Summaries of Arkansas Cotton Research 2022

Edited by Fred Bourland

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

ARKANSAS AGRICULTURAL EXPERIMENT STATION

September 2023 Research Series 695

This publication is available on the internet at https://aaes.uada.edu/communications/publications/

Cover Photo: A cotton field with a high weed population on the left and a less weedy one on the right with the blue dye illustrating the sprays in the area at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center. Photograph by Tristen Avent, Graduate Assistant, Department of Crop, Soil, and Environmental Sciences, Fayetteville.

Layout, technical editing, and cover design by Gail Halleck

Arkansas Agricultural Experiment Station (AAES), University of Arkansas System Division of Agriculture, Fayetteville. Deacue Fields, Vice President for Agriculture. Jean-François Meullenet, AAES Director and Senior Associate Vice-President for Agriculture–Research. WWW/CC2023.

ISSN: 1941-1618 CODEN:AKAMA6

Summaries of Arkansas Cotton Research 2022

Fred Bourland, Editor

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

Table of Contents

Cotton Incorporated and the Arkansas State Support Committee

The *Summaries of Arkansas Cotton Research 2022* 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 state's 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. Funding for cotton production research in Arkansas in 2021 and 2022.

Researcher	Short Title	2021	2022
Bourland	Breeding Cotton for Arkansas Conditions	$26,000	$26,000
Barber	Integrated Pest Management for Weeds	$31,359	$31,359
Faske	BMP for Root-Knot Nematodes and Target Spot	$13,598	$0
Robertson	Cotton Research Verification/Applied Research	$50,000	$50,000
Robertson	Increasing Profitability by Reducing Input Costs	$30,000	$30,000
Robertson	Evaluation of Plant Population	$0	$31,200
Rojas	Seed Treatment Efficacy and Cotton Seedling Disease	$7,000	$7,000
Spurlock	BMP for Root-Knot Nematodes and Target Spot	$0	$13,598
Thrash	2- and 3-gene *Bt* vs. Non-*Bt* for Arkansas	$20,000	$20,000
Thrash	Impact of Water Quality on Insecticides	$10,000	$10,000
Total		**$187,957**	**$219,157**

Acknowledgments

The organizing committee would like to express appreciation to Gail Halleck for her help in formatting this research series for publication.

Disclaimer

Summaries of

Arkansas Cotton Research

— 2022 —

Review of the 2022 Arkansas Cotton Crop

The current economic environment continues to drive the need to produce record or near-record yields to be profitable. Price volatility in 2022 added another level of difficulty in the quest for being profitable. The cotton market saw significant movement after reaching a $1.5802 per pound high in May 2022, cotton prices corrected and more than halved in value at the October 2022 low, and then consolidated around the 80 cents per pound level in December 2022 (Cotton is Consolidating). Great uncertainties still exist for the upcoming season, most of which are outside of our control. These include, but are not limited to, weather extremes, inflation, supply chain disruptions, rising interest rates, and a strengthening U.S. dollar. Most economists recommend using a price range of 72 to 78 cents per pound for planning and budgeting projections for 2023. We must continue to focus on things we can control and hope for a little luck and help from Mother Nature. The art and science related to production agriculture continue to be as much art as it is science.

Overview

Cotton acreage in Arkansas has increased from an all-time low of 210,000 acres in 2015 and basically leveled off around 500,000 acres prior to 2022. In 2022, Arkansas producers planted 640,000 acres, up 25% from the 480,000 acres planted in 2021. Much of the acreage expansion was observed in several southwest and central Arkansas counties. While these areas were not new to cotton production, cotton had not been planted there in several years. Producers harvested 630,000 acres, up 33 percent from last year. Lint yield averaged 1,196 pounds per harvested acre, down 52 pounds from last year, but still our second-best on record. Production was approximately 1.57 million bales, up 27 percent from last year (USDA-NASS Arkansas Crop Production). Our current five-year average is 1,188 lb lint/ac. Arkansas ranks third in harvested acres and cotton production behind Texas and Georgia. Arkansas ranks fourth in lint yield per acre behind California, Arizona, and New Mexico (Crop Production 2022 Summary).

Planting

Essentially all cotton plantings in 2022 contained traits for enhanced insect and weed control. The Cotton Varieties Planted report released by the United States Department of Agriculture–Agricultural Marketing Service was discontinued after its 2020 publication. Therefore, no official estimate is available for cotton plantings. An informal survey of crop consultants statewide was conducted in late June for the purpose of estimating cotton varieties planted. Responses were received from 20 consultants from all cotton-growing regions of the state. Results of the unofficial survey indicated 16 varieties accounted for 97% of the 640,000 acres planted statewide in 2022 and are as follows:

Variety	Planted Acres (%)
DP 2038 B3XF	30.05
DP 2127 B3XF	10.89
ST 5091 B3XF	7.56
ST 4490 B3XF	7.54
DP 2115 B3XF	6.49
DP 1646 B2XF	6.39
NG 4936 B3XF	6.15
DP 2012 B3XF	5.47
DP2020 B3XF	4.32
NG 3195 B3XF	4.27
PHY 411 W3FE	2.78
DP 2141 B3XF	1.33
DP 2239 B3XF	1.02
NG 4190 B3XF	0.95
PHY 400 W3FE	0.93
DP 2131 B3TXF	0.89

Based on this survey, it is estimated that 96% of the cotton varieties planted in 2022 contained XtendFlex® herbicide-tolerant traits (XF). Plantings of varieties containing the Enlist™ weed control system traits (FE) was estimated at almost 4% in 2022.

Varieties containing three-gene *Bt* traits (B3 and W3) increased to just over 90% of the acres statewide. Approximately 1% of the acres were planted to varieties containing Bollgard® 3 ThryvOn™ technology (B3T). The five most widely planted varieties DP 2038 B3XF, DP 2127 B3XF, ST 5091 B3XF, ST 4990 B3XF, and DP 2115 B3XF accounted for 62.5% of acres.

Cotton planting progress was well ahead of that observed in 2021 through mid-May and essentially mirrored that of our five-year average much of our 2022 planting window (https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Progress_&_Condition/2022/index.php). While the rate of our planting progress was good through mid-May, late-planting of cotton was observed into June especially in areas of the state where acreage expansion occurred.

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/2022/index.php) indicate the percentage of the acres statewide receiving a rating of excellent dropped to the low point of the season at the end of July. These ratings reflected the rebound of the crop from rainfall statewide at the end of July and first of August. Planting progress basically mirrored our five-year average. Therefore, seeing that fruiting followed that pattern was not a big surprise. Harvest progress reflected our five-year average for the first two-thirds of harvest. Harvest progress proceeded at a more rapid pace as dry conditions continued as we wrapped up the harvest.

Our weather was the dominant driving force for this crop. Regarding temperatures in 2022, readings were a little warmer than average, especially during late spring and early summer (https://www.weather.gov/lzk/2022.htm). In Little Rock, the 27th warmest May on record (2.2 degrees above average) and the 6th warmest July (3.8 degrees above average) were observed. Triple-digit heat in July was one of the factors that led to a developing drought that lasted through the end of the year. The year started wet through spring, but quickly dried out in the summer/fall. Precipitation was largely subpar from June through October. However, there were downpours in late July, especially in northeast and far southern Arkansas.

Relief continued in August, as it was a wetter than average month statewide by just over an inch. This relief from the drought gave our crop a second wind, and the almost perfect conditions for boll development through nearly the entire month of September propelled a potentially average crop to a very good one. It was the 10th driest September on record (2.33 inches below average), and the harsh drought conditions of 2022 followed in early October. Heading into mid-October, drought conditions were widespread across Arkansas. The drought resulted from heat and a lack of rain in June/July and dry conditions in September. The drought started from 11 June to 26 July. It was very hot, especially in the west. A ridge of high pressure became dominant across Arkansas in September. Under the high, well above-average temperatures were common, and raindrops were few and far between. By the end of the month, rainfall was one to more than three inches subpar.

Inputs

In our 2022 Cotton Research Verification Sustainability Program (CRVSP), the average operating cost for cotton was $657.66/ac. Tarnished plant bug (TPB) numbers were like in past years in the CRVSP fields, which were treated an average of 3.29 times in 2022. The TPB pressure was similar across all fields, which were sprayed 2 to 5 times during the growing season. Each field had an average of 1.14 burndowns and 4.14 herbicide applications for the 2022 season. Chemical costs averaged $216.92/ac and were nearly 32.9% of operating expenses. Seed and associated technology fees averaged $106.24/ac, or 16.6% of operating expenses. Fertilizer and nutrient costs averaged 28.2% of operating expenses and were $185.38/ac.

Costs do not include land costs, management, or other expenses and fees not associated with production. The price received for cotton of $0.84/lb is the estimated Arkansas annual average for the 2022 production year. The average yield in the verification fields was 1389 lb/ac lint, which was 189 lb/ac over that used in the 2022 enterprise budget and 193 lb/ac over the state average. The average operating cost for cotton in these fields was $657.66/ac. Average operating costs were $0.49/lb lint, which is under the enterprise budget operating costs of $0.58 lb/lint. Operating costs ranged from a low of $553.86/ac to a high of $714.59/ac.

Yield and Quality

A near record yield of 1196 lb lint/ac second to only last year was produced in 2022 https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Annual_Summary/2022/arannsum22.pdf. Many felt that an almost perfect September for boll development helped produce one of the best top crops we have ever experienced. Little losses from boll rot or seedcotton falling to the ground were observed in 2022. Basically, for much of the state, whatever the plant made went to the gin. All these factors combined will nearly always contribute to record or near-record yields. However, seedcotton was very dry at harvest, resulting in lighter than usual module weights because dry cotton produces less dense modules.

Fiber quality was very good in 2022 https://www.ams.usda.gov/mnreports/cnwwqo.pdf. We currently have 29 active gins in the state. Many of these gin operators commented how rare it was for them to see so many color grades of 11 and leaf of 1. This cotton lint is the brightest white with the least amount of leaf material we can produce. Color grades were very good season long, with 93.6% of bales receiving color grades of 31 or better. Micronaire averaged 4.47, with only 10% of Arkansas cotton classed in the discount range for high micronaire. Staple averaged 37.57, and leaf averaged 2.4.

Summary

Arkansas ended the 2022 season ranked 3rd nationally in harvested acres (630,000 acres) behind Texas and Georgia, 4th in lint yield on an acre basis (1,196 lb/ac) behind California, Arizona, and New Mexico, and 3rd in total production (1,570,000 bales) behind Texas and Georgia. The string of consecutive years with record-breaking or near-record yields is helping to sustain cotton acres at our current level. Harvest and ginning capacity are limiting factors for acre expansion. Our current production continues to push our ginning capacity of 29 gins and on-farm picker capacity to the limit. Multiple surveys of cotton planting intentions for 2023 all reflect a move back toward the half-million acre mark Arkansas producers planted the last few years prior to last year. The 2023 Arkansas Prospective Plantings released in March of 2023 by USDA-NASS calculated acreage intentions at 480,000 acres, down 25% from the 640,000 acres planted in 2022 https://www.nass.usda.gov/Statistics_by_State/Arkansas/Publications/Crop_Releases/Prospective_Plantings/2023/arplant23.pdf.

Bill Robertson
Professor, Cotton Extension Agronomist–Retired
Jackson County Extension Center, Newport

2022 Judd Hill Cooperative Research Station: Overview of Cotton Research

A. Beach,[1] B. Milano,[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. 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. See Table 1 for a list of 2022 research at Judd Hill.

Table 1. List of 2022 cotton research at Judd Hill Cooperative Research Station.

Project Leader(s)	Discipline	Title
Arlene Adviento-Borbe, Michelle Reba, Tina Teague	Multi-disciplinary	Influence of tillage practices on water quality of irrigation runoff and total N loss in a cotton production
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests: transgenic test with 40 entries and conventional test with 16 entries
Fred Bourland	Cotton Breeding	Cotton Strain Tests, six tests evaluating a total of 120 entries
Fred Bourland	Cotton Breeding	Cotton industry strain tests, total of 865 plots
Alejandro Rojas	Plant Pathology	2022 National Cottonseed Treatment (NCST) Test

2022 Conditions and Observations

Compared to historical averages, accumulative temperatures (DD60s) were greater during the 2022 growing season at Judd Hill (Table 2). Accumulative DD60s from April through October were 22% higher than the historical average and were consistently higher in each month. Daily high temperatures were relatively warm throughout most of the season, with 24 days—mostly in June and July—exceeding 95 °F (Fig. 1). Except for the lack of rain in June, monthly rainfall amounts were similar to historical averages. With adequate moisture and good soil temperatures, most plots at Judd Hill achieved excellent stands. The plants grew well and established excellent boll loads. Insect pressure was light throughout the season. Verticillium wilt at Judd Hill in 2022 was moderate but intense in localized areas. Harvest was completed in October.

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

Acknowledgments

We are indebted to Mike Gibson and the Judd Hill Foundation for their generous support and assistance. Cooperative efforts provided by 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.

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

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2022	105	394	609	741	592	415	126	2983
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2455
2022 rainfall (in.)	7.2	5.1	0.9	5.4	3.0	2.2	3.4	27.2
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; https://www.ncdc.noaa.gov/cdo-web/datatools/normals

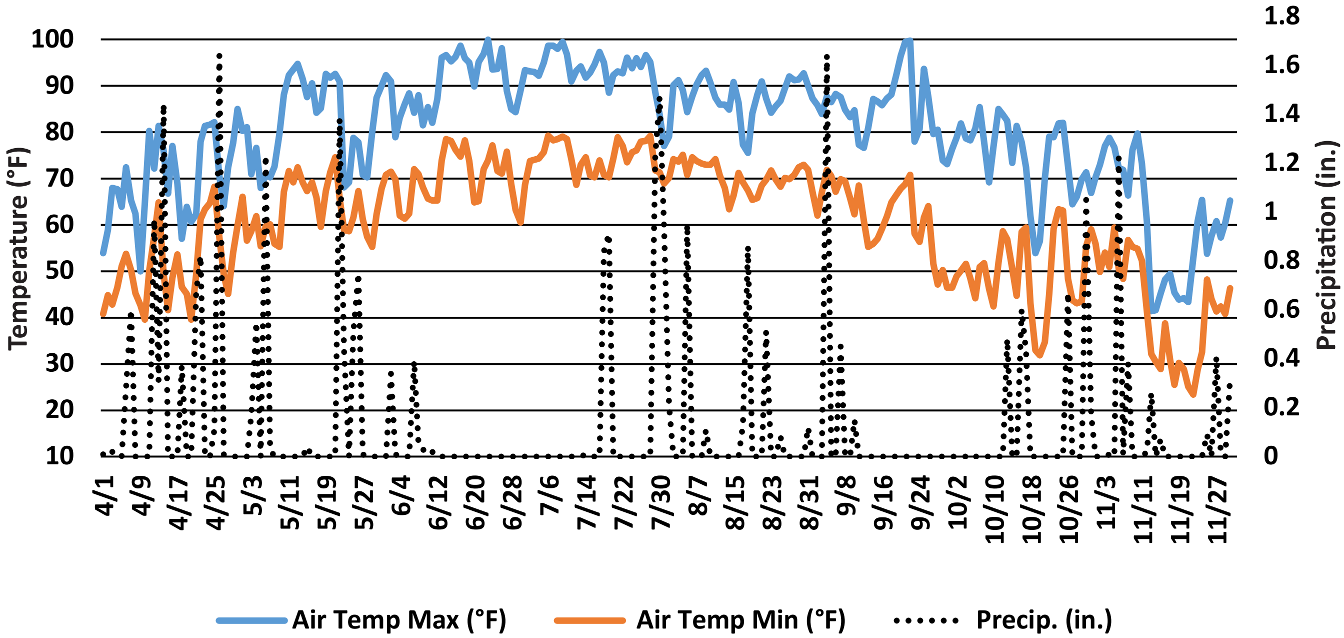

Fig. 1. 2022 Judd Hill temperature and precipitation.

2022 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 a list of 2022 cotton research at Manila).

Table 1. List of 2022 cotton research at Manila Airport.

Project Leader	Discipline	Title
Tina Gray Teague	Multi-disciplinary	Seeding rate, cover crop, potassium fertilizer rate and timing and cover crop termination timing effects on maturity and yield of mid-South cotton
Fred Bourland	Cotton Breeding	Arkansas Transgenic Cotton Variety Test (40 entries)
Bill Robertson	Agronomy	Evaluation of cotton in large-plot on-farm variety testing

2022 Conditions and Observations

The weather data below were measured at Wildy's Farm Shop, about five miles from Manila Airport. Wet conditions delayed the planting of plots in Manila until 10 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, except for two periods (9 June–19 July and 12 September–13 October) in which accumulative rainfall was >0.1 in. (Fig. 1). Manila weather data are compared to historical weather data from Keiser, about 15 miles southeast of Wildy's Farm. Heat units (DD60s) accumulated from April through October were 9% greater than the historical average (Table 2). Rainfall during the same period was 24% higher than the historical average. Plots were furrow-irrigated and scheduled based on cooperating producer's standard practices. Mepiquat chloride (Pix) to control internode elongation and plant height was required at normal rates. Insect pressure was relatively light during the 2022 season, with the primary insect pest being plant bugs. Insect pressure was generally light in 2022. Harvest was completed in early November. Lint yields at Manila in 2022 were very good, as indicated by an average lint yield of 1456 lb/ac in the Arkansas Transgenic Cotton Variety Test.

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

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.

Table 2. Weather conditions at Wildy Farms, Manila.

Weather factor	April	May	June	July	Aug.	Sept.	Oct.	Total
DD60s in 2022	92	380	595	721	575	384	102	2851
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2612
Rainfall (in.) 2022	10.2	5.2	2.2	4.2	6.4	2.6	3.2	34.0
Hist. avg. rainfall (in.)[b]	4.8	4.2	5.4	4.0	2.6	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;
https://www.ncdc.noaa.gov/cdo-web/datatools/normals

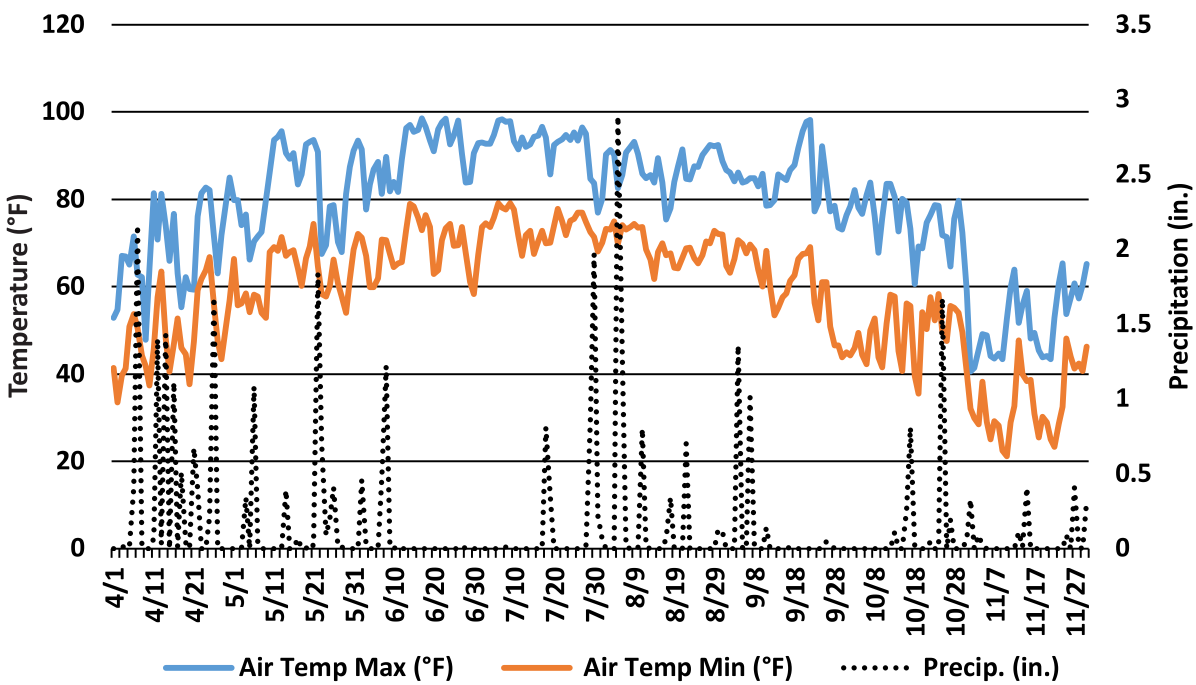

Fig. 1. 2022 Manila temperature and precipitation.

2022 Northeast Research and Extension Center: Overview of Cotton Research

A. Beach,[1] B. Milano,[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, weeds, soil fertility, irrigation, and agricultural engineering. Innovative practices evaluated at Keiser have included narrow row culture, mechanical harvest (pickers, strippers, and the cotton combine), and the cotton caddy (forerunner to the 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 the application of mepiquat chloride on this soil type, plants develop unaltered heights at this station. See Table 1 for a list of 2022 cotton research at Keiser.

Table 1. List of 2022 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, 40 entries and conventional test, 20 entries)
Fred Bourland	Cotton Breeding	National Cotton Variety Test (8 entries), Regional High Quality Strain Test (11 entries) and Regional Breeders' Network Test (32 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests, six tests evaluating a total of 120 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
Fred Bourland	Cotton Breeding	Evaluation of cotton industry strain tests (48 entries in 192 plots)
Fred Bourland	Cotton Breeding	Fiber quality in cotton NAM families (480 plots)
Jason Norsworthy	Weed Science	Control of weeds in cotton
Glenn Studebaker	Entomology	Tarnished plant bugs (TPB): - Verification of TPB resistance in cultivars - TPB standardized efficacy study
Glenn Studebaker	Entomology	Bollworm in cotton: - Efficacy of various Bt cultivar technologies
Glenn Studebaker	Entomology	Thrips in cotton: - Efficacy of seed treatments and in-furrow insecticides on control of thrips - Efficacy of foliar insecticide on control of thrips
Glenn Studebaker	Entomology	Cotton aphid standardized efficacy study
Ben Thrash	Entomology	Regulated trials (1 trial, 24 treatments, 72 plots)

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

2022 Conditions and Observations

Similar to conditions experienced in recent years, rainfall in April delayed land preparation at Keiser in 2022. The planting of cotton plots was completed in mid-May. Adequate moisture and good soil temperatures resulted in good stands in most plots. Daily high temperatures were relatively warm throughout most of the season, with 15 days—mostly in June and early July—exceeding 95 °F (Table 2, Fig. 1). Except for a period from mid-June to early July, frequent rains caused fields to be relatively wet throughout the season. Both insect and disease incidences were low at Keiser in 2022. Defoliants were applied on time using ground application. Relatively low rainfall in September and October facilitated the timely harvest of plots. Lint yields at Keiser in 2022 were very good, as indicated by an average lint yield of 1309 lb/ac in the Arkansas Transgenic Cotton Variety Test.

Acknowledgments

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.

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 2022	99	376	573	692	544	364	90	2736
Historical avg. DD60s[a]	49	293	522	634	552	348	57	2612
Rainfall (in.) 2022	6.5	3.0	6.5	4.7	4.6	0.5	3.1	26.9
Hist. avg. rainfall (in.)[b]	4.8	4.2	5.4	4.0	2.6	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; https://www.ncdc.noaa.gov/cdo-web/datatools/normals

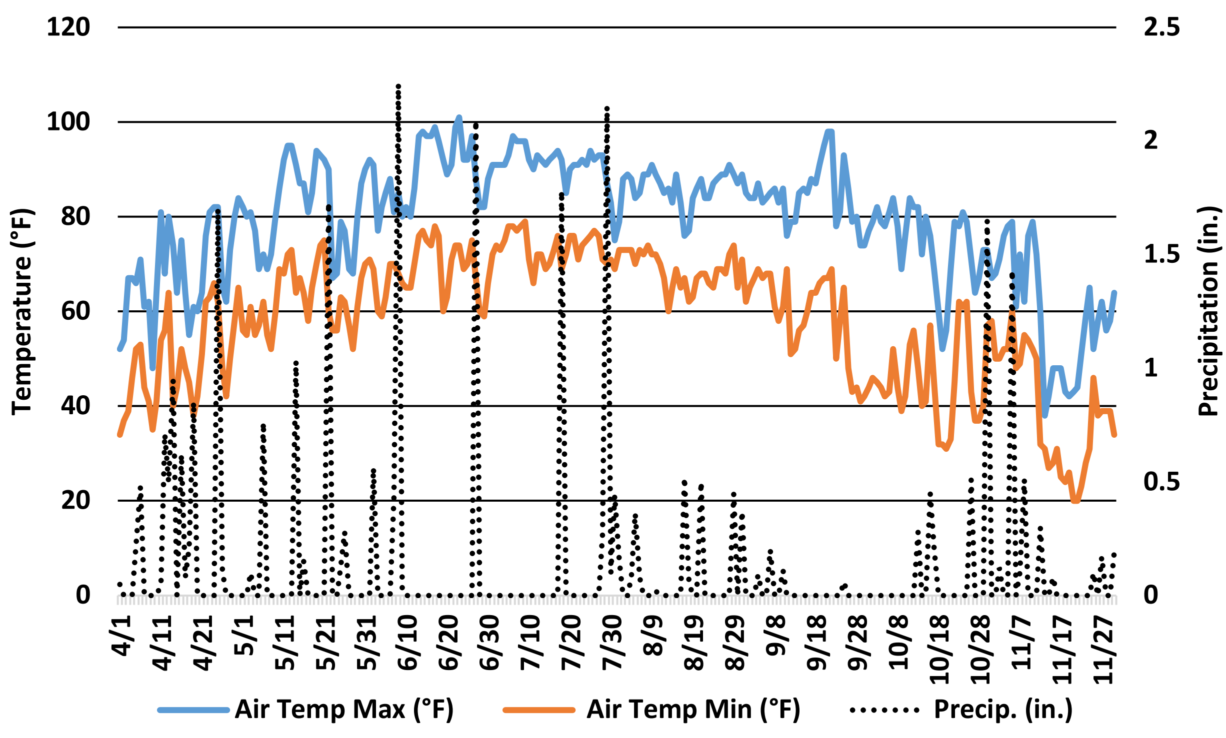

Fig. 1. 2022 Keiser temperature and precipitation.

2022 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. List of 2022 cotton research at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station.

Project Leader	Discipline	Title
Alejandro Rojas	Plant Pathology	Seed treatment efficacy and cotton seeding disease prevalence in Arkansas (15 treatments, 75 plots)
Alejandro Rojas	Plant Pathology	Evaluation of microbial seed inoculants on cotton performance (8 treatments, 32 plots)
Tom Barber	Weed Science	Cotton response to sublethal rates of herbicide 2,4-D
Tom Barber	Weed Science	Cotton response to drift rates of Rice herbicides
Tom Barber	Weed Science	Cotton response to drift rates of Reviton
Tom Barber	Weed Science	Evaluating Prowl H2O Post in Cotton
Tom Barber	Weed Science	Evaluation of High Load Warrant in Cotton
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests – Transgenic, 40 entries and Conventional, 20 entries
Fred Bourland	Cotton Breeding	Cotton strain tests, six tests evaluating a total of 120 entries
Fred Bourland	Cotton Breeding	Cotton breeding trial of 240 Advanced F_6 progenies
Fred Bourland	Cotton Breeding	Cotton observation plots of 960 F_5 preliminary progenies
Fred Bourland	Cotton Breeding	Fiber Quality Gene Sequencing, 20 plots
Fred Bourland	Cotton Breeding	Cotton industry strain tests, total of 256 plots
Jason Norsworthy and Tom Barber	Weed Science	Long-term integrated weed management in cotton (16 treatments, 64 plots)
Jason Norsworthy and Tom Barber	Weed Science	Determine the influence of furrow irrigation timing or rainfall activation of residual herbicides on fertilizer in cotton (24 treatments, 96 plots)
Ben Thrash	Entomology	Evaluation of Thryvon cotton for control of tobacco budworm, thrips, and tarnished plant bug (13 trials, 398 plots)
Ben Thrash	Entomology	Lepidoptera (2 trials, 23 treatments, 92 plots)
Ben Thrash	Entomology	Aphids trials (2 trial, 14 treatments, 56 plots)
Ben Thrash	Entomology	Thrips trials (4 trials, 25 treatments, 100 plots)

[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.

2022 Conditions and Observations

As has occurred in recent years, LMCRS experienced relatively high rainfall and mild temperatures through most of the 2022 growing season (Fig. 1). High rainfall in April (Table 1) delayed land preparation and planting on the station, but most cotton plots were planted before mid-May. 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 13% greater than the historical average (Table 2). Rainfall during the same period was 5% higher than the historical average. 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. Lint yields in the 2022 Transgenic Cotton Variety Test averaged 1761 lb/ac, which was higher than any other 2022 location.

Acknowledgments

The authors wish to thank 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.

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 2022	109	387	600	718	577	556	138	3084
Historical avg. DD60s[a]	65	339	548	650	594	398	98	2709
2022 rainfall (in.)	7.3	6.2	2.4	2.7	6.2	1.6	2.0	28.3
Hist. avg. rainfall (in.)[b]	5.0	5.1	3.9	3.8	2.6	2.5	4.1	27.0

[a] 30-year average of data collected in Lee County 1986–2015.
[b] 30-year average of data collected at the Marianna Station 1981–2010;
http://www.ncdc.noaa.gov/cdo-web/datatools/normals

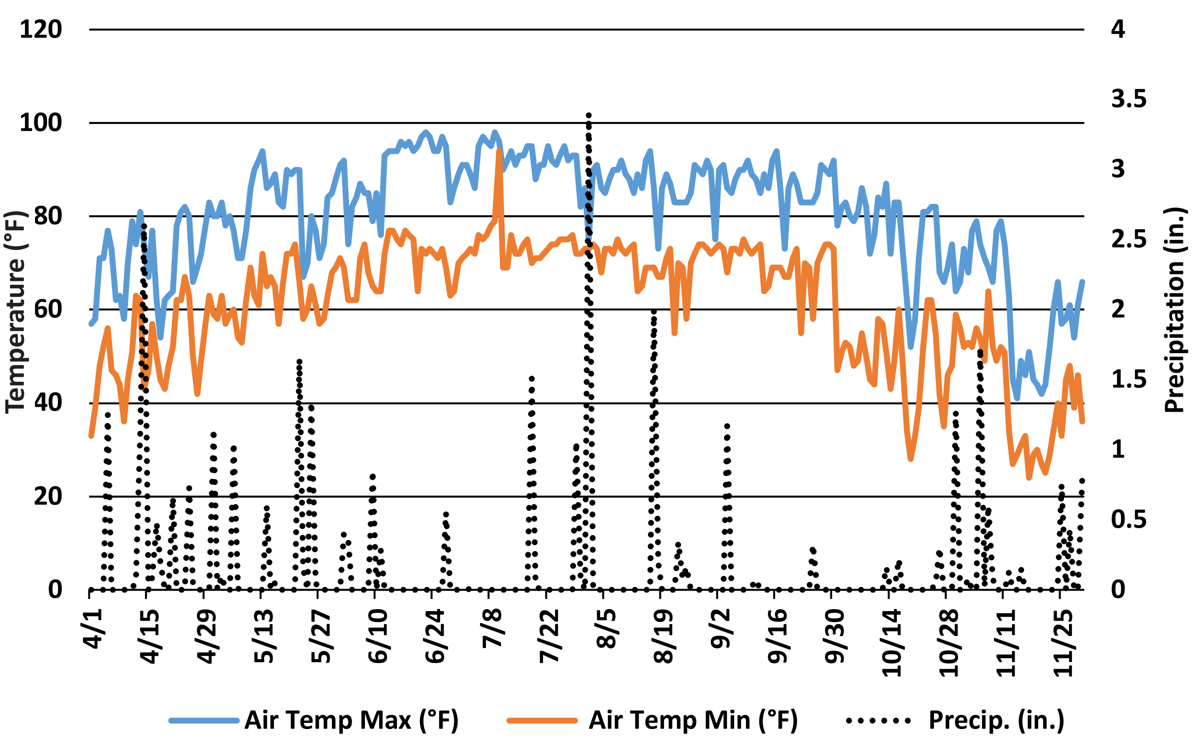

Fig. 1. 2022 temperature and precipitation at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna.

2022 Rohwer Research Station: Overview of Cotton Research

L. Martin[1]

Background

Cotton research has always been a primary focus at the University of Arkansas System Division of Agriculture's 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 2022 are listed in Table 1.

Table 1. List of 2022 cotton research at the University of Arkansas System Division of Agriculture's Rohwer Research Station.

Project Leader	Discipline	Title
Fred Bourland	Cotton Breeding	Arkansas Cotton Variety Tests (Transgenic, 40 entries and Conventional, 20 entries)
Fred Bourland	Cotton Breeding	Cotton Strain Tests, six tests evaluating a total of 120 entries
Fred Bourland	Cotton Breeding	Cotton breeding trial of 240 Advanced F_6 progenies
Fred Bourland	Cotton Breeding	Cotton observation plots of 960 F_5 preliminary progenies
Terry Spurlock	Plant Pathology	Cotton Variety Foliar Target Spot
Terry Spurlock	Plant Pathology	Cotton Seedling Disease Seed Treatments
Terry Spurlock	Plant Pathology	National Predictive Modeling Initiative
Trenton Roberts	Soil Fertility	Cotton Response to Nitrogen and Potassium Fertilization

2022 Conditions and Observations

Research trials at Rohwer were planted during the first week of May. Warm temperatures and light rainfall occurred within a few days after planting (Fig. 1). Plant stands were uniform, and no loss of seedlings was noticed after emergence. However, a loss of plant stands was noticed during the last week of May. High, but labeled, rates of herbicides applied at preemergence were determined to be the cause of seedling loss. Replanting of the variety and strain tests was completed on 1 June. Emergence of replanted cotton was confirmed on 6 June, and plant stands were uniform. Defoliants were applied to all cotton on 6 October and 20 October. A defoliation program was followed by a two-step application program, including boll opening along with a high probability of vegetative regrowth. Plants in the second planting did not develop and mature well and consequently produced low yields.

Acknowledgments

The author 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.

[1] Resident Director, University of Arkansas System Division of Agriculture, Southeast Research and Extension Center, Rohwer Research Station, Rohwer.

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 2022	118	438	584	709	626	436	151	3062
Historical avg. DD60s[a]	100	354	551	661	618	415	167	2866
Rainfall (in.) 2022	4.5	5.0	4.5	1.9	2.2	1.1	1.6	20.8
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

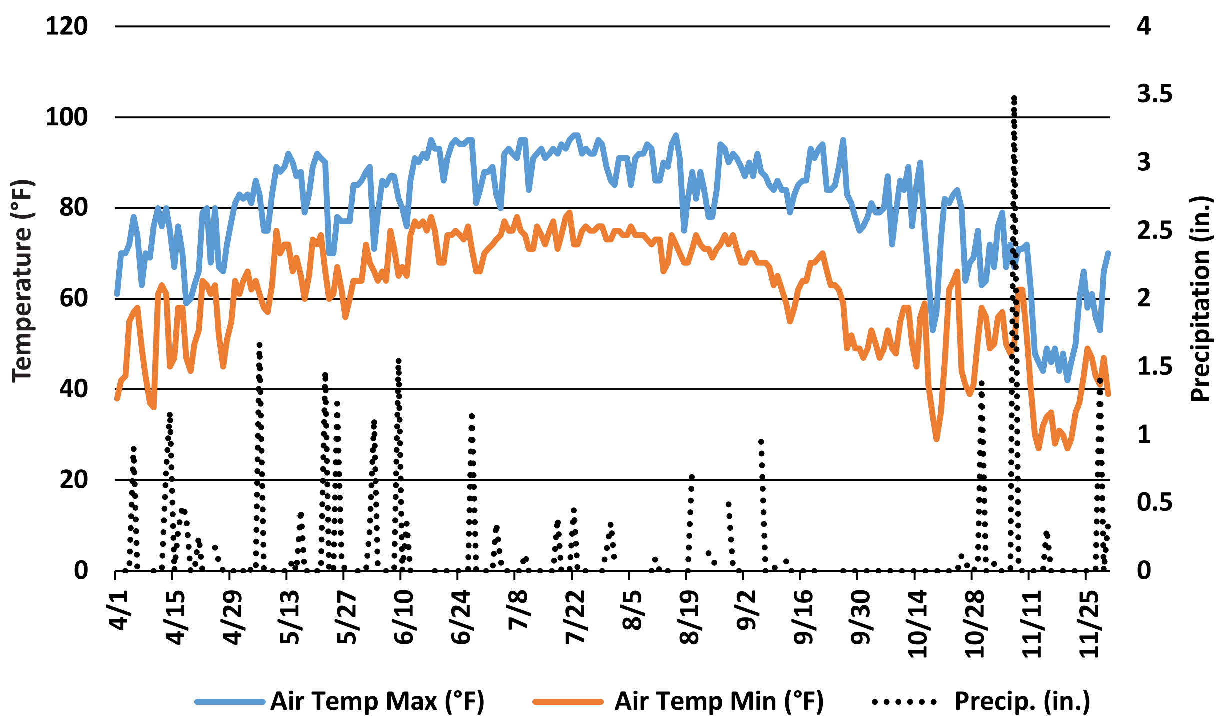

Fig. 1. 2022 temperature and precipitation at the University of Arkansas System Division of Agriculture's Rohwer Research Station.

Cotton Research Verification Sustainability Program: 2022 Economic Update

J. McAlee,[1] B. Robertson,[1] B. Watkins,[2] and D. Madden[1]

Abstract

The University of Arkansas System Division of Agriculture's Cotton Research Verification Sustainability Program (CRVSP) works with producers to grow cotton more sustainably with the objective of improving profitability. Since its inception, the program has had an average yield 19.4% higher than the same state average over the same time period. In 2022, the program's average yield was 1392 lb/ac compared to the state average of 1196 lb/ac. The average return to total specified costs was $357.15/ac. The verification field low was $37.37/ac in the Desha/Drew farmer standard with no cover crop (FS/NC) field, and the high was $644.59/ac in the Judd Hill crop intensification (CI) field. Total operating expenses averaged $0.49/lb lint, and total expenses averaged $0.61/lb lint. For cotton to continue being a viable commodity, profitability must be consistently improved.

Introduction

The University of Arkansas System Division of Agriculture has been conducting the Cotton Research Verification Sustainability Program (CRVSP) 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 CRVSP, there have been 350 irrigated fields entered into the program. In the 43 years of the program, lint yield averaged 1084 lb/ac or 19.4% over the state average of 874 lb/ac for the same timeframe. The success of the cotton program spawned verification programs in corn, rice, soybean, and wheat in Arkansas and similar programs in other mid-South states.

Procedures

The 2022 CRVSP was composed of 7 fields in 4 locations. Locations included Drew County, Lee County, Poinsett County, and the Judd Hill Foundation. Field size ranged from 17 to 80 acres. Fields were visited weekly to scout for pests and meet with the producers, county extension agents, and consultants. In the fall of 2021, all no-till fields were broadcast seeded with cover crops. The diversity of the fields in the program reflects cotton production in Arkansas. Four of the fields were managed as "farmer standard with no cover crop" (FS/NC), two were managed as "no-tillage with cover crop" (NT/C), and one field was managed as "crop intensification" (CI). The no-till cover fields were seeded with a straight cereal rye cover crop. The crop intensification field was a no-till field seeded with a cereal rye and hairy vetch blend; this field also used a cut seeding rate planting at 25K seed per acre, allowing the plants to express more lateral growth and put bigger roots down into the soil. 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

A wide range of yields were observed across the state. Weather played a big role in yield variability with the 2022 crop. Much of the state experienced a long dry period during the early- and mid-season, but a large portion of southern Arkansas had wet weather during the late season. Each field experienced unique conditions and challenges. A significant chemical burn associated with a herbicide application made on June 7th at the 4th true leaf occurred on the Judd Hill fields. The injury delayed the crop development, but late-season conditions were favorable, and yield did not appear to suffer. The Poinsett field was directly adjacent to both corn fields as well as a thick riparian area which led to multiple treatments for tarnished plant bugs. The Desha/Drew field had several issues, which included late-season potash deficiency and problems with hard-lock and boll rot from the extended wet conditions late-season, resulting in a dramatic yield reduction.

Tarnished plant bug (TPB) numbers were similar to past years in the CRVSP fields and were treated an average of 3.29 times in 2022 compared to 3.75 times and 3.33 times in 2021 and 2020, respectively. Tarnished plant bug pressure was similar across all fields and were sprayed 2 to 5 times during the growing season. Each field had an average of 1.14 burndowns and 4.14 herbicide applications for the 2022 season. Pest control represents a big expense and can impact yields greatly. Chemical costs averaged $216.92/ac and were nearly 32.9% of operating expenses. Seed and associated technology fees

[1] Program Associate, Professor/Cotton Agronomist, and Administrative Assistant, respectively, Jackson County Extension Center, Newport.
[2] Instructor, Agriculture and Natural Resources, Jonesboro.

averaged $106.24/ac, or 16.6% of operating expenses. Fertilizer and nutrient costs averaged 28.2% of operating expenses and were $185.38/ac. Records of field operations on each field provided the basis for estimating expenses. Production data from the seven 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 $0.84/lb is the estimated Arkansas annual average for the 2022 production year. The average yield in the verification fields was 1389 lb/ac lint, which was 189 lb/ac over the 2022 enterprise budget and 193 lb/ac over the state average of 1196 lb/ac. The average operating cost for cotton in these fields was $657.66/ac. Average operating costs were $0.49/lb lint is under the enterprise budget operating costs of $0.58 lb/lint. Operating costs ranged from a low of $553.86 in the Desha/Drew FSNC field to a high of $714.59 in the Lee County FSNC field. Returns to operating expenses averaged $510.10/ac across verification fields which was an increase of $199.46/ac over the enterprise budget. The range was from a low of $181.34/ac in the Desha/Drew FS/NC field to a high of $787.10/ac in the Judd Hill CI field. Average fixed costs were $151.97/ac which led to average total costs of $809.62/ac. The average return to total specified costs was $357.15/ac, compared to $144.74/ac on the enterprise budget. The verification field low was $37.37 in the Desha/Drew FS/NC field, and the high was $644.59 in the Judd Hill Crop Intensification (CI) field. Total expenses averaged $0.61/lb lint and were under the enterprise budget by $0.11.

Practical Applications

The Cotton Research Verification Sustainability Program strives to meet its goals and provide timely information to the Arkansas Cotton Community. The program has become a vital tool in the educational efforts of the University of Arkansas System Division of Agriculture, which serves a broad base of clientele, including cotton growers, consultants, researchers, and county extension agents. The program continues to serve as a building point for the state enterprise budgets. While the enterprise budget generally overestimates expenses and slightly underestimates revenue, it still serves as a valuable planning tool for producers. For cotton to continue being a viable commodity, profitability must be consistently improved.

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 in and support of this study. Support was also provided by the University of Arkansas System Division of Agriculture.

Table 1. Summary of revenue and expenses per acre for seven fields in the 2022 Cotton Research Verification Sustainability Program Compared to the online 2022 enterprise budget.

	Field								
Revenue/Expenses	**Desha/Drew FS/NC**[a]	**Judd Hill CI**	**Judd Hill NT/C**	**Judd Hill FS/NC**	**Lee NT/C**	**Lee FS/NC**	**Poinsett FS/NC**	**7 Field Verification Average**	**2022 Enterprise Budget**
Revenue									
Yield (lb)	875	1618	1613	1713	1423	1377	1104	1389	1200
Price ($/lb)	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
Total Crop Revenue	**735.00**	**1358.88**	**1355.00**	**1439.16**	**1195.32**	**1156.68**	**927.36**	**1166.77**	**1008.00**
Cottonseed Value	**144.73**	**267.57**	**266.81**	**283.38**	**235.36**	**227.76**	**182.60**	**229.74**	**198.48**
Expenses									
Seed	56.00	90.99	119.60	100.80	141.10	117.60	117.60	106.24	133.00
Fertilizer and Nutrients	162.92	170.51	188.59	188.59	200.17	200.17	186.70	185.38	177.79
Herbicide	64.42	97.73	106.12	107.96	130.02	187.46	74.07	109.68	130.01
Insecticide	43.86	28.68	76.82	83.51	18.38	18.38	94.53	52.02	65.08
Other Chemicals	91.88	44.00	44.00	44.00	53.11	53.11	56.46	55.22	26.00
Custom Applications	21.00	28.50	28.50	28.00	21.00	21.00	14.00	23.14	14.00
Other Inputs	16.53	27.27	27.20	28.65	24.45	23.79	19.84	23.96	21.23
Diesel Fuel	15.19	14.41	15.42	17.67	15.40	15.40	16.09	15.65	20.91
Irrigation Energy Costs	18.43	12.28	18.43	18.43	18.43	24.57	24.57	19.31	36.85
Input Costs	**490.23**	**514.37**	**624.68**	**617.61**	**622.06**	**661.48**	**603.86**	**590.61**	**624.87**
Fees	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
Repairs and Maintenance[b]	24.02	23.54	24.02	24.02	24.02	24.50	24.50	24.09	25.46
Labor, Field Activity	5.87	6.63	7.10	8.14	7.19	7.11	7.62	7.09	10.36
Production Expenses	**541.62**	**566.04**	**677.30**	**671.27**	**674.77**	**714.59**	**657.48**	**643.30**	**682.19**
Interest	12.24	12.59	15.07	14.94	15.01	15.90	14.63	14.34	15.18
Post-Harvest Expenses	144.73	267.57	266.80	283.38	235.36	227.76	182.60	229.74	198.48
Operating Expenses	**553.86**	**578.63**	**692.37**	**686.21**	**689.78**	**730.63**	**672.11**	**657.66**	**697.37**
Returns to Operating Expenses	**181.34**	**787.10**	**662.54**	**752.86**	**505.55**	**426.05**	**255.27**	**510.10**	**310.64**
Capital Recovery of Fixed Costs	143.97	135.66	151.98	167.81	149.10	151.57	163.69	151.97	165.90
Total Specified Expenses[c]	**697.63**	**714.29**	**844.44**	**854.12**	**838.87**	**882.20**	**835.78**	**809.62**	**863.26**
Returns to Specified Expenses	**37.37**	**644.59**	**510.55**	**585.05**	**356.45**	**274.48**	**91.58**	**357.15**	**144.74**
Operating Expenses/lb	0.63	0.36	0.43	0.40	0.48	0.53	0.61	0.49	0.58
Total Expenses/lb	0.80	0.44	0.52	0.50	0.59	0.64	0.76	0.61	0.72

[a] Abbreviations: NT/C = no-till cover; FS/NC = farmer standard no cover; CI = crop intensification.
[b] Includes employee labor allocated to repairs and maintenance.
[c] Does not include land costs, management, or other expenses and fees not associated with production.

Cotton Research Verification Sustainability Program: 2022 Sustainability Update

J. McAlee,[1] B. Robertson,[1] B. Watkins,[2] and D. Madden[1]

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 seven fields in 2022. Four of these fields included different irrigation sets, which allowed for a comparison of water usage in farmer standard practices (till no-cover) to that of a modified production system (no-till cover). All fields were monitored for inputs, which were used to calculate economics, and entered in the Fieldprint Calculator. Operating expenses averaged $0.05 less in the no-till cover fields compared to the farmer standard practice fields in 2022. Metrics from the Fieldprint Calculator favored no-till cover with regard to improving sustainability. Soil conservation, or erosion, was reduced by 73.77%, and greenhouse gas emissions decreased by 3.70%. The adoption of practices to improve soil health will likely be limited until producers become more comfortable reducing expenses.

Introduction

As the cost of production continues to increase, producers must become more efficient to stay 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. 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 producers' environmental footprint for each field and evaluating the connection between profitability and sustainability. 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 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. The objective of this study was to compare conventional practices to more sustainable practices both economically and to evaluate field metrics using the Fieldprint Calculator.

Procedures

The 2022 CRVSP was composed of seven fields in five locations. Locations included Drew County, Lee County, Poinsett County, and the Judd Hill Foundation. Four of these fields in two of the locations (Lee County and the Judd Hill Foundation) were paired comparison fields adjacent to each other with similar soil types and included different irrigation sets, which allowed for comparison of farmer standard practices (till no-cover, FS/NC) to that of a modified production system (no-till cover, NT/C). In fall 2021, the Lee NT/C was broadcast seeded with 'Elbon' cereal rye at a target seeding rate of 40 lb/ac. The Judd Hill NT/C field was broadcast with a cover blend of 40 lb/ac of cereal rye and 1 lb/ac of hairy vetch. Fields in this project averaged approximately 40 ac. Throughout the study, all producers' inputs were recorded, providing the information needed to calculate both fixed and variable

[1] Program Associate, Professor/Cotton Agronomist, and Administrative Assistant, respectively, Crop, Soil, and Environmental Sciences, Jackson County Extension Center, Newport.
[2] Instructor, Agriculture and Natural Resources, Jonesboro.

costs. Field data were collected by soil moisture sensors and rain gauges. 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 in. to aid in irrigation scheduling.

