conducted research in conjunction with Discovery Farms in Southeast Arkansas: https://aaes.uada.edu/centers-and-programs/discovery-farm-program/. The Discovery Farm's focus is on edge-of-field water quality, where they trace irrigation efficiency and nutrient and sediment losses. All fields in Desha County included two irrigation sets, farmer standard practice, and a modified irrigation system. Comparisons were made on how each irrigation set impacted edge-of-field water quality and ultimately the profitability and sustainability of each system. Fields located in Clay County, Agricenter, and St. Francis county were not monitored for edge-of-field water quality. However, fields were established for observation of farmer standard practices compared to that of a modified production system using a no-till cover crop.

In fall 2019, all no-till cover fields were broadcast seeded with 'Elbon' cereal rye at a target seeding rate of 56 lb/ac with

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the exception of the USTP/BCI field. The USTP/BCI no-till cover field is the only one within the study that had a cover crop blend that consisted of 25 lb/ac cereal rye, 25 lb/ac black oats, and 2 lb/ac hairy vetch. Fields in this project averaged approximately 40 ac, with each system comprising half of the field. Throughout the study, all producers' inputs were recorded, providing the information needed to calculate both fixed and variable costs. Field data were collected by soil moisture sensors, rain gauges, flow meters, and trapezoidal flumes. A set of four soil Watermark soil moisture sensors were also placed in both no-till with cover and farmer standard tillage at 6, 12, 18, and 30 inches. The trapezoidal flumes at the Discovery Farm fields allowed us to determine the exact efficiency of each rainfall or irrigation event. Flow meter readings documented how much water was applied across furrow irrigated fields.

Results and Discussion

Concern that water would not flow well down the row in no-till with cover crop fields was alleviated after the first irrigation. After large rainfall events, we observed that water infiltrated quickly in no-till cover crop system, which decreased runoff when compared to a stale seedbed re-hipped. The producer in Clay County fields elected to run tillage equipment to flatten the top of rows for planting, all other no-till cover fields had no tillage operations compared to multiple tillage operations on most farmer standard tillage fields. The fields had an increased yield primarily as a result of increased soil health, with no-till cover producing 1299 lb lint/ac when compared to farmer standard tillage producing 1279 lb lint/ac. (Table 1) Improvements were also observed with regard to sustainability measures with an established no-till cover crop production system when compared to farmer standard tillage practice. The environmental footprint calculated by the Fieldprint Calculator showed a smaller or more sustainable footprint in no-till with cover.

Practical Applications

In this one-year study to improve soil health, no-till with cover crop practices resulted in a 1.59% increase in lint yield. This year unfortunately, irrigation water use did not decrease as anticipated; at one location, no-till cover got irrigated one additional time compared to that of till no-cover as it started raining. Other fields were irrigated the same number of times, but fields in Southeast Arkansas had slightly more water applied to no-till cover fields. Soil conservation or soil erosion was decreased almost 70% using no-till with cover. Additional research is needed to further evaluate how lint yield and profitability are influenced by seasonal rainfall interactions and irrigation efficiency, which appears to be yield-limiting in the mid-South in wet years. The adoption of practices to improve soil health will likely be limited until producers become more comfortable reducing expenses. A slight yield increase coupled with reducing expenses will have a more consistent positive impact on profitability.

Table 1. Harvested Lint yield, operating expenses, and metrics used to evaluate sustainability as affected by tillage and cover crops in ten fields averaged across 2020.

Parameters	No-till Cover	Till No-Cover	% Change No-till vs. Till
Yield (lb lint harvest/ac)	1299.24	1278.53	1.59%
Operating Expenses ($/ac)	499.00	500.50	-0.30%
Operating Expenses ($/lb lint harvested)	0.388	0.398	-2.58%
Land Use (ac/lb lint)	0.00079	0.00081	-2.59%
Soil Conservation (Ton/acre/yr.)	2.3	3.9	-69.57%
Irrigation Water Use (ac-in./lb)	0.018	0.013	28.26%
Energy Use (BTU/lb)	4731	5006	-5.82%
Greenhouse Gas Emissions (lb CO_2e/lb)	1.52	1.58	-3.95%

Cotton Research Verification Sustainability Program: 2020 Economic Report

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

Abstract

The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability Program (CRVSP) works with producers to grow cotton more efficiently with the objective of improving profitability. The average return to total specified costs in 2020 was $122.17/ac. The verification field low was -$53.08/ac in the Desha South field, and the high was $288.44/ac in the Clay farmer standard/no cover (FS/NC) field. Total operating expenses averaged $0.42/lb lint, and total expenses averaged $0.53/lb lint. For cotton to continue being a viable commodity, profitability must be improved.

Introduction

The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980. This is an interdisciplinary effort in which best recommendation 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 331 irrigated fields entered into the program. The success of the cotton program spawned verification programs in rice, soybean, wheat, and corn in Arkansas and similar programs in other mid-South states. In 2014, the CRVP became known as the Cotton Research Verification Sustainability Program (CRVSP). The CRVSP expands beyond that of the traditional verification programs by measuring the producers' environmental footprint for each field and evaluating the connection between profitability and sustainability.

Procedures

The 2020 CRVSP was composed of 12 fields in four locations, Desha county (6), Clay county (2), St. Francis county (2), and the Agricenter (2). Each field was entered into the Field to Market Fieldprint Calculator (www.fieldtomarket.org). Two fields in Desha county, Shop and Weaver, entered the sixth year, Clay county, Desha county, and St. Francis county each had one field that entered the second year, and the Agricenter field entered the first year of a modified no-till with cover crop production system (Table 1). Increasing both efficiency and profitability will continue to be a main part of the program.

The CRVSP has worked along with the University of Arkansas System Division of Agriculture's Discovery Farms Program in Southeast Arkansas in 4 of the 12 fields for the last 6 years. Discovery Farms' focus is to monitor edge-of-field water quality. Fields were watered in two sets on Discovery Farm Fields. The split-field arrangement provides the opportunity to compare two production strategies. The farmer standard tillage was compared to a no-till system with cereal rye cover crop. The fields at St. Francis and Clay counties were not watered in two sets to allow for that unique comparison, and the Agricenter fields were dryland. In the fall of 2019, all no-till cover fields were broadcast seeded with 'Elbon' cereal rye at a target seeding rate of 56 lb/ac with the exception of the U.S. Cotton Trust Protocol/Better Cotton Initiative (USTP/BCI) field. The USTP/BCI no-till cover field is the only one within the study that had a cover crop blend which consisted of 25 lb/ac cereal rye, 25 lb/ac black oats, and 2 lb/ac hairy vetch. Irrigated fields were either furrow or pivot irrigated. The diversity of the fields in the program reflects cotton production in Arkansas. Field records were maintained, and economic analysis was conducted at the end of the season to determine net return/ac for each field in the program.

Results and Discussion

The majority of cotton in Arkansas was planted in May. Tarnished plant bug (TPB) numbers slightly decreased this year in the CRVSP fields, which were treated an average of 3.33 times compared to 3.57 times in 2019. TPB pressure was similar across all fields, which were sprayed 3 to 5 times during the growing season (except the BCI Trust Protocol field, which received no plant bug treatments). Each field had an average of 1.58 burndowns and 1.83 herbicide applications for the 2020 season. The average number of treatments for moth/worms was 0.83. The average costs for herbicides and insecticides were $71.97 and $63.23, respectively. Pest con-

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trol 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/lb lint indicate the commodity price needed to meet each cost type. Costs in this report do not include land costs, management, or other expenses and fees not associated with production. Budget summaries for cotton are presented in Table 1. The price received for cotton of $0.62/lb is the estimated Arkansas annual average for the 2020 production year. The average cotton yield for these verification fields was 1302 lb/ac lint, 102 lb/ac lint greater than the state average.

The average operating cost for cotton in these fields was $537.46/ac (Table 2). Chemical costs averaged $183.27/ac and were 34% of operating expenses. Seed and associated technology fees averaged $117.34/ac, or 22% of operating expenses, and included five fields with a cover crop. Fertilizer and nutrient costs averaged 15% of operating expenses and were $82.36/ac.

The average yield in the verification fields was 1302 lb/ac lint, which was a 102 lb/ac lint increase when compared to both the 2020 enterprise budget and the statewide average yield. Average operating costs were $0.42/lb lint compared to the yearly enterprise budget operating costs of $0.53 lb/lint. Operating costs ranged from a low of $376.23 in the USTP/BCI farmer standard/no cover (FS/NC) field to a high of $726.30 in the Desha North field. Returns to operating averaged $269.87/ac across verification fields which was an increase of $161.71/ac over the enterprise budget. The range was from a low of $113.10/ac in the Desha South field to a high of $450.75/ac in the Clay FS/NC field. Average fixed costs were $147.70/ac which led to average total costs of $685.17/ac. The average return to total specified costs was $122.17/ac, compared to -$68.77/ac on the enterprise budget. The verification field low was -$53.08 in the Desha South field, and the high was $288.44 in the Clay FS/NC field. Total operating expense averaged $0.42/lb lint, compared to $0.53/lb lint in the enterprise budget. Total expenses averaged $0.53/lb lint, compared to $0.68/lb lint in the enterprise budget. While the enterprise budget slightly over-estimated expenses and slightly under-estimated revenue, it still serves as a valuable planning tool for producers. For cotton to continue being a viable commodity, profitability must be improved.

Practical Applications

The CRVSP 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

The authors would like to acknowledge Cotton Incorporated for its support of this project. The authors would like to thank producers and County Extension agents for their interest and support of this study. Support was also provided by the University of Arkansas System Division of Agriculture.

Table 1. Field location, field name, years in program, tillage type with or without cover crop, and irrigation method for 2020 verification fields.

Location	Field name	Years in Program	No-till Cover Crop	Farmer Standard till with No Cover	Irrigation Method
Clay	Clay NTC	2	x		Furrow
Clay	Clay FSNC	2		x	Furrow
Desha	Weaver NTC	6	x		Furrow
Desha	Weaver FSNC	6		x	Furrow
Desha	Shop NTC	6	x		Furrow
Desha	Shop FSNC	6		x	Furrow
St. Francis	St. Francis NTC	2	x		Pivot
St. Francis	St. Francis FSNC	2		x	Pivot
Agricenter	USTP/BCI NTC	1	x		Dryland
Agricenter	USTP/BCI FSNC	1		x	Dryland
Desha	Desha North	2		x	Furrow
Desha	Desha South	2		x	Furrow

Table 2. Summary of revenue and expenses per acre for 12 fields in the 2020 Cotton Research Verification Sustainability Program compared to the online 2020 enterprise budget.

Revenue/Expenses	Field													
	Clay NT/C[a]	Clay FS/NC	Weaver NT/C	Weaver FS/NC	Shop NT/C	Shop FS/NC	St. Francis NT/C	St. Francis FS/NC	USTP/ BCI NT/C	USTP/ BCI FS/NC	Desha North	Desha South	12 Field Verific. Average	2020 Enterp. Budget
Revenue														
Yield (lb)	1542	1547	1288	1328	1266	1441	1438	1172	962	905	1384	1353	1302.16	1200
Price ($/lb)	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
Tot. Crop Rev.	**956.04**	**959.14**	**798.56**	**823.36**	**784.92**	**893.42**	**891.70**	**726.42**	**596.44**	**561.10**	**858.08**	**838.86**	**807.34**	**744.00**
Cottonseed Value	**230.53**	**231.28**	**192.56**	**198.54**	**189.27**	**215.43**	**215.01**	**175.16**	**143.82**	**135.30**	**206.91**	**202.27**	**194.67**	**179.88**
Expenses														
Seed	138.96	118.80	114.96	94.80	114.96	94.80	133.35	113.19	155.40	132.00	98.40	98.40	117.34	114.00
Fertilizer & Nutrients	81.69	81.69	77.20	77.20	77.20	77.20	97.97	97.97	66.77	66.77	93.31	93.31	82.36	85.06
Herbicides	34.27	34.27	42.10	102.69	42.10	102.69	77.35	77.35	66.16	66.16	109.25	109.25	71.97	112.72
Insecticides	99.47	99.47	69.34	62.64	69.34	62.64	54.12	54.12	0.00	0.00	93.79	93.79	63.23	100.93
Other Chemicals	30.37	30.37	22.33	22.33	22.33	22.33	29.82	29.82	22.42	22.42	161.17	161.17	48.07	25.72
Custom Applications	0.00	0.00	48.00	56.00	48.00	56.00	54.00	46.50	0.00	0.00	31.00	31.00	30.88	16.00
Other Inputs	29.57	29.65	25.34	26.00	24.97	27.89	23.96	19.52	10.68	10.05	26.94	26.42	23.42	10.51
Diesel Fuel	17.03	17.17	15.94	16.35	15.94	16.35	13.37	13.37	15.30	15.44	16.87	16.87	15.83	46.08
Irrigation Energy Costs	24.54	24.54	16.83	15.50	17.07	16.83	9.00	7.50	0.00	0.00	17.72	17.72	13.94	35.43
Input Costs	**455.90**	**435.96**	**432.04**	**473.51**	**431.91**	**476.73**	**492.94**	**459.34**	**336.73**	**312.84**	**648.45**	**647.93**	**467.02**	**546.45**
Fee's	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41	21.41
Repairs & Maintenance[b]	29.01	28.94	26.50	26.16	26.52	26.27	27.21	26.78	25.70	25.63	28.71	28.71	27.18	31.39
Labor, Field Act.	8.62	8.49	8.12	8.08	8.12	8.10	5.44	5.37	6.41	6.28	8.29	8.29	7.47	20.23
Production Exp.	**514.94**	**494.80**	**488.07**	**529.16**	**487.96**	**532.51**	**547.00**	**512.90**	**390.25**	**366.16**	**706.86**	**706.34**	**523.08**	**619.48**
Interest	14.16	13.61	13.42	14.55	13.42	14.64	15.04	14.10	10.73	10.07	19.44	19.42	14.38	16.36
Post Harvest Exp.	230.53	231.28	192.56	198.54	189.27	215.43	215.01	175.17	143.82	135.30	206.91	202.27	194.67	179.88
Operating Exp.	**529.10**	**508.41**	**501.49**	**543.71**	**501.38**	**547.15**	**562.04**	**527.00**	**400.98**	**376.23**	**726.30**	**725.76**	**537.46**	**635.84**
Returns to Op. Exp.	**426.94**	**450.75**	**297.07**	**279.65**	**283.54**	**346.27**	**329.66**	**199.42**	**195.46**	**184.87**	**131.78**	**113.10**	**269.87**	**108.16**
Capital Recovery & Fixed Costs	161.11	162.31	135.47	134.07	135.57	134.62	154.28	150.90	135.27	136.47	166.18	166.18	147.70	176.93
Tot. Specified exp.[c]	**690.20**	**670.70**	**636.96**	**677.79**	**636.95**	**681.77**	**716.33**	**677.91**	**536.27**	**512.70**	**892.48**	**891.94**	**685.17**	**812.77**
Returns to Spec. Exp.	**265.84**	**288.44**	**161.60**	**145.57**	**147.97**	**211.65**	**175.37**	**48.51**	**60.17**	**48.40**	**-34.40**	**-53.08**	**122.17**	**-68.77**
Operating Exp./lb	0.34	0.33	0.39	0.41	0.40	0.38	0.39	0.45	0.42	0.42	0.52	0.54	0.42	0.53
Total Expenses/lb	0.45	0.43	0.49	0.51	0.50	0.47	0.50	0.58	0.56	0.57	0.64	0.66	0.53	0.68

[a] Abbreviations: NT = no till; C = cover; NC = no cover; USTP/BCI = U.S. Cotton Trust Protocol/Better Cotton Initiative; FS/NC = farmer standard no cover.

[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.

Improving Sustainability: Program to Demonstrate Implementation and Benefits of the U.S. Cotton Trust Protocol and Better Cotton Initiative Cotton Program

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Abstract

Cotton produced in the United States is highly prized by the global textile industry for its quality. While American cotton farmers use advanced production methods, they still face sustainability challenges. In response to the documented sustainability demand from retailers and suppliers, Better Cotton Initiative (BCI) launched a Better Cotton program in the United States in 2014. Recently, the U.S. Cotton Industry initiated the U.S. Cotton Trust Protocol (Trust Protocol), a program designed to drive continuous improvement and increase awareness of the benefits of implementing best practices. A field study was established to show standard production practices (conventional tillage without the use of cover crops) compared to a management strategy utilizing cover crops and greatly reduced tillage in an effort to improve soil health and sustainability and to enroll fields into both the Trust Protocol and BCI programs. Enrolling farms into either program is not a difficult task and should not be a deterrent for producers interested in participating in either of these programs. While no statistical yield differences in the first year were observed in this study, differences in sustainability metrics and improvements in soil health are clear.

Introduction

The United States is the third-largest cotton-producing country in the world, and its cotton quality is highly prized by the global textile industry. While U.S. cotton producers use advanced production methods, they still face sustainability challenges.

In response to demand from retailers, suppliers, and interested farmer groups, Better Cotton Initiative (BCI) launched a Better Cotton program in the United States in 2014. The BCI program operates a global standard system for sustainable cotton production. To help U.S. farms meet program requirements and set targeted goals for continuous improvement, BCI developed a resource planning template for its seven principles of sustainability. The template emphasizes multi-year objective setting for continuous improvement of production and management systems that farmers can use to evaluate their progress.

Recently, the U.S. Cotton Industry initiated the U.S. Cotton Trust Protocol (Trust Protocol), a program designed to confirm and increase awareness that most U.S. cotton producers are farming responsibly and striving for continuous improvement. The Trust Protocol was developed to help the U.S. cotton production sector reduce its environmental footprint via specific sustainability goals targeted for 2025: 1) a 13% increase in productivity (i.e., reduced land use per pound of fiber); 2) an 18% increase in irrigation efficiency; 3) a 39% reduction in greenhouse gas emissions; 4) a 15% reduction in energy expenditures; 5) a 50% reduction in soil loss; and 6) a 30% increase in soil carbon.

Both BCI and the Trust Protocol programs have similar goals in supporting U.S. farmers in addressing these and other sustainability challenges and improving their performance. This project will help provide data to support "substantial equivalency" between the two programs and would simplify the adoption of both programs for the supply chain. The major limitation currently is scaling up awareness and adoption of the sustainability initiatives. Increasing the working knowledge of sustainability efforts among Extension agents and consultants has a great potential to improve adoption.

Objectives are to 1) establish demonstration fields that show standard production practices (conventional tillage without the use of cover crops) compared to a management strategy utilizing cover crops and greatly reduced tillage in an effort to improve soil health and sustainability and to enroll fields into both Trust Protocol and BCI programs and 2) evaluate changes in operating expenses and profitability and compare to changes in environmental footprint as calculated using the Field to Market Fieldprint Platform.

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[4] Advisor to the Cotton Trust Protocol, Agricultural and Biological Engineering Services, Cordova, Tennessee.
[5] Vice President/Chief Sustainability Officer and Sustainability Manager, respectively, Cotton Incorporated, Carey, North Carolina.
[6] Director of Farm and Research, Agricenter International, Memphis, Tennessee.

Procedures

An on-farm study site of 30 acres was selected at the Agricenter International in Memphis, Tennessee. The Agricenter provides multiple opportunities to share educational opportunities for the various segments of the supply chain. The site in 2019 was a conventional-tilled, dryland Waverly Silt Loam field. In 2020, a three-year study was initiated by splitting the field in half, with one side planted into cover crops with no-tillage (improved soil health and sustainability field) and the other side using conventional tillage without the use of cover crops (standard practice field). The cover crop blend consisting of 25 lb/ac cereal rye, 25 lb/ac black-seeded oats, and 2 lb/ac hairy vetch was broadcasted on the soil surface immediately after harvest on 5 December 2019. All production practices were recorded to facilitate the creation of a budget. Soil health was evaluated using several measurements, including soil samples (standard fertility and Haney for soil health), bulk density, water infiltration rates, and Watermark Soil Moisture Sensors (6, 12, 18 and 30 in.). In-season pest management, nutrient management, and harvest preparation were identical for both fields. Field information and inputs were entered into the Field to Market Fieldprint Platform. The study was harvested with an onboard model cotton picker. Grab samples were collected and ginned to determine lint fraction and fiber quality through high volume instrument (HVI) analysis.

Results and Discussion

Program Enrollment

All commercial cotton fields (50 acres) at the Agricenter were enrolled into both the Trust Protocol and the BCI programs. It took approximately one hour to complete the self-assessment forms for each program. Documentation regarding: 1) soil health, water management, and biodiversity composed primarily of conservation plans and contracts with NRCS; 2) nutrient management plan based on routine soil sampling and following nutrient application recommendations; 3) crop protection primarily including approval of chemical storage, application records, scouting reports and pesticide recommendation; and 4) worker well-being as documented in the Agricenter employee handbook were reviewed and organized in preparation of a third-party verification.

The verifier was very knowledgeable of local farming practices, very organized, and clear in his requests. The verifier was satisfied that the documentation needed to fulfill transparency requirements to satisfy the needs of the supply chain were in place and that the Agricenter was in compliance with both programs. The on-site verification for both programs took less than two hours to complete.

Soil Health and Environmental Footprint

In the first year of cotton production following a cover crop, differences were observed. Watermark soil moisture sensors detected water infiltration occurring at all four depths on the improved soil health side, while only the two shallow sensors detected water infiltration on the standard practice side after individual rainfall events (Fig. 1). This difference is thought to be a direct result of improved soil health. Fieldprint platform output results showed improved sustainability with the improved soil health field compared to the standard practice field shown on a spidergram with smaller values indicating less resource use (Fig. 2).

No significant yield differences were observed. However, a trend was observed for higher yield on the improved soil health field compared to the standard practice field. A summary of yield improvements and individual sustainability metrics documenting the initial steps toward continuous improvement are included in Table 1.

Practical Applications

While no statistical yield differences in the first year were observed in this study, differences in sustainability metrics and improvements in soil health are clear. Enrolling farms into either program is not a difficult task and should not be a deterrent for producers interested in participating in either of these programs. This is important to document our practices as brands and retailers look to source sustainably produced fibers.

Acknowledgments

The authors would like to acknowledge Cotton Incorporated and BCI for their support of this project. The authors would also like to thank Agricenter International for their interest and support of this study. Support was also provided by the University of Arkansas System Division of Agriculture.

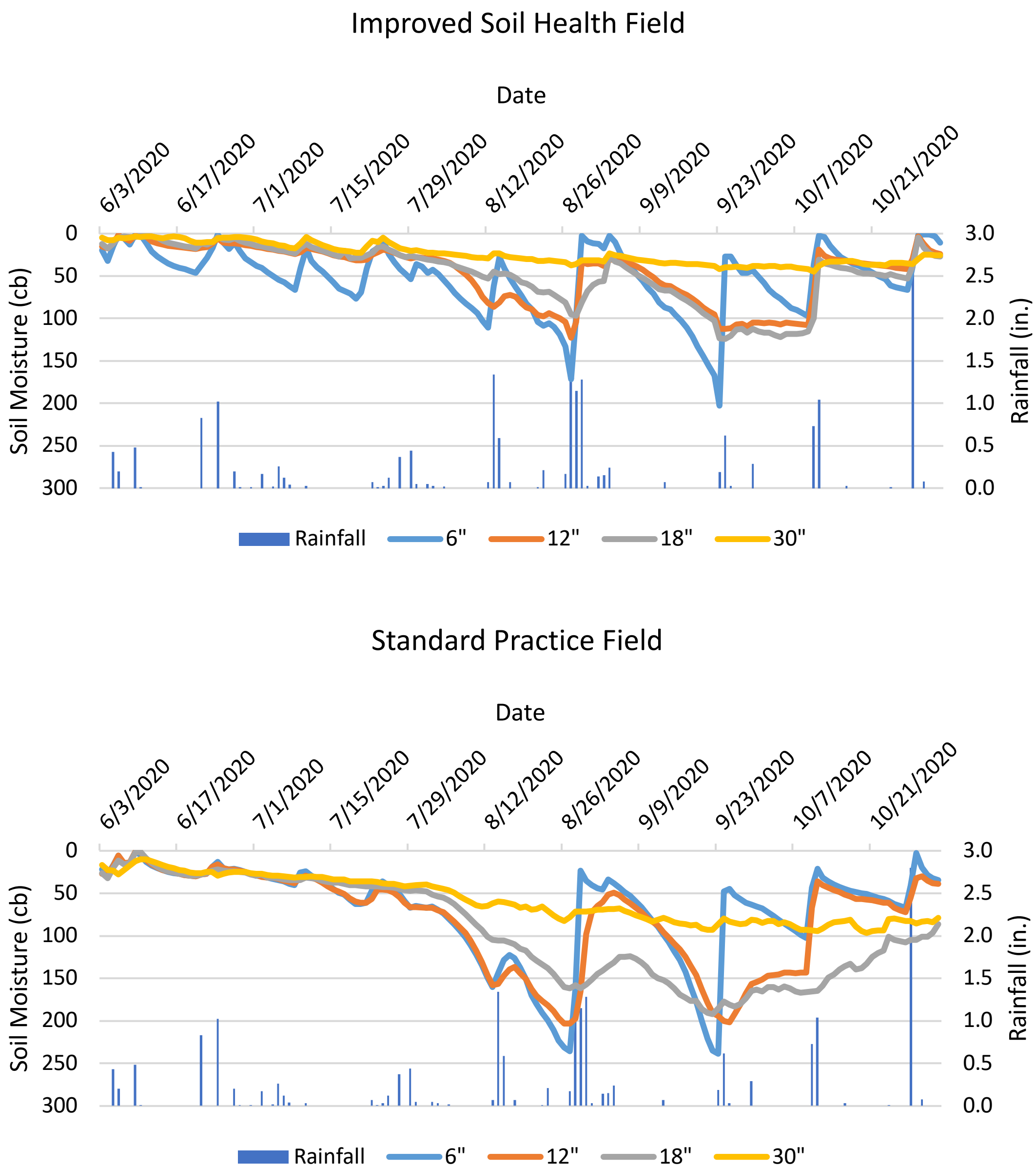
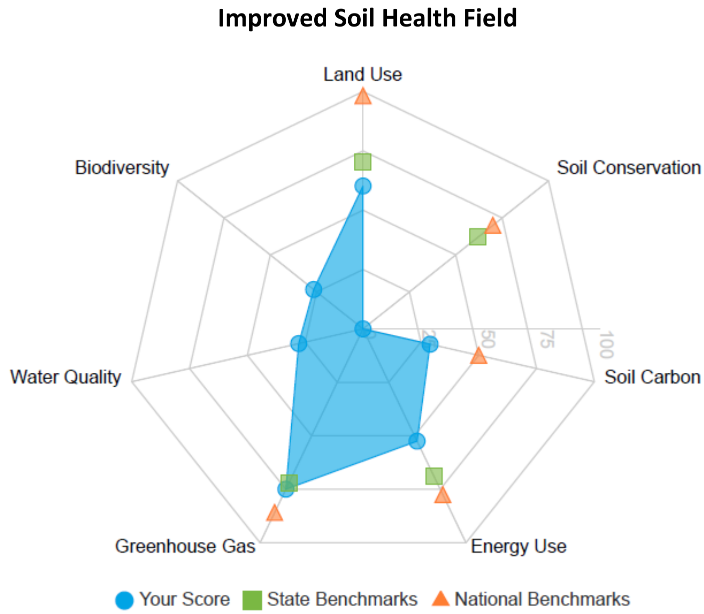


Fig. 1. Watermark soil moisture readings at 4 depths and rainfall events for both the improved soil health and standard practice fields. A soil moisture reading of 0 represents field capacity.



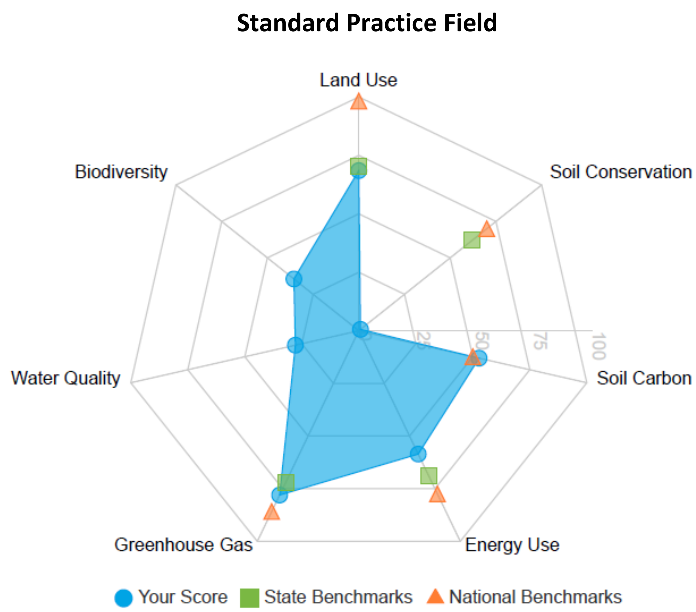


Fig. 2. Comparison of Field to Market Fieldprint Platform output from improved soil health field compared to standard practice field. Fieldprint results are shown on the spidergram as relative indices on a scale of 1–100 that represent metric scores. The indices are calculated so that smaller values and a smaller shaded area on the spidergram indicate less resource use or environmental impact from a field.

Table 1. Lint yield and metrics from the Fieldprint calculator used to evaluate sustainability as affected by practices to improve soil health in the 2020 Agricenter International fields.

Parameters	Improved Soil Health Field	Standard Practice Field	% Change Improved vs. Standard
Yield (lb lint/ac)	962	905	6.30%
Land Use (ac/lb lint)	0.0010	0.0011	- 9.09%
Soil Conservation (Ton/ac/year)	1.2	2.3	- 47.83%
Energy Use (BTU/lb lint)	4904	5232	- 6.27%
Greenhouse Gas Emissions (lb CO_2eq/lb. lint)	1.6	1.7	- 5.88%

Cotton Research Verification Sustainability Program: Five Year Review

A. Free,[1] B. Robertson,[1] M. Daniels,[2] and B. Watkins[3]

Abstract

Practices that lead to improved soil health often improve profitability and sustainability as well as have a positive impact on the field's environmental footprint. The objectives of this five-year project were to 1) improve efficiency specifically regarding irrigation water use, 2) increase soil health, and 3) document differences in farmer standard tillage fields to that of a modified production system no-till cover through the utilization of the Fieldprint Calculator. The University of Arkansas Cotton Research Verification Sustainability program conducted research in eight fields from 2015 to 2019. Each field included different irrigation sets, which allowed for comparison of farmer standard practices (till no-cover) to that of a modified production system (no-till cover). All fields were monitored for inputs, entered in the Fieldprint Calculator, and used to calculate expenses. The yield on no-till cover increased an average of 6.1% and was $0.02/lb lint cheaper to produce than Farmer Standard tillage no-cover in 2015 to 2019. The metrics from the Fieldprint Calculator all favored no-till cover with regards to improving sustainability. Soil conservation or erosion was reduced by 76.96%, and greenhouse gas emissions decreased by 9.22%. Several improvements were observed by using no-till and cover crops in this study, resulting in increased yield, decreased footprint size, and increased profitability.

Introduction

As the cost of production continues to increase, producers must be more efficient to be profitable. The key to remaining profitable is to strive for continuous improvement in all aspects of their operation. Cotton producers utilize many different production practices to improve efficiency and profitability. Producers are often hesitant to adopt new no-till with cover technology not only due to the associated costs but also concerns about irrigation efficiency. The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Program (CRVP) since 1980 with the objective of demonstrating the profitability of University production recommendations. All field inputs are now entered into the Fieldprint Calculator. The Fieldprint Calculator, https://calculator.fieldtomarket.org/#/, is a tool developed by Field to Market: The Alliance for Sustainable Agriculture. The Fieldprint Calculator was designed in an effort to help educate producers on how adjustments in management could affect environmental factors. Utilization of the calculator assists producers by making estimates over seven sustainability factors: land use, soil conservation, soil carbon, irrigation water use, water quality, and greenhouse gas emissions. Fieldprint Calculator estimates fields' performance and compares results to national and state averages. Calculated summaries give producers insight into the ability areas for improved management on their farm.

Procedures

The Cotton Research Verification Sustainability Program (CRVSP) conducted research in eight fields in three Arkansas counties (Desha, Mississippi, and St. Francis) in 2015 through 2019. In Desha County, the CRVSP conducted research in conjunction with Discovery Farms in Southeast Arkansas https://aaes.uada.edu/centers-and-programs/discovery-farm-program/. Discovery Farm's focus is on edge-of-field water quality, where they trace irrigation efficiency and nutrient and sediment losses. All fields in Desha County included two irrigation sets, farmer standard practice, and a modified irrigation system. Comparisons were made on how each irrigation set impacted edge-of-field water quality and ultimately profitability and sustainability of each system. Fields located in Mississippi and St. Francis counties were not monitored for edge-of-field water quality. However, fields were established for observation of farmer standard practices compared to those of a modified production system using a no-till cover crop.

Elbon cereal rye, broadcast at a rate of 56 lb/ac, was the cover crop used in all no-till cover fields. Fields in this proj-

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ect averaged approximately 40 ac, with each system comprised half of the field. Throughout the study, all producers' inputs were recorded, providing the information needed to calculate both fixed and variable costs. Field data were collected by soil moisture sensors, rain gauges, evapotranspiration (Et) gauges, flow meters, and trapezoidal flumes. A set of three soil Watermark soil moisture sensors were also placed in both no-till with cover and farmer standard tillage at 6, 12, and 18 inches. Evapotranspiration gauges were adjusted after each rainfall or irrigation event at fields and were used to trigger irrigations. The trapezoidal flumes at the Discovery Farm fields allowed us to determine the exact efficiency of each rainfall or irrigation event. Using the rainfall and irrigation efficiency data from those two fields allowed us to set the Et gauges accurately. In the other four fields, estimates of the efficiencies of each irrigation or rainfall event were made and Et gauges were set accordingly. Flow meter readings documented how much water was applied across furrow irrigated fields.

