Received: 15 October 2025 | Accepted: 12 May 2026

DOI: 10.1002/agj2.70452

Agronomy Journal

ORIGINAL ARTICLE

Crop Economics, Production, and Management

Determining if preemergent herbicide injury on ThryvOn cotton alters management strategies

Lance Wortman[1] | **Meredith M. Kimbrell**[1] | **Caitlyn Lawton**[2] | **Sarah Hobby**[3] | **Scott Graham**[2] | **Steve Brown**[4] | **Phillip Roberts**[3] | **John Snider**[1] | **Lavesta C. Hand**[1]

[1]Department of Crop and Soil Science, University of Georgia Tifton Campus, Tifton, Georgia, USA

[2]Department of Entomology and Plant Pathology, Auburn University, Auburn, Alabama, USA

[3]Department of Entomology, University of Georgia Tifton Campus, Tifton, Georgia, USA

[4]Department of Crop, Soil, and Environmental Sciences, Auburn University, Auburn, Alabama, USA

Correspondence
Lavesta C. Hand, Department of Crop and Soil Science, University of Georgia Tifton Campus, Tifton, GA, USA. Email: camphand@uga.edu

Assigned to Associate Editor Ramdeo Seepaul.

Funding information
Alabama Cotton Commission; Georgia Cotton Commission; Cotton Incorporated

Abstract

Glyphosate-resistant Palmer amaranth (*Amaranthus Palmeri* S. Wats.) caused cotton growers to increase the use of preemergence (PRE) herbicides. These herbicides can cause crop injury, which increases the susceptibility window of cotton to thrips (*Thysanoptera*: *Thripidae*). With the use of PREs in cotton, management strategies for ThryvOn varieties are unknown. In this study, PRE herbicides at multiple rates (none, 1x, and 2x) were evaluated for ThryvOn (Deltapine [DP] 2211 B3TXF) and non-ThryvOn (DP 2127 B3XF) varieties with or without a foliar insecticide treatment (acephate [200 g ai ha^{-1}] applied at one-leaf stage) to determine the combined effects of herbicide injury and thrips management on the growth of ThryvOn and non-ThryvOn cotton. Experiments were conducted in Tifton, GA, and Prattville, AL, in 2023 and 2024. Generally, herbicide injury was greater in DP 2127 B3XF and thrips injury was greater for any treatment of DP 2127 B3XF than any DP 2211 B3TXF treatment. Herbicide injury early in the season did not increase thrips injury in ThryvOn cotton. Plant heights, total nodes, shoot fresh biomass, and lint yield were only impacted by cultivar. Although one cultivar had ThrvyOn and the other did not, differences cannot be attributed to the trait alone as the two varieties evaluated were not isolines. Fruit retention and cutout date were not significantly different. Therefore, these results indicate agronomic management should not generally differ between ThryvOn and non-ThryvOn cotton.

Plain Language Summary

Glyphosate-resistant Palmer amaranth made growers rely more heavily on at plant residual herbicides for acceptable weed control. These herbicides can injure cotton seedlings, which can slow growth and extend the period of susceptibility to damage from thrips. However, a new transgenic trait in cotton called ThryvOn provides

Abbreviations: DAP, days after planting; DP, Deltapine; FFB, first fruiting branch; NAWF, nodes above white flower; PRE, preemergence.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.
© 2026 The Author(s). *Agronomy Journal* published by Wiley Periodicals LLC on behalf of American Society of Agronomy.

cotton protection from thrips. This study evaluates if preemergent herbicide injury affects thrips management decisions as well as growth and development of ThryvOn and non-ThryvOn cotton. Overall, results indicated that injury from at plant residual herbicides did not make ThryvOn cotton more susceptible to thrips injury. Interestingly, herbicide injury was lower in ThryvOn cotton than non-ThryvOn cotton. Growth and development did not differ among ThryvOn and non-ThryvOn cotton. Thus, agronomic management decisions should be variety specific as opposed to managing based on trait packages.

1 | INTRODUCTION

Upland cotton (*Gossypium hirsutum* L.) is one of the most important crops for growers in the southeastern United States, with it being the most widely planted row crop in Georgia and Alabama (USDA-NASS, 2024). Because cotton has slow emergence and growth, it is susceptible to early-season weed competition (Cook et al., 2011; 2013; Doğan et al., 2014). Prior to the confirmation of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri* S. Wats), growers were able to use broad-spectrum, nonselective herbicides to control a significant amount of competitive weed species (Culpepper et al., 2006; Doğan et al., 2014). However, in 2006, due to the widespread occurrence of glyphosate-resistance in Palmer amaranth, many growers had to abandon their fields (Culpepper et al., 2008). Glyphosate resistant Palmer amaranth changed weed management systems, causing a reversal to more diverse, complex, and expensive control measures (Culpepper et al., 2008). Instead of using postemergence (POST) herbicides almost exclusively, growers now rely on preemergence (PRE) herbicides such as fomesafen (Reflex, Syngenta Crop Protection LLC), acetochlor (Warrant, Bayer CropScience LP), diuron (Direx, E. I. du Pont de Nemours and Company), and fluridone (Brake, SePRO Corporation) (Hand et al., 2024). These PRE herbicides can injure cotton, which could slow seedling growth. Copeland et al. (2017) observed cotton in Mississippi treated with PRE herbicides had significantly less biomass at the two-leaf stage, heights at the four-leaf stage, and yield. Similar results were observed in South Carolina when acetochlor and fomesafen were combined at a 3x rate, which resulted in a decrease in plant height at 28 and 42 days after planting (DAP) (Holladay et al., 2024). Though PRE herbicides can cause injury to cotton, PREs are recommended for cotton production systems where herbicide resistant weeds are present (Copeland et al., 2017).