Results and Discussion

Cover crop fields tolerated the long dry period of the summer better than the farmer standard practice fields did due to better water infiltration and the ability to keep the soil cooler during the hottest parts of the day. It took longer for the cover crop fields to form a hardpan from compaction than it did for the farmer standard fields as well. The Judd Hill fields did have minimal tillage done with a furrow cleaner. Yield was lower in the Judd Hill NT/C field compared to the FS/NC field. This can be attributed to the wrong choice of cultivar with a reduced seeding rate. The two NT/C fields produced an average yield of 1,520 lb/ac compared to the two FS/NC fields average of 1,545 lb/ac. Water usage was lower in the no-till cover fields this year, with cover fields receiving an average of 5 ac in. of water compared to 7 ac in. in the farmer standard fields (data not shown). On a per-pound basis, water usage decreased by 31.25% in the cover crop fields (Table 2). The operating expenses for the no-till cover averaged $0.05 cheaper to produce compared to that of the no-cover (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. Soil conservation or erosion was reduced by 73.77%, and greenhouse gas emissions decreased by 3.7%. 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, non-replicated study to improve soil health, less water was used in cover crop fields, which made for a higher efficiency per pound of lint. This can be attributed to better water infiltration rates in the no-till fields. Cover crops and no-till can provide a yield boost in dry years, but additional research is needed to further evaluate how lint yield and profitability are influenced by seasonal rainfall interactions and irrigation efficiency. 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.

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 in and support of this study. Support was also provided by the University of Arkansas System Division of Agriculture.

Table 1. Summary of average revenue and expenses per acre for four fields in the 2022 Cotton Research Verification Sustainability Program comparing no-till cover to farmer standard tillage fields.

	Field					
Revenue/Expenses	**Judd Hill NT/C[a]**	**Judd Hill FS/NC**	**Lee NT/C**	**Lee FS/NC**	**2 Field NT/C Average**	**2 Field FS/NC Average**
Revenue						
Yield (lb)	1618	1713	1423	1377	1520	1545
Price ($/lb)	0.84	0.84	0.84	0.84	0.84	0.84
Total Crop Revenue	**1358.88**	**1439.16**	**1195.32**	**1156.68**	**1277.10**	**1297.92**
Cottonseed Value	**267.57**	**283.38**	**235.36**	**227.76**	**251.47**	**255.57**
Expenses						
Seed	90.99	100.80	141.10	117.60	116.05	109.20
Fertilizer and Nutrients	170.51	188.59	200.17	200.17	185.34	194.38
Herbicide	97.73	107.96	130.02	187.46	113.88	147.71
Insecticide	28.68	83.51	18.38	18.38	23.53	50.95
Other Chemicals	44.00	44.00	53.11	53.11	48.56	48.56
Custom Applications	28.50	28.00	21.00	21.00	24.75	24.50
Other Inputs	27.27	28.65	24.45	23.79	25.86	26.22
Diesel Fuel	14.41	17.67	15.40	15.40	14.91	16.54
Irrigation Energy Costs	12.28	18.43	18.43	24.57	15.36	21.50
Input Costs	**514.37**	**617.61**	**622.06**	**661.48**	**568.22**	**639.55**
Fees	21.50	21.50	21.50	21.50	21.50	21.50
Repairs and Maintenance[b]	23.54	24.02	24.02	24.50	23.78	24.26
Labor, Field Activity	6.63	8.14	7.19	7.11	6.91	7.63
Production Expenses	**566.04**	**671.27**	**674.77**	**714.59**	**620.41**	**692.93**
Interest	12.59	14.94	15.01	15.90	13.80	15.42
Post-Harvest Expenses	267.57	283.38	235.36	227.76	251.47	255.57
Operating Expenses	**578.63**	**686.21**	**689.78**	**730.63**	**634.21**	**708.42**
Returns to Operating Expenses	**787.10**	**752.86**	**505.55**	**426.05**	**646.33**	**589.46**
Capital Recovery of Fixed Costs	135.66	167.81	149.10	151.57	142.38	159.69
Total Specified Expenses[c]	**714.29**	**854.12**	**838.87**	**882.20**	**776.58**	**868.16**
Returns to Specified Expenses	**644.59**	**585.05**	**356.45**	**274.48**	**500.52**	**429.77**
Operating Expenses/lb	0.36	0.40	0.48	0.53	0.42	0.47
Total Expenses/lb	0.44	0.50	0.59	0.64	0.52	0.57

[a] Abbreviations: NT/C = no-till cover; 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.

Table 2. Lint yield, operating expenses, and metrics used to evaluate sustainability as affected by tillage and cover crops in the 2022 Arkansas Cotton Research Verification Sustainability Program.

Parameters	No-Till/ Cover	Farmer standard/ No cover	% Change NT/C vs. FS/NC
Yield (lb lint /ac)	1520	1545	-1.64%
Operating Expense ($/ac)	639.82	687.76	-7.49%
Operating Expense ($/lb lint harvested)	0.42	0.45	-7.14%
Soil Conservation (Tons/lb lint eq./year)	0.0020	0.0034	-70.96%
Irrigation Water Use (ac-in./lb)	0.0080	0.0105	-31.25%
Energy Use (BTU/lb)	4391	4522	-3.00%
Greenhouse Gas Emissions (lb CO_2eq/lb)	1.35	1.4	-3.70%

Arkansas Cotton Variety Test 2022

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

Abstract

Other than variations in transgenic technologies and seed treatment, the costs of cotton planting seed are relatively constant. Choosing the best cotton variety to plant can often determine whether the producer experiences a successful production year. The producer must assume that the 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 adaptations to certain soil and pest situations may exist. Varieties that are now available or may soon be available to producers are annually evaluated in small and large plot tests in Arkansas. Results from the small plot tests, which usually include 40 to 60 lines and are mostly conducted on experiment stations, provide information on which lines are best adapted to Arkansas environments. Based on these results, varieties are chosen and evaluated in large plot on-farm tests. These large plot tests represent various growing conditions, growers' management, and environments of Arkansas cotton producers. Results from the large plot tests are used to supplement and verify 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 Agriculture. 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 strains were evaluated in small plots at Arkansas research sites (Manila, Keiser, Judd Hill, Marianna, and Rohwer) in the 2022 Arkansas Cotton Variety Test. Transgenic and conventional entries were evaluated in separate tests. Stands in the tests at Rohwer were adversely affected by herbicides and were subsequently replanted but did not achieve acceptable maturity. Yields from Rohwer were reported but not included in over-location means. Entries in the 2022 Arkansas Cotton Variety Test were evaluated into two groups—transgenic and conventional varieties. The 40 entries in the transgenic test included 1 B2XF, 27 B3XF, 11 W3FE, and 1 GLTP lines, of which 25 were included in the 2021 Arkansas Cotton Variety Test. The conventional test included 20 entries, all developed in the University of Arkansas System Division of Agriculture's Cotton Breeding Program. Seven of these were in the 2021 test.

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. All entries in the experiments were evaluated for response to tarnished plant bug and bacterial blight in separate tests at Keiser. Originators of seed supplied seed of their entries treated with their standard fungicides. Prior to planting, all seeds were uniformly treated with imidacloprid (Gaucho®) at a rate of 6 oz/100 lb seed. Plots were planted with a constant number of seeds (about 3.5 seed/row ft). All varieties were planted in two-row plots on 38-inch centers ranging from 40 to 50 feet in length. Experiments were arranged in a randomized complete block with four replications. Although exact inputs varied across locations, cultural inputs at each location were generally based on the University of Arkansas System Division of Agriculture's Cooperative Extension Service recommendations for cotton production. Cereal rye was planted in the test plot area at Marianna as a cover crop. Con-

[1] Professor, Program Technician, and Program Assistant, respectively, University of Arkansas System Division of Agriculture, Northeast Research and Extension Center, Keiser.
[2] Resident Director, University of Arkansas System Division of Agriculture, Lon Mann Cotton Research Station, Marianna.
[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 Jackson County Extension Center, Newport.

ventional tillage was employed at all other locations. All plots were machine-harvested with 2-row or 4-row cotton pickers modified with load cells for harvesting small plots.

Large Plot Tests

A group of 10 transgenic XtendFlex varieties (DG 3456 B3XF, DG 3511 B3XF, DP 2020 B3XF, DP 2038 B3XF, DP 2115 B3XF, DP 2127 B3XF, NG 3195 B3XF, NG 4190 B3XF, ST 4595 B3XF, and ST 5091 B3XF) was evaluated at 9 locations from Ashley County to Mississippi County. Two Enlist varieties (PHY 411 W3FE and PHY PX1140A383-04 W3FE) were included in 7 of the 9 locations. 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. The studies were harvested with the producer's equipment. Grab samples were collected and ginned on a laboratory gin for lint fraction and fiber quality.

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/ (Bourland et al., 2022).

Small Plot Tests

Heat units were close to historical averages at each Arkansas location. Daily high temperatures exceeded 95 °F on 15 days at Keiser (9 days in June), but only 2 days at Marianna (101 °F on 31 July and 97 °F on 1 August); and 3 days at Rohwer (96 °F on 22 and 23 July, and 16 August). Rainfall in 2022 was lower than the historical average and particularly lower in August and September, which provided excellent harvest conditions.

Variety by location interactions in the transgenic test were significant for most of the traits measured in 2022. In the conventional test, interactions occurred for lint yield, percent open bolls, and fiber density. 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.

The transgenic varieties included 25 that were evaluated in both 2021 and 2022. The five transgenic varieties producing the highest two-year yield means over all locations were ST 5091 B3XF, NG 3195 B3XF, DP 2127 B3XF, PX1140A-385-04 W3FE (an advanced Phytogen line), and DG 3535 B3XF. Six conventional lines were evaluated in both 2021 and 2022.

Large Plot Tests

On-farm plots were established with a wide range of planting and harvest dates to best fit the needs of the cooperating producers. Acceptable plant stands were achieved at each location. Lint yield was summarized across locations.

Practical Applications

Varieties that perform well over 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 provided 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 specific adaptations of varieties. When choosing a variety, producers should first examine the 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 pests, 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 staff 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, B. Milano, C. Kennedy, L. Martin, and B. Robertson. 2022. Arkansas Cotton Variety Test 2021. Arkansas Agricultural Experiment Station. Research Series 683.

Evaluation of Cotton in Large-Plot On-Farm Variety Testing in Arkansas for 2022

B. Robertson,[1] J. McAlee,[1] C. Henderson,[1] and D. Madden[1]

Abstract

A primary purpose of large- and small-plot evaluation of cotton varieties is to provide unbiased information on the performance of specific varieties. Large-plot, on-farm variety testing supplements small-plot variety trials by confirming the performance of lines under actual producer conditions. The objective of this study was 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 analysis. Lint yield was summarized across locations. The relative ranking among varieties was consistent across locations.

Introduction

Yield is often the primary selection criteria used for variety selection. When selecting varieties for planting, a producer should not simply choose the top-yielding variety at any single testing location but look at the averages of multiple locations and years. Each variety has its strengths and weaknesses. The challenge is to identify these characteristics and adjust management strategies to enhance strengths while minimizing 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% of the farm. The acreage of a variety may be slightly expanded if it performs well in the first year. Consider planting the bulk of the farm to three or four proven varieties of different maturities to reduce the risk of weather interactions and to spread harvest timings.

Procedures

Replicated strips were planted with the producer's planter the length of the field. The study was managed according to the remainder of the field in which the study was located. Two varieties chosen by five seed companies (Bayer, Americot, BASF, Phytogen, and Nutrien) were evaluated in this study. The study was harvested with the producer's equipment. Grab samples were collected for lint fraction and fiber quality.

Results and Discussion

On-farm plots were established at seven locations (Table 1) with a wide range of planting and harvest dates. All locations, except Clark County, were planted within a narrow (seven-day) planting window. Harvest occurred over a wide range of dates. Nodes after white flower data were recorded to calculate the date of cutout at five locations (Table 2). Yields were summarized by and across all locations (Table 3). The maturity of varieties did not appear to be related to lint yields in this study.

Practical Applications

There were some differences between varieties relative to planting date, with earlier planting favoring the later-maturing varieties. While the lint yield differences were observed, the ranking by yield of varieties relative to one another across locations is a suitable method of evaluating variety performance.

Acknowledgments

The authors would like to acknowledge Cotton Incorporated for their support of this project. Support was also provided by the University of Arkansas System Division of Agriculture.

[1] Professor/Cotton Extension Agronomist, Program Associate, Program Technician, and Administrative Assistant, respectively, Jackson County Extension Center, Newport.

Table 1. Planting dates, harvest dates, and final plant population for the 2022 Arkansas large-plot variety testing program.

	Clark County	Jefferson County	Lee-Phillips County	Lonoke County	Mississippi County	Poinsett County	St. Francis County
Planting Date	5/7/2022	5/12/22	5/12/2022	5/13/22	5/18/22	5/13/22	5/18/22
Harvest Date	10/22/22	10/5/22	9/26/22	10/20/22	11/3/22	11/3/22	10/27/22
Plant Population	27129	34452	34134	40439	30682	24124	37509

Table 2. Days to cutout in the 2022 Arkansas large-plot variety testing program.

Variety	Jefferson County	Lee-Phillips County	Lonoke County	Mississippi County	St. Francis County	Average Days to Cutout
	---			Days		---
DG 3511 B3XF	75	77	87	83	73	79
PHY PX1140 W3FE	77	77	85	83	73	79
NG 3195 B3XF	76	78	85	84	74	79.4
DG 3456 B3XF	76	78	86	87	78	81
ST 5091 B3XF	78	80	90	84	73	81
DP 2020 B3XF	83	75	88	87	73	81.2
PHY 411 W3FE	79	78	92	83	74	81.2
ST 4595 B3XF	80	78	88	83	77	81.2
DP 2127 B3XF	77	80	87	88	82	82.8
DP 2115 B3XF	78	78	86	85	89	83.2
NG 4190 B3XF	83	80	92	83	80	83.6
DP 2038 B3XF	81	79	88	87	86	84.2

Table 3. Lint yield and ranking (R) of varieties in the 2022 Arkansas large-plot variety testing program.

	Clark County		Jefferson County		Lee-Phillips County		Lonoke County		Mississippi County		Poinsett County		St. Francis County		Average Rank	
Variety	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**	**Lint**	**R**
	(lb/ac)		**(lb/ac)**		**(lb/ac)**		**(lb/ac)**		**(lb/ac)**		**(lb/ac)**		**(lb/ac)**		**(lb/ac)**	
DP 2115 B3XF	611	7	1489	1	1792	5	1504	2	1880	1	1529	5	1789	5	1513	3.7
DP 2127 B3XF	706	1	1405	5	1913	2	1379	7	1768	3	1407	8	1856	1	1484	3.9
ST 4595 B3XF	693	2	1342	10	1781	6	1659	1	1800	2	1534	3	1799	4	1515	4.0
NG 3195 B3XF	517	12	1425	3	2063	1	1489	3	1645	6	1433	7	1833	2	1486	4.9
ST 5091 B3XF	661	5	1415	4	1856	3	1486	4	1631	8	1367	11	1820	3	1462	5.4
DP 2038 B3XF	662	4	1483	2	1810	4	1084	12	1738	4	1262	12	1728	6	1395	6.3
PHY 411 W3FE	669	3	1397	6	1637	10	1345	8	1473	10	1573	2	1589	10	1383	7.0
DG 3456 B3XF	608	8	1391	7	1613	11	1448	6	1720	5	1443	6	1599	9	1403	7.4
PHY PX1140 W3FE	571	10	1350	8	1591	12	1473	5	1630	9	1393	9	1615	8	1375	8.7
NG 4190 B3XF	611	6	1340	11	1692	7	1289	9	1467	11	1378	10	1674	7	1350	8.7
DG 3511 B3XF	573	9	1349	9	1639	9	1263	10	1420	12	1613	1	1572	12	1347	8.9
DP 2020 B3XF	520	11	1240	12	1652	8	1136	11	1638	7	1531	4	1578	11	1328	9.1
LSD P = 0.05	Not replicated		122		302.8		100.9		178.8		124.9		102.4			

University of Arkansas System Division of Agriculture's Cotton Breeding Program: 2022 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 113 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 113 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

Conventional breeding lines and strains are annually evaluated at multiple locations in the University of Arkansas System Division of Agriculture's Cotton Breeding Program. Development and testing of strains generally progress in the following manner:

Year 1	Initial cross of selected parents at Keiser
Year 1	Advance of F_1 generation in winter increase
Year 2	F_2 segregating populations: modified single-seed descent at Keiser
Year 3	F_3 segregating populations: modified single-seed descent at Keiser
Year 4	F_4 segregating populations: individual plant selections at Keiser
Year 5	F_5 first-year progeny rows at Keiser, Marianna, and Rohwer
Year 6	F_6 Advanced Progenies at Keiser, Marianna, and Rohwer
Year 7–10	Evaluation of strains in replicated Arkansas tests over four Arkansas locations
Year 9	Evaluation of selected strains in regional, multiple state tests
Year 11	If needed, additional testing in Arkansas Conventional Variety Test.

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.

Arkansas testing locations include the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center at Keiser (the base of breeding program and testing of all generations), the Judd Hill Cooperative Research Station at Judd Hill (replicated tests of all strains), the Lon Mann Cotton Research Station at Marianna (observation of progenies and replicated tests of all strains), and the Rohwer Research Station at Rohwer (observation of progenies and replicated tests of all strains).

Results and Discussion

Breeding Lines

Breeding lines evaluated in 2022 were derived from crosses made in 2013 (F_7 generation) through 2022 (F_1 generation). The primary objectives of these crosses included the development of enhanced nectariless lines (with the goal

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

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' into higher-yielding lines.

In addition to the 24 crosses, the 2022 breeding effort also included field evaluation of 24 F_1 populations, 23 F_3 populations, 24 F_4 populations, 891 first-year progenies, and 216 advanced progenies. Bolls were harvested from superior plants in F_1 and F_3 populations and bulked by population. Individual plants (1200) were selected from the F_4 populations. After discarding individual plants for fiber traits, ~900 progenies from the individual plant selections will be evaluated in 2023. From the first-year progenies in 2022, 274 were selected based on field performance. Ones having low fiber quality will be discarded prior to being advanced to 2023 testing. Out of the 2022 Advanced Progeny, 72 F_6 advanced progenies were promoted to strain status.

Strain Evaluation

In 2022, a total of 116 strains (72 Preliminary Strains, 18 New Strains, and 26 Advanced Strains) were evaluated in replicated tests at four experiment stations in Arkansas. UA222 and UA48 were included as checks in each test. Over locations, numerical lint yields of 85 and 117 of the 119 strains produced numerically greater lint yields than UA222 and UA48, respectively. Only 52 and 5 of the 116 strains produced fiber quality scores that exceeded those of UA222 and UA48, respectively. 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 to improve fiber quality by reducing bract trichomes continues.

Genetic Releases

Genetic releases are a major function of public breeding programs. A total of 105 germplasm lines and 8 varieties have been released from this program. These lines represent unique genetic materials that have demonstrated improved yield, yield components, host-plant resistance and/or fiber quality. Seven conventional varieties released since 2010 include UA48 (Bourland and Jones, 2012a; UA222 (Bourland and Jones, 2012b), UA103 (Bourland and Jones, 2013), UA107 (Bourland and Jones, 2018a), UA114 (Bourland and Jones, 2018b), UA212ne (Bourland and Jones, 2020) and UA248 (Bourland and Jones, 2021). All of these varieties have produced high yields, expressed excellent fiber quality, are early maturing, and are resistant to bacterial blight.

Registration publications for Arkot 0902 (Bourland et al., 2023) and for Arkot 1005, Arkot 1015, and Arkot 1019 (Bourland and Jones, 2023) were completed in 2022. Release for four additional lines (Arkot 1102ne, Arkot 1112, Arkot 1114, and Arkot 1115) has been approved. The release of lines from 2012 crosses and some lines which express visible true leaf at emergence will be proposed after data analyses are completed.

Practical Applications

The University of Arkansas is developing cotton lines possessing 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 yields. 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 staff at the stations of the University of Arkansas System Division of Agriculture is greatly appreciated. The author is particularly grateful to Brittany Hallett and Victoria Stout, Agriculture Lab Technicians, who perform and oversee much of the 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. 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. 2021. Registration of 'UA212-ne'–a nectariless cotton cultivar. J. Plant Reg. 15:1-6.

Bourland, F.M., P. Chee, and D.C. Jones. 2023. Registration of Arkot 0902 cotton germplasm line. J. Plant Reg. 17:146-151.

Bourland, F.M. and D.C. Jones. 2023. Registration of Arkot 1015 and Arkot 1019 cotton germplasm lines. J. Plant Reg. 17:164-170.

Evaluation of Twelve Runner-Type Peanut Cultivars in 2022 in Mississippi County, Arkansas

M. Emerson,[1] T.R. Faske,[1] and B. Baker[1]

Abstract

Field performance of twelve runner-type peanut (*Arachis hypogea* L.) cultivars was evaluated in an on-farm trial in 2022 near Manila, Arkansas. The field site was a sandy loam soil previously cropped (2020 and 2021) in cotton (*Gossypium hirsutum* L.). The cultivar, Georgia 16HO, had greater pod yield compared to TamRun OL19L and ARSOK R93-1. However, pod yield averaged 6,294 lb/ac across all cultivars, which is a very good yield average. No yield-limiting disease was observed. The southern root-knot nematode (*Meloidogyne incognita*) density at planting and at harvest was 32 and 56 second-stage juveniles/100 cm^3 soil, respectively. Nematode density was sustained due to several host weeds within the field study. These data provide an indication of the yield potential of runner-type cultivars from Georgia, Texas, and Oklahoma in a major peanut-growing area of Arkansas.

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important fiber crop grown worldwide, with the U.S. contributing to nearly one-quarter of the world's supply of lint (Koenning et al., 2004). Historically, the cotton boll weevil, *Anthonomus grandis* Boheman, was the costliest pest of cotton in the United States (Smith et al., 1994). The boll weevil eradication program's success has allowed the cotton industry to focus more on diseases, weeds, insects, and nematodes. The southern root-knot nematode [*Meloidogyne incognita* (Kofold & White) Chitwood] and reniform nematode [*Rotylenchulus reniformis* (Linford & Oliveira)] are the most important, yield-limiting pests of cotton across the U.S. Cotton Belt (Lawrence et al., 2018). Of the two species, the root-knot nematode is one of the most widely distributed and economically important (Thomas and Kirkpatrick, 2001). During the 2021 cropping season, it was estimated that 2.8% (515,500 bales) was lost due to *Meloidogyne incognita* across the US Cotton Belt (Lawrence et al., 2021). In Arkansas, lint yield losses were estimated at 2.2%, equivalent to 27,700 bales (Lawrence et al., 2021). Crop rotation, nematicides, and host plant resistance are useful tools to manage the southern root-knot nematode. Crop rotation can be an effective option when non-host or resistant crops are grown in sequence with cotton. Peanut (*A. hypogaea* L.) is a non-host crop to both nematode species, and there are a few cotton cultivars with resistance to both the southern root-knot nematode and reniform nematode (PHY 411 W3FE, PHY 443 W3FE, and DP 2141NR B3XF. Currently, there is limited information on the field performance of runner-type peanut cultivars (*A. hypogea* L. subsp. *hypogaea* var. *hypogeae*), the most common peanut type grown in the state, which were developed in other peanut-growing regions, especially the southwest—Oklahoma and Texas. The objective is to evaluate twelve peanut cultivars, including a few from Oklahoma and Texas, for yield production and profitability in northeast Arkansas.

Procedures

Twelve peanut cultivars were planted in a field near Manila, Arkansas. The cultivars, both standard and high oleic (Table 1), were planted on 17 May approximately 1-in. deep in a randomized complete block design with five replications. Cultivars were planted at a seeding rate of 6 seed/ft of row in a Routon-Dundee-Crevasse complex, sandy loam soil (59% sand, 36% silt, 5% clay) previously cropped in cotton (2020 and 2021). Weeds and diseases were controlled based on recommendations by the University of Arkansas System Division of Agriculture's Cooperative Extension Service. This study was irrigated by a center-pivot irrigation system. Plots consisted of two, 25-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 (Primo Power CL® traditional liquid for peanut, Verdesian Life Sciences, Cary, N.C., at 7.0 fl oz/ac) were applied in-furrow at planting through a 0.22-in.-diam. (0.55-mm-ID) line meter and a 0.07-in.-diam. (1.8-mm-ID and 4.0-mm-OD) poly-tubing using a pressurized sprayer to deliver 9.4 gal/ac.

Plant stand was assessed on 31 May by counting plants emerged in ten row feet. Peanut plants were dug on 22 Oct. (156 DAP) and thrashed on 27 Oct. with a KMC 3020 two-row thrasher (Kelley Manufacturing Co., Tifton, Ga.) equipment with a bagging system for small plots. A 3-lb subsample of each cultivar was graded by USDA personnel at the Birdsong Peanut facility in Portia, Ark. Data were subjected to analysis of variance using ARM Software v. 2022.7 and

[1] Program Associate, Professor, and Program Technician, respectively, Department of Entomology and Plant Pathology, Lonoke Extension Center, Lonoke.

mean separation by Tukey's honestly significant difference Procedure at $P = 0.05$.

Soil samples were collected within each replication at planting and at harvest to assess the benefit of peanut in rotation with cotton in managing southern root-knot nematode and reniform nematode. Soil samples were a composite of 8 soil cores taken 8 to 10 in. deep with a 0.75-in.-diam soil probe. Nematodes were collected with a modified Baermann funnel system and enumerated using a stereoscope.

Results and Discussion

Peanut plant population at 26 days after planting (DAP) was similar among cultivars and averaged 3.7 plants per row feet (Table 2). This was somewhat expected given that foundation seed was used in the study, which is usually of high germination and vigor. Further, conditions after planting were warm with adequate moisture that promoted quick emergence. Peanut germplasm lines developed in Texas and Oklahoma are selected for the canopy to spread out during the cropping season. By mid-season, entries from Oklahoma and Texas entries had vines touching in the middle, except for ARSOK 95-1, NemaTAM II, and AG 18. ARSOK R96-8 has more of an upright growth, which is expected as it was derived from a cross between a runner (Lariat) and Spanish (OLé) cultivars (K. Chamberlin, ARS, Stillwater, Okla., pers. comm.).

A greater ($P = 0.05$) pod yield was observed with Georgia 16HO compared to TamRun OL19 and ARSOK R93-1 (Table 3). All cultivars, except TamRun OL19 and ARSOK R93-1, have a pod yield above 6,000 lb/ac. All grades were above loan price (73), except TamRun OL18L, TamRun OL19, and ARSOK R96-8. Grades ranged from 68 to 79 among cultivars. Georgia 20VHO had the best grade (79), which calculated to a greater crop value (Table 3). In general, high O/L cultivars with a similar yield to a standard peanut had a greater value per acre. For example, Georgia 09B produced 113 lb/ac less than Georgia 06G; but with the addition of $35/ac for high O/L cultivars, the total value per acre was $78 over that of Georgia 06G. The cultivars with the greatest total value per acre were Georgia 09B, Georgia 16HO, and Georgia 20VHO. In 2022, the average cost of peanut production in Arkansas was approximately $501 to $640/ac. At the highest average cost, these cultivars would have ranged from $406 to $850 in profit. These values in profit do not account for premiums in contract prices which in 2022 was an additional $200/ac.

The initial southern root-knot nematode density at planting ranged from 0 to 73 J2/100 cm^3 of soil with an average of 32. This density was a moderate to high damage threshold for cotton production in Arkansas. Nematode densities remained about the same by the end of the season and ranged from 1 to 214 J2/100 cm^3 of soil with an average of 56. Weed hosts detected in the study consisted of Eclipta (*Eclipta prostrata*, syn. *Eclipta alba*), Morning-glory (*Ipomoea grandifolia*), and Teaweed (*Sida spinosa*) that likely contributed to the sustaining the nematode density (Rich et al. 2009). Therefore, despite peanut being a non-host, weeds can contribute to maintaining southern root-knot nematode densities for the subsequent cotton crop.

Practical Applications

The southern root-knot nematode is an important yield-limiting pathogen of cotton in Arkansas. Peanut is an excellent rotational crop if weeds are controlled to manage yield-limiting cotton nematodes. Several runner-type peanut cultivars and genotypes from Oklahoma and Texas have good yield potential that is similar to some of the cultivars currently grown in the state; however, Georgia 09B, Georgia 16HO, and Georgia 20VHO are more profitable than others.

Acknowledgments

The authors would like to thank the Arkansas peanut producers, the Arkansas Peanut Growers Association, the University of Arkansas System Division of Agriculture, and the National Peanut Board for supporting this research. Furthermore, Wildy Family Farms for providing space and Mr. Dale Wells for communicating the logistics of planting and harvest. Finally, the gift of seed from Georgia Seed Development, Texas A&M AgriLife Research, USDA-ARS & Oklahoma Agriculture Experiment Station, and Alabama Crop Improvement Association.

Literature Cited

Koenning S., T. Kirkpatrick, J. Starr, J. Wrather, N. Walker, and J. Mueller. 2004. Plant Parasitic Nematodes Attacking Cotton in the United States. Plant Disease 88:100-113.

Lawrence, K., A. Hagan, R. Norton, J. Hu, T. Faske, R. Hutmacher, J. Mueller, I. Small, Z. Grabau, R. Kemerait, C. Overstreet, P. Price, T. Allen, S. Atwell, J. Idowu, R. Boman, J. Goodson, H. Kelly, J.E. Woodward, and T.A. Wheeler. 2018. Cotton disease loss estimates committee report, 2017. pp. 161-163. Proc. the Beltwide Cotton Conf., Natl, Cotton Counc, Am., Memphis, Tenn.

Lawrence, K., A. Scherer, R. Norton, J. Hu, T. Faske, R. Hutmacher, J. Mueller, I. Small, Z. Grabau, B. Kemerait, R. Onofre, P. Price, T. Watson, T. Allen, K. Bissonnette, J. Idowu, G. Collins, S. Byrd, H. Kelly, T. Wheeler, and T. Isakeit. 2021. Cotton disease loss estimates committee report, 2021. pp. 219-222. Proc. Beltwide Cotton Conf., Natl. Cotton Council, Amer. San Antonio, Texas.

Smith, J.W. and F.A. Harris. 1994. *Anthonomus* (Coleoptera: Curculionida). pp. 223-258. *In*: Insect Pests of Cotton. G.A. Matthews and J.P. Tunstall (eds.) CAB International, Wallingford, U.K.

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, 2nd ed. St. Paul, Minn.: APS Press.

Rich, J.R., J.A. Brito, R. Kaur, and J.A. Ferrell. 2009. Weed Species of *Meloidogyne*: A Review. Nematropica No 2 39:157-185.

Table 1. Runner-type peanut cultivars, type, and source used in 2022 in an on-farm cultivar trial in Mississippi County.

Entries†	Oleic Acid Concentration	Maturity‡	Seed Size§	Seed Source
Georgia 06G	standard	ML	L	GA Seed Dev., Plains, Georgia
Georgia 18RU	standard	ML	M-L	GA Seed Dev., Plains, Georgia
Georgia 09B	high	M-ML	M	AL Crop Imp. Assoc., Headland, Alabama
Georgia 16HO	high	ML	L	AL Crop Imp. Assoc., Headland, Alabama
Georgia 20VHO	high	ML	M	GA Seed Dev., Plains, Georgia
TamRun OL18L	high	ML	L	TX A&M AgriLife Fnd. Seed, Vernon, Texas
TamRun OL19	high	ML	L	TX A&M AgriLife Fnd. Seed, Vernon, Texas
AG18	high	ML	M	TX A&M AgriLife Fnd. Seed, Vernon, Texas
NemaTAM II	high	ML	M-L	TX A&M AgriLife Fnd. Seed, Vernon, Texas
ARSOK R93-1	high	ML	L	USDA-ARS and OK Ag. Exp. Sta., Stillwater, Oklahoma
ARSOK R95-1	high	ML	L	USDA-ARS and OK Ag. Exp. Sta., Stillwater, Oklahoma
ARSOK R96-8	high	ML	M	USDA-ARS and OK Ag. Exp. Sta., Stillwater, Oklahoma

† All cultivars are runner-type peanut, except ARSOK R96-8, which is a runner x spanish hybrid.
‡ Categories as medium (M = 133–139 days), medium-late (ML = 140–145 days).
§ Categories: large (L = 600–650 s/lb), medium (M = 651–725 s/lb).

Table 2. Plant stand on eleven runner-type peanut cultivars in a 2022 on-farm trial in Mississippi County.

Entries†	7 days after emergence stand‡ (28 May)
Georgia 06G	3.6
Georgia 18RU	3.8
Georgia 09B	3.7
Georgia 16HO	4.0
Georgia 20VHO	3.6
TamRun OL18L	3.7
TamRun OL19	3.4
AG18	4.0
NemaTAM II	3.6
ARSOK R93-1	3.8
ARSOK R95-1	3.8
ARSOK R96-8	3.5
P > F	

† All cultivars are runner-type peanut, except ARSOK R96-8, which is a runner x spanish hybrid.
‡ Stand count is total number of plants per row ft.

Table 3. Grade, value, and yield of eleven runner-type peanut cultivars in a 2022 on-farm trial in Mississippi County.

Entries[†]	Grade[‡]	% Sound Splits	Value/T[§]	Yield (lb/ac)	Value/ac
Georgia 06G	76	2	$369.76	6,870 ab[¶]	$1,270.13
Georgia 18RU	76	8	$366.56	6,340 ab	$1,162.00
Georgia 09B	75	6	$398.35	6,757 ab	$1,345.83
Georgia 16HO	74	3	$395.14	7,542 a	$1,490.07
Georgia 20VHO	79	4	$417.79	6,707 ab	$1,401.06
TamRun OL18L	68	6	$368.88	6,125 ab	$1,129.69
TamRun OL19	72	4	$386.92	5,406 b	$1,045.84
AG18	74	3	$396.54	6,286 ab	$1,246.33
NemaTAM II	73	2	$390.33	6,127 ab	$1,195.97
ARSOK R93-1	74	4	$396.54	5,609 b	$1,112.10
ARSOK R95-1	75	5	$399.15	6,102 ab	$1,217.81
ARSOK R96-8	68	6	$364.68	6,805 ab	$1,240.82
P > F	--	--	--	0.038	--

[†] All cultivars are runner-type peanut, except ARSOK R96-8, which is a runner x spanish hybrid.

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

[§] USDA Price Table for 2016 (each SS% >4% docked $0.80/%). Prices also include in addition $35.00 per ton for High O/L.

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

Evaluation of Plant Population on Varieties in Arkansas Large-Plot Variety Trials

B. Robertson,[1] J. McAlee,[1] R. Benson,[2] C. Henderson,[1] J. Clark,[3] and D. Madden[1]

Abstract

Producers tend to be cautious and utilize a higher seeding rate to aid in creating sufficient plant stands. Questions surrounding seeding rates are becoming more commonplace as seed costs continue to increase. The ability to utilize prescription seeding rate technology coupled with data collection from yield monitor files allows researchers to easily collect lint yield data from large-plot research of different plant populations of multiple varieties. The objective of this study was to evaluate four seed drop rates embedded into the large-plot variety testing program of 12 varieties (DP 2020 B3XF, DP 2038 B3XF, DP 2115 B3XF, DP 2127 B3XF, NG 3195 B3XF, NG 4190 B3XF, ST 4595 B3XF, ST 5091 B3XF, PHY 411 W3FE, PHY PX1140A383-04 W3FE, DG 3456 B3XF, DG 3511 B3XF) at two locations in Arkansas. A prescription for seed drop rates of 15K, 30K, 45K, and 60K seed/ac was developed for each variety. Lint yields were estimated using yield monitor data and lint percentages from grab samples. Lint yield was slightly lower at the lowest seed drop rate compared to the other rates. Little differences were seen in the three highest seed drop rates. DP 2020 B3XF and DP 2038 B3XF exhibited the most variation in lint yield over the seed drop rates. Reduced variability across varieties reinforces current seed drop recommendations.

Introduction

Seeding rates used by producers tend to err on the high side as their primary objective is to establish an adequate plant stand. As seed costs become an increasingly significant part of operating costs, questions regarding plant population are more common. Most literature shows a rise in yield from very low populations and a yield plateau across all other populations, no matter how high. Many studies find no yield advantage of plant populations greater than 21,000 plants per acre or 1.5 plants per foot of row on 38-in. rows. Plant population studies have traditionally been conducted in small-plot research. The ability to utilize prescription technology coupled with data collection from yield monitor files has led to the potential of researchers to collect data from large-plot research on multiple varieties. The objective of this study was to evaluate four seed drop rates/ac (15K, 30K, 45K, and 60K) embedded into the large-plot variety testing program on 12 varieties (DP 2020 B3XF, DP 2038 B3XF, DP 2115 B3XF, DP 2127 B3XF, NG 3195 B3XF, NG 4190 B3XF, ST 4595 B3XF, ST 5091 B3XF, PHY 411 W3FE, PHY PX1140A383-04 W3FE, DG 3456 B3XF, DG 3511 B3XF) at two locations (Poinsett and Mississippi counties) in Arkansas.

Procedures

A prescription for seed drop rates of 15K, 30K, 45K, and 60K seed/ac was developed in a replicated manner within each variety for each of the 12 varieties entered in the large-plot variety testing program (Fig. 1). Varieties were planted in replicated strips with the producer's planter through the length of the field. The study was managed according to the remainder of the field in which the study was located. Each variety was harvested separately into round modules on pickers equipped with yield monitors. Yield monitor data were made available to calculate the percentage of yield monitor seed mass coming from each plot within a variety (Fig. 2). The percentage for each plot was applied to the actual harvested seed cotton weight for the specific variety. Grab samples (approximately one pound of seed cotton) were collected, and 100 g were ginned on 10-saw gin. An average of these ginned samples was used for each variety to calculate pounds of lint per acre. Fiber samples were sent to the USDA Classing Office in Memphis, Tennessee, to determine high volume instrument (HVI) fiber quality traits.

Results and Discussion

A similar emergence percentage of seed drop was observed at all four seed drop rates (Table 1). However, emergence was lower than expected. In previous work, final plant populations at harvest are generally around 80% of seed drop, while plant emergence at two to three weeks after planting is generally 85% of seed drop rates. In this study, only two varieties exceeded, 80% and the overall average was 74% two to three weeks after planting. One variety, DG 3456 B3XF,

[1] Professor/Cotton Extension Agronomist, Program Associate, Program Technician, and Administrative Assistant, respectively, Jackson County Extension Center, Newport.
[2] Program Associate, ASU Research Unit, Jonesboro.
[3] Program Technician, Crop, Soil, and Environmental Sciences, Jonesboro.

averaged only 58% across all seed drop rates. Lint yield was slightly lower at the lowest seed drop rate compared to the other rates (Fig. 3). Little differences in lint yield occurred in the three highest seed drop rates. For each variety, variability in lint yield was greatest at the lowest and highest seed drop rates. Yield across varieties was least variable at the 30K/ac and 45K/ac seed drop rates. Reduced variability across varieties reinforces current seed drop recommendations of 33K/ac on sandy and silt loam soils and 41K/ac on clay loam soils. DP 2020 B3XF and DP 2038 B3XF exhibited the most extreme differences in lint yield relative to seed drop rate (Table 2). However, neither variety showed any trend of relative performance as plant density increased. In contrast, DG 3456 B3XF and DG 3511 B3XF tended to produce higher relative lint yields at lower populations. The third highest lint yield (1,600 lb lint/ac) of the 12 varieties was recorded with DG 3456 B3XF at the lowest seed drop rate. The emergence rate of 62.7% of seed drop resulted in 0.68 plants per foot of row on 38-in. rows for DG 3456 B3XF. The fourth-highest lint yield (1,556 lb lint/ac) was achieved with DG 3511 B3XF. Greater yields trended for NG 3195 B3XF at higher populations. The other varieties produced relatively consistent lint yield rankings across all four seed drop rates.

Practical Applications

Observations of yield response to seed drop rate in this study were consistent with most recent studies on cotton. Variability in yield at extreme populations supports current seeding rate recommendations. Some varieties appear to respond differently to seed drop rates. Future research should include additional locations to help strengthen the potential to statistically separate differences within varieties commonly planted.

Acknowledgments

The authors would like to acknowledge Cotton Incorporated for their support of this project. The authors would also like to thank Judd Hill Foundation and cooperating producers Marty White, Jesse Flye, and David Wildy for their interest in and support of this study. Support was also provided by the University of Arkansas System Division of Agriculture.

Table 1. Average final stand expressed as percent of seed drop rate/ac in Poinsett and Mississippi Counties.

Variety	15K	30K	45K	60K	Average
ST 4595 B3XF	74.6	67.4	79.6	70.1	72.9
DP 2127 B3XF	73.9	62.4	64.4	73.6	68.6
DP 2115 B3XF	81.0	76.2	78.8	78.5	78.6
NG 3195 B3XF	70.8	84.2	68.8	75.2	74.8
ST 5091 B3XF	68.5	77.7	70.8	64.6	70.4
DG 3456 B3XF	62.7	52.2	52.1	64.9	58.0
DP 2038 B3XF	70.3	67.6	72.2	68.9	69.8
DG 3511 B3XF	75.9	72.0	85.4	78.0	77.8
PHY PX1140 W3FE	73.9	91.4	86.0	80.8	83.0
PHY 411 W3FE	84.8	87.6	75.7	86.2	83.6
NG 4190 B3XF	68.8	62.5	65.2	70.9	66.9
DP 2020 B3XF	85.1	100.7	84.1	75.8	86.4
Average	74.2	75.2	73.6	74.0	74.2
Plants/Row ft (38 in.)	0.81	1.64	2.41	3.23	

Table 2. Average lint yield and ranking (R) of 12 varieties at four seed drop rates in Poinsett and Mississippi Counties in 2022.

Variety	15K		30K		45K		60K		Average	
	Lint	R	Lint	R	Lint	R	Lint	R	Lint	R
	(lb/ac)		(lb/ac)		(lb/ac)		(lb/ac)		(lb/ac)	
DP 2115 B3XF	1681	2	1650	3	1709	1	1778	1	1705	2
ST 4595 B3XF	1750	1	1638	4	1596	3	1685	2	1667	3
DG 3456 B3XF	1600	3	1652	2	1493	10	1582	6	1582	5
DP 2127 B3XF	1519	6	1611	6	1591	5	1643	4	1591	5
DP 2020 B3XF	1545	5	1682	1	1465	12	1646	3	1585	5
DG 3511 B3XF	1556	4	1593	7	1542	6	1375	12	1517	7
NG 3195 B3XF	1442	10	1497	11	1594	4	1623	5	1539	8
DP 2038 B3XF	1344	12	1550	8	1631	2	1475	10	1500	8
PHY 411 W3FE	1460	9	1621	5	1488	11	1522	8	1523	8
PHY PX1140 W3FE	1515	7	1535	9	1496	8	1499	9	1511	8
ST 5091 B3XF	1466	8	1504	10	1493	9	1532	7	1499	9
NG 4190 B3XF	1384	11	1404	12	1510	7	1393	11	1423	10
Average lint yield (lb/ac)	1522		1578		1551		1563		1553	

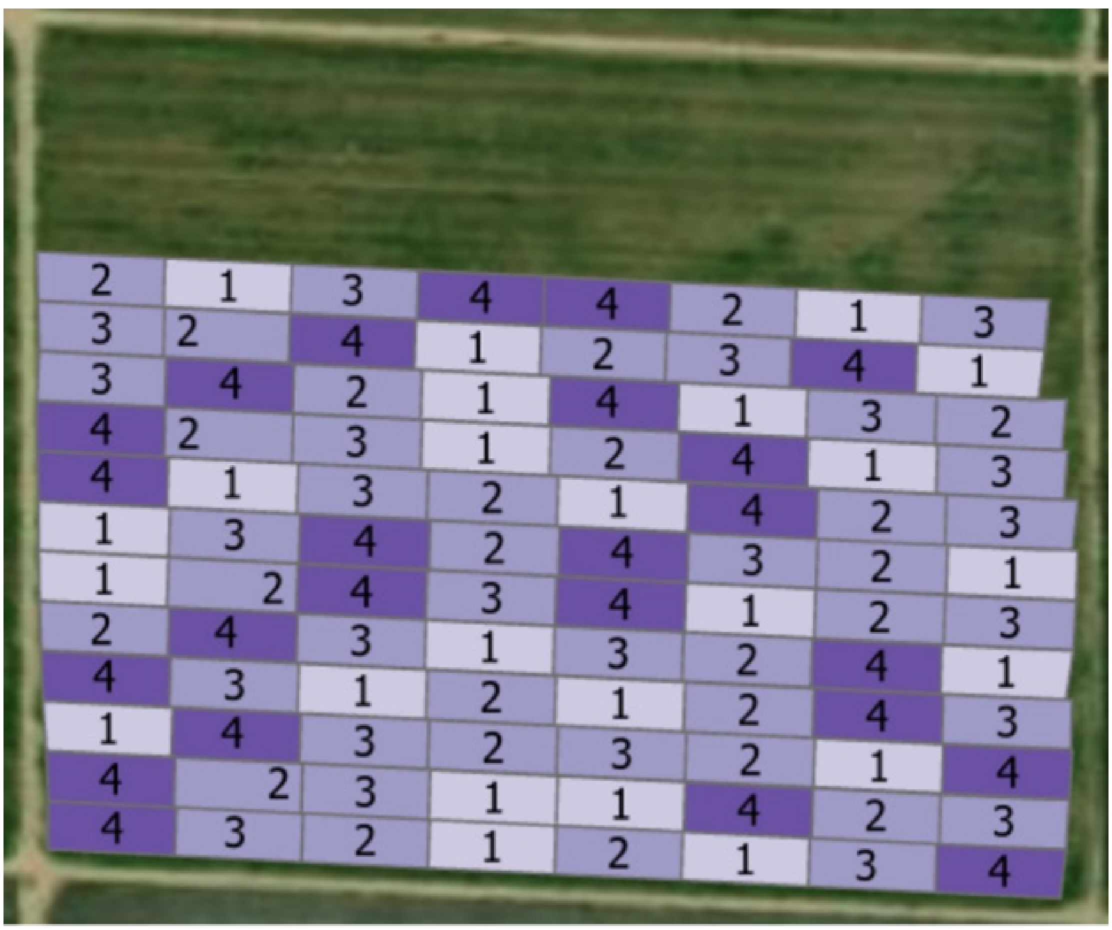

Fig. 1. Seed drop rate prescription for four cotton seed planting rates (1 = 15K, 2 = 30K, 3 = 45K, 4 = 60K) in Poinsett County in 2022.

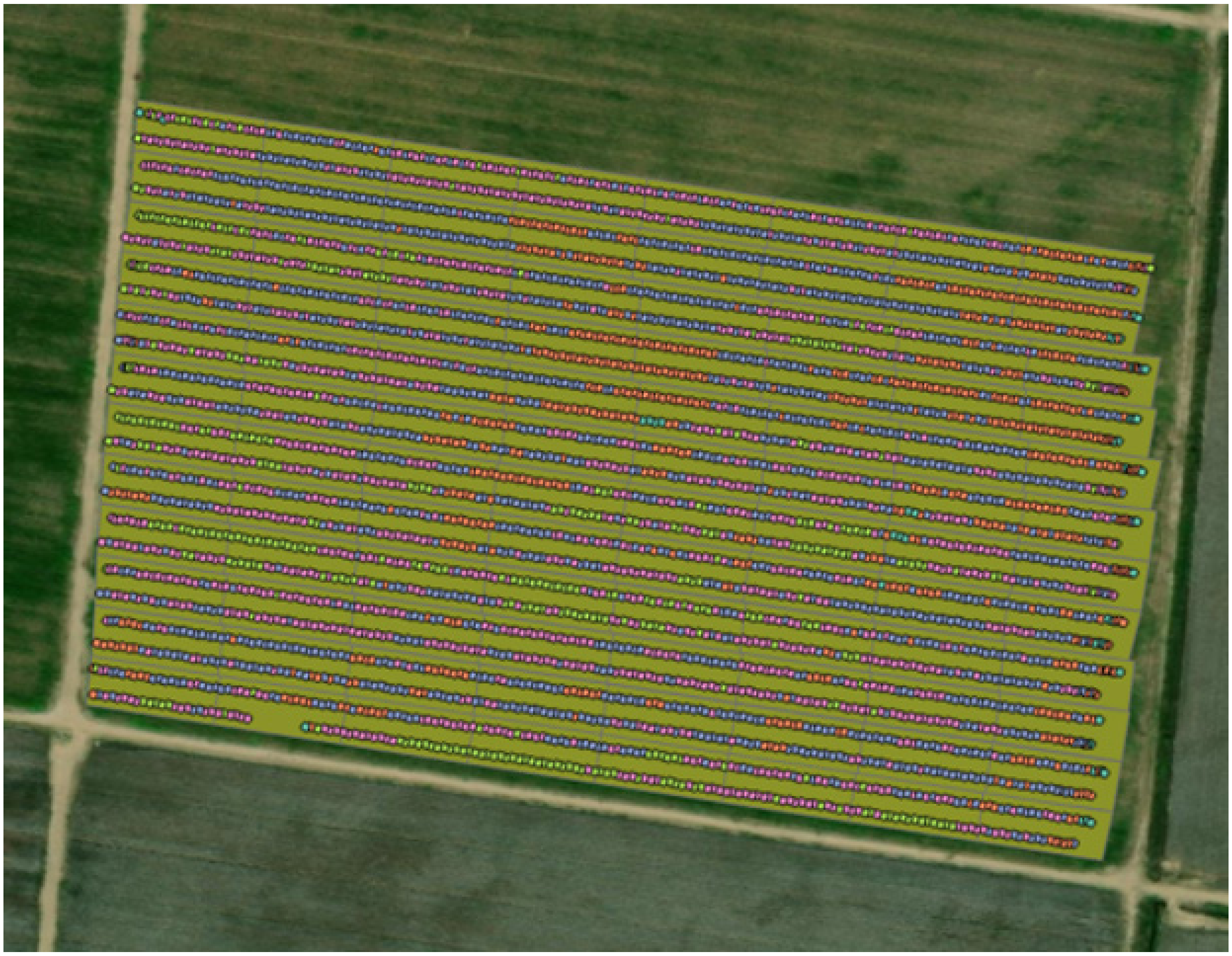

Fig. 2. Display of yield monitor data for the 2022 cotton variety test in Poinsett County. The order of the colors from lowest to highest yielding amount of cotton picked are blue, orange, purple, pink, and green, respectively.