Results and Discussion

Soil compaction was consistently lower in no-till with cover, soil moisture was consistently higher in no-till with cover, and irrigation water flow rates down the row were slower in no-till with cover (Table 1). Concerns that water would not flow well down the row in no-till with cover crop fields were alleviated after the first irrigation. After large rainfall events, we observed that water infiltrated quickly in no-till cover crop system, which decreased runoff when compared to a stale seedbed re-hipped with a cover crop. Furrow irrigated no-till with cover crop fields on flat rows had one tillage operation using FurrowRunner compared to multiple tillage operations in farmer standard tillage. The FurrowRunner provided a narrow trench in the row middle, which assisted water movement through the field while leaving all cover crop residue on the sides of the furrow and top of the row. The fields had an increased yield primarily as a result of increased soil health, with no-till cover producing 1397 lb lint/ac when compared to farmer standard tillage producing 1312 lb lint/ac. Improvements were also observed with regard to sustainability measures with an established no-till cover crop production system when compared to farmer standard tillage practice. The environmental footprint calculated by Fieldprint Calculator, showed a smaller or more sustainable footprint in no-till with cover.

Practical Applications

In this five-year study (2015 to 2019) to improve soil health, no-till with cover crop practices resulted in a 6% increase in lint yield and increased water use efficiency, requiring 22.45% less water to produce a pound of cotton (Table 1). Increased water infiltration caused irrigation water to move more slowly through the no-till cover fields. Soil conservation or soil erosion was decreased almost 77% using no-till with cover. Additional research is needed to further evaluate how lint yield and profitability are influenced by seasonal rainfall interactions with improved water infiltration, which appears to be yield-limiting in the mid-South in wet years. The adoption of practices to improve soil health will likely be limited until producers become more comfortable reducing expenses. A slight yield increase coupled with reducing expenses will have a more consistent positive impact on profitability.

Table 1. Harvested Lint yield, operating expenses, and metrics used to evaluate sustainability as affected by tillage and cover crops in eight fields averaged across five years (2015–2019).

Parameters	No-till Cover	Till No-Cover	% Change No-till vs. Till
Yield (lb lint harvest/ac)	1397	1312	6.10%
Operating Expenses ($/ac)	570.06	550.81	3.38%
Operating Expenses ($/lb lint harvested)	0.421	0.444	-5.51%
Land Use (ac/lb lint eq.)[a]	0.00065	0.00071	-7.95%
Soil Conservation (Tons/lb lint eq. /yr.)[a]	0.00184	0.00326	-76.96%
Irrigation Water Use (ac-in./lb lint eq. above dryland lint yield)[a]	0.020	0.024	-22.45%
Energy Use (BTU/lb lint eq.)[a]	4816	5378	-11.65%
Greenhouse Gas Emissions (lb CO_2eq/lb lint eq.)[a]	1.28	1.40	-9.22%

[a] In order to account for the economic contribution of cotton seed to the value of lint with regard to sustainability, harvested lint yield/0.83 = lint yield equivalent.

Arkansas Cotton Variety Test 2020

F.M. Bourland,[1] A. Beach,[1] E. Brown,[1] C. Kennedy,[2] L. Martin,[3] and B. Robertson[4]

Abstract

Other than variation in transgenic technologies and seed treatment, the 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. In 2020, small plot tests included 51 transgenic and 10 conventional lines and were mostly conducted on experiment stations. Results from the small plot tests 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 the 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 Arkansas. 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. Our current testing system attempts to offset this rapid turnover by supplementing small plot variety testing at five locations (coordinated by Bourland) with subsequent evaluation in large plot extension plots at multiple sites (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

Cotton varieties and advanced breeding lines were evaluated in small plots at Arkansas research sites (Manila, Keiser, Judd Hill, Marianna, and Rohwer) in the 2020 Arkansas Cotton Variety Test (Bourland et al., 2020). Transgenic and conventional entries were evaluated in separate tests. The 51 entries in the transgenic test included 7 B2XF, 30 B3XF, 12 W3FE, and 2 GLTP lines, which were evaluated at all five locations. The conventional test included 10 entries that were evaluated at all locations except Manila. Reported data include lint yield, lint percentage, plant height, percent open bolls, yield component variables, fiber properties, leaf pubescence, stem pubescence, and bract trichome density. An apparent sampling error compromised data from boll samples at Manila. Consequently, average lint percentages from the other four locations were used to calculate lint yields at Manila. Fiber data and other parameters calculated using boll sample data were not reported. All entries in the experiments were evaluated for response to tarnished plant bug and bacterial blight in separate tests at Keiser.

Large Plot Tests

A core group of 12 transgenic varieties was evaluated at 9 locations from Ashley County to Clay County. Two additional locations contained 9 of the core 12 varieties. Two varieties chosen by the seed company were entered for this study: BASF, Bayer, Americot, Dow, and Nutrien. 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. The 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 studies were harvested with the producer's equipment. Grab samples were collected for lint fraction and fiber quality, with the exception of Clay county, which was ginned in a commercial gin.

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[3] Program Technician, University of Arkansas System Division of Agriculture, Rohwer Research Station, Rohwer.
[4] Professor/Cotton Extension Agronomist, University of Arkansas System Division of Agriculture's Newport Extension Center, Newport.

Results and Discussion

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

Small Plot Tests

Both heat units and rainfall in 2020 were close to historical averages at each Arkansas location. Temperatures exceeding 95 °F were very few—2 days (97 °F on 16 July and 96 °F on 1 August) at Keiser, and 0 days at Marianna and Rohwer. The absence of extremely high temperature and the occurrence of relatively high rainfall provided excellent growing conditions throughout the season. Rainfall in 2020 was near the historical average rainfall at Keiser but greatly exceeded historical averages at Marianna and Rohwer.

Variety by location interactions in the transgenic test were significant for all parameters except lint percentage, seed index, fibers per seed, quality score, fiber length, strength, and elongation. In the conventional test, interactions occurred for lint yield, lint percentage, open bolls, seed per acre, and fiber elongation. Despite the interactions, several of the top-yielding varieties were similar at each site. Parameters measured at only one location included leaf pubescence, bract trichome density, tarnished plant bug damage, and bacterial blight response. Significant variety effects for each of these parameters were found in both 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. Full-season COTMAN indicated no unexpected stress at any location. Nodes above white flower data were recorded for all varieties to calculate days to cutout. Lint yield was summarized across locations.

Practical Applications

Varieties that perform well across all locations of the Arkansas Cotton Variety Tests possess wide adaptation. Specific adaptation may be found for varieties that do particularly well at Keiser (north Delta, clay soil adapted), Judd Hill (north Delta, Verticillium wilt tolerant), Manila (north Delta, sandy soil adapted), Marianna (applicable to most Arkansas environments), and Rohwer (more southern location may favor late maturing lines). The 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 response to bacterial blight and tarnished plant bug. Results from large plot tests provide more information on the 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 match their geographical and cultural conditions. Secondly, they should examine results from multiple years of small plots for consistency of performance. Thirdly, variety selection can be fine-tuned by examining pest, yield components, 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.

Literature Cited

Bourland, F., A. Beach, E. Brown, C. Kennedy, L. Martin, and B. Robertson. 2020. Arkansas Cotton Variety Test 2020. Arkansas Agricultural Experiment Station. Research Series 674.

Evaluation of Cotton in Large-Plot On-Farm Variety Testing in Arkansas for 2020

B. Robertson,[1] J. McAlee,[1] A. Free,[1] and W. Haigwood[1]

Abstract

Yield is often the primary selection criteria used for variety selection. When selecting the varieties for planting, don't simply choose the top-yielding variety at any single testing location or year, but look at the averages of several years and locations. Each variety has its strengths and weaknesses. The challenge is to identify these characteristics and adjust management strategies to enhance strengths while minimizing the weaknesses. The objective of this study is to evaluate growth characteristics and lint yield of select varieties in large-plot on-farm testing. Replicated strips were planted the length of the field and managed according to the remainder of the field in which the study was located. The study was harvested with the producer's equipment. Grab samples were collected for lint fractions and fiber quality. On-farm plots were established at 9 locations with a wide range of planting and harvest dates. Lint yield and loan value were summarized across locations. While the lint yield differences were observed, it is important to remember that the varieties tested are a subset of the top-performing commercially available varieties.

Introduction

Yield is often the primary selection criteria used for variety selection. When selecting the varieties for planting, don't simply choose the top-yielding variety at any single testing location or year, but look at the averages of several years and locations. Each variety has its strengths and weaknesses. The challenge is to identify these characteristics and adjust management strategies to enhance strengths while minimizing the weaknesses. The best experience is based on first-hand, on-farm knowledge. Evaluate yield and quality parameters of unbiased testing programs to learn more about new varieties. Plantings of new varieties should be limited to no more than 10 percent of the farm. Acreage of a variety may be expanded slightly if it performs well the first year. Consider planting the bulk of the farm to three or four proven varieties of different maturity to reduce the risk of weather interactions and to spread harvest timings. The objective of this study is to evaluate growth characteristics and lint yield of select varieties in large-plot on-farm testing.

Procedures

Replicated strips were planted the length of the field and managed according to the remainder of the field in which the study was located. Two varieties chosen by the seed company were entered for this study: Bayer, Americot, BASF, Phytogen, and Nutrien. The study was harvest with the producer's equipment. Grab samples were collected and ginned on at tabletop gin to determine lint fraction and fiber quality.

Results and Discussion

On-farm plots were established at 9 locations with a wide range of planting and harvest dates (Table 1). Full season COTMAN indicated no unexpected stress (Table 2). NAWF data was recorded for all varieties at the selected locations to calculate days to cutout. Lint yield and loan value were summarized across all locations (Table 3). Producer management of plant height was very aggressive in 2020 and may have led to yield reductions in varieties that tend to be more responsive to plant growth regulators (PGRS).

Practical Applications

There were some variances between varieties relative to planting date, with earlier planting favoring the later-maturing varieties. While the lint yield differences were observed, it is important to remember that the varieties tested are a subset of the top-performing commercially available varieties.

Acknowledgments

The authors would like to acknowledge Cotton Incorporated, along with the seed companies Bayer, Americot, BASF, Phytogen, and Nutrien, for their support of this study. The authors would also like to thank the producers and the Cooperative Extension Agents of the University of Arkansas System Division of Agriculture Research and Extension, across locations, for their interest and support of this study.

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Table 1. Planting dates, harvest dates, and plant populations for locations in the 2020 large-plot variety testing program, where all 12 varieties were included.

	Ashley County	Clark County	Craighead County	Desha County	Lonoke County	Jefferson County	Mississippi County	Poinsett County	St. Francis County
Planting Date	5/22/2020	6/1/2020	5/19/2020	5/6/2020	5/5/2020	5/14/2020	5/25/2020	5/7/2020	5/21/2020
Harvest Date	10/23/2020	11/2/2020	11/3/2020	11/4/2020	10/21/2020	10/26/2020	11/10/2020	10/16/2020	11/7/2020
Plant Population	32670	36505	35599	34771	28403	33370	38401	32918	33543

Table 2. COTMAN–days from planting to cutout (nodes above white flower = 5) for varieties at select locations, in the 2020 large-plot variety testing program.

Variety	Craighead County	Desha County	Lonoke County	Mississippi County	Poinsett County	St. Francis County	Average to Cutout
	---------- days after planting ----------						
NG 4098 B3XF	79	89	81	80	82	74	80.8
PHY 390 W3FE	81	91	78	80	85	75	81.7
ST 4550 GLTP	83	91	78	80	82	77	81.8
DP 2012 B3XF	79	94	82	84	82	74	82.5
DP 2020 B3XF	79	94	82	80	87	73	82.5
NG 4936 B3XF	84	91	82	82	85	75	83.2
PHY 400 W3FE	82	90	80	83	88	77	83.3
DG 3456 B3XF	82	91	87	80	86	75	83.5
DG 3535 B3XF	82	95	85	80	89	75	84.3
DP 2038 B3XF	81	98	83	84	87	75	84.7
DP 1646 B2XF	83	94	84	84	88	79	85.3
ST 4990 B3XF	86	98	84	82	88	77	85.8

Table 3. Lint yield, average yield ranking, loan values, and per acre income of varieties in the 2020 large-plot variety testing program, for locations in which all 12 varieties were included.

																			Average			
Variety	Ashley Co.	R	Clark Co.	R	Craighead Co.	R	Desha Co.	R	Jeff. Co.	R	Lonoke Co.	R	Miss. Co.	R	Poins. Co.	R	St. Fran. Co.	R	Lint	Rank	Loan Value	Per Acre Income
	--lb/ac and Rank--																				(¢/lb)	($)
DP 2012 B3XF	1065	2–4	1125	1	1740	5	1347	3	1337	1	1364	4	1743	4	1888	6	1574	6	1465	3.67	50.79	744.02
DG 3456 B3XF	971	9	1011	6–7	1810	2	1218	10	1265	4	1551	1	1794	2	1990	2	1664	1	1475	4.17	51.84	764.52
DP 2020 B3XF	1030	6–7	1069	3	1752	4	1330	4	1209	8	1326	6	1672	5	1881	7	1578	5	1427	5.39	50.93	727.03
DP 2038 B3XF	948	11	1009	8	1910	1	1136	11	1163	10	1429	3	1899	1	2090	1	1615	4	1467	5.56	50.53	741.03
ST 4550 GLTP	1030	6–7	1070	2	1720	7	1299	6	1246	6	1276	7	1779	3	1654	12	1656	2	1414	5.72	50.85	719.26
NG 4936 B3XF	1059	5	1065	4	1569	12	1367	2	1333	2	1243	8	1660	6	1876	8	1524	8	1411	6.11	50.36	710.40
DP 1646 B2XF	1065	2–4	1003	10	1733	6	1371	1	1307	3	1141	11	1649	7	1941	3	1269	12	1387	6.22	51.02	707.46
DG 3535 B3XF	952	10	1011	6–7	1713	8	1286	7	1171	9	1452	2	1567	11	1895	5	1633	3	1409	6.83	50.73	714.70
PHY 390 W3FE	1140	1	1004	9	1782	3	1282	8	1246	5	1231	10	1573	10	1803	10	1481	10	1394	7.33	50.95	710.08
PHY 400 W3FE	1065	2–4	964	11	1611	10	1304	5	1150	11	1358	5	1627	9	1936	4	1510	9	1392	7.44	51.24	713.09
ST 4990 B3XF	992	8	928	12	1591	11	1279	9	1214	7	1233	9	1489	12	1739	11	1542	7	1334	9.56	51.01	680.59
NG 4098 B3XF	877	12	1028	5	1688	9	1048	12	993	12	1103	12	1636	8	1821	9	1440	11	1293	10.00	50.62	654.32

University of Arkansas System Division of Agriculture's Cotton Breeding Program: 2020 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 should provide higher, more consistent yields with fewer inputs. The current program has released over 100 germplasm lines and varieties. A strong breeding program relies upon continued research to develop techniques that can be used to identify genotypes with favorable genes. Improved lines that possess these favorable genes are subsequently selected and evaluated.

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 that are highly adapted to Arkansas environments and that possess good host-plant resistance traits. Bourland has led the program since 1988 and has been responsible for over 100 germplasm and variety releases. He has established methods for evaluating and selecting several cotton traits. The current program primarily focuses on the development of 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. Most transgenic varieties are developed by backcrossing transgenes into advanced conventional genotypes.

Procedures

Breeding lines and strains are annually evaluated at multiple locations in the Division's Cotton Breeding Program. During early generations, breeding lines are evaluated in non-replicated tests because seed numbers are limited. Tests of breeding lines include the initial crossing of parents, generation advance in F_2 and F_3 generations, individual plant selections from segregating F_4 populations, and evaluation of the 1st year (F_5) and advanced (F_6) 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 characteristics. Selected advanced progeny are promoted to strains, which are evaluated in replicated strain tests at multiple Arkansas locations to determine yield, yield components, fiber quality, host-plant resistance, and adaptation properties. Superior strains are then evaluated over multiple years and in regional tests. Improved strains are used as parents in the breeding program and/or are released as germplasm lines or varieties.

Results and Discussion

Breeding Lines

The primary objectives of crosses made in 2015 through 2020 (F_1 through F_6 generations evaluated in 2020) included the 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 fiber quality index). Particular attention has been given to combining the fiber quality of UA48 (Bourland and Jones, 2012a) into higher-yielding lines such as UA222 (Bourland and Jones, 2012b). Breeding line development exclusively focuses on conventional cotton lines.

All of the 24 cross combinations made in 2020 were between superior lines developed in the UA cotton breeding program. The combinations included eight crosses made with Ark 1102-55, a line identified as having seed that possesses unusually high oil and protein content in the 2019 Regional Breeders' Testing Network (RBTN) test. The F_1 seed of the crosses has been sent to a winter nursery for generation advance. The 2020 breeding effort also included field evaluation of 24 F_2 populations, 23 F_3 populations, 23 F_4 populations, 921 1st year progenies, and 192 advanced progenies. Bolls were harvested from superior plants in F_2 and F_3 populations and bulked by population. Individual plants (1150) were selected from the F_4 populations. After discarding individual plants for fiber traits, ~920 progenies from the individual plant selections will be evaluated in 2021. From the 1st year progenies in 2020, 216 were advanced to 2021 testing. Out of the 2020 Advanced Progenies, 72 F_6 advanced

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progenies were promoted to strain status. All but 15 of the selected 72 F_6 advanced progeny have either UA48 or UA 222 as a parent.

Strain Evaluation

In 2020, a total of 111 strains (72 Preliminary Strains, 18 New Strains, 18 Advanced Strains, and three in the 2020 Arkansas Conventional Variety Test) were evaluated in replicated tests at four experiment stations in Arkansas. UA222 and UA48 were included as checks in each test. Lint yield of 28 and 111 strains exceeded yields of UA222 and UA48, respectively. Based on Q-score values, 83 and 20 of the 111 strains produced better fiber quality than UA222 and UA48, respectively. Several of the high-yielding lines also have excellent fiber quality. Screening for host-plant resistance included evaluation for resistance to seed deterioration, bacterial blight, Verticillium wilt, and tarnished plant bug. Work to improve yield stability by focusing on yield components and improving fiber quality by reducing bract trichomes continues.

Germplasm Releases

Genetic releases are a major function of public breeding programs. A total of 97 germplasm lines and eight varieties have been released from this program, including six germplasm lines (Arkot 0822, Arkot 0908-52, Arkot 0908-56, Arkot 0908-60, Arkot 0912-18 and Arkot 0912-41) in 2020. Arkot 0822 is a sister line to UA248 (Bourland and Jones, 2021) and was derived from crossing UA48 and Arkot 0016 (Bourland and Jones, 2011). The Arkot 0908 lines were derived from crossing UA222 with GA230 (a variety developed by the University of Georgia). Parents of the Arkot 0912 lines were UA48 and UA222. The eight conventional varieties released since 2010 include UA48; UA103 (Bourland and Jones, 2013), UA222, UA107 (Bourland and Jones, 2018a), UA114 (Bourland and Jones, 2018b), UA212ne (Bourland and Jones, 2020) and UA248. Relative performances of the Arkot 0908 and Arkot 0912 lines indicate that they are worthy of variety status, but the current demand for conventional varieties is now low. The lines are being used by other public and private breeders, and some are being transformed into transgenic varieties. All of these releases have produced high yields, expressed excellent fiber quality, are early maturing, and are resistant to bacterial blight. They provide germplasm and varieties that possess novel and improved traits and adaptation.

Practical Applications

The University of Arkansas System Division of Agriculture's Cotton Breeding Program is developing cotton lines that possess enhanced host-plant resistance, improved yield and yield stability, and excellent fiber quality. 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 varieties. In either case, Arkansas cotton producers should benefit from having genetic lines that are specifically adapted to their growing conditions.

Acknowledgments

The author extends appreciation to Cotton Incorporated for their support of this program. The assistance of the Directors, Program Technicians and staffs at the stations of the University of Arkansas System Division of Agriculture is greatly appreciated. The author is particularly grateful to Brittany Hallett and Wendy Allen, Agriculture Lab Technicians, who perform and oversee much of daily work associated with the program.

Literature Cited

Bourland, F.M. 2004. Overview of the University of Arkansas Cotton Breeding Program. pp. 1093-1097. *In:* Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, Texas. 5-9 Jan. National Cotton Council, Memphis, Tenn.

Bourland, F.M. 2013. Novel approaches used in the University of Arkansas cotton breeding program. pp. 409-418. *In:* Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, Texas. 7-10 Jan. National Cotton Council, Memphis, Tenn.

Bourland, F.M. 2018. History of cotton breeding and genetics at the University of Arkansas. J. Cotton Sci. 22:171-182.

Bourland, F.M., and D.C. Jones. 2011. Registration of Arkot 0015a, Arkot 0015b, and Arkot 0016 germplasm lines of cotton. J. Plant Reg. 5:379-383.

Bourland, F.M. and D.C. Jones. 2012a. Registration of ‘UA48’ cotton cultivar. J. Plant Reg. 6:15-18.

Bourland, F.M. and D.C. Jones. 2012b. Registration of ‘UA222’ cotton cultivar. J. Plant Reg. 6:259-262.

Bourland, F.M. and D.C. Jones. 2013. Registration of ‘UA103’ cotton cultivar. J. Plant Reg. 7:135-139.

Bourland, F.M. and D.C. Jones. 2018a. Registration of ‘UA 107’ okra leaf cultivar of cotton. J. Plant Reg. 12:176-180.

Bourland, F.M. and D.C. Jones. 2018b. Registration of ‘UA114’ cultivar of cotton. J. Plant Reg. 12:181-185.

Bourland, F.M. and D.C. Jones. 2020. Registration of ‘UA21 2ne’, a nectariless cotton cultivar. J. Plant Reg. 14:266-272.

Bourland F.M. and D.C. Jones. 2021. Registration of ‘UA248’ cotton cultivar. J. Plant Reg. 15:1–6.

Field Performance of Eleven Runner-Type Peanut Cultivars in 2020 in Mississippi County, Arkansas

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Abstract

The field performance of eleven runner-type peanut (*Arachis hypogea* L.) cultivars was evaluated in an on-farm trial in 2020 in a loamy sand soil previously cropped (2018 and 2019) in cotton (*Gossypium hirsutum* L.). The cultivar, Georgia 06G had the greatest pod yield compared to Georgia 09B. Pod yield averaged 6,254 lb/ac across all runner-type cultivars. Southern blight (caused by *Sclerotium rolfsii* Sacc.) was first observed at the end of August, and Georgia 09B had a greater disease incidence than Georgia 06G. These runner-type cultivars are adapted to the area and have excellent yield potential in northeast Arkansas.

Introduction

Crop rotation is a useful practice to manage soilborne diseases such as the southern root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. The southern root-knot nematode is one of the most yield-limiting plant-parasitic nematodes that affects U.S. cotton (*Gossypium hirsutum* L.) production (Thomas and Kirkpatrick, 2001). During the past two cropping seasons (2018–2019), estimated yield losses by M. *incognita* averaged 2.8% across the U.S. Cotton Belt and 2.2% in Arkansas (Lawrence et al., 2019; Lawrence et al., 2020). Crop rotation options are limited with M. *incognita* as corn (*Zea mays* L.), cotton, grain sorghum [S*orghum bicolor* (L.) Moench], and soybean [*Glycine max* (L.) Merr.] are susceptible, while peanut (*Arachis hypogea* L.) is the only non-host row crop grown in Arkansas.

Some cotton farmers have incorporated peanut as a rotational crop; however, there is limited information on the field performance of peanut cultivars in Arkansas. Currently, the most common type of peanut grown in the state is the runner-type peanut (*A. hypogea* L. subsp. *hypogaea* var. *hypogeae*) because of its high yield potential. Since all cultivars grown in the state were primarily developed in Florida and Georgia, there is a need to evaluate the field performance of these cultivars in Arkansas. Unlike other row crops, there is no official variety testing program for peanut in Arkansas; but in 2019, an on-farm peanut cultivar trial was conducted (Faske et al., 2020).

Since 2010, there has been a renewed interest in peanut production in Arkansas. During the first few years, most of the peanut production was in Lawrence and Randolph counties but now has migrated to Craighead and Mississippi County. According to the USDA-FSA, 23,261 ac or 61% of the 2020 Arkansas peanut crop was produced in Craighead and Mississippi Counties. Though peanut acreage has increased, there is only one report of a runner-type peanut cultivar trial in Arkansas (Faske et al., 2020). Thus, the objective of this study was to evaluate eleven peanut cultivars for disease resistance, yield production, and profitability potential in Mississippi County.

Procedures

Eleven peanut cultivars were planted in a field trial near Manila, Arkansas. The cultivars (Table 1) were planted at 1-in. deep on 21 May at a seeding rate of 6 seed/ft of row in a Routon-Dundee-Crevasse complex, loamy sand soil (79% sand, 18% silt, 3% clay) previously cropped in cotton (2018 and 2019). Weeds were controlled based on recommendations by the University of Arkansas System Division of Agriculture's Cooperative Extension Service. This study was furrow irrigated. Plots consisted of two 20-ft-long rows spaced 38-in apart separated by an 8-ft fallow alley. Imidacloprid (Admire Pro®, Bayer CropScience, Research Triangle Park, N.C., at 7.0 fl oz/ac) and peanut inoculant (Exceed® traditional liquid for peanut, Visjon Biologicals, Wichita Falls, Texas, at 14.0 fl oz/ac) was applied in-furrow at planting through a 0.07-in.-diam. (1.8-mm-ID and 4.0-mm-OD) poly tubing using a pressurized sprayer to deliver 8.4 gal/ac. The experimental design was a randomized complete block design with four replications per cultivar.

Plant stand was assessed in June based on seedlings per 10 row-ft and converted to seedlings per row-ft. Disease incidence of southern blight was rated on the number of 6-in. foci per row-ft and converted to percent of plot infect-

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ed. Peanut maturity of the runner-type peanut cultivars was evaluated on 14 September (116 days after planting (DAP)) based on the hull-scrape method (Williams and Drexler, 1981). Pod loss was estimated after digging based on the number of pods in a 1 sq ft transect systemically placed at the beginning and middle of each plot. Air-dried pod (n = 100) weights of each cultivar were used to estimate yield loss. Plots were dug on 24 October (156 DAP) and thrashed on 5 November with a mobile plot thrasher (Kincaid Equipment Manufacturing, Haven, Kansas). Pod yield are reported as air-dry weights at 6% moisture. Data were subjected to analysis of variance using ARM Software (V. 9.0) and mean separation by Tukey's honestly significant difference at $P = 0.05$. A subsample (3-lb) for each cultivar was collected from the second replication (not subject to analysis) and graded by USDA at Birdsong Peanut near Portia, Arkansas.

Soil samples were collected within two blocks at planting and at harvest to assess the change in M. *incognita* population density with peanut as a rotation crop. Soil samples were a composite of a minimum of 10 soil cores taken 8 to 10 in. deep with a 0.75-in.-diam soil probe. Second-stage juveniles were collected with a Baermann ring system and enumerated using a stereoscope.

Results and Discussion

Peanut plant stand at 11 DAP varied among cultivars and the lowest ($P \leq 0.05$) plant stand (<3 plants/row-ft) was observed with TUFRunner 297, AU-NPL 17, and FloRun 311 compared to Georgia 07W, Georgia 12Y, Georgia 16HO, and Lariat (Table 2). Environmental conditions were cool and wet for May, which may have slowed seed germination and seeding emergence. Poor plant stands were a common, widespread issue across the state in 2020, which suggest poor environmental conditions contributed to the poor plant stands rather than seed quality. Most runner-type peanut had a semi-bunch or prostrate growth with intermediate canopy height, while Lariat had a semi-bunch growth and tall canopy height.

The majority of these runner-type peanut cultivars are marketed as medium maturity (135–145 day), while Georgia 12Y as a medium-late maturity cultivar. However, based on the hull-scape method, Georgia 06G and Georgia 12Y were >50% mature. In contrast, Georgia 18RU had the most mature pods in a similar trial (Faske et al., 2020). There was no difference among cultivars for pod loss, which may have been associated with cool conditions in September that slowed peanut maturity. Of these runner-type peanut cultivars, Georgia 06G had the greatest ($P \leq 0.05$) yield compared to Georgia 09B.

The runner-type peanut cultivars with the best grade were Georgia 0G6, which calculated to greater crop value per ton (Table 3). A high percentage of sound splits was observed with Georgia 06G, Georgia 07W, Georgia 18RU, and TURRunner 511. Those cultivars with the greatest value per acre were Georgia 06G, Georgia 07W, and Georgia 18RU, and were the most profitable (Table 3). Currently, the average cost of peanut production is \$430 to \$450/ac. The yield average was 6,254 lb/ac across all runner-type cultivars, which was above the statewide average of 4,800 lb/ac estimated by the USDA-FSA.

The most common diseases of peanut in Arkansas are southern blight caused by *Sclerotium rolfsii* Sacc., a soilborne disease, and late leaf spot caused by *Cercosporidium personatum* (Berk and M.A. Curtis) Deighton, a foliar disease. Southern blight was observed in late August, with the greatest ($P \leq 0.05$) disease incidence on Georgia 09B compared to Georgia 06G (Table 2). There was a significant negative correlation ($r = -0.34$, $P = 0.018$) between southern blight incidence and yield. No other yield-limiting disease was observed in the field.

The field was previously grown for two years in cotton and the initial southern root-knot nematode population density at planting was 10 J2/100 cm^3 of soil, which is a low threshold for cotton in Arkansas (Mueller et al., 2012). The southern root-knot nematode population density at harvest was the same as that observed at planting, which indicates there was no increase in root-knot nematode population densities with peanut. Given the wide host range of the southern root-knot nematode, weeds in the field plots may have sustained nematode densities in the samples collected or this root-knot nematode was something other than M. *incognita*, maybe M. *hapla*. There was a slight increase with lesion nematode (*Pratylenchus* sp.) from 4 individuals/100 cm^3 soil at planting to 25 individuals/100 cm^3 soil at harvest. These data support the rotation of peanut with cotton to manage the southern root-knot nematode.

Practical Applications

Peanut is an excellent rotation crop to manage soilborne nematodes such as the southern root-knot nematode and its profitability fits well in the Arkansas cotton production system. Currently, the most common peanut cultivars grown are Georgia 09B and Georgia 06G with less than 10% of acreage planted in TUFRunner 297 and FloRun 331. These results provide information on a few runner-type peanut cultivars that farmers may consider as future rotation in their cotton production system.

Acknowledgments

The authors would like to thank the Arkansas peanut producers, Arkansas Peanut Growers Association, and National Peanut Board for supporting this field research. We would like to thank Wildy Farms for allowing us to have or plots on the farm and Dale Wells for communicating the logistics of planting and harvest. The authors would also like to thank the various foundation seed organizations (Table 1) for providing seed and Delta Peanut and Birdsong Peanut for assistance with grading. Support was also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Faske, T.R., A. Vangilder, and M. Emerson. 2020. Field performance of twelve peanut cultivars in Mississippi County, Arkansas. pp. 100-106 *In:* F.M. Bourland (ed.) Summaries of Arkansas Cotton Research 2019. Arkansas Agricultural Experiment Station Research Series 668. Fayetteville, Ark.

Lawrence, K., A. Hagan, R. Norton, J. Hu, T. Faske, R. Hutmacher, J. Mueller, I. Small, Z. Grabau, R. Kemerait, D. Jardine, P. Price, T. Allen, C. Meeks, J. Idowu, L. Thiessen, S. Byrd, J. Goodson, H. Kelly, T.A. Wheeler, T. Isakeit, and H.L. Mehl. 2020. Cotton disease loss estimates committee report, 2019. pp. 117-119. *In:* Proc. Beltwide Cotton Prod. Res. Conf., Austin, Texas. 8-10 Jan. National Cotton Council, Memphis, Tenn.

Lawrence, K., A. Hagan, R. Norton, J. Hu, T. Faske, R. Hutmacher, J. Mueller, I. Small, Z. Grabau, R. Kemerait, P. Price, T. Allen, S. Atwell, J. Idowu, L. Thiessen, S. Byrd, J. Goodson, H. Kelly, T. A. Wheeler, T. Isakeit, and H. Mehl. 2019. Cotton disease loss estimates committee report, 2018. pp. 54-56. *In:* Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, LA. 8-10 Jan. National Cotton Council, Memphis, Tenn.

Mueller, J., S. Koenning, T. Kirkpatrick, B. Kemerait, C. Overstreet, and R. Nichols. 2012. Managing nematodes in cotton-based cropping systems. pp. 1-4. Cotton Incorporated.

Thomas, S.H. and T.L. Kirkpatrick. 2001. Root-knot nematodes. pp. 40-42. *In:* T.L. Kirkpatrick and C.S. Rothrock, (eds.) Compendium of cotton diseases. St. Paul, Minn. APS Press.

Williams, E.J. and J.S. Drexler. 1981. A non-destructive method for determining peanut pod maturity. Peanut Sci. 8:134-141.

Table 1. Peanut cultivars, type, seed size, and source used in 2020 in an on-farm cultivar trial in Mississippi County.