Since injury from PRE herbicides can slow cotton growth, the period of susceptibility to thrips (*Frankliniella* spp.) can be prolonged on seedling cotton (Roberts et al., 2015). Thrips are the most consistent and predictable insect pest in cotton, with 98% of cotton acres in the United States being infested each year (Cook et al., 2023). Among the multiple species of thrips found in cotton, tobacco thrips (*Frankliniella fusca* Hinds) is the most common species observed across the Southeast (Cook et al., 2003; Reay-Jones et al., 2017; Wang et al., 2018). Typically, in Georgia, growers who plant earlier in the year have a higher risk of infestation (Chappell et al., 2020). Thrips first feed on the lower surface of the cotyledons and then move to the terminal bud (Cook et al., 2011; Hand et al., 2024), which causes malformed leaves, stunted plants, delayed maturity, and could reduce yield if damage is excessive (Hand et al., 2024). Smaller plants are more sensitive to thrips injury than larger plants in terms of yield loss, with the four-leaf stage being the end of the susceptibility window (Catchot et al., 2014; Hand et al., 2024; Roberts et al., 2015; Stewart & Lentz, 2010). Several effective control measures can be utilized for thrips management in cotton: in-furrow granular insecticides, in-furrow liquid insecticides, seed treatments, and foliar applied insecticides (Hand et al., 2024). Recently, some of these control measures have become less effective as there have been reports of thrips resistance to acephate, imidacloprid, and thiamethoxam across the US cotton belt (Huseth et al., 2016, 2018; Johnson et al., 2003; Krob et al., 2022). Because resistance has been observed to multiple insecticides across the US cotton belt, growers will need to start to utilizing other methods for control of thrips.

ThryvOn, a product of Bayer CropScience, is the first developed transgenic thysanopteran and hemipteran active *Bacillus thuringiensis* (*Bt*) Cry51Aa2.834_16 toxin expressed in MON 88702 cotton (Huseth et al., 2019). This toxin has activity against key pests, most importantly tobacco thrips, western flower thrips (*Frankliniella occidentalis* Pergande), and tarnished plant bug (*Lygus lineolaris* Palisot de Beauvois) (Graham et al., 2023). Previous research has demonstrated that in ThryvOn cotton there is not a high mortality rate, but there are reductions in thrips populations, feeding, and egg laying during early stages of production, which is where economic losses can occur (Bachman et al., 2017; Graham et al., 2019). Research findings across the US cotton belt demonstrate low to no thrips injury at the one-leaf stage to four-leaf stage, which removes the need for supplemental foliar sprays

in ThryvOn cotton (Graham et al., 2019; Hand et al., 2024; Whitfield, 2023).

Previous work has demonstrated that increased injury from PRE herbicides to seedling cotton prolongs the susceptibility window to thrips feeding in non-ThryvOn cotton (Roberts et al., 2015). PRE herbicides are necessary due to increases in herbicide resistance and the removal of some POST herbicides from the marketplace. Additionally, increasing insecticide resistance in thrips populations has complicated management strategies, leading to more ThryvOn varieties being developed and planted each growing season. This study's objective is to evaluate the combined effects of PRE herbicide rates and thrips management strategies on ThryvOn and non-ThryvOn cotton.

Core Ideas

- Increased herbicide injury did not increase thrips susceptibility in ThryvOn cotton.
- Cotton growth and development did not differ between ThryvOn and non-ThryvOn cotton.

2 | MATERIALS AND METHODS

2.1 | Field preparations

Trials were conducted in Tifton, GA, and Prattville, AL, in 2023 and 2024. Field trials were planted on April 24, 2023, and April 17, 2024, in Tifton and May 2, 2023, and April 24, 2024, in Prattville. Both Tifton and Prattville locations were irrigated according to local extension recommendations with the soil types for Tifton being classified as Tifton loamy sand and Prattville being Lucedale fine sandy loam. A thrips infestation predictor tool provided by North Carolina State University was used to predict optimum planting time for highest thrips infestations (Chappell et al., 2020). Trials were planted in a conventionally tilled system on 91-cm row spacing. Plots were four rows wide and 9.15 m long and planted in a randomized complete block design with 12 treatments and four replications. Treatments were a full factorial of variety (two levels), PRE herbicide rate (three levels), and foliar thrips treatment (two levels). Deltapine (DP) 2127 B3XF was the non-ThryvOn variety and DP 2211 B3TXF was the ThryvOn variety. These varieties were selected due to similar characteristics, availability, and yield potential (C. Corkern, personal communication, February 1, 2023; Mailhot et al., 2025). Both varieties included a seed treatment of imidacloprid at 0.375 mg ai per seed (Gaucho 600 seed treatment, Bayer CropScience LP).