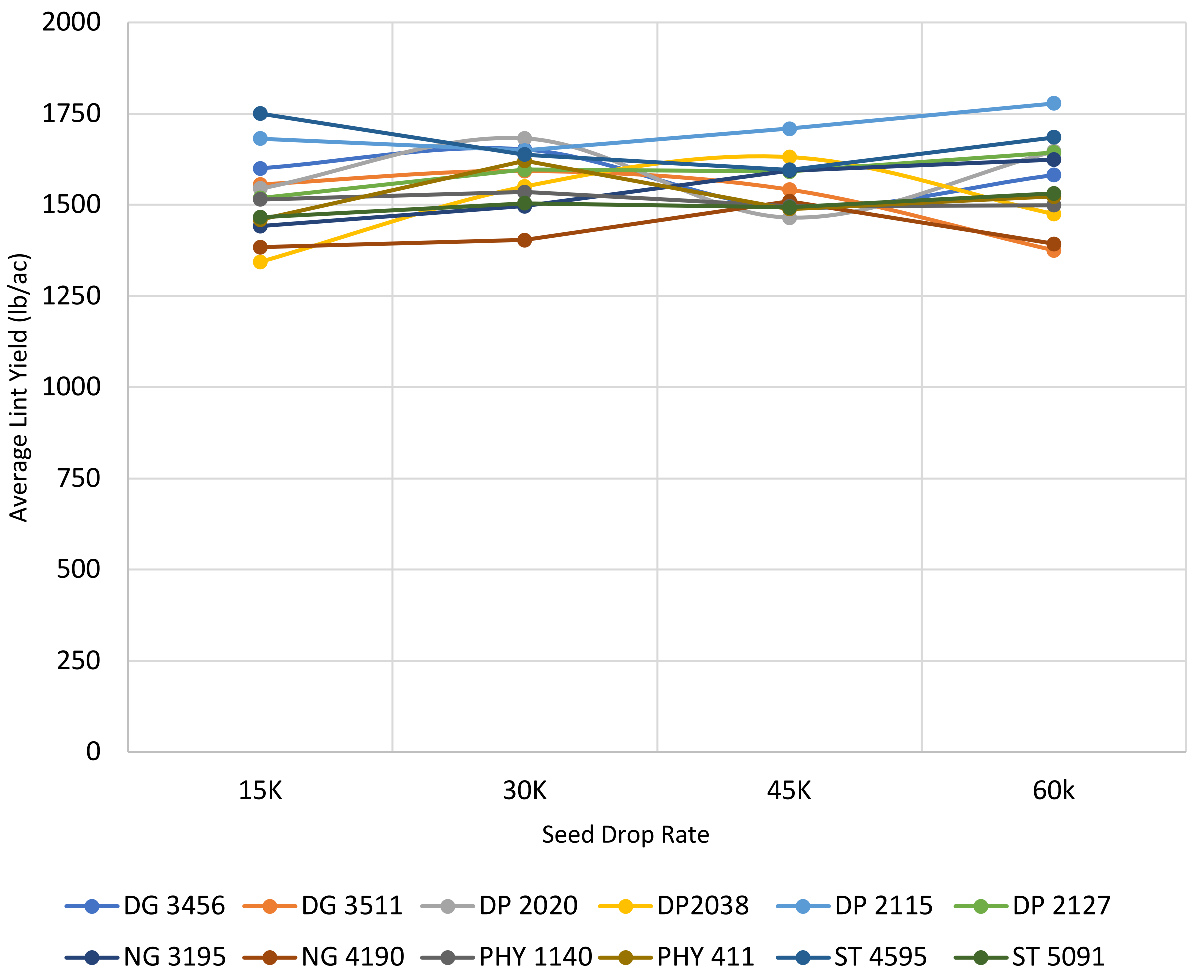

Fig. 3. Average lint yield and ranking of lint yield of 12 varieties at four seed drop rates in Poinsett and Mississippi counties in 2022.

Increasing Profitability by Reducing Input Costs Facilitated by Improving Soil Health

B. Robertson,[1] J. McAlee,[1] B. Watkins,[2] C. Henderson,[1] and D. Madden[1]

Abstract

Improving soil health reduces the producer's environmental footprint, which is key to meeting the goals of the U.S. Cotton Industry to supply brands and retailers with the sustainably produced fiber they desire. Widespread adoption of practices to improve soil health will be more likely to occur when producers can utilize the strengthened relationship of their crop with improved soil health to include soil microbes and an enhanced effective rooting zone to reduce inputs without sacrificing yield and/or profitability. The Arkansas Soil Health Alliance, https://www.facebook.com/Arsoilhealth/, recommendation of crop intensification (CI) coupled with no-till and diverse cover crops to greatly reduce inputs in a strategy toward regenerative cotton production was established in a 40-ac block and compared to the cooperating producer's standard practice in both a system using conventional tillage without a cover crop (PS/NC) in an adjoining 40-ac block and a system utilizing reduced tillage/no-tillage with a single-species cereal rye cover crop (PS/CC) in an 80-ac block. A 1.7 ac block was grazed within the crop intensification (CI+Gr) field to evaluate the yield benefit of incorporating livestock grazing of sheep into the cotton production system. In this report of the second year of this study, yields of all systems did not out-yield the producer standard practice (PS/NC) field. However, positive improvements in return to operating expenses compared to the PS/NC were observed and were greatest with the CI+Gr field of $74.57/ac followed by the CI field of $27.30/ac. The PS/CC field was short by $90.32/ac compared to the PS/NC field. Widespread adoption of practices to improve soil health will not occur based solely on a yield response. For adoption to occur, producers must utilize the improved relationship of their crop with soil microbes and a greatly improved effective rooting zone to reduce inputs without sacrificing yield and/or profitability.

Introduction

The Cotton Research Verification Sustainability Program has demonstrated the effectiveness of improving soil health on positively impacting various soil health parameters in Arkansas and how yield is impacted. In dry years, economic benefits include as much as a 10% increase in yield and a $0.09 reduction in cost per pound of production. In wet years, the yield improvements are greatly diminished. Improving soil health can consistently be accomplished in both wet and dry years. Reducing the producer's environmental footprint is key to meeting the goals of the U.S. Cotton Industry to supply brands and retailers with the sustainably produced fiber they desire. Widespread adoption of practices to improve soil health will not occur based solely on a yield response. For adoption to occur, producers must utilize the improved relationship of their crop with soil health to include soil microbes and a greatly improved effective rooting zone to reduce inputs without sacrificing yield. An educational and demonstration program to improve producer confidence in reducing or eliminating inputs without sacrificing yield will facilitate reduced production costs and the ability to achieve sustainable improvements in profitability. This will help ensure that U.S. cotton producers have a role in providing the fiber brands and that retailers have committed to source.

Procedures

Production strategies were evaluated employing differing input strategies to improve profitability by utilizing on-farm comparisons of four systems in three adjacent fields ranging from 40 to 80 ac. The fields consisted of predominantly mhoon silt loam soils and were furrow irrigated. These fields were paired field comparisons and had four replicated harvest areas consisting of roughly 1.1 ac each. The Arkansas Soil Health Alliance, https://www.facebook.com/Arsoilhealth/, recommendation of crop intensification (CI) as a strategy toward regenerative cotton production coupled with no-till and diverse cover crops to greatly reduce inputs was established in a 40-ac block. The practice of CI is to maintain or increase yield while reducing inputs. Reducing inputs is possible by improving soil health, and one of the goals of this study is to improve soil health. The CI plan has been implemented to try to follow the USDA's four principles of soil health (soil armor, minimizing disturbance, plant diversity, and continual living plants/roots). This should aid us in the ability to meet our other goal of reducing inputs such as cutting water usage, fertilizer, chemical, and seed costs, all while maintaining yield. The CI was compared to the cooperating producer's standard practice in both a system using conventional tillage

[1] Professor/Cotton Extension Agronomist, Program Associate, Program Technician, and Administrative Assistant, respectively, Jackson County Extension Center, Newport.
[2] Instructor, Agriculture and Natural Resources, Jonesboro.

without a cover crop (PS/NC) in an adjoining 40-ac block and a system utilizing reduced tillage with a single-species cereal rye cover crop (PS/CC) in an 80-ac block. On 9 April 2022, a 1.7 ac block was grazed within the CI (CI+Gr) field to evaluate the yield benefit of incorporating livestock grazing of sheep into the cotton production system. This was done to give a simple evaluation of regenerative practices. There are five principles of regenerative agriculture, the first four are the same as the soil health principles, and the fifth is the incorporation of livestock into the system. This portion of the test was not replicated and was used to see if further research should be pursued. The Fieldprint Calculator, https://calculator.fieldtomarket.org/, was used to document differences in the four systems. Lint yields were calculated from seed cotton weights from machine-picked plots. Turnout was calculated from grab samples and ginned on a tabletop gin. Operating expenses, profitability, and changes in environmental footprint were compared.

Results and Discussion

In the second year of cotton production following a cover crop, differences in soil health were observed (data not shown). Watermark soil moisture sensors detected water infiltration occurring at deeper depths on the fields with improved soil health. However, issues were encountered in both the cover crop field and the crop intensification fields. Herbicide injury greatly impacted the growth of the cover crops in both fields. Both fields were terminated in mid-April due to a lack of growth. Both producer standard fields were seeded with DP 2038 B3XF at 36K seed per acre on 13 May, which produced good stands and grew off well. The CI fields were seeded with DP 2038 B3XF at 25K seed per acre on the same day. Stands were slightly skippy from the onset of the season, but plant growth filled in the skips as the season progressed. Yields were good in all fields, with the PS/NC field producing slightly higher yield than the other production systems (Table 1). The yield decreases of the CI fields (Table 1) highlight the complicated mechanisms involved in improving soil health and building soil microbe activity to the point that input reduction will not negatively impact lint yield. Expenses differed between production systems. A summary of the budget analysis of operating expenses revealed that $6.16/ac more was spent on the PS/CC field, $107.58/ac less on the CI field, and $106.73/ac less on the CI+Gr field compared to the PS/NC field (Table 2). Change in return to operating expenses was greatest with the CI+Gr field of $74.57/ac followed by the CI field of $27.30/ac. The PS/CC field was short by $90.32/ac compared to the PS/NC field. It takes time to build soil health to the point of successfully reducing inputs without significantly impacting profitability. Comparisons of the systems using the Field to Market Fieldprint Platform suggest that the cover crop production strategies have a positive impact on reducing energy and greenhouse gas emissions expressed on an acre basis (Table 3).

Practical Applications

Improving soil health reduces producers' environmental footprint, which is key to meeting the goals of the U.S. Cotton Industry to supply brands and retailers the sustainably produced fiber they desire. Widespread adoption of practices to improve soil health will not occur based solely on a yield response. For adoption to occur, producers must utilize the improved relationship of their crop with improved soil health to include soil microbes and a greatly improved effective rooting zone to reduce inputs without sacrificing yield. The timeframe necessary to achieve the well-balanced ecosystem necessary to sustain a crop intensification production system is not clearly understood. One complication discovered this year was the choice of cultivar (DP2038 B3XF). In a plant population study in an adjacent field, DP 2038 B3XF was found to not perform well at the lower planting populations used in the first two years of this study. A more suitable cultivar will be utilized in the third year of this study. With the building of soil health, we will likely experience more learning opportunities for problems that we have not yet faced. With these lessons, we can adapt our inputs to better fit this strategy toward a regenerative farming system.

Acknowledgments

The authors would like to acknowledge Cotton Incorporated for their support of this project. The authors would like to thank Judd Hill Foundation and cooperating producers Marty White and Jesse Flye for their interest and support of this study. The authors would also like to thank CWC farms for the use of sheep for grazing. Support was provided by the University of Arkansas System Division of Agriculture.

Table 1. Expenses and revenue of production systems to improve soil health compared to the producer standard field at Judd Hill in 2022.

	Field system			
Revenue/Expenses	**PS/NC[a]**	**PS/CC**	**CI**	**CI+Gr**
Revenue				
Yield (lb)	1713	1613	1618	1675
Price ($/lb)	0.84	0.84	0.84	0.84
Total Crop Revenue	**1439.16**	**1355.00**	**1358.88**	**1407.00**
Cottonseed Value	**283.38**	**266.81**	**267.57**	**277.05**
Expenses				
Seed	100.80	119.60	90.99	90.99
Fertilizer and Nutrients	188.59	188.59	170.51	170.51
Herbicide	107.96	106.12	97.73	97.73
Insecticide	83.51	76.82	28.68	28.68
Other Chemicals	44.00	44.00	44.00	44.00
Custom Applications	28.00	28.50	28.50	28.50
Other Inputs	28.65	27.20	27.27	28.10
Diesel Fuel	17.67	15.42	14.41	14.41
Irrigation Energy Costs	18.43	18.43	12.28	12.28
Input Costs	**617.61**	**624.68**	**514.37**	**515.20**
Fees	21.50	21.50	21.50	21.50
Repairs and Maintenance[b]	24.02	24.02	23.54	23.54
Labor, Field Act.	8.14	7.10	6.63	6.63
Production Expenses	**671.27**	**677.30**	**566.04**	**566.87**
Interest	14.94	15.07	12.59	12.61
Post-Harvest Expenses	283.38	266.80	267.57	277.05
Operating Expenses	**686.21**	**692.37**	**578.63**	**579.48**
Returns to Operating Expenses	**752.86**	**662.54**	**787.10**	**827.53**
Capital Recovery of Fixed Costs	167.81	151.98	135.66	135.66
Total Specified Expenses[c]	**854.12**	**844.44**	**714.29**	**715.13**
Returns to Specified Expenses	**585.05**	**510.55**	**644.59**	**691.87**
Operating Expenses/lb	0.40	0.43	0.36	0.35
Total Expenses/lb	0.50	0.52	0.44	0.43

[a] Abbreviations: PS/NC = producer standard no cover; PS/CC = producer standard cover crop; CI = crop intensification; CI+Gr = crop intensification + grazing.

[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.

Table 2. Summary of expenses and income compared to the producer standard/ No cover field as influenced by production systems at Judd Hill in 2022 on a per acre basis.

Production System	**Lint Yield**	**Change in Operating Expense**	**Change in Gross Revenue**	**Change in Return to Operating Expense**
Producer Standard/No Cover	1713	--	--	--
Producer Standard/Cover Crop	1613	6.16	-84.16	-90.32
Crop Intensification	1618	-107.58	-80.28	27.30
Crop Intensification + Grazing	1675	-106.73	-32.16	74.57

Table 3. Fieldprint Calculator metrics used to evaluate sustainability in the four systems at Judd Hill.

	Field			
Parameter	**PS/NC**[a]	**PS/CC**	**CI**	**CI+GR**
Yield (lb lint/ac)	1713	1613	1618	1675
Soil Conservation (tons/ac/year)	3.6	1.7	1.6	1.6
Irrigation Water Use (ac-in./lb)	0.007	0.008	0.006	0.005
Energy Use (BTU/lb)	3866	4312	3760	3647
Greenhouse Gas Emissions (lb CO_2eq/lb)	1.2	1.3	1.2	1.2

[a] PS/NC = producer standard no cover; PS/CC = producer standard cover crop; CI = crop intensification; CI+Gr = crop intensification + grazing.

Seed Treatment Efficacy and Cotton Seedling Disease Prevalence in 2022 in Arkansas

M. Araujo,[1] R. Zaia,[1] M. Da Silva,[1] and J.A. Rojas[1]

Abstract

As part of the National Cottonseed Treatment Program, seed treatment trials were established in two locations in Arkansas, Judd Hill (Poinsett County) and Marianna (Lee County). A total of fifteen treatments were evaluated on cultivar `DP 1646 B2XF' targeting fungal and oomycete soilborne pathogens affecting cotton seedling health. Of the 15 treatments, 4 treatments were control or standard practices, and the remaining 11 treatments were nominated by industry. Plots were evaluated for plant stand at 30 days post-planting and yield at the end of the season. Plant stands were above 88% and 90% for Marianna and Judd Hill, respectively. The control treatment containing gaucho only (insecticide) had the lowest plant stand in both locations, while combinations of three or more active ingredients provided better germination. Average cottonseed yields were 3386 lb/ac and 4777 lb/ac for Marianna and Judd Hill, respectively.

Introduction

Cotton crop is susceptible to both abiotic and biotic stresses, the latter being the most significant and caused by insect pests and plant pathogens. Among those, cotton seed poor germination caused by soilborne pathogens is one of the key issues affecting this crop (Kelly et al., 2023). Seedling diseases of cotton (*Gossypium hirsutum* L.) affect germination and plant stand in fields, and can account for losses of up to 23% of the lint yield (Rothrock et al., 2012). Seedling root rot and damping-off are often symptoms observed in the field, which may reduce plant population and also delay crop development (DeVay et al., 2001). The most important pathogens commonly associated with seed and seedling diseases are *Rhizoctonia solani*, *Pythium* spp., *Fusarium* spp., and black root rot caused by *Thielaviopsis basicola* (Toksoz et al., 2009). This complex of pathogens can act alone or together, causing devastating symptoms and also increasing the complexity of the diagnosis. *Rhizoctonia* may cause seed rot and postemergence damping off. The lesions are reddish brown at the base of the hypocotyl, and these can progressively thin the stem and cause the girdling of plants (Rothrock, 1996). *Pythium* species are widespread and common in cotton fields, and the effects of the disease are greater at 61–68 ºF (16–20 ºC), but often recommended planting temperature is 65 ºF or above, which limits the effect of this pathogen. Soil moist conditions will also favor *Pythium*, causing devastating effects that result in seed root and root rot, especially in preemergence (DeVay et al., 2001). *Fusarium* spp. pathogen is common in cotton seedlings and often acts as a secondary pathogen that colonizes wounded tissue either by nematodes or other soilborne pathogens (DeVay et al., 2001). *Fusarium*, similar to *Pythium*, can result in preemergence damping off, and if seedlings survive, plants will exhibit necrotic lesions in roots and hypocotyl. Seedlings can also become girdled and wilt (DeVay et al., 2001).

Conditions for proper and fast germination of cotton seed and seedling development include a soil temperature of 65 ºF or higher, and seeds planted on beds with proper water infiltration and drainage. Growers often plant early to increase the growing season, avoiding competition by weeds that could outcompete plants for water or harbor insect pests. However, early planting often exposes seed to moist and cool soils that favor most of the pathogens mentioned earlier. The National Cottonseed Program annually evaluates different fungicide seed treatment performance on cotton. In 2022, we conducted research at two locations in Arkansas to represent distinct environmental conditions and disease pressure. Standard treatments include Allegiance (mefenoxam) which controls *Pythium*, EverGol Prime (penflufen) which controls *Rhizoctonia solani,* and a combination of Proline (prothioconazole) for *Fusarium* and Spera (myclobutanil) for *Thielaviopsis* and different combinations of these active ingredients. Seed treatments are expected to increase plant stand reducing seed rot and seedling disease.

Procedures

Seed from cultivar DP 1646 B2XF was selected, and base treatment containing Gaucho 600 (insecticide - 12.8 oz/cwt) was applied to the seed for the control treatment, and the remaining 14 fungicide treatments are identified in Table 1. Germination of the seed before planting was evaluated under controlled conditions using potting mix in the greenhouse. Fifty seeds were placed in plastic trays, and emergence was recorded 14 days after. The fungicide seed treatment trial

[1] Graduate Assistant, Graduate Assistant, Program Associate, and Assistant Professor, respectively, Department of Entomology and Plant Pathology, Fayetteville.

including 15 treatments was planted at Marianna and Judd Hill on 12 May and 18 May, respectively. A total of 15 seed treatments were included in the field trial and were planted in a complete randomized block design using two-row plots 30 feet long, with a planting rate of 5 seeds per foot. Of the 15 treatments included in the study, treatments one through four are standard and/or control treatments and included insecticide alone, insecticide + mefenoxam (oomyceticide), insecticide + fungicide, and insecticide + four fungicides. The other remaining 11 treatments were selected based on recommendations done to the National Cottonseed Treatment Program. Percent germination prior to planting was established for all the different treatments using a moist towel paper using 50 seeds per treatment. Paper was rolled and moistened using sterile distilled water and incubated at 77 ºF (25 ºC) for seven days. The number of seed with radicles longer than 2 cm was recorded as germinated, and percent germination was established.

Stand counts at Marianna were done on 13 June and on 14 June at Judd Hill (Table 1). Data were analyzed with JMP 15 Pro (SAS Institute Inc., Cary N.C.); values with the same letter within a column are not significantly different, where percent stand was analyzed across locations using Mixed Model–Tukey's honestly significant difference (HSD) means separation with $\alpha = 0.05$ and by location using the Fit Model–Standard Least Squares procedure–Tukey's HSD means separation with $\alpha = 0.1$. Fifty plants from the untreated control were collected to establish inoculum pressure and disease severity. Plants collected were assessed for root discoloration and disease index for hypocotyl damage (Pate, 2020). The scale for hypocotyl damage was 1 = no symptoms, 2 = a few pinpoint lesions and diffuse color areas, 3 = distinct necrotic lesions, 4 = girdling lesion, and 5 = dead seedling. The scale for root region was 1 = no symptoms, 2 = 1–10% of root system discolored, 3 = 11–25% of root system discolored, 4 = 26–50% of root system discolored, 5 = 51–75% of root system discolored, and 6 = >75% of root system discolored.

Plots were harvested using a plot picker on 23 October at Judd Hill and 4 November for Marianna. Yield from each row was averaged and converted to seed cotton pounds per acre. Data were analyzed with JMP 15 Pro (SAS Institute Inc., Cary N.C.), where seed cotton yield (lb/ac) was analyzed across locations using Mixed Model.

Results and Discussion

Percent emergence before planting was evaluated using potting mix in the greenhouse, and all but two treatments had a germination higher than 80%. Treatments 10 (myclobutanil + prothioconazole + fluoxastrobin + penflufen + metalaxyl) and 11 (myclobutanil + prothioconazole + fluoxastrobin + penflufen + metalaxyl + tryfloxystrobin) had germination of 70% and 73%, respectively. Field emergence determined as stand counts were recorded at 30 days post planting. At Marianna, the percent stand ranged from 88% to 98%, but it did not differ significantly (Table 1). The treatment that had the highest stand was number 9 with 98% (myclobutanil, prothioconazole, fluoxastrobin, penflufen, metalaxyl), and the lowest was treatment 1 with only Gaucho (Table 1). The Judd Hill location had significant differences, with percent stand ranging from 90% to 94%. Treatment 5 (azoxystrobin, sedaxane, metalaxyl, myclobutanil, fludioxinil) had the highest stand count with a 94.9% stand, and the lowest was again treatment 1 with 90% stand. Of those standard treatments, treatments that included at least four different chemistries (myclobutanil, prothioconazole, penflufen, mefenoxam), which target *Thielaviopsis*, *Rhizoctonia,* and *Pythium*, had the best performance.

Root discoloration was about 25–50% for both locations, and the disease index in the hypocotyl was 1.5 and 1.6 Judd Hill and Marianna, respectively. Root disease indices were 2.9 and 1.9 for Judd Hill and Marianna, respectively. In terms of disease pressure, *Thielaviopsis* (black root rot) was only present in Judd Hill, while *Pythium*, *Fusarium,* and *Rhizoctonia solani* were present at both locations.

Plots were defoliated in mid-September 2022 for both sites. The Marianna location was harvested on 11 October, and Judd Hill was harvested on 20 October. There were no significant differences in yield among the treatments (Table 1). There were significant differences between locations, where Marianna had an overall lower yield than Judd Hill. While most treatments had similar behavior, treatment 11 trended to be the highest yield for both locations.

Practical Applications

Management of seedling diseases relies mostly on the use of seed treatments for the control of fungal and oomycete soilborne pathogens. The continuous monitoring of chemistries to effectively control pathogens will aid the decision-making process for the coming season. In addition, the development of tolerance against chemistries by soilborne pathogens is a major risk, and it is necessary to monitor the efficacy of different active ingredients and the potential risk of resistance by soilborne pathogens. This paper reports the results of the research only. The mention of a pesticide in this paper does not constitute a recommendation.

Acknowledgments

The authors appreciate the support provided by Arkansas cotton producers through check-off funds administered by Cotton Incorporated. Support was also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

DeVay, J.E., T.L. Kirkpatrick, and C.S. Rothrock. 2001. Seedling diseases. pp. 13-14. *In*: Compendium of Cotton Diseases. T.L. Kirkpatrick and C.S. Rothrock (eds.) American Phytopathological Society, St. Paul, Minn.

Rothrock, C. 1996. Cotton diseases incited by *Rhizoctonia solani*. *In*: *Rhizoctonia* Species: Taxonomy, Molecular

Biology, Ecology, Pathology and Disease Control, ed. B Sneh. Springer, p. 269–277.

Rothrock, C.S.; S.A. Winters, P.K. Miller, E. Gbur, L.M. Verhalen, B.E. Greenhagen, T.S. Isakeit, W.E. Batson, F.M. Bourland, P.D. Colyer, T.A. Wheeler, H.W. Kaufman, G.L. Sciumbato, P.M. Thaxton, K.S. Lawrence, W.S. Gazaway, A.Y. Chambers, M.A. Newman, T.L. Kirkpatrick, J.D. Barham, P.M. Phipps, F.M. Shokes, L.J. Littlefield, G.B. Padgett, R.B. Hutmacher, R.M. Davis, R.C. Kemerait, D.R. Sumner, K.W. Seebold, J.D. Mueller, R.H. Garber. 2012. Importance of fungicide seed treatment and environment on seedling diseases of cotton. Plant Dis 2012, 96 (12):1805–1817. https://doi.org/10.1094/pdis-01-12-0031-sr

Pate, S. 2020. Analyzing Populations of Cotton Seedling Disease and Evaluating Seed Treatment Efficacy. Masters Thesis. Available at: https://trace.tennessee.edu/utk_gradthes/6091.

Kelly, H.M., A. Blazek, A. Ali, T.W. Allen, T.H. Wilkerson, R.C. Kemerait, K.S. Lawrence, A. Strayer-Scherer, C. Monclova-Santana, P. Price, A. Rojas, T. Spurlock, and I. Small. 2023. Report of the Cottonseed Treatment Committee for 2022. In Proceedings of the 2023 Beltwide Cotton Conferences, New Orleans, La.

Toksoz, H., C.S. Rothrock, T.L. and Kirkpatrick. 2009. Efficacy of seed treatment chemicals for black root rot, caused by *Thielaviopsis basicola*, on cotton. Plant Dis. 93:354–362.

Table 1. Cotton seedling stands and cottonseed yield (lb/ac) for Marianna and Judd Hill with seed treatments associated with the 2022 National Cottonseed Treatment Program.

Treatment	Marianna Emergence	Marianna Cottonseed Yield	Judd Hill Emergence	Judd Hill Cottonseed Yield	Product
	(%)	(lb/ac)	(%)	(lb/ac)	
1	88.9	3732	90.1 b[†]	4622	NTC - Gaucho only
2	93.1	3277	92.6 ab	4523	Allegiance FL
3	94.5	3591	91.3 ab	4589	Evergol prime
4	95.9	3538	93.4 ab	4825	Spera, Proline 480 sc, Allegiance fl, Evergol prime
5	92.9	3373	94.9 a	4815	Albaugh, Mefenoxam, Ipconazole, Azoxystrobin, Myclobutanil
6	97.2	3354	94.1 ab	4413	Apron XL LS, Maxim 4FS, Rally, Vibrance CST
7	95.8	3015	94.0 ab	5167	Apron XL LS, Maxim 4FS, Rally, Vibrance CST, Vayantis 0.1
8	89.5	2909	93.3 ab	5219	Apron XL LS, Maxim 4FS, Rally, Vibrance CST, Vayantis 0.2
9	98.2	3432	92.5 ab	5354	Spera, Proline 480 SC, Fluoxastrobin FS480, Evergol prime, Allegiance FL
10	94.9	3127	93.1 ab	4493	Spera, Proline 480 SC, Fluoxastrobin FS480, Evergol prime, Allegiance FL, Evergol Xtend
11	94.5	3722	92.5 ab	5459	Spera, Proline 480 SC, Fluoxastrobin FS480, Evergol Prime, Evergol Xtend
12	96.3	3557	92.5 ab	4762	Allegiance, Maxium, Spera, Dynasty, Apron Xl, Kabina
13	94.5	3325	91.6 ab	4905	Allegiance, Maxium, Spera, Vibrance CST, Kabina
14	94.8	3248	92.5 ab	4181	Stamina 1.5, Systiva XS, Allegiance FL, Spera 240 FS, Copeo Prime
15	95.4	3601	92.3 ab	4339	Stamina 3.1, Systiva XS, Allegiance FL, Spera 240 FS, Copeo Prime

[†] Data were analyzed with JMP 15 Pro (SAS Institute Inc., Cary N.C.), values with the same letter within a column are not significantly different, where percent stand was analyzed by location using the Fit Model–Standard Least Squares procedure–Tukey's honestly significant difference means separation with $\alpha = 0.05$.

Utility of See & Spray™ Ultimate in Cotton Cover Crops

T.H. Avent,[1] J.K. Norsworthy,[1] T.C. Smith,[1] L.M. Schwartz-Lazaro,[2] W.L. Patzoldt,[2] and M.M. Houston[2]

Abstract

John Deere recently announced the commercial release of See & Spray™ Ultimate, which facilitates precision herbicide applications in row crops. Currently, no published literature exists detailing the performance of this new technology in cotton production systems or the ability of the system to detect weeds through cover crop canopy. Research was conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center to evaluate See & Spray Ultimate's performance with a fallow, cereal rye, and hairy vetch cover crop system in XtendFlex® cotton. The experiment evaluated a dual-tank and a single-tank See & Spray program versus a broadcast standard with consistent herbicide rates across preemergence (PRE), early-postemergence (EPOST), and mid-postemergence (MPOST) herbicide programs. The See & Spray single-tank program was the only application method to cause a slight reduction in Palmer amaranth (*Amaranthus palmeri* S. Wats.) control from 98% with the broadcast standard to 94% 14 days after the EPOST application. Additionally, Palmer amaranth control improved from 95% with no cover crop to 98% with a cereal rye cover crop. By 14 days after the MPOST, all application methods and cover crop systems were comparable. By the end of the season, cover crops were the only factor to influence yield, whereas cotton without a cover crop yielded better than with cover crops. Results from this research indicate that See & Spray Ultimate can be utilized with cover crops in cotton, but the machine was operated with a medium sensitivity setting (level 4), and herbicide savings and weed control with this technology will likely vary with different sensitivity settings.

Introduction

The utilization of precision sprayers in current production systems could potentially reduce herbicide inputs (Cardina et al. 1997; Metcalfe et al. 2019; Wiles et al. 1992). With the commercial release of See & Spray™ Ultimate, Arkansas cotton (*Gossypium hirsitum* L.) producers need more insight into the capabilities of this new technology for production systems. Additionally, this technology is the first to provide in-season targeted applications capable of distinguishing weeds from crops. The See & Spray Ultimate platform is also equipped with a dual tank and plumbing system, which facilitates simultaneous broadcast and See & Spray applications. However, no published literature has determined if targeted broadcast applications with See & Spray Ultimate can provide comparable weed control to traditional herbicide applications. With the increasing development of resistance in Palmer amaranth (*Amaranthus palmeri* S. Watts), ensuring comparable or improved control is paramount to preserve effective herbicide chemistries (Bagavathiannan and Norsworthy 2012; Heap 2023). As part of an integrated weed management strategy, previous research has shown that cereal rye (*Secale cereale* L.) cover crops can reduce Palmer amaranth emergence by ≥63% (DeVore et al. 2012; Palhano et al. 2018). The ability of See & Spray Ultimate to detect weeds through cover crop biomass has yet to be evaluated; therefore, an experiment was conducted at the Northeast Research and Extension Center to determine the performance of See & Spray Ultimate in XtendFlex® Cotton with cover crops.

Procedures

The experiment was designed as a two-factor factorial within a randomized complete block with 4 replications. The first factor consisted of different cover crops: fallow or no cover crop, cereal rye at 60 lb/ac, or hairy vetch (*Vicia villosa* Roth) at 20 lb/ac. The second factor consisted of different application methods: nontreated, broadcast standard, See & Spray dual tank, or See & Spray single tank. Herbicide rates remained consistent across application methods (Table 1). Plots were 12.6 ft (4 rows) by 100 ft in length. Cover crops were drill-seeded on 27 Oct 2021, and all cover crop systems, including fallow, received a preplant burndown application on 22 April 2022. DP 2020 B3XF was originally planted to standing residue on 12 May 2022 and replanted (due to vacuum line failure) on 5 June 2022 at 44,000 seeds/ac. Preemergence (PRE), early-postemergence (EPOST), and mid-postemergence (MPOST) applications occurred on

[1] Graduate Assistant, Distinguished Professor/Elms Farming Chair of Weed Science, and Graduate Assistant, respectively, Department of Crop, Soil, and Environmental Sciences, Fayetteville.
[2] Senior Agronomist, Director of Agronomy, and Research Agronomist, respectively Blue River Technology, Sunnyvale, California.

13 May, 24 June, and 11 July, respectively. Preemergence through MPOST applications occurred with a scaled-down version of See & Spray Ultimate attached to a front-end loader of a JD6130M at 8 MPH and 15 GPA with a level 4 sensitivity. The entire trial also received a hooded, lay-by application of Direx 4L and MSMA 6 Plus, both at 32 fl oz/ac.

Evaluations included visible Palmer amaranth control and crop injury 14 days after EPOST and MPOST applications. Control and injury were evaluated on a 0% to 100% scale, with 0% representing no injury or control and 100% representing complete crop death or no weeds present (Frans and Talbert, 1977). Seedcotton was harvested from all four rows using a 4-row John Deere picker equipped with load cells to measure plot yields. Assuming a lint turnout of 41.3%, lint yield was then calculated and reported as lb/ac. All data were analyzed using JMP Pro v. 17 (SAS Institute Inc., Cary, N.C.), subjected to analysis of variance, and means separated using Tukey's honestly significant difference at $\alpha = 0.05$.

Results and Discussion

Early in the season, utilizing See & Spray single tank programs caused a slight reduction in Palmer amaranth control (Table 2). At 14 days after EPOST, the broadcast standard and See & Spray dual tank program provided comparable control (98% and 97%, respectively), whereas the single tank program reduced control to 94%. Though control was greater than 90% regardless of application method, a reduction in control indicates more weeds present for the subsequent application and a greater potential for the development of herbicide-resistant weeds through escapes (Bagavathiannan and Norsworthy, 2012). The cereal rye cover crop also increased Palmer amaranth control by 3 percentage points relative to the fallow system at 14 DAEPOST. By 14 days after MPOST, no differences existed between the two factors for Palmer amaranth control.

Despite cover crops influencing cotton injury 14 days after EPOST applications, the response was <1%, and no differences existed after the MPOST application (Table 2). Averaged over application methods, the use of cover crops reduced lint yield by 206 and 106 lb/ac, but this response was not associated with the See & Spray Ultimate technology. Averaged over cover crops, the nontreated was the only application method to reduce yield. The other application methods, which included herbicides, were comparable to each other, yielding between 1,152 to 1,210 lb/ac. The increased yield is unsurprising since competition with weeds is known to reduce cotton yields (Buchanan and Burns, 1970; Keeley and Thullen, 1989). The extremely low yield of the untreated check indicates the weed pressure in this test.

Practical Applications

Although very little crop response was observed in this study, other studies utilizing the dual boom system have reduced soybean injury caused by Weed Science Society of America Group 15 herbicides such as Dual Magnum and Warrant (unpublished data). Future replications of this experiment will perhaps show a similar response in cotton. Additionally, during each application, careful attention was placed on determining if the machine would have any system errors, and each plot was walked after treatment to see if any weeds were missed. No weeds were missed, and no system errors were observed in the different cover crop systems during the applications. Based on the results of this study, See & Spray Ultimate could be utilized in cotton with cereal rye or hairy vetch. A slight reduction in Palmer amaranth control was observed early in the season when applying residual herbicides through the See & Spray system (single tank programs). Based on this response, producers utilizing this technology should continue to broadcast residual herbicides to ensure optimal control and reduce the number of weeds present for subsequent applications. Furthermore, this experiment was carried out under specific machine settings, and adjusting sensitivity settings could impact the results observed.

Acknowledgments

Funding for this research was provided by Blue River Technology; additionally, the authors are grateful to Blue River for providing the scaled See & Spray™ Ultimate machine and the Northeast Research and Extension personnel for facilitating this research.

Literature Cited

Bagavathiannan M. and J. Norsworthy. 2012. Late-season seed production in arable weed communities: management implications. Weed Science. 60:325–334.

Buchanan G.A. and E.R. Burns. 1970. Influence of weed competition on cotton. Weed Science. 18:149–154.

Cardina J., G.A. Johnson, and D.H. Sparrow. 1997. The nature and consequence of weed spatial distribution. Weed Science. 45:364–373.

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 Technology. 26:832–838.

Frans R.E. and R.E. Talbert. 1977. Design of field experiments and the measurement and analysis of plant responses. pp. 15–23 in Truelove B. (ed.), Research Methods in Weed Science. Auburn, Ala.: Southern Weed Science Society.

Heap I. 2023. The international survey of herbicide resistant weeds. Accessed 17 January 2023. Available at: https://www.weedscience.org/Pages/Species.aspx

Keeley P.E. and R.J. Thullen. 1989. Growth and competition of black nightshade (*Solanum nigrum*) and Palmer amaranth (*Amaranthus palmeri*) with cotton (*Gossypium hirsutum*). Weed Science 37:326–334.

Metcalfe H., A.E. Milne, K. Coleman, A.J. Murdoch, and J. Storkey. 2019. Modelling the effect of spatially variable

soil properties on the distribution of weeds. Ecological Modelling. 396:1–11.
Palhano M.G., J.K. Norsworthy, and T. Barber. 2018. Cover crops suppression of Palmer amaranth (*Amaranthus palmeri*) in cotton. Weed Technol. 32:60–65.
Wiles L.J., G.W. Oliver, A.C. York, H.J. Gold, and G.G. Wilkerson. 1992. Spatial distribution of broadleaf weeds in North Carolina soybean (*Glycine max*) fields. Weed Science. 40:554–557.

Table 1. List of treatments for herbicide programs and subsequent herbicide rates.

	Application timing					
	Preemergence		Early-postemergence		Mid-postemergence	
Treatment	Broadcast	See & Spray	Broadcast	See & Spray	Broadcast	See & Spray
Nontreated	-	-	-	-	-	-
Broadcast standard	Cotoran Caparol Gramoxone		Engenia[†] RUPmax[‡] Dual Mag		Interline RUPmax Warrant	
See & Spray dual tank	Cotoran Caparol	Gramoxone	Dual Mag	Engenia RUPmax	Warrant	Interline RUPmax
See & Spray single tank		Cotoran Caporal Gramoxone		Engenia RUPmax Dual Mag		Interline RUPmax Warrant
	Herbicide	**Rate**	**Herbicide**	**Rate**	**Herbicide**	**Rate**
	Cotoran 4L	24 oz/ac	Engenia	22 oz/ac	Interline	2 pt/ac
	Caparol 4L	24 oz/ac	Roundup PowerMAX 3	30 oz/ac	Roundup PowerMAX 3	30 oz/ac
	Gramoxone 3 SL	22 oz/ac	Dual Mag	1 pt/ac	Warrant	3 pt/ac

[†] Applications of Engenia included a volatility and drift reducing agent.
[‡] Abbreviations: RUPmax = Roundup PowerMAX 3; Dual Mag = Dual Magnum.

Table 2. Palmer amaranth (PA) control, cotton injury, and lint yield in response to cover crops, application method, or the interaction of the two factors.

	14 DAEPOST†		14 DAMPOST		
Factors	**PA**	**Injury**	**PA**	**Injury**	**Yield**
Cover crop	---------------------------%---------------------------				**lb/ac**
Cereal rye	98 a‡	<1 a	97	0	835 b
Fallow	95 b	0 b	96	0	1,042 a
Legume	96 ab	0 b	99	0	936 b
P-value§	0.0026	0.0104	0.0913	1.0	0.0001
Application method					
Nontreated	-	-	-	-	206 b
Broadcast Standard	98 a	1	98	0	1,152 a
See & Spray dual tank	97 a	0	97	0	1,180 a
See & Spray single tank	94 b	1	96	0	1,209 a
P-value	0.0002	0.2316	0.1026	1.0	< 0.0001
Cover crop * application method					
P-value	0.5130	0.2183	0.2206	1.0	0.3483

† Abbreviations: DAEPOST= days after early-postemergence; DAEMPOST = days after mid-postemergence.
‡ Means within a column for each factor level not containing the same letter differ according to Tukey's honestly significant difference (α = 0.05).
§ *P*-values were generated using the fit model platform of JMP Pro version 17.

Residual Herbicide Options to Control Glufosinate-Resistant Palmer Amaranth

P. Carvalho-Moore,[1] J.K. Norsworthy,[1] M.C.C.R. Souza,[1] L.B. Piveta,[1] T. King,[1] A. Godar,[1] L.T. Barber,[2] and T.R. Butts,[2]

Abstract

Resistance to glufosinate in Palmer amaranth (*Amaranthus palmeri* S. Wats.) was first reported in 2021 in Arkansas. Alternative chemical control methods are highly sought to avoid the spread of this problematic herbicide-resistant weed across the southern region of the United States. This study aimed to determine the effectiveness of herbicides labeled for preplant or preemergence applications in cotton (*Gossypium hirsutum* L.) and soybean (*Glycine max* L.) to control glufosinate-resistant Palmer amaranth. The preemergence (PRE) treatments were imazaquin (0.12 lb ai/ac), pendimethalin (1 lb ai/ac), diuron (1 lb ai/ac), metribuzin (0.67 lb ai/ac), flumioxazin (0.063 lb ai/ac), saflufenacil (0.045 lb ai/ac), fomesafen (0.25 lb ai/ac), trifludimoxazin (0.045 lb ai/ac), acetochlor (1.124 lb ai/ac), *S*-metolachlor (1.24 lb ai/ac), pyroxasulfone (0.129 lb ai/ac), and fluridone (0.15 lb ai/ac). Irrigation in the amount of 1 inch was applied after application to ensure the activation of herbicides. A postemergence (POST) treatment with glufosinate at 0.585 lb ai/ac was applied twenty days after preemergence treatments to confirm the presence of a glufosinate-resistant accession in the trial site. A randomized complete block design with 4 replicates was used with a nontreated control for comparison. Visual control (%) was rated, and aboveground biomass was collected 6 weeks after PRE treatments. Biomass reduction (%) was calculated in comparison to the nontreated control. The lowest visual control and biomass reduction were observed in treatments that received only glufosinate POST or imazaquin preemergence due to resistance to these herbicides. Low control and biomass reduction were also detected following the treatment with pendimethalin. Besides the herbicides mentioned above, visual control and biomass reduction rates were similar for all other herbicides. Although most of the tested herbicides provided acceptable Palmer amaranth control, overlapping multiple effective residual herbicides and POST-applied options are crucial to controlling glufosinate-resistant populations.

Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is a prolific weed that can evolve resistance to herbicides (Heap, 2023; Sellers et al., 2003). Thus far, this weed has been confirmed resistant to nine sites of action (SOA). Multiple resistance to several SOA in a single population has been reported (Carvalho-Moore et al., 2023; Heap, 2023; Shyam et al., 2020). Glufosinate resistance in Palmer amaranth populations from Arkansas was confirmed in 2021 (Priess et al., 2022). Ironically, glufosinate is highly used for postemergence (POST) control of herbicide-resistant Palmer amaranth nationwide. Without glufosinate, POST herbicidal options are scarce, and effective control of this challenging weed requires using residuals earlier in the season.

Palmer amaranth can emerge in Arkansas from March until October. If an effective weed control program is not used, Palmer amaranth plants may escape and produce seeds. The produced seeds will restock the seedbank and ensure the infestation of weeds, including those carrying herbicide-resistant traits (Keeley et al., 1987). With effective residual control, plants will likely be controlled, reducing the seeds deposited in the soil and the perpetuation of herbicide resistance in the area. Therefore, this study was conducted to determine the effectiveness of preplant or preemergence (PRE) herbicides in cotton (*Gossypium hirsutum* L.) or soybean (*Glycine max* L.) to control glufosinate-resistant Palmer amaranth.

Procedures

A field experiment was conducted at the University of Arkansas System Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center, Fayetteville, Ark., in 2022. An area containing a previously characterized Palmer amaranth population highly resistant to glufosinate was selected to conduct this experiment (Priess et al., 2022). The experiment was organized as a randomized complete block design with 4 replications. The PRE treatments were imazaquin at 0.12 lb ai/ac, pendimethalin at 1 lb ai/ac, di-

[1] Program Associate, Post Doctoral Fellow, and Professor, respectively, Department of Entomology and Plant Pathology, Lonoke Extension Center, Lonoke.
[2] Professor/Extension Weed Scientist and Assistant Professor/Extension Weed Scientist, respectively, Department of Crop, Soil, and Environmental Sciences, Lonoke.

uron at 1 lb ai/ac, metribuzin, 0.67 lb ai/ac, flumioxazin at 0.063 lb ai/ac, saflufenacil at 0.045 lb ai/ac, Ffomesafen at 0.25 lb ai/ac, acetochlor at 1.124 lb ai/ac, *S*-metolachlor at 1.24 lb ai/ac, pyroxasulfone at 0.129 lb ai/ac, and fluridone at 0.15 lb ai/ac. The new active ingredient trifludimoxazin was also included at 0.045 lb ai/ac. Trifludimoxazin will likely be labeled as a preplant and burndown option in selected row crops. Overhead irrigation in the amount of 1 inch was applied after application to ensure the activation of herbicides. A POST treatment with glufosinate at 0.585 lb ai/ac was applied 20 days after PRE treatments to confirm the presence of the glufosinate-resistant accession in the trial site. A nontreated control was used for comparison.

Visible ratings of Palmer amaranth control (%) and aboveground biomass from two 2.69 ft^2 quadrats randomly placed in each plot were collected 6 weeks after PRE treatments. Biomass reduction (%) was calculated in comparison to the nontreated control. The collected data were subjected to analysis of variance using JMP Pro v. 17 (SAS Institute, Inc., Cary, N.C.). Means were separated using Fisher's protected least significance difference ($\alpha = 0.05$).

Results and Discussion

The treatments of imazaquin or pendimethalin obtained the lowest visual control observed in this trial, with 32% and 49%, respectively (Fig. 1). Visual control was similar in all other treatments and ranged from 88% to 97%. Similar results were also observed with biomass reduction (Fig. 2). The lowest biomass reduction was obtained from the imazaquin treatment (6%). Additionally, biomass reduction following applications of saflufenacil (45%) or pendimethalin (49%) was not satisfactory either. Biomass reduction ranged from 81 to 99% in the other treatments and was not different. The POST application with glufosinate controlled only 46% of the Palmer amaranth plants and had a 15% biomass reduction, confirming the presence of glufosinate-resistant plants in the experimental area.