Cultivars†	Peanut Type	Number of seeds/lb	Seed Source
Georgia 06G	Standard, runner	604	Alabama Crop Improvement Assoc. Inc., Headland, Ala.
Georgia 07W	Standard, runner	636	Alabama Crop Improvement Association
Georgia 18RU	Standard, runner	672	Georgia Seed Development, Plains, Ga.
Georgia 12Y	Standard, runner	691	Alabama Crop Improvement Association
TUFRunner 297	High O/L‡, runner	544	Florida Foundation Seed Producers, Inc., Marianna, Fla.
Lariat	High O/L, runner	579	Oklahoma Foundation Seed Stocks, Stillwater, Okla.
AU-NPL 17	High O/L, runner	550	Alabama Crop Improvement Association
TUFRunner 511	High O/L, runner	574	Florida Foundation Seed Producers
Georgia 16HO	High O/L, runner	676	Alabama Crop Improvement Association
FloRun 331	High O/L, runner	695	Florida Foundation Seed Producers
Georgia 09B	High O/L, runner	644	Alabama Crop Improvement Association

† All cultivars are runner-type peanut.

‡ O/L = oleic/linoleic ratio.

Table 2. Peanut plant stand, maturity, southern blight incidence, and pod loss for eleven peanut cultivars in a 2020 on-farm trial in Mississippi County.

Cultivars	Stand† (1 June)	% Maturity‡ (30 Sept.)	Southern blight§ (29 Aug.)	Pod Loss¶
				(lb/ac)
Georgia 06G	3.6 bcd#	63	0.7 b	152.7
Georgia 07W	4.3 ab	30	1.6 ab	176.0
Georgia 18RU	3.4 b–e	30	0.9 ab	267.3
Georgia 12Y	4.3 ab	50	0.7 b	125.5
TUFRunner 297	2.7 cde	30	2.1 ab	149.9
Lariat	4.9 a	45	0.2 b	224.2
AU-NPL 17	2.6 de	10	1.3 ab	136.4
TUFRunner 511	3.3 b–e	40	1.6 ab	179.0
Georgia 16HO	4.2 ab	40	0.2 b	251.6
FloRun 331	2.5 e	20	0.2 b	187.9
Georgia 09B	3.7 bc	50	7.5 a	281.4
P > F	0.001	…	0.017	0.09

† Stand count is the total number of plants per row-ft.

‡ Percent of pods from a sample that are dark brown to black (harvestable peanuts) based on the hull scrap method.

§ Percent of plot infected with southern blight caused by *Sclerotium rolfsii*.

¶ Estimated number of pods detached from plants after digging.

Means in each column followed by the same letter are not significantly different at α = 0.05 according to Tukey's honest significant difference test.

Table 3. Grade, value, and yield of eleven peanut cultivars in a 2020 on-farm trial in Mississippi County.

Cultivars†	Grade‡	% Sound Splits	Value/T§	Yield	Value/ac
				(lb/ac)	
Georgia 06G	78	7	$374.18	7,313 a¶	$1,368.19
Georgia 07W	73	7	$350.13	6,818 ab	$1,193.59
Georgia 18RU	76	7	$364.56	6,596 ab	$1,202.32
Georgia 12Y	71	3	$342.91	6,348 ab	$1,088.40
TUFRunner 297	74	5	$356.54	6,200 ab	$1,105.27
Lariat	77	5	$370.47	6,137 ab	$1,136.79
AU-NPL 17	72	5	$346.96	6,037 ab	$1,047.30
TUFRunner 511	73	9	$348.53	5,988 ab	$1,043.50
Georgia 16HO	76	4	$366.96	5,982 ab	$1,097.58
FloRun 331	73	6	$350.93	5,881 ab	$1,031.91
Georgia 09B	74	5	$356.54	5,495 b	$979.59
P > F	--	--	--	0.019	--

† All cultivars are runner-type peanut.

‡ Grade (total SMK) was based on USDA standard for peanut and conducted at Birdsong Peanut in Portia, Arkansas.

§ USDA Price Table for 2016 (each SS% >4% docked $0.80/%).

¶ Means in each column followed by the same letter are not significantly different at α = 0.05 according to Tukey's honest significant difference test.

Evaluation of Selected Insecticides for Control of Cotton Aphid in Arkansas

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Abstract

Cotton aphid (*Aphis gossypii*, Glover) is a minor pest that is present on almost all cotton acres in the mid-South. Insecticide resistance has been documented to multiple insecticide classes for cotton aphids. A study was conducted in 2020 to determine the efficacy and residual control of selected insecticides for cotton aphid control. Terminals from 5 plants were removed from all plots 4 days after application to determine the efficacy of insecticides for cotton aphid. All treatments reduced cotton aphid density compared to the untreated control, and Transform at 1 oz/ac performed better than Admire Pro. These data will help formulate recommendations for cotton growers to help maintain profitability.

Introduction

Multiple insect pests feed on cotton throughout the growing season. One of these pests is the cotton aphid (*Aphis gossypii*, Glover), which feeds on the underside of cotton leaves, causing the leaves to crinkle and cup downward. Infestations of cotton aphids have been documented throughout the growing season, from the seedling stage through cutout. Female aphids give birth to live young, so population densities can increase rapidly, especially following a broad-spectrum insecticide application that could eliminate beneficials from the field (Blackmon and Eastop, 1984). Cotton aphids are considered a minor pest of cotton, occurring at low populations on all acres of cotton. In 2019, only 16% of the total cotton acreage in Arkansas was treated for cotton aphid, with an average cost of $20.00 (includes application cost) per application (Cook and Threet, 2020). Cotton aphids have a history of developing resistance to insecticides rapidly after the introduction of a new mode of action (Mallet and Luttrell, 1991). It is important that all labeled insecticides for control of cotton aphids are monitored on a yearly basis. The objective of this study was to determine the efficacy and residual control for cotton aphids of multiple insecticides.

Procedures

A study was conducted in 2020, near Carlisle, Arkansas, to determine the efficacy and residual activity of selected insecticides for the control of cotton aphid. The plot size was 4 rows by 50 ft long. Treatments included: Untreated Control (UTC, non-sprayed), Sefina 3 oz/ac, Sivanto Prime 7 oz/ac, PQZ 3.2 oz/ac, Transform 0.75 and 1 oz/ac, Admire Pro 1.7 oz/ac, Carbine 2 oz/ac, and Strafer Max 1.1 oz/ac. Treatments were applied with a multi-boom equipped Mudmaster sprayer and delivering 10 GPA through TeeJet TX-VS6 hollow cone nozzles. Plots were arranged in a randomized complete block design. Applications were made on 8 Aug. Plots were sampled 4 and 7 days after application. In order to determine cotton aphid density, 5 cotton terminals were removed per plot and transported to the University of Arkansas System Division of Agriculture's Lonoke Extension Center, Lonoke, Arkansas. Terminals were washed with an alcohol solution, filtered, and then counted to determine aphid density. Data were processed using Agriculture Research Manager Version 10, analysis of variance, and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

A reduction in aphid density was observed for all treatments 4 days after application (Fig. 1). Transform at 1 oz/ac reduced aphid density lower than Admire Pro. No other separations were observed among treatments. At 7 days after application, aphid populations had declined to a level well below threshold, and sampling was not conducted.

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Practical Applications

Cotton aphids are a minor pest of cotton in the mid-South; however, they can cause yield reduction and require treatment on some acreage each year. With known resistance to multiple classes of insecticides, it is imperative that insecticides are tested on a yearly basis to determine efficacy and residual control. All products tested provided suppression of cotton aphids, but Transform at 1 oz/ac performed more consistently than the other products.

Acknowledgments

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Literature Cited

Blackmon R.L. and V.F. Eastop. 1984. Aphids on the world's crops: an identification guide. Wiley, New York, NY.

Cook, D.R. and M. Threet. 2020. 2019 Cotton insect losses estimates. pp. 692-693. *In:* Proc. Beltwide Cotton Prod. Res. Conf., Austin, Texas. 8-10 Jan. National Cotton Council, Memphis, Tenn.

Mallet J. and R. Luttrell. 1991. A model of insecticidal control failure: the example of *Heliothis virescens* on cotton. Supplement to the Southwestern Entomologist. 15:201-212.

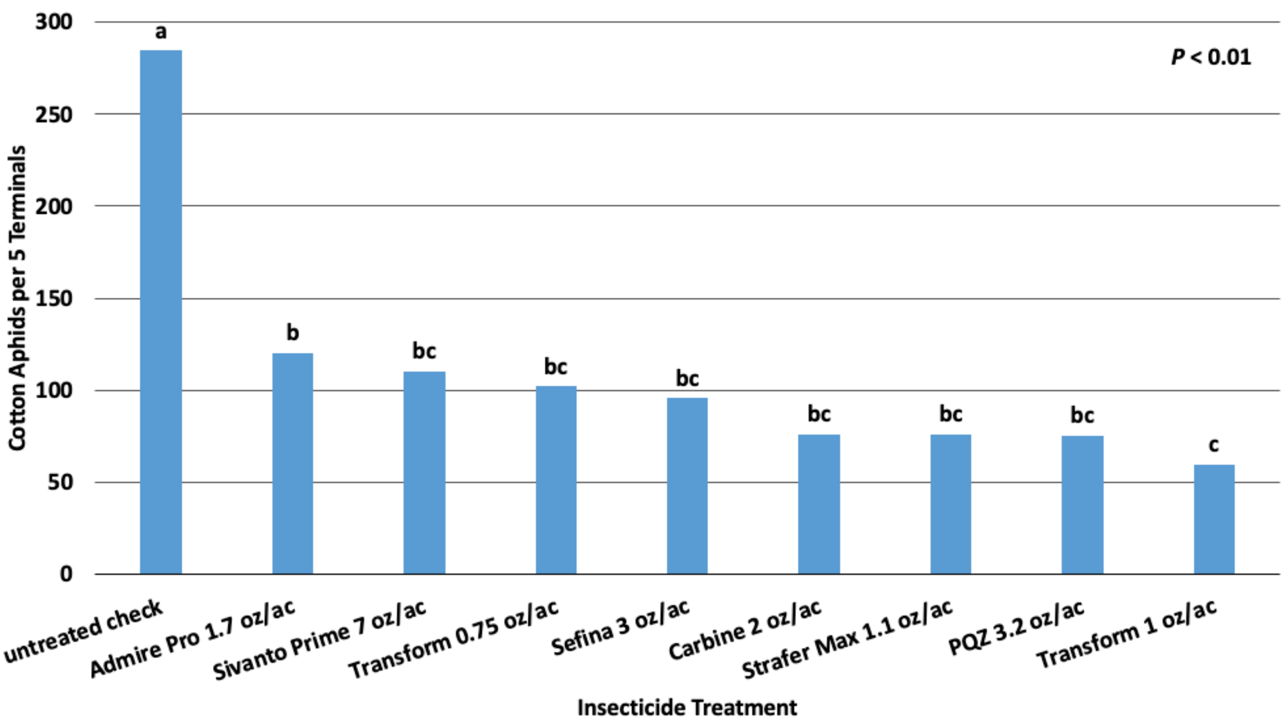

Fig. 1. Efficacy of cotton aphid for multiple insecticides 4 days after application at Carlisle, Arkansas in 2020. Means followed by different letters are significantly different at *P* = 0.10.

Foliar Control of Thrips in Cotton

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Abstract

Thrips are an early-season pest in cotton that can delay maturity and cause yield loss. With the development of thiamethoxam (Cruiser) resistant thrips in Arkansas, and a decline in acephate efficacy, there is a continued need to evaluate products for thrips control. The objective of this study, conducted at Tillar, Arkansas, was to evaluate selected insecticides for the control of thrips. Results indicated that foliar applications of Orthene, Dimethoate, Radiant, Bidrin, and Intrepid Edge provided control of thrips.

Introduction

Thrips are an early-season pest in cotton that can delay maturity and cause yield loss. Symptoms of thrip damage on seedling cotton are crinkled leaves, burnt edges, and a silvery appearance. The level of damage varies from year to year based on the severity of the thrips infestation (Hopkins et al., 2001). In 2012 and 2013, observations were made that indicated tobacco thrips (*Frankliniella fusca*), the predominant species found in cotton, had developed tolerance/resistance to Cruiser (thiamethoxam). In 2014, Herbert and Kennedy (2015) conducted studies in the Mid-South and Southeastern U.S. that confirmed resistance to the neonicotinoid insecticides thiamethoxam and imidacloprid. This evidence was further reinforced in Arkansas by Plummer et al. (2015). In 2019, bioassays were conducted in Tennessee to evaluate the efficacy of acephate in thrips from across the mid-South due to an observed decline in control (Thrash et al., 2019). Insecticide seed treatments (IST) and additional foliar insecticide application(s) are often necessary to effectively control thrips creating high input costs for growers. This trial was conducted to evaluate the efficacy of select insecticides for the control of thrips.

Procedures

Plot size was 12.5 ft by 40 ft in a randomized complete block design with 4 replications. Treatments included: Intrepid Edge 3 oz/ac, Orthene (acephate) 0.25 lb/ac and 0.5 lb/ac; Bidrin 3.2 oz/ac, Dimethoate 6.4 oz/ac, Radiant 1.5 oz/ac + NIS 0.25%, and Karate Z 1.28 oz/ac. All treatments, including the untreated check (UTC), were treated with a base fungicide package of Trilex Advanced 1.6 oz/cwt. Foliar applications were made at 10 gal/ac set at 40 psi using Tee Jet 9001 VS flat fan nozzles. Plots were planted on 11 May and treated at the 2 leaf growth stage on 2 June. Thrips samples were taken 3 and 8 days after application (DAA) by collecting 5 plants per plot and placing them in jars with 70% alcohol solution. Samples were washed and filtered in the laboratory at the University of Arkansas System Division of Agriculture's Lonoke Extension Center, Lonoke, Arkansas. and thrips were counted using a dissection scope. Also, plant damage was estimated at 3 and 8 DAA these timings using a 1–5 scale, with a rating of 1 = no damage and 5 = severe damage. Data were processed using Agriculture Research Manager, Version 2018.5 (Gylling Data Management, Inc., Brookings, S.D.). Analysis of variance was conducted, and Duncan's New Multiple Range Test ($P = 0.10$) was used to separate means.

Results and Discussion

Results indicated that at 3 DAA, all treatments had fewer thrips than the fungicide only and Karate Z; and Intrepid Edge had fewer thrips than Bidrin, Dimethoate, and Radiant + NIS (Fig. 1). All the insecticide treatments, except Karate Z, had fewer thrips than the UTC at 8 DAA (Fig. 2). All of the insecticide treatments, except Karate, resulted in lower damage ratings compared to the UTC, and Intrepid Edge had lower damage ratings than Radiant + NIS and Orthene 0.25 lb at 3 DAA (Fig. 3).

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Practical Applications

Thrips management in cotton is essential for maintaining yield and earliness in cotton. With continuing issues of insecticide resistance and profitability, best management practices for controlling this pest continue to evolve. The use of these products will be driven by the price of application, planting system, and market prices. With few insecticides left to control thrips, cultural control methods need to be implemented to help reduce their impact on cotton yields.

Acknowledgments

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Literature Cited

Hopkins, J.D., J.D Reaper, III, D.R. Johnson, and G.M. Lorenz, III. 2001. Thrips management in Arkansas cotton. pp. 216-223. *In*: D.M. Oosterhuis (ed.) Summaries of Arkansas Cotton Research 2014. Arkansas Agricultural Experiment Station. Research Series 497. Fayetteville, Ark.

Herbert, A., and G. Kennedy. 2015. New survey shows high level and widespread resistance of thrips to neonicotinoid insecticides. Available at: https://blogs.ext.vt.edu/ag-pest-advisory/files/2015/02/NeonicThripsResistance.pdf

Plummer W.A., G.M. Lorenz III, N.M. Taillon, H.M. Chaney, and B.C. Thrash. 2015. Control of thrips with insecticide seed treatments in Arkansas 2014. pp 159-162. *In*: D.M. Oosterhuis (ed.) Summaries of Arkansas Cotton Research 2014. Arkansas Agricultural Experiment Station. Research Series 625. Fayetteville, Ark.

Thrash, B., G. Lorenz, N. Bateman, S. Stewart, B. Catchot, A. Catchot, F. Musser, J. Gore, S. Brown, D. Kerns, G. Kennedy, A, Huseth, D. Reisig, and S. Taylor. 2019. Performance of acephate against tobacco thrips and evidence of possible resistance. pp. 79-83. *In:* F.M. Bourland (ed.) Summaries of Arkansas Cotton Research 2017. Arkansas Agricultural Experiment Station. Research Series 668. Fayetteville, Ark.

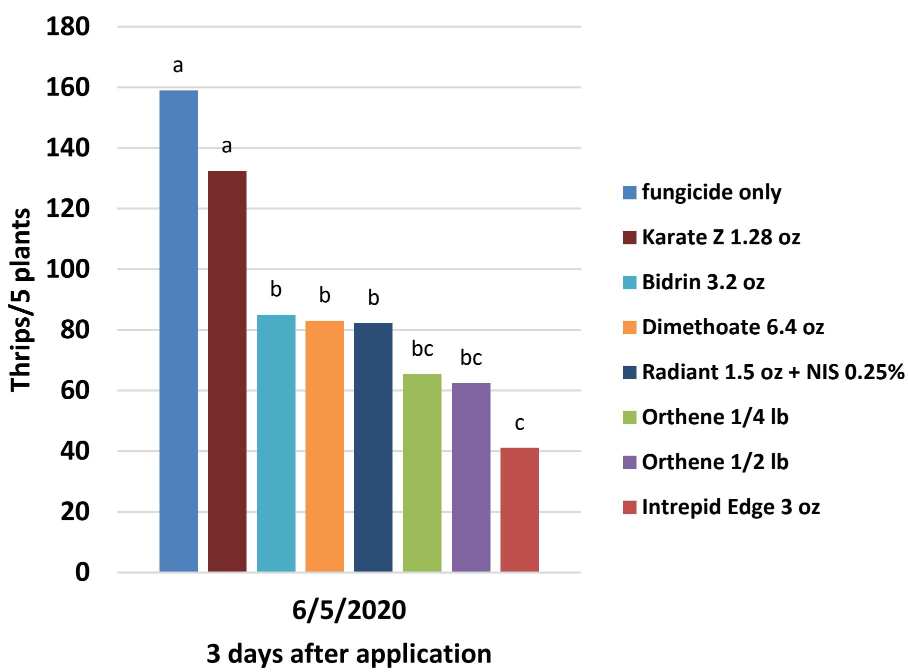

Fig. 1. Efficacy of selected insecticides at 3 days after application for control of thrips. Means followed by the same letter are not significantly different.

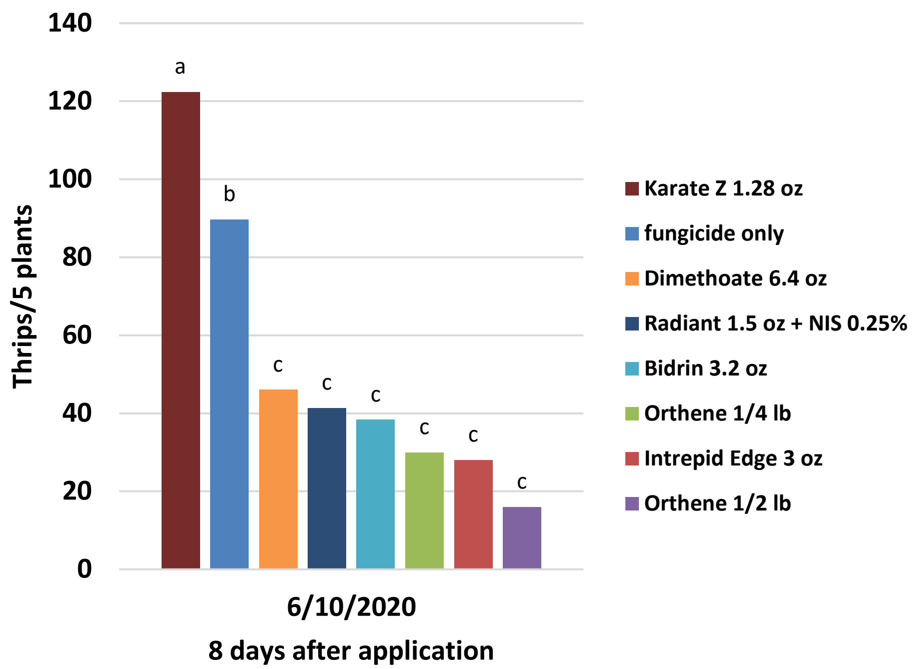

Fig. 2. Efficacy of selected insecticides at 8 days after application for control of thrips. Means followed by the same letter are not significantly different.

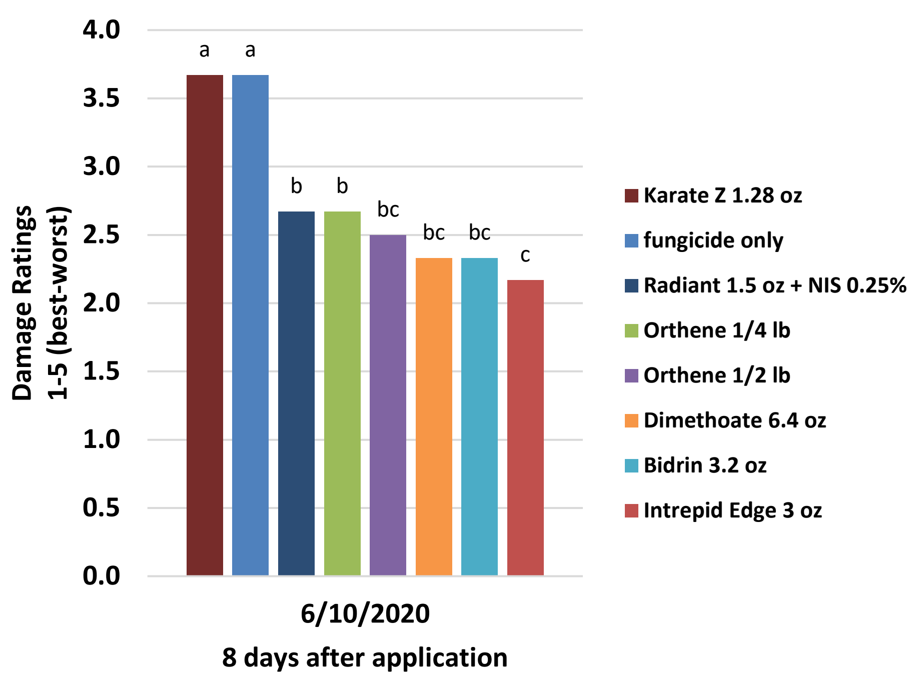

Fig. 3. Damage ratings of selected insecticides at 8 days after application for control of thrips. Means followed by the same letter are not significantly different.

Efficacy of Seed Treatments and In-Furrow Insecticides for Control of Thrips in Cotton

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Abstract

Thrips are early-season pests of cotton that can stunt or kill small plants, resulting in delayed maturity and yield loss. Insecticide seed treatments, primarily neonicotinoids, have been the most common method Arkansas farmers have used to control thrips in recent years. However, resistance to two neonicotinoids, thiamethoxam and imidacloprid, has been confirmed in tobacco thrips. In 2020, a test was conducted at Tillar, Arkansas, to evaluate the efficacy of insecticides applied in-furrow and as seed treatments for the control of thrips in cotton. Sampling was conducted at 1st leaf, 2nd leaf, and 5th leaf growth stages. Results indicated Ag Logic, Orthene alone, and Orthene seed treatment in combination with Gaucho resulted in the best control in this test.

Introduction

In 2020, Arkansas ranked number four in U.S. cotton production, with an estimated 525,000 acres planted (NASS, 2020). Thrips are one of the most damaging insect pests of seedling cotton in Arkansas. Multiple species of thrips are present in Arkansas cotton, including western flower thrips (*Frankliniella occidentalis*), flower thrips (*Frankliniella tritica*), soybean thrips (*Neohydatothrips variabilis*), and onion thrips (*Thrips tabaci*); however, tobacco thrips (*Frankliniella fusca*) are the most prevalent (Cook et al., 2021). Thrips damage cotton by stunting growth and delaying fruiting, ultimately resulting in yield loss (Greene et al., 2020). Thrips damage is characterized by a silvery leaf with crinkled and burnt edges. In 2019, thrips infested 100% of cotton acres in Arkansas, and 18% of those acres were treated with a supplemental foliar insecticide at an average cost of $13 per acre (Cook and Threet). The objective of this study was to evaluate currently used products for thrips control.

Procedures

In 2020, a trial was conducted in Tillar, Arkansas, to evaluate insecticide seed treatments, in-furrow (IF) insecticides, and combinations for control of thrips. Plot size was 12.5 ft (4 rows) by 40 ft, arranged in a randomized complete block design with 4 replications. Treatments consisted of a fungicide only untreated check (UTC), Orthene 97 6.4 oz/cwt, Orthene 97 6.4 oz/cwt + Gaucho 600 FS 0.375 mg ai/seed, Gaucho 600 FS 0.375 mg ai/seed, Aeris Seed Applied System 0.75 mg ai/seed, Ag Logic in-furrow (IF) 4 lb ai/ac, Gaucho 600 FS 0.375 mg ai/seed + Orthene (IF) 1 lb ai/ac, Orthene (IF) 1 lb ai/ac, and Admire Pro (IF) 9.2 fl oz/ac. Thrips density was estimated by sampling 5 random plants from each plot and immediately placing them in a jar with a 70/30 alcohol and water solution. Samples were taken at the 1st, 2nd, and 5th true leaf growth stages. The samples were processed at the University of Arkansas System Division of Agriculture's Lonoke Extension Center, and thrips were counted using a dissection scope.

Results and Discussion

At the 1st true leaf assessment, all treatments had fewer thrips than the UTC (Fig. 1). At the 2nd true leaf assessment, all treatments except Gaucho 0.375 mg and Orthene 6.4 oz were significantly lower than the UTC, and Ag Logic provided better control of thrips when compared to Gaucho 0.375 mg (Fig. 2). At the 5th leaf growth stage, Gaucho 0.375 mg and Aeris Seed Applied System 0.75 mg were the only treatments not different than the UTC. Gaucho 0.375 + Orthene (IF) 1 lb, Orthene 6.4 oz, Admire Pro (IF) 9.2 oz, Orthene (IF)1 lb, Ag Logic (IF) 4 lb, provided better control than Gaucho 0.375 mg and Aeris Seed Applied System 0.75 mg. (Fig. 3). In this study, Ag logic, Orthene alone, and Orthene in combination with other insecticides provided the best level of control.

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Practical Applications

Thrips are the most damaging pest of young cotton in Arkansas and growers are continually looking for cost-effective ways to control thrips. With the development of insecticide resistance or tolerance, it is necessary to monitor insecticides for the development of control issues.

Acknowledgments

The authors would like to express their appreciation to the support provided by the University of Arkansas System Division of Agriculture and Regional Cotton Incorporated for funding. Also, the authors appreciate AJ Hood and Tillar and Co. for letting us use their land for our tests.

Literature Cited

Cook, D., A. Herbert, D.S. Akin, and J. Reed. 2021. Biology, crop injury, and management of thrips (*Thysanoptera: Thripidae*) Infesting Cotton Seedling in the United States 2011. https://academic.oup.com/jipm/article/2/2/B1/860751

Cook, D.R. and M. Threet. 2019. Cotton Insect Losses-2019. Accessed 1 March 2021. Available at: https://www.biochemistry.msstate.edu/resources/2019loss.php

Greene, J.K., P. Francis, F. Reay-Jones, and S. Conzemius. 2020. Best Management Practices for Thrips (Thysanoptera: Thripidae) in Cotton. Land-Grant Press. Clemson University, South Carolina. Accessed on 30 Nov. 2020. Available at: https://lgpress.clemson.edu/publication/best-management-practices-for-thrips-thysanoptera-thripidae-in-cotton/

NASS. 2020. National Agriculture Statistic Service. Accessed 1 March 2021. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=ARKANSAS

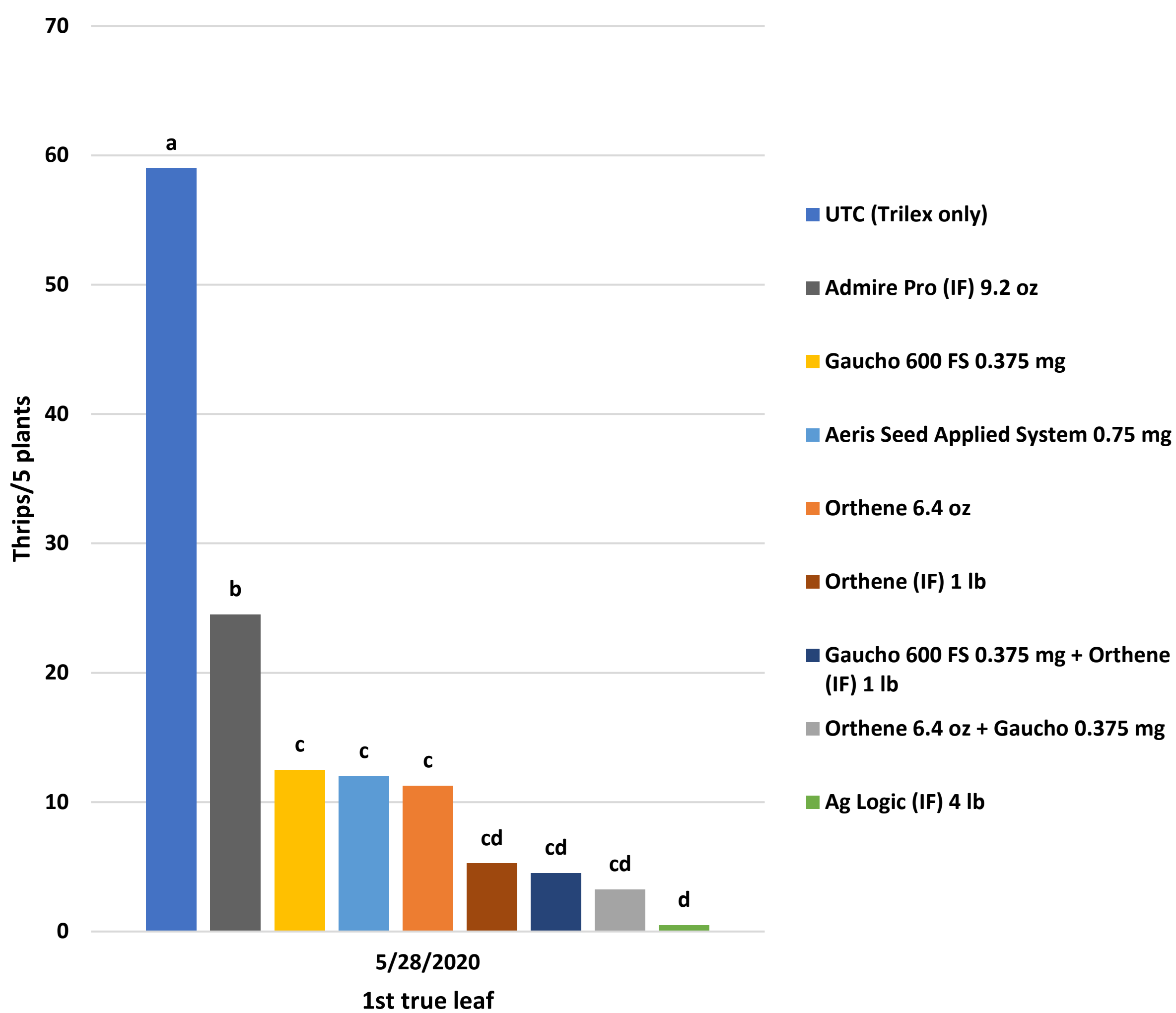

Fig. 1. Evaluation of multiple insecticide seed treatments and in-furrow insecticides for control of thrips at the 1st true leaf growth stage, Tillar, Arkansas in 2020. Means followed by the same letter are not significantly different at *P* = 0.05.