Three PRE treatments (none, 1x, and 2x) with the 1x treatment being 270 g ai ha^{-1} fomesafen (Reflex, Syngenta Crop Protection LLC) and 810 g ai ha^{-1} acetochlor (Warrant, Bayer CropScience LP) and the 2x rate being double the 1x. All PRE treatments were applied within 3 days of planting and activated by irrigation. For thrips management, a foliar application of 200 g ai ha^{-1} acephate (Orthene 97, AMVAC Chemical Corp) and a non-treated check were evaluated across variety and PRE herbicide treatments. The foliar thrips application was made at the one-leaf stage. Other pesticides, irrigation, and fertilizers were applied uniformly across the entire trial according to local extension recommendations (Brown, 2019; Hand et al., 2024).

2.2 | Agronomic data collection

Approximately 28 DAP, herbicide injury was evaluated through visual ratings. Visual herbicide injury ratings were conducted on a 0%–100% scale with 0 being no crop injury and 100 being crop death. At the same time, plant heights, total nodes, and shoot and root fresh biomass were collected from the center two rows of each plot to evaluate the effect of variety, herbicide injury, and thrips management on early-season growth. For data collection, plants from 1 m of row were cut at the soil line, collected into labeled bags and taken back to the lab. Shoots were then measured for plant heights, weighed in grams, and nodes were counted. After shoots were clipped, a shovel was used to dig plant roots from the ground. Roots were extracted from approximately 0.0425 m^3 of soil, and loose soil was removed from roots in the field. They were then bagged and taken back to the lab and weighed in grams. Shoot and root weights were divided by the total number of plants sampled in order to get an average weight per plant prior to analysis.

At first bloom, first fruiting branch (FFB), first position fruit retention, plant heights, and total nodes were evaluated. Additionally, nodes above white flower (NAWF) was evaluated from the uppermost first position white flower up to the uppermost unfurled leaf weekly on 10 plants per plot until cutout (NAWF = 3), which is when significant vegetative growth ceases and is used as an indicator of crop maturity (Bednarz & Nichols, 2005). Utilizing weekly NAWF measurements, days to cutout were calculated relative to DAP utilizing linear regression analysis, similar to Chalise et al. (2022) and Lawton et al. (2023). At cutout, end of season heights and total mainstem nodes were evaluated to determine growth differences over the entire season. Heights were taken from 20 plants per plot and total mainstem nodes were taken on 10 plants per plot. Both measurements were then averaged for each plot prior to statistical analysis. All data were collected from the center two rows of each plot. All end of season measurements (cutout date, heights, and nodes) were collected in all locations except Alabama in 2024.

2.3 | Thrips data collection

Thrips injury rating and thrips counts were taken at 14, 21, and 28 DAP. Thrips counts were taken by removing five plants from each plot at random and immediately submerging and twirling the leaves vigorously in a 118 mL medical cup filled with 59 mL of 70% ethyl alcohol to dislodge the thrips. Cups were then sealed and transported to the laboratory. Thrips were then washed through a screen with 125 µm openings into a glass scintillation vial. Vials were then poured into a gridded Petri dish where immature and adult thrips were enumerated using a stereomicroscope. Thrips visual injury ratings were accessed once seedlings had one true leaf and continued until the four-true leaf stage. Ratings were on a scale from 0 to 5 with 0 = no damage and 5 = dead plants (Hawkins et al., 1966; Kerns et al., 2019).

2.4 | Harvest data collection

When cotton reached maturity (60% open boll), plots were defoliated according to local extension recommendations (Brown, 2019; Hand et al., 2024). Prattville plots were harvested November 18, 2023, and September 4, 2024, and Tifton plots were harvested October 3, 2023, and September 20, 2024. The center two rows were mechanically harvested (John Deere 9930) approximately 2–3 weeks after defoliation. Seed cotton was then ginned to determine lint percentage and lint yield—Georgia samples were ginned at the University of Georgia MicroGin in Tifton, GA (C. Li et al., 2011), while Alabama samples were ginned on a tabletop gin.

2.5 | Statistical analysis

All response variables were subjected to analysis of variance in JMP Pro version 17 (SAS Institute) to determine the combined effects of ThryvOn technology, PRE herbicide rate, and foliar thrips spray on cotton growth, development, and yield. For herbicide injury ($p = 0.7672$), heights at 28 DAP ($p = 0.8980$) and first bloom ($p = 0.3570$), nodes at 28 DAP ($p = 0.6800$) and first bloom ($p = 0.3489$), FFB ($p = 0.9128$), first position retention ($p = 0.1683$), fresh shoot ($p = 0.8796$) and root ($p = 0.5697$) biomass, and thrips population ($p = 0.0699$) and injury ($p = 0.8404$), there were no year-by-location-by-treatment interactions. Thus, the aforementioned response variables were combined across year and location, and year, location, and replication were considered a random effect. Cutout date, end-of-season nodes, and end-of-season heights had to be separated by location, but Georgia data could be combined across year. Therefore, year and replication were considered random effects. Lint yield had to be separated by year ($p < 0.0001$) and location ($p < 0.0001$) for analysis with replication as a random effect. All p-values for tests of differences between least squares means were compared using Tukey's honestly significant difference test ($\alpha = 0.05$).