In the present study, only four herbicides obtained visual control or biomass reduction above 95%, which indicates the necessity of overlapping different chemistries. Recent studies with Palmer amaranth or tall waterhemp (*Amaranthus tuberculatus* [Moq.] J.D.Sauer) showed that most of the POST herbicides labeled in row crops controlled less than 80% of plants present in the field (Houston et al., 2019; Werle et al., 2023). On the other hand, the majority of the PRE chemistries tested by Houston et al. (2019) obtained ≥80% Palmer amaranth biomass reduction. These results further support the importance of including residuals in the herbicide program. Additionally, among the best herbicide resistance management practices, the use of multiple effective modes of action is recommended (Norsworthy et al., 2012).

Trifludimoxazin is the newest protoporphyrinogen IX oxidase (PPO) inhibitor. This herbicide strongly inhibits the PPO enzyme and seems to be a promising option to control herbicide-resistant Palmer amaranth. Additionally, trifludimoxazin was confirmed to inhibit the enzyme carrying some resistance-conferring mutations (Porri et al., 2022). This active ingredient effectively controlled the glufosinate-resistant Palmer amaranth population tested in this study. However, results will highly depend on each population's PPO resistance level and the mechanism imparting resistance.

Practical Applications

Actions to reduce the spread of Palmer amaranth populations carrying glufosinate resistance are highly sought since this herbicide is still a valuable tool in controlling herbicide-resistant weeds. Regarding chemical control, the POST options are scarce depending on the cropping system, and effective control will likely be achieved early in the season using residuals. However, the overlapping of different chemistries is necessary to effectively manage and contain the resistance and avoid resistance development to different herbicides.

Acknowledgments

The authors thank their fellow Weed Science colleagues at the University of Arkansas and the University of Arkansas System Division of Agriculture for supporting this research. The authors also acknowledge the funding provided by BA.

Literature Cited

Carvalho-Moore, P., J.K. Norsworthy, L.B. Piveta, M.C.C.R. Souza, F. Gonzalez-Torralva, S. McElroy, L.T. Barber, and T.R. Butts. 2023. Glufosinate-Resistant Palmer amaranth Accession in Arkansas: Response to Different Postemergence Herbicides and Initial Molecular Insights. International Weed Genomic Consortium Annual Meeting, Arlington, Va. Jan 29th – Jan 30th.

Heap, I. 2023. The international herbicide-resistant weed database. Accessed 15 Feb. 2023. Available at: http://roadsideweeds.com/Summary/Species.aspx

Houston, M.M., J.K. Norsworthy, T. Barber, and C. Brabham. 2019. Field evaluation of preemergence and postemergence herbicides for control of protoporphyrinogen oxidase-resistant Palmer amaranth (*Amaranthus palmeri* S. Watson). Weed Technol. 33:610-615.

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

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

Porri, A., M. Betz, K. Seebruck, M. Knapp, P. Johnen, M. Witschel, R. Aponte, R. Liebl, P.J. Tranel, and J. Lerchl. 2023. Inhibition profile of trifludimoxazin towards PPO2 target site mutations. Pest Manage. Sci. 79:507-519.

Priess, G.L., J.K. Norsworthy, N. Godara, A. Mauromoustakos, T.R. Butts, T.L. Roberts, and T. Barber. 2022. Confirmation of glufosinate-resistant Palmer amaranth and response to other herbicides. Weed Technol. 36:368–372.

Sellers, B.A., R.J. Smeda, W.G. Johnson, J.A. Kendig, and M.R. Ellersieck. 2003. Comparative growth of six *Amaranthus* species in Missouri. Weed Sci. 51:329–333.

Shyam, C., E.A. Borgato, D.E. Peterson, J.A. Dille, and M. Jugulam. 2020. Predominance of metabolic resistance in a six-way-resistant Palmer amaranth (*Amaranthus palmeri*) population. Front. Plant Sci. 11:614618–614618.

Werle, R., A. Mobli, R.P. DeWerff, and N.J. Arneson. 2023. Evaluation of foliar-applied postemergence corn–soybean herbicides on giant ragweed and waterhemp control in Wisconsin. Agrosyst., Geosci. Environ. 6:e20338.

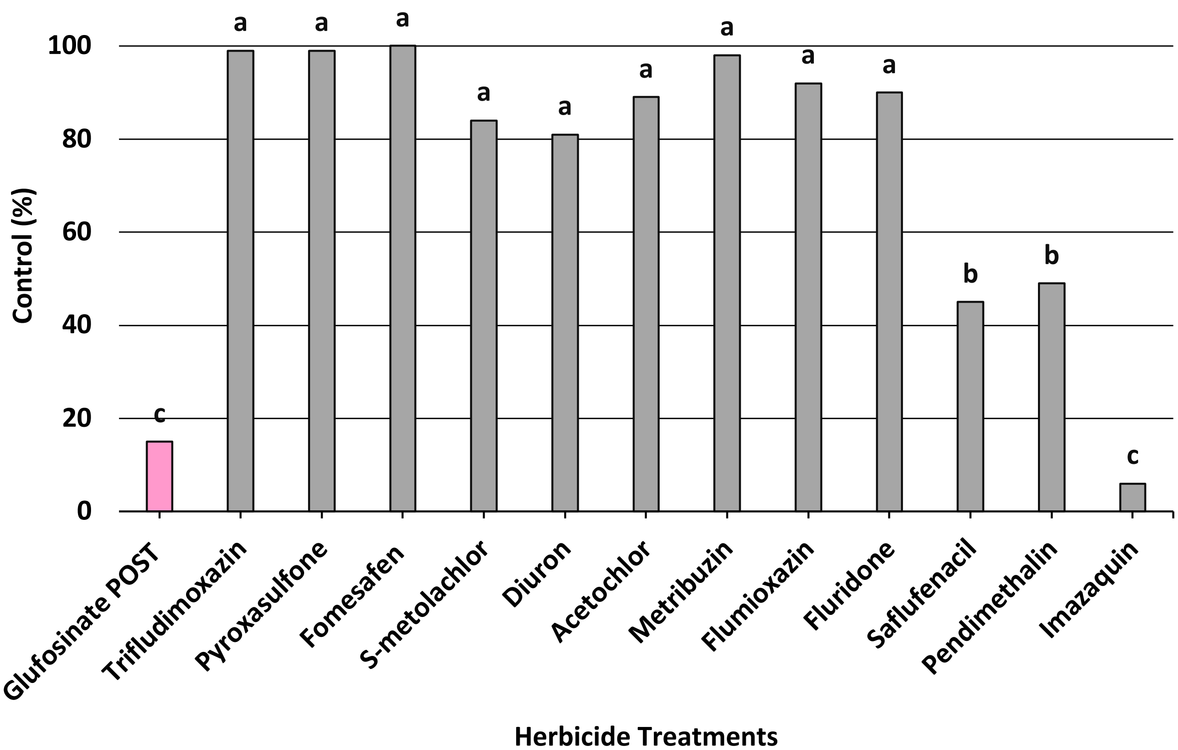

Fig. 1. Palmer amaranth visual control (%) at six weeks after preemergence treatments. Glufosinate treatment (pink bar) was applied postemergence (POST). Treatments with the same lowercase letter are not different according to Fisher’s protected least significant difference at α = 0.05.

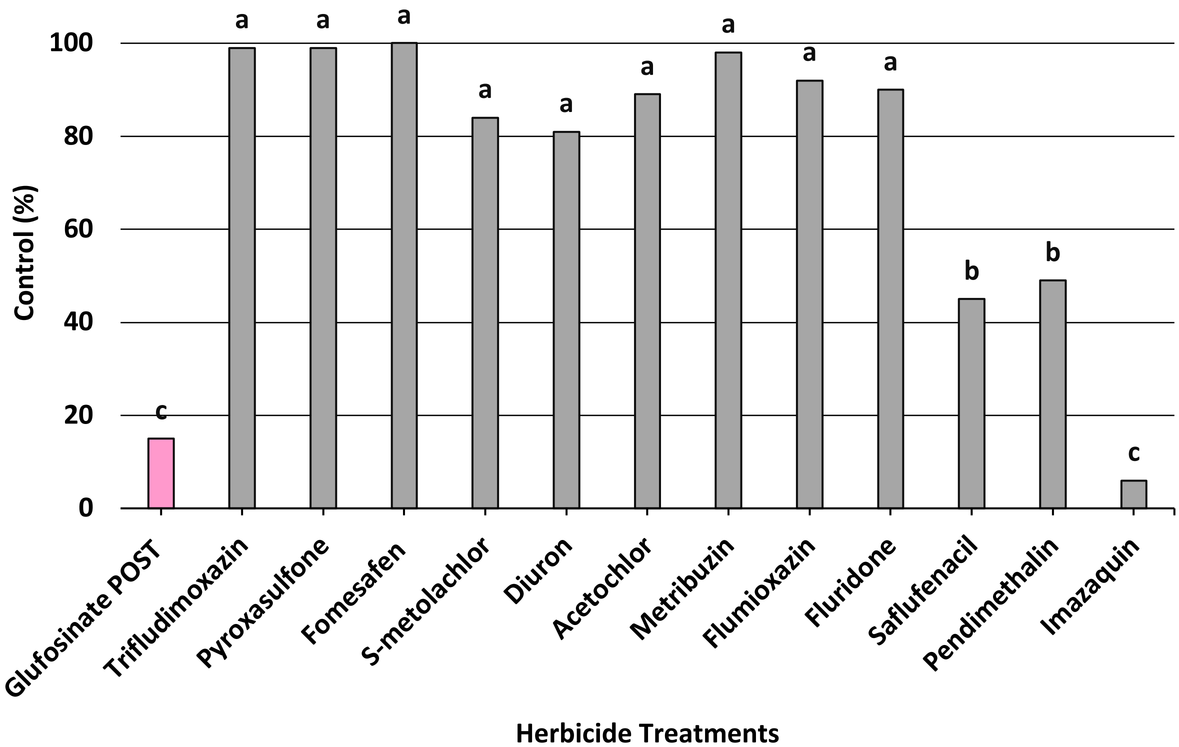

Fig. 2. Palmer amaranth biomass reduction (%) at six weeks after preemergence treatments. Glufosinate treatment (pink bar) was applied at postemergence (POST). Treatments with the same lowercase letter are not different according to Fisher's protected least significant difference at $\alpha = 0.05$.

Evaluation of Residual Palmer Amaranth Control with Soil-Applied Herbicides in a Dryland System

M.C. Castner,[1] J.K. Norsworthy,[1] and L.T. Barber[2]

Abstract

One of the best management practices for reducing postemergence selection for Palmer amaranth [*Amaranthus palmeri* (S.) Wats.] is the use of soil-applied herbicides. To evaluate the incidence of activating rainfall on residual herbicide activity and performance with single preemergence applications of Alite 27®, Dual Magnum®, Valor®, XtendiMax®, and Zidua®), five bare ground experiments were conducted in 2021 and 2022 in Fayetteville, Ark. Treatments were arranged as a single-factor (herbicide) randomized complete block design with four replications. In addition to visible weed control evaluations, a WatchDog® weather station was placed in the field to monitor rainfall for each 28-day experiment. For most of the evaluated herbicides, a delayed activating rainfall reduced initial weed control over instances where immediate (within a few days) activation occurred. At 14 days after treatment (DAT), without adjusting for rainfall, box and whisker plots indicate that 3 out of 5 herbicides have minimal variation with comparable levels of Palmer amaranth control (above 85%). Greater variation in control was observed with Alite 27 and XtendiMax, with data points as low as 50 and 40%, respectively. Trends in the results at 28 DAT were similar to 14 DAT; however, variation in control began to increase for all herbicides, which indicated that the environment influenced the residual activity over time. Overall, rainfall soon after an XtendiMax application reduced performance, unlike the other herbicides evaluated. For most soil-applied herbicides, choosing the appropriate herbicide and timeliness of an activating irrigation event is imperative to optimize weed control.

Introduction

Palmer amaranth [*Amaranthus palmeri* (S.) Wats.] has been regarded as one of the most troublesome weeds for Midsouth row crop producers for almost two decades, primarily due to its tendency to evolve resistance to herbicides. One of the best management practices for mitigating postemergence selection pressure for weed resistance is utilizing residual herbicides at planting and overlapping throughout the growing season to prevent continuous emergence (Norsworthy et al., 2012). Generally, soil-applied herbicides require an activating rainfall or irrigation event of 0.5 in. close to the time of application to become plant-available, and performance may decline from delayed incorporation (Anonymous, 2022). In dryland systems, rainfall events cannot be regulated, and it is crucial to be mindful of the chemical nature of the herbicide applied and how its efficacy can fluctuate depending on rainfall, soil texture, and soil pH.

Procedures

To evaluate the incidence of activating rainfall on residual herbicide activity and performance with single preemergence applications of Alite 27® at 3 fl oz/ac, Dual Magnum® at 24 fl oz/ac, Valor® at 2.5 oz/ac, XtendiMax® 22 fl oz/ac, and Zidua® at 2.5 oz/ac, five sequential bare ground experiments were conducted in 2021 and 2022, in Fayetteville, Ark., over a range of various environmental conditions. Treatments were arranged as a single-factor (herbicide) randomized complete block design with four replications, each plot measuring 20 by 6 ft. All treatments were applied to freshly tilled silt loam soil with a four-nozzle boom calibrated to 15 GPA and fitted with AIXR110015 nozzles. Palmer amaranth was visibly assessed on a scale of 0 (no control) to 100% (no weeds present) at 7, 14, 21, and 28 days after treatment (DAT). Following assessments at 28 DAT, the experiment was terminated and repeated in a different area until the fifth run was completed for each site year. In addition to visible weed control evaluations, a WatchDog® weather station was placed in the field to monitor rainfall for each 28-day experiment.

Visible weed control data were pooled over the ten site years and subjected to analysis of variance for the 14 and 28 DAT evaluations. Mean separation and box and whisker plots were used to show the variation of each herbicide treatment ($\alpha = 0.05$). In addition to mean separation, analysis of covariance was used to determine the effect of a delayed activating rainfall on Palmer amaranth control with days until 0.5 in. activation serving as the covariate. For analysis of covariance, data were pooled over the ten site years from all visible assessments (7 to 28 days after treatment) for each herbicide and evaluated for the interaction of activating rainfall and Palmer amaranth control ($\alpha = 0.05$).

[1] Graduate Assistant and Distinguished Professor, Department of Crop, Soil, and Environmental Sciences, Fayetteville.
[2] Professor, Cooperative Extension Service, Lonoke.

Results and Discussion

Except XtendiMax (dicamba), a delayed activating rainfall reduced initial weed control over instances where immediate (0 to 3 days) activation occurred (Fig. 1). Without adjusting for rainfall, at 14 days after treatment (DAT), box and whisker plots indicated that 3 out of 5 herbicides have minimal variation and have comparable Palmer amaranth control levels above 85% (Fig. 2). Greater variation in control was observed with Alite 27 and XtendiMax, with data points as low as 50% and 40%, respectively. The 60 percentage point variability in control of Palmer amaranth with XtendiMax is not surprising because it is primarily recommended as a postemergence herbicide; however, dicamba can provide residual activity under dry conditions and be utilized preemergence in dryland fields if an activating rainfall is expected to be delayed (Norsworthy et al., 2009; Underwood et al., 2017).

Trends in the results at 28 DAT (Fig. 3) were similar to 14 DAT; however, variation in control increased over time for all herbicides, which indicated the environment influenced residual activity over time. At both the 14 and 28 DAT evaluation timings, Dual Magnum, Valor, and Zidua provided more consistent control across the ten differing environments. Rainfall immediately following an XtendiMax application reduced performance, unlike the other herbicides evaluated that were more effective with timely rainfall (Fig. 1). When residual activity begins to decline in a commercial setting (approximately 21 to 28 DAT), mixing a soil-applied herbicide in a postemergence application is recommended to prevent continuous weed emergence. For most soil-applied herbicides, choosing the appropriate herbicide and timeliness of an activating irrigation event is imperative to optimize weed control and preserve current crop technologies.

Practical Applications

Not all herbicides share similar physical and chemical properties, meaning there is often a herbicide standard for a specific crop and weed species that offers both effective and consistent performance. When selecting a residual herbicide, it is important to recognize that efficacy can depend on the inherent susceptibility of a weed to a particular herbicide or its potential behavior when exposed to a range of environmental conditions. Additionally, sequentially applying residual herbicides throughout the growing season to prevent weed emergence is equally important as selecting the most effective herbicide to avoid an overreliance on future herbicide-resistance traits.

Acknowledgments

The authors would like to thank the University of Arkansas System Division of Agriculture, the United Soybean Board, and the Milo J. Shult Agricultural Research and Extension Center for funding and support in conducting this research.

Literature Cited

Anonymous. 2022. Zidua product label. BASF Corporation. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/ Accessed 27 February 2022. Available at: https://www.cdms.net/ldat/ldE0R027.pdf

Norsworthy J.K., M. McClelland, and G.M. Griffith. 2009. Cronquist response to pre-plant application of residual herbicides in cotton (*Gossypium hirsutum* L.). J Crop Prot 28:62-67.

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

Underwood M.G., N. Soltani, D.C. Hooker, D.E. Robinson, J.P. Vink, C.J. Swanton, P.H. Sikkema. 2017. Benefit of tank mixing dicamba with glyphosate applied after emergence for weed control in dicamba- and glyphosate-resistant soybean. Can. J. Plant Sci. 97:891-901.

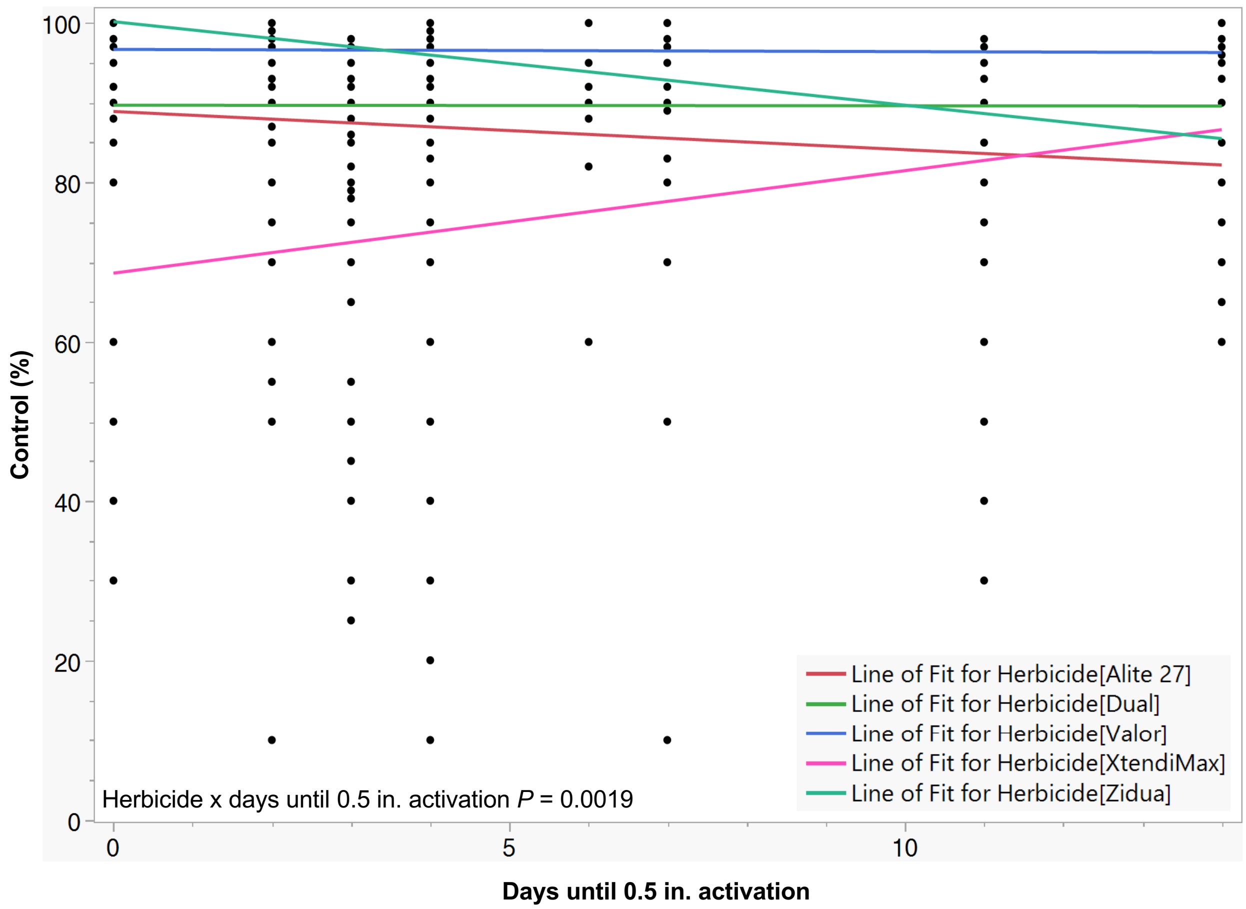

Fig. 1. Analysis of covariance with days until 0.5 in of rainfall serving as the covariate for each herbicide treatment. All data from the 10 site-years combined from 2021 and 2022 in Fayetteville, Ark., were pooled over each visible assessment and for each herbicide at 7, 14, 21, and 28 days after treatment and evaluated for the interaction of activating rainfall and Palmer amaranth control. A significant *P*-value indicates that not all slopes are equal (α = 0.05). Abbreviations: Dual = Dual Magnum.

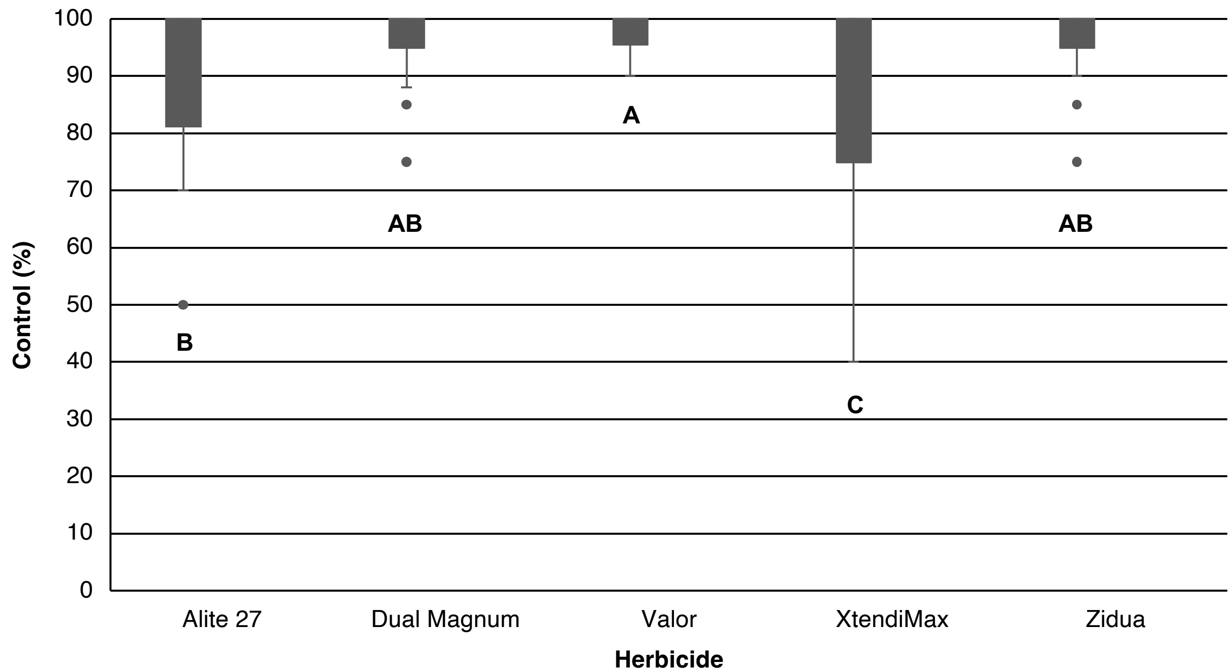

Fig. 2. Residual Palmer amaranth control at 14 days after treatment, averaged over 10 site-years from 2021 and 2022, in Fayetteville, Ark. Means followed by the same letter are not significantly different (α = 0.05).

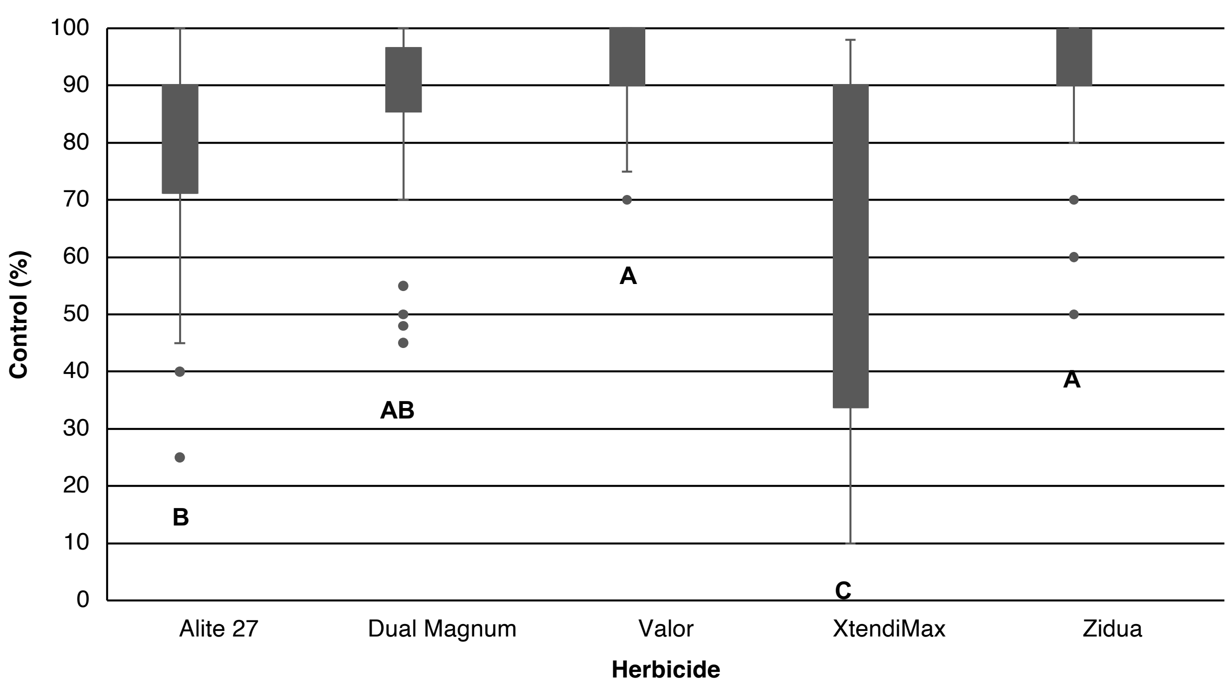

Fig. 3. Residual Palmer amaranth control at 28 days after treatment, averaged over 10 site-years from 2021 and 2022, in Fayetteville, Ark. Means followed by the same letter are not significantly different (α = 0.05).

Effects of Water Quality on Insecticide Performance for the Control of Tarnished Plant Bug, *Lygus lineolaris*, in Cotton

T. Davis,[1] G.M. Lorenz,[2] B.C. Thrash,[2] N.R. Bateman,[3] M. Mann,[2] W. A. Plummer,[2] S.G. Felts,[3] T. Ibbotson,[2] C.A. Floyd,[1] C. Rice,[1] T. Newkirk,[1] A. Whitfield,[1] and Z. Murray[1]

Abstract

Insecticide efficacy often varies by location and year. Many factors can influence an insecticide's efficacy, but an often-overlooked factor is the quality of water in a carrier solution. Multiple experiments were conducted to evaluate the impact of water quality on insecticide efficacy. In the first experiment, leaf dip assays were conducted with Transform, Orthene, Bidrin, and Centric, each mixed in three waters with hardness levels of 10.9, 178, and 430 ppm. Transform, Orthene, Bidrin, and Centric were also mixed in three waters having pHs of 6.47, 8.03, or 9.27, with an untreated check. Adult plant bugs were placed on a one-half-inch leaf disc after drying, and mortality was observed at 48 hours. In the second experiment, Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were each mixed in three waters with hardness levels of 10.9, 178, and 430 ppm, then applied to cotton for tarnished plant bug control. In the third experiment, Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were each mixed in three waters with pHs of 6.47, 8.03, and 9.27, then applied to cotton and evaluated for tarnished plant bug control. In the fourth experiment, Bidrin was mixed with waters with a pH of 6.4 and 9.1. AMS, Quest, Smoke, Diversify, and an experimental compound were each added to water with a pH of 9.1 prior to the addition of Bidrin, then applied to cotton. In the fifth experiment, Bidrin was mixed with water having a hardness of 10.9 ppm (soft water) or 430 ppm (hard water). AMS, Quest, Smoke, Diversify, and an experimental compound were each added to water with a hardness of 430 ppm, Bidrin was then added, and the solutions were then applied to cotton. No differences in treatments were present in the first, second, or third experiments. In the fourth experiment, the experimental compound and Quest provided better control than Smoke at 4 days after treatment (DAT). At 7 DAT, Smoke continued to provide the poorest control. In the fifth experiment, there were no differences at 3 DAT, but at 7 DAT, Diversify provided better control than the soft water.

Introduction

Most insecticides used in agriculture are required to be dissolved or suspended in water (Schilder, 2008). A spray solution is often 95% or more water (Whitford et al., 2009). Water is commonly seen as a clean input, and its quality is commonly overlooked. Measures of water quality consist of hardness and pH. Water hardness is the amount of dissolved calcium and magnesium in water (Whitford et al., 2009). Spray solutions containing hard water have the potential to cause antagonism. This may reduce the degree or speed of the activity of pesticides or reduce active ingredient uptake. Water hardness in the mid-South ranges from very soft to very hard. The pH of water is how acidic or alkaline the solution is. Water at various ranges of pH in a spray solution may affect how long the molecule in the pesticide stays intact (Schilder, 2008). Most pesticides perform best in slightly acidic water. The objective of this study is to evaluate the impacts of water hardness and pH on insecticide efficacy for the control of tarnished plant bug in cotton.

Procedures

Waters of varying quality that were used in these trials were made in the lab. In the water hardness trials, the soft water was filtered water from the greenhouse and had a hardness of 10.9 ppm. To increase the hardness, soft water was mixed in a 7-gallon Aqua-Tainer with magnesium chloride until the hardness was above 500 ppm. Approximately one-third of the solution was then poured into another Aqua-Tainer, and soft water was added until it reached the desired hardness. Varying pH water was made in a similar way. The same dilution method was used, but to raise the pH, sodium hydroxide was used.

Experiment 1–Cotton Leaf Dip Assay. Assay was conducted with Transform, Orthene, Centric, and Bidrin at the

[1] Graduate Assistants, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Distinguished Professor/Extension Entomologist, Assistant Professor/Extension Entomologist, Program Associate, Program Associate, and Program Associate, respectively, Department of Entomology and Plant Pathology, Lonoke.
[3] Assistant Professor/Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Stuttgart.

University of Arkansas System Division of Agriculture's Lonoke Research and Extension Center. The assays consisted of 25 treatments, including the untreated check. Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were each mixed in three waters having hardness of 10.9, 178, and 430 ppm. Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were also mixed in three waters having pH of 6.47, 8.03, and 9.27. Leaf discs with a diameter of one-half inch were dipped in each treatment, the leaves allowed to dry, then placed in 100-mm Petri dishes with a damp cotton pad and a tarnished plant bug adult. The adults were observed at 24 and 48 hours for mortality.

All field experiments were conducted in Marianna, Ark., at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station. Plot size was 12.5 ft. (4 rows) by 40 ft. Trials were arranged as randomized complete blocks with 4 replications. All treatments were mixed and allowed to sit for 3 hours prior to application. Applications were made using a Bowman Mudmaster at 10 gpa using a TXVS-6 hollow cone nozzle. Plots were sampled at 3 and 7 days after applications. Plots were sampled using a 2.5-ft shake sheet with two samples per plot for a total of 10 row ft. Tarnished plant bug nymphs and adults were counted. Data were analyzed using JMP 9.4.

Experiment 2–Water Hardness Field Test. Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were each mixed in three waters having hardness levels of 10.9, 178, and 430 ppm for a total of 13 treatments, including an untreated check. This test was conducted three times.

Experiment 3–Water pH Field Test. Transform 1.5 oz/ac, Orthene 0.75 lb/ac, Bidrin 8 oz/ac, and Centric 2 oz/ac were each mixed in three waters with pHs of 6.47, 8.03, and 9.27 for a total of 13 treatments, including an untreated check. This test was conducted three times.

Experiment 4–Water Conditioner pH Field Test. Bidrin was mixed with water with a pH of 6.47 and 9.27. The surfactants AMS, Quest, Smoke, Diversify, and experimental were mixed into water with a pH of 9.27 then Bidrin was added for a total of 8 treatments, including an untreated check. This test was conducted two times.

Experiment 5–Water Conditioner Hardness Field Test. Bidrin was mixed with water with hardness levels of 10.9 and 430 ppm. The surfactants AMS, Quest, Smoke, Diversify, and an experimental compound were mixed into water with a hardness of 430 ppm then Bidrin was added for a total of 8 treatments including an untreated check. This test was conducted two times.

Results and Discussion

In the cotton leaf dip assays, Acephate had a negative correlation to very hard water, $P < 0.01$. All other treatments had no differences (Fig. 1). There were no differences in mortality for any treatment as water pH increased (Fig. 2). In the water hardness field trial, there were no differences in percent control among the treatments at 4 or 7 days after treatments (Figs. 3 and 4). In the pH trial, there were no differences among the treatments 4 or 7 days after treatment (Figs. 5 and 6). In the water conditioner pH trial, the experimental HM1895 and Quest showed better control than Smoke at 3 days after treatment (Fig. 7). At 7 days after treatment, all treatments other than High pH provided greater control than Smoke (Fig. 8). In the water conditioner hardness trial, there were no differences among treatments at 3 days after treatment (Fig. 9). At 7 days after treatment, Diversify had better control than the soft water (Fig. 10).

Practical Applications

Water quality is commonly overlooked by many growers. Research shows that some pesticide's efficacy is affected by water hardness and pH. This study showed no differences in control of Transform, Bidrin, and Centric when mixed with a range of water hardness and a range of pHs. Acephate had a negative correlation in the lab but not in the field. The results from this study and future research will help make recommendations to growers on how to handle water quality and water conditioners in a spray solution to improve insect control in cotton.

Acknowledgments

We would like to thank the Cotton State Support Committee, Cotton Incorporated, Helena Agri Enterprises, and the University of Arkansas System Division of Agriculture for their support and funding for this project.

Literature Cited

Schilder, Annemiek. Effect of Water pH on the Stability of Pesticides. MSU Extension, 2 Oct. 2018. https://www.canr.msu.edu/news/effect_of_water_ph_on_the_stability_of_pesticides

Whitford, F., D. Penner, B. Johnson, L. Bledsoe, N. Wagoner, J. Garr, K. Wise, J. Obermeyer, and A. Blessing. 2009. The Impact of Water Quality on Pesticide Performance. Purdue Extension, Nov. 2009. https://www.extension.purdue.edu/extmedia/ppp/ppp-86.pdf

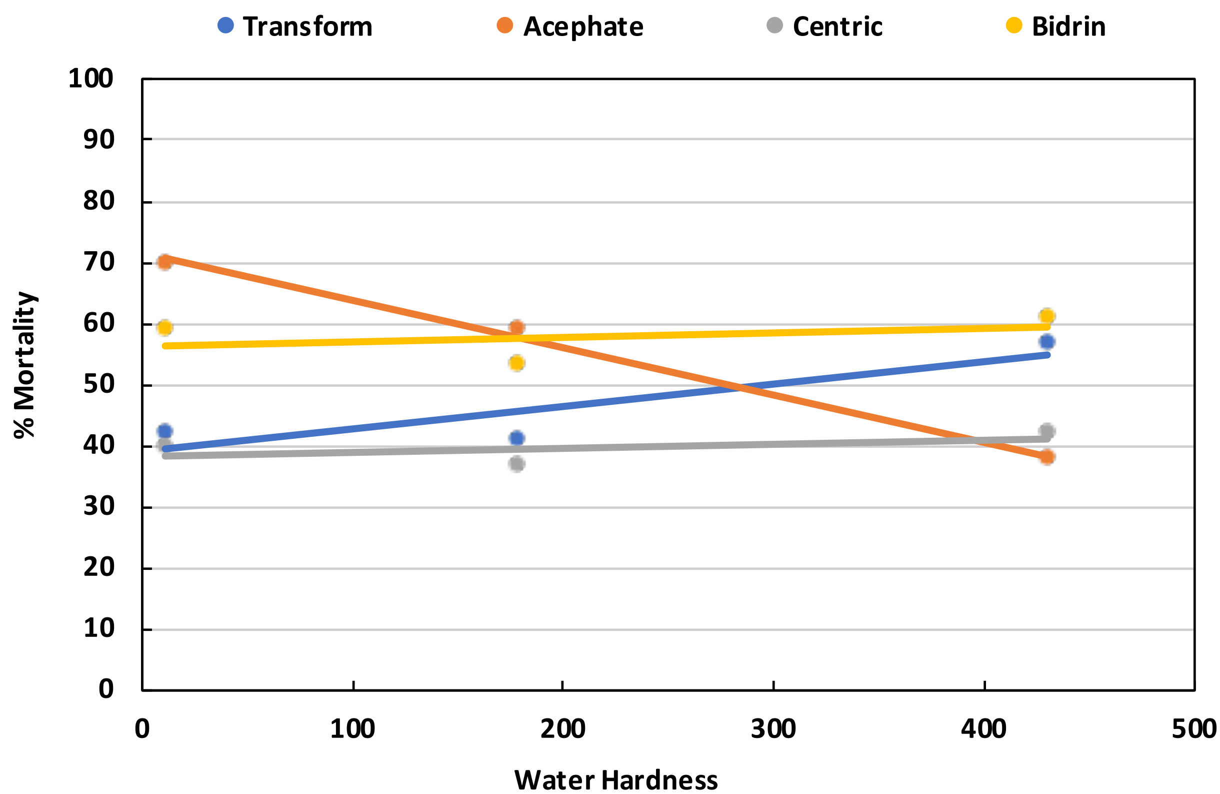

Fig. 1. Percent mortality for the effects of water hardness on insecticide efficacy for tarnished plant bug 48 hours after treatment in the water hardness leaf dip assay.

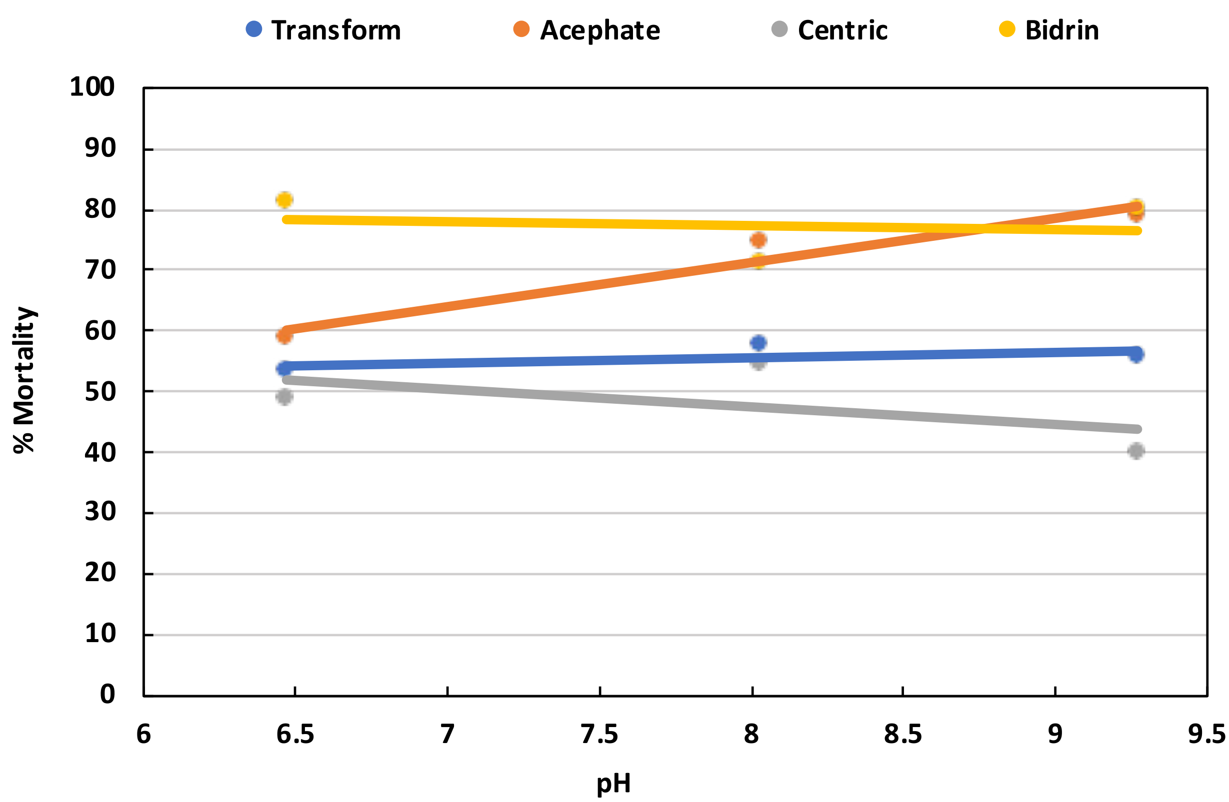

Fig. 2. Percent mortality for the effects of water pH on insecticide efficacy for tarnished plant bug 48 hours after treatment in the water pH leaf dip assay.

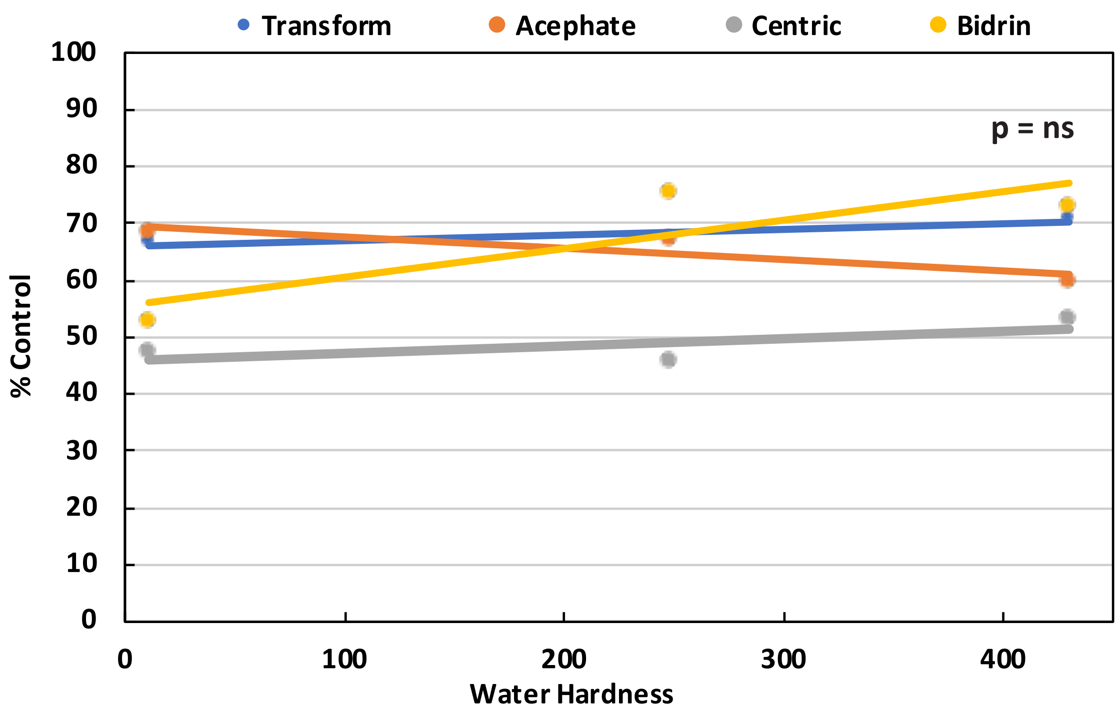

Fig. 3. Percent control for the effects of water hardness on cotton insecticides for the control of tarnished plant bugs 4 days after application in the water hardness field trial.

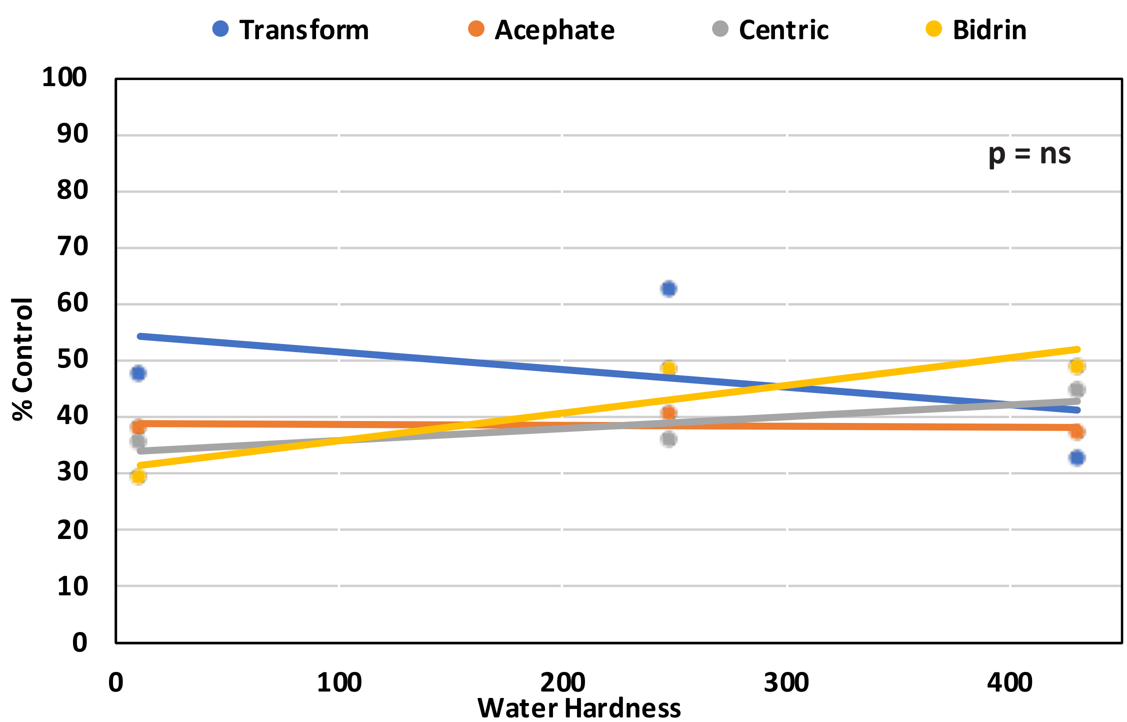

Fig. 4. Percent control for the effects of water hardness on cotton insecticides for the control of tarnished plant bugs 7 days after application in the water hardness field trial.

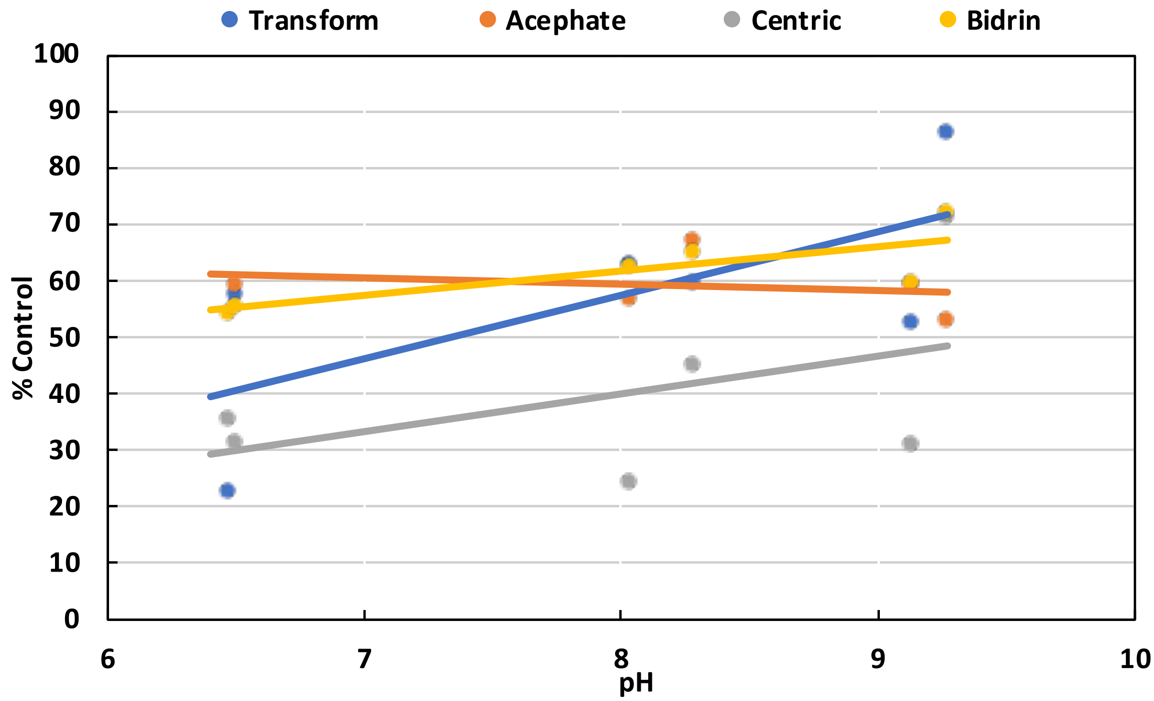

Fig. 5. Percent control for the effects of water pH on cotton insecticides for the control of tarnished plant bugs 4 days after application in the pH field trial.