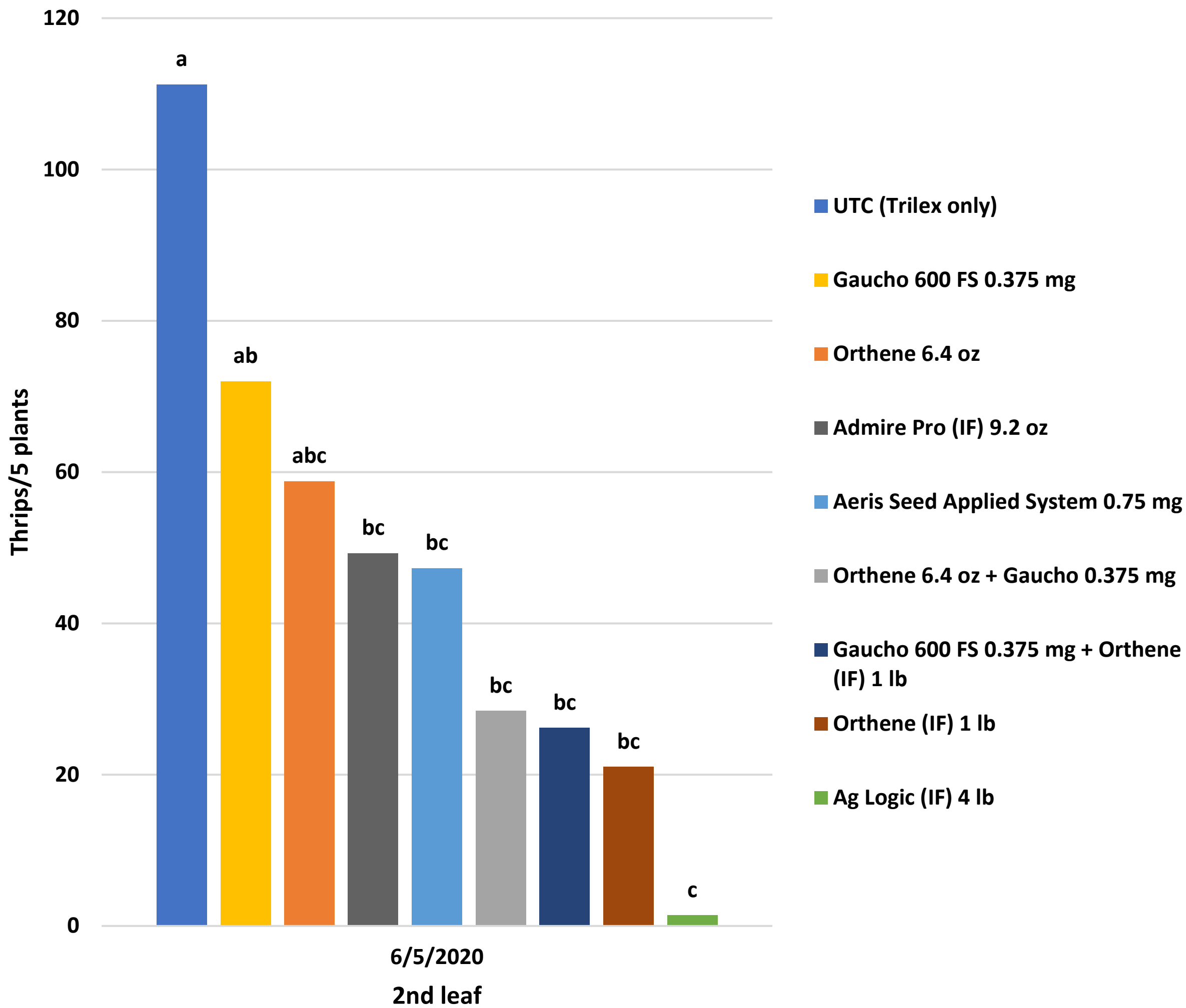

Fig. 2. Evaluation of multiple insecticide seed treatments and in-furrow insecticides for control of thrips at the 2nd leaf growth stage, Tillar, Arkansas in 2020. Means followed by the same letter are not significantly different at *P* = 0.05

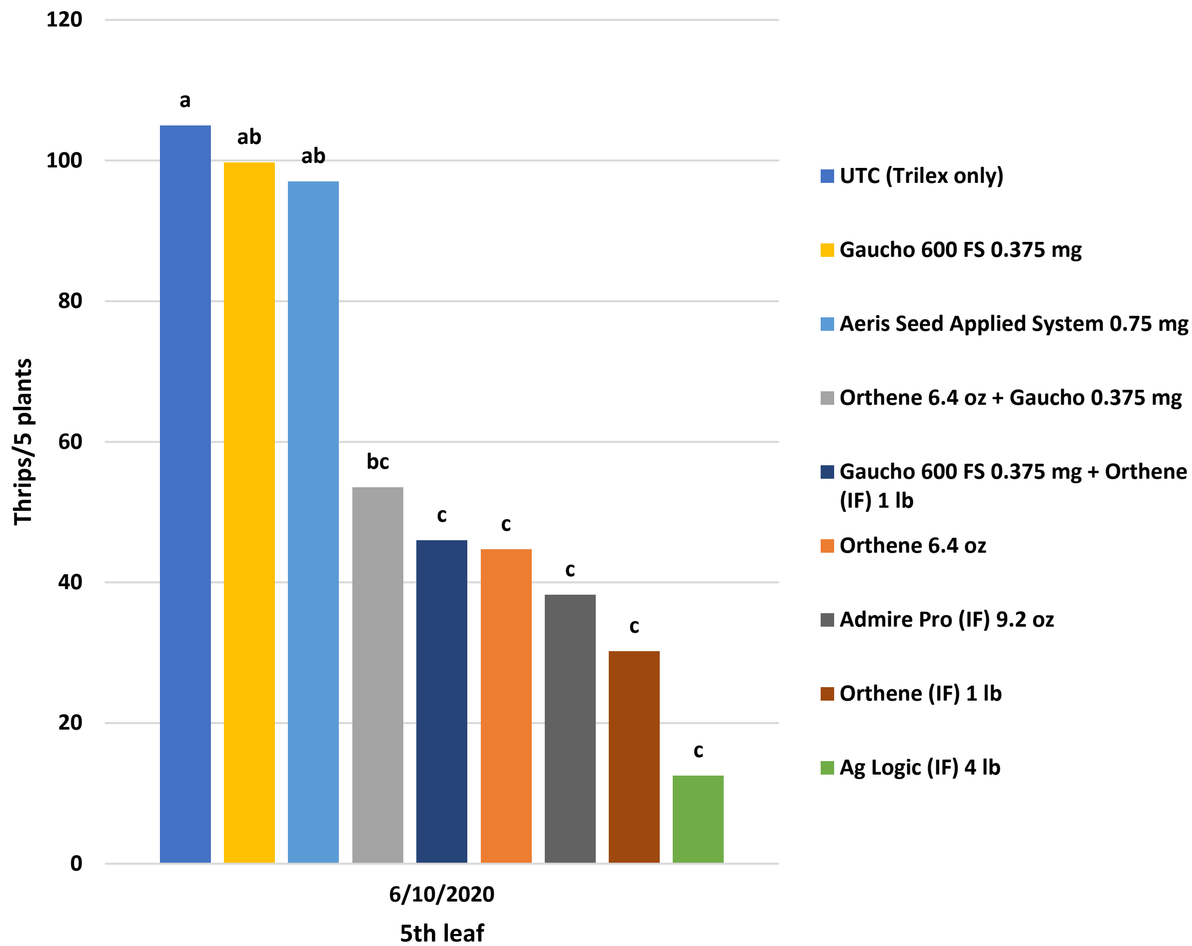

Fig. 3. Evaluation of multiple insecticide seed treatments and in-furrow insecticides for control of thrips at the 5th leaf growth stage, Tillar, Arkansas in 2020. Means followed by the same letter are not significantly different at *P* = 0.05.

Evaluation of Current Insecticides for Control of Tarnished Plant Bugs in Cotton

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Abstract

Tarnished plant bug (TPB), *Lygus lineolaris*, is the number one insect pest in mid-South cotton production. Tarnished plant bug feeding causes square loss, deformed flowers, and damaged bolls, ultimately resulting in reduced yield. TPB is a difficult pest to manage in cotton, with growers averaging 4–6 insecticide applications per year. A regional mid-South study was conducted from 2017 through 2020 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, to evaluate the efficacy and residual control of insecticides currently available for TPB control. These trials were also used to monitor for potential resistance issues in the mid-Southern U.S. Insecticides evaluated included: Transform (sulfoxaflor), Centric (thiamethoxam), Vydate (oxamyl), Orthene (acephate), Brigade (bifenthrin), Bidrin (dicrotophos), Couraze Max (imidacloprid), Carbine (flonicamid) and Diamond (novaluron). Treatments were initiated when a threshold of 3 TPB per 5 row feet was observed in the test area. At 7 days after the first application, all treatments reduced TPB numbers below the untreated. However, only Centric kept TPB densities under threshold, so a second application was made at 7 days after treatment (DAT). Following the second application, all treatments reduced TPB densities compared to the untreated check, but many of the tested insecticides failed to provide consistent control. Results from this study indicated that Diamond, Transform, Orthene, and Brigade + Orthene performed consistently better than the other insecticides.

Introduction

Tarnished plant bug (TPB), *Lygus lineolaris*, feeds on cotton terminals, squares, flowers, and bolls, causing a reduction of overall lint yield as well as lint quality. In Arkansas, cotton producers will often make 4–6 insecticide applications to control TPB to protect yield (Cook, 2019). Multiple insecticide applications are costly for cotton producers and reduce profitability. It is recommended that producers budget approximately $100/ac for control of TPB throughout the season (Division of Agriculture, 2019). Mid-South cotton producers seek insecticides that deliver a high level of efficacy and residual control. The objectives of this study were to evaluate the efficacy and residual control of insecticides labeled and recommended for use, watch for potential resistance issues, and provide the optimal chemical control strategies to keep Arkansas cotton producers profitable.

Procedures

As one location of a regional mid-South project, a study was conducted in 2020 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station. The results of this study were compared to similar ones across the mid-South so that the best methods of control could be determined. The plot size was 12.5 ft (4 rows) by 50 ft long. A total of 10 treatments were used in this study, including an untreated check (UTC) (Table 1). The first treatment was initiated when TPB densities reached the action threshold of 6 TPB per 10 row feet. A second application was made 7 days later after the majority of treatments once again reached 6 TPB per 10 row feet. Applications were made using a Bowman Mudmaster (Bowman Manufacturing Newport, Arkansas) at a pressure of 40 psi and a rate of 10 GPA. Tarnished plant bug densities were determined using a 2.5 ft drop cloth and taking two samples per plot for a total of 10 row feet. Plots were sampled at 4 and 7 days after the first application (4 DAA1, 7 DAA1) and 4, 7, and 11 days after the second application (4 DAA2, 7 DAA2, 11 DAA2). Data were processed using Agriculture Research Manager Version 10, analysis of variance, and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

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Results and Discussion

At 4 DAA1, all treatments reduced plant bug densities compared to the UTC (Fig. 1). There was no significant difference between Transform, Centric, Brigade + Orthene, and Vydate, which all reduced TPB populations below the threshold. At 7 DAA1, Centric and Transform were the only treatments to keep TPB densities below the threshold, but were not significantly different from Brigade + Orthene, Bidrin, or Diamond (Fig 2). At 4 DAA2, Brigade + Orthene, Orthene, and Transform provided better control of TPB than Carbine or Couraze Max (Fig. 3). All treatments reduced TPB densities compared to the UTC, but Carbine and Couraze Max did not reduce the population below the threshold. At 7 DAA2, Vydate, Centric, Carbine, and Couraze Max began to lose control, and TPB populations exceeded the threshold (Fig. 4). Plots receiving Diamond, Transform, and Orthene reduced plant bug populations below threshold 7 DAA2. At 11 DAA2, Transform, Diamond, Orthene, and Brigade + Orthene provided greater control than Carbine, Couraze Max, and Vydate (Fig 5). Overall, this study indicated that Diamond, Transform, Orthene, and Brigade + Orthene performed consistently better than the other insecticides. Carbine and Couraze Max did not provide the protection needed to prevent crop damage. Studies should continue to monitor resistance, evaluate the efficacy of currently available insecticides, and evaluate experimental compounds that may be available in the future.

Practical Applications

Using a product that does not provide a good level of control could result in increased applications being required, which could drastically reduce the producer's profits. The information provided by this research validates the current insecticide recommendations and aid in maintaining the profitability of mid-South cotton producers. These data provide information for best management practices for control of TPB in mid-South cotton production.

Acknowledgments

We would like to thank Cotton Incorporated for their support of this work. We would also like to thank the staff at the Lonoke Extension office and the staff at the Lon Mann Cotton Research Station for their support with this study. Support was also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Cook, D.R. and M. Threet. 2019. Cotton Insect Loss Estimates for Arkansas. Mississippi State University Resources, www.biochemistry.msstate.edu/resources/2019loss.php

Division of Agriculture. 2019 Crop Enterprise Budgets for Arkansas Field Crops planted in 2019. University of Arkansas System Division of Agriculture Cooperative Extension Service, Fayetteville. Available at: https://www.uaex.edu/farm-ranch/economics-marketing/farm-planning/Budget_Manuscript_2019.pdf

Table 1. Trade names and rates of insecticides applied in a trial conducted to evaluate control of tarnished plant bugs at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna during 2020.

Trade Name	Active Ingredient	Rate
Transform	Sulfoxaflor	1.5 oz/ac
Centric	Thiamethoxam	2.0 oz/ac
Vydate	Oxamyl	12.8 oz/ac
Orthene	Acephate	0.77 lb/ac
Brigade + Orthene	Bifenthrin + Acephate	6 oz/ac + 0.77 lb/ac
Bidrin	Dicrotophos	8.0 oz/ac
Couraze Max	Imidacloprid	1.9 oz/ac
Carbine	Flonicamid	2.85 oz/ac
Diamond	Novaluron	9.0 oz/ac

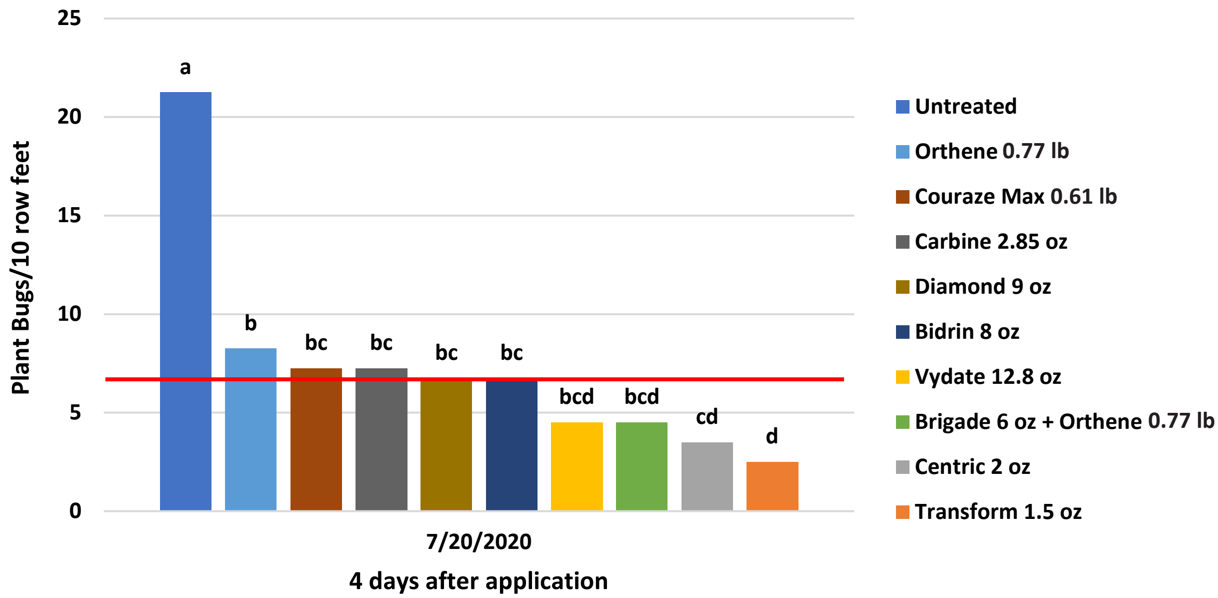

Fig. 1. Plant bug population 4 days after the first application of all evaluated insecticides on cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, in 2020. Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means. The red line marks the action threshold of 6 tarnished plant bugs per 10 row feet.

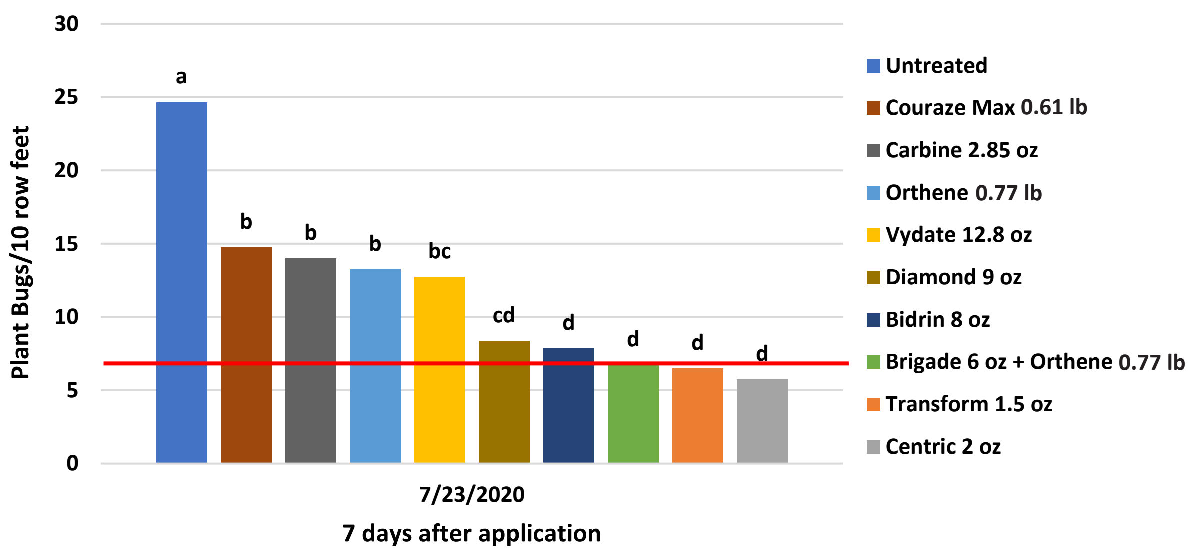

Fig. 2. Plant bug population 7 days after the first application of all evaluated insecticides on cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, in 2020. Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means. The red line marks the action threshold of 6 tarnished plant bugs per 10 row feet.

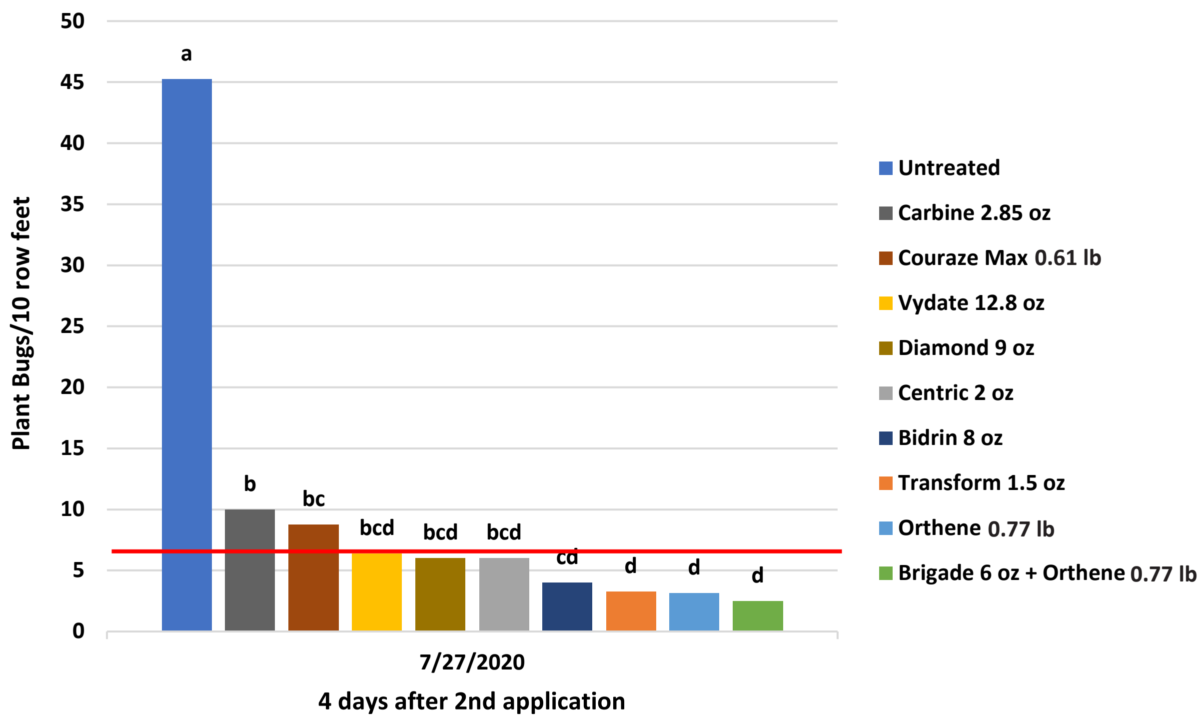

Fig. 3. Plant bug population 4 days after the second application of all evaluated insecticides on cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, in 2020. Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means. The red line marks the action threshold of 6 tarnished plant bugs per 10 row feet.

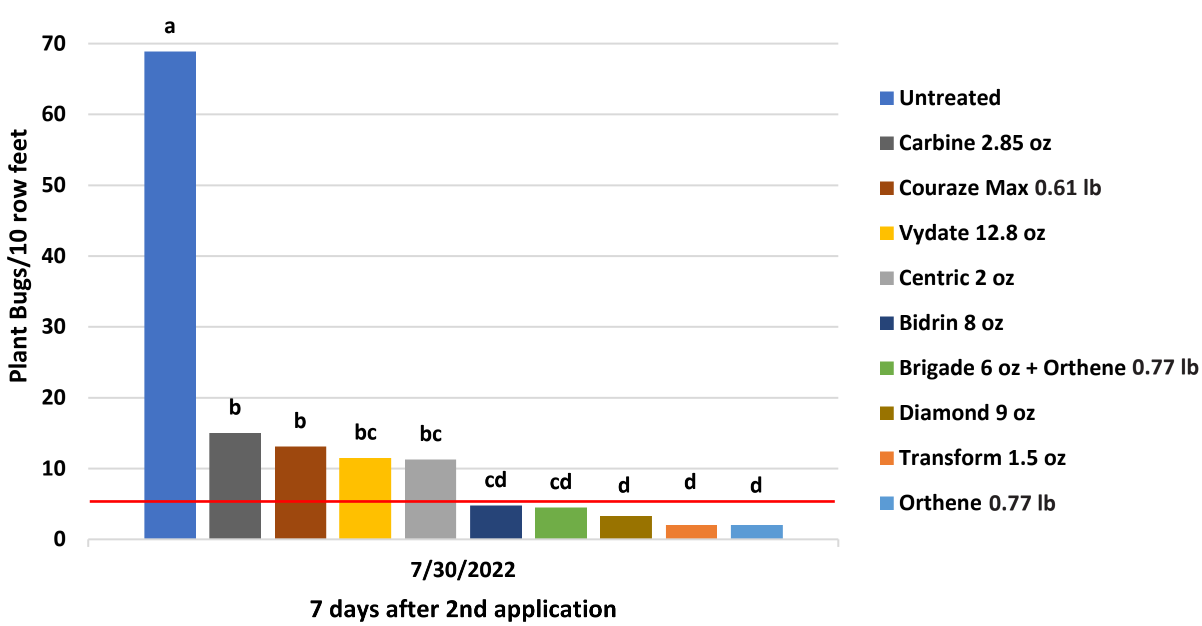

Fig. 4. Plant bug population 7 days after the second application of all evaluated insecticides on cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, in 2020. Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means. The red line marks the action threshold of 6 tarnished plant bugs per 10 row feet.

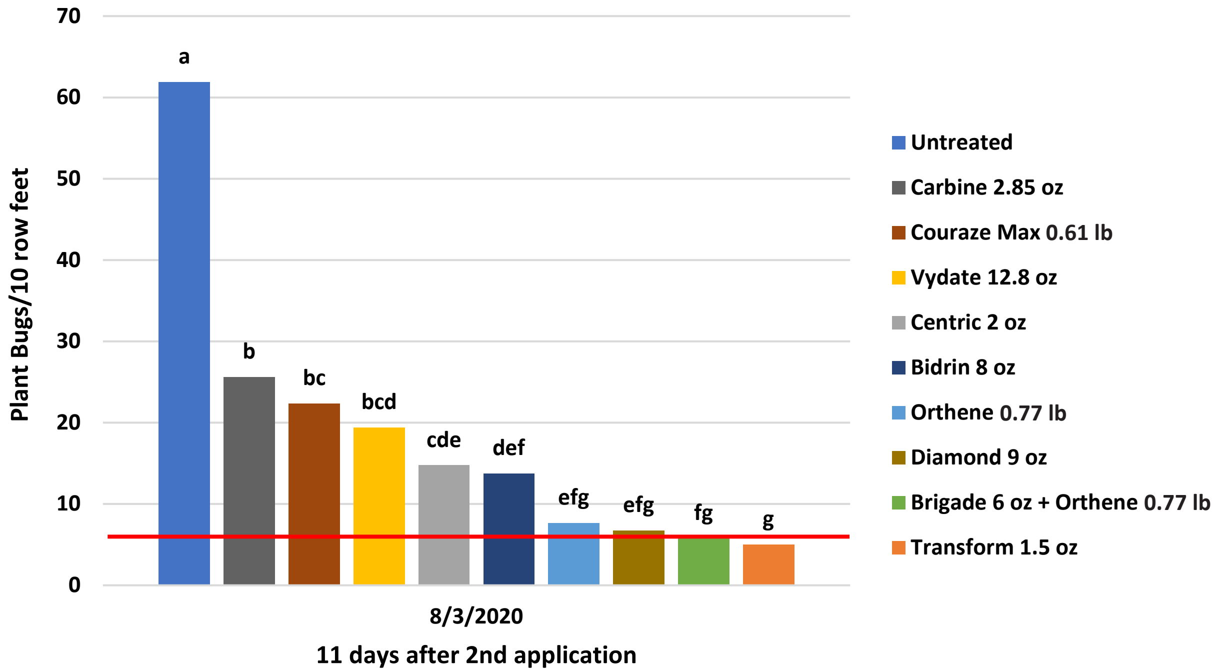

Fig. 5. Plant bug population 11 days after the second application of all evaluated insecticides on cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, in 2020. Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means. The red line marks the action threshold of 6 tarnished plant bugs per 10 row feet.

Large Block Evaluation of Thryvon Cotton Against Tobacco Thrips and Tarnished Plant Bug

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Abstract

Thryvon is a new *Bt* technology that will help cotton growers manage two major insect pests of cotton including tobacco thrips and tarnished plant bugs. Thryvon and non-Thryvon cotton were planted at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station and evaluated for thrips and tarnished plant bug densities. Both Thryvon and non-Thryvon cotton contained a treatment that was managed or unmanaged for plant bugs. Both the managed and non-managed Thryvon cultivar had lesser densities of both thrips and tarnished plant bugs and produced greater yields when compared to either of the non-Thryvon treatments. This technology will reduce insecticide applications and help growers manage these pests.

Introduction

A new transgenic *Bt* cotton technology, known as Thryvon™, will be released on limited acreage to growers in 2021. Cotton plants containing the Thryvon technology produce the Cry51Aa2 protein to control several species of insect pests. These include two major pests of Arkansas cotton, tobacco thrips (*Frankliniella fusca*) and tarnished plant bug (*Lygus lineolaris*). Both insects have become resistant to multiple insecticide classes, and new control methods are greatly needed (Herbert and Kennedy, 2015; Snodgrass, 1996). The objective of this study was to evaluate the effectiveness of Thryvon cotton on tobacco thrips and tarnished plant bug.

Procedures

Cotton was planted at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station on 26 May 2020. Plots were planted on 38-inch rows, 0.5 acres in size, with 3 replications. There were 4 total treatments, a Thryvon and non-Thryvon cultivar, with each cultivar containing a plot that was either managed or unmanaged for plant bugs. No treatments were made for thrips. Plots were arranged in a randomized complete block design. Thrips samples were taken on 11 June by collecting 5 plants per plot and placing them in jars with 70% alcohol solution. Samples were washed and filtered in the lab at the Lonoke Agricultural Extension and Research Center, Lonoke, Arkansas, and thrips were counted using a dissection scope. Managed plots were treated with Orthene or Transform when plant bug densities reached 3 per 5 row feet on a black drop cloth and 6 per 5 row feet after cotton reached cutout on 14 August. Treatments were applied with a multi-boom equipped Mudmaster sprayer and delivering 10 GPA through TeeJet TX-VS6 hollow cone nozzles. Data were processed using Agriculture Research Manager Version 10, Analysis of variance, and Duncan's New Multiple Range Test (P = 0.10) to separate means.

Results and Discussion

The Thryvon technology greatly reduced thrips densities when compared non-Thryvon cultivar (Fig. 1). In the non-managed plots, plant bug densities were lesser in the Thryvon cultivar than in the non-Thryvon cultivar at 2 of the 8 sample dates (Table 1). In the managed plots, the Thryvon cultivar had lesser plant bug densities than the non-Thryvon cultivar in 3 of the 8 sample dates. Both Thryvon and non-Thryvon cultivars received the same number of applications for plant bugs. In the managed plots, square retention was

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never different between the Thryvon and non-Thryvon cultivars at any sample date (Table 2). However, in the non-managed plots square retention was greater in the Thryvon cultivar than the non-Thryvon cultivar at 3 of the 7 sample dates. There were no differences in boll damage between any treatments. No yield differences were found between the managed and non-managed Thryvon cotton, however both Thryvon treatments, regardless of management strategy, yielded greater than both the managed and non-managed non-Thryvon treatments. (Fig. 2). The lack of yield differences between the managed and non-managed Thryvon cultivars indicates our current plant bug thresholds may not fully apply to this new technology and should be reevaluated.

Practical Applications

Thrips and tarnished plant bugs are major insect pests of cotton in Arkansas and are becoming more difficult to control each year. Thryvon technology will provide another management option for these pests.

Acknowledgments

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

Literature Cited

Snodgrass, G.L. 1996. Insecticide resistance in field populations of the tarnished plant bug (*Heteroptera: Miridae*) in cotton in the Mississippi delta. J. Econ. Ento. 89(4): 783–790. https://doi.org/10.1093/jee/89.4.783

Herbert, A., and G. Kennedy. 2015. New survey shows high level and widespread resistance of thrips to neonicotinoid insecticides. Available at: https://blogs.ext.vt.edu/ag-pest-advisory/files/2015/02/NeonicThripsResistance.pdf

Table 1. Tarnished plant bug densities over time in Thryvon and non-Thryvon cotton cultivars that were either managed or non-managed for plant bugs at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station Marianna, Arkansas, in 2020.

	Sample Date							
	13-July	17-July	20-July	27-July	3-August	7-August	14-August	18-August
	------------------------------Number of tarnished plant bugs/5 row ft----------------------------------							
Thryvon Managed	6.0 c†	5.0 a‡	1.2 c	2.6 b	5.2 b‡	4.4 a‡	1.8 c	0.9 b
Non-Thryvon Managed	8.0 b†	7.0 a‡	1.8 bc	2.6 b	4.8 b‡	5.4 a‡	4.8 b	5.2 a
Thryvon	8.0 b	8.8 a	5.6 ab	4.7 a	10.2 a	5.3 a	5.4 b	7.4 a
Non-Thryvon	9.0 a	12.2 a	9.5 a	4.5 a	8.3 ab	6.8 a	8.3 a	7.4 a

† Treated with 1.5 oz/ac Transform.

‡ Treated with 0.75 lb/ac Orthene.

Table 2. Percent square retention and boll damage over time in Thryvon and non-Thryvon cotton cultivars that were either managed or non-managed at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station Marianna, Arkansas, in 2020.

	Sample Date						
	16-July	20-July	27-July	3-August	7-August	14-August	18-August
	----------------------------% Square Retention-----------------------------						% Boll Damage
Thryvon Managed	94.0 a	91.7 a	92.7 a	92.7 a	89.3 ab	90.0 a	1.7 a
Non-Thryvon Managed	85.0 a	86.0 ab	87.3 a	88.0 ab	85.3 b	82.7 a	8.3 a
Thryvon	90.0 a	91.3 a	90.0 a	86.7 b	92.0 a	86.0 a	13.3 a
Non-Thryvon	90.0 a	83.3 b	83.3 a	79.3 c	72.0 c	78.0 a	18.3 a

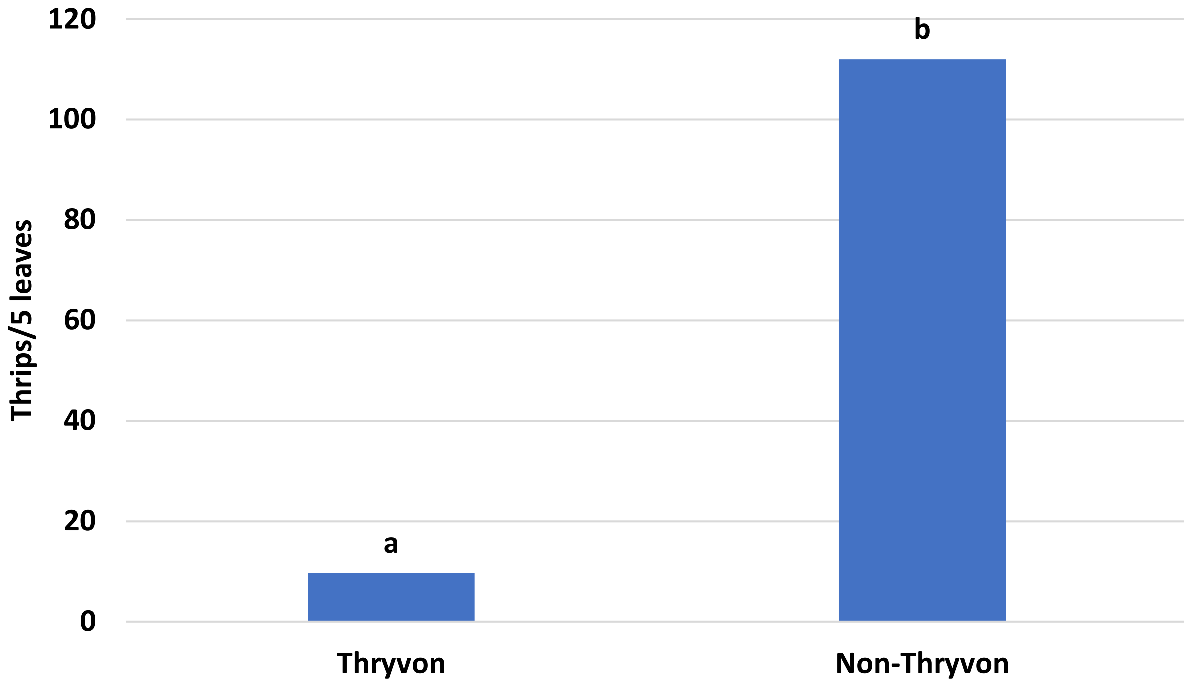

Fig. 1. Comparison of thrips densities between Thryvon and non-Thryvon cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas in 2020. Means followed by the same letter are not significantly different.