3 | RESULTS AND DISCUSSION

3.1 | Thrips population and injury

Both variety ($p < 0.0001$) and foliar thrips treatment ($p = 0.0195$) significantly affected thrips populations 14 DAP. With respect to variety, DP 2211 B3TXF had lower thrips populations than DP 2127 B3XF when averaged across foliar thrips treatment and PRE herbicide rate (Table 1). This confirms previous research demonstrating ThryvOn cotton has reduced thrips populations compared to non-ThryvOn cotton (Graham et al., 2019). A foliar thrips treatment of acephate at one-leaf reduced thrips populations by 24% compared to no foliar treatment, averaged across variety and PRE herbicide rate (data not shown). It should be noted that development of thrips resistance to acephate has been observed across the US cotton belt, particularly in the Mid-South (Johnson et al., 2003; Krob et al., 2022), thus these results are positive for growers in the lower Southeast, demonstrating that control with acephate was acceptable at the time of these studies. Similar to 14 DAP, thrips populations at 28 DAP were only influenced by variety ($p < 0.0001$), where DP 2211 B3TXF reduced thrips populations 58% compared to DP 2127 B3XF, averaged across foliar thrips treatment and PRE herbicide rate (Table 1).

Thrips injury at 28 DAP was influenced by the interaction between variety, PRE herbicide rate, and foliar thrips spray ($p = 0.0108$) (Table 2). For DP 2211 B3TXF, no significant differences were observed among PRE herbicide rates or foliar thrips treatments. For DP 2127 B3XF, a 2x PRE herbicide rate with no foliar thrips treatment had higher thrips injury than any DP 2127 B3XF treatment with a foliar thrips treatment. All DP 2211 B3TXF treatments had less thrips injury than any DP 2127 B3XF treatment. For growers, planting a ThryvOn variety would reduce the risk of significant thrips injury, whereas the non-ThryvOn variety would benefit from a foliar thrips spray if thrips reached threshold levels.

3.2 | Herbicide injury

There was a significant interaction between variety and PRE herbicide rate for herbicide injury ($p = 0.0134$). Averaged across foliar thrips treatment, DP 2127 B3XF had higher levels of herbicide injury at the 1x and 2x PRE herbicide rates than DP 2211 B3TXF at the same herbicide rates (Table 3). Previous research has demonstrated an increase in plant injury as fomesafen rates increased (X. Li et al., 2018; Main et al.,

TABLE 1 Thrips populations at 14 days after planting (DAP), plant heights, and shoot biomass at 28 DAP, plant heights and nodes at first bloom, and lint yield in response to variety for cotton planted in Prattville, AL, in 2024.

Variety	Thrips per five plants at 14 DAP	Plant heights at 28 DAP (cm)	Shoot biomass at 28 DAP (g)	Plant heights at first bloom (cm)	Nodes at first bloom	Alabama 2024 lint yield (kg ha^{-1})
DP 2211 B3TXF	5.7B	14.2A	13.9A	69.7A	11.9B	1362B
DP 2127 B3XF	9.4A	12.8B	11.5B	62.9B	12.2A	1456A
	$p < 0.0001$	$p < 0.0001$	$p = 0.0024$	$p < 0.0001$	$p = 0.0363$	$p = 0.0027$

Note: Data are averaged across foliar thrips spray treatments and preemergence herbicide rates. All data with the exception of lint yield are averaged across locations and years. Means within a column followed by the same letter are not different according to Tukey's honestly significant difference test ($\alpha = 0.05$).
Abbreviation: DP, Deltapine.

2012). More varieties and PRE herbicides should be evaluated to determine if PRE herbicides are less injurious in ThryvOn cotton compared to non-ThryvOn varieties.

3.3 | Early-season heights, nodes, and biomass

Total nodes and root biomass were not affected by variety, PRE herbicide rate, or foliar thrips treatment (data not shown). Heights at 28 DAP were influenced by variety ($p < 0.0001$) and PRE herbicide rate ($p = 0.0027$). Similar responses were noted with shoot biomass, which was affected by variety ($p = 0.0044$) and PRE herbicide rate ($p = 0.0227$). With respect to variety, DP 2211 B3TXF (14.2 cm) was taller than DP 2127 B3XF (12.8 cm) when averaged across PRE herbicide rate and foliar thrips treatment. Additionally, DP 2211 B3TXF had higher shoot biomass (13.9 g plant^{-1}) than DP 2127 B3XF (11.5 g plant^{-1}). This could explain the differences observed in visual herbicide injury, although the data were only influenced by variety, not PRE herbicide rate. Similar observations were made by Farmer et al. (2025), where a ThryvOn variety had greater biomass in high pressure thrips environments; however, the same trend was not observed by Graham and Stewart (2018). This could be explained by Graham & Stewart (2018) using isolines rather than Farmer et al. (2025) which evaluated two commercial varieties, similar to this work. Averaged across variety and foliar thrips treatments, treatments that did not receive a PRE herbicide (14.1 cm) were taller than those that received a 2x PRE herbicide rate (12.8 cm). The 1x PRE herbicide rate did not reduce plant heights compared to cotton not treated with PRE herbicides (data not shown). Similar results were observed with shoot biomass, where plants that did not receive a PRE herbicide had higher biomass (13.8 g plant^{-1}) than those that received a 2x PRE herbicide rate (11.1 g plant^{-1}), and the 1x PRE herbicide rate did not reduce shoot biomass relative to not utilizing a PRE herbicide. While previous research has indicated that PRE herbicides have the potential to injure cotton seedlings, these data suggest that utilizing PRE herbicides at labeled rates did not reduce early-season heights or shoot biomass compared to the nontreated in the lower Southeast (Copeland et al., 2017; Main et al., 2012).