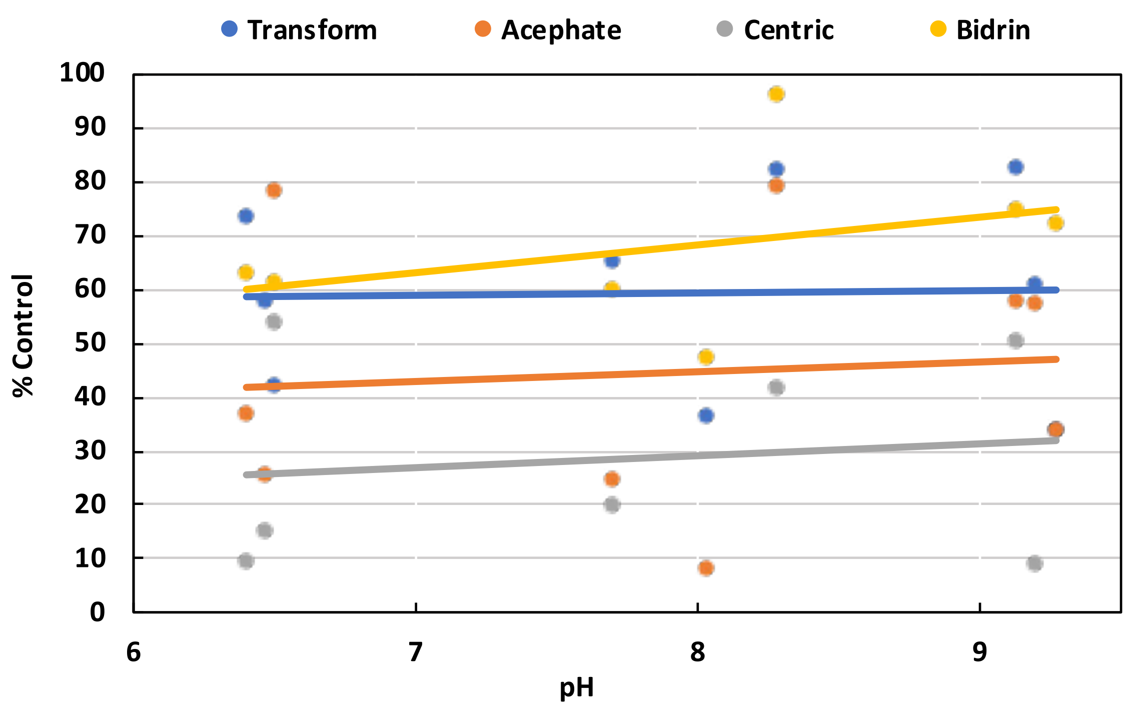

Fig. 6. Percent control for the effects of water pH on cotton insecticides for the control of tarnished plant bugs 7 days after application in the water pH field trial.

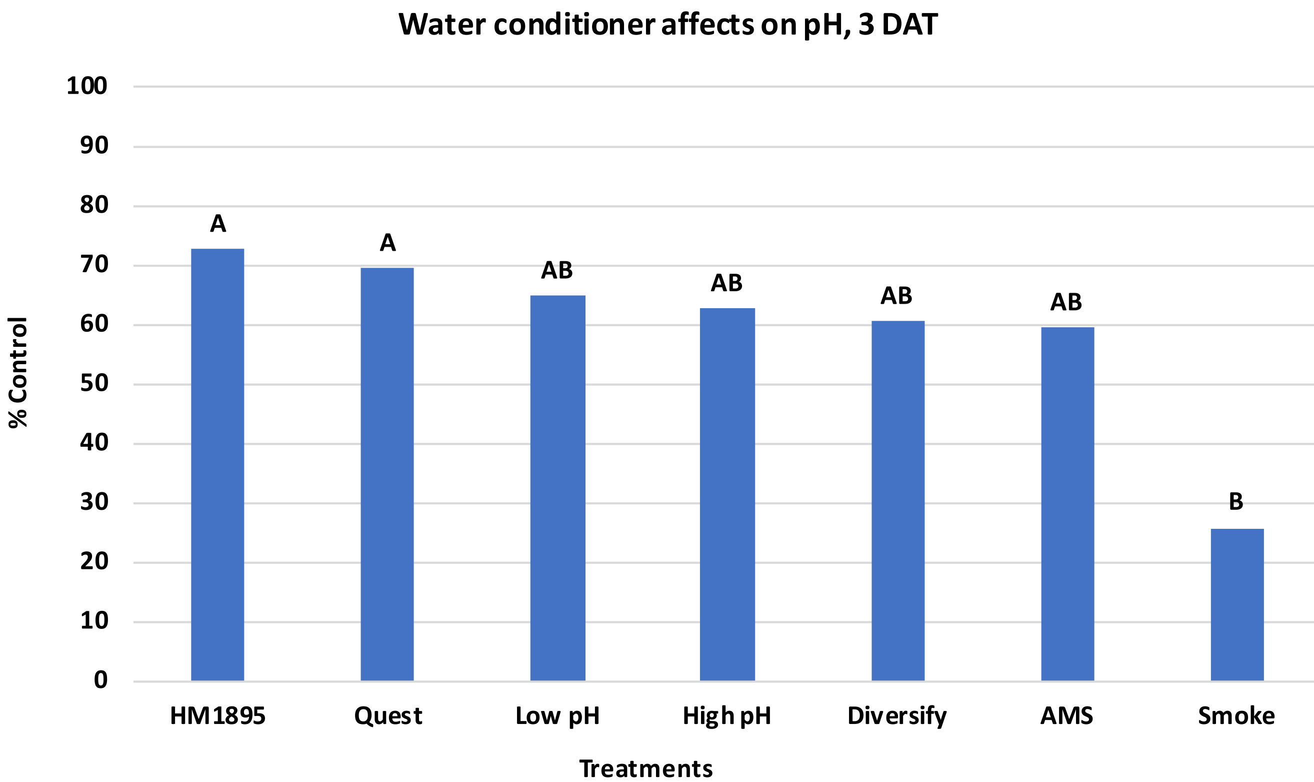

Fig. 7. Percent control of surfactants for cotton insecticides for the control of tarnished plant bugs 3 days after application in the water conditioner pH trial.

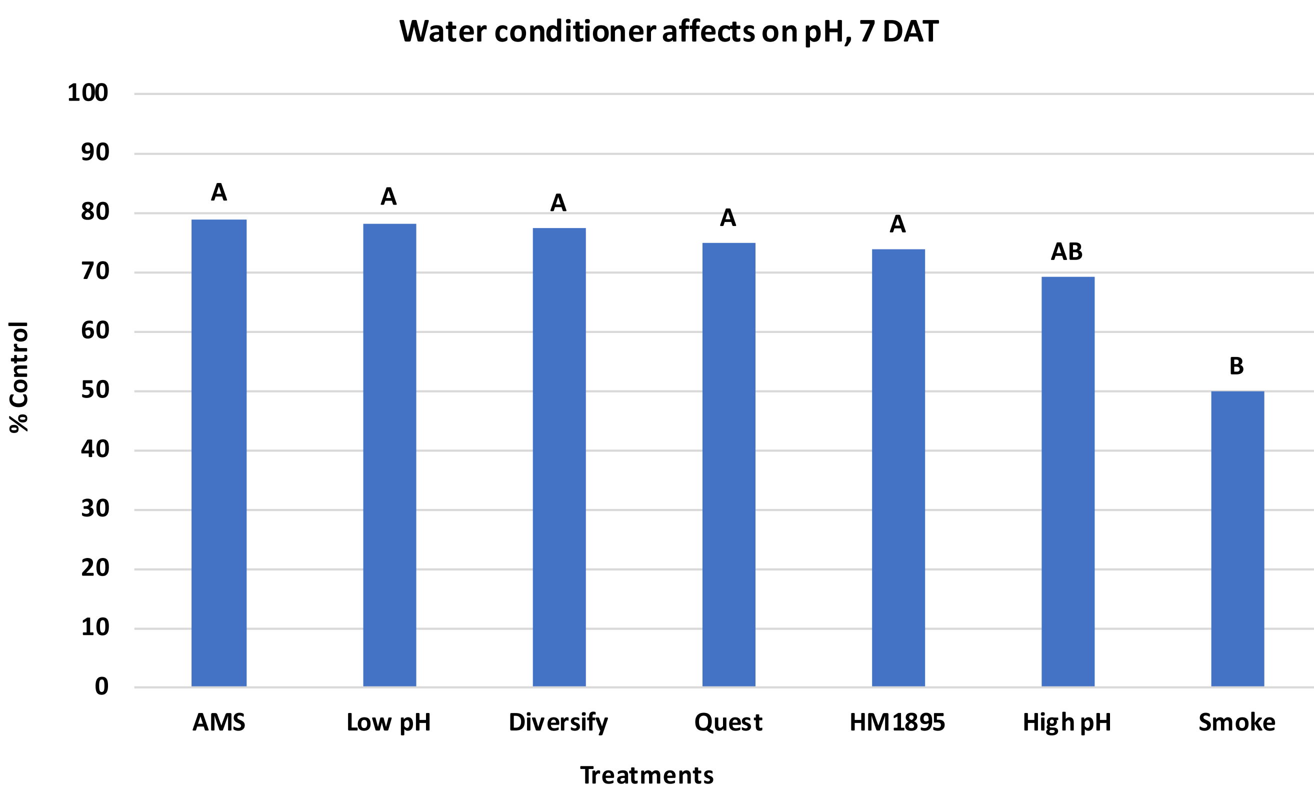

Fig. 8. Percent control of surfactants for cotton insecticides for the control of tarnished plant bugs 7 days after application in the water conditioner pH trial.

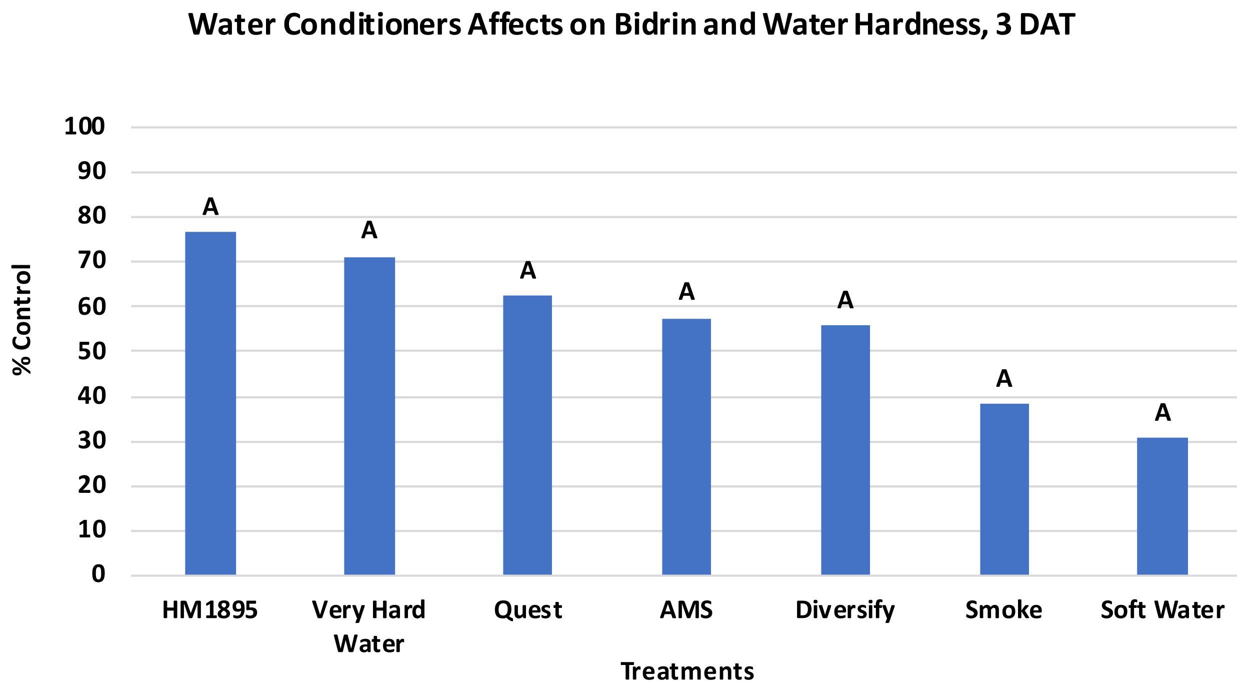

Fig. 9. Percent control of surfactants for cotton insecticides for the control of tarnished plant bugs 3 days after application in the water conditioner hardness trial.

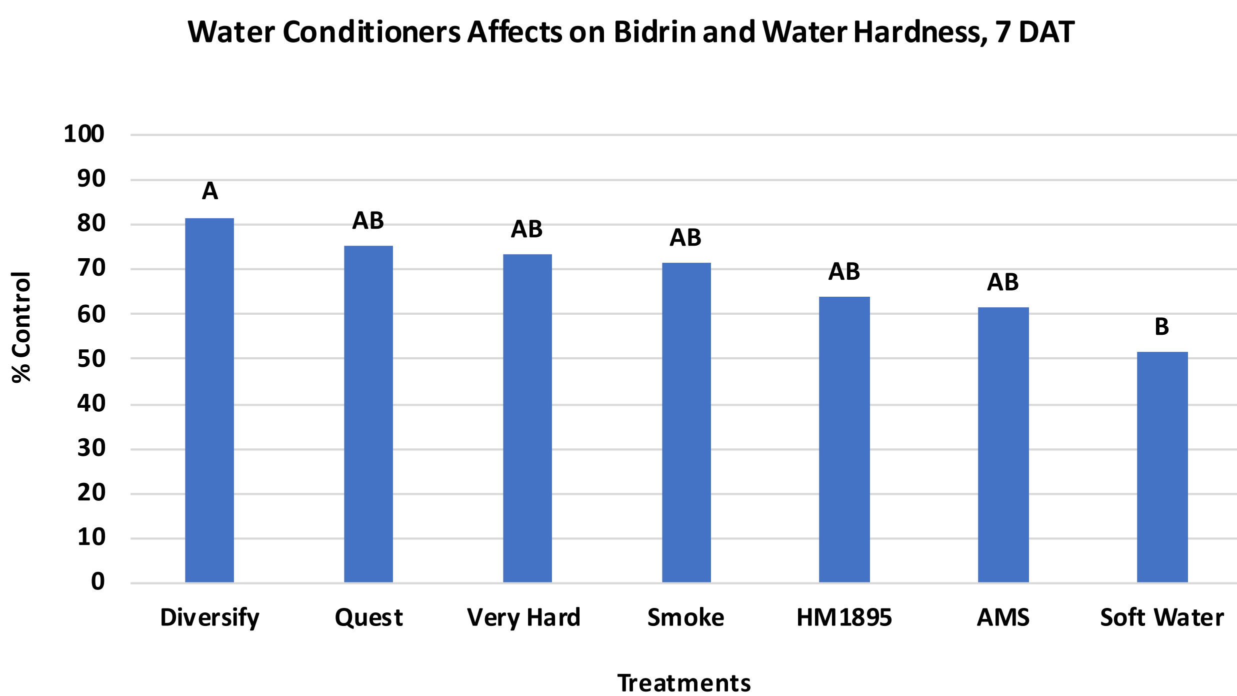

Fig. 10. Percent control of surfactants for cotton insecticides for the control of tarnished plant bugs 7 days after application water conditioner hardness trial.

Evaluation of Envoke in Enlist and XtendFlex Cotton Systems

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

Abstract

Yellow nutsedge (*Cyperus esculentus*) has the capability of competing with cotton throughout the season, causing a yield reduction of 34%. Envoke gives another option in a cotton production system for controlling problematic weeds such as morningglories and yellow nutsedge. Two studies were conducted in 2022 at Tillar, Ark., in a Herbert silt loam soil with the objective of evaluating Envoke rates and tank mixtures when applied postemergence in Enlist and XtendFlex cotton systems. Trials were arranged in a randomized complete block design with four replications. Herbicides used included individual and combinations of Envoke at 0.075 and 0.125 oz/ac, Enlist One at 32 oz/ac, Engenia at 12.8 oz/ac, Roundup PowerMax 3 at 30 oz/ac, Dual Magnum at 16 oz/ac, and Warrant at 64 oz/ac. All data were analyzed using JMP Pro 17 and subjected to analysis of variance using Tukey's honestly significant difference ($\alpha = 0.05$). The higher rate of Envoke generally resulted in greater injury, especially when combined with Roundup PowerMax and either Enlist One or Engenia at 21 days after treatment (DAT) compared to the lower rate. No control of Palmer amaranth was observed by Envoke due to it being an acetolactate synthase-resistant population. Palmer amaranth control was not decreased due to the tank mixture of Envoke with either Enlist One or Engenia. The use of Envoke in a tank mixture with either Enlist One or Engenia will provide an alternative to yellow nutsedge control in both Enlist and XtendFlex systems.

Introduction

Glyphosate (group 9), protoporphyrinogen oxidase (PPO) (group 14), acetolactate synthase (ALS) (group 2), and the threat of auxin resistance in Palmer amaranth (*Amaranthus palmeri*) remains a major concern for cotton growers in Arkansas, due to reduced control options. Yellow nutsedge (*Cyperus esculentus*) populations are increasing to alarming levels in many cotton-producing areas. Herbicide programs that utilize multiple modes of action applied timely are essential in controlling these troublesome weeds (Barber et al., 2022). Envoke (an ALS herbicide) provides an additional mode of action to improve control of yellow nutsedge in Enlist and XtendFlex cotton systems. The majority of Palmer amaranth populations are resistant to ALS chemistry, and Envoke is not expected to provide control. However, there is a concern that Envoke may antagonize Enlist One and Engenia herbicides resulting in reduced Palmer amaranth control. Our objective in 2022 was to evaluate Enlist and XtendFlex herbicide tank-mix systems that contain Envoke for cotton injury and potential antagonism from Envoke.

Procedures

Two trials were established on a population of glyphosate and ALS-resistant Palmer amaranth at Tillar, Ark., in a Herbert silt loam soil on 19 May 2022. One trial was established to evaluate Envoke in an Enlist cotton system, while the second was established to evaluate Envoke in an XtendFlex cotton system. The cultivars planted were PHY 411 W3FE and DP 2127 B3XF. Herbicide treatments were arranged in a randomized complete block design with four replications. All applications were applied at 15 GPA to emerged weeds in 5–6 node cotton. TeeJet 11002 AIXR spray tips were used for Enlist applications, while TeeJet 11002 TTI was used for XtendFlex. Herbicide treatments included Envoke at 0.075 and 0.125 oz/ac, and combinations of these rates with Enlist One at 32 oz/ac, Engenia at 12.8 oz/ac, Roundup PowerMax 3 at 30 oz/ac, Dual Magnum at 16 oz/ac, and Warrant at 64 oz/ac (Tables 1 and 2). Visual cotton injury ratings were taken at 7 and 21 days after application, while weed control ratings of Palmer amaranth were taken at 21 days after application. Cotton was harvested, and seedcotton yield was recorded. Means were separated using Tukey's honestly significant difference at $\alpha = 0.05$.

Results and Discussion

At 7 days after postemergence application, visual cotton injury in the Enlist trial ranged from 0% to 29% (Fig. 1). Envoke at 0.125 oz/ac plus Roundup PowerMax 3 at 30 oz/ac caused 29% injury, which was the highest numerically. Enlist One at 32 oz/ac plus Roundup PowerMax 3 at 30 oz/ac

[1] Program Associate and Program Associate, Department of Crop, Soil, and Environmental Sciences, Research and Extension, Monticello.

[2] Professor, Program Associate, and Program Associate, respectively, Department of Crop, Soil, and Environmental Sciences, Research and Extension, Lonoke.

caused no cotton injury. All other Envoke mixtures caused greater than 20% injury 7 days after application. Cotton injury in the XtendFlex trial ranged from 0 to 15%. Envoke at 0.075 oz/ac plus Roundup PowerMax 3 at 30 oz/ac caused the highest injury at 15%. All other XtendFlex treatments were injury free 7 days after treatment. Envoke applied alone, and in tank mixes, caused higher injury when applied to Enlist cotton at 7 days after a 5-6 node application.

At 21 days after postemergence application, visual cotton injury was 9% or less for all treatments (Fig. 2). Postemergence herbicides in combination with Envoke at 0.125 oz/ac resulted in the highest levels of injury. All other Enlist treatments resulted in 5% or less injury. Injury in XtendFlex cotton increased up to 28% in the most injurious treatment. Envoke at 0.125 oz/ac plus Engenia at 12.8 oz/ac plus Roundup PowerMax 3 at 30 oz/ac, caused 28% injury, which was the highest in the trial. All other XtendFlex treatments containing 0.075 oz/ac Envoke caused 5% or less injury 21 days after treatment.

At 21 days after application, Palmer amaranth control ranged from 0 to 97% in both the Enlist and XtendFlex systems (Fig. 3). Palmer amaranth control was not attained by Envoke alone in either study. Enlist One and Engenia are needed, in the respective systems, for Palmer amaranth control. Antagonism was not noted in any system, regardless of the Envoke rate. Acceptable Palmer amaranth control was attained when systems with multiple modes of action were used.

There were no significant seedcotton yield differences between any Enlist or XtendFlex treatments (data not shown). The highest numerical Enlist cotton yields were 3998 lb/ac seed cotton provided by Envoke at 0.125 oz/ac plus Roundup PowerMax 3 at 30 oz/ac and 3911 lb/ac provided by Envoke at 0.125 oz/ac plus Enlist One at 32 oz/ac plus Roundup PowerMax 3 at 30 oz/ac. In the XtendFlex system, Envoke at 0.125 oz/ac plus Engenia at 12.8 oz/ac plus Roundup PowerMax 3 at 30 oz/ac produced 4366 lb/ac seedcotton, while Envoke at 0.075 oz/ac plus Roundup PowerMax 3 at 30 oz/ac produced 4147 lb/ac.

Practical Applications

The data collected from these trials do support Envoke as a tank-mix partner in an Enlist or XtendFlex cotton system. Weed control systems that contain multiple modes of action are the best option for complete control of multiple weed species. Application of Envoke alone at 0.075 or 0.125 oz/ac did not provide adequate control of Palmer amaranth at Tillar.

Acknowledgments

We would like to thank the University of Arkansas System Division of Agriculture's Research and Extension for support in this research endeavor.

Literature Cited

Barber, L.T., T.R. Butts, J.W. Boyd, H.E. Wright Smith, K. Cunnigham, G. Selden, J.K. Norsworthy, N. Burggos, and M. Bertucci. 2022. Recommended chemicals for weed and brush control. MP44 2023. University of Arkansas System Division of Agriculture, Cooperative Extension Service, Little Rock.

Table 1. 2022 post-emergent herbicide treatments in the Enlist trial.

Treatment	Herbicide	Rate in oz product/ac
1	Envoke 1	0.075
2	Envoke 2	0.125
3	Envoke 1	0.075
	Roundup PowerMax 3	30
4	Envoke 2	0.125
	Roundup PowerMax 3	30
5	Enlist One	32
	Roundup PowerMax 3	30
6	Envoke 2	0.125
	Enlist One	32
	Roundup PowerMax 3	30
7	Envoke1	0.075
	Enlist One	32
	Roundup PowerMax 3	30
	Dual Magnum	16
8	Envoke1	0.075
	Enlist One	32
	Roundup PowerMax 3	30
	Warrant	64

Table 2. 2022 post-emergent herbicide treatments in the XtendFlex trial.

Treatment	Herbicide	Rate in oz product/ac
1	Envoke 1	0.075
2	Envoke 2	0.125
3	Envoke 1	0.075
	Roundup PowerMax 3	30
4	Envoke 2	0.125
	Roundup PowerMax 3	30
5	Envoke 1	0.075
	Engenia	12.8
	Roundup PowerMax 3	30
6	Envoke 2	0.125
	Engenia	12.8
	Roundup PowerMax 3	30
7	Envoke 1	0.075
	Engenia	12.8
	Roundup PowerMax 3	30
	Dual Magnum	16
8	Envoke 1	0.075
	Engenia	12.8
	Roundup PowerMax 3	30
	Warrant	64

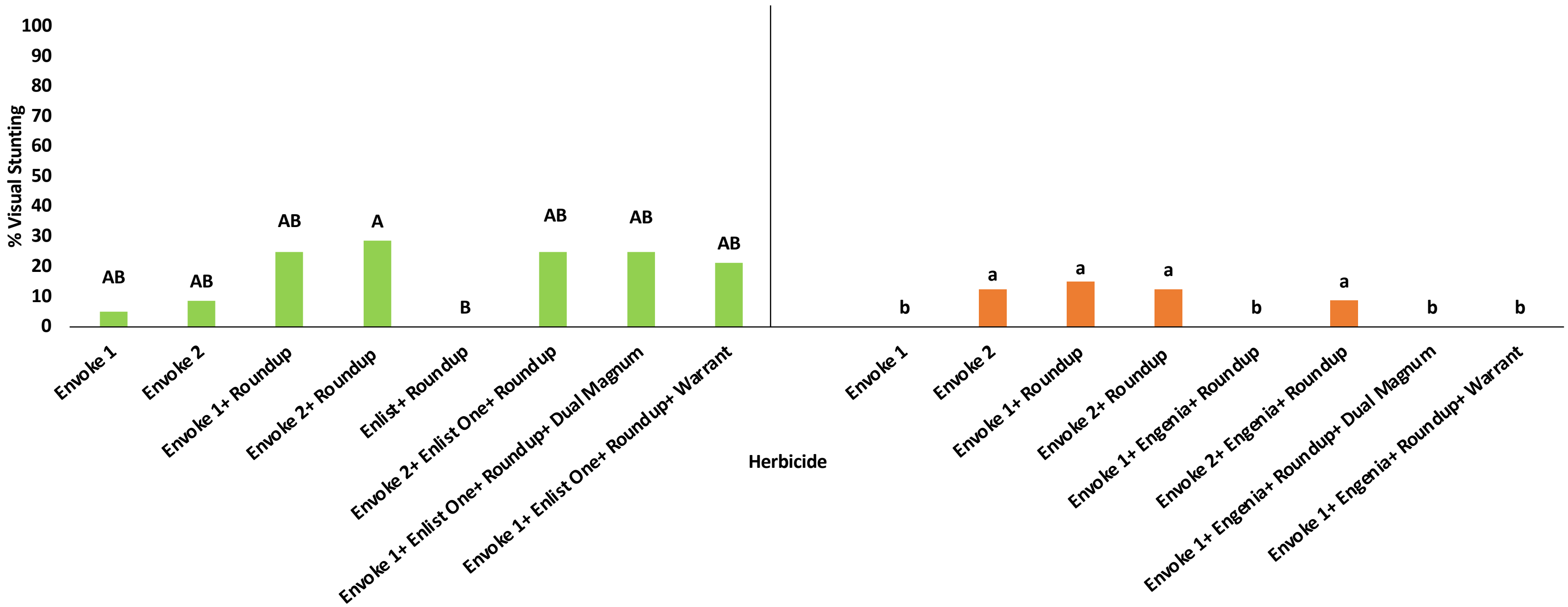

Fig. 1. Percent visual injury in Enlist (green bar) *P* = 0.0047 and XtendFlex cotton (orange bar) *P* < 0.0001, Tillar, Arkansas 2022, 7 days after postemergence application.

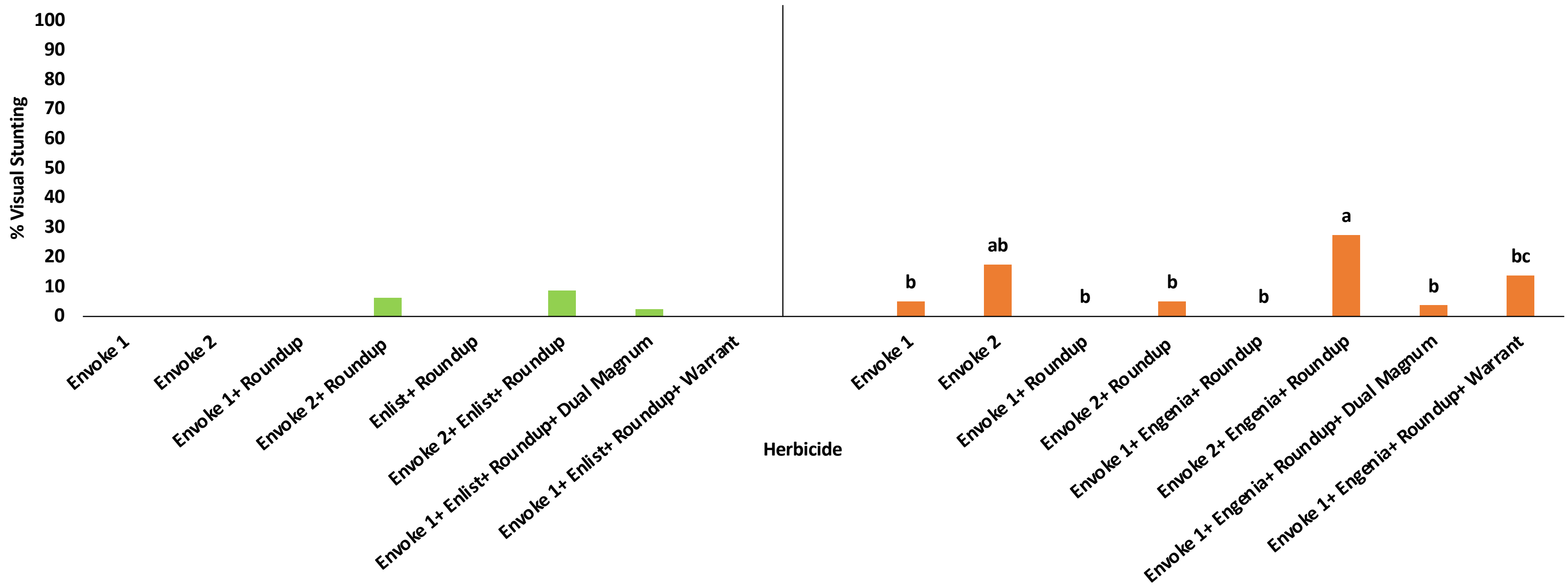

Fig. 2. Fig. 2 Percent visual injury in Enlist (green bar) P = NS and XtendFlex cotton (orange bar) *P* = 0.0013, Tillar, Arkansas 2022, 21 days after postemergence application.

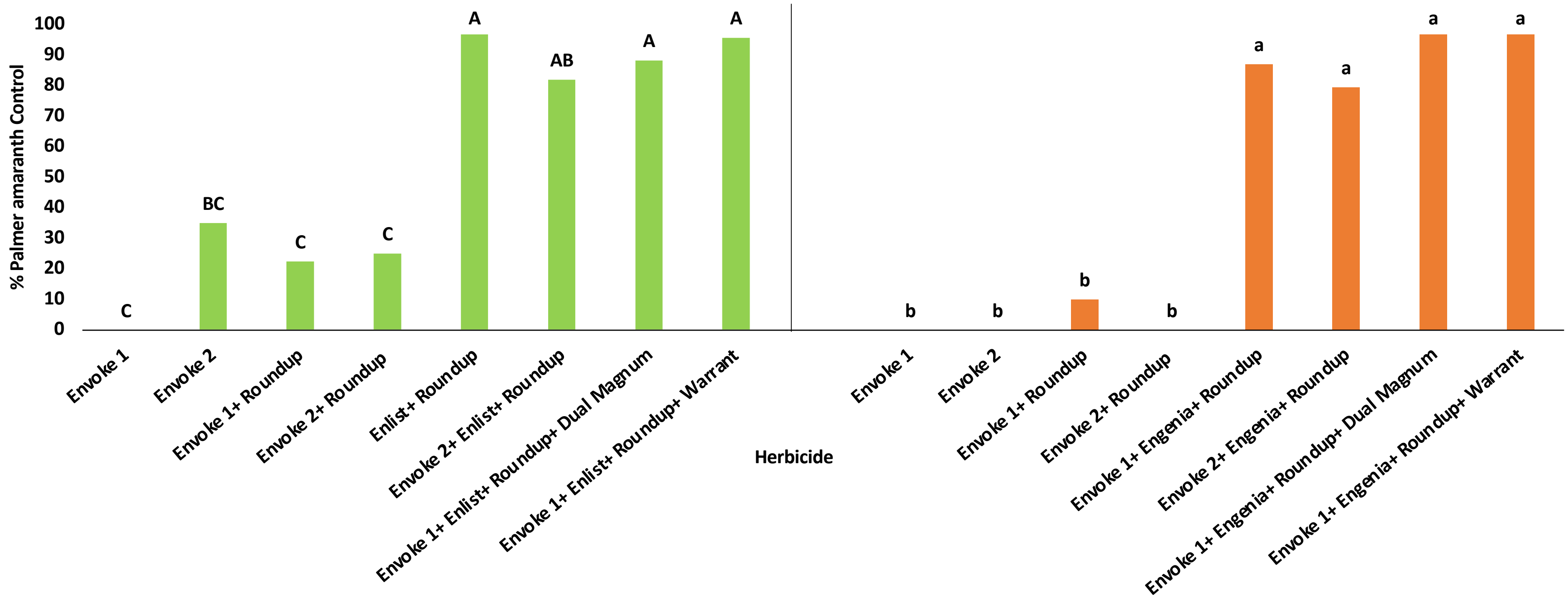

Fig. 3. Palmer amaranth control in Enlist (green bar) *P* < 0.0001 and XtendFlex cotton (orange bar) *P* < 0.0001, Tillar, Arkansas 2022, 21 days after postemergence application.

Impact of Foliar Insecticides on ThryvOn and non-ThryvOn Cotton for Control of Tarnished Plant Bug

P.G. Maris,[1] B.C. Thrash,[2] N.R. Bateman,[3] W.A. Plummer,[2] M. Mann,[2] T. Ibbotson,[2] S.G. Felts,[3] C.A. Floyd,[4] A. Whitfield,[1] Z. Murray,[1] T. Newkirk,[1] and T. Davis[1]

Abstract

Tarnished plant bug (TPB) (*Lygus lineolaris*) is the number one insect pest of cotton in Arkansas, causing square loss, deformed flowers, and damaged bolls, ultimately reducing yield. Tarnished plant bug is difficult to control, and growers average 4–6 insecticide applications per year targeting TPB. Multiple insecticides are available for control of TPB, but resistance to some modes of action has been documented in this pest. Thryvon is a new cotton biotech trait that will provide season-long protection against TPB and thrips species, reducing the need for some insecticide applications. Cotton cultivars incorporating ThryvOn express the Cry51Aa *Bt* proteins that have been proven to provide some suppression of TPB. A study was conducted during the 2022 growing season at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna to determine if the efficacy of TPB insecticides was different on ThryvOn and non-ThryvOn cotton. Insecticide treatments included bifenthrin (6.4 fl oz/ac), acephate (0.75 lb/ac), novaluron (6 fl oz/ac), sulfoxaflor (1.5 oz/ac), and thiamethoxam (2 oz/ac). Plots were sampled at 3, 7, and 11 days after the first application and 4, 7, and 11 days after the second application. A general trend was observed that insecticide efficacy was improved with all insecticides in ThryvOn cotton when compared to non-ThryvOn cotton. This same trend was observed for square retention and yield.

Introduction

Tarnished plant bug (TPB) is currently the most economically important insect pest of Arkansas cotton. TPB is a perennial pest that can go through three generations a season in cotton. TPB has hundreds of viable wild hosts. In early spring, it feeds on these hosts, increasing its numbers, prior to moving into squaring cotton. Using piecing-sucking mouthparts, TPB consumes plant nutrients from fruiting structures (Musser et al., 2009). This feeding can cause the loss of apical dominance, square shed, damaged blooms, and boll injury, all of which can lead to yield reduction. TPB is the main target of foliar-applied insecticides on cotton in the mid-southern United States (Musser et al., 2009). Cotton producers in Arkansas average four to six applications of a foliar insecticide per year to control TPB. The high cost of insecticides, and concerns about resistance development, have made control options like biotechnology traits an increasingly more popular option of control for growers (Whitfield et al., 2022).

ThryvOn cotton contains the Cry51Aa gene, which provides plant protection against TPB and thrips species. Preliminary research with ThryvOn suggests that growers will still have to make foliar applications for TPB; however, fewer applications will be needed (Arthur and Kerns, 2022). The Cry51Aa trait can be stacked with Bollgard 3 to provide protection against caterpillar pests, as well as the XtendFlex system to provide tolerance to multiple herbicides. The objective of this study was to determine if TPB insecticide efficacy was different between ThryvOn and non-ThryvOn cotton.

Procedures

A study was conducted during the 2022 growing season at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna to determine the efficacy of TPB for multiple foliar insecticides in both ThryvOn and non-ThryvOn cotton. The ThryvOn cotton cultivar was DP 2131 B3TXF, and the non-ThryvOn cultivar was DP 2038 B3XF. Six treatments were applied to ThryvOn and non-ThryvOn cotton, which included five insecticides and an untreated check (Table 1). Applications were made using a Bowman Mudmaster at 10 gpa using a cone-jet nozzle. Plots were 25 ft (8 rows on 38 in. centers) by 50 ft., and all treatments were arranged as a split block design with 4 replicate blocks.

[1] Graduate Assistants, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Assistant Professor/Extension Entomologist, Program Associate, Program Associate, and Program Associate, respectively, Department of Entomology and Plant Pathology, Lonoke.
[3] Associate Professor/Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Stuttgart.
[4] Assistant Professor/Crop Protection Specialist, Department of Plant Science and Technology Faculty, Portageville, Missouri.

After treatments were applied, plots were sampled at 3, 7, and 11 days after application (DAA). A second application was made after the 11 DAA sampling, and plots were resampled 4, 7, and 11 days after the second application (DAA2). Yield was recorded using a plot picker equipped with an onboard weighing system. Data were processed using Agriculture Research Manager Version 10, AOV, and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

Differences between ThryvOn and non-ThryvOn treatments were observed in TPB density and plot yield. Bifenthrin provided an average of 47% control of TPB on ThryvOn cotton compared to the -6% control on non-ThryvOn cotton (Fig. 1). Negative control in this treatment may be attributed to the elimination of beneficial insects that are commonly associated with pyrethroid insecticides like bifenthrin. Across all sampling dates, acephate provided 62% average TPB control on ThryvOn cotton, compared to non-ThryvOn cotton, where it only provided 35% control (Fig. 2). Diamond provided 65% average control across all sample dates when applied to ThryvOn cotton compared to an average of 51% control in non-ThryvOn cotton (Fig. 3). Transform provided average of 74% control in ThryvOn cotton across all sample dates compared to an average of 55% control in non-ThryvOn cotton (Fig. 4). Centric provided an average of 43% control in ThryvOn cotton compared to 25% in non-ThryvOn cotton (Fig. 5). ThryvOn cotton yielded significantly greater than non-ThryvOn cotton within each insecticide treatment except for Diamond (Fig. 6). There were no yield differences across insecticide treatments in ThryvOon cotton. Across all non-ThryvOn cotton treatments, Diamond and Transform yielded greater than all other chemical treatments. In non-ThryvOn cotton, Diamond and Transform provided the greatest yield increase.

Overall, insecticides performed better in ThryvOn cotton compared non-ThryvOn cotton. This could be due to the TPB already being weaker from feeding on ThryvOn or an increase in activity searching for a better feeding site, increasing their exposure to insecticides throughout the canopy. Regardless, increases in efficacy were observed in ThryvOn. This same trend was observed for yield. It appears that growers planting ThryvOn can expect better overall insecticide performance.

Practical Applications

In areas where TPB is a concern, the combination of ThryvOn cotton and any insecticide could potentially reduce the need for subsequent insecticide applications, but more work needs to be done to determine how this will affect yield and insect pest populations.

Acknowledgments

The authors would like to thank Cotton Incorporated and Bayer Crop Science for funding this research, as well as the Cooperative Extension Service and the University of Arkansas System Division of Agriculture's Entomology Team for their help in conducting this research.

Literature Cited

Arthur, B. and D. Kerns. Evaluation of ThryvOn Cotton as a Control Method of Cotton Fleahoppers *Pseudatomocelis Seriatus* (Reuter). 2022. p. 59. In Proc. Beltwide Cotton Conf. 2022. Natl. Cotton Council Am., Memphis, Tenn. Available at: https://www.cotton.org/beltwide/proceedings/2005-2022/index.htm

Musser, F., A. Catchot, S. Stewart, R. Bagwell, G. Lorenz, K. Tindall, G. Studebaker, B. Leonard, D. Akin, D. Cook, and C. Daves. 2009. Tarnished plant bug (Hemitera: Miridae) thresholds and sampling comparisons for flowering cotton in the mid-southern United States. J. Econ. Ento.Vol. 102 no. 5 pp.1828: Field and Forage Crops.

Whitfield, A., G. Lorenz, B.C. Thrash, N. Bateman, S.G. Felts, W.A. Plummer, M. Mann. C.A. Floyd, C. Rice., T. Newkirk, Z. Murray, and T. Harris. 2022. Evaluation of ThryvOn technology for control of thrips and tarnished plant bugs in cotton. p. 440. InProc. Beltwide Cotton Conf.. 4-6 Jan. Natl. Cotton Counc. Am. Memphis, Tenn. pp. 440. Available at: https://www.cotton.org/beltwide/proceedings/2005-2022/index.htm

Table 1. A list of foliar applied insecticides and the rate at which they were applied for control of Tarnished Plant Bug on ThryvOn and non-ThryvOn cotton in studies conducted at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022.

Trade Name	Rate
Bifenthrin	6.4 (oz/ac)
Acephate	0.75 (lb/ac)
Diamond (novaluron)	6.0 (oz/ac)
Transform (sulfoxaflor)	1.5 (oz/ac)
Centric (thiamethoxam)	2.0 (oz/ac)

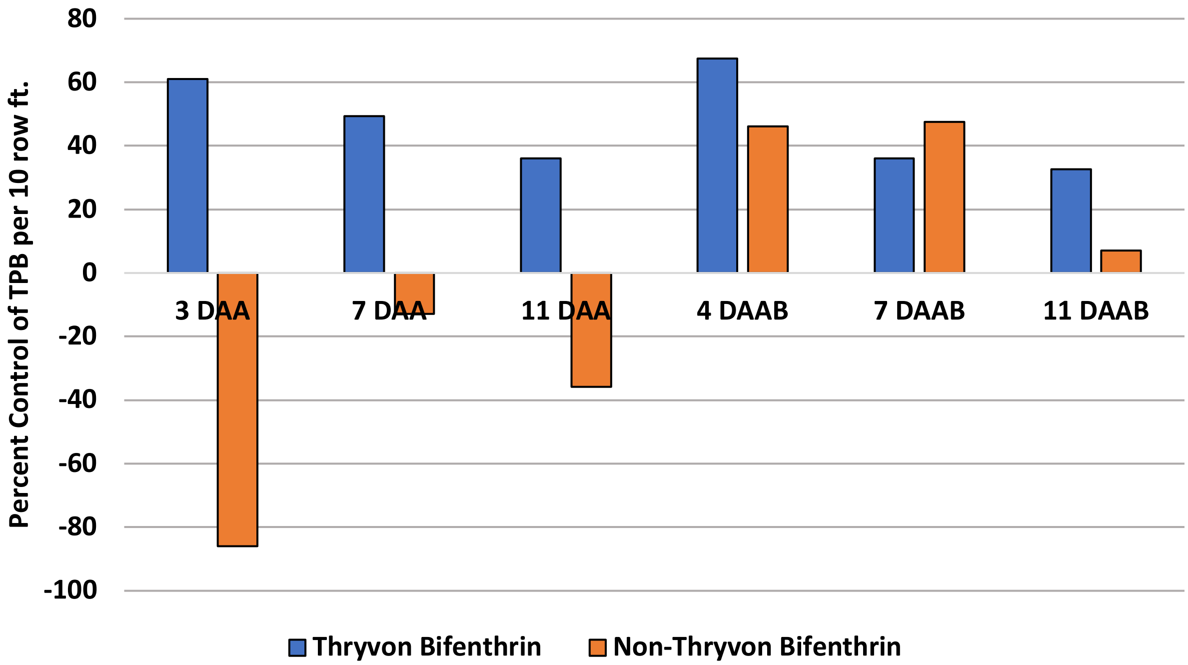

Fig. 1. Comparing percent control compared to the untreated check of Tarnished Plant Bug (TPB) provided by Bifenthrin on ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. DAA = days after application A, DAAB = days after application B.

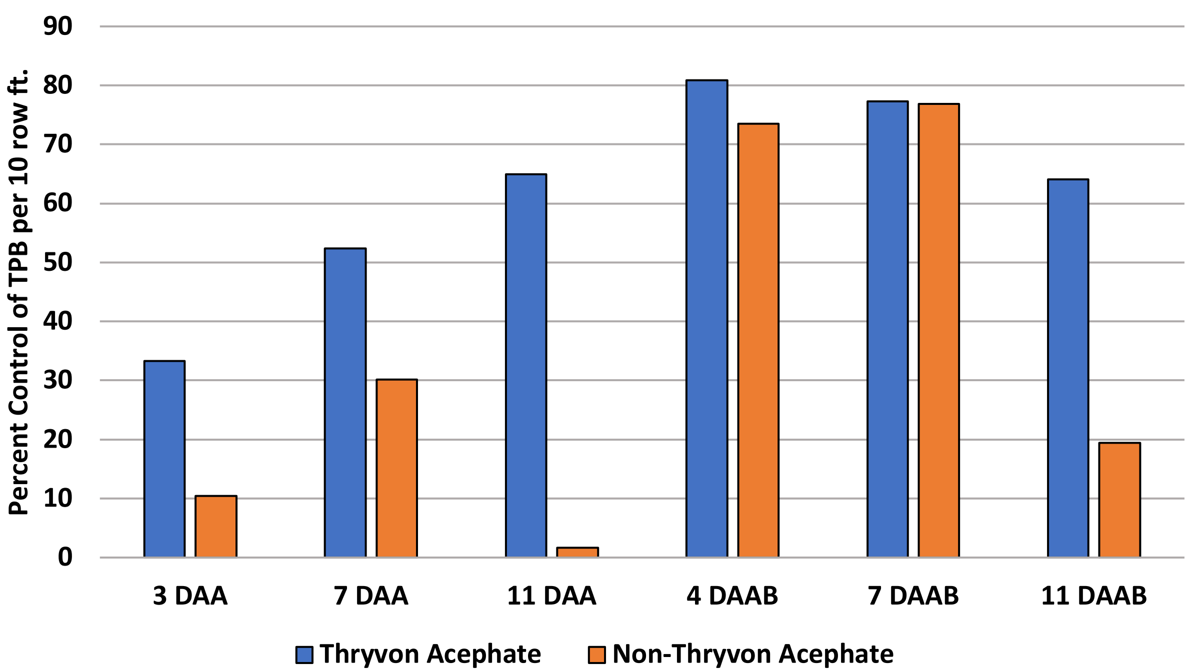

Fig. 2. Comparing percent control compared to the untreated check of tarnished plant bug (TPB) provided by Acephate on ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. DAA = days after application A, DAAB = days after application B.