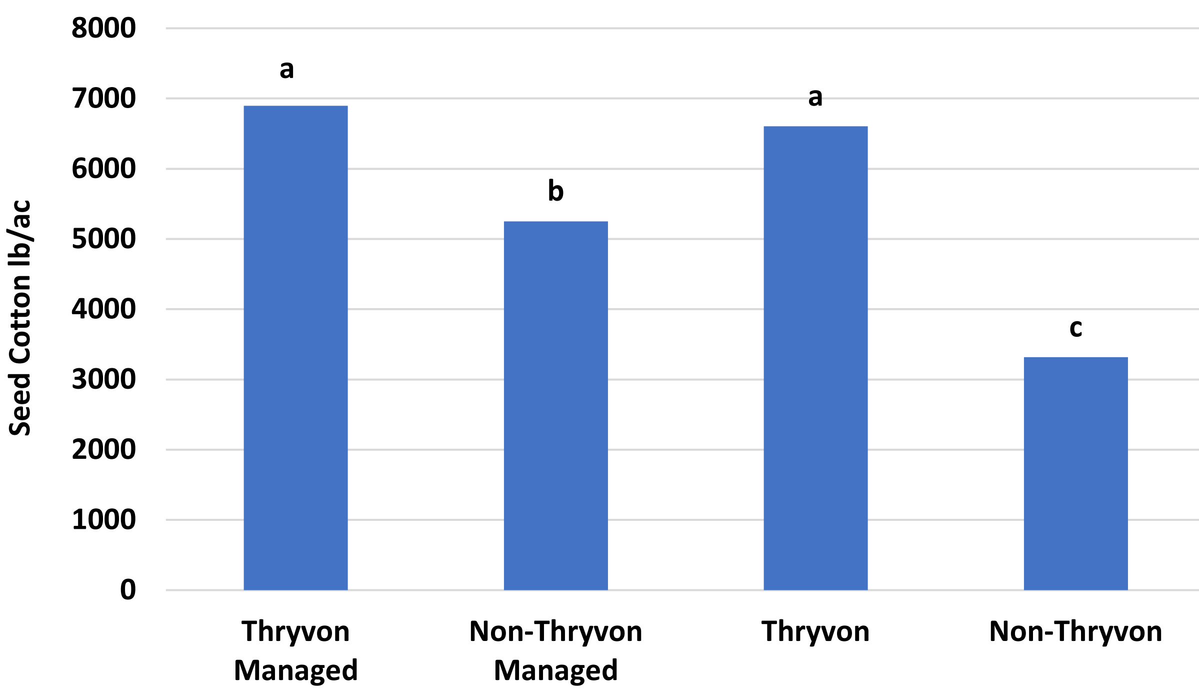

Fig. 2. Yields of Thryvon and non-Thryvon cotton that was managed or non-managed for tarnished plant bug at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas in 2020. Means followed by the same letter are not significantly different.

Efficacy of Selected Insecticides for Control of *Helicoverpa zea* in Non-*Bacillus thuringiensis* Cotton

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Abstract

A test was conducted on a grower field in 2020 in Drew County, Arkansas, to evaluate the efficacy and residual control of selected foliar insecticides and rates on cotton bollworm in non-*Bacillus thuringiensis (Bt)* cotton. Selected insecticides included Prevathon, Besiege, Intrepid Edge, Brigade + Prevathon, Brigade + Acephate, and an untreated check. Results indicate that Prevathon and Prevathon + Brigade provided an increase in residual control when compared to Intrepid Edge. A similar trend was observed for yield. These data suggest that growers should be using a diamide to get the highest efficacy and greatest protection from cotton bollworm.

Introduction

Historically, the cotton bollworm, *Helicoverpa zea* (Boddie), has 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). 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 cotton bollworm has been increasing in recent years. This has led to the development of a new treatment threshold for the mid-South of 6% damaged fruit, with bollworms present, or eggs present on 25% of plants (Studebaker et al., 2018). High costs associated with technology fees for cotton bollworm control have encouraged growers and consultants to look for ways to reduce costs. Planting conventional (non-*Bt*) cotton and using foliar insecticides for cotton bollworm control may be a more cost-effective way to grow cotton in the mid-South. The objective of this study was to determine which insecticides will provide the highest level of efficacy and residual control for cotton bollworm in non-*Bt* cotton.

Procedures

A trial was conducted on a grower field in Drew County, Arkansas, on a non-*Bt* cotton cultivar (PHY 425 RF) in 2020. Plot size was 12.5 ft (4 rows) by 40 ft. Treatments were arranged in a randomized complete block design with 4 replications. Treatments included: untreated check (UTC), Prevathon (*chlorantraniliprole*) 14 and 20 oz/ac, Prevathon 14 and 20 oz/ac + Brigade (*bifenthrin*) 6.4 oz/ac, Besiege (*chlorantraniliprole* + *lambda-cyhalothrin*) 7.2 and 10.2 oz/ac, Intrepid Edge (*methoxyfenozide* + *spinetoram*) 8 oz/ac, Acephate 97UP (*acephate*) 0.75 lb/ac + Brigade 6.4 oz/ac, Radiant (*spinetoram*) 5 oz/ac + Brigade 6.4 oz/ac. Insecticides were applied using a Mud Master high clearance sprayer fitted with TXVS-6 nozzles at 19.5-in. spacing with a spray volume of 10 gal/ac at 40 psi. Damage was rated by sampling 25 squares, flowers, and bolls per plot. Ratings were taken 3, 7, 14, and 21 days after application (DAA). The data were processed using Agriculture Research Manager 2020 (Gylling Data Management, Inc., Brookings, S.D.) with Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

All treatments had less damage than the untreated check at 7, 10, 14, and 21 DAA (Figs. 1–4). Results indicated that at 7 DAA, Prevathon 20 oz/ac plus Bifenthrin 6.4 oz/ac had less fruit damage than Radiant 5 oz/ac plus Bifenthrin 6.4 oz/ac and Besiege 7.2 oz/ac (Fig. 1). Prevathon at 14 oz/ac and 20 oz/ac plus Bifenthrin 6.4 oz/ac had less fruit damage than Radiant 5 oz + Bifenthrin 6.4 oz at 10 DAA. (Fig 2). At 14 DAA Prevathon 20 oz/ac + Bifenthrin 6.4 oz/ac had less

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damage than Acephate 0.75 lb/ac plus Bifenthrin 6.4 oz/ac (Fig. 3). At 21 DAA, Prevathon 14 oz/ac alone and Prevathon 14 oz/ac and 20 oz/ac with Bifenthrin 6.4 oz/ac had less fruit damage than Intrepid Edge 8 oz (Fig. 4).

Foliar insecticide application increased yield 138–880 lb seed cotton/ac above the UTC (Fig. 5). All treatments except for Intrepid Edge 8 oz had a higher yield than the UTC. Prevathon 20 oz plus Bifenthrin 6.4 oz had a higher yield than Besiege 7.2 oz, Prevathon 14 oz plus Bifenthrin 6.4 oz, Acephate 0.75 lb plus Bifenthrin 6.4 oz, and Radiant 5 oz plus Bifenthrin 6.4 oz.

Practical Applications

Cotton bollworm continues to be a major pest of cotton in the mid-South. With increasing technology fees associated with *Bt* cotton, growers could possibly grow non-*Bt* cotton and spray for cotton bollworm cheaper than growing *Bt* cotton. These data suggest that if growers decide to grow non-*Bt* cotton that using Prevathon at high rates with or without bifenthrin would provide adequate control of cotton bollworm and provide a long residual control of this pest.

Acknowledgments

The authors would like to thank Cotton Incorporated for funding of this project, as well as A.J. Hood and Tillar and Company for allowing us to conduct research on their land. Support was also provided by Corteva and Syngenta and by the University of Arkansas System Division of Agriculture for this research.

Literature Cited

Studebaker, G., N. Bateman, J. Davis, J. Hopkins, D.R. Johnson, J. Lee, K. Loftin, G. Lorenz, P. Spradley, J. Zawislak, D.T. Johnson, N. Joshi, and T. Teague. 2018. Cotton Insect Control. pp. 79. MP144 2018 Insecticide Recommendations for Arkansas.

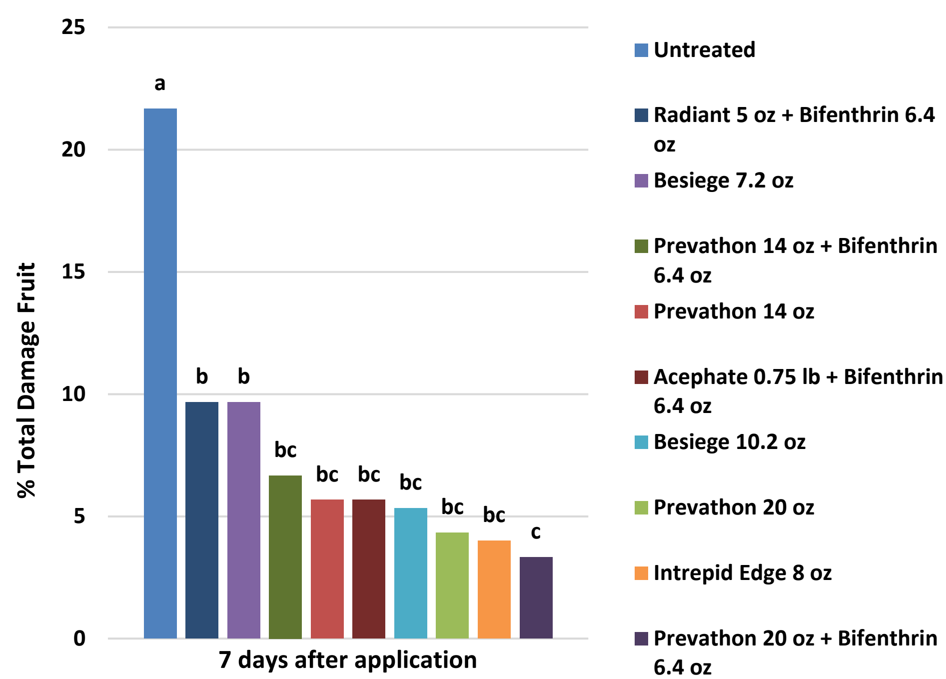

Fig. 1. Efficacy of selected insecticides at 7 days after application for control of bollworm. Means followed by the same letter are not significantly different.

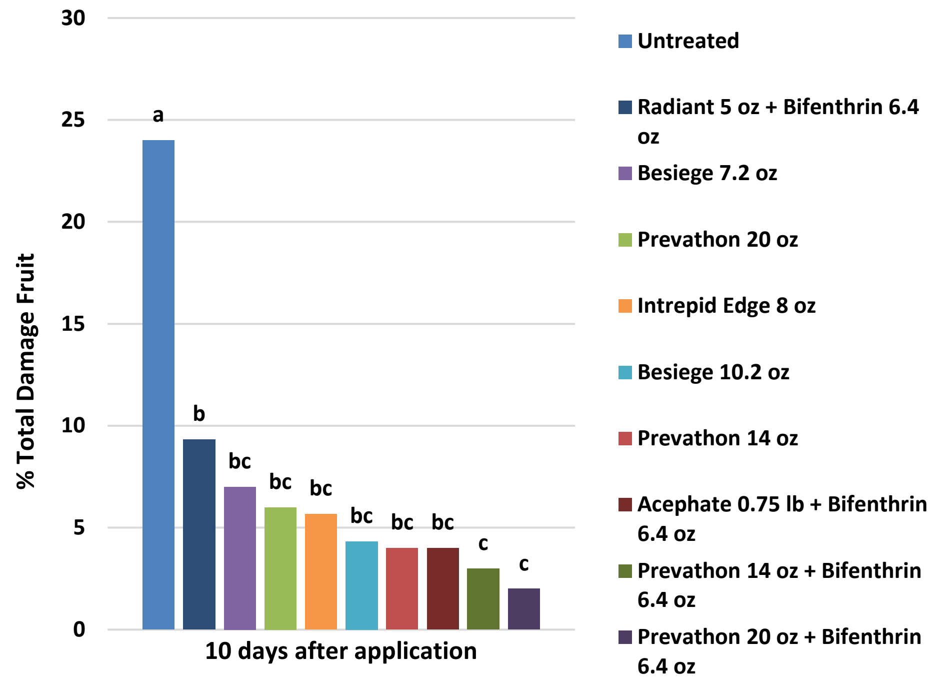

Fig. 2. Efficacy of selected insecticides at 10 days after application for control of bollworm. Means followed by the same letter are not significantly different.

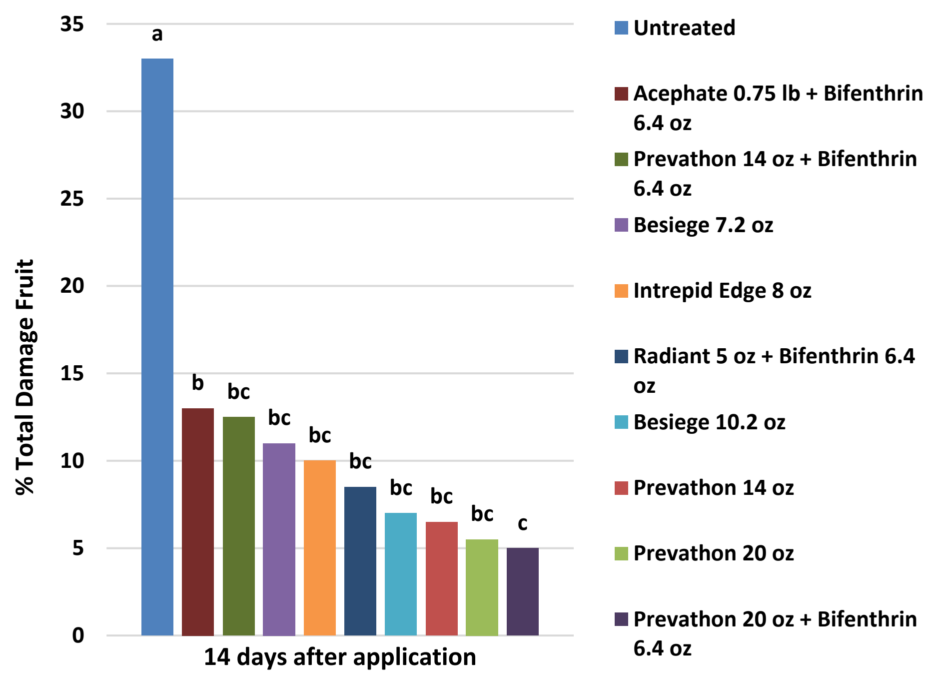

Fig. 3. Efficacy of selected insecticides at 14 days after application for control of bollworm. Means followed by the same letter are not significantly different.

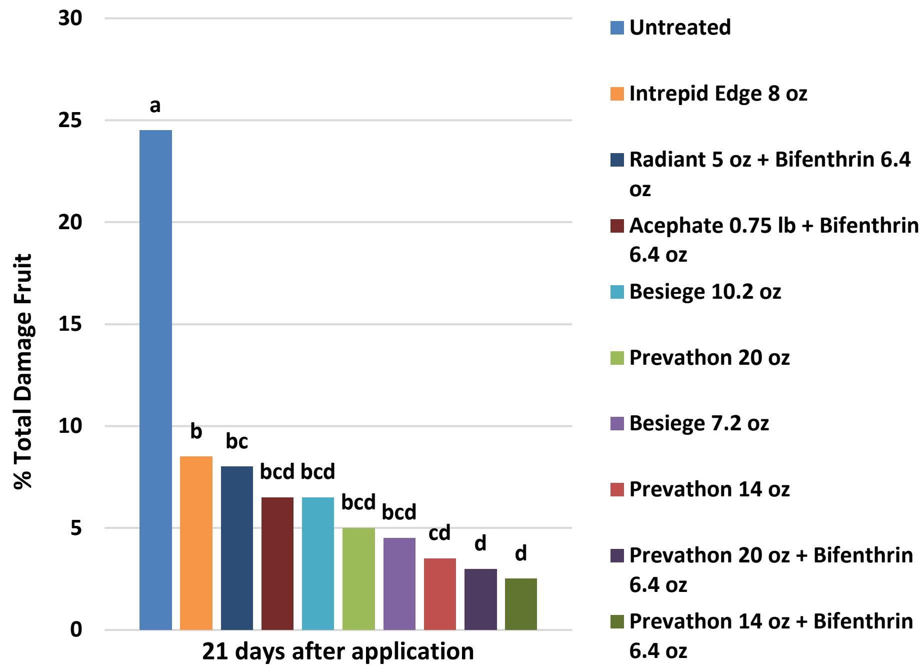

Fig. 4. Efficacy of selected insecticides at 21 days after application for control of bollworm. Means followed by the same letter are not significantly different.

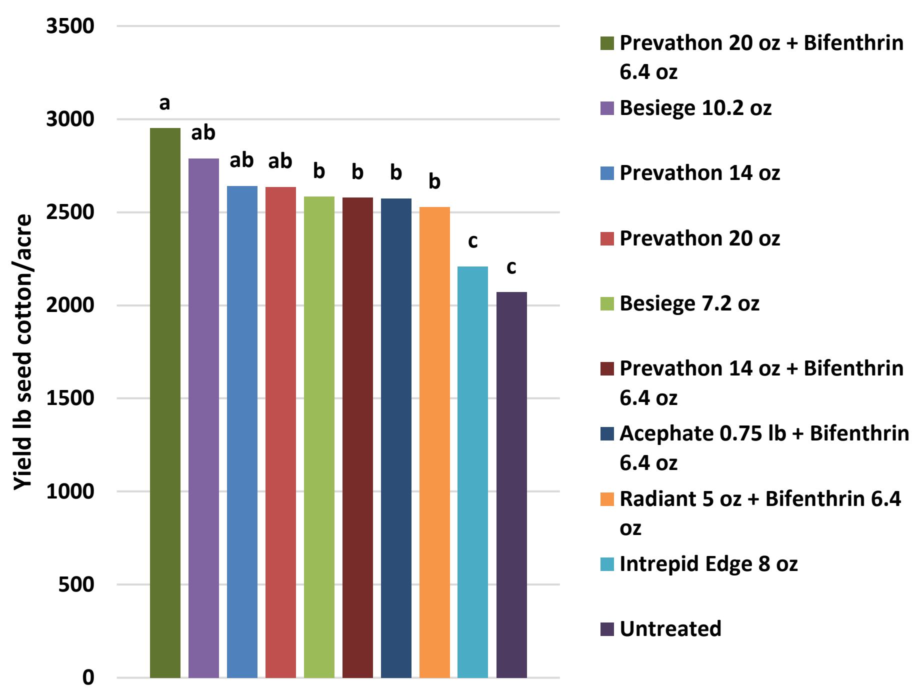

Fig. 5. Yield data for non-*Bt* cotton sprayed with selected insecticides for control of bollworm. Means followed by the same letter are not significantly different.

Comparison of Transgenic *Bacillus thuringiensis* Technologies in Arkansas Cotton Systems for Control of Cotton Bollworm, *Helicoverpa zea*

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Abstract

Cotton bollworm (*Helicoverpa zea*) is a major pest of cotton and can cause severe yield loss if not controlled. One of the most common methods of controlling this pest is the use of transgenic *Bacillus thuringiensis (Bt)* technologies. An experiment was conducted in Drew County, Arkansas, in 2020 to evaluate the efficacy of several *Bt* technologies. In this trial unsprayed three gene cultivars had similar levels of damage as the two gene cultivar when sprayed with Prevathon at 20 oz/ac. Results indicate that dual gene cultivars may require supplemental foliar applications to manage high populations of bollworm. Triple gene cultivars yielded greater than Bollgard II and did not require a supplemental insecticide application to control bollworm.

Introduction

Cotton is a high input crop, and many growers are struggling to profit due to the increasing production costs and stagnant cotton prices. Finding ways to reduce production costs is imperative. Each year cotton bollworm (*Helicoverpa zea*, Bodie) infests 100% of all cotton planted in Arkansas (Cook, 2019). Despite the widespread use of dual gene transgenic *Bacillus thuringiensis* (*Bt*) cotton cultivars, cotton bollworm remains a major pest of flowering cotton, and foliar insecticides are often needed to supplement control. Fleming et al. (2018) conducted studies in 2017 that indicated widespread resistance to Cry1Ac, a major protein used in *Bt* cotton. Recent research has established a new bollworm threshold based on damaged fruit rather than insect numbers, with the new threshold being set at 6% fruit damage with larvae present. Because of the high technology fees associated with these traits and the growing concern of *Bt* resistance, it is important to monitor the efficacy of these traits. Of particular interest are comparisons of dual gene cultivars to the newer three gene cultivars. The objective of this study was to determine if two or three gene cotton is more cost-effective for growers to plant, with the understanding that the two gene cotton may need supplemental foliar applications to control bollworm.

Procedures

Cotton was planted 12 May 2020 in Drew County, Arkansas, to evaluate two and three gene cotton for control of cotton bollworm. Plot size was 12.5 ft (4 rows) by 40 ft long, in a split block design with 4 replications. Cultivars included: Non-*Bt* (DP 1822 XF); WideStrike 3 (PHY 400 W3FE); TwinLink Plus (ST 5471 GLTP); Bollgard 2 (DP 1518 B2XF); Bollgard 3 (DP 1845 B3XF). Each cultivar had both an unsprayed treatment and a treatment that was sprayed with Prevathon 20 oz/ac. The Prevathon application was made on 28 July using a Mudmaster high clearance sprayer fitted with TXVS-6 flat fan nozzles at 19.5-in. spacing with a spray volume of 10 gal/ac, at 40 psi. Damage ratings were taken 3, 7, 10, 14, and 21 days after application (DAA) by sampling 25 squares, 25 flowers, and 25 bolls per plot when present. The data were processed using Agriculture Research Manager 2019 (Gylling Data Management, Inc., Brookings, S.D.) and Duncan's New Multiple Range with an alpha level of $P = 0.05$.

Results and Discussion

At every sampling date, the unsprayed non-Bt cultivar had greater damage than all other cultivars (sprayed or un-

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sprayed) and the sprayed non-*Bt* cultivar (Figs. 1–5). No differences in damaged fruit were found among the Widestrike 3, TwinLink Plus and Bollgard 3 technologies (sprayed or unsprayed) and the sprayed BollGard 2. Damage in the unsprayed Bollgard 2 was equal to other technologies (sprayed and unsprayed) at 3 and 7 DAA, but was higher at 10 and 14 DAA

The Prevathon application increased yield in the non-*Bt*, Bollgard II, and Twinlink Plus cultivars (Fig. 6). This study indicates that Bollgard 2, when sprayed with Prevathon at 20 oz/ac had similar damage as unsprayed Bollgard 3 cultivars. The dual gene cotton cultivars may not provide the protection needed to prevent fruit damage from bollworms and may require additional foliar applications to keep damage at an acceptable level. Only one of the triple gene cultivars, Twinlink Plus, benefited from a foliar insecticide application for control of bollworm. Studies should be continued to monitor these trends and keep growers informed.

Practical Applications

Resistance has recently been recorded in cotton bollworm to two gene cotton cultivars. These results imply that growers planting dual gene cultivars should budget at least one application of a diamide to prevent yield loss. Triple gene cultivars appear to provide sufficient control of bollworm but should still be monitored to prevent unexpected yield loss. Growers should consider yield potential first and then technology when selecting cultivars, but be aware that dual gene cultivars may need a supplemental foliar application for worm control.

Acknowledgments

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

Literature Cited

Cook, D.R. 2019. 2018 Cotton Insect Losses. pp. 721-780. *In:* Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, Texas. 3-5 Jan. National Cotton Council, Memphis, Tenn.

Fleming D, F. Musser, D. Reisig, J. Greene, S. Taylor, M. Parajulee, G. Lorenz, A. Catchot, J. Gore, D. Kerns, S. Stewart, D. Boykin, M. Caprio, and N. Little. 2018. Effects of transgenic *Bacillus thuringiensis* cotton on insecticide use, heliothine counts, plant damage, and cotton yield: A meta-analysis, 1996-2015. PLoS ONE 13(7): e0200131. https://doi.org/10.1371/journal.pone.0200131

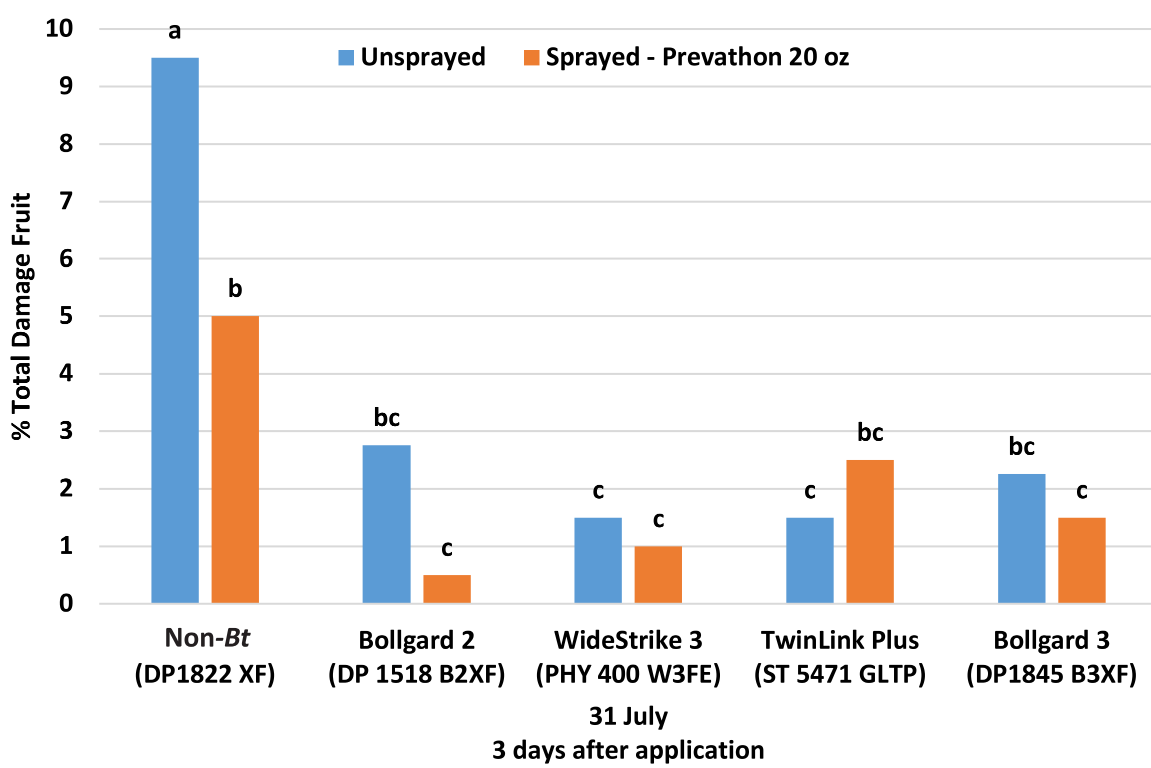

Fig. 1. Combined damage of 25 squares, 25 flowers, and 25 bolls 3 days after application of Prevathon 20 oz/ac in Drew County, Arkansas. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

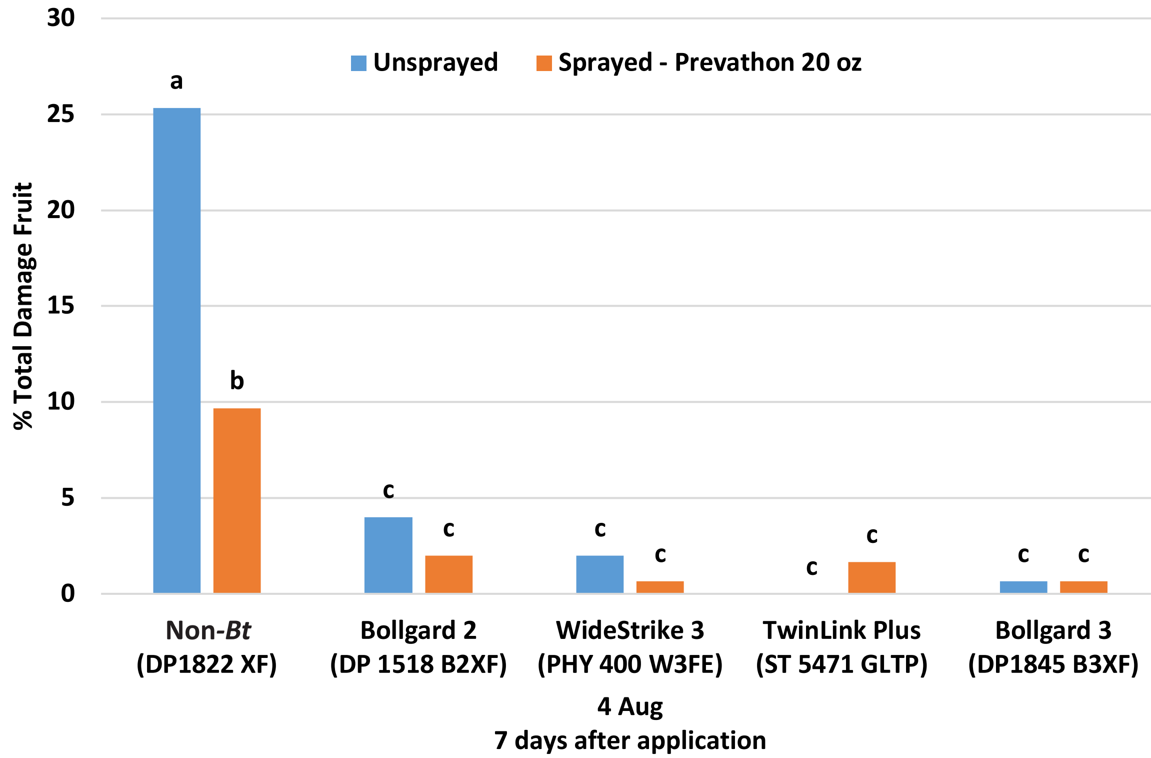

Fig. 2. Combined damage of 25 squares, 25 flowers, and 25 bolls 7 days after application of Prevathon 20 oz/ac in Drew County, Arkansas. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

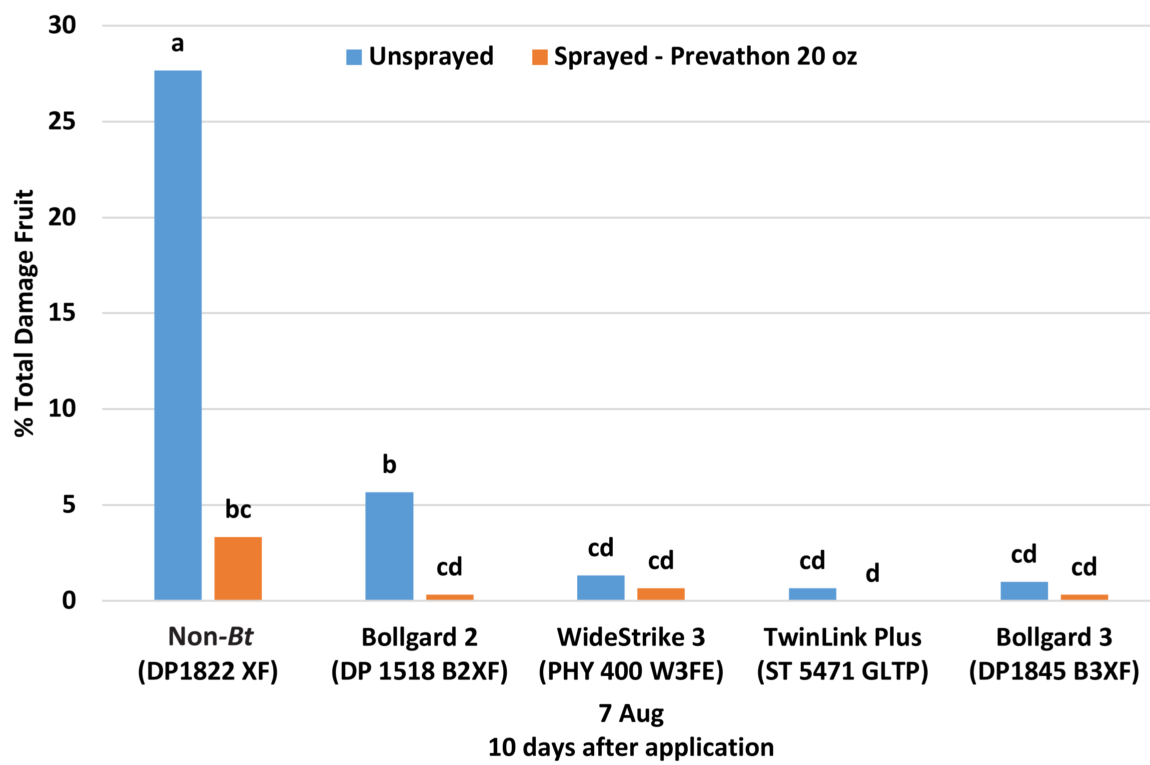

Fig. 3. Combined damage of 25 squares, 25 flowers, and 25 bolls 10 days after application of Prevathon 20 oz/ac in Drew County, Arkansas. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