3.4 | First fruiting branch, plant heights, total nodes, first position fruit retention at first bloom, and cutout date

FFB was impacted by the interaction between variety and PRE herbicide rate ($p = 0.0129$). Differences were observed in FFB when either variety were treated with the nontreated or 1x rate of PRE herbicides (5.4 to 5.5 for DP 2127 B3XF, and 4.9 to

TABLE 2 Thrips injury in response to variety, herbicide rate, and foliar application at 28 days after planting (DAP) in 2023 and 2024 in Tifton, GA, and Prattville, AL.

Variety	PRE herbicide rate[a]	Foliar thrips treatment[b]	Thrips injury 28 DAP
DP 2127 B3XF	0	Yes	1.9B
		No	2.2AB
	1x	Yes	2.1B
		No	2.3AB
	2x	Yes	1.9B
		No	2.6A
DP 2211 B3TXF	0	Yes	0.8C
		No	0.9C
	1x	Yes	0.9C
		No	0.9C
	2x	Yes	1.3C
		No	0.9C
			$p = 0.0108$

Note: Means within a column followed by the same letter are not different according to Tukey's honestly significant difference test ($\alpha = 0.05$).
Abbreviations: DP, Deltapine; PRE, preemergence.
[a]1x rate = 270 g ai ha^{-1} fomesafen (Reflex, Syngenta Crop Protection LLC) and 810 g ai ha^{-1} acetochlor (Warrant, Bayer CropScience LP).
[b]Acephate sprayed at a rate of 200 g ai ha^{-1}.

TABLE 3 Effects of variety and preemergence (PRE) herbicide rate on node of first fruiting branch (FFB) averaged across foliar thrips treatments for cotton planted in Tifton, GA, and Prattville, AL, in 2023 and 2024.

Variety	PRE herbicide rate[a]	Herbicide injury	FFB
DP 2211 B3TXF	0	0E	4.94C
	1x	12D	5.10BC
	2x	21B	5.27AB
DP 2127 B3XF	0	0E	5.51A
	1x	16C	5.44A
	2x	25A	5.34AB
		$p = 0.0134$	$p = 0.0129$

Note: Herbicide injury was rated on a 0–100 scale where 100 indicates no living plants in plot. Means within a column followed by the same letter are not different according to Tukey's honestly significant difference test ($\alpha = 0.05$).
Abbreviation: DP, Deltapine.
[a]1x rate = 270 g ai ha^{-1} fomesafen (Reflex, Syngenta Crop Protection LLC) and 810 g ai ha^{-1} acetochlor (Warrant, Bayer CropScience LP).

5.3 for DP 2211 B3TXF). It is well documented that FFB is dictated by variety (Dong et al., 2010; Fan et al., 2004; C. Li et al., 2012; Song et al., 2005), which is demonstrated in these data. However, it is interesting that FFB was similar for both varieties when treated with a 2x rate of PRE herbicides (Table 3). Previous work has demonstrated that fruit distribution can differ in cotton in response to herbicide injury. York et al. (2000) demonstrated that where significant carryover injury occurred in cotton following peanut, less fruit was produced below node 13, where 57% of the bolls were above node 14. In cotton where carryover injury did not occur, 61% of the bolls were below node 13.

Both plant heights ($p < 0.0001$) and total nodes ($p = 0.0363$) at first bloom were affected by variety (Table 1). Averaged across PRE herbicide rate and foliar insecticide application, DP 2211 B3TXF was 69.7 cm tall with 11.9 total nodes plant^{-1}, where DP 2127 B3XF was 62.9 cm tall with 12.2 total nodes plant^{-1}. Although these differences were present at first bloom, by the end of the season there were no differences in plant heights or total nodes (data not shown). Plant heights and total nodes have been well documented to vary among varieties (Ali & Hameed, 2011; Chalise et al., 2022). Thus, these results cannot be attributed to ThryvOn technology alone.

Previous research has evaluated fruit retention of ThryvOn and non-ThryvOn cotton varieties in high tarnished plant bug pressure situations, demonstrating that near-isolines of traited cotton treated aggressively for tarnished plant bugs had higher

TABLE 4 Lint yield in 2023 from cotton planted in Prattville, AL, and Tifton, GA, in response to variety and foliar insecticide application.