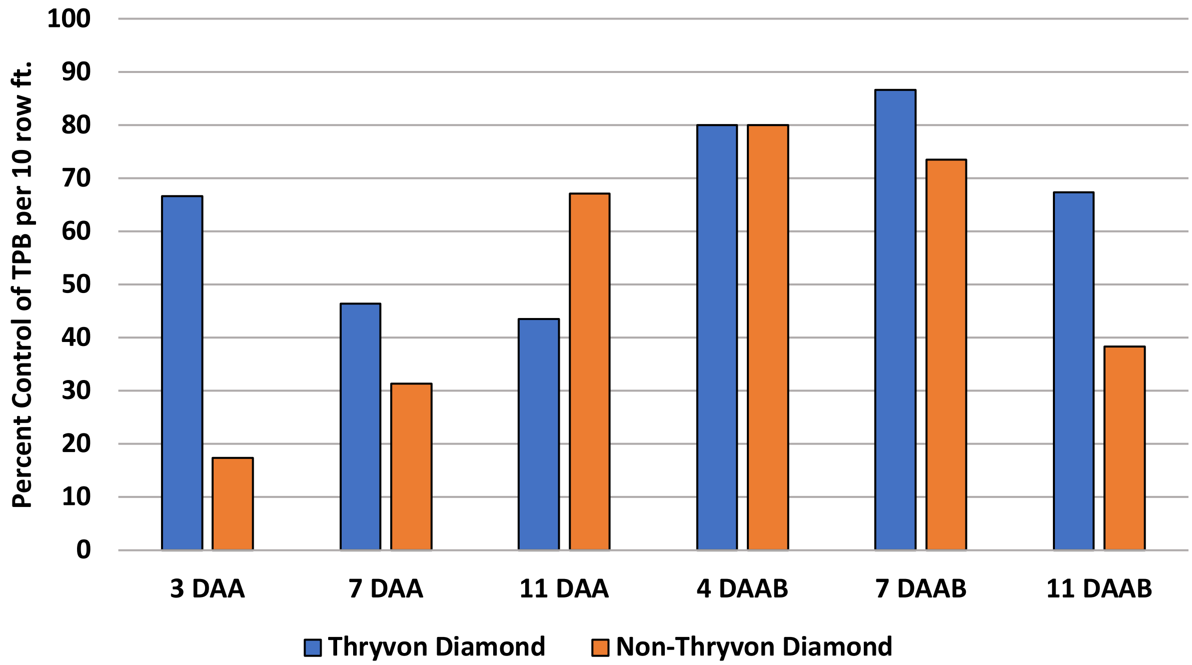

Fig. 3. Comparing percent control compared to the untreated check of tarnished plant bug (TPB) provided by Diamond on ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. DAA = days after application A, DAAB = days after application B.

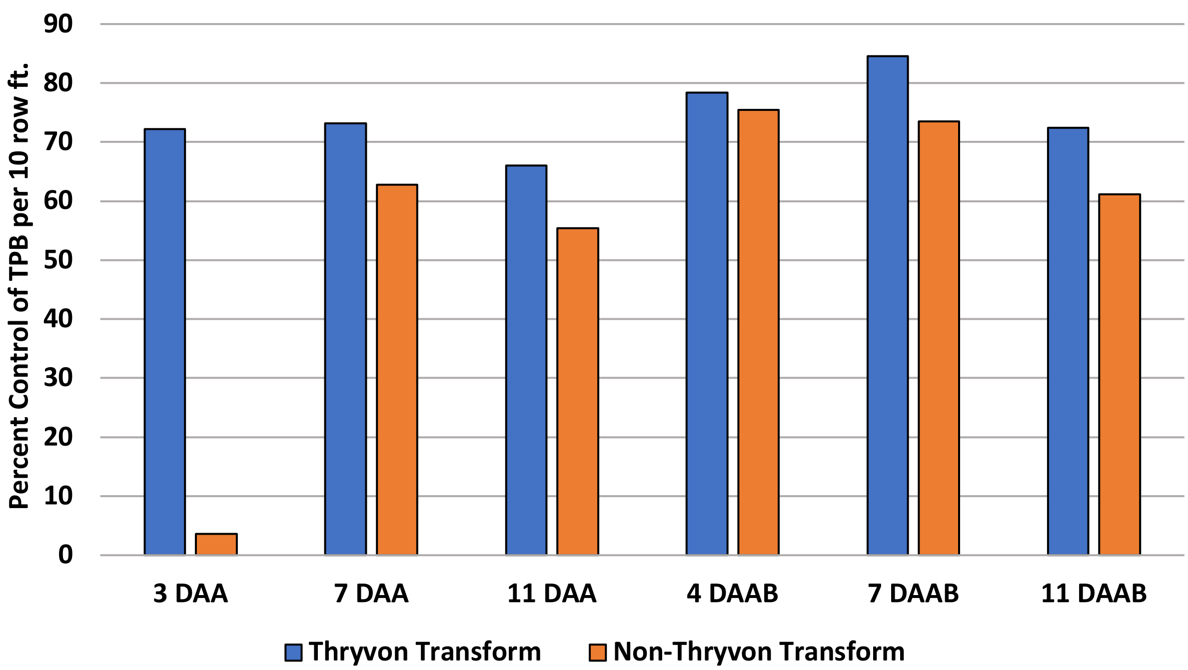

Fig. 4. Comparing percent control compared to the untreated check of tarnished plant bug (TPB) provided by Transform on ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. DAA = days after application A, DAAB = days after application B.

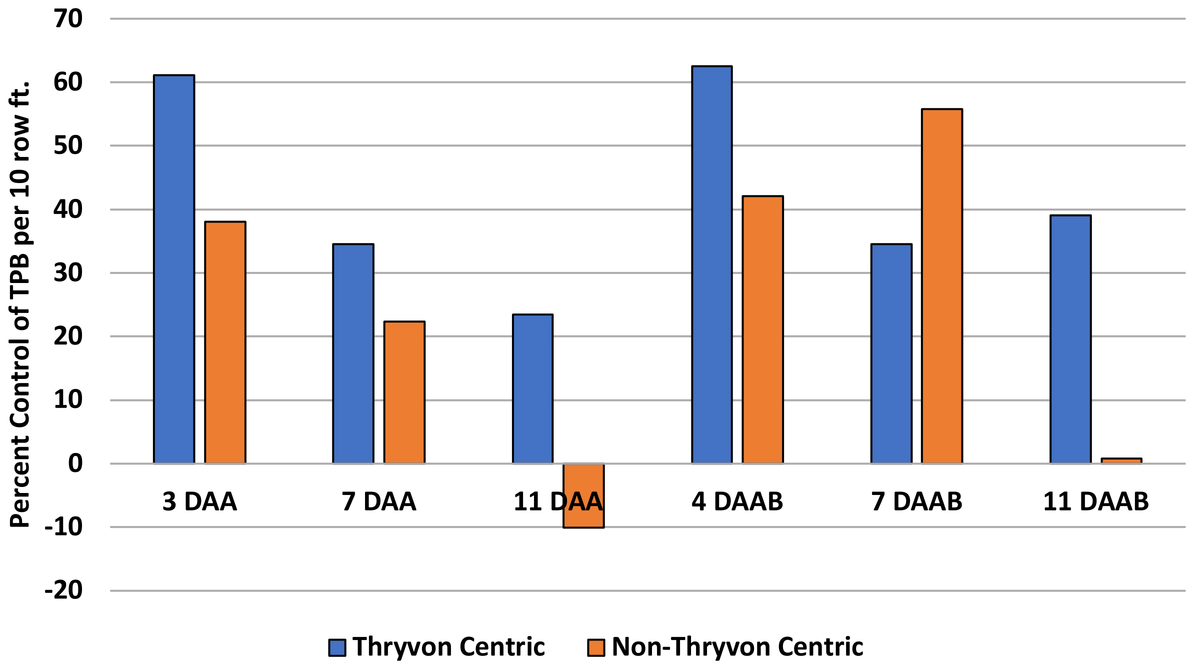

Fig. 5. Comparing percent control compared to the untreated check of tarnished plant bug (TPB) provided by Centric on ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. DAA = days after application A, DAAB = days after application B.

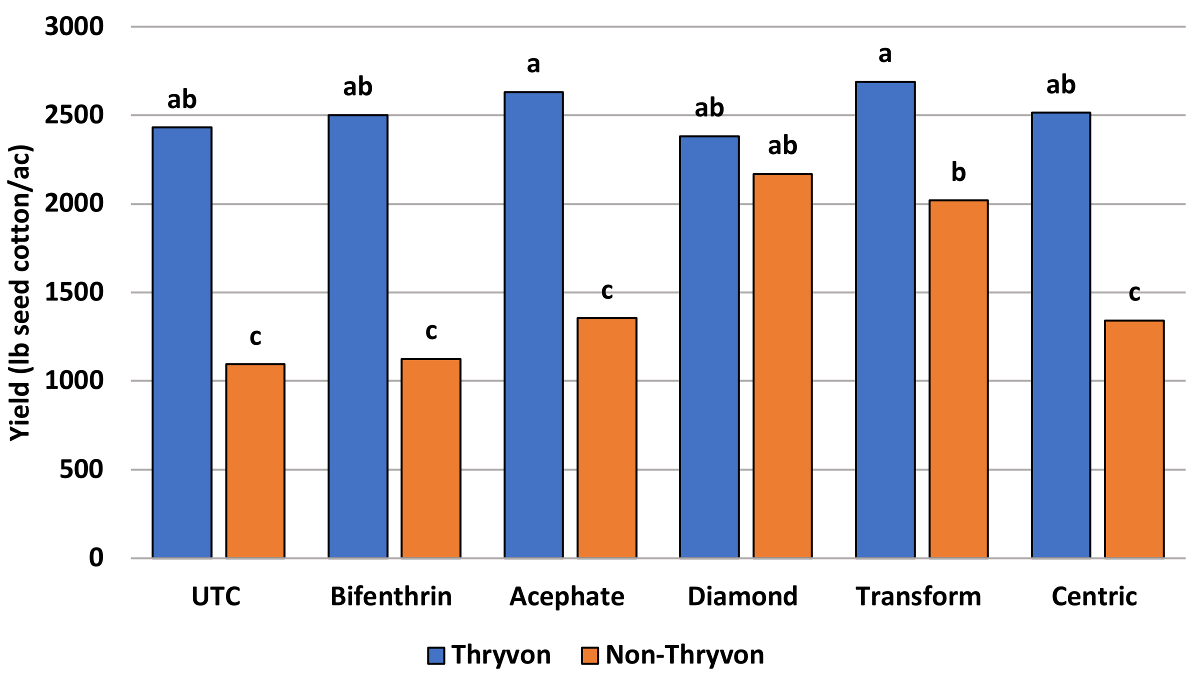

Fig. 6. Yield in pounds of seed cotton per acre across multiple insecticides for control of tarnished plant bug as well as an untreated check, in ThryvOn and non-ThryvOn cotton at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna in 2022. Treatments with the same letter are not different according to Tukey's honestly significant difference test at α = 0.01.

Assessment of Foliar Insecticide Applications in Arkansas Cotton Systems for Control of Cotton Bollworm, *Helicoverpa zea*

Z. Murray,[1] B.C. Thrash,[2] N.R. Bateman,[3] W. A. Plummer,[2] T. Ibbotson,[2] Mathew Mann,[2] S.G. Felts,[3] C.A. Floyd,[4] T. Newkirk,[1] A. Whitfield,[1] and T. Harris[1]

Abstract

Transgenic *Bt* cotton has not eliminated the need for supplemental foliar insecticidal applications. Prior to the introduction of transgenic cotton expressing insecticidal proteins derived from *Bt*, foliar insecticides were used as the main control method of *Helicoverpa zea*. Due to high technology fees and documented cotton bollworm resistance to transgenic *Bt* technologies, supplemental foliar applications may be required to manage high populations of *H. zea*. Despite additional input costs, growers could achieve greater profits with an insecticide application when bollworm threshold is exceeded. Research was conducted in 2022 in Drew County, Arkansas, to evaluate several insecticides, including Prevathon, acephate, and bifenthrin, for efficacy and residual control of *H. zea* on multiple *Bt* cotton technologies. Results suggest that sprayed Bollgard II had similar levels of damage to all Bollgard III treatments. All Bollgard II treatments, sprayed Bollgard II, and non-*Bt* plots receiving a second insecticide application had similar yields, which were greater than unsprayed non-*Bt* and non-*Bt* sprayed with Prevathon or acephate plus bifenthrin.

Introduction

Prior to the introduction of transgenic cotton expressing insecticidal proteins derived from *Bt*, foliar insecticides were used as the main control method of *Helicoverpa. zea*. However, transgenic *Bt* cotton has not eradicated the need for supplemental foliar insecticidal applications. In 1995, Arkansas growers averaged 4.6 insecticide applications for boll/bud worms (Williams, 1996). Growers treated 95% acres out of the 1 million acres planted in Arkansas with an average application cost of $10.45. In 2021, 100% of the 470,000 acres of cotton planted in Arkansas consisted of transgenic cultivars (Cook, 2022). Approximately 100% of the acres were infested with *H. zea*/Budworm, with only 92,100 acres being treated. Growers averaged 1.2 insecticide applications at $31.46 per application. Resistance in *H. zea* to *Bt* cotton cultivars has become an important concern due to increased feeding damage on various fruiting forms. Dual gene cotton (2-*Bt* genes) may not provide the protection needed to manage cotton *H. zea,* and foliar applications may be required. The objective of this study was to determine the cost-effectiveness of less expensive short residual insecticides compared to more expensive long residual insecticides on non-*Bt*, dual gene, and three gene cotton for controlling *H. zea*.

Procedures

A study was conducted in Tillar, Arkansas, in 2022 to determine the efficacy and residual control of *H. zea* using multiple insecticides on multiple *Bt* technologies. A non-*Bt* (DP 1822 XF), a two-gene (DP 1646 B2XF), and a three-gene cultivar (DP 1845 B3XF) were planted on 18 May. Plot size was 12.5 ft (4 rows) by 40 ft. Treatments within each cultivar included: Untreated check (UTC); prevathon at 20 oz/ac (Prev)); prevathon at 20 oz/ac) followed by Prevathon at 20 oz/ac (Prev FB Prev); prevathon at 20 oz/ac) followed by acephate (0.75 lb/ac) plus bifenthrin (6.4 oz/ac) (Prev FB Ace + Bifen); and acephate at 0.75 lb/ac) plus bifenthrin at 6.4 oz/ac (Ace + Bifen). Each insecticide application was initiated when the 6% fruit damage threshold was exceeded in the non-*Bt* plots. The first applications of Prev and Ace + Bifen were applied on 19 July. Data collection occurred at 3, 7, 10, 14, and 21 days after application (DAA1) for the first series of sprays. For treatments receiving a second application, Prev or Ace + bifen was applied when bollworm threshold was triggered on 4 August. Data collection occurred 4 and 11 days after the second application (DAA2). Each application was made using a Mudmaster high clearance sprayer fitted with TXVS-6 flat fan nozzles at 19.5-in.

[1] Graduate Assistants, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Assistant Professor/Extension Entomologist, Program Associate, Program Associate, and Program Associate, respectively, Department of Entomology and Plant Pathology, University of Arkansas System Division of Agriculture Lonoke Extension Center, Lonoke, Arkansas.
[3] Associate Professor/Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, University of Arkansas System Division of Agriculture's Rice Research and Extension Center, Stuttgart.
[4] Assistant Professor/Crop Protection Specialist, Department of Plant Science and Technology Faculty, Portageville, Missouri.

spacing with a spray volume of 10 gal/ac at 40 psi. In each plot, 25 squares, 25 flowers, and 25 bolls were sampled, and the number damaged was recorded. The two center rows of each plot were harvested on 13 October and yield was reported as lb/ac of seed cotton. All data were processed using PROC GLIMMIX in SAS v 9.4 (SAS Institute, Inc., Cary N.C.) with $\alpha = 0.05$.

Results and Discussion

Similar observations occurred from three DAA through 14 DAA in both sprayed and unsprayed, non-*Bt* plots. The percent damaged fruit exceeded the 6% fruit damage threshold in all non-*Bt* plots between three and 14 DAA (Figs. 1–2). When the second application was initiated, decreased damage was observed in all plots receiving the second application when compared to the unsprayed non-*Bt* (Fig. 3). Except for BG3, all plots that received a second application of insecticide had similar levels of damage and had less damage than plots that did not receive a second application at 11 DAA2 (Fig. 4). Non-*Bt* plots sprayed with two applications of Prev, and plots sprayed with Prev FB Ace + bifen had similar yields as the dual gene and three gene plots (Fig. 5).

Practical Applications

Supplemental foliar applications may be needed in order to protect yield from cotton bollworm in non-*Bt* and Bollgard II technologies. These results imply that growers applying Prevathon at 20 oz/ac will achieve adequate control across non-*Bt* and two gene cultivars. Acephate plus Bifenthrin may not provide sufficient control of high populations of bollworms. Growers should consider pest pressure and fruit damage loss when selecting insecticide, as well as technology.

Acknowledgments

Appreciation is expressed to Cotton Inc, Mid-South Entomologist Working Group, and the Arkansas Entomology Team. Support was also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Cook, D.R. 2022. Cotton Insect Losses for the United States during 2021; Mississippi State Univeristy: by M Threet. Mississippi State University.

Williams, M.R. 1996. Cotton Insect Losses for 1995, Mississippi State University. Beltwide Proceedings; 1995.

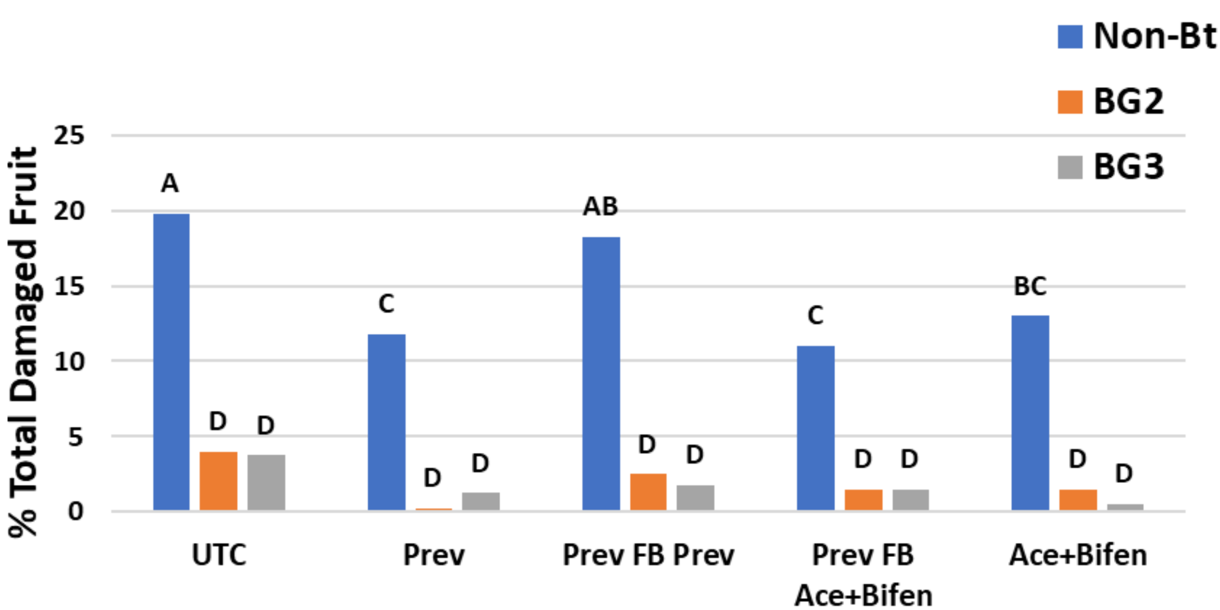

Fig 1. Percent fruit damage on DP 18 22 XF (non-Bt) DP 1646 B2 RF (BG2) and (DP 1845 B3XF (BG3) cotton measured on 21 July 2022, 3 days after application (3 DAA) of Prevathon (Prev), acephate (Ace) or bifenthrin (Bifen) in Drew County, Arkansas. UTC is the untreated check.

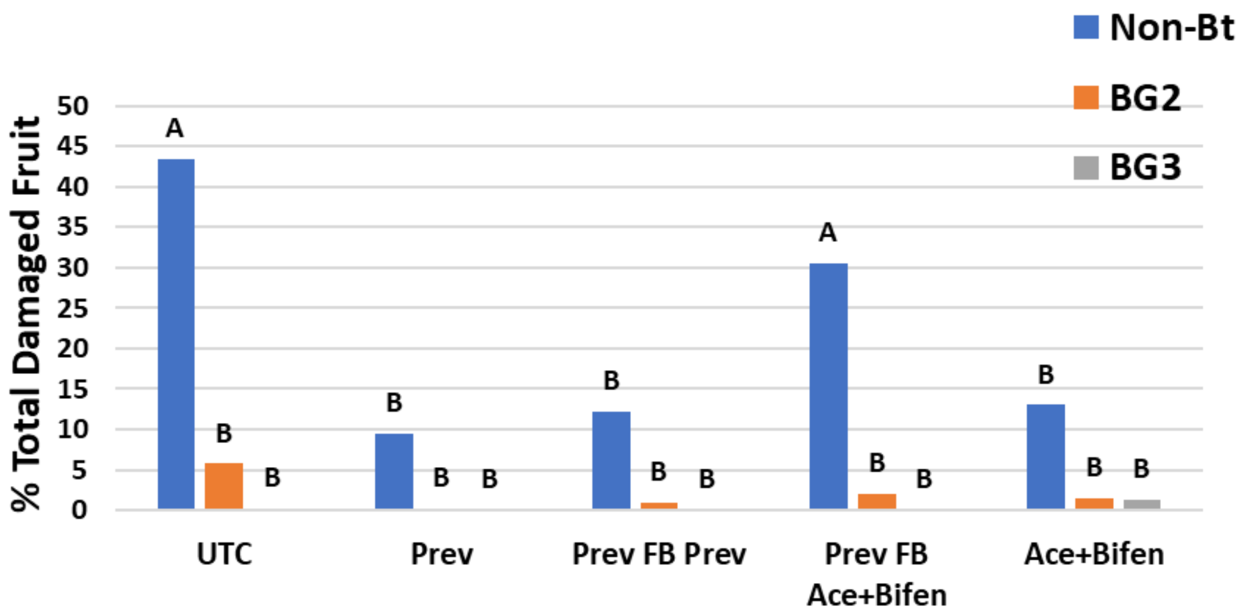

Fig 2. Percent fruit damage on DP 18 22 XF (non-Bt) DP 1646 B2 RF (BG2) and (DP 1845 B3XF (BG3) cotton measured on 1 August 2022, 14 days after the application of Prevathon (Prev), acephate (Ace) or bifenthrin (Bifen) in Drew County, Arkansas. UTC is the untreated check.

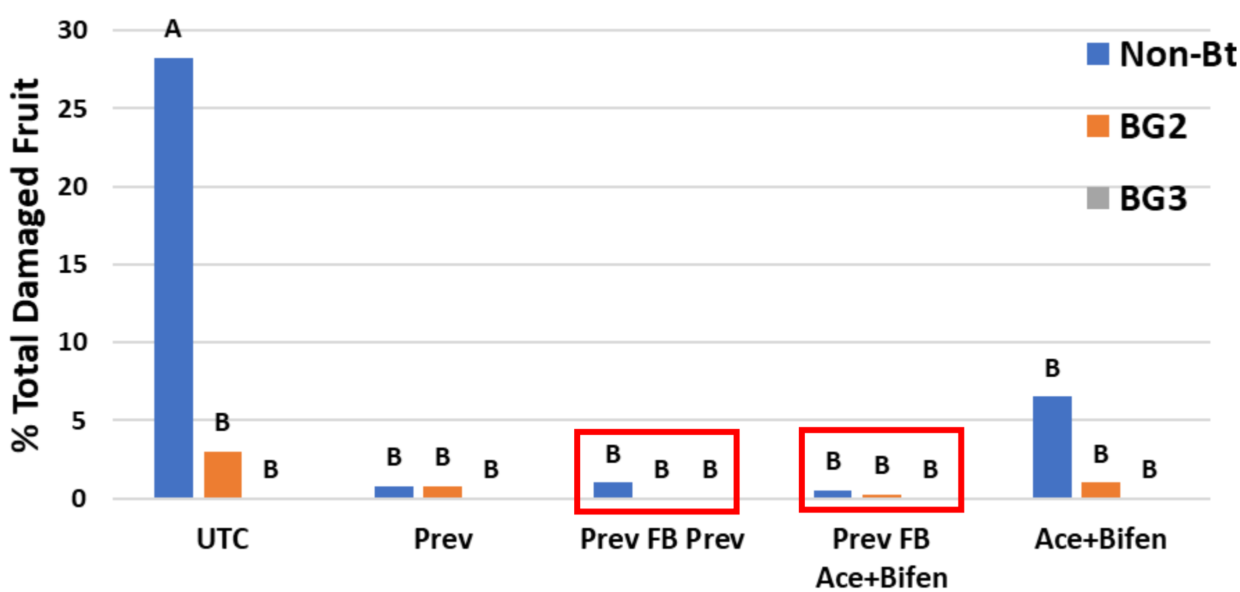

Fig 3. Percent fruit damage on DP 18 22 XF (non-Bt) DP 1646 B2 RF (BG2) and (DP 1845 B3XF (BG3) cotton measured on 8 August 2022, 4 days after the second application (DAA2) of Prevathon (Prev), acephate (Ace) or bifenthrin (Bifen) in Drew County, Arkansas. Red boxes were placed around the plots that received the second application. UTC is the untreated check.

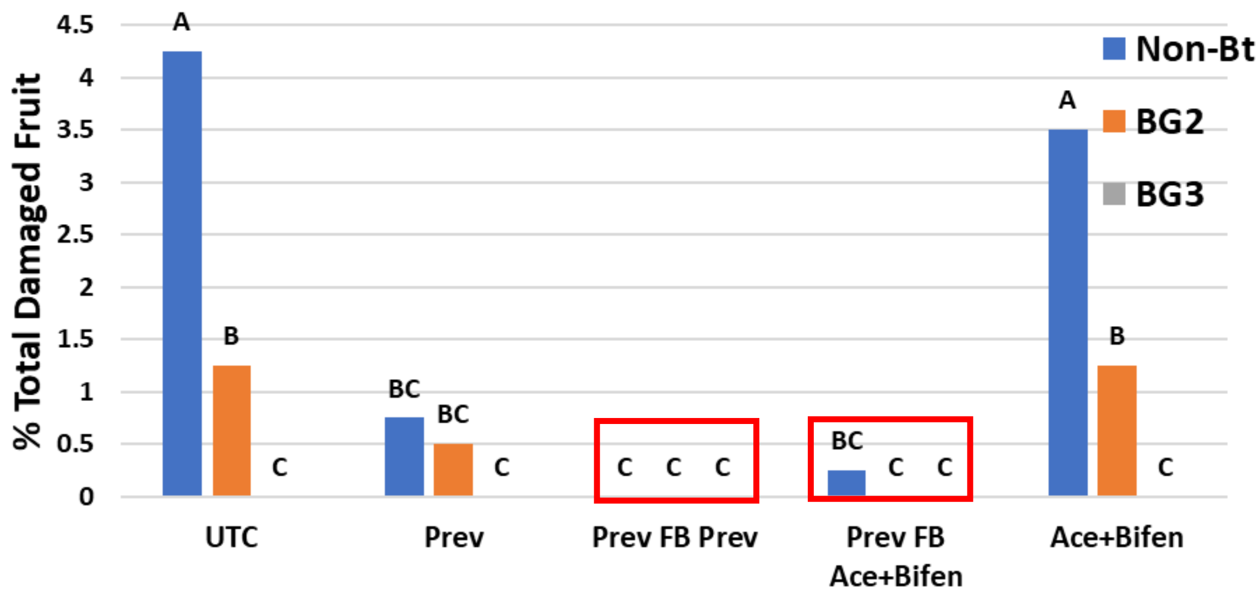

Fig 4. Percent fruit damage on DP 18 22 XF (non-Bt) DP 1646 B2 RF (BG2) and (DP 1845 B3XF (BG3) cotton measured on 15 August 2022, 11 days after the second application of Prevathon (Prev), acephate (Ace) or bifenthrin (Bifen) in Drew County, Arkansas. Red boxes were placed around the plots that received the second application. UTC is the untreated check.

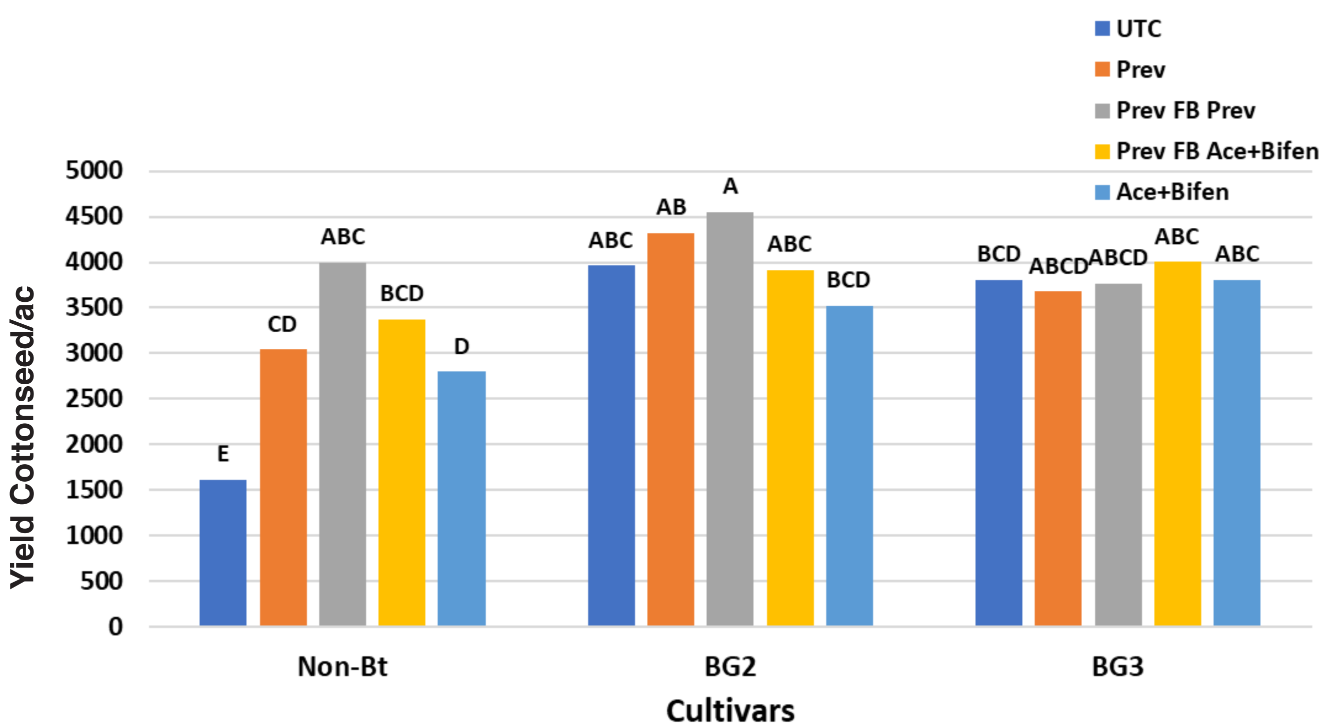

Fig 5. Yield of DP 18 22 XF (non-Bt) DP 1646 B2 RF (BG2) and (DP 1845 B3XF (BG3) cotton with and without (UNT) an application of Prevathon (Prev), acephate (Ace) or bifenthrin (Bifen) in Drew County, Arkansas, in 2022. UTC is the untreated check.

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

Z. Murray,[1] B.C. Thrash,[2] N.R. Bateman,[3] W. A. Plummer,[2] T. Ibbotson,[2] M. Mann,[2] S.G. Felts,[3] C.A. Floyd,[4] T. Newkirk,[1] A. Whitfield,[1] and T. Harris[1]

Abstract

Bollworm (*Helicoverpa zea*, Bodie) is currently the second most damaging insect pest of cotton in Arkansas. The primary method used to control bollworms in cotton is the use of transgenic *Bacillus thuringiensis* (*Bt*) technologies. Resistance to dual-gene cotton cultivars has recently been documented in bollworm, and results indicate that supplemental foliar applications may be needed to manage high populations. Research was conducted in 2021 and 2022 at Tiller (Drew County), Arkansas, to evaluate the efficacy of several Bt technologies. Results suggest that sprayed dual-gene cultivars had similar levels of damage to unsprayed three-gene cultivars. All three-gene treatments, sprayed non-*Bt*, and sprayed Bollgard II, had similar yields, which were greater than unsprayed non-*Bt* and unsprayed Bollgard II. These data suggest that dual-gene cultivars may need a supplemental foliar application for bollworm.

Introduction

Helicoverpa zea is the second most damaging insect pest of cotton in Arkansas. Foliar insecticides and insecticidal proteins from *Bacillus thuringiensis* (*Bt*) in transgenic cotton are common *H. zea* management tools used in cotton production. Genetically-engineered crops were rapidly adopted in 1996 when they were commercially introduced in the U.S. Transgenic *Bt* cotton has not eradicated the need for supplemental foliar insecticidal applications (Fleming et al., 2018). Resistance to dual-gene cotton cultivars has recently been documented in *H. zea*, and results indicate that supplemental foliar applications may be needed to manage high populations. Research was conducted in 2021 and 2022 on a grower field at Tiller (Drew County), Arkansas, to evaluate the efficacy of several *Bt* technologies and the economic value of dual gene and three gene technologies.

Procedures

Studies were conducted in Tillar, Arkansas, in 2021 and 2022. Plots were planted between 16 May 2021 and 18 May 2022 using a non-*Bt* (DP 1822 XF), a dual gene (DP 1518 B2XF), and two three-gene cultivars (DP 1845 B3XF and PHY 400 W3FE). Plot size was four rows, 96.5 cm apart and 12.2 m long, with four replications. Fallow alleys measuring 3.04 m long separated the replications. Each cultivar had plots that were either unsprayed or sprayed with 20 oz/ac of chlorantraniliprole (Prevathon 0.43 SC, FMC Corporation; Philadelphia, Pa.) for a total of eight treatments. The Prevathon application was made on 22 July 2021 and 19 July 2022 using a Mudmaster high clearance sprayer fitted with TXVS-6 flat fan nozzles at 50-cm spacing with a spray volume of 10 gal/ac, at 40 psi. Data collection occurred at 4, 7, 10, 14, and 21 days after application (DAA). In each plot, 25 squares, 25 flowers, and 25 bolls were sampled, and the number damaged for each was recorded. The two center rows of each plot were harvested on 1 Nov. 2021 and 13 Oct. 2022. Yield was reported as lb/ac cotton. Seedcotton yield was converted to lint yield by multiplying seedcotton yield by 0.454. All data were processed using PROC GLIMMIX in SAS v. 9.4 (SAS Institute, Inc., Cary N.C.) with $\alpha = 0.05$.

Results and Discussion

In the initial 2021 observation (4 DAA), unsprayed non-*Bt* treatment had the greatest amount of damaged fruit (Table 1). Sprayed non-*Bt*, sprayed dual-gene, and all three-gene plots had the least amount of damage. At seven DAA, the percent damaged fruit was greatest in unsprayed non-*Bt* and unsprayed dual gene, while all other treatments had lesser amounts of damage. Amounts of damage in unsprayed non-*Bt* and unsprayed dual-gene were greater than all other treatments throughout the sampling periods. At 21 DAA,

[1] Graduate Assistants, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Assistant Professor/Extension Entomologist, Program Associate, Program Associate, and Program Associate, respectively, Department of Entomology and Plant Pathology, University of Arkansas System Division of Agriculture Lonoke Extension Center, Lonoke, Arkansas.
[3] Associate Professor/Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, University of Arkansas System Division of Agriculture's Rice Research and Extension Center, Stuttgart.
[4] Assistant Professor/Crop Protection Specialist, Department of Plant Science and Technology Faculty, Portageville, Missouri.

the total damaged fruit levels decreased. *H. zea* larvae were observed transitioning to the pupae stage across plots. Both unsprayed non-*Bt* and unsprayed Bollgard II treatments had significantly lower yields (Table 2). Unsprayed non-*Bt* and Unsprayed Bollgard II treatments benefited from a chlorantraniliprole application.

Seasonal fruit damage was relatively low at the Tillar location in 2022. Unsprayed non-*Bt* fruit damage at four DAA was the only treatment to benefit from the chlorantraniliprole application (Table 1). At 10 and 14 DAA, damage in the unsprayed non-*Bt*, unsprayed dual gene, and unsprayed three-gene treatment was above the 6% damaged fruit threshold. Yields at Tillar in 2022 showed no differences among any treatments (Table 2).

Practical Applications

Resistance has recently been recorded in bollworms to dual-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. Three-gene cultivars appear to provide sufficient control of bollworms but should still be monitored to prevent unexpected yield loss. Growers should consider yield performance history 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 Cotton Incorporated, Mid-South Entomologist Working Group, and the Arkansas Entomology Team. Support was also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

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: e0200131. https://dx.doi.org/10.1371/journal.pone.0200131

Table 1. Percent total damage of combined fruiting structures recorded at 4, 7, 10, 14, and 21 days after a chlorantraniliprole application on four cotton cultivars during 2021–2022 growing seasons.

	Tillar 2021					Tillar 2022				
Treatments	**4**	**7**	**10**	**14**	**21**	**4**	**7**	**10**	**14**	**21**
	------------	------------	------------	------------	------------	(%) ------------	------------	------------	------------	------------
Non-*Bt*	23.0 a[†]	24.0 a	37.0 a	34.3 a	13 a	22.6 a	4.0 abc	17.5 a	15 a	14.5 ab
Bollgard II	12.0 b	24.0 a	33.6 a	23.6 b	7.0 b	7.2 bc	3.3 abc	11.7 ab	17.3 a	3.5 ab
Bollgard 3	5.7 bc	1.0 b	0.3 b	1.0 c	0.0 c	0.25 c	10.2 a	17.2 a	25 a	26 a
WideStrike 3	3.7 c	0.6 b	2.0 b	0.6 c	0.3 c	1.0 c	8.5 ab	17.25 a	17.3 a	8.0 ab
Non-Bt[‡]	3.7 c	0.6 b	1.3 b	0.0 c	0.6 c	12.5 ab	1.5 bc	1.25 b	1.3 a	2.0 ab
Bollgard II[‡]	5.5 bc	2.0 b	0.3 b	0.6 c	0.6 c	0.0 c	2.2 bc	2.5a b	0.0 a	2.0 ab
Bollgard 3[‡]	2.2 c	1.0 b	0.3 b	0.0 c	0.6 c	0.25 c	0.2 c	2.25 ab	1.0 a	1.5 ab
Widestrike 3[‡]	2.2 c	1.6 b	0.6 b	2.3 c	0.0 c	0.5 c	1.5 bc	1.0 b	5.0 a	0.5 ab
P-value[§]	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	0.0005	0.145	0.0809	0.3917	0.422

[†] Average percent total damage followed by a different letter are significantly different according to a pairwise *t*-test at $\alpha = 0.05$.

[‡] Sprayed with chlorantraniliprole.

[§] A *P*-value measures the probability of obtaining the observed results. The lower the *P*-value, the greater the statistical significance of the observed difference.

Table 2. Average lint yield for four cotton cultivars with and without a chlorantraniliprole application.

Treatments	Tillar 2021 Mean yield	Tillar 2022 Mean yield
	(lb/ac)	(lb/ac)
Non-*Bt*	334 b†	1223 a
Bollgard II	218 b	1240 a
Bollgard 3	1138 a	1485 a
WideStrike 3	1351 a	1390 a
Non-Bt‡	1242 a	1332 a
Bollgard II‡	1279 a	875 a
Bollgard 3‡	1309 a	1232 a
Widestrike 3‡	1152 a	1119 a
P-value§	<0.0001	0.6376

† Average lint yield followed by a different letter are significantly different according to a pairwise *t*-test at $\alpha = 0.05$.

‡ Sprayed with chlorantraniliprole.

§ A *P*-value measures the probability of obtaining the observed results. The lower the *P*-value, the greater the statistical significance of the observed difference.

Comparing Cotton Tolerance and Palmer amaranth Control When Utilizing Florpyrauxifen-Benzyl-Coated Fertilizer Applied at Various Growth Stages

S.L. Linn,[1] J.K. Norsworthy,[1] T.H. Avent,[1] P. Carvalho-Moore,[1] and L.T. Barber[2]

Abstract

In cotton (*Gossypium hirsutum*) production, maximizing Palmer amaranth (*Amaranthus palmeri* S. Wats.) control is imperative while minimizing the amount of injury caused to the crop. This study was designed to determine the optimal cotton growth stage for applying florpyrauxifen-benzyl-coated fertilizer in cotton to attain adequate Palmer amaranth control while maintaining minimal cotton injury. The study was initiated on 10 May 2022 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station in Marianna, Arkansas, and designed as a two-factor factorial in a randomized complete block. The first factor was the application timing (growth stage): 1- to 2-leaf, 3- to 4-leaf, 5- to 6-leaf, and 10- to 12-node growth stages. The second factor was the presence or absence of florpyrauxifen-benzyl at 16 fl oz/ac coated onto fertilizer. The fertilizer blend utilized as the florpyrauxifen-benzyl carrier consisted of urea at 175 lb/ac and muriate of potash at 100 lb/ac. Cotton injury and Palmer amaranth control ratings were taken 14 days after treatment (DAT). Improved Palmer amaranth control was observed for the florpyrauxifen-benzyl-coated fertilizer applications at the 1- to 2 and 3-to 4-leaf growth stages. Concerning the 6- to 8-leaf and 10- to 12-node growth stage treatments, Palmer amaranth control did not improve with the florpyrauxifen-benzyl-coated fertilizer treatments compared to those without the herbicide. Cotton in the 6- to 8-leaf treatments displayed the most crop injury. However, the injury was less than 15% among the other treatments. These findings suggest the potential for improved Palmer amaranth control and minimal cotton injury from florpyrauxifen-benzyl-coated fertilizer applied at selected growth stages. Additional site years are needed to support or refute these findings, and further research is needed to determine the likelihood of yield loss due to florpyrauxifen-benzyl injury.

Introduction

Cotton (*Gossypium hirsutum* L.) producers rely on residual and postemergence herbicides for season-long control of Palmer amaranth (*Amaranthus palmeri* S. Wats.). Adding residual herbicides in a weed control program is vital because it reduces the chances of weed populations evolving herbicide resistance (Tingle and Chandler, 2017). Diversifying modes of action in the cotton herbicide portfolio can provide producers with increased potential for combating weed resistance (Norsworthy et al., 2012). Florpyrauxifen-benzyl is a group 4 herbicide or a synthetic auxin. Herbicides from this group cause abnormal growth increases that destroy vascular tissue or growth inhibition (WSSA, 2011). Florpyrauxifen-benzyl has selective postemergence control of sedges, grasses, and broadleaves, including Palmer amaranth (Corteva, 2021). Florpyrauxifen-benzyl is currently only registered for use in rice (*Oryza sativa* L.) for both aerial and ground applications, coated onto urea and applied at the 4- to 5-leaf rice growth stage (Corteva, 2022).

Utilizing fertilizer blends as carriers for herbicide is a concept that has now been used in crops such as rice, corn (*Zea mays* L.), and cotton. By applying herbicides coated onto fertilizers, the number of passes a producer has to make in the field will decrease due to combining the herbicide and fertilizer application into one process (Corteva, 2020). In addition, using herbicides coated onto fertilizer could allow for herbicides not labeled to be used in cotton production, thus adding additional modes of action to the cotton herbicide portfolio. This herbicide application method could be used in cotton production if the crop displays tolerance to florpyrauxifen-benzyl-coated fertilizer and provides effective weed control. While florpyrauxifen-benzyl is not registered for use in cotton, a study found that only 11% of cotton injury was detected following florpyrauxifen-benzyl post-directed (Doherty et al., 2016). This study was designed to determine which growth stage is optimal for the application of florpyrauxifen-benzyl coated onto fertilizer and applied over the top of cotton.

[1] Graduate Assistant, Distinguished Professor, Senior Graduate Assistant, and Senior Graduate Assistant, respectively, Department of Crop, Soil, and Environmental Sciences, Fayetteville.
[2] Professor, Department of Crop, Soil, and Environmental Sciences, Lonoke.

Procedures

A field study was conducted on silt-loam soil at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station at Marianna, Arkansas, in 2022 to evaluate the effect of florpyrauxifen-benzyl-coated fertilizer applied postemergence at various cotton growth stages. Dicamba-resistant cotton (DP 2020 B3XF) was planted at a 1-in. depth into four-row plots (38-in. spacing) 25 ft in length. The study was designed as a two-factor factorial in a randomized complete block with four replications. The first factor was the application timing (growth stage). There were four application timings: 1- to 2-leaf, 3- to 4-leaf, 5- to 6-leaf, and 10- to 12-node growth stages. The second factor was the presence or absence of florpyrauxifen-benzyl at 0.02625 lbs/ac coated onto granular fertilizer. The fertilizer blend utilized as the florpyrauxifen-benzyl carrier consisted of urea at 175 lb/ac and muriate of potash at 100 lb/ac. A preemergence application of paraquat at 0.625 lb/ac and fluometuron at 0.75 lb/ac was applied to all plots. Before each treatment application and at the 1- to 2-leaf growth stage for the 10- to 12-node treatment, glyphosate at 1.125 lb/ac and glufosinate at 0.548 lbs/ ac were applied to control emerged weeds. Visible cotton injury and Palmer amaranth control evaluations were collected 14 days after treatment (DAT). All data from this experiment were analyzed using analysis of variance with JMP Prov v.17. Means were separated using Student's *t* least squared means ($\alpha = 0.05$).

Results and Discussion

At 14 days after treatment (DAT), Palmer amaranth was controlled more effectively at the 1- to 2- and 3- to 4-leaf stages when the florpyrauxifen-benzyl-coated fertilizer was applied (Fig. 1). The florpyrauxifen-benzyl fertilizer treatments applied to 1- to 2-leaf cotton provided 96% Palmer amaranth control. In contrast, control was only 69% in the absence of the florpyrauxifen-benzyl coated onto fertilizer. Applying florpyrauxifen-benzyl on fertilizer at the 3- to 4-leaf stage resulted in a 27-percentage point increase in Palmer amaranth control compared to the treatment without the herbicide coated onto fertilizer. Palmer amaranth control was not improved by applying florpyrauxifen-benzyl-coated fertilizer at the 6- to 8-leaf and 10- to 12-node growth stages. The lack of Palmer amaranth control is surprising because when florpyrauxifen-benzyl was post-directed in cotton, Palmer amaranth was controlled from 89% to 99% (Doherty et al., 2019). This may be because coverage could decrease when using the herbicide coated on fertilizer compared to the post-directed treatment.

The 6- to 8-leaf treatments with florpyrauxifen-benzyl-coated fertilizer had more injury compared to the treatment without the herbicide (Fig. 2). Other than 6- to 8-leaf treatment with florpyrauxifen-benzyl, the cotton injury was less than 15% across all application timings. A minimal crop injury was expected, as cotton was injured by 11% when florpyrauxifen-benzyl was post-directed in another study (Doherty et al., 2019). At the 10- to 12-node treatment, the injury was less than 5% for both the presence and absence of the herbicide. The cotton yield per herbicide treatment was not determined. Thus, additional research is needed to determine if yield loss potential may be associated with florpyrauxifen-benzyl injury.

Practical Applications

Florpyrauxifen-benzyl coated onto fertilizers could save cotton growers the expense of an additional trip through the field. The utilization of florpyrauxifen-benzyl-coated fertilizers showed improved Palmer amaranth control with minimal crop injury when applied at earlier stages (until the 4-leaf stage). Therefore, additional studies to optimize the use of this herbicide and ensure its crop safety are necessary.

Acknowledgments

We thank the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station staff for their assistance in conducting this research.

Literature Cited

Corteva, 2020. Impregnation offers stress-free rice weed control. Accessed 19 December 2022. Available at: https://www.corteva.us/Resources/crop-protection/rice/impregnation-rice-weed-control.html

Corteva, 2021. Loyant® product label. Accessed 19 December 2022. Available at: https://s3-us-west-1.amazonaws.com/agrian-cg-fs1-production/pdfs/Loyant_Label3.pdf

Corteva, 2022. Control weeds with treated fertilizer. Accessed 15 December 2022. Available at: www.corteva.us/Resources/crop-protection/rice/control-weeds-herbicide-coated-fertilizer.html

Doherty, R.C., T. Barber, L. Collie, Z. Hill, and A. Ross. 2020. Evaluation of Loyant® Post-Directed in Arkansas Cotton. *In*: F. Bourland (ed.) Summaries of Arkansas Cotton Research 2019. Arkansas Agricultural Experiment Station Research Series 668:36-44. Fayetteville.

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

Tingle, C.H and J.M Chandler, 2017. The effect of herbicides and crop rotation on weed control in glyphosate-resistant crops. Weed Technol. 18:940-946.