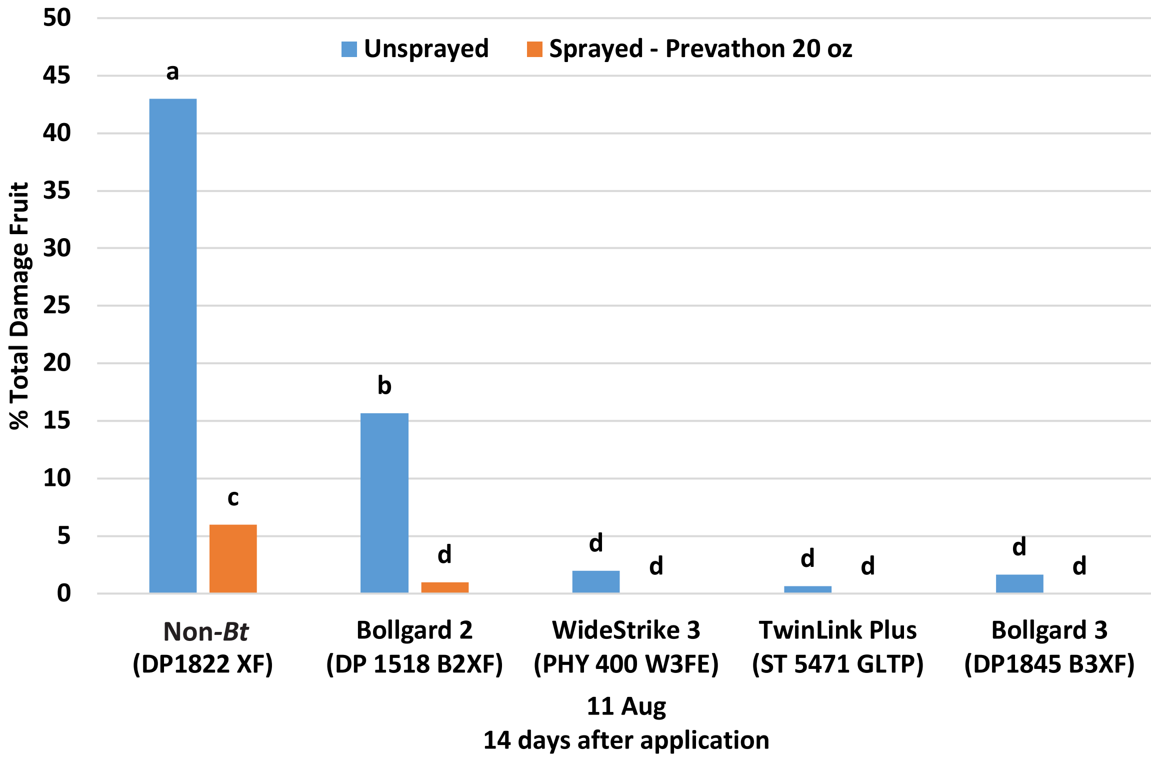

Fig. 4. Combined damage of 25 squares, 25 flowers, and 25 bolls 14 days after application of Prevathon 20 oz/ac in Drew County, Arkansas. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

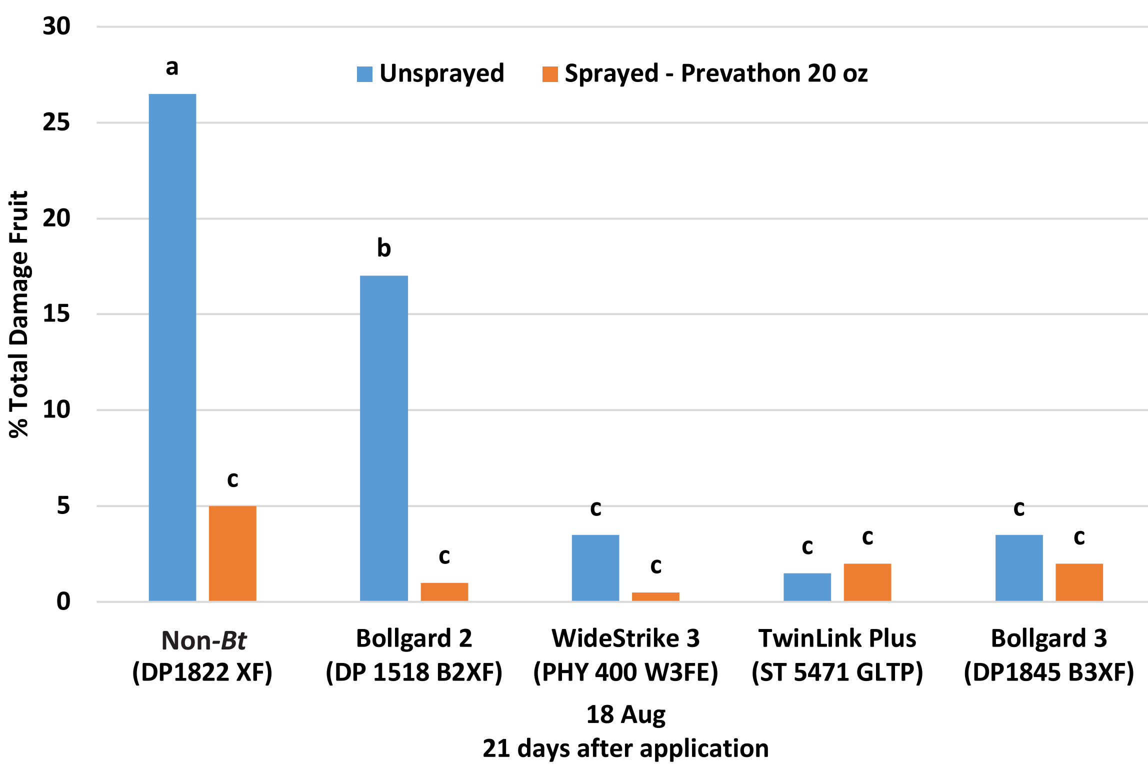

Fig. 5. Combined damage of 25 squares, 25 flowers, and 25 bolls 21 days after application of Prevathon 20 oz/ac in Drew County, Arkansas. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

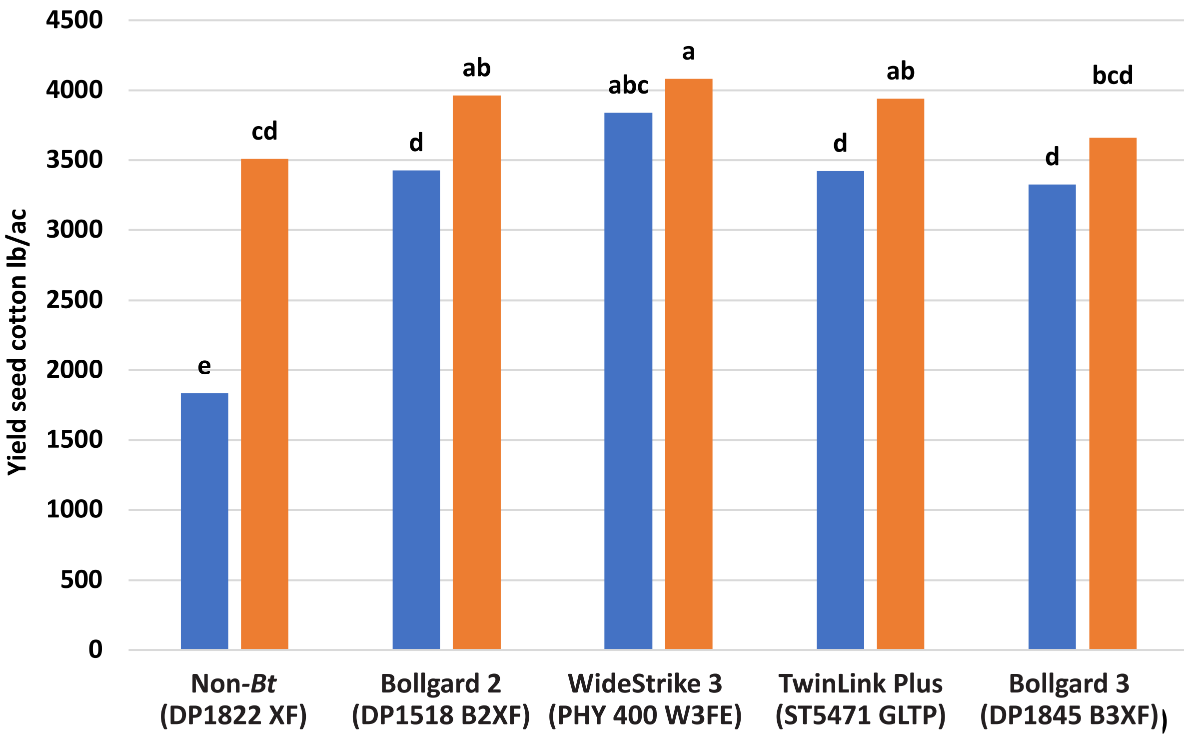

Fig. 6. Yield of non-*Bacillus thuringiensis (Bt)*, two *Bt* gene, and three *Bt* gene cotton cultivars, with and without an application of Prevathon. Treatments with the same letter are not significantly different according to Fisher's protected least significant difference at α = 0.05.

Impact of Integrated Weed Management Strategies on Palmer Amaranth in Cotton

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Abstract

Multiple herbicide-resistant weeds have resulted in a need to adopt a multifaceted approach to reduce selection pressure and mitigate the evolution of herbicide resistance. Previous studies have suggested that cover crops, deep tillage, zero-tolerance mechanical weed control, and the use of residual herbicides along with postemergence herbicides can all disrupt the emergence of weeds. A long-term study was initiated in Marianna, Arkansas, during the fall of 2018 to evaluate the influence of a one-time deep tillage, rye cover crop, dicamba- and non-dicamba-based herbicide programs, and zero-tolerance weed removal on Palmer amaranth (*Amaranthus palmeri* S. Wats.) emergence and density in the soil seedbank. This study was arranged as a split, split, split-plot with zero-tolerance being the whole-plot factor, deep tillage the sub-plot factor, cover crops the sub-sub-plot factor, and herbicide programs the sub-sub-sub-plot factor. Weed densities and emergence were measured in each plot at 21, 42, 63, and 72 days after planting, and inflorescence-producing weed counts were taken at harvest. Results from 2019 suggest that the use of deep tillage and zero-tolerance both reduced the amount of weed seed returned to the seedbank. Deep tillage reduced the number of inflorescence-producing weeds at the end of the season by 75%. Zero-tolerance reduced inflorescence-producing Palmer amaranth populations at the end of the season by 63%. Deep tillage also reduced cumulative, in-season Palmer amaranth emergence by 74%. This information will be beneficial in assisting crop producers on how to effectively control and reduce weed populations in an integrated manner.

Introduction

Palmer amaranth has developed resistance to eight different sites of action, limiting the number of effective chemical weed control options in cotton production systems (Heap, 2020). Previous research has found that by layering integrated weed management strategies such as chemical, mechanical, and cultural control methods, the evolution of herbicide resistance and weed populations may be curtailed (Beckie, 2011). Research investigating the utility of integrated practices for Palmer amaranth control found that cover crops and deep tillage were both effective in reducing Palmer amaranth emergence during the season (DeVore et al., 2012). Efforts have also been made in Arkansas to establish a “Zero-tolerance” threshold for Palmer amaranth, where no Palmer amaranth is permitted to reach maturity within a field. Such efforts have been found to be successful even within the first year (Barber et al., 2017). By preventing emergence and seed production, Palmer amaranth seedbanks may rapidly decline to nearly zero within 4 to 5 years (Korres et al., 2018). The objective of this study is to determine best management practices for long-term control of Palmer amaranth in cotton production systems.

Procedures

A long-term experiment was initiated in the fall of 2018 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas. The experiment was a randomized complete block with a split, split, split-plot arrangement of treatments with four replications. The main plot factor was with or without a one-time hand-weeding event at 77 days after planting to simulate a zero-tolerance program. The sub-plot factor was with or without a one-time deep tillage event to a depth of 6 inches during the fall of 2018. The sub-sub plot factor was with or without cereal rye cover crop, which was planted in November 2018 at 75 lb of seed/ac. The sub-sub-sub plot factor was the use of either a dicamba in-crop (Table 1) or a non-dicamba in-crop (Table 2) herbicide program. DP 1518 B2XF cotton cultivar was planted at 46,000 seeds/acre on 38-in. wide rows on 15 May 2019. Burndown applications were applied 14 days prior to planting, preemergence (PRE) application at planting, early postemergence (EPOST) application at 21 days after planting, mid-postemergence (MPOST) applications at 42 days after planting, and lay-by applications at 63 days after planting. Palmer amaranth

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counts were taken in four random quadrants measuring 2.7 ft^2 in each plot. Counts were taken 21, 42, 63, and 72 days after planting. The number of inflorescence-producing weeds was recorded from each plot immediately prior to harvest. Additionally, the time to hand-weed each plot was recorded to measure variability in time due to differences in weed densities. All data were analyzed using JMP Pro 14.2 and subjected to analysis of variance. Means were separated using Fisher's protected least significant difference ($\alpha = 0.05$).

Results and Discussion

The deep tillage event significantly reduced cumulative emergence of Palmer amaranth through 72 days after planting by 74% when averaged over cover crop and herbicide programs, reducing total emergence from 106,401 Palmer amaranth plants per acre to 25,683 Palmer amaranth per acre (Fig. 1). Deep tillage also reduced the amount of inflorescence-producing Palmer amaranth plants per acre by 75% when averaged over hand-weeding, cover crop, and herbicide programs, reducing the population from 576 plants/acre down to 145 plants/ac (Fig. 2). Hand weeding also significantly impacted the number of inflorescence-producing Palmer amaranth, reducing its density by 63% when averaged over all other factors (Fig. 3). The use of cover crops and either herbicide program was not found to significantly impact the cumulative emergence of Palmer amaranth (P = 0.448 and P = 0.678 respectively). The use of cover crops or either herbicide program also did not significantly impact the number of inflorescence-producing Palmer amaranth plants during the first year of this long-term study (P = 0.132 and P = 855 respectively). The lack of a cover crop effect may be the result of late planting of the cereal rye in 2018 which lessened its biomass production. No interactions were found to be significant during the first year of this study.

Practical Applications

When used as part of an integrated weed management system with a layered herbicide program, the use of deep tillage can significantly lower the amount of Palmer amaranth that may compete with cotton during the growing season. The use of deep tillage and a one-time hand-weeding event may both also reduce the number of Palmer amaranth plants that will produce seeds for future growing seasons, especially when used as part of an integrated program. By reducing or eliminating the number of seeds returned to the seedbank, weed populations will decline through continued stewardship.

Acknowledgments

The authors would like to thank Cotton Incorporated and the University of Arkansas System Division of Agriculture for their support of this research.

Literature Cited

Barber, L.T., J.K. Norsworthy, and A.M. Vangilder. 2015. A Community-Based Program for Glyphosate-Resistant Palmer Amaranth Management. University of Arkansas Cooperative Extension. Accessed on 12 February 2020. Available at: https://www.uaex.edu/publications/pdf/FSA2177.pdf

Beckie, H.J. 2011. Herbicide resistant weeds: management tactics and practices. Weed Technol. 20:793-814.

DeVore, J.D., J.K. Norsworthy, and K.R. Brye. 2012. Influence of deep tillage and a rye cover crop on glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) emergence in cotton. Weed Technol. 26:832–838.

Heap, I.M. 2020. International Survey of Herbicide Resistant Weeds. Accessed on 22 January 2020. Available at: http://www.weedscience.org/Summary/Species.aspx?WeedID=14

Korres, N.E., J.K. Norsworthy, B.G. Young, D.B. Reynolds, W.G. Johnson, S.P. Conley, R.J. Smeda, T.C. Mueller, D.J. Spaunhorst, K.L. Gage, M. Loux, G.R. Kruger, and M.V. Bagavathiannan. 2018. Seedbank persistence of Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus tuberculatus*) across diverse geographical regions of the United States. Weed Sci. 66:446-456.

Table 1. Dicamba in-crop herbicide program at Marianna, Arkansas in 2019.

Timing[a]	Herbicide	Rate
		(lb ai or ae/ac)
Burndown	Roundup PowerMAX	1.1
	Clarity	0.4
PRE	XtendiMax Plus VaporGrip	1.0
	Cotoran	1.0
EPOST	Tavium Plus VaporGrip	0.5 + 1.0
	Roundup PowerMAX	1.1
	Warrant	1.1
MPOST	Interline	0.6
	Roundup PowerMAX	1.1
	Warrant	1.1
Layby	Valor	0.06
	MSMA	2.0

[a] Abbreviations: PRE = preemergence, EPOST = early-postemergence, MPOST = mid-postemergence

Table 2. Non-dicamba in-crop herbicide program at Marianna, Arkansas in 2019.

Timing[a]	Herbicide	Rate
		(lb ai or ae/ac)
Burndown	Roundup PowerMAX	1.1
	Clarity	0.4
PRE	Gramoxone	0.6
	Cotoran	1.0
EPOST	Interline	0.6
	Roundup PowerMAX	1.1
	Warrant	1.1
MPOST	Interline	0.6
	Roundup PowerMAX	1.1
	Warrant	1.1
Layby	Valor	0.06
	MSMA	2.0

[a] Abbreviations: PRE = preemergence, EPOST = early-postemergence, MPOST = mid-postemergence

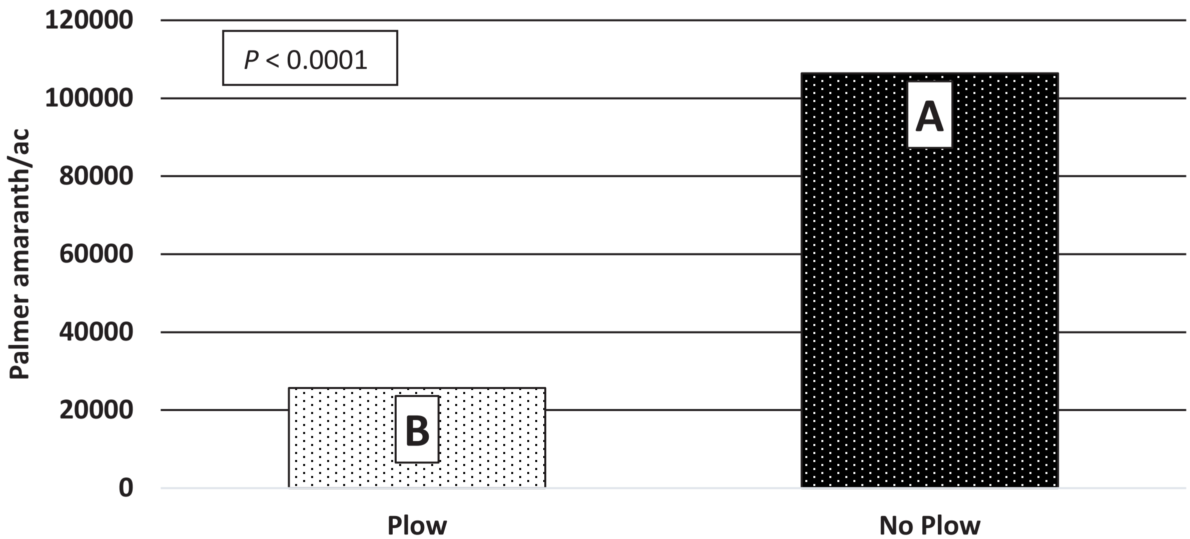

Fig. 1. Cumulative Palmer amaranth emergence by tillage program (moldboard plow presence or absence) averaged over herbicide program, cover crop, and zero-tolerance at Marianna, Arkansas in 2019. Means with the same letter are not statistically different (α = 0.05). The use of a one-time deep-tillage event significantly reduced cumulative emergence of Palmer amaranth by 76%.

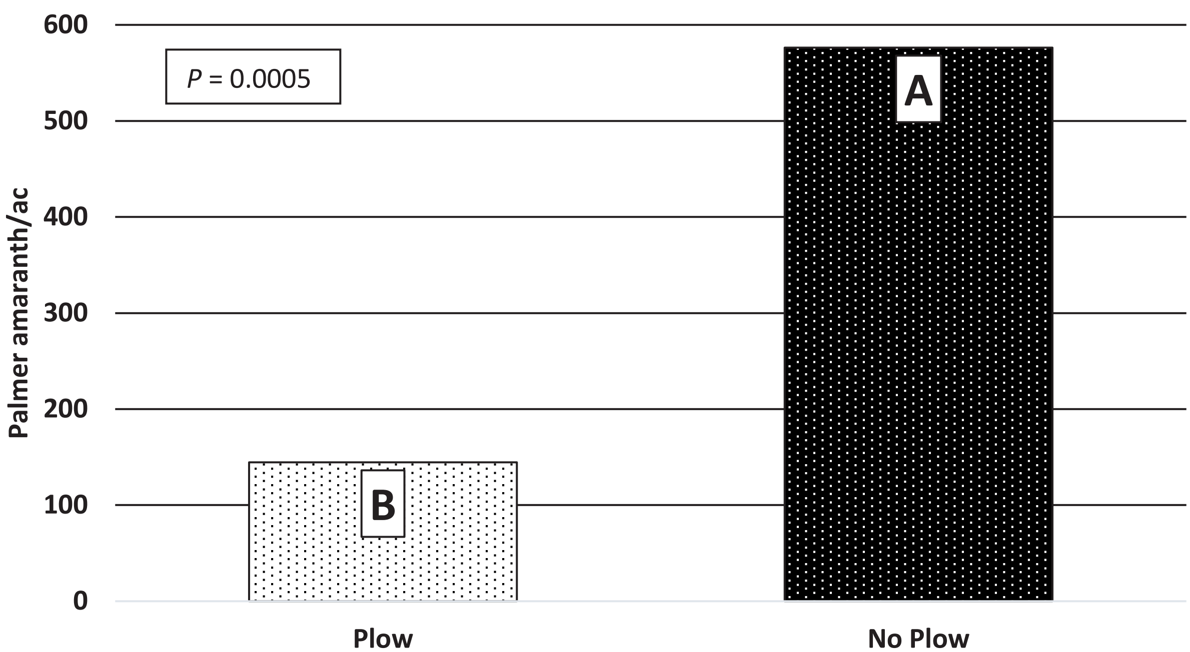

Fig. 2. Inflorescence-producing Palmer amaranth at harvest by tillage (moldboard plow presence or absence) averaged over herbicide program, cover crop, and zero-tolerance at Marianna, Arkansas in 2019. Means with the same letter are not statistically different (α = 0.05). The use of a one-time deep-tillage event reduced inflorescence-producing Palmer amaranth by 75%.

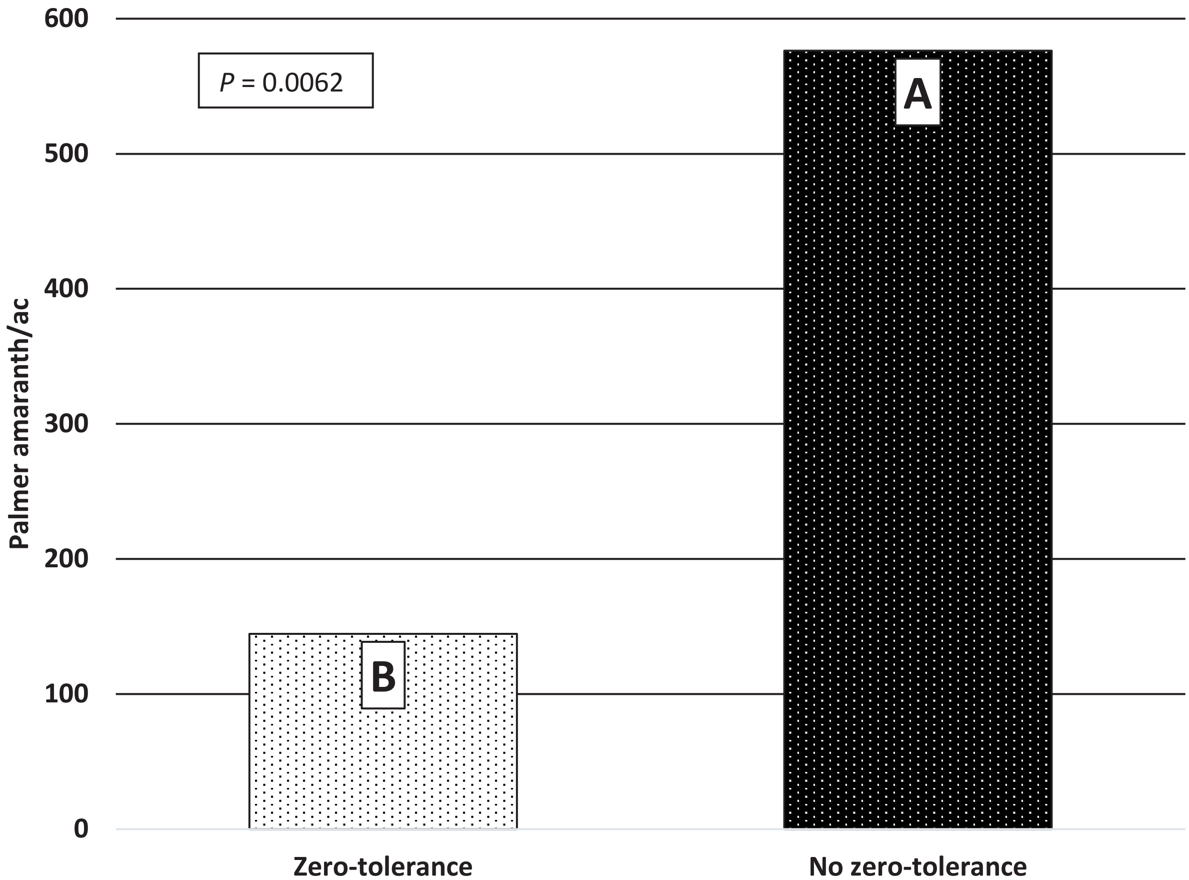

Fig. 3. Inflorescence-producing Palmer amaranth at harvest by zero-tolerance (with or without) program averaged over herbicide program, cover crop, and tillage at Marianna, Arkansas in 2019. Means with the same letter are not statistically different (α = 0.05). Zero-tolerance reduced the number of inflorescence-producing Palmer amaranth by 63%.

Use of Auxin Herbicides Other than 2,4-D in Enlist Cotton

J.W. Beesinger,[1] J.K. Norsworthy,[1] L.T. Barber,[2] and R.B. Farr[1]

Abstract

Tolerance to auxin herbicides other than 2,4-D has been observed with Enlist cotton. The use of auxins other than 2,4-D to control problematic weedy species could allow producers more options to develop programs that use multiple sites of action and alleviate problems with local restrictions on herbicide applications. An experiment was conducted to determine cotton tolerance and weed control when fluroxypyr, triclopyr, and 2,4-D were applied with and without glufosinate to Enlist cotton. Applications of herbicides were made on 10- to 12-in. weeds and on PHY 360 W3FG. Visual assessments of cotton injury were taken 21 days after application, and weed control ratings were assessed 28 days after application. Fluroxypyr and triclopyr, when applied with glufosinate, were as efficacious as 2,4-D and glufosinate alone and when combined. Applications of triclopyr or fluroxypyr alone or with glufosinate did not result in greater cotton injury than 2,4-D alone or 2,4-D plus glufosinate.

Introduction

All cotton grown in the United States is planted in states with herbicide-resistant Palmer amaranth (*Amaranthus palmeri*). Arkansas alone has Palmer amaranth resistant to more than five herbicide sites of action (Heap, 2021; USDA-NASS, 2021). Using multiple sites of action in the same field to control Palmer amaranth and reducing the size of the soil seedbank are recommended. XtendFlex and Enlist cotton systems allow for the use of an auxin herbicide (dicamba and/or 2,4-Dy), glyphosate, and glufosinate. Enlist cotton has tolerance to auxin herbicides other than 2,4-D (Rose et al., 2020). The herbicides 2,4-D, triclopyr, and fluroxypyr have historically been used to control broadleaf weed species. Use of auxin herbicides other than 2,4-D to control broadleaf weeds in cotton may provide less risk for damage to neighboring non-Enlist cotton crops. Additionally, being able to safely apply auxins other than 2,4-D or dicamba to cotton could give producers options where regulations restrict the use of certain herbicides. The objective of this research was to evaluate Enlist cotton for tolerance and weed control with triclopyr and fluroxypyr herbicides both alone and in combination with glufosinate compared to applications of 2,4-D with and without glufosinate.

Procedures

A trial was conducted at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, to test the hypothesis that other auxin herbicides could be used for broadleaf weed control in Enlist cotton. PHY 360 W3FG was planted at a rate of 40,000 seeds ac-1 and divided into four plots that consisted of four 38-in.-wide rows 20 ft long. The experiment was designed as a two-factor factorial, with the first factor being auxin herbicide (fluroxypyr, triclopyr, or 2,4-D). The second factor was the use or non-use of glufosinate (alone and in combination with the three auxin herbicides). All applications were made on 10- to 12-in. tall weeds at 15 gal/ac using a CO_2-pressurized backpack sprayer (Table 1). Visible assessments of crop injury and weed control were taken every 7 days until 28 days after application. Injury ratings were taken on a scale of 0–100, with 0 representing no crop response and 100 indicating crop death. Weed control ratings were also taken on a scale of 0–100, with 0 meaning no control and 100 signifying no remaining weeds in a plot. After all evaluations were collected, the crop was destroyed prior to maturity. Colby's method was utilized to determine the existence of antagonism or synergism between glufosinate and the auxin herbicides using the equation $E = X+Y-XY/100$ where E represents the expected value for control, which was statistically compared to the actual determined value using analysis of variance, and X and Y are the percentage of control observed from each herbicide applied alone (Colby, 1967).

Results and Discussion

At 28 days after treatment, fluroxypyr and triclopyr alone provided the least amount of Palmer amaranth control but performed as well or better than 2,4-D on entireleaf morn-

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ingglory and common cocklebur (Table 2). When glufosinate was added to applications of triclopyr and fluroxypyr, efficacy was improved over applications of triclopyr and fluroxypyr alone but not over the use of glufosinate alone. When glufosinate plus fluroxypyr were mixed, differences were observed from the expected control that was calculated and the actual control observed, indicating antagonism when controlling common cocklebur and entireleaf morningglory (data not shown). No treatment or combination resulted in cotton injury greater than 10% at 21 days after treatment, indicating all herbicide treatments were relatively safe to cotton.

Practical Applications

The ability to safely apply triclopyr and fluroxypyr with and without glufosinate in Enlist cotton could provide growers with more options to use to control problematic weeds. Rotating and combining sites of action is key to mitigating herbicide resistance, and the use of auxins other than 2,4-D with glufosinate would allow producers to maintain weed-free fields while using multiple sites of action.

Acknowledgments

Thanks are extended to the hourly workers and graduate students at the Altheimer Laboratory for their help in conducting the trial as well as the University of Arkansas System Division of Agriculture.

Literature Cited

Colby, S.R. 1967. Calculating synergistic and antagonistic responses of herbicide combinations. Weeds 15:20–22.

Heap, I. The international herbicide-resistant weed database. Accessed on 3 February 2021.

Rose, J. 2020. Sensitivity of Enlist™ and Roundup Ready Xtend® technologies to auxin herbicides and comparison of resistance to susceptible cotton and soybean cultivars. Theses and Dissertations.

USDA-NASS. 2021. United States Department of Agriculture - National Agricultural Statistics Service, *Quick Stats*. Accessed 3 February 2020. Available at: https://quickstats.nass.usda.gov/

Table 1. Herbicide treatments, rate of application, and nozzles used.

Treatment	Herbicides Applied	Rate	Nozzle
		fl oz/ac	
1	Nontreated Check		
2	Fluroxypyr	11.2	XR 110015
3	Triclopyr	16	XR 110015
4	2,4-D	32	AIXR 110015
5	Glufosinate	32	XR 110015
6	Fluroxypyr + glufosinate	11.2 + 32	XR 110015
7	Triclopyr + glufosinate	16 + 32	XR 110015
8	2,4-D + glufosinate	32 + 32	AIXR 110015

Table 2. PHY 360 W3FG cotton injury and control of weed species by herbicide treatment from the experiment conducted at Fayetteville, Arkansas, in 2020.

	21 DAT †	Control Ratings 28 DAT‡		
Herbicides applied	Cotton injury§	Palmer amaranth	Common cocklebur	Entireleaf morningglory
	(%)			
Fluroxypyr	6	57 b¶	97 a	97 a
Triclopyr	2	69 b	96 a	96 ab
2,4-D	3	90 a	96 a	95 ab
Glufosinate	1	94 a	90 ab	92 ab
Fluroxypyr + glufosinate	2	95 a	86 b	76 b
Triclopyr + glufosinate	2	98 a	96 ab	91 ab
2,4-D + glufosinate	3	98 a	99 a	94 a

† DAT = days after treatment.

‡ Control ratings taken on 0–100% scale with 0 representing no control and 100 meaning control of all weeds of a species present.

§ Cotton injury observed using a 0–100% scale with 0 meaning no injury and 100 indicating plant death.

¶ Means followed by the same letter are not significantly different.

Optimizing Sequential Applications of Dicamba and Glufosinate for the XtendFlex System

J.A. Fleming,[1] J.K. Norsworthy,[1] L.T. Barber,[2] G.L. Priess,[1] and R.B. Farr[1]

Abstract

Due to current label restrictions, producers cannot mix dicamba and glufosinate for postemergence applications on cotton. Because of this, producers must seek alternative application methods to fully utilize both of these herbicides for weed control in XtendFlex® crops. Six field trials were conducted in Fayetteville, Keiser, Crawfordsville, and Marianna, Arkansas to evaluate sequential dicamba and glufosinate applications. Four of these trials evaluated Palmer amaranth four to ten inches tall, and in the other two trials, it was less than four inches tall. Treatments included multiple timings of dicamba followed by (fb) glufosinate, glufosinate fb dicamba, dicamba fb dicamba, and glufosinate fb glufosinate. A mixture of dicamba and glufosinate, as well as dicamba and glufosinate alone, were also evaluated. Overall, dicamba fb glufosinate 14 days later had the highest Palmer amaranth control and was the only treatment to reach 100% control at the labeled weed size. Single applications of dicamba, glufosinate, and dicamba plus glufosinate did not result in Palmer amaranth control greater than 80% regardless of weed size. The implementation of sequential applications of dicamba and glufosinate, two effective sites of action for POST control of Palmer amaranth, will also help mitigate the evolution of herbicide resistance and help preserve available technologies.