Variety	Foliar thrips treatment[a]	AL 2023 lint yield (kg ha^{-1})	GA 2023 lint yield (kg ha^{-1})
DP 2127 B3XF	No	2081A	1212B
DP 2127 B3XF	Yes	1937AB	1557A
DP 2211 B3TXF	No	1929B	1255B
DP 2211 B3TXF	Yes	1960AB	1128B
		$p = 0.0339$	$p = 0.0004$

Note: Data are averaged across preemergence (PRE) herbicide rates. Means within a column followed by the same letter are not different according to Tukey's honestly significant difference test ($\alpha = 0.05$).
Abbreviation: DP, Deltapine.
[a]Acephate sprayed at a rate of 200 g ai ha^{-1}.

first position fruit retention than non-traited cotton that was also treated aggressively for tarnished plant bugs (Graham & Stewart, 2018). However, where the present study was conducted is considered a low-pressure tarnished plant bug area, and there were no significant differences in first position fruit retention with respect to variety, PRE herbicide rate, or foliar thrips treatment (data not shown). Additionally, no differences were noted in days to cutout in any location with respect to variety, PRE herbicide rate, or thrips treatment, indicating that maturity was not influenced in this study (data not shown).

Some academic and industry scientists have stated that many of the benefits associated with ThryvOn technology include earlier fruiting, higher fruit retention, and earlier maturity, while some have stated that different plant growth regulator recommendations for ThryvOn may be necessary, based on differences in vigor and fruit retention (Shannon, 2023). Data from this study demonstrate that in the lower Southeast, fruit retention and maturity do not differ in ThryvOn compared to non-ThryvOn cotton, heights and nodes at the end of the season did not differ between the two varieties, indicating similar growth over the entire season. While FFB differed between the two varieties, this difference could likely be attributed to differences in genetics rather than the ThryvOn trait. Thus, in the lower Southeast, agronomic management should be variety specific regardless of the trait package utilized by growers.

3.5 | Lint yield

Yield was separated between year and location as indicated by interactions between year, location, and treatment. In 2023, lint yields in both locations were only affected by the interaction between foliar insecticide application and variety ($p = 0.0339$ in Alabama, $p = 0.0004$ in Georgia). Thus, data are averaged across PRE herbicide rate. In Alabama, the only differences observed were between DP 2211 B3TXF with no foliar thrips treatment (1947 kg ha^{-1}) and DP 2127 B3XF with no foliar thrips treatment (2101 kg ha^{-1}), averaged across PRE herbicide rate. However, both varieties that were treated with a foliar thrips spray yielded similar to the two aforementioned treatments (Table 4). In Georgia in 2023, the highest yielding treatment was DP 2127 B3XF that received a foliar insecticide application (1571 kg ha^{-1}), while yield was reduced in other treatments (1138–1267 kg ha^{-1}) averaged across PRE herbicide rate. In Alabama in 2024, lint yield was only affected by variety, where DP 2127 B3XF (1456 kg ha^{-1}) yielded higher than DP 2211 B3TXF (1362 kg ha^{-1}) when averaged across PRE herbicide rate and foliar insecticide application ($p = 0.0027$) (Table 1). In Georgia in 2024, lint yield was not influenced by variety, PRE herbicide rate, or foliar insecticide application. Although yields in 2023 were affected by a significant interaction between variety and foliar insecticide application, the major trend across all locations was that DP 2127 B3XF was the higher yielding variety compared to DP 2211 B3TXF. Variety performance varies across years and environments, and when a new trait is introduced it is not uncommon to see slightly lower yields associated with the first commercial varieties expressing the new trait until the trait is placed in elite germplasm (Mills et al., 2008). Early releases of ThryvOn varieties have been targeted to fit heavy tarnished plant bug infested and treated acres, which are largely in the Mid-South (Mississippi, Louisiana, Arkansas, Tennessee, and Missouri), which could be one reason why DP 2127 B3XF performed better in the lower Southeast than the ThryvOn variety that was evaluated.

4 | CONCLUSIONS

The objective of this study was to determine if PRE herbicides would alter management strategies for thrips in ThryvOn varieties in the lower Southeast. Based on current recommendations of excessive plant injury and immature thrips present on ThryvOn varieties, thrips management strategies should not be altered with respect to PRE herbicides (Hand et al., 2024). Less thrips injury occurred on DP 2211 B3TXF than on DP 2127 B3XF even with a foliar application. Herbicide

injury in the present study was lower in DP 2211 B3TXF; therefore, future research should be conducted to determine if ThryvOn varieties are more tolerant to PRE herbicide injury than non-ThryvOn varieties. Plant heights, number of mainstem nodes, FFB, and lint yield differences were an indicator of differences in variety and could not be associated with ThryvOn technology. There was no difference in cutout date or fruit retention, indicating that agronomic management should be heavily dictated by variety as opposed to the traits within varieties. ThryvOn is an important trait for management of thrips and tarnished plant bugs across the US cotton belt. Future research should evaluate ThryvOn technology response to plant growth regulators management, multiple production environments (i.e., rainfed vs. irrigated), and PRE herbicide injury.

AUTHOR CONTRIBUTIONS

Lance Wortman: Data curation; formal analysis; investigation; writing—original draft; writing—review and editing. **Meredith M. Kimbrell**: Data curation; investigation; writing—original draft; writing—review and editing. **Caitlyn Lawton**: Data curation; investigation; writing—review and editing. **Sarah Hobby**: Data curation; investigation; writing—review and editing. **Scott Graham**: Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; resources; writing—review and editing. **Steve Brown**: Conceptualization; data curation; investigation; methodology; resources; writing—review and editing. **Phillip Roberts**: Conceptualization; data curation; investigation; methodology; project administration; writing—review and editing. **John Snider**: Writing—review and editing. **Lavesta C. Hand**: Conceptualization; data curation; funding acquisition; investigation; methodology; project administration; resources; supervision; writing—review and editing.