WSSA, 2011. Weed Science Society of America. Summary of herbicide mechanism of action according to the Weed Science Society of America. Accessed 16 February 2023. Available at https://wssa.net/wp-content/uploads/WSSA-Mechanism-of-Action.pdf

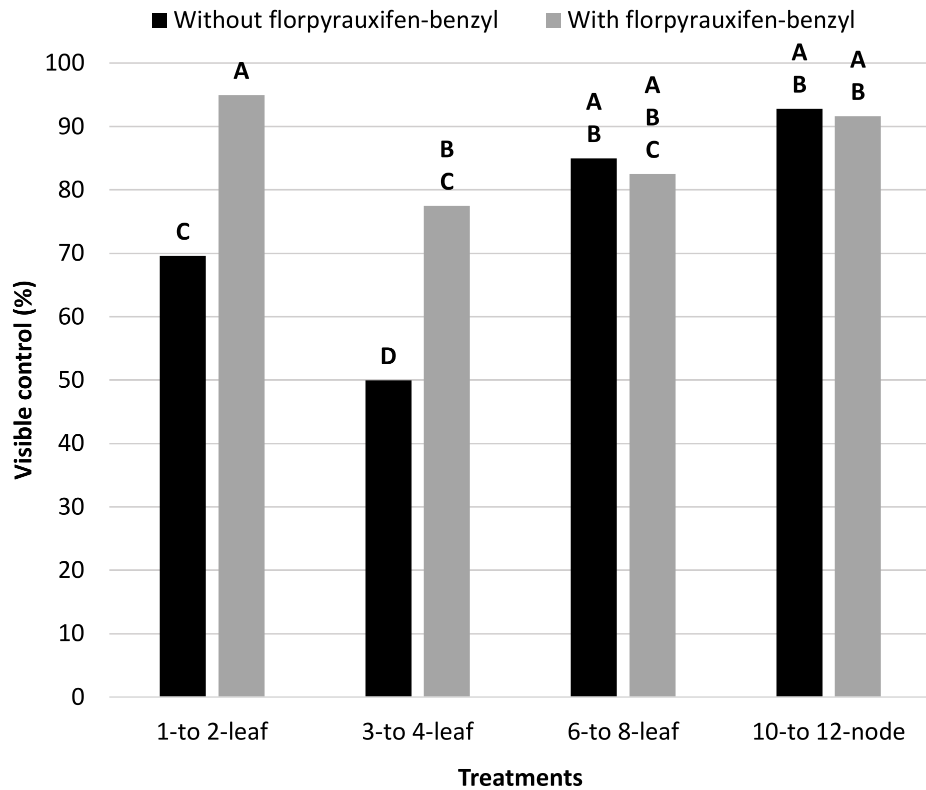

Fig. 1. Palmer amaranth control 14 days after treatment (DAT), Marianna, Arkansas. The label underneath each pair of columns states the application growth stage. The black columns represent treatments without florpyrauxifen-benzyl coated onto fertilizer; the gray columns represent treatments with florpyrauxifen-benzyl coated onto fertilizer. Means followed by the same letter are not significant (α = 0.05).

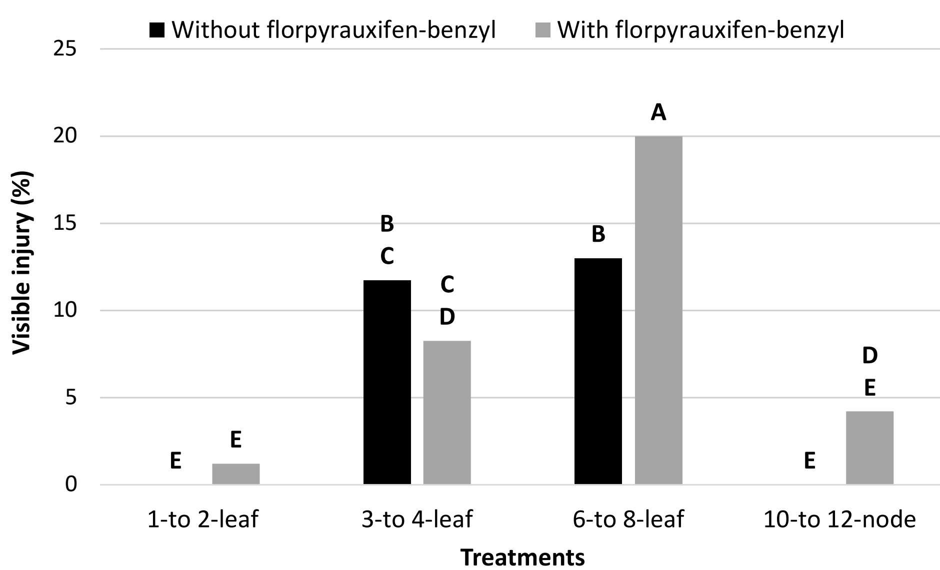

Fig. 2. Palmer amaranth control 14 days after treatment (DAT), Marianna, Arkansas. The label underneath each pair of columns states the application growth stage. The black columns represent treatments without florpyrauxifen-benzyl coated onto fertilizer; the gray columns represent treatments with florpyrauxifen-benzyl coated onto fertilizer. Means followed by the same letter are not significant (α = 0.05).

Impact of Weed Management Practices Over Four Years on Palmer Amaranth in Cotton

T.C. Smith,[1] J.K. Norsworthy,[1] and L.T. Barber[1]

Abstract

In U. S. cotton production systems, Palmer amaranth [*Amaranthus palmeri* (S.) Wats.] is the most problematic weed and can reduce yield and harvest efficiency. Palmer amaranth emerges and thrives in cotton, where canopy closure is prolonged relative to other row-crops grown in the mid-South. In 2018, at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research and Extension Station near Marianna, Arkansas, a trial was initiated to evaluate the long-term implications of integrated weed management strategies on Palmer amaranth emergence. The experiment took place over four years with plots located in the same test site. The experiment consisted of 16 treatments with 4 replications comparing multiple weed management strategies alone and in combination: deep tillage, a cereal rye cover crop, zero-tolerance, and a dicamba-based weed control program or a standard glufosinate program. Averaged over the first four years of the study, using zero tolerance, a cereal rye cover crop, or a plow event reduced Palmer amaranth emergence by 56%, 58%, and 63%, respectively. When a plow event was combined with a dicamba-based herbicide program or when a plow event, a dicamba-based program, and cover crop were utilized, Palmer amaranth emergence was reduced by 93%. Using a plow event plus a dicamba-based herbicide program or using a one-time plow event in combination with a dicamba-based program and a cover crop had the greatest reduction of Palmer amaranth emergence over the four-year period.

Introduction

In the U. S., Palmer amaranth [*Amaranthus palmeri* (S.) Watson] has been ranked as the most troublesome weed in cotton (Van Wychen, 2023). Palmer amaranth has also been classified as the number one weed in cotton systems in Arkansas. The prolific seed production of over 600,000 seeds in a single growing season is one characteristic that makes Palmer amaranth difficult to manage (Keeley et al., 1987). Due to their small size, Palmer amaranth seeds are easily dispersed by wind, water, animal waste, tillage, and farm equipment (Norsworthy et al., 2014). The continued use of herbicide-resistant crops has led to a quicker evolution of herbicide-resistant weed populations and subsequent increased selection pressure on herbicides (Duke and Powles, 2009). The practice of alternating or combining different weed management strategies has been used to reduce herbicide-resistant weed populations caused by repetitive use of herbicides. Cultural practices, such as using cover crops, have shown a 91% reduction in Palmer amaranth emergence due to the high percentage of ground coverage. When zero-tolerance was implemented in a field, Palmer amaranth emergence was reduced by 65% (Barber et al., 2015). Deep tillage using a moldboard plow provided a 69% reduction in Palmer amaranth emergence in cotton (DeVore et al., 2013).

Procedures

A field trial was initiated in 2018 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Center near Marianna, Ark., to evaluate the effect of integrated weed management strategies on Palmer amaranth emergence in a cotton system. Plots measuring 25 ft wide by 120 ft long with 38-in. row spacing were planted with DP 1518 B2XF cotton at a rate of 44,000 seed/ac. In the fall of 2018, a single deep tillage event was made to designated plots. The trial was arranged as a randomized complete block, consisting of 16 treatments and 4 replications. Treatments included combinations of integrated weed management practices (Table 1). Each year following harvest, plots with a cover crop treatment were seeded with cereal rye at 75 lb/ac. The cereal rye cover crop was terminated at least two weeks prior to planting cotton. Herbicide treatments were applied as preemergence, postemergence at 21 days after planting (DAP), postemergence at 42 DAP, and layby at 63 DAP. Herbicide applications were sprayed at 15 gal./ac using a tractor-mounted hooded sprayer and a tractor-mounted post-direct sprayer with hoods. TeeJet® TTI 110015 nozzles were used for dicamba applications, and TeeJet® AIXR 110015 nozzles for non-dicamba applications.

[1] Graduate Assistant, Distinguished Professor, and Assistant Professor/Extension Weed Scientist, respectively, Department of Crop, Soil, and Environmental Sciences, Fayetteville.

Weed counts were taken in four - 1 square meter quadrants per plot at 21, 42, 63, and 77 DAP, and seedcotton yield was taken at crop maturity. Total weed count data averaged over the four-year period were subjected to analysis of variance using JMP Pro 17, and means were separated using Tukey's honestly significant difference ($\alpha = 0.05$).

Results and Discussion

Palmer amaranth emergence was highly variable depending on the management strategy or combination of strategies used. However, all treatments, regardless of the combination of strategies, provided at least a 23% reduction in Palmer amaranth emergence compared to the standard glufosinate-based program (Table 2). When any non-chemical single management strategy was implemented, emergence was reduced by 56% to 63%. The sole use of zero tolerance as an added strategy resulted in 56% less emergence compared to the standard program, showing results similar to those by Barber et al. (2015). Implementing a cover crop provided a 59% reduction in Palmer amaranth emergence. The one-time deep tillage event in 2018 provided a 63% reduction of Palmer amaranth emergence over four years, showing a similar result of a 69% reduction observed over a 2-year period in prior research (DeVore et al., 2012). The dicamba-based program, when used alone, provided a reduction of 75% compared to the standard program.

Combinations consisting of two management strategies provide comparable results when each strategy was used alone except for plow combined with a dicamba-based program or plow combined with zero-tolerance, which provided 94% and 23% reduction in Palmer amaranth emergence, respectively (Table 2). For three-way combinations of a plow, zero-tolerance, and a dicamba-based program; plow, zero-tolerance, and a cover crop; or plow, cover crop, and dicamba-based program, there was ≥85% reduction in Palmer amaranth emergence. However, combining all four management strategies provides a comparable reduction to when a dicamba-based program was used without any other management strategies. Overall, using a deep tillage event plus a dicamba-based program, or deep tillage, cover crop plus a dicamba-based program, had the highest reduction of Palmer amaranth emergence compared to the standard program. Yield data showed no differences between any single or combination of management strategies.

Practical Applications

Currently, Palmer amaranth is resistant to nine modes of action, and the evolution of herbicide resistance continues to convey more challenges for producers trying to manage this troublesome weed. Using different weed management practices alone can aid in controlling Palmer amaranth. However, the integrated use of the strategies can reduce Palmer amaranth emergence and provide multiple means of control. In addition, using multiple means of control will reduce selection for resistance to herbicides without negatively affecting yield.

Acknowledgments

The authors would like to thank Cotton Incorporated for funding this research and the University of Arkansas System Division of Agriculture's Lon Mann Cotton Station for assistance in conducting this research.

Literature Cited

Barber L.T., K.L. Smith, R.C. Scott, J.K. Norsworthy, and A.M. Vangilder (2015) Zero Tolerance-A Community-Based Program for Glyphosate-Resistant Palmer Amaranth Management. University of Arkansas System Division of Agriculture. Publication number FSA2177-PD-3-2015N. 6 pp. Available at: https://www.uaex.uada.edu/counties/lawrence/docs/FSA2177.pdf

DeVore J.D., J.K. Norsworthy, and K.R. Brye. 2013. Influence of deep tillage, a rye cover crop, and various soybean production systems on Palmer amaranth emergence in soybean. Weed Technol. 27:263–270.

Duke S. and S. Powles. 2009. Glyphosate-resistant crops and weeds: now and in the future. Agrobiforum 12:346-357.

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

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.

Palhano M.G., J.K. Norsworthy, and T. Barber. 2018. Cover crop suppression of Palmer amaranth (*Amaranthus palmeri*) in cotton. Weed Technol. 32:60–65.

Van Wychen L. 2022. 2022 Survey of the most common and troublesome weeds in broadleaf crops, fruits & vegetables in the United States and Canada. Weed Science Society of America National Weed Survey Dataset. Accessed 20 February 2023. Available at: https://wssa.net/wssa/weed/surveys/

Table 1. Herbicide programs with common names, application rates, and application timing.

	Dicamba program		Standard program	
Timing	**Common name**	**Rate**	**Common name**	**Rate**
		(lb ai/ae)		**(lb ai/ae)**
Burndown	glyphosate	1.1	glyphosate	0.6
	dicamba	0.5	dicamba	0.5
PRE	dicamba	0.5	paraquat	0.6
	fluometuron	1.0	fluometuron	1.0
21 DAP	dicamba	0.5	glufosinate	0.6
	S-metolachlor	1.0	*S*-metolachlor	1.0
	glyphosate	1.0	glyphosate	1.0
42 DAP	glufosinate	0.6	glufosinate	0.6
	glyphosate	1.1	glyphosate	1.1
	acetochlor	1.1	acetochlor	1.1
Layby	flumioxazin	0.06	flumioxazin	0.06
	MSMA	2.0	MSMA	2.0

[†] Abbreviations: PRE = preemergence; DAP = days after preemergence.

Table 2. Weed management strategies and their effect on Palmer amaranth emergence and cotton yield.

Management strategy	Reduction of PA[†]	Yield
	(%)	(lb/ac)
std	--	1,697
dic	75 f[‡]	1,659
cc	59 cd	1,683
plow	63 d	1,621
ztol	56 c	1,543
dic + cc	68 e	1,715
plow + cc	77 f	1,704
plow + dic	94 j	1,608
plow + ztol	23 b	1,553
ztol + cc	61 cd	1,580
ztol + dic	82 g	1,512
plow + cc + dic	94 j	1,651
plow + ztol + cc	85 gh	1,533
plow + ztol + dic	87 hi	1,459
ztol + cc + dic	75 f	1,618
plow + ztol + cc + dic	89 i	1,643

† Abbreviations: PA = Palmer amaranth; std = standard program; dic = dicamba-based program; cc = cover crop; plow = deep tillage; ztol = zero-tolerance.

‡ Means within a column followed by the same letter are not different according to Tukey's honestly significant difference (α = 0.05).

Sensitivity of 2021 Palmer amaranth Accessions from Arkansas to Dicamba, 2,4-D, and Glufosinate

M.C.C.R. Souza,[1] J.K. Norsworthy,[1] P. Carvalho-Moore,[1] M.L. Zaccaro-Gruener,[1] L.B. Piveta,[1] L.T. Barber,[2] and T.R. Butts[2]

Abstract

The use of Enlist®, XtendFlex®, and LibertyLink® cropping systems are effective tools to facilitate weed management in cotton (*Gossypium hirsutum* L.). These technologies enable farmers to use 2,4-D, dicamba, or glufosinate over the top of cotton in season. However, the incidence of Palmer amaranth (*Amaranthus palmeri* S. Wats.) escapes demonstrates the importance of surveilling the spread of herbicide resistance. Therefore, this study aimed to evaluate herbicide resistance in Palmer amaranth accessions collected after glufosinate and auxin mimic herbicides (2,4-D or dicamba) were applied for weed control. A total of 22 accessions from eastern Arkansas were collected in the 2021 growing season. Herbicide treatments were equivalent to 0.5× or 1× rate of 2,4-D (Enlist One®) at 0.48 and 0.95 lb ae/ac, dicamba (XtendiMax®) at 0.25 and 0.5 lb ae/ac, and glufosinate (Liberty®) at 0.29 and 0.58 lb ai/ac, respectively. All treatments were applied to greenhouse-grown Palmer amaranth plants with 5 to 6 leaves, and 2 runs of 50 plants per accession were sprayed per treatment. Plant mortality (%) was assessed 21 days after treatment. Treatments with 2,4-D, dicamba, and glufosinate at 0.5× resulted in 80% or less mortality to 18, 13, and 6 accessions, respectively. Treatments with a 1× rate provided more than 80% control to all accessions treated with dicamba; meanwhile, only 18 and 21 accessions treated with 2,4-D and glufosinate, respectively, resulted in the same level of mortality. 2 accessions that resulted in less than 60% mortality after treatment with a 1× rate of 2,4-D were further evaluated, and resistance to 2,4-D was confirmed. These findings demonstrate the importance of monitoring weed survival in production fields. Implementing integrated weed management strategies to reduce selective pressure over current herbicide options could help mitigate herbicide resistance cases.

Introduction

The development of genetically engineered crops such as Enlist® (Corteva Agriscience, Indianapolis, Ind.), XtendFlex® (Bayer CropScience, Pittsburgh, Pa.), and LibertyLink® (BASF, Florham Park, N.J.) cropping systems enable farmers to spray 2,4-D, dicamba, or glufosinate over the top during the season, contributing to weed management. However, the recurrent use of these herbicides can lead to the evolution of herbicide-resistant weeds. For instance, Palmer amaranth (*Amaranthus palmeri* S. Wats.) resistance to 2,4-D, dicamba, and glufosinate was recently confirmed in some U.S. states (Heap, 2023; Jones, 2022; Kumar et al., 2019; Priess et al., 2022; Foster and Steckel, 2022). Palmer amaranth is currently the most problematic weed for agronomic crops in the U.S. (Wychen, 2022).

Palmer amaranth resistance to 2,4-D was first reported in Kansas in 2015 (Kumar et al., 2019), followed by the confirmation of the first case of dicamba resistance in Tennessee in 2020 (Foster and Steckel, 2022). Furthermore, Palmer amaranth is the first and only broadleaf weed resistant to glufosinate, and resistance to this herbicide was first reported in Arkansas in 2020, followed by North Carolina in 2022 (Heap, 2023; Jones, 2022; Priess et al., 2022). In addition, Palmer amaranth is resistant to herbicides targeting seven other sites of action, making this weed extremely hard to control (Heap, 2023). The high occurrence of Palmer amaranth resistance to herbicides is partly due to the outcrossing nature of this species. Its pollen grains can be dispersed over long distances, spreading adaptative characteristics such as herbicide resistance (Ward et al., 2013).

Due to the current herbicide resistance scenario of Palmer amaranth, it is necessary to monitor the fields that regularly use foundational herbicides to assess their efficacy over time. Therefore, this study aimed to assess the sensitivity to 2,4-D, dicamba, and glufosinate in Palmer amaranth accessions collected in 2021 from Arkansas cotton (*Gossypium hirsutum* L.), rice (*Oryza sativa* L.), and soybean [*Glycine max* (L.) Merr.] fields.

Procedures

Palmer amaranth seeds from 22 accessions that were escapes from weed management programs were collected

[1] Graduate Assistant, Distinguished Professor, Senior Graduate Assistant, Senior Graduate Assistant, and Research Scientist, respectively, Department of Crop, Soil, and Environmental Sciences, Fayetteville.
[2] Professor and Assistant Professor, respectively, Department of Crop, Soil, and Environmental Sciences, Lonoke.

from cotton, rice, and soybean fields in eastern Arkansas at the end of the 2021 growing season. Areas targeted in this survey had a history of utilizing herbicide programs, including 2,4-D, dicamba, or glufosinate. Seeds were planted and seedlings transplanted 5 to 7 days after emergence to 50-cell trays (Plug tray 50 Square, 21 by 11.5 in.; Hummert International, Earth City, Mo.) filled with potting soil (Sun Gro Horticulture, Seba Beach, Alberta, Canada). When seedlings reached the 5- to 6-leaf stage and were approximately 3 to 4 in. tall, the 2,4-D, dicamba, or glufosinate treatments were applied at a 0.5 and 1× rate. The 1× rate was equivalent to 0.95 lb ae/ac of 2,4-D (Enlist One® Corteva Agriscience, Indianapolis, Ind.), 0.5 lb ae/ac of dicamba (XtendiMax® with VaporGrip®, Bayer CropScience, St. Louis, Mo.), and 0.58 lb ai/ac of glufosinate (Liberty® 280 SL, BASF Corporation, Research Triangle Park, N.C.). Herbicides were sprayed in a spray chamber using 2 1100067 nozzles at 1 mph calibrated to deliver 20 gal/ac. Each herbicide rate was applied in 2 runs of 50 plants per accession. The number of alive and dead plants was collected 21 days after treatment (DAT), and mortality was calculated using Equation 1. Mortality data were used to generate box and whisker plots using JMP Pro 16.2 (SAS Institute Inc., Cary, N.C.). Outliers recognized by the analysis would need further assessment to determine whether resistance to either herbicide had occurred.

$$\text{Mortality} = 100 \times \left(\frac{\text{Initial number of plants} - \text{Number of plants alive}}{\text{Initial number of plants}}\right)$$

Eq. 1

Results and Discussion

There were substantial differences in Palmer amaranth sensitivity among accessions to the three herbicides tested (Fig. 1). Herbicide treatments at the 0.5× rate averaged 65%, 78%, and 88% mortality for 2,4-D, dicamba, and glufosinate, respectively. At the 1× rate, the average mortality increased to 86%, 96%, and 98% for 2,4-D, dicamba, and glufosinate, respectively. In a similar study, Zaccaro-Gruener et al. (2021) reported 93% and 88% mortality rates associated with 1× rates of dicamba and glufosinate, respectively. Compared to this previous study, we found comparable sensitivity of accessions to dicamba at a 1× rate but higher sensitivity of plants treated with glufosinate. Overall, treatments with 2,4-D, dicamba, and glufosinate at 0.5× resulted in 80% or less mortality to 18, 13, and 6 accessions, respectively. Treatments with a 1× rate provided more than 80% control to all accessions treated with dicamba, while 18 and 21 accessions treated with 2,4-D and glufosinate resulted in the same level of mortality, demonstrating that these herbicides are still effective in controlling Palmer amaranth.

Evaluations of Palmer amaranth mortality at 1× rate of 2,4-D resulted in two accessions with low mortality (outliers) having 54% and 59%, respectively (Fig. 2). Low mortality at a 1× rate usually indicates herbicide resistance. Further studies were conducted in 2022, confirming that these two accessions were resistant to 2,4-D due to metabolism enhancement (Hwang et al., 2023). At a 1× rate, glufosinate also displayed some outliers (Fig. 2). However, all the accessions tested exhibited at least 80% mortality.

These findings demonstrate the importance of regularly monitoring fields that are treated with herbicides such as 2,4-D, dicamba, and glufosinate to identify developing herbicide resistance. In addition, this is a necessary approach to assist the implementation of integrated weed management strategies in reducing selective pressure over current herbicide options.

Practical Applications

It is essential to monitor potential problematic accessions that might spread herbicide resistance. The findings in this study indicate that field escapes are a concern for the sustainability of these herbicides and associated technologies. A joint effort from researchers, consultants, and farmers is necessary to help mitigate the spread of herbicide resistance and avoid new cases. Developing and applying weed management tactics focused on incorporating non-chemical and chemical approaches might be a valuable alternative to reduce reliance on herbicides and prevent the development of herbicide resistance.

Acknowledgments

The authors would like to express appreciation for the support of this research by the United Soybean Board. Support is also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Foster, D.C. and L.E. Steckel. 2022. Confirmation of dicamba-resistant Palmer amaranth in Tennessee. Weed Technol. 36:777-780.

Heap, I. 2023. The International Herbicide-Resistant Weeds. Accessed 15 February 2023. Available at: https://www.weedscience.org/home.aspx

Hwang, J.I., J.K. Norsworthy, L.B. Piveta, M.C.C.R. Souza, L.T. Barber, and T.R. Butts. 2023. Metabolism of 2, 4-D in resistant Amaranthus palmeri S. Wats. (*Palmer amaranth*). Crop Protection 165:106169.

Jones, E.A.L. 2022. Glufosinate Resistance in North Carolina and the Development of a Rapid Assay to Confirm the Evolution of Glufosinate-resistant Weeds. Ph.D. dissertation. Raleigh, NC: North Carolina State University. 202 pp.

Kumar,V., R. Liu, G. Boyer, and P.W. Stahlman. 2019. Confirmation of 2, 4-D resistance and identification of multiple resistance in a Kansas Palmer amaranth (*Amaranthus palmeri* S. Wats.) population. Pest Manag. Sci 75:2925-2933.

Priess, G.L., J.K. Norsworthy, N. Godara, A. Mauromoustakos, T.R. Butts, T.L. Roberts, and T. Barber. 2022. Confirmation of glufosinate-resistant Palmer amaranth and response to other herbicides. Weed Technol. 36:368-372.

Wychen, V.L. 2022. Survey of the most common and troublesome weeds in broadleaf crops, fruits, and vegetables in the United States and Canada. Weed Science Society of America national weed survey dataset. Accessed 15 February 2023. Available at: https://wssa.net/wssa/weed/surveys/

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

Zaccaro-Gruener, M.L., J.K. Norsworthy, L.B. Piveta, M.M. Houston, T.R. Butts, and L.T. Barber. 2021. Evaluations of Palmer amaranth susceptibility to dicamba and glufosinate. *In*: J. Ross (ed.) Arkansas Soybean Research Studies 2020. Arkansas Agricultural Experiment Station Research Series 680:172-177. Fayetteville.

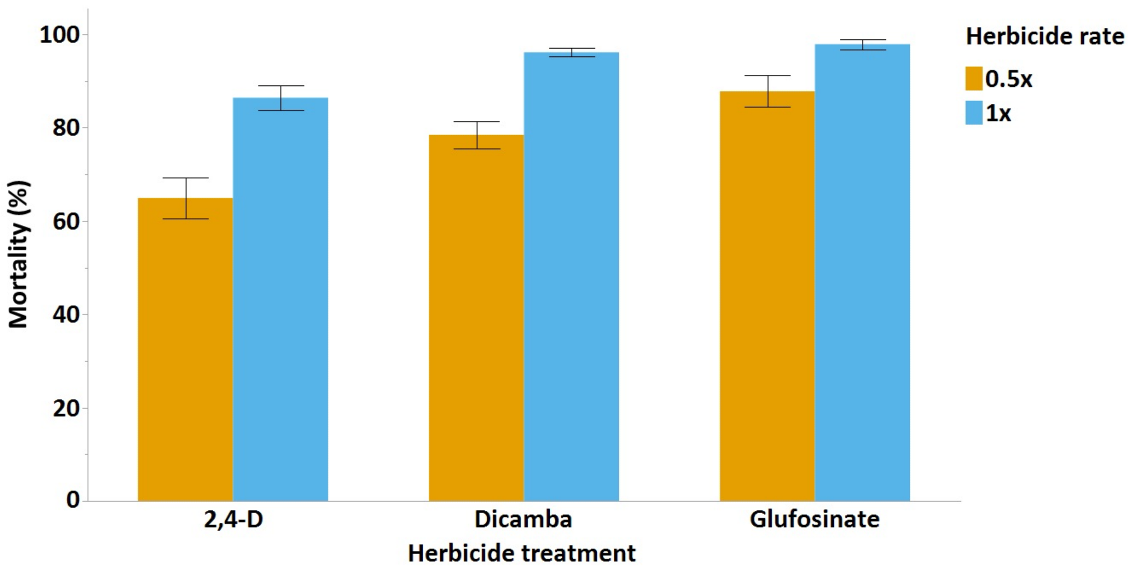

Fig. 1. Average mortality (%) across 22 Palmer amaranth (*Amaranthus palmeri* S. Wats.) accessions treated with 2,4-D, dicamba, or glufosinate at 0.5× or 1× rates (orange and blue bars, respectively) at 21 days after treatment. Error bars were calculated based on one standard error of the means.

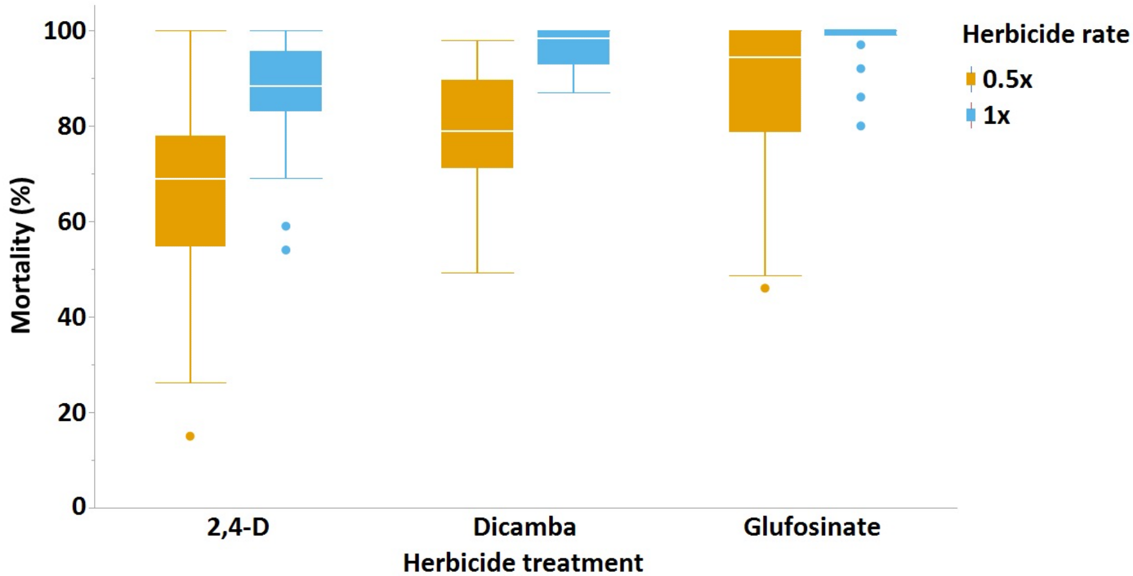

Fig. 2. Distribution of mortality (%) of 22 Palmer amaranth (*Amaranthus palmeri* S. Wats.) accessions treated with 2,4-D, dicamba, or glufosinate at 0.5× or 1× rates (orange and blue bars, respectively) at 21 days after treatment. Boxes represent the 50% quartile, the line is the median value, and the points represent the outliers.

Response of Target Spot to Foliar Fungicide Application on Cotton

T. Spurlock,[1] R. Zaia,[2] A. Rojas,[2] and R. Hoyle[1]

Abstract

Foliar fungicide trials were established at ten locations in southeast Arkansas from 2020–2022. The objectives of the work were to determine the diseases that impacted cotton in southeast Arkansas, yield losses associated with these diseases, and the value of foliar fungicides applied. Trials were arranged in a randomized complete block design, with each fungicide treatment replicated three times and a non-treated control included in each replication. Each treatment block was 36 rows wide and extended the length of the field. Treatments at each location were Miravis Top applied at 13.6 fl oz/ac, and Priaxor applied at either 6 or 8 fl oz/ac in 10 gal of carrier water volume with a ground-driven sprayer. The levels of foliar diseases were determined at the time of fungicide application (approximately the fourth week of flowering) and again prior to defoliation. Yield data were provided by the farmers' yield monitors on the cotton picker. Across years, target spot was present in all trials, and yield differences by fungicide treatment were found in seven of nine trial locations. This indicates target spot is a significant problem in southeastern Arkansas. Further, we learned that disease rating data did not always result in the nontreated having more target spot than the fungicide-applied plots due to the diseases' ability to rapidly defoliate susceptible varieties.

Introduction

Corynespora leaf spot, or target spot, of cotton is caused by *Corynespora cassiicola* (Berk. & M.A. Curtis) C.T. Wei, which has recently emerged as a yield-limiting disease across the southeastern U. S. (Sumabat et al., 2018; Mehl et al., 2020). Several publications reported the first occurrence and the re-emergence of the disease in North America, including Florida, Georgia, Virginia, Tennessee, Mississippi, Louisiana, and Alabama (Mehl et al., 2020). Target spot incidence and severity have been increasing, especially in soybean and cotton, possibly due to monoculture farming or cotton and soybean rotations. When moderate to severe, target spot causes premature defoliation of cotton leaves and significant yield losses if not properly controlled (Sumabat et al., 2018; Bowen et al., 2018; Bradley et al., 2021). An example of severe target spot can be seen in Fig. 1.

Procedures

The study was conducted over a period of 3 years, with field trials established on cooperating farmers' fields at 10 locations in southeast Arkansas beginning in 2020 (Fig. 2). Cotton was planted within the normal plating date range and was managed according to the farmer regarding the use of herbicides, fertility, insecticides, plant growth regulators, and defoliation of the cotton crop.

In all trials, treatments were arranged in a randomized complete block design, planted on 38-in. rows with each fungicide treatment replicated three times. A nontreated control and two fungicides were evaluated: pydiflumetofen + difenoconazole (as Miravis Top applied at 13.6 fl oz/ac, Syngenta Crop Protection) and fluxapyroxad + pyraclostrobin (as Priaxor applied at 6.0 fl oz/ac in 2021 and 2022, and 8.0 fl oz/ac in 2020, BASF Corporation). Fungicide treatments were applied to the field at approximately the third or fourth week of flowering with a 30-ft boom mounted on a ground-driver sprayer in a total water volume of 10 gal/ac at 40 psi using TeeJet XR11002VS tips at 5.0 mph.

To determine the amount of target spot present in each treatment block, five points were georeferenced approximately equidistant throughout each block. Disease severity was based on visual observations where 0 = no disease and 9 = severe disease. Data were collected at an approximate 5 ft radius around each point. Diseases were assessed at the time of fungicide applications and just prior to defoliation. Cotton was harvested with a commercial picker, and yield was adjusted to the 33% turnout for comparison. Disease ratings were treated as ordinal data and rank transformed prior to analysis of variance (ANOVA). Georeferenced yield and disease data were buffered within each treatment block, cleaned, and subjected to ANOVA. For both disease data and yield data, means separations were completed using Tukey's honestly significant difference test at $P = 0.05$.

Results and Discussion

There was a significant yield response to fungicide treatment in 7 of 9 locations across all years (Table 1). Yield data were collected from all locations except Marvel in 2020. Tar-

[1] Associate Professor and Research Technician, respectively, Department of Entomology and Plant Pathology, Monticello.
[2] Graduate Student and Assistant Professor, respectively, Department of Entomology and Plant Pathology, Fayetteville.

get spot was generally more severe in the nontreated plots. However, due to rapid blighting and leaf drop in the nontreated plots, a single disease assessment did not always capture differences in target spot severity among the treatments. At times, there was numerically more target spot in the fungicide-treated plots at the time of disease rating. Therefore, more frequent disease assessments are planned for future trials. Overall, the fungicide treatments were observed to provide yield protection in the current study, where both products provided acceptable control.

Practical Applications

The results from this work agree with other studies (Bowen et al., 2018; Mehl et al., 2019), suggesting that the use of fungicides can provide yield protection and add value to the crop where target spot is moderate to severe. In southeast Arkansas, it is now evident that scouting for target spot and sometimes applying a foliar fungicide is necessary to protect the crop. However, the results of this study do not justify applications of fungicides in every field situation.

Acknowledgments

We thank the cooperating farmers for providing a field location for these trials and the Arkansas Cotton State Support Board and Cotton Incorporated for generously providing funding for this project. We also thank cooperating Arkansas County Extension Agents for assistance with the trials. Specifically, Robert Goodson, Phillips County (retired); Kevin Norton, Ashley County; Kurt Beatty, Chicot County; John David Farabaugh, Desha County; Scott Hayes, Drew County; and Clay Gibson (formerly of Chicot County). Support is also provided by the University of Arkansas System Division of Agriculture.

Literature Cited

Bowen, K.L., A.K. Hagan, M. Pegues, J. Jones, and H.B. Miller. 2018. Epidemics and yield losses due to *Corynespora cassiicola* on cotton. Plant Dis. 102:2494–2499.

Bradley, C.A., T.W. Allen, A.J. Sisson, G.C. Bergstrom, K.M. Bissonnette, J. Bond, et al. 2021. Soybean Yield Loss Estimates Due to Diseases in the United States and Ontario, Canada, from 2015 to 2019. Plant Health Prog. 22:483–495.

Mehl, H.L., N.S. Dufault, T.W. Allen, A.K. Hagan, P. Price, R.C. Kemerait, et al. 2020. Multiyear regional evaluation of foliar fungicide applications for cotton target spot management in the southeastern United States. Plant Dis. 104:438–447.

Sumabat, L.G., R.C. Kemerait, and M.T. Brewer. 2018. Phylogenetic diversity and host specialization of *Corynespora cassiicola* responsible for emerging target spot disease of cotton and other crops in the southeastern United States. Phytopathology. 108:892–901.

Table 1. Summary of results from three years of on-farm fungicide trials in Arkansas.

Year	Location (nearest town)	Application Date	Treatment Response to Target spot	Average Yield (lb/lint)
2020	Kelso	13 July	NS	1632
2020	Wilmont	21 July	***	1156*
2020	Marvel	16 July	NS	NA
2021	Kelso	4 August	*	1591 *
2021	Parkdale	9 August	*	1048 ***
2021	Montrose	12 August	NS	1491
2022	Monticello	18 July	*	1367 ***
2022	Kelso	20 July	NS	1611 ***
2022	Parkdale	25 July	NS	1302 ***
2022	Halley	25 July	NS	1307***

*P = 0.05, **P = 0.01, ***$P \leq 0.001$, NS = not significantly different, NA = not available.

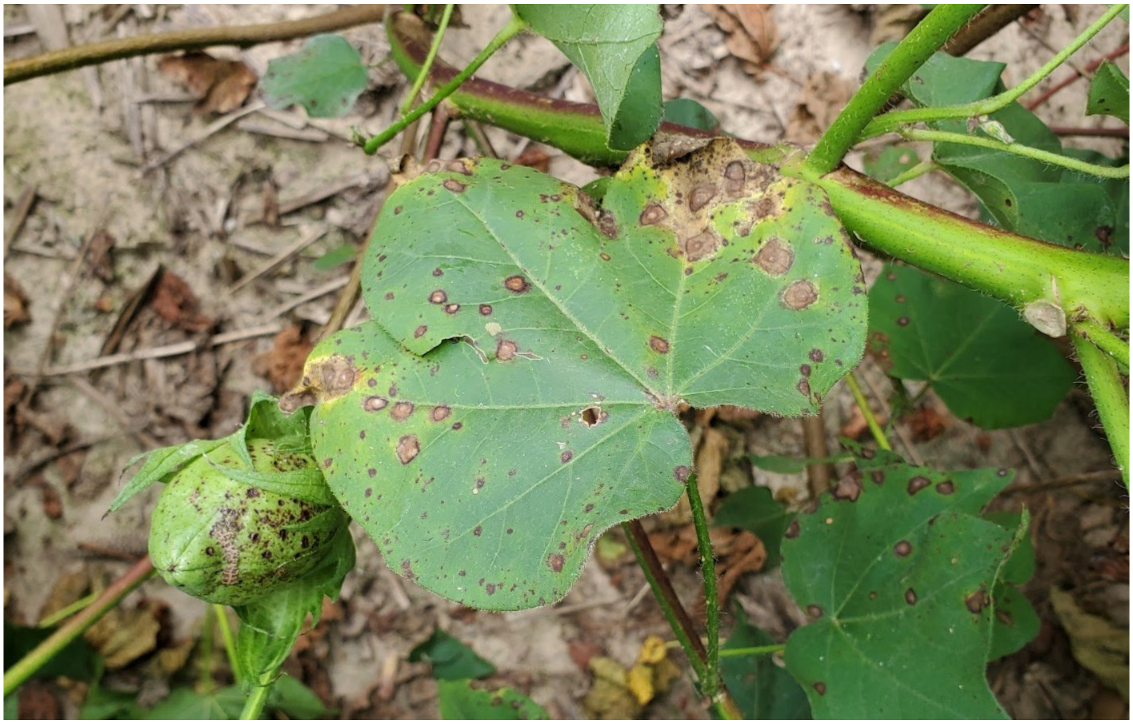

Fig. 1. Severe target spot on a susceptible cotton variety.

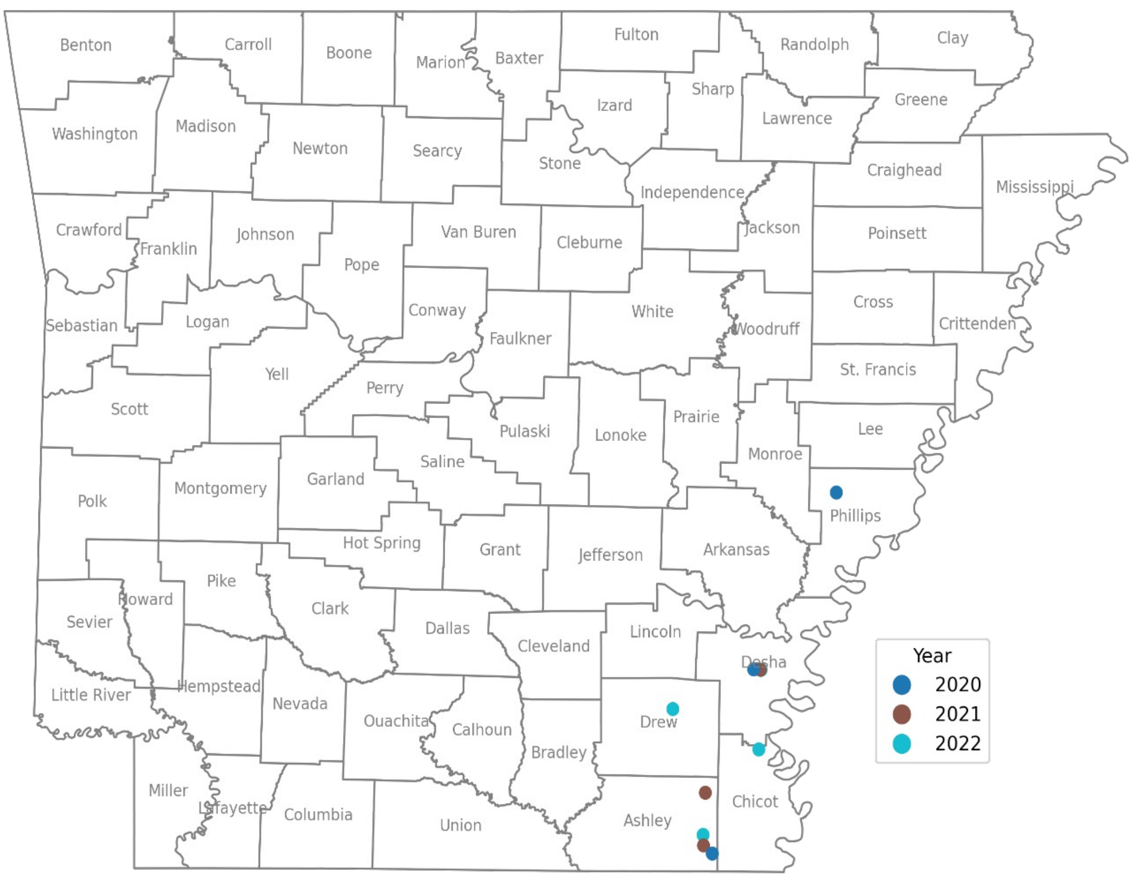

Fig. 2. Cotton fungicide trial locations in 2020, 2021, and 2022.

Management of Tobacco Thrips With In-Furrow and Foliar Insecticides in Northeast Arkansas

G.E. Studebaker[1] and M. Mann[1]

Abstract

Tobacco thrips are an important pest of cotton early season that may cause stand loss, yield loss, and delays in maturity. Two separate field trials were conducted at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser, Arkansas, in 2022, evaluating the efficacy of insecticide seed treatments, in-furrow insecticides, and foliar insecticides for tobacco thrips in cotton. Imidacloprid as an in-furrow spray or seed treatment and Ag Logic provided protection for seedlings for up to 25 days after planting. Intrepid Edge, Radiant, Orthene at 0.52 lb/ac, Bidrin, and ISM-555 provided protection from thrips for up to 11 days after application as foliar treatments. ISM-555 also provided protection for up to 15 days after application.

Introduction

Tobacco thrips, *Frankliniella fusca*, are one of the more damaging insect pests of seedling cotton in Arkansas, infesting 100% of the cotton acreage each year (Cook, 2021). Thrips damage seedling cotton by feeding in the terminal, which results in crinkled leaves and reduced leaf area. Heavy feeding often results in delayed maturity and sometimes can cause stand loss. The majority of cotton growers utilize either an insecticide seed treatment or in-furrow insecticide as a preventative measure to manage thrips on seedling cotton. However, at-planting preventative measures can be overwhelmed by high populations and may require a foliar insecticide to maintain control. The University of Arkansas recommends a foliar insecticide when thrips numbers reach two to five per plant and damage is evident (Studebaker, 2022). The objective of these studies was to evaluate the efficacy of at-planting as well as foliar insecticides for management of tobacco thrips in cotton.

Procedures

Two separate field trials were planted on 12 May 2022 at the University of Arkansas System Division of Agriculture's Northeast Research and Extension Center, Keiser, Arkansas. The first trial was used to evaluate the efficacy of at-planting insecticides, while the second was to evaluate foliar-applied insecticides against tobacco thrips. Research plots were four rows on 38 in. centers by 40 feet long arranged in a randomized complete block design with four replications in both trials.

For the at-planting insecticide trial, granular insecticide treatments were applied into the seed furrow in front of the press wheel at planting. The in-furrow spray (IFS) treatments were applied in a volume of 5 gpa, with the spray directed into the seed furrow ahead of the press wheel. Thrips numbers were evaluated at 19, 25, 33, and 39 days after planting. Samples were collected by selecting five plants per plot at random, clipping the plants, and placing them in a jar containing a 70% alcohol solution. Samples were then washed, filtered, and counted under a dissecting microscope. The foliar insecticide trial was sprayed at second true leaf with a high clearance small plot sprayer. Insecticides were applied at a volume of 10 GPA through two TX6 hollow cone nozzles per row. Plots were evaluated for thrips at 4, 7, 11, and 15 days after application in the same manner as the at-planting insecticide trial. All data were analyzed using Agriculture Research Manager Version 10, analysis of variance, and Duncan's New Multiple Range Test ($P = 0.05$) for mean separation.

Results and Discussion

Thrips numbers were generally low at the beginning of the at-planting insecticide study, with only an average of 8.2 thrips per five plants in the untreated plots 19 days after planting (Table 1). However, numbers substantially increased to over 50 per five plants by 25 days after planting. At 25 days, only the Aeris, AgLogic, Orthene + Gaucho, and Admire Pro treatments had significantly reduced thrips numbers, with Admire Pro also being significantly lower than all other treatments. Admire Pro was also the only treatment providing protection at 33 days after planting.

Results for the foliar insecticide trial are reported in Table 2. All insecticides, with the exception of Intrepid Edge and Dimethoate, significantly reduced thrips numbers at four days after application. However, by seven days, the Intrepid Edge was significantly better than the untreated check. By 11 days after treatment, all insecticides were significantly lower than

[1] Professor and Program Associate, respectively, Department of Entomology and Plant Pathology, Northeast Research and Extension Center, Keiser.

the untreated plots with the exception of Dimethoate and Orthene at 0.21 lb/ac. The experimental product, ISM-555, was the only treatment that was still significantly lower than the untreated plots 15 days after application.

From both studies, it appears that Orthene, as an at-planting option and as a foliar, does not give adequate control. In the foliar trial, the high rate of Orthene does appear to still be effective. The neonicotinoid seed treatments Ag Logic and Admire Pro IFS appear to be good at-planting options for thrips management. Intrepid Edge, Radiant, Orthene at the higher rate, and ISM-555 are good foliar insecticide options for thrips management. ISM-555 appears to be the best foliar option giving significant protection from thrips for up to 15 days after application.

Practical Applications

Tobacco thrips have historically been an important pest of cotton and will likely continue to be in the future. Although resistance to certain neonicotinoid insecticides has been an issue in the past, it appears that imidacloprid is still a viable option for thrips management. When foliar insecticides become necessary, growers also have workable options for thrips control with Intrepid Edge and Radiant but should consider using higher rates if using Orthene (acephate).

Acknowledgments

The authors would like to thank the University of Arkansas System Division of Agriculture, Cotton Incorporated, and Syngenta for providing support to conduct these studies.

Literature Cited

Cook, D.R. 2021. Cotton insect loss estimates for Arkansas. pp. 145-200. In: Proc. Beltwide Cotton Prod. Res. Conf., San Antonio, TX. National Cotton Council, Memphis, Tenn.

Studebaker, G.E (ed.). 2022. Cotton insect control. pp. 74-84. In: Insecticide Recommendations for Arkansas - MP144. Little Rock, AR. University of Arkansas System Division of Agriculture Cooperative Extension Service.

Table 1. Total number of tobacco thrips per five cotton plants sampled from insecticide seed treatments and in-furrow insecticides at various timings in northeast Arkansas in 2022.