Introduction

Palmer amaranth has been a significant weed of concern for cotton producers due to its ability to produce large numbers of seed with high genetic variability, which has led to resistance to multiple herbicide modes of action (Keeley et al., 1987; Norsworthy et al., 2014). XtendFlex® cotton was first introduced in 2015 to help producers control problematic weeds such as Palmer amaranth. XtendFlex® gave cotton producers access to a new triple-stacked herbicide resistance gene that allowed the use of dicamba, glyphosate, and glufosinate for postemergence applications. This new technology added the glufosinate resistance gene to improve the previous system. By adding an effective mode of action, cotton producers can better combat the growing issue with herbicide-resistant weed populations and better mitigate resistance to currently effective herbicides (Norsworthy et al., 2012). Currently, the labels for the dicamba products Xtendimax and Engenia do not allow for mixing with glufosinate. Due to the label restriction, producers must sequentially apply dicamba and glufosinate to utilize both effective modes of action.

Procedures

A total of six experiments were conducted in 2019 and 2020, three each year. Experiments were conducted at Keiser, Crawfordsville, and Marianna, Arkansas in 2019 and at Fayetteville, Keiser, and Marianna, Arkansas in 2020. Each experiment was a single factor randomized complete block design with four replications. Plots were 6.3 ft wide by 20 ft long at all locations. Two 0.8- to 1.6-ft^2 quadrants were established in each plot, and the density of Palmer amaranth plants was taken before the initial application. Natural densities of Palmer amaranth were utilized at all locations other than Fayetteville in 2020, where seed collected from Crittenden County, Arkansas, was overseeded. Average Palmer amaranth height was recorded before the initial application, and data were separated by Palmer amaranth size either less than 4 in. (labeled) or 4 to 10 in. (above labeled). Treatments consisted of dicamba and glufosinate applied individually, together, and sequentially (Table 1). Palmer amaranth control was rated visually 14 and 28 days after the final application (DAFA) for each treatment. Ratings were assessed on a scale of 0 to 100%, 0 being no visual control, and 100 being complete Palmer amaranth death. Final live Palmer amaranth counts were taken in the initially established quadrants 28 DAFA and used to determine each treatment's final quantitative mortality. Data were analyzed using JMP 15.1 Pro, and means were separated using Fisher's Protected least significant difference ($\alpha = 0.05$). Site year by herbicide was non-significant and considered a random effect.

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Results and Discussion

Two site-years, Crawfordsville 2019 and Keiser 2020, were analyzed as labeled applications to Palmer amaranth (less than 4 in.), with the other four site years discussed having applications made to above-labeled size Palmer amaranth (4–10 in.). For most treatments, an increase in visual control was observed at 28 DAFA compared to 14 DAFA at both labeled and above-labeled weed sizes (Tables 2–3). At labeled weed size, multiple treatments provided >90% visual control of Palmer amaranth (Table 2). Dicamba followed by (fb) glufosinate 14 days later was the only treatment to reach 100% control and mortality. While no treatment reached 100% control, when applied to Palmer amaranth above labeled size, dicamba fb glufosinate 14 days later provided the greatest level of control at 92%, which is five percentage points better than the next highest treatment of dicamba fb glufosinate 21 days later (Table 3). Comparing single applications, mortality at labeled Palmer amaranth size was 92%, 85%, and 85% for dicamba, glufosinate, and dicamba + glufosinate, respectively. At the above labeled Palmer amaranth size, a significant decrease in single applications' efficacy is observed with mortality decreasing to 57%, 49%, and 66% for dicamba, glufosinate, and dicamba + glufosinate treatments, respectively. Among sequential applications that only utilized a single mode of action, dicamba fb dicamba 14 days later was the only treatment observed to control Palmer amaranth at both labeled (Table 2) and above-labeled (Table 3) weed size greater than 90%. Glufosinate fb glufosinate seven days later showed 98% mortality when applied to Palmer amaranth at labeled heights (Table 2), which is similar to the data observed by Meyer and Norsworthy (2020) that indicated a seven day time interval was optimum for sequential applications of glufosinate.

Practical Applications

Single applications of dicamba, glufosinate, or dicamba + glufosinate are not effective at controlling Palmer amaranth. If utilization of a single mode of action is desired, dicamba fb dicamba 21 days later was the best treatment with a 98% mortality of labeled Palmer amaranth. While a single mode of action does result in a high level of control, it is not recommended due to the potential for herbicide resistance. The recommended option for producers is utilizing dicamba fb glufosinate 14 days later. This is the only treatment that had 100% control at labeled Palmer amaranth size. This treatment also utilized two effective modes of action, which will further mitigate target-site herbicide resistance (Norsworthy et al., 2012). Another major takeaway from this study is the effect of weed size at application timing. A reduction in control up to 20% was observed with some treatments when applied to the above labeled Palmer amaranth. Based on this, it is of the utmost importance that producers make applications to Palmer amaranth when it is below four inches to achieve the highest possible level of control. Overall, when adequately utilized, the XtendFlex® herbicide technology will provide high Palmer amaranth control levels while utilizing multiple sites of action to help mitigate herbicide resistance development.

Acknowledgments

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Literature Cited

Keeley, P.E., C.H. Carter, and R.J. Thullen. 1987. Influence of planting date on the growth of Palmer amaranth (*Amaranthus palmeri*). Weed Sci. 35:199–204.

Meyer, C. and J. Norsworthy. 2020. Timing and application rate for sequential applications of glufosinate are critical for maximizing control of annual weeds in LibertyLink® Soybean. International J. Agron. 2020:1-7.

Norsworthy, J.K., G.M. Griffith, T. Griffin, M. Bagavathiannan, and E.E. Gbur. 2014. In-field movement of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) and its impact on cotton lint yield: evidence supporting a zero-threshold strategy. Weed Sci. 62:237-249.

Norsworthy, J.K., S.M. Ward, D.R. Shaw, R. Llewellyn, R.L. Nichols, T.M. Webster, K.W. Bradley, G. Frisvold, S.B. Powles, N.R. Burgos, W. Witt, and M. Barrett. 2012. Reducing the risks of herbicide resistance: best management practices and recommendations. Weed Sci. 60:31–36.

Table 1. Experimental treatments, including herbicides, herbicide rate, and the time interval between the sequential applications.

Herbicide	Rate	Days between sequential applications
Nontreated	-	-
Dicamba	22 oz/ac	-
Glufosinate	32 oz/ac	-
Dicamba + glufosinate	22 oz/ac + 32 oz/ac	-
Dicamba fb† dicamba	22 oz/ac fb 32 oz/ac	7, 14, and 21 days
Glufosinate fb glufosinate	32 oz/ac fb 32 oz/ac	7, 14, and 21 days
Dicamba fb glufosinate	22 oz/ac fb 32 oz/ac	0.2 (6 hours), 3, 7, 14, and 21 days
Glufosinate fb dicamba	32 oz/ac fb 22 oz/ac	0.2 (6 hours), 3, 7, 14, and 21 days

† fb = followed by.

Table 2. Percent control and mortality when labeled (<4 inch) Palmer amaranth was treated with single and sequential dicamba and glufosinate applications averaged over two site-years of data, Crawfordsville 2019 and Keiser 2020.

		Palmer amaranth control†				Palmer amaranth mortality†	
Herbicide	Days between applications	14 DAFA‡		28 DAFA‡		28 DAFA‡	
dicamba	na	80	ef§	74	ij	92	bcd
glufosinate	na	76	fgh	65	k	85	e
dicamba + glufosinate	na	78	fg	76	hij	85	e
dicamba fb‡ dicamba	7	82	def	86	defg	98	abc
dicamba fb dicamba	14	78	fg	97	ab	94	abc
dicamba fb dicamba	21	78	fg	97	ab	98	ab
glufosinate fb glufosinate	7	92	ab	94	abc	98	ab
glufosinate fb glufosinate	14	83	cdef	78	ghij	92	cd
glufosinate fb glufosinate	21	61	i	72	jk	88	de
dicamba fb glufosinate	0.2	88	bcd	81	fghi	94	abcd
dicamba fb glufosinate	3	95	ab	94	abc	97	abc
dicamba fb glufosinate	7	98	a	94	abc	95	abc
dicamba fb glufosinate	14	96	ab	100	a	100	a
dicamba fb glufosinate	21	72	gh	95	abc	98	abc
glufosinate fb dicamba	0.2	89	bcd	90	bcde	93	bcd
glufosinate fb dicamba	3	91	abc	93	abcd	97	abc
glufosinate fb dicamba	7	88	bcde	83	efgh	95	abc
glufosinate fb dicamba	14	77	fgh	91	abcd	95	abc
glufosinate fb dicamba	21	69	h	87	cdef	93	bcd

† Palmer amaranth control and mortality are expressed as a percent of the nontreated.

‡ DAFA = days after final application; fb = followed by.

§ Means followed by the same letter within a column are not statistically different according to Fisher's protected least significant difference (α = 0.05).

Table 3. Percent control and mortality when above labeled Palmer amaranth (4–10 in.) were treated with single and sequential dicamba and glufosinate applications averaged over four site-years of data, Keiser and Marianna 2019 and Fayetteville and Marianna 2020.

		Palmer amaranth control†				Palmer amaranth mortality†	
Herbicide	Days between applications	14 DAFA‡		28 DAFA‡		28 DAFA‡	
dicamba	na	62	ef§	65	gh	57	fg
glufosinate	na	54	f	59	h	49	g
dicamba + glufosinate	na	61	ef	59	h	66	ef
dicamba fb‡ dicamba	7	81	bc	85	abc	88	abc
dicamba fb dicamba	14	79	bc	85	abc	90	a
dicamba fb dicamba	21	73	cd	82	bcd	89	ab
glufosinate fb glufosinate	7	81	bc	77	cde	77	bcde
glufosinate fb glufosinate	14	78	bc	76	def	75	cde
glufosinate fb glufosinate	21	63	e	76	def	66	ef
dicamba fb glufosinate	0.2	67	de	68	fg	71	def
dicamba fb glufosinate	3	77	bc	76	def	72	de
dicamba fb glufosinate	7	79	bc	69	fg	84	abcd
dicamba fb glufosinate	14	92	a	92	a	89	ab
dicamba fb glufosinate	21	84	ab	87	ab	89	ab
glufosinate fb dicamba	0.2	67	de	65	gh	65	ef
glufosinate fb dicamba	3	80	bc	79	bcde	74	de
glufosinate fb dicamba	7	78	bc	75	def	80	abcd
glufosinate fb dicamba	14	75	cd	81	bcd	83	abcd
glufosinate fb dicamba	21	54	f	71	efg	58	fg

† Palmer amaranth control and mortality are expressed as a percent of the nontreated.

‡ DAFA = days after final application; fb = followed by.

§ Means followed by the same letter within a column are not statistically different according to Fisher's protected least significant difference ($\alpha = 0.05$).

Effects of Weed Size on Control with Sequential Applications of Dicamba and Glufosinate

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Abstract

The commercial launch of XtendFlex cotton technology allows producers to make postemergence applications of dicamba, glufosinate, and glyphosate. Weed size is a vital component of a postemergence chemical weed control program as it helps in managing the troublesome weeds at a critical time. Weed size can affect herbicide efficacy and interactions among herbicides. Field experiments were conducted at Keiser, Arkansas in 2019 and 2020, at an on-farm site near Crawfordsville, Arkansas in 2019, at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas in 2020, and at the Milo J. Shult Agricultural Research and Extension Center, Fayetteville, Arkansas in 2020. The objective of the experiments was to determine the effects of weed size on sequential applications of dicamba, dicamba plus glyphosate, and glufosinate. All the experiments were implemented as three-factor, randomized complete block designs with factor-A being herbicide treatment (XtendiMax followed by (fb) Liberty, Liberty fb XtendiMax, XtendiMax + Roundup PowerMax fb Liberty, and Liberty fb XtendiMax + Roundup PowerMax), factor-B being the timing of sequential application (3-day and 14-day interval), and factor-C being weed size (3- to 4-in. and 14- to 16-in.). XtendiMax + Roundup PowerMax fb Liberty at 3-day and 14-day interval, and Liberty fb XtendiMax + Roundup PowerMax at a 14-day interval provided control above 90% on 3- to 4-in. tall Palmer amaranth at 28 days after the final application (DAFA). XtendiMax + Roundup PowerMax fb Liberty at 3-day and 14-day intervals were the most effective treatments and highly consistent in controlling the labeled and above-labeled sizes of Palmer amaranth. Sequential applications resulted in higher mortality at 28 days after the final application (DAFA) to 3- to 4-in. tall Palmer amaranth when compared with 14- to 16-in. tall plants. Optimizing multiple herbicide sites of action at critical periods of weed management in cotton helps to mitigate some of the risk for herbicide resistance.

Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is one of the most problematic, pervasive, and economically damaging weeds in cotton throughout the mid-southern United States because of its high fecundity, rapid growth rate, wide genetic diversity, and capability of evolving resistance to herbicides (Riar et al., 2013; Ward et al., 2013). Palmer amaranth can rapidly overtake cotton once resistance evolves, causing up to 100% yield loss in heavily infested areas (Norsworthy et al., 2014). Palmer amaranth has already evolved resistance to eight sites of action (SOAs), and it is imperative to incorporate multiple herbicide SOAs for mitigating further herbicide-resistance development (Heap, 2020; Norsworthy et al., 2012). The commercial launch of XtendFlex cotton technology allows producers to apply dicamba, glufosinate, and glyphosate over-the-top of cotton. The XtendFlex cotton technology was grown on approximately 95% of total acreage under cotton cultivation in the United States in 2019 (USDA-ERS, 2020). Weed size can influence the efficacy of weed control in measures by affecting the herbicide performance, including interactions among herbicides (Meyer and Norsworthy, 2019). Therefore, research was conducted to determine the effects of weed size on the efficacy of sequential applications of dicamba, dicamba plus glyphosate, and glufosinate.

Procedures

Field trials were conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser, Arkansas, in 2019 and 2020, at an on-farm site near Crawfordsville, Arkansas, in 2019, at the Lon Mann Cotton Research Station, Marianna, Arkansas, in 2020, and at the Milo J. Shult Agricultural Research and Extension Center, Fayetteville, Arkansas, in 2020. Trials were implemented as a randomized complete block design with a three-factor factorial treatment structure replicated four times. The three factors were herbicide treatment, timing of sequential application, and Palmer amaranth height at the initial application (Table 1). Herbicide treatments were applied to native Palmer amaranth populations without a crop

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present in each location. Non-cropped plots (bareground) were 6.3 ft by 20 ft. The herbicide treatments dicamba (XtendiMax), dicamba (XtendiMax) plus glyphosate (Roundup PowerMax), and glufosinate (Liberty) were applied sequentially in various combinations on Palmer amaranth populations of size 3- to 4-in. and 14- to 16-in. at the time of initial application (Table 1). Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 15 gal/ac of spray solution at 3 mph. All glufosinate applications were made with Air Induction Extended Range (AIXR) 110015 nozzles and all dicamba and dicamba plus glyphosate applications were made with Turbo TeeJet Induction (TTI) 110015 nozzles. Palmer amaranth counts were taken in two random quadrants measuring 2.6 ft^2 in each plot before initial application and at 28 DAFA to calculate the percent mortality. Visible Palmer amaranth control ratings were taken on a scale of 0 to 100%, with 0% representing no control and 100% representing complete control following the 28 DAFA for each treatment. Data were subjected to analysis of variance by using JMP Pro 15 where site-year was considered a random effect. Means were subjected to analysis of variance and separated using Fisher's protected least significance difference at 0.05 level of significance.

Results and Discussion

Interactions including site-year were not observed (*P*-value > 0.05); therefore, site-years were pooled in the analysis. Treatments containing XtendiMax + Roundup PowerMax fb Liberty at 3-day and 14-day interval (treatments 5 and 9) and Liberty fb XtendiMax + Roundup PowerMax at 14-day interval (treatment 7) provided >90% control of 3-4-in. tall Palmer amaranth (Table 2). Liberty fb XtendiMax showed poor efficacy as <75% control observed on 3- to 4-in. tall Palmer amaranth and <51% control observed on 14- to 16-in. tall Palmer amaranth when applied at a 3-day interval (treatment 2). Overall, increased control was achieved on 3- to 4-in. tall Palmer amaranth when compared with 14- to 16-in. tall as none of the treatments were capable of providing >83% on 14- to 16-in. tall Palmer amaranth (Table 2).

Similarly, 3- to 4-in. tall Palmer amaranth was observed to be more sensitive to sequential applications than 14- to 16-in. tall Palmer amaranth. Herbicide treatments caused >83% mortality on 3- to 4-in. Palmer amaranth with the exception of Liberty fb XtendiMax at the 3-day interval (treatment 2), which resulted in <73% mortality when evaluated at 28 DAFA (Table 3). Furthermore, increasing the sequential application interval from 3-day to 14-day resulted in higher percent mortality on 14- to 16-in. tall Palmer amaranth (Table 3).

Practical Applications

Weed size is an essential component for ensuring the sustainability of chemical control programs. The incorporation of multiple effective sites of action mitigates the herbicide resistance development and returns in optimum control if applied on smaller weed sizes. Multiple options are available to growers for managing the 3- to 4-in. tall Palmer amaranth.

Acknowledgments

The authors would like to thank the University of Arkansas System Division of Agriculture and Bayer Crop Science, St. Louis, Missouri, for supporting this research.

Literature Cited

Heap, I.M. 2020. International survey of herbicide resistant weeds. Weed Science Society of America. Accessed on 2 January 2021. Available at: www.weedscience.org

Meyer C.J. and Norsworthy J.K. 2019. Influence of weed size on herbicide interactions for Enlist™ and Roundup Ready® Xtend® technologies. Weed Tech. 33:569–577.

Norsworthy, J.K., S.M. Ward, D.R. Shaw, R. Llewellyn, R.L. Nichols, T.M. Webster, K. W. Bradley, G. Frisvold, S.B. Powles, N.R. Burgos, W. Witt, and M. Barrett. 2012. Reducing the risks of herbicide resistance: Best management practices and recommendations. Weed Sci. 60 (SP I):31–62.

Norsworthy, J.K., G. Griffith, T. Griffin, M. Bagavathiannan, and E.E. Gbur. 2014. In-field movement of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) and its impact on cotton lint yield: Evidence supporting a zero-threshold strategy. Weed Sci. 62:237-249.

Riar, D.S., J.K. Norsworthy, L.E. Steckel, D.O. Stephenson, and J.A. Bond. 2013 Consultant perspectives on weed management needs in midsouthern United States cotton: a follow-up survey. Weed Tech. 27:778-787.

USDA-ERS. 2020. United States Department of Agriculture Economic Research Service. Recent Trends in GE Adoption. Accessed 14 January 2021. Available at: https://www.ers.usda.gov/data-products/adoption-of-genetically-engineered-crops-in-the-us/recent-trends-in-ge-adoption.aspx

Ward, S.M., T.M. Webster, and L.E. Steckel. 2013. Palmer amaranth (*Amaranthus palmeri*): a review. Weed Tech. 27:12–27.

Table 1. List of herbicide treatments, sequential application timings, rates used for two weed sizes of Palmer amaranth.

Treatment	Herbicide treatment	Sequential application interval[†]	Rate	Weed height
		days	fl oz/ac	Inches
1	Nontreated	-	-	-
2	Liberty fb[‡] XtendiMax	3 days	32 22	3- to 4-in. and 14- to 16-in.
3	Liberty fb XtendiMax + Roundup PowerMax	3 days	32 22 + 32	3- to 4-in. and 14- to 16-in.
4	XtendiMax fb Liberty	3 days	22 32	3- to 4-in. and 14- to 16-in.
5	XtendiMax + Roundup PowerMax fb Liberty	3 days	22 + 32 32	3- to 4-in. and 14- to 16-in.
6	Liberty fb XtendiMax	14 days	32 22	3- to 4-in. and 14- to 16-in.
7	Liberty fb XtendiMax + Roundup PowerMax	14 days	32 22 + 32	3- to 4-in. and 14- to 16-in.
8	XtendiMax fb Liberty	14 days	22 32	3- to 4-in. and 14- to 16-in.
9	XtendiMax + Roundup PowerMax fb Liberty	14 days	22 + 32 32	3- to 4-in. and 14- to 16-in.

[†] Time interval between sequential applications.
[‡] fb = followed by.

Table 2. Palmer amaranth control percent averaged over five site years.

Treatment	Herbicide treatment	Palmer amaranth control 28 DAT[†]	
		3- to 4-in.	14- to 16-in.
		------------------------ % --------------------	
1	Nontreated	-	-
2	Liberty fb[‡] XtendiMax (3 days)	74 d[§]	51 g
3	Liberty fb XtendiMax + Roundup PowerMax (3 days)	83 bc	59 ef
4	XtendiMax fb Liberty (3 days)	88 ab	54 fg
5	XtendiMax + Roundup PowerMax fb Liberty (3 days)	94 a	56 f
6	Liberty fb XtendiMax (14 days)	85 b	63 e
7	Liberty fb XtendiMax + Roundup PowerMax (14 days)	93 a	72 d
8	XtendiMax fb Liberty (14 days)	89 ab	77 cd
9	XtendiMax + Roundup PowerMax fb Liberty (14 days)	91 a	83 bc

[†] Days after treatment (DAT).

[‡] fb = followed by.

[§] Letters within a column are used to separate means. Data with the same letters are not significantly different (α = 0.05).

Table 3. Palmer amaranth mortality percent averaged over five site years.

Treatment	Herbicide treatment	Palmer amaranth mortality 28 DAT[†]	
		3- to 4-in.	14- to 16-in.
		------------------------- % -------------------	
1	Nontreated	-	-
2	Liberty fb[‡] XtendiMax (3 days)	73 e[§]	48 h
3	Liberty fb XtendiMax + Roundup PowerMax (3 days)	82 cd	57 g
4	XtendiMax fb Liberty (3 days)	85 abc	52 gh
5	XtendiMax + Roundup PowerMax fb Liberty (3 days)	92 a	55 g
6	Liberty fb XtendiMax (14 days)	84 c	64 f
7	Liberty fb XtendiMax + Roundup PowerMax (14 days)	93 a	73 e
8	XtendiMax fb Liberty (14 days)	88 abc	76 de
9	XtendiMax + Roundup PowerMax fb Liberty (14 days)	90 ab	82 bcd

[†] Days after treatment (DAT).

[‡] fb = followed by.

[§] Letters within a column are used to separate means. Data with the same letters are not statistically different (α = 0.05).

Determining the Optimal Rate of Potassium Tetraborate Tetrahydrate to Reduce Dicamba Volatility

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Abstract

Labeled applications of the N, N-bis (3-aminopropyl) methylamine (BAPMA) salt of dicamba (Engenia™) and diglycolamine salt of dicamba with VaporGrip™ (XtendiMax™) have resulted in a record number of off-target complaints following their introduction in 2017 for use as preemergence and postemergence control of broadleaf weeds in Xtend cotton (*Gossypium hirsutum* L.) and soybean [*Glycine max* (L.) Merr] systems. In efforts to reduce dicamba volatility, the University of Arkansas System Division of Agriculture has pursued potassium tetraborate tetrahydrate (potassium borate) as a volatility-reducing agent. Two low-tunnel volatility trials were conducted at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, in 2020 to determine the optimal rate of potassium borate to function as a volatility-reducing agent and a nutritional additive. The diglycolamine (DGA) salt of dicamba plus the potassium salt of glyphosate was applied in a mixture with 0, 0.03, 0.07, 0.13, 0.27, and 0.53 lb/ac of boron (B) in the form of potassium borate. Each treatment was applied four times to two moist flats that were placed under each tunnel and removed 48 hours after application. Regarding the three evaluated qualitative parameters (maximum soybean injury, average injury, and distance traveled), dicamba volatility was significantly reduced as potassium borate rate increased. At B rates of 0.13 to 0.53 lb B/ac, dicamba movement was reduced by 9 to 11 ft, respectively, compared to DGA dicamba plus glyphosate. High-volume air sampler data followed similar trends to qualitative assessments, with the least amount of total dicamba detected at 0.27 and 0.53 lb B/ac. As the potassium borate rate increased, the variability in detectable dicamba was likewise reduced. Overall, the addition of potassium borate to dicamba can effectively reduce dicamba volatility at rates sufficient to alleviate potential B deficiencies.

Introduction

The introduction of the XtendFlex™ technology allows cotton producers to utilize the XtendiMax™ (diglycolamine salt of dicamba (DGA)) plus VaporGrip™ and Engenia™ (N,N-bis (3-aminopropyl) methylamine (BAPMA)) formulations of dicamba for postemergence control of problematic broadleaf weeds. However, usage of these relatively new low-volatile formulations of dicamba has caused a record number of complaints regarding damage caused by off-target movement of the herbicide via volatility, specifically in geographies similar to the mid-South (Oseland et al., 2020). To combat dicamba volatility, the University of Arkansas System Division of Agriculture has pursued potassium tetraborate tetrahydrate (potassium borate) as a volatility reducing agent due to its capacity as an ion scavenger, pH buffer, and nutritional additive. The additive functions by scavenging hydrogen protons that are present under low solution pH conditions, preventing the formation of volatile dicamba acid. Preliminary data from 2019 suggest that potassium borate is very promising in reducing dicamba volatility, minimizing risks for producers that utilize the technology (unpublished data 2019).

Procedures

Two low tunnel experiments were conducted at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, in 2020 to determine the optimal rate of potassium borate needed to reduce dicamba volatility. Treatments were arranged as a single-factor randomized complete block with three replications. A glufosinate-resistant soybean cultivar (CDZ 4938) was planted on 36-in. rows to serve as a dicamba-sensitive bioindicator for qualitative assessments. For each treatment, two flats (15 by 19 in.) were filled with moist soil and treated with DGA dicamba plus glyphosate combined with six rates of potassium borate (14% boron (B) by weight) that were based on lb B/ac (0, 0.03, 0.07, 0.13, 0.27, 0.53). All flats were treated with a CO_2-pressurized sprayer delivering an output of 15 gal/ac using TTI110015 nozzles at least 0.5 miles from the field to mitigate potential dicamba contamination. Traditionally, one whole plot measuring 12.67 by 20 ft (253 ft^2) is sprayed with a 1X rate of the herbicide. However, in order to compensate for plot area due to such a small treated area (soil flats equivalent to 2 ft^2) under the low tunnel (100 ft^2), all treatments were mixed

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at a 1X rate and applied to each flat four times to simulate a 4X rate, with a 1X being 0.5 lb ae/ac dicamba and 1.13 lb ae/ac glyphosate. The 4X rate of each herbicide allows for greater visible auxin symptomology to detect differences amongst treatments and is representative of a 1X rate when considering the size of the whole plot area. The two treated flats were placed into the appropriate low-tunnel (5 by 20 ft long) on either side of a high-volume air sampler located in the center of each low-tunnel. All low tunnels, flats, and high-volume air samplers were removed to a safe distance from the field 48 hours after trial initiation. For qualitative assessments, the two rows of soybean under each low-tunnel were divided into eight quadrants to evaluate visible injury and distance to 5% injury 14, 21, and 28 days after treatment (DAT). Maximum injury was determined from a single quadrant with the greatest visible injury under a given low tunnel out of all eight quadrants. Distance to 5% injury was measured from the center of each low-tunnel in the direction where greater dicamba symptomology was present, which is typically observed in the downwind direction from the treated flats. Dicamba residue collected in the high-volume air sampler via polyurethane foam (PUF) and filter paper was extracted and analyzed by the Mississippi State University Chemical Laboratory, which provided the total amount of volatile dicamba detected (ng) under each low tunnel. All data were pooled overruns and subjected to analysis of variance in JMP Pro 15 and separated using Fisher's protected least significant difference ($\alpha = 0.05$).

Results and Discussion

The addition of potassium borate significantly reduced visible dicamba symptomology, i.e., volatility, based on the two qualitative parameters evaluated (maximum soybean injury and distance traveled) and decreased the opportunity for volatility as potassium borate rate increased. Maximum visible injury to soybean was reduced 29 to 36 percentage points 21 DAT when potassium borate was applied at a range of 0.13- to 0.53- lb B/ac, respectively, compared to DGA dicamba plus glyphosate with no additive (37%) (Fig. 1). Displaying a similar trend to maximum visible injury to soybean, the total distance traveled to 5% dicamba symptomology further indicated that a minimum rate of 0.13 lb B/ac is needed to mitigate lateral movement of dicamba by reducing the volatility of the herbicide (Fig. 2). Based on the visible parameters evaluated, potassium borate applied at 0.03 to 0.07 lb B/ac would not serve as an acceptable rate to reduce dicamba volatility. High-volume air sampler data reflected visible evaluations, confirming a decreasing relationship of dicamba volatility per the total detectable amount of dicamba (ng) from the PUF and filter paper as the rate of potassium borate increased (Fig. 3). As the rate of potassium borate increased, the variability among detected dicamba in a 48-hour period decreased. Based on the predictive curve, when the additive exceeds approximately 0.3 lb B/ac, there was little advantage in further reducing dicamba volatility. Additionally, potassium borate rates providing an acceptable reduction in dicamba volatility in this experiment were sufficient to satisfy a foliar B recommendation in cotton (up to 0.5 lb B/ac) (Howard et al., 1998).

Practical Applications

Due to the high number of complaints regarding the off-target movement of dicamba in Arkansas following the introduction of the Xtend technology in 2017, addressing dicamba volatility is important to preserve the technology for producers combatting resistant weeds, as well as the public perception of herbicides. It is unacceptable for labeled postemergence applications of dicamba to impact producers choosing to plant sensitive cultivars of soybean or cotton to homeowners that have sensitive vegetation in proximity to production areas. Developing an effective volatility-reducing agent is crucial for mitigating off-target movement of dicamba so that producers can have a reliable product that stays in the field without the risk of damaging non-target areas.

Acknowledgments

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Literature Cited

Howard, D.D., C.O. Gwathmey, and C.E. Sams. 1998. Foliar feeding of cotton: evaluating potassium sources, potassium solution buffering, and boron. Agron J. 90:740-746.

Oseland, E., M. Bish, L. Steckel, and K. Bradley. 2020. Identification of environmental factors that influence the likelihood of off-target movement of dicamba. Pest Manag. Sci. 76:3282-3291.

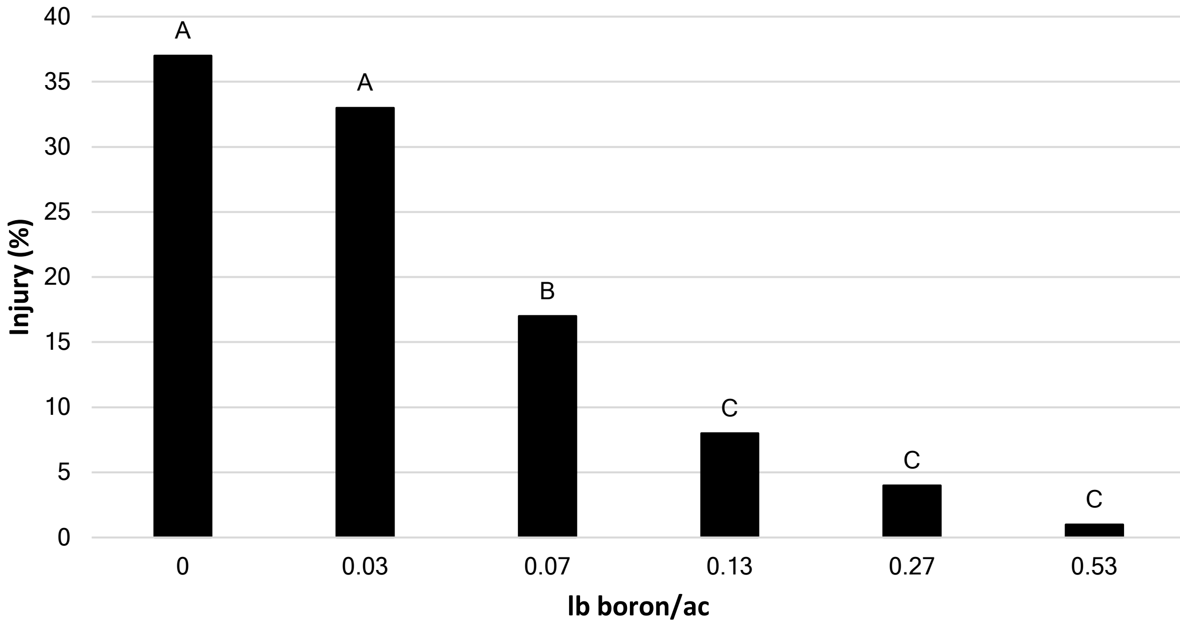

Fig. 1. Maximum soybean injury from volatilization caused by dicamba pooled over two runs at 21 days after treatment from the eight established quadrants located under the low tunnel at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas. Means followed by the same letter are not significantly different (α = 0.05).