ACKNOWLEDGMENTS

This experiment would not have been possible without the financial support received from the Alabama Cotton Commission and the Georgia Cotton Commission. The authors would like to thank Chandler Rowe and Trey Davis as well as graduate students and student workers who assisted throughout both growing seasons in data collection.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ORCID

Lance Wortman https://orcid.org/0009-0003-8944-8628
Caitlyn Lawton https://orcid.org/0009-0003-3868-8808
John Snider https://orcid.org/0000-0001-6535-7711
Lavesta C. Hand https://orcid.org/0000-0002-7343-6900

REFERENCES

Ali, H., & Hameed, R. A. (2011). Growth, yield and yield components of American cotton (*Gossypium hirsutum* L.) as affected by cultivars and nitrogen fertilizer. *Chemical Analysis*, *15*(30), 15.

Bachman, P. M., Ahmad, A., Ahrens, J. E., Akbar, W., Baum, J. A., Brown, S., Clark, L., Fridely, J., Gowda, A., Greenplate, J., Jensen, P., Mueller, G., Odegaard, M., Tan, J., Ufferman, J., & Levine, S. L. (2017). Characterization of the activity spectrum of MON 88702 and the plant-incorporated protectant Cry51Aa2. 834_16. *PLoS ONE*, *12*(1), e0169409.

Bednarz, C. W., & Nichols, R. L. (2005). Phenological and morphological components of cotton crop maturity. *Crop Science*, *45*, 1497–1503. https://doi.org/10.2135/cropsci2004.0321

Brown, S. (2019). *Cotton production calendar*. Alabama Cooperative Extension System. https://www.aces.edu/wp-content/uploads/2018/12/ANR-2361_CottonCalendar_070119L.pdf

Catchot, A., Adams, B., Allen, C., Bibb, J., Cook, D., Dodds, D., Gore, J., Jackson, R., Von Kanel, B., Larson, E., Layton, B., Luttrell, R., & Musser, F. (2014). *Insect management guide for agronomic crops 2014* (Publication 2471). Mississippi State University Extension Service.

Chalise, D. P., Snider, J. L., Hand, L. C., Roberts, P., Vellidis, G., Ermanis, A., Collins, G., Lacerda, L., Cohen, Y., Pokhrel, A., Parkash, V., & Lee, J. M. (2022). Cultivar, irrigation management, and mepiquat chloride strategy: Effects on cotton growth, maturity, yield, and fiber quality. *Field Crops Research*, *286*, 108633.

Chappell, T. M., Ward, R. V., DePolt, K. T., Roberts, P. M., Greene, J. K., & Kennedy, G. G. (2020). Cotton thrips infestation predictor: A practical tool for predicting tobacco thrips (*Frankliniella fusca*) infestation of cotton seedlings in the south-eastern united states. *Pest Management Science*, *76*(12), 4018–4028. https://doi.org/10.1002/ps.5954

Cook, D. R., Allen, C. T., Burris, E., Freeman, B. L., Herzog, G. A., Lentz, G. L., Leonard, B. R., & Reed, J. T. (2003). A survey of thrips (*Thysanoptera*) species infesting cotton seedlings in Alabama, Arkansas, Georgia, Louisiana, Mississippi, and Tennessee. *Journal of Entomological Science*, *38*(4), 669–681.

Cook, D. R., Herbert, A., Akin, D. S., & Reed, J. (2011). Biology, crop injury, and management of thrips (*Thysanoptera: Thripidae*) infesting cotton seedlings in the United States. *Journal of Integrated Pest Management*, *2*, B1–B9.

Cook, D. R., Leonard, B. R., Burris, E., & Gore, J. (2013). Impact of thrips infesting cotton seedlings on cotton yield distribution and maturity. *Journal of Cotton Science*, *17*, 23–33.

Cook, D. R., Threet, M., & Huff, K. (2023). *Cotton crop losses 2022: Biochemistry, molecular biology, entomology, and plant pathology*. Mississippi State University. https://www.biochemistry.msstate.edu/resources/2019loss.php

Copeland, J. D., Dodds, D. M., Catchot, A. L., Jr., Gore, J., & Wilson, D. G., Jr. (2017). Evaluation of planting date, variety, and pre herbicide on thrips infestations, cotton growth and development, and lint yield. *Journal of Cotton Science*, *21*(2), 94–103. https://doi.org/10.56454/qgfl9233

Culpepper, A. S., Grey, T. L., Vencill, W. K., Kichler, J. M., Webster, T. M., Brown, S. M., York, A. C., Davis, J. W., & Hanna, W. W. (2006). Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. *Weed Science*, *54*(4), 620–626. https://doi.org/10.1614/ws-06-001r.1

Culpepper, A. S., Whitaker, J., MacRae, A., & York, A. (2008). Distribution of glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) in Georgia and North Carolina during 2005 and 2006. *Journal of Cotton Science*, *12*, 306–310.

Doğan, M., Jabran, K., & Unay, A. (2014). Integrated weed management in cotton. In B. Chauhan & G. Mahajan (Eds.), *Recent advances in weed management* (pp. 197–222). Springer. https://doi.org/10.1007/978-1-4939-1019-9_9

Dong, N., Li, Q., Wang, L., Ai, J., Hu, H., & Zhang, B. (2010). Mixed inheritance of earliness and its related traits of short-season cotton under different ecological environments. *Journal of Cotton Science*, *22*, 304–311.

Fan, S., Yu, S., Zhang, C., Yuan, R., & Song, Z. (2004). Study on heredity and combining ability of earliness of short season cotton. *Journal of Cotton Science*, *16*, 211–215.

Farmer, W. B., Gore, J., Catchot, A. L., Jr., Crow, W. D., Cook, D., Pieralisi, B. K., Towles, T., Brown, S., Stewart, S., Reisig, D., & Huseth, A. (2025). The influence of imidacloprid seed treatment on non-ThryvOn and ThryvOn cotton. *Journal of Economic Entomology*, *118*, 700–706.

Graham, S. H., Musser, F. M., Jacobson, A. L., Chitturi, A., Catchot, B., & Stewart, S. D. (2019). Behavioral responses of thrips (*Thysanoptera: Thripidae*) and tarnished plant bug (Hemiptera: Miridae) to a new Bt toxin, Cry51Aa2. 834_16 in cotton. *Journal of Economic Entomology*, *112*(4), 1695–1704.

Graham, S. H., Reisig, D., Huseth, A., Greene, J., & Roberts, P. (2023). *Maximizing insect control in ThryvOn cotton in the Southeast*. Alabama Cooperative Extension System. https://www.aces.edu/blog/topics/crop-production/maximizing-insect-control-in-thryvon-cotton-in-the-southeast/

Graham, S. H., & Stewart, S. D. (2018). Field study investigating Cry51Aa2. 834_16 in cotton for control of thrips (*Thysanoptera: Thripidae*) and tarnished plant bugs (Hemiptera: Miridae). *Journal of Economic Entomology*, *111*(6), 2717–2726.

Hand, C., Culpepper, S., Vance, J., Kermerait, B., Yangxuan, L., Hall, D., Lyons, D., Mallard, J., Edwards, P., Porter, W., Fuhrer, L., Roberts, P., Smith, A., Virk, S., Bag, S., Sintim, H., Singleton, T., & Lee, J. (2024). *2025 Georgia cotton production guide*. The University of Georgia.

Hawkins, B. S., Peacock, H. A., & Steele, T. E. (1966). Thrips injury to upland cotton (*Gossypium hirsutum* L.) varieties. *Crop Science*, *6*, 256–258. https://doi.org/10.2135/cropsci1966.0011183x000600030012x

Holladay, S. K., Marshall, M. W., Plumblee, M. T., Jones, M. A., Narayanan, S., & Inman, M. D. (2024). Can cotton seed size mitigate preemergence herbicides injury? *Crop, Forage & Turfgrass Management*, *10*(1), e20286.

Huseth, A. S., Chappell, T. M., Chitturi, A., Jacobson, A. L., & Kennedy, G. G. (2018). Insecticide resistance signals negative consequences of widespread neonicotinoid use on multiple field crops in the US cotton belt. *Environmental Science & Technology*, *52*(4), 2314–2322.

Huseth, A. S., Chappell, T. M., Langdon, K., Morsello, S. C., Martin, S., Greene, J. K., Ames, H., Jacobson, A., Reay-Jones, F., Reed, T., Reisig, D., Roberts, P., Smith, R., & Kennedy, G. G. (2016). *Franklinella fusca* resistance to neonicotinoid insecticides: An emerging challenge for cotton pest management in the eastern United States. *Pest Management Science*, *72*(10), 1934–1945.

Huseth, A. S., D′Ambrosio, D. A., Yorke, B. T., Head, G. P., & Kennedy, G. G. (2019). Novel mechanism of thrips suppression by Cry51Aa2.834_16 bt toxin expressed in Cotton. *Pest Management Science*, *76*(4), 1492–1499. https://doi.org/10.1002/ps.5664

Johnson, D. R., Lorenz, G. M., III, Hopkins, J. D., Reaper, J. D., III, & Walsh, K. D. (2003). Insecticide screening for thrips control on cotton, 2001A. *Arthropod Management Tests*, *28*(1), F50.

Kerns, C. D., Greene, J. K., Reay-Jones, F. P., & Bridges, W. C., Jr. (2019). Effects of planting date on thrips (*Thysanoptera: Thripidae*) in cotton. *Journal of Economic Entomology*, *112*(2), 699–707.

Krob, J. L., Stewart, S. D., Brown, S. A., Kerns, D., Graham, S. H., Perkins, C., Huseth, A., Kennedy, G., Reisig, D., Taylor, S., Towles, T., Kerns, D., Thrash, B., Lorenz, G., Bateman, N., Cook, D., Crow, W., Gore, J., Catchot, A., … Catchot, B. (2022). Standardized field trials in cotton and bioassays to evaluate resistance of tobacco thrips (*Thysanoptera: Thripidae*) to insecticides in the southern United States. *Journal of Economic Entomology*