		Days After Planting			
Treatment	**Rate**	**19**	**25**	**33**	**39**
Untreated		8.2 a‡	52.6 a	18.9 ab	39.9 a
Orthene 97 S	6.4 oz/cwt	6.4 ab	47.0 a	25.6 a	23.8 ab
Orthene 97 S + Gaucho 5 FS	6.4 oz/cwt 0.375 mg ai/seed	2.4 abc	21.7 abc	10.3 bc	23.8 ab
Gaucho 5 FS	0.375 mg ai/seed	1.4 bc	20.1 abc	8.3 bc	38.7 a
Aeris	0.75 mg ai/seed	0.6 c	11.0 c	9.2 bc	21.6 ab
Ag Logic 15 G	4 lb/ac	1.2 bc	17.8 bc	6.2 bc	24.0 ab
Orthene 97 S + Gaucho 5 FS	1 lb/ac IFS† 0.375 mg ai/seed	1.0 bc	11.7 c	7.8 bc	7.5 b
Orthene 97 S	1 lb ac IFS†	1.5 bc	33.0 abc	7.5 bc	11.5 ab
Admire Pro 4.6 F	9.2 fl oz/ac IFS†	0.3 c	0.6 d	1.4 c	11.3 ab

† IFS denotes in-furrow spray application.

‡ Means followed by the same letter are not significantly different at $P = 0.05$.

Table 2. Total number of tobacco thrips per five cotton plants sampled from foliar insecticide treatments at 4, 7, 11, and 15 days after application in northeast Arkansas in 2022.

		Days After Application			
Treatment[†]	**Formulation/ac**	**4**	**7**	**11**	**15**
Untreated		43.4 a[‡]	51.4 a	44.9 a	16.5 ab
Intrepid Edge	3 fl oz	34.5 ab	9.1 b	7.6 cd	15.5 ab
Orthene 97 S	0.21 lb	10.3 c	30.6 a	24.3 ab	13.5 ab
Orthene 97 S	0.52 lb	18.9 bc	14.8 b	14.3 bc	12.5 ab
Bidrin 8 EC	3.2 fl oz	6.7 c	30.6 a	14.0 bc	6.8 bc
Dimethoate 4 EC	6.4 fl oz	34.2 ab	42.0 a	28.8 ab	21.8 a
Radiant 1 SC	1.5 fl oz	8.5 c	8.4 b	6.6 cd	19.3 a
ISM 555 SC	1.03 fl oz	6.0 c	9.5 b	2.1 d	1.8 c

† All insecticide treatments were applied with a 0.25% non-ionic surfactant.

‡ Means followed by the same letter are not significantly different at *P* = 0.05.

Evaluation of ThryvOn Technology for Control of Tobacco Thrips in Cotton

A. Whitfield,[1] B.C. Thrash,[2] N.R. Bateman,[3] S.G. Felts,[3] W.A. Plummer,[2] T. Newkirk,[1] Z. Murray,[1] and T. Harris[1]

Abstract

Tobacco thrips are one of the most important pests in mid-South cotton production. Thrips are a pest of seedling cotton, feeding on the leaf tissue of plants which can result in stunted growth, delayed fruiting, loss of apical dominance, and possible stand loss. Field studies were conducted in 2021 and 2022 to evaluate ThryvOn, a new transgenic trait in cotton that produces the *Bt* toxin Cry51Aa, for control of tobacco thrips. ThryvOn cotton was tested at three Arkansas locations, Marianna, Tillar, and Keiser. The trials evaluated thrips control on ThryvOn vs. non-ThryvOn cotton and the effect of insecticide seed treatments on ThryvOn cotton. ThryvOn cotton had significantly fewer thrips and less injury than non-ThryvOn cotton. Results from this study indicate that ThryvOn has the potential to be a valuable tool for thrips management.

Introduction

Tobacco thrips, *Frankliniella fusca*, are the most important pests of seedling cotton in Arkansas. One hundred percent of cotton acres in Arkansas are infested with thrips (Cook, 2019). Feeding injury on cotton seedlings causes ragged and crinkled leaves, a silver or whitish appearance, and the size of the first true leaf can be greatly reduced. Thrips feeding injury can result in stunted growth, delayed fruiting, loss of apical dominance, and possible stand loss. In Arkansas, cotton producers will typically use an insecticide seed treatment or an insecticide applied in-furrow at planting to help manage thrips. Additionally, growers are frequently required to apply a foliar insecticide to successfully manage tobacco thrips. Because of this, mid-South cotton producers are seeking alternative methods of control that offer season-long protection. ThryvOn technology is the first cotton biotech trait that will provide season-long protection against tarnished plant bug and thrips species and will reduce the need for some insecticide applications. Currently, researchers have established an action threshold of 2–5 thrips per plant with damage present for thrips management. The objective of this study was to evaluate ThryvOn technology for the control of tobacco thrips.

Procedures

Experiments were conducted in 2022 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station located in Marianna, Arkansas (Marianna), on a grower field in Tillar, Arkansas (Tillar), and the Northeast Research and Extension Center in Keiser, Arkansas (Keiser). Prior to planting, seeds were treated with a fungicide seed treatment at a standard recommended rate. Trials were planted on 11 May at Marianna, 18 May at Tillar, and on 20 May at Keiser. Treatments were ThryvOn (DP 2131 B3TXF) and non-ThryvOn (DP 2055 B3XF) cotton. The cultivars are not isogenic. Both cultivars were treated with Acceleron Elite insecticide seed treatment. At each location, a non-replicated strip trial was conducted with plot size being 37.5 ft. (12 rows) by 600 ft. Thrips samples were collected at 2 to 3 true leaf in a quart mason jar containing a 70% alcohol solution with 4 samples randomly taken per plot on the same day and 5 plants per sample. In 2022, whole-plot visual ratings of thrips injury were taken at the 1-2 and 3-4 leaf stages. Thrips ratings were on a 0–5 scale, with 0 representing no injury to any plant in the plot and 5 representing no living plants in the plot. Samples were washed and filtered, and thrips were counted using a dissection microscope.

In the second test, plots were planted on 27 May at the Lon Mann Cotton Research Station; Thryvon cotton was compared with and without AgLogic (aldicarb). Plot sizes were 12.5 ft (4 rows) by 50 ft with 4 replications per treatment. Treatments included a Thryvon (DP 2131 B3TXF) and non-Thryvon (DP 2055 B3XF) cotton cultivars, with each containing an untreated check, 3.5 lb/ac AgLogic in-furrow, 5 lb/ac AgLogic in-furrow and Gaucho insecticide in combination with the two cotton cultivars for a total of eight treatments. All treatments had a base fungicide seed treatment. On 15 June, thrips samples were collected in a jar with 70% alcohol solution, and 4 samples were taken per plot (5 plants per sample) at 2 to 3 true leaf. Samples were washed and

[1] Graduate Assistant, Graduate Assistant, Graduate Assistant, and Graduate Assistant, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Lonoke.
[3] Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Stuttgart.

filtered, and thrips were counted using a dissection microscope. A damage rating was also collected, with a damage rating ranging from 0 (good) to 5 (bad). Once cotton reached desirable moisture, plots were mechanically harvested using a two-row research cotton picker to determine seedcotton yield. All data were processed using Agriculture Research Manager Version 10, AOV, and Duncan's New Multiple Range Test ($P = 0.10$) to separate means.

Results and Discussion

Non-ThryvOn cotton seedlings had a greater number of total thrips when compared to ThryvOn cotton seedlings at all locations. Due to a late planting date, thrips density was higher at the Tillar location, where non-ThryvOn cotton had 183 thrips/5 plants while the ThryvOn had 25.25 total thrips/5 plants (Fig. 1). At Marianna in 2022, non-ThryvOn cotton had 197 thrips/5 plants while the ThryvOn had a total of 58 thrips/5 plants (Fig. 2). At Keiser in 2022, non-ThryvOn cotton had 103 thrips/5 plants while the ThryvOn had 27 total thrips/5 plants (Fig. 3). For thrips injury, non-ThryvOn cotton had more thrips injury with a rating of 2.1, than ThryvOn cotton, 0.6, meaning thrips injury on ThryvOn cotton was reduced by 71.4% when compared to non-Thryvon cotton (Fig. 4).

In the second test, all products reduced damage in the non-ThryvOn and ThryvOn cultivar when compared to the untreated cultivars (Fig. 5). All ThryvOn treatments had lower damage ratings than the untreated and treated non-ThryvOn cotton. Adult thrips numbers were greater in the treated and untreated non-ThryvOn plots than all other treatments (Fig. 6). Thrips nymph densities were lower in the untreated and treated ThryvOn cotton than their respective treatments in the non-ThryvOn cotton. No treatment improved ThryvOn or non-ThryvOn cotton yields (Fig. 7).

In summary, thrips densities and injury were generally reduced in ThryvOn cotton when compared to non-ThryvOn cotton. These observations are similar to those of other extension and research entomologists throughout the U.S. (personal communication). Based on these data, Arkansas does not recommend treatment of tobacco thrips in ThryvOn cotton. Because of widespread resistance in tobacco thrips to neonicotinoids and acephate, ThryvOn technology has the potential to be a valuable tool in controlling this early-season pest.

Practical Applications

Tobacco thrips have consistently been an important pest of Arkansas cotton. Growers have been looking for alternative methods of control that could reduce insecticide applications as well as increase yield. The information provided from this study shows that ThryvOn cotton has the potential, depending on technology cost, to be a valuable tool in thrips management.

Acknowledgments

We would like to thank Cotton Incorporated and Bayer Crop Science for their support of this work. We would also like to thank the staff at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station and Northeast Research and Extension Center for their support.

Literature Cited

Cook, D.R. 2019. Cotton insect losses 2019. pp. 769-833 *In*: Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, LA. 8-10 Jan. National Cotton Council, Memphis, Tenn.

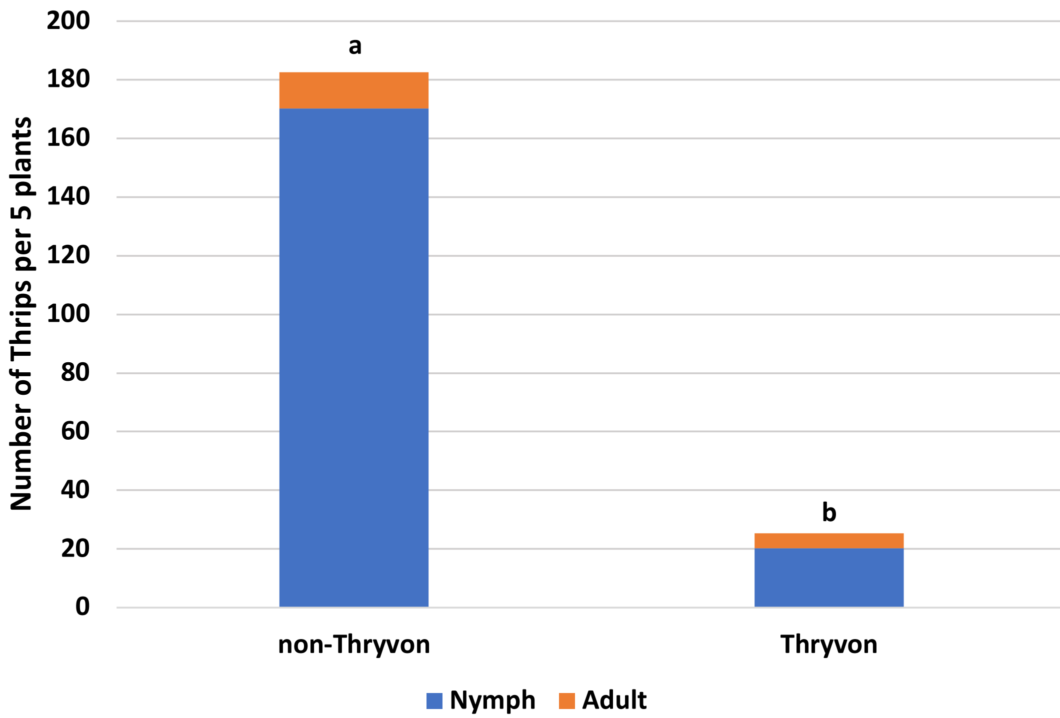

Fig. 1. Number of thrips on ThryvOn seedlings and non-ThryvOn seedlings at Tillar, Arkansas, in 2022 (Test 1). Treatments with the same lowercase letter are not significantly different according to All pairs, Tukey's honestly significant difference test (*P* = 0.05) to separate means.

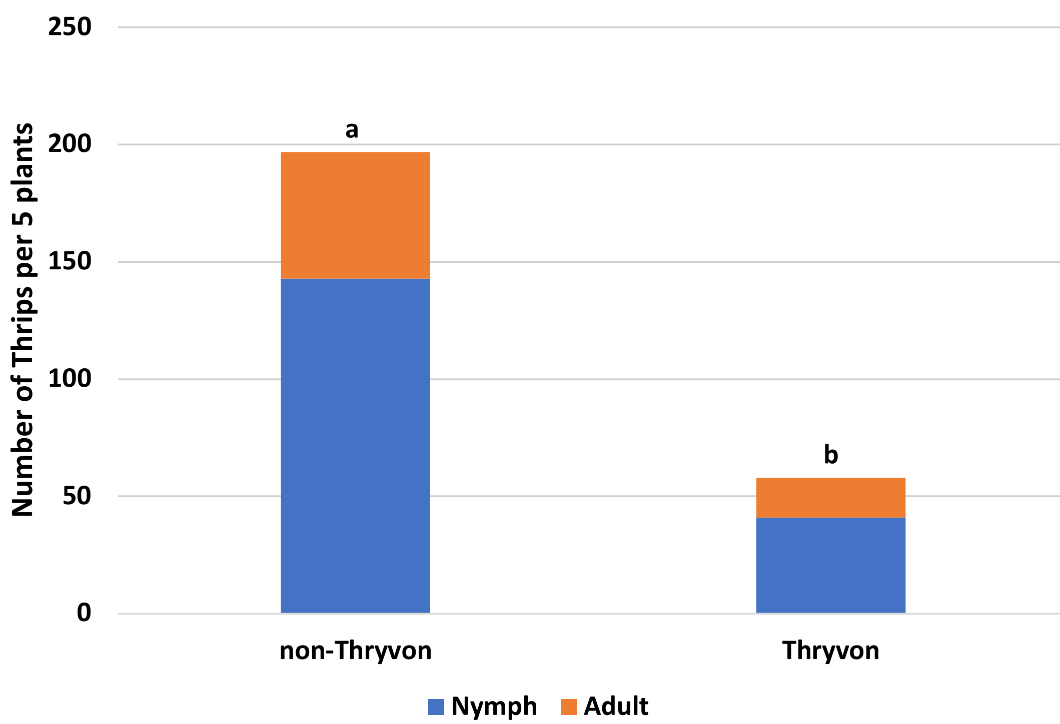

Fig. 2. Number of thrips on ThryvOn seedlings and non-ThryvOn seedlings at Marianna, Arkansas, in 2022 (Test 1). Treatments with the same lowercase letter are not significantly different according to All pairs, Tukey's honestly significant difference test (*P* = 0.05) to separate means.

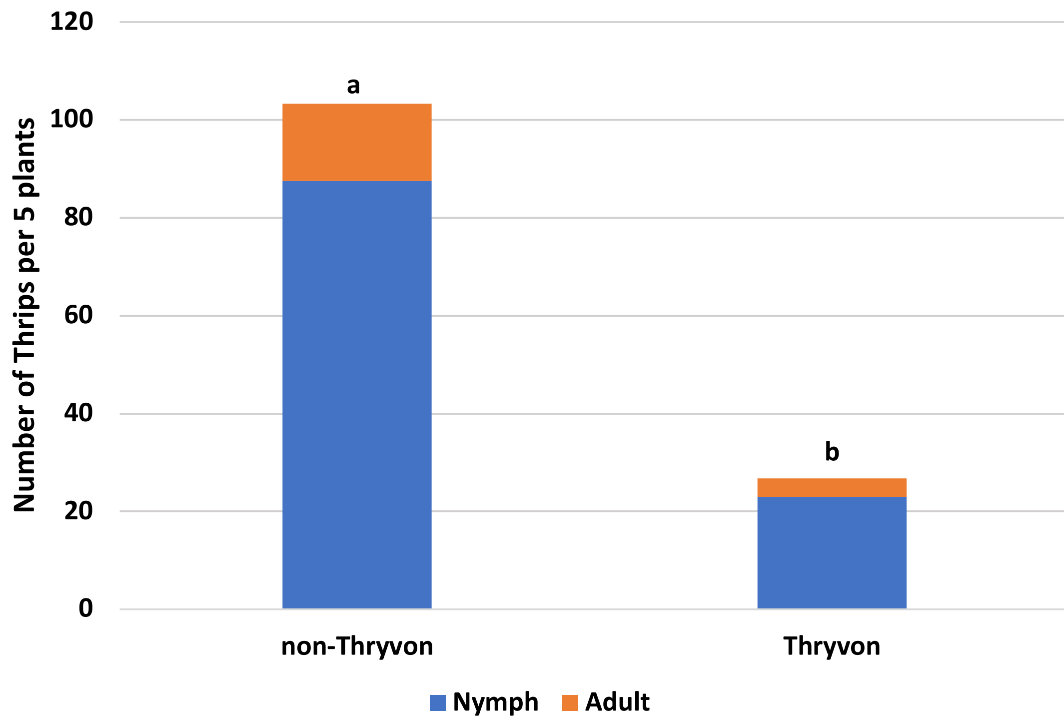

Fig. 3. Number of thrips on ThryvOn seedlings and non-ThryvOn seedlings at Keiser, Arkansas, in 2022 (Test 1). Treatments with the same lowercase letter are not significantly different according to All pairs, Tukey's honestly significant difference test (*P* = 0.05) to separate means.

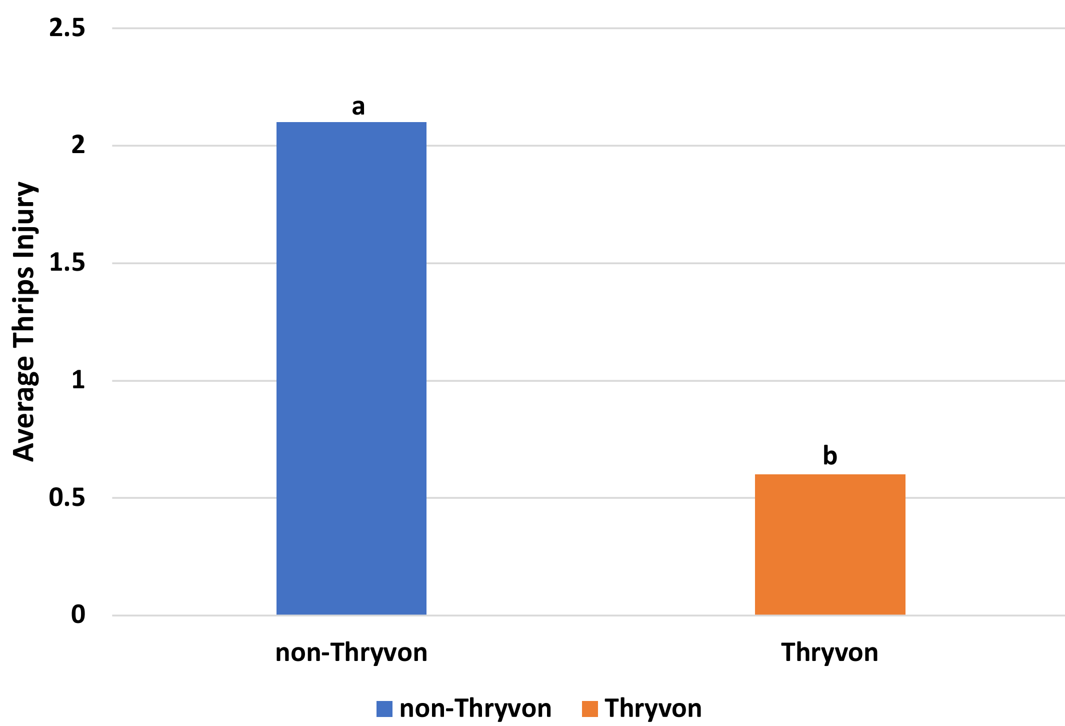

Fig. 4. Average thrips injury for ThryvOn seedlings and non-ThryvOn seedlings when averaged across one year and three locations (Test 1). Treatments with the same lowercase letter are not significantly different according to All pairs, Tukey HSD Test (*P* = 0.05) to separate means.

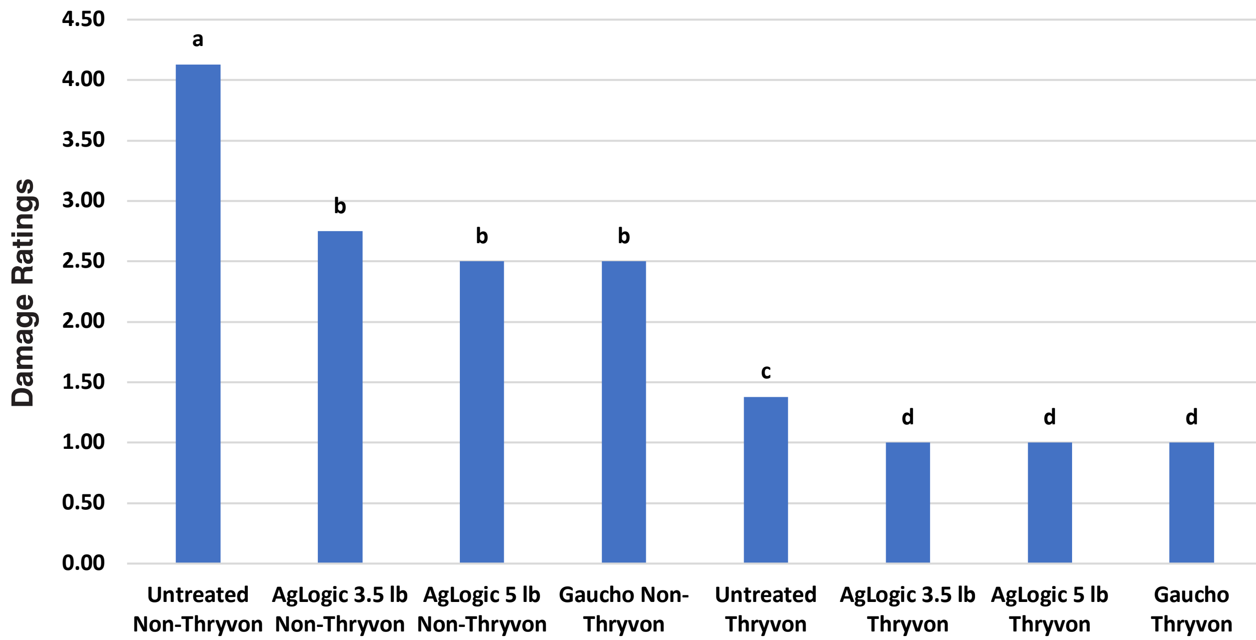

Fig. 5. Damage ratings (0 = no damage, 5 = dead plant) associated with Gaucho seed treatment and AgLogic (3.5 lb/ac and 5 lb/ac) on Thryvon and non-Thryvon cotton at Marianna, Arkansas, in 2022 (Test 2). Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means.

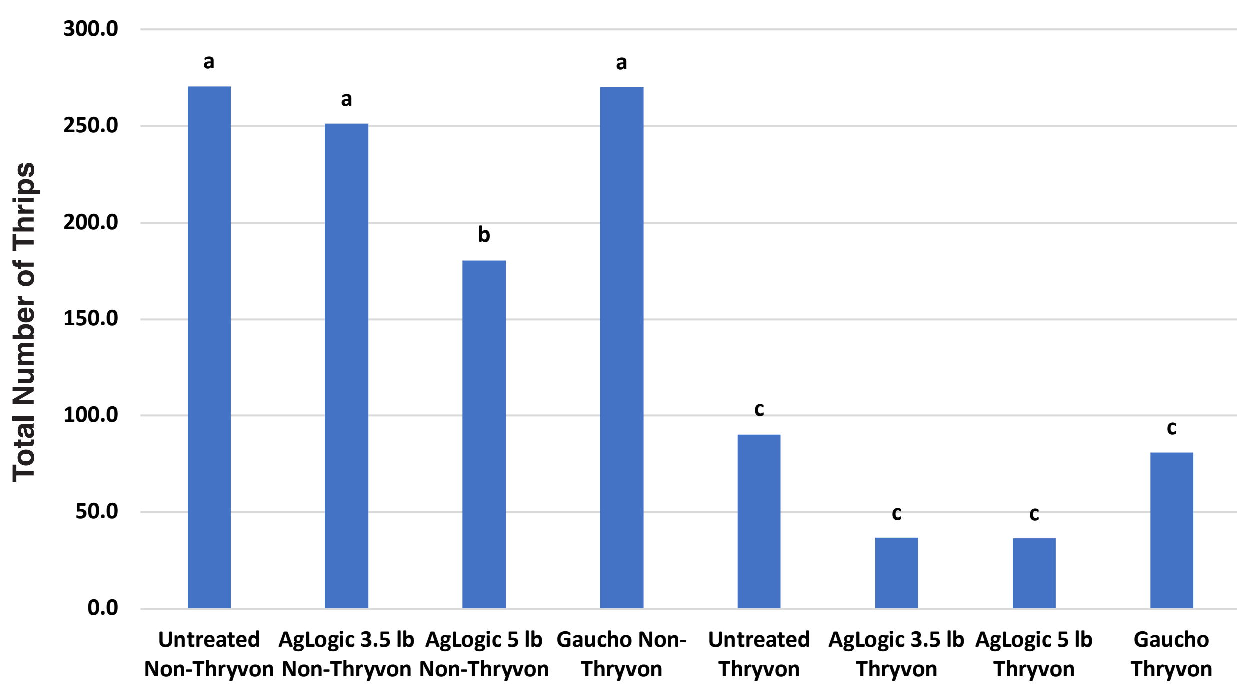

Fig. 6. Number of thrips associated with Gaucho seed treatment and AgLogic (3.5 lb/ac and 5 lb/ac) on Thryvon and non-Thryvon cotton at Marianna, Arkansas, in 2022 (Test 2). Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (P=0.10) to separate means.

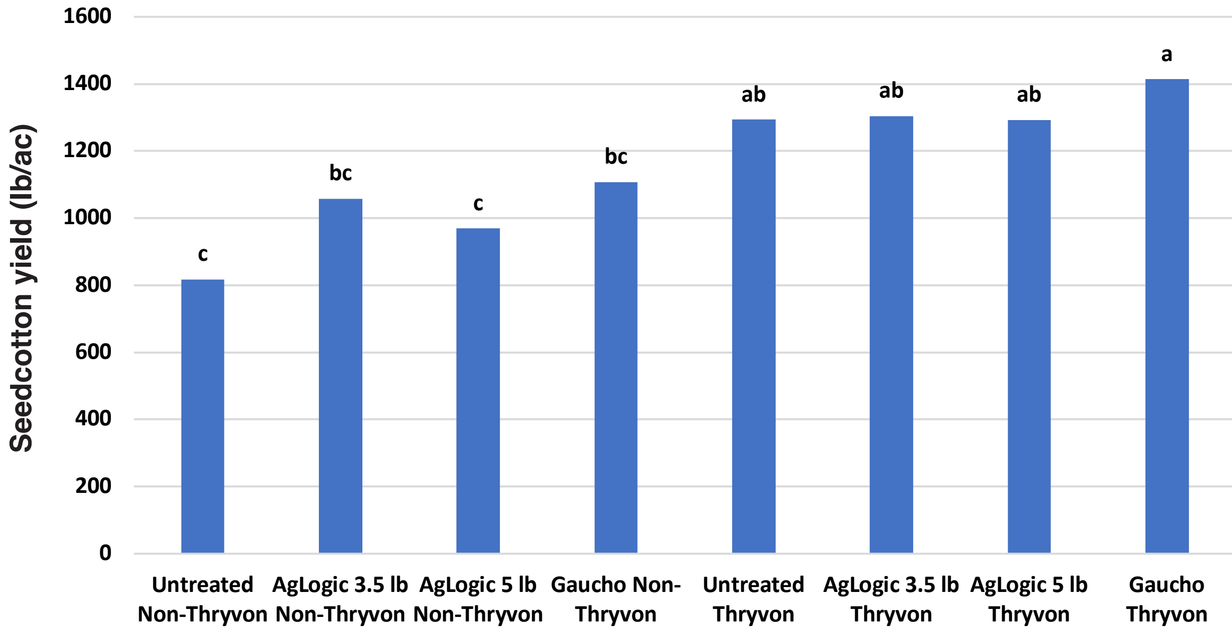

Fig. 7. Seedcotton yield (lb/ac) associated with Gaucho seed treatment and AgLogic (3.5 lb/ac and 5 lb/ac) on Thryvon and non-Thryvon cotton at Marianna, Arkansas, in 2021 (Test 2). Treatments with the same lowercase letter are not significantly different according to Duncan's New Multiple Range Test (*P* = 0.10) to separate means.

Evaluation of ThryvOn Technology for Control of Tarnished Plant Bug in Cotton

A. Whitfield,[1] B.C. Thrash,[2] N.R. Bateman,[3] S.G. Felts,[3] W.A. Plummer,[2]
T. Newkirk,[1] Z. Murray,[1] and T. Harris[1]

Abstract

Tarnished plant bug (TPB) is the most important pest in mid-South cotton production, causing square loss, deformed flowers, and damaged bolls, ultimately reducing yield. Tarnished plant bug is difficult to control, with growers averaging 4–6 insecticide applications per year. A field study was conducted at two locations across two years to evaluate ThryvOn, a new transgenic trait in cotton producing the *Bt* protein Cry51Aa, for TPB control. The trial consisted of ThryvOn and non-ThryvOn cotton that was either left untreated or sprayed at 1x, 2x, or 3x the currently recommended University of Arkansas System Division of Agriculture's Cooperative Extension Service threshold. When treated at standard threshold, ThryvOn required 2.5 applications for TPB compared to 4.0 in non-Thryvon over both locations and years. Yields of the ThryvOon were not affected by the application treatments. Results from this study indicate that Thryvon may be a valuable tool in TPB management.

Introduction

Tarnished plant bug (TPB), *Lygus lineolaris*, is the number one insect pest of cotton in Arkansas. Tarnished plant bug typically feeds on cotton terminals, squares, flowers, and bolls, causing a reduction in lint yield as well as lint quality. Arkansas cotton producers typically make 4–6 insecticide applications to control TPB (Cook, 2019). Multiple insecticide applications are very expensive for producers causing them to continually seek alternative methods of control. It is currently recommended that growers budget approximately $100 per acre to allow for proper control of TPB throughout the season (CES, 2019). ThryvOn technology is the first cotton biotech trait that may provide season-long protection against tarnished plant bug and may reduce the need for some insecticide applications. ThryvOn cultivars are also stacked with Bollgard 3 XtendFlex technology offering protection against bollworm, tobacco budworm, and other common worm pests, and are tolerant to glyphosate, glufosinate, and dicamba. The current action threshold is 3 TPBs per 5 row feet in non-ThryvOn cotton, and maintaining a square set greater than 80% is recommended, but this threshold may need to be modified for use in ThryvOn cultivars. The objectives of this study were to evaluate ThryvOn technology for control of TPB and determine if thresholds for TPBs will need to be changed.

Procedures

In the first test, experiments were conducted in 2021 and 2022 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station (LMCRS) located in Marianna, Arkansas, and on a grower's field in Tillar, Arkansas. Trials in 2021 were planted on 20 May at LMCRS and on 2 June on the grower's field. Trials in 2022 were planted on 11 May at LMCRS and on 18 May on the grower's field. Plot sizes were 12.5 ft. (4 rows) by 50 ft with 4 replications per treatment. Treatments included treating TPB on ThryvOn (DP 2131 B3TXF) and non-ThryvOn (DP 2055 B3XF) cotton when 1x, 2x, and 3x threshold levels were attained. Samples were taken with a 2.5 ft drop cloth, and 2 samples were taken per plot for a total of 10 row ft. Square retention was also recorded by checking 25 plants per plot. Plots were scouted once per week, and an application was made when threshold was met (Tables 1 and 2). Treatment thresholds in 2021 included untreated check, 6 nymphs per 10 row ft (1x threshold), 6 large nymphs per 10 row ft, 12 nymphs per 10 row ft (2x threshold), 12 large nymphs per 10 row ft., and 18 per 10 row ft of any size (3x threshold) but not all treatments were triggered. Treatment thresholds in 2022 were adjusted to include untreated check, 6 nymphs per 10 row ft. (1x threshold), 12 nymphs per 10 row ft. (2x threshold), 18 per 10 row ft. (3x threshold), 80% square retention, and 85% square retention. When the target threshold was met, plots were sprayed with 1.75 oz/ac of Transform using a Mud-Master sprayer fitted with 80-02 dual flat fan nozzles with 19.5-in. spacing. The spray volume was 10 gal/ac at 40 psi. Once cotton reached desirable moisture, plots were mechanically harvested using a two-row research cotton picker. Seed cotton was then weighed to determine yields. Data were processed using JMP Pro version 16.2.0 and Tukey's honestly significant difference (P = 0.10) to separate means.

[1] Graduate Assistants, respectively, Department of Entomology and Plant Pathology, Fayetteville.
[2] Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Lonoke.
[3] Extension Entomologist and Program Associate, respectively, Department of Entomology and Plant Pathology, Stuttgart.

The second test was a cage study to determine the relative efficacy and plant injury between non-ThryvOn cotton and ThryvOn cotton and was conducted in 2022 at LMCRS. Eight rows of non-ThryvOn cotton were planted next to eight rows of ThryvOn cotton. Plot sizes were 8 rows x 1000 ft and left untreated throughout the season. Twenty-four hours before infestation, wild TPBs were collected with sweep nets on wild hosts and placed in a bug dormer with heads of wild hosts. The TPBs sat in the dormers overnight to ensure healthy insects were used for the experiment. Prior to placing a 1-gallon mesh paint strainer on the top 4 nodes of flowering cotton, plants were thoroughly examined to ensure no TPB were on the plant and no visual injury was present. Cages were then infested with 0, 1, or 3 adult TPB using an aspirator. The experiment was designed as a randomized complete block design with ten replications for each infestation level in ThryvOn and non-ThryvOn cotton. Infested cages were carefully placed over the top 4 nodes of the cotton plant and secured around the stem with a wire tag. The infestation level was then labeled on the tag for proper sampling. After seven days, cages were removed by cutting the stem one inch below the cage. Through visual observations, the number of dead vs. alive TPB within the cage was recorded. Next, the cage was opened, and plant material was removed. After observing the top four nodes, the number of total squares and damaged squares were recorded per cage.

Results and Discussion

Based on current threshold recommendations for TPB, 2 to 5 insecticide applications were needed to manage TPB depending on the year and test location (Tables 1 and 2). At three of the four locations across both years, non-ThryvOn cotton required more applications than non-ThryvOn cotton for control of TPB. Across both years and locations, non-ThryvOn cotton averaged more TPB/10 row ft (19.9) than ThryvOn cotton (14.8). ThryvOn technology reduced the number of TPB per 10 row ft by 25.4% when compared to non-ThryvOn. When comparing small nymphs to large nymphs in ThryvOn and non-ThryvOn cotton, 80.4% of the total TPB in ThryvOn cotton were small nymphs, and 16.0% were large nymphs. Whereas, in non-ThryvOn cotton, 75.8% were small nymphs, and 20.0% were large nymphs. Across all sites and years, untreated ThryvOn plots had greater square retention (82%) than untreated non-ThryvOn plots (67%). ThryvOn yields did not differ over the treatment thresholds (Fig. 1), and control of TPB was obtained with roughly half the number of applications when compared to non-ThryvOn in three of the four site years (Tables 1 and 2).

In the 2022 cage study, ThryvOn cotton had 14% and 8.7% greater percent mortality than the non-ThryvOn cotton when 1 and 3 tarnished plant bugs, respectively, were caged on plants. Non-ThryvOn cotton had 33% and 46% greater square loss than the ThryvOn cotton when 1 and 3 tarnished plant bugs, respectively, were caged on plants.

Thryvon cotton reduced the number of total TPB found in the field and had improved square retention over comparable non-ThryvOn plots. These data indicate that Thryvon cotton has the ability to reduce TPB applications while continuing to maintain yield when compared to non-Thryvon treatments.

Practical Applications

Tarnished plant bug has been the most important pest within cotton for over a decade. Growers need alternative methods of control that reduce the number of insecticide applications and increase yield. These data suggest that Thryvon has the potential to be a valuable tool in controlling TPB.

Acknowledgments

We would like to thank Cotton Incorporated and Bayer Crop Science for their support of this work. We would like to thank all the staff at the University of Arkansas System Division of Agriculture's Lonoke Extension office for their cooperation and collaboration with this trial. I would also like to thank the staff at the Lon Mann Cotton Research Station for their support. We would also like to thank A.J. Hood at Tillar and Company for allowing us to conduct research on their land.

Literature Cited

CES. 2019. University of Arkansas System Division of Agriculture's Cooperative Extension Service. 2019 Crop Enterprise Budgets for Arkansas Field Crops Planted in 2019. https://www.uaex.uada.edu/farm-ranch/economics-marketing/farm-planning/Budget_Manuscript_2019.pdf

Cook, D.R. 2019. Cotton insect losses 2018. pp. 769-833. *In*: Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, La. 8-10 Jan. National Cotton Council, Memphis, Tenn.

Table 1. Number of insecticide applications on ThryvOn and non-ThryvOn cotton at normal threshold, 3 large nymph, 2x threshold, 6 large nymph, and 3x threshold at Marianna and Tillar, Arkansas, in 2021.

Threshold Level	ThryvOn, Marianna	Non-ThryvOn, Marianna	ThryvOn, Tillar	Non-ThryvOn, Tillar
Normal Threshold	2	5	4	4
3 Large Nymph	0	1	0	2
2x Threshold	2	3	3	5
6 Large Nymph	0	0	0	0
3x Threshold	1	1	1	4
Total	5	10	8	15

Table 2. Number of insecticide applications on ThryvOn and non-ThryvOn cotton at normal threshold, 2x threshold, 3x threshold 80% square retention, and 85% square retention at Marianna and Tillar, Arkansas, in 2022.

Threshold Level	ThryvOn, Marianna	Non-ThryvOn, Marianna	ThryvOn, Tillar	Non-ThryvOn, Tillar
Normal Threshold	2	5	2	2
2x Threshold	2	4	1	1
3x Threshold	2	2	1	1
80% square retention	0	2	0	0
85% square retention	2	3	0	0
Total	8	16	4	4

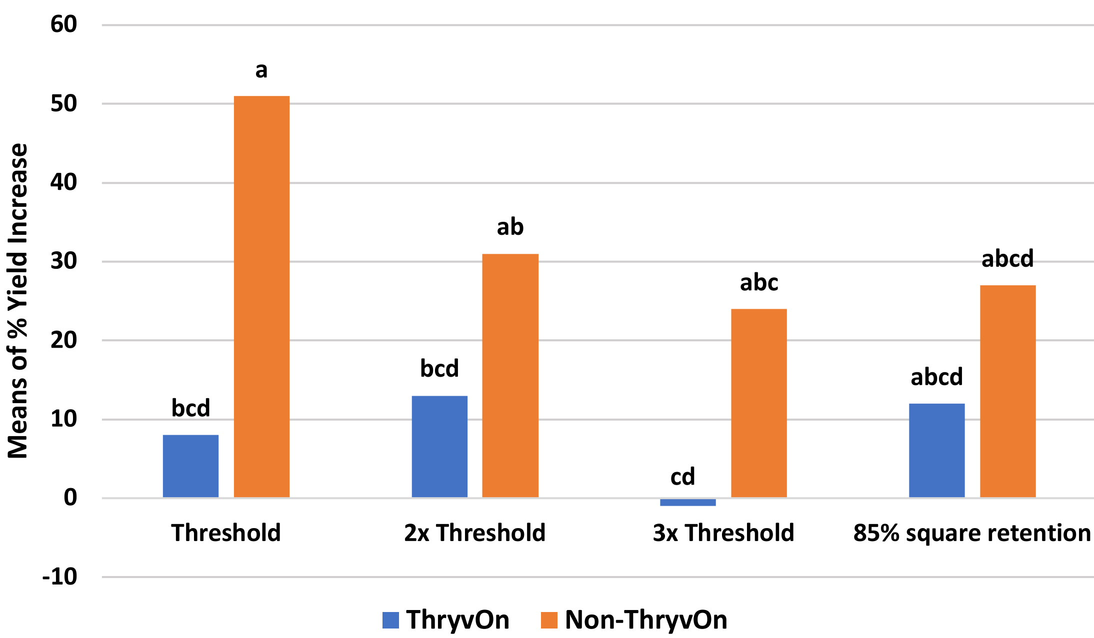

Fig. 1. Average yield % increase, when compared to the untreated check, for ThryvOn and non-ThryvOn cotton when averaged across two years and two locations. Treatments with the same lowercase letters are not significantly different according to all pairs, Tukey's honestly significant difference test (P = 0.05) to separate means. 85% square retention was only conducted in 2022.

Cotton Tolerance to Low Concentrations of a Postemergence-Applied Diflufenican Mixture

M.C. Woolard,[1] J.K. Norsworthy,[1] P. Carvalho-Moore,[1] T.H. Avent,[1] L.T. Barber[2]

Abstract

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is the most problematic weed in various cropping systems in Arkansas. Producers across the state have few herbicide options due to Palmer amaranth's resistance to nine modes of action. Diflufenican is a herbicide that will soon become labeled in soybean production to control herbicide-resistant Palmer amaranth. Additionally, diflufenican is a Weed Science Society of America Group 12 herbicide adding a new mode of action to soybean production. Although diflufenican is targeted for soybean production, additional research is needed to evaluate the sensitivity of common adjacent crops to soybean to the herbicide. A field experiment was conducted at the Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, to evaluate the sensitivity of cotton to low rates of a postemergence-applied diflufenican mixture. A diflufenican mixture was applied at the 3-node growth stage at 0, 0.00156, 0.00625, 0.025, and 0.1 times the anticipated 1X labeled rate. The only injury level different from zero was associated with the 0.1X rate at 7 and 14 days after application (DAA), but this injury was transient, with no injury observed at 21 DAA. There were no differences among treatments in seedcotton yields. Overall, the diflufenican mixture appears to possess a minimal risk for injury to cotton caused by physical drift.

Introduction

Palmer amaranth (*Amaranthus palmeri* S. Wats.) is the most problematic weed in soybean [*Glycine max* (L.) Merr.] and cotton (*Gossypium hirsutism* L.) production (Van Wychen 2022). Currently, Palmer amaranth has resistance to nine different modes of action (Heap, 2023), leaving producers with few herbicide options. Recently, Bayer CropScience announced its intent to register a new herbicide, diflufenican (DFF), for soybean production. Diflufenican was first introduced in Europe for use in crops such as lentils and winter cereals (Anonymous, 2021) and has been shown to have excellent activity on broadleaf weed species (Hu et al., 2020).

Additionally, diflufenican is a Weed Science Society of America group 12 herbicide and would be a new mode of action for soybean producers in the U.S. (Anonymous, 2021). While this new herbicide will be labeled for soybean production, there are currently no published data on the potential for low rates of diflufenican to injure adjacent crops such as cotton. Typically, cotton is planted in Arkansas from 1 May to 20 May (Robertson et al., 2021), and the soybean planting date spans from 15 April to 15 July (Jeremy Ross, pers. comm.). Hence, the potential for drifting a diflufenican mixture onto established cotton exists due to the overlap in planting dates. An experiment was conducted to evaluate cotton sensitivity to postemergence (POST) applications of low rates of a diflufenican mixture.

Procedures

A field experiment was conducted in 2022 at the Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas. The trial's objective was to evaluate cotton's sensitivity to post applications of low rates of a diflufenican mixture. The cotton cultivar PHY 360W3FE was planted at 44,000 seeds/ac, and plot dimensions were 12 ft wide by 22 ft long. A broadcast application of Cotoran at 1.6 pt/ac and Caparol at 1.5 pt/ac were applied preemergence (PRE), and standard cotton herbicides were used throughout the growing season to control weeds. The trial was designed as a randomized complete block design with one factor (DFF rate) and four replications. The DFF mixture was applied to the cotton at the 3-node growth stage at 0, 0.00156, 0.00625, 0.025, and 0.1 times the anticipated 1X labeled rate. The treatments were applied 3 miles hr with a CO_2-pressurized backpack sprayer using AIXR 110015 calibrated to deliver 15 gal/ac. Crop injury ratings were collected 7, 14, 21, and 28 days after application (DAA). The injury was evaluated on a scale of 0 to 100%, with 0 being no crop injury and 100 being crop death. SPAD meter readings of the uppermost unfolded leaf of 5 plants per plot were collected at each evaluation timing. RGB (red, green, blue) drone images were captured at each rating time and analyzed using Field Analyzer software to assess ground cover. Finally, two 10 ft rows of plots were harvested, and cottonseed yield was determined. Data were subjected to

[1] Graduate Assistant, Distinguished Professor, Graduate Assistant, Graduate Assistant, respectively, Department of Crop, Soil, and Environmental Sciences, Fayetteville.
[2] Professor, Department of Crop, Soil, and Environmental Sciences, Lonoke.

analysis of variance, and means were separated using Fisher's protected least significant difference ($\alpha = 0.05$).

Results and Discussion

By seven days after application (DAA), the highest injury observed was 4% for the 1/10X treatment, with all other treatments having no injury observed (Table 1). Even at a high simulated drift rate of 1/10X, low amounts of cotton injury were observed. By 14 DAA, injury increased to 7 and 2% for the 1/10X and 1/40X treatments, respectively. Although there was an increase in injury at this evaluation timing, crop injury was less than 10% for all treatments. The early cotton injury was transient, with no crop response observed for any treatments at 21 DAA. While injury was observed, the cotton plants would likely recover quickly. SPAD meter readings ranged from 39.66 to 41.64 and 29.53 to 39.57 at 7 and 14 DAA, respectively (Table 2). The injury observed did not have any impact on leaf chlorophyll concentrations. Groundcover ranged from 123% to 131% and 103% to 113% of the nontreated at 7 and 14 DAA, respectively (Table 2). Overall, there was no reduction in cotton groundcover from the different rates of the diflufenican mixture evaluated. Seedcotton yields ranged from 2000 to 2620 lb/ac with no statistical differences observed.

Practical Applications

If the DFF mixture is approved for soybean production, there seems to be a low risk of injury from physical drift onto already-established cotton. Even at a high simulated drift rate, the visible injury never exceeded 10% for any treatments evaluated. Additional research is needed to assess the risk of carryover injury to cotton from a DFF mixture application in soybean, as they are common rotational crops in Arkansas.

Acknowledgments

The authors thank the University of Arkansas System Division of Agriculture, the Milo J Shult Agricultural Research and Extension Center in Fayetteville, Cotton Incorporated, and Bayer CropScience for funding this research.

Literature Cited

Anonymous. 2021. Bayer further commits to crop protection innovation with planned introduction of diflufenican. Accessed 30 Jan 2023. Available at: https://www.bayer.com/en/us/diflufenican

Heap. I. 2023. International Herbicide-Resistant Weed Database. Accessed 30 Jan 2023. Available at: http://www.weedscience.org/Pages/Species.aspx

Hu Z., J. Li, Y. Zhang, and Y. Shi. 2020. Determination of residue of diflufenican in wheat and soil by spectrometry conditions. J. Sci. Food Agric. 101:215-219.

Robertson, B., T. Barber, and B. Thrash. 2022. 2022 Arkansas cotton quick facts. Accessed 1 Feb. 2023. Available at: https://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/cotton/2022-Arkansas-Cotton-Quick-Facts.pdf

Van Wychen L (2022) 2022 Survey of the most common and troublesome weeds in broadleaf crops, fruits, & vegetables in the United States and Canada. Weed Science Society of America National Weed Survey Dataset. Accessed 30 Jan. 2023. https://wssa.net/wssa/weed/surveys/

Table 1. Cotton injury at 7, 14, and 21 days after application (DAA) of five rates the diflufenican mixture at the Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, in 2022.

	Injury[a]		
Diflufenican rate	7 DAA	14 DAA	21 DAA
	(%)		
0.1X	4 a	7 a	0
0.025X	0 b	2 b	0
0.00625X	0 b	0 b	0
0.00156X	0 b	0 b	0
0X	--	--	--

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

Table 2. Soil Plant Analysis Development (SPAD) meter readings and percent ground cover 7 and 14 days after application (DAA) of five rates of the diflufenican mixture at the Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas, in 2022.

	SPAD meter readings[a]		Groundcover[a]	
Diflufenican rate	7 DAA	14 DAA	7 DAA	14 DAA
	-------Average SPAD Reading-------		-----------------------%-----------------------	
0X	39.66	31.00	100	100
0.1X	41.64	39.57	123	110
0.025X	41.41	30.00	124	113
0.00625X	40.00	30.62	131	109
0.00156X	40.72	29.53	131	103

[a] There were no statical differences in treatments between SPAD meter readings or ground cover.

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System