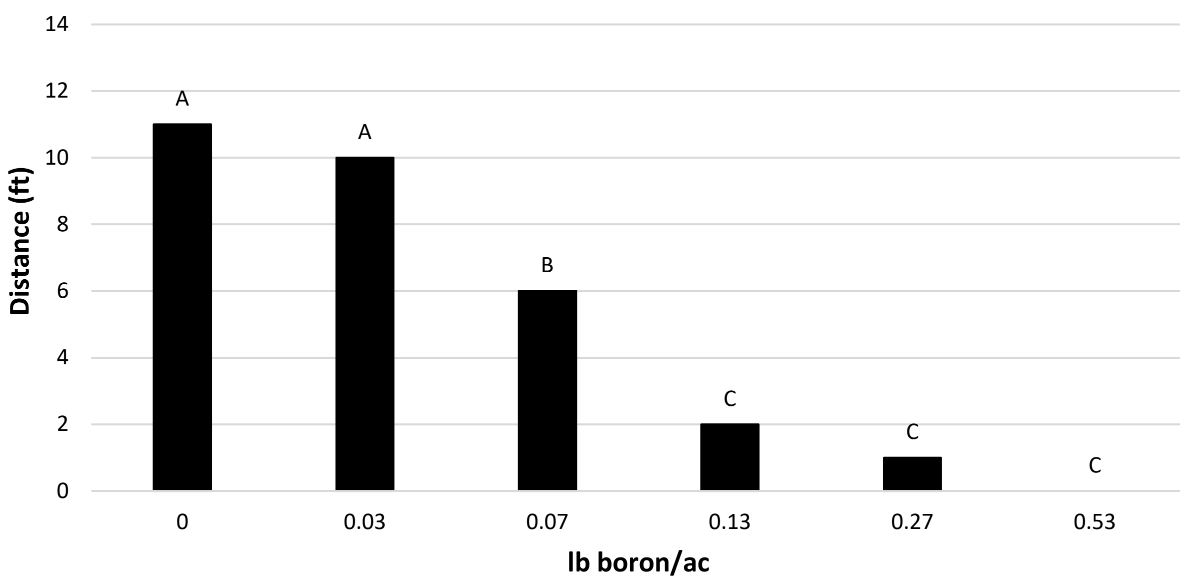

Fig. 2. Distance in feet dicamba traveled from the center of the low tunnel to cause ≤5% visible injury pooled over two runs at 21 days after treatment at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas. Means followed by the same letter are not significantly different (α = 0.05).

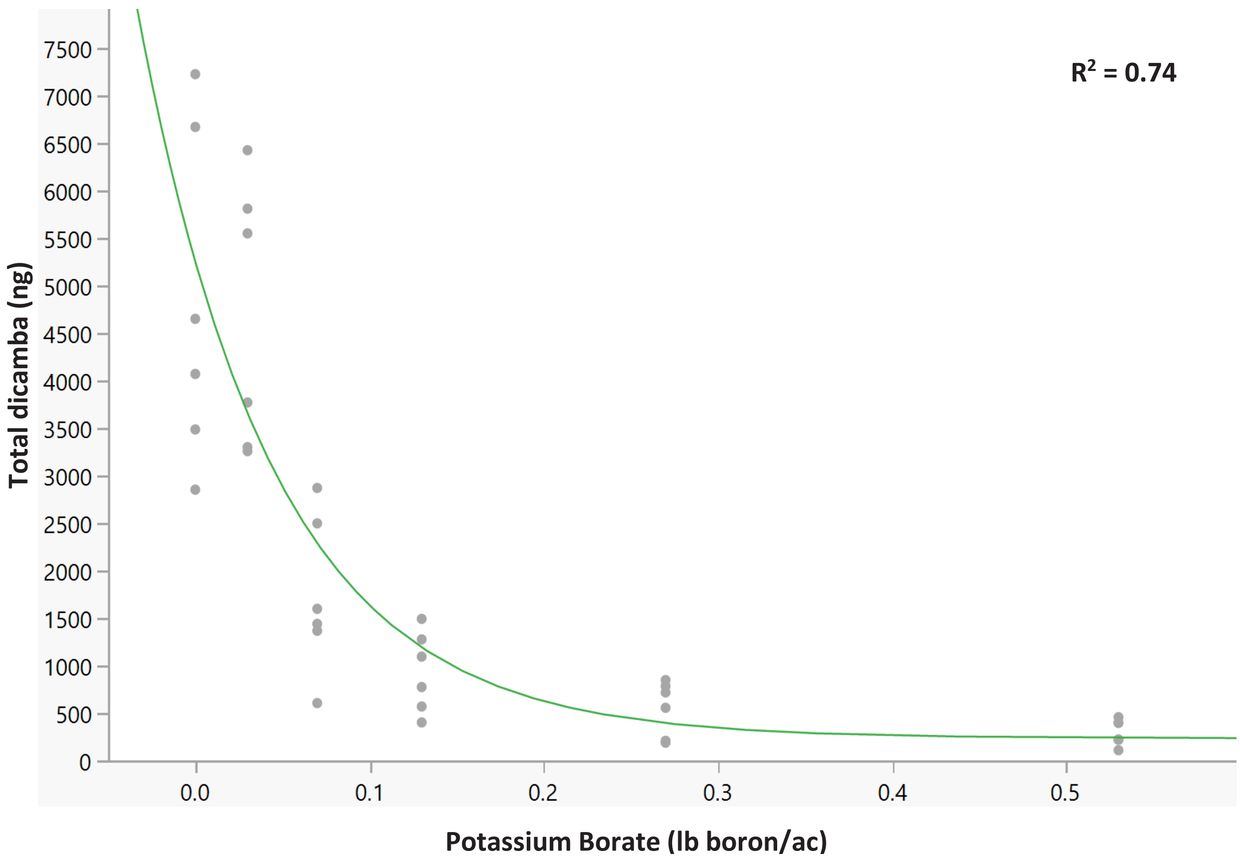

Fig. 3. Total amount of dicamba captured from the high-volume air sampler extracted from the polyurethane foam and filter paper at each boron rate 0- to 48-hours after application when pooled over two runs. The line fit to total dicamba data is a nonlinear exponential 3p curve.

Cotton Tolerance to Post-Directed Applications of Loyant (Florpyrauxifen-benzyl)

R.C. Doherty,[1] T. Barber,[2] L Collie,[2] Z. Hill,[1] and A. Ross[2]

Abstract

Cotton (*Gossypium hirsutum* L.) herbicide systems that contain multiple modes of action and are applied timely are essential in controlling Palmer amaranth (*Amaranthus palmeri*). Arkansas cotton growers need new and improved methods and chemistry to manage this and other troublesome weeds. Trials were established in 2019 and 2020 to evaluate weed efficacy and crop response following Loyant applications post-directed in cotton. Trials were established at Marianna, Arkansas, in a Loring silt loam soil and at Tillar, Arkansas, in a Herbert silt loam soil. In 2019, PHY 350 W3FE was established at Tillar and DP 1646 B2XF at Marianna; while in 2020, PHY 400 W3FE was established at both locations. The trials were arranged in a randomized complete block design with four replications. All treatments received Brake FX preemergence at 40 oz/ac (fluometuron 33.2 oz/ac + fluridone 6.8 oz/ac) followed by Liberty (glufosinate) at 32 oz/ac plus Dual Magnum (metolachlor) at 21oz/ac at 3-4 leaf cotton. Post-directed herbicides evaluated included Loyant (florpyrauxifen-benzyl) at 5, 8, and 16 oz/ac, Durango (glyphosate) at 32 oz/ac and Roundup PowerMax (glyphosate) at 32 oz/ac. In 2019 and 2020, post-direct applications of Loyant were applied to 8- or 10-node cotton. Palmer amaranth control and epinasty were recorded at 21 days after 10-node post-direct applications at both locations. Loyant provided greater than 89% control of Palmer amaranth, as long as the rate applied was 8 oz/ac or greater. Cotton injury was significant when Loyant was applied at the 8-node growth stage; however, injury was generally reduced when applications were made to 10-node cotton. Yield reductions from all Loyant applications were observed at Marianna in 2019. No significant yield reductions were observed at either location in 2020, with the exception of, Loyant 16 oz/ac applied to 8-node cotton at Marianna.

Introduction

Controlling glyphosate, protoporphyrinogen oxidase (PPO) inhibitor, and acetolactate synthase (ALS)-resistant Palmer amaranth, while maintaining crop safety, remains a major concern for cotton growers in Arkansas. Herbicide programs that utilize multiple modes of action applied timely and with residuals are essential in controlling this troublesome weed (Barber et al., 2020). Enlist™ and XtendFlex™ technologies provide an opportunity and the flexibility to use multiple modes of action, over-the-top and post-directed, for control of a wide variety of weeds, including Palmer amaranth. Loyant may provide another option for post-directed weed control if crop safety exists. Our objective was to establish the appropriate rate of Loyant required for weed control and evaluate crop safety.

Procedures

In 2019, PHY 350 W3FE was seeded at Tillar in a Herbert silt loam soil, and DP 1646 B2XF (the only non-Enlist cultivar evaluated) was seeded at Marianna in a Loring silt loam soil. In 2020, PHY 400 W3FE was used in tests at both Tillar and Marianna. Each trial was arranged in a randomized complete block design with four replications. All plots received Brake FX preemergence at 40 oz/ac (fluometuron 33.2 oz/ac + fluridone 6.8 oz/ac) followed by Liberty (glufosinate) at 32 oz/ac plus Dual Magnum (s-metolachlor) at 21 oz/ac on 3–4 node cotton (Table 1). Post-directed herbicides evaluated included Loyant (florpyrauxifen-benzyl) at 5, 8, and 16 oz/ac, Durango (glyphosate) at 32 oz/ac and Roundup PowerMax (glyphosate) at 32 oz/ac. The multiple Loyant rates, applied alone and tank mixed with Roundup or Durango, were applied post-direct to 8- and 10-node cotton to evaluate cotton response. Visual weed control ratings of Palmer amaranth were recorded 21 days after the 10-node application at Tillar in 2019 and 2020. Fertility and pest management were maintained throughout the period of the experiment based on University of Arkansas System Division of Agriculture's Cooperative Extension Service recommendations, and seed cotton yield was collected for each plot and analyzed to determine if any yield loss occurred from Loyant injury. Means were separated using Fisher's protected least significant difference at alpha = 0.05.

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Results and Discussion

In 2019, epinasty at Marianna increased as the Loyant rate increased (Fig. 1). Epinasty ranged from 2.5%, with Loyant at 5 oz/ac to 11.3% with Loyant at 16 oz/ac. No visual injury was noted in any Loyant treatment at Tillar (data not shown). Weed control was not recorded at Marianna, but Loyant plus glyphosate provided 89-99% control of Palmer amaranth at Tillar 21 days after the 10-node application (Fig. 2.). Compared to the weed-free check, cotton yields were reduced by 9 of the 10 Loyant treatments on XtendFlex cotton at Marianna in 2019 (Fig. 3). The highest yield reduction was noted when Loyant was applied at 16 oz/ac to 8-node cotton. Yield was equal or greater than the weed-free check with all Loyant treatments on PHY 350 W3FE cotton at Tillar in 2019.

In 2020, epinasty at Marianna ranged from 0%, with Loyant at 0.013 lb ai/ac to 6% with Loyant at 16 oz/ac (Fig. 1.). No visual injury was noted in any Loyant treatment at Tillar (data not shown). Since no weeds had emerged by the time of application at Marianna, weed control ratings were not recorded. Loyant provided 74–99% control of Palmer amaranth at Tillar 21 days after the 10-node application, with Loyant at 5 oz/ac plus Roundup at 32 oz/ac providing the least control (Fig. 2.). Marianna cotton yield was reduced by Loyant at 16 oz/ac plus Roundup at 32 oz/ac applied to 8-node cotton, while yield was equal or greater than the weed-free check with the other nine Loyant treatments (Fig. 4). Cotton yield at Tillar was equal or greater than the weed-free check with all Loyant treatments. Preliminary data from 2019 and 2020 suggest that Loyant applied at 8 oz/ac may be a viable option for pigweed control when post-directed in older (10-node) cotton.

Practical Applications

The preliminary evaluation of Loyant herbicide as a potential post-direct or layby option in cotton appears promising. Loyant at 8 or 16 oz/ac plus Durango at 32 oz/ac or Roundup at 32 oz/ac provided excellent control of Palmer amaranth while causing very little injury to Enlist™ cotton. Extra care and more precise application methods may need to be administered while applying Loyant post-direct in XtendFlex™ cotton or Enlist™ cotton prior to 10 nodes of growth. This system must also include early season residuals applied preemergence and early-post-emergence to insure complete weed control. These and other data can be used to provide justification for a special use permit for Loyant in cotton, but more research is necessary to fully determine crop sensitivity.

Acknowledgments

The authors would like to thank the University of Arkansas System Division of Agriculture, Research and Extension for support in this research endeavor.

Literature Cited

Barber, L. T. John W. Boyd, G. Selden, J.K. Norsworthy, N. Burgos and M. Bertucci. 2019. MP44 2020. Recommended chemicals for weed and brush control. University of Arkansas, Division of Agriculture, Research and Extension, Little Rock, Ark.

Table 1. Post-directed herbicide treatments using Loyant to control Palmer amaranth in 2019 and 2020 at Marianna and Tillar, Arkansas.

Herbicide	Rate	Timing
	oz product/ac	
Loyant 5	5	8 and 10 node cotton post-directed
MSO	0.5 %v/v	
Loyant 8	8	8 and 10 node cotton post-directed
MSO	0.5 %v/v	
Loyant 5	5	8 and 10 node cotton post-directed
Roundup	32	
Loyant 8	8	8 and 10 node cotton post-directed
Durango DMA	32	
Loyant 16	16	8 and 10 node cotton post-directed
Roundup	32	

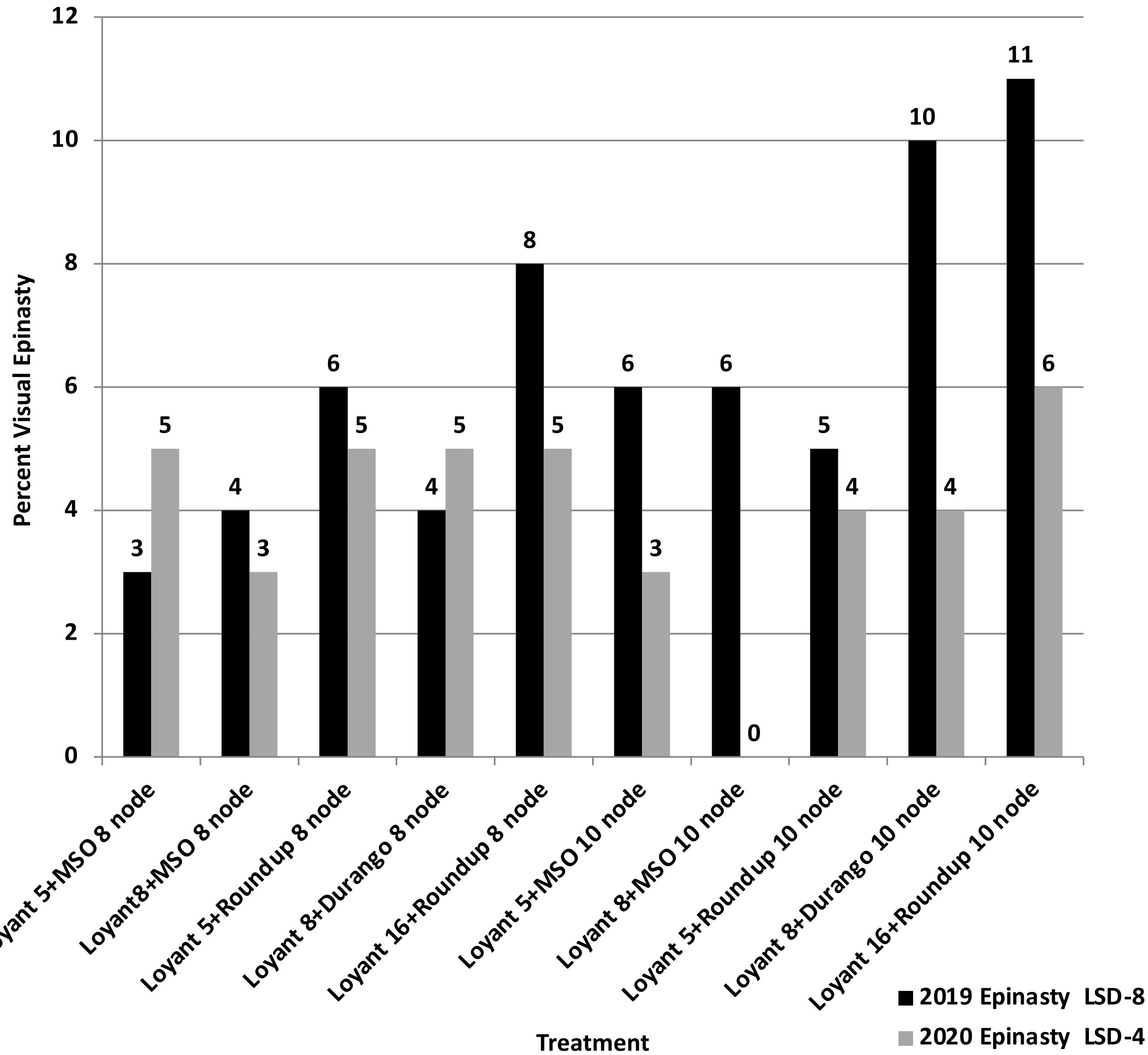

Fig. 1. Percentage of plants showing epinasty at 21 days after 10-node application of treatments (listed in Table 1) at Marianna, Arkansas, in 2019 (least significant difference 0.05 = 8) and 2020 (least significant difference 0.05 = 4).

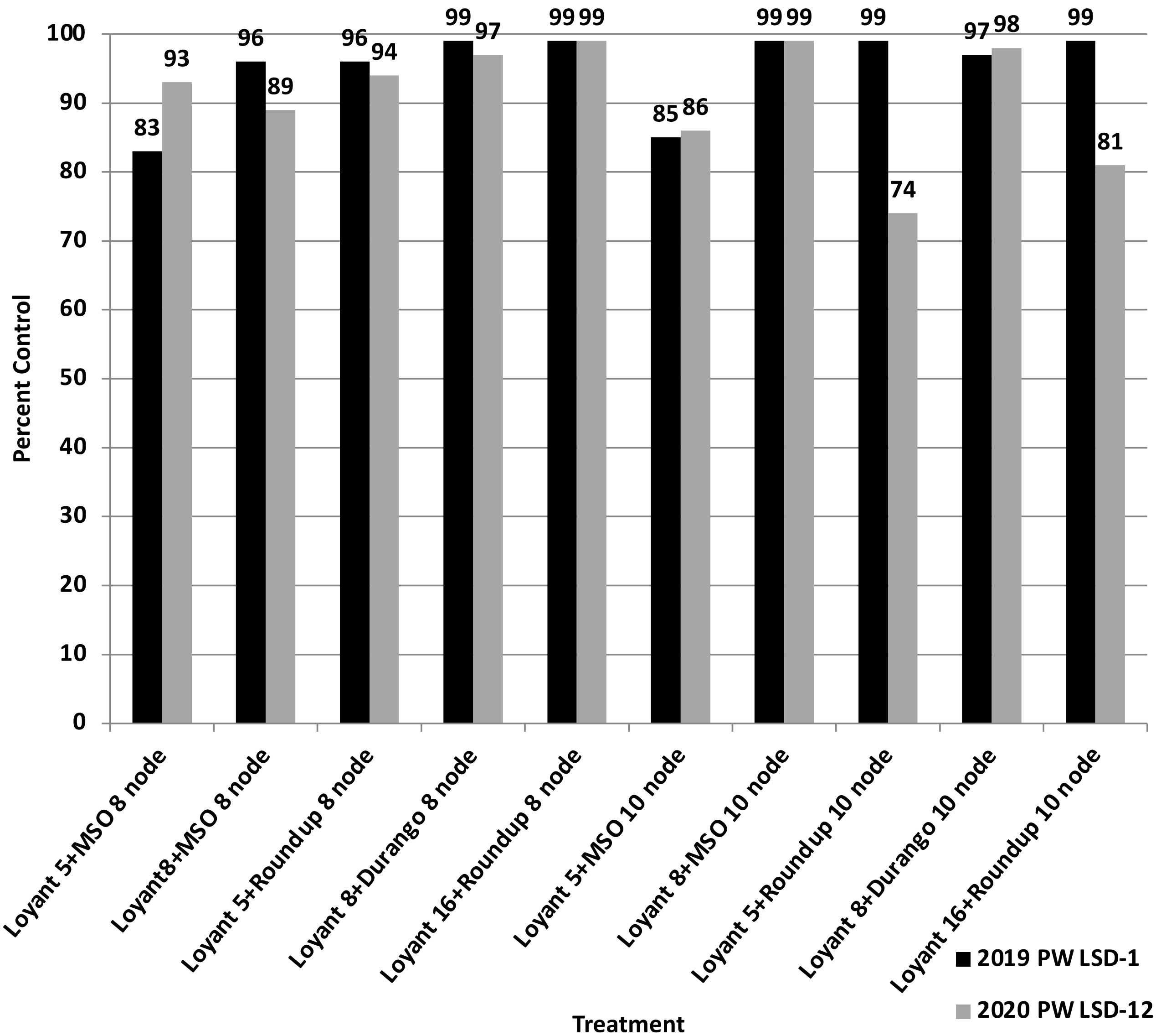

Fig. 2. Percentage of control of Palmer amaranth at 21 days after 10-node application of treatments (listed in Table 1) at Tillar, Arkansas, in 2019 (least significant difference 0.05 = 1) and 2020 (least significant difference 0.05 = 12).

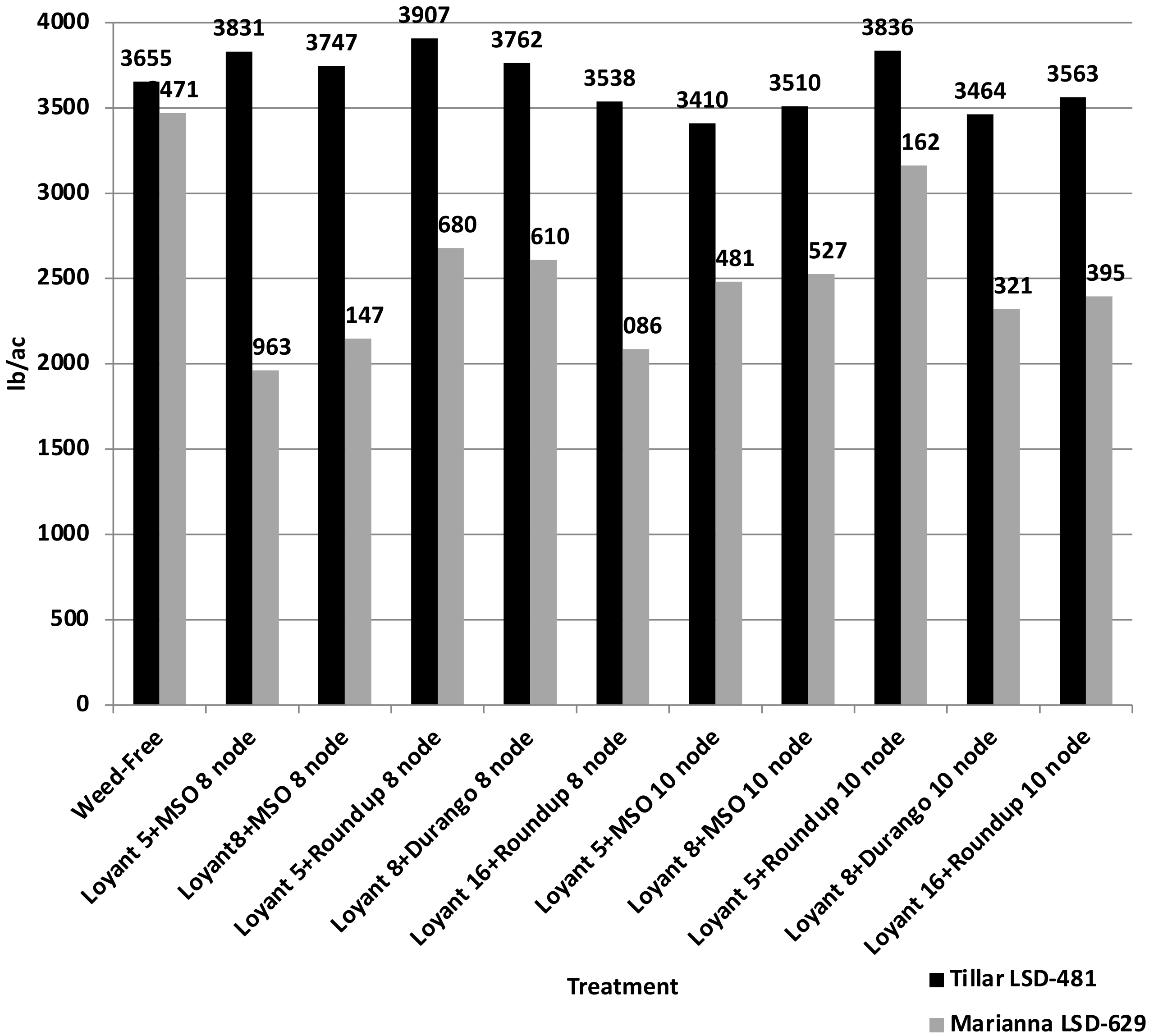

Fig. 3. Seed cotton yield following herbicide treatments (listed in Table 1) for Palmer amaranth at Tillar, Arkansas, (least significant difference 0.05 = 482) and at Marianna, Arkansas, (least significant difference 0.05 = 629) in 2019.

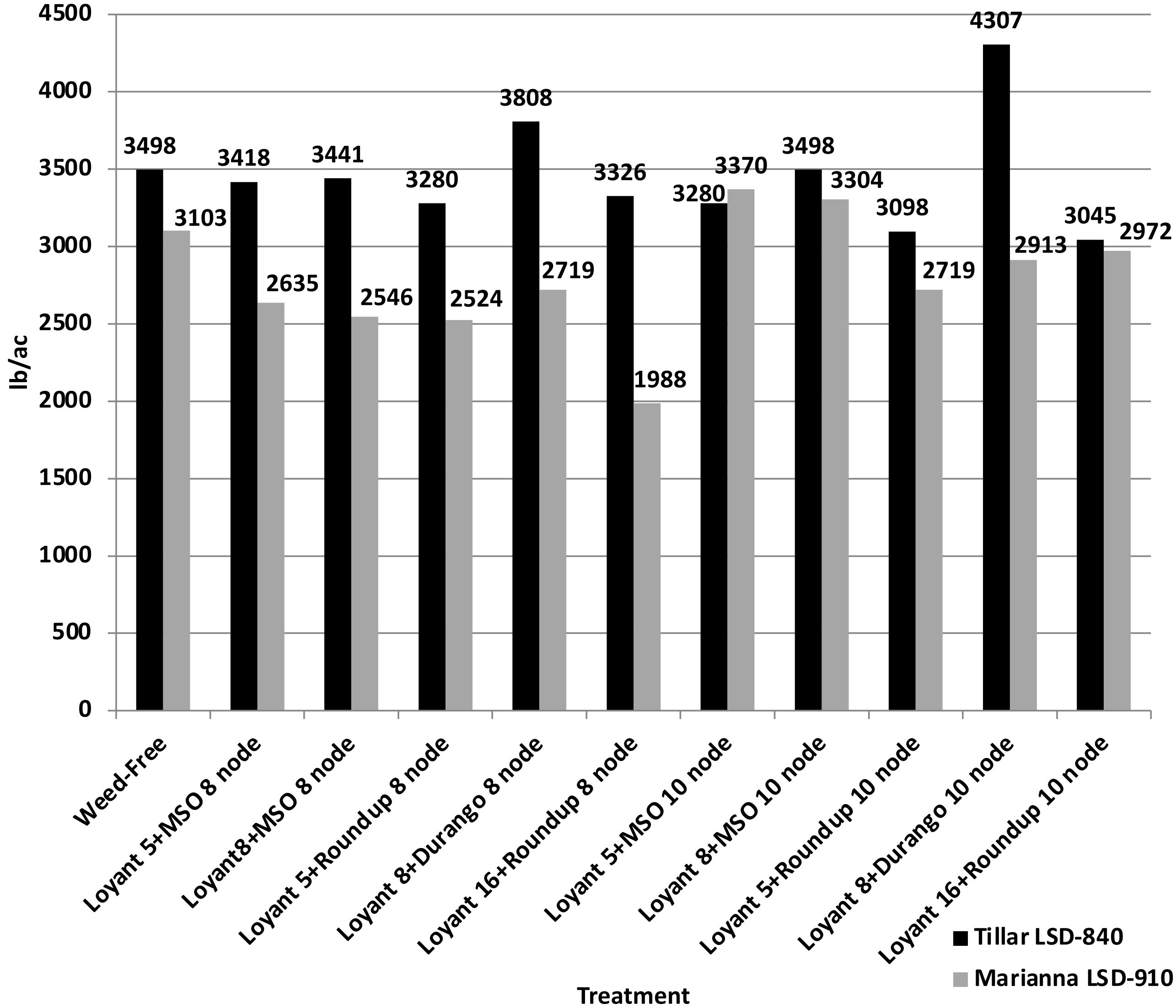

Fig. 4. Seed cotton yield following herbicide treatments (listed in Table 1) for Palmer amaranth at Tillar, Arkansas, (least significant difference 0.05 = 840) and at Marianna, Arkansas, (least significant difference 0.05 = 910) in 2020.

Evaluation of Cotton Yield to In-Season Soil Applied Potassium

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Abstract

The increased yield potential of new cultivars has pushed cotton yields in Arkansas to 3–4 bales/acre. Such high yields put a substantial demand on the cotton root systems' ability to take up sufficient potassium (K) and other nutrients, especially in soils with shallow rooting. The objective of this study was to evaluate application timing and rates of K on cotton yield and quality. The on-farm study from 2016 to 2020 near Judd Hill was a conventional-tilled, furrow irrigated field. The producer's standard K fertility program timings consisted of pre-plant, 4 to 6 leaf, and 1 week prior to first flower. Alternative strategies consisted of shifting the in-season K applications to either the 4 to 6 leaf or the one week prior to first flower timing. A treatment that consisted of no in-season applications represented the current University of Arkansas System Division of Agriculture's Cooperative Extension Service recommendation. While no statistical yield differences were observed within years, it appears that a trend for improved yields may be obtained when shallow rooting conditions exist, especially during boll fill.

Introduction

New and improved cultivars and better management practices have pushed cotton yields in Arkansas to 3–4 bales/ac. Such high yields put a substantial demand on the cotton root systems' ability to take up sufficient potassium (K) and other nutrients. The frequency and severity of K deficiency symptoms also have increased on highly productive soils over the past decade, especially in soils with shallow rooting. Insufficient K levels as a result of shallow rooting could decrease yields and fiber quality and lead to decreased grower profits. The objective of this study was to evaluate application timing and rates of K on cotton yield and fiber quality. Based on these findings, soil K recommendations will be re-evaluated and modified as appropriate to optimize yields.

Procedures

An on-farm study site was selected at Judd Hill based on cooperators' and consultants' desire to address their questions on the K needs of cotton on their soil and yields. The site was a conventional-tilled, furrow irrigated Mhoon Silt Loam field. The four-year study was conducted using a randomized complete block design (RCBD) with 4 replications. Plots were 6 rows (38 in.) wide and 1200 ft long. The producer's standard fertility program consisted of pre-plant, 4 to 6 leaf, and 1 week prior to first flower applications (Table 1). Alternative strategies consisted of shifting the in-season K applications to either the 4 to 6 leaf (in season early only) or the one week prior to first flower timing (in season late only) (Table 2). A treatment that consisted of no in-season applications (pre-plant only) of K represented the current university recommendations. Seed cotton was hand-picked from four plants (one hill) in each plot and ginned on a table-top gin to calculate percent lint and provide samples for HVI fiber analysis. Plots were machine harvested.

Results and Discussion

A trend was observed for increased yield associated with in-season K applications in 2016, 2017, 2019, and 2020 in which dry conditions were observed during much of boll fill. When dry conditions during boll fill are experienced, the lack of water infiltration below six inches with furrow irrigation often results in the loss of deep roots shifting the plant into a shallow rooting/poor uptake situation. No advantage was observed in 2018 when significantly above-average rainfall was received during boll fill allowing the plants to maintain a deeper effective rooting zone.

Practical Applications

While no statistical yield differences within years were observed in this study, it appears that a trend for improved yields may be obtained when the effective rooting depth is restricted during boll fill. More research is needed to fully evaluate the impact of soil moisture on plants' response to soil-applied K.

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Table 1. Producer standard fertilizer application timings and rates of nutrient applications season long at Judd Hill from 2016 to 2020.

Nutrient	Application Timing			Season Total
	Pre-Plant	4 to 6 Leaf	1 Week Prior to First Flower	
	-- lb/ac	--		
Nitrogen	18	46	46	110
Phosphorus	46	0	0	46
Potassium	60	30	30	120
Sulfer	0	12	12	24
Boron	0	0.5	0.5	1.0

Table 2. Alternative strategies evaluated for K-Study application timings and lint yield lb/ac at Judd Hill from 2016 to 2020, keeping all other nutrient rates and timings consistent with each strategy.

K Timing	Lint Yield					
	2016	2017	2018	2019	2020	Average
	--- lb/ac	---				
In-season Early + Late	1627	1643	1640	1733	1754	1676
In-season Late Only	1459	1650	1745	1618	1686	1629
In-season Early Only	1572	1588	1590	1671	1715	1623
Pre-plant Only	1413	1581	1740	1669	1474	1580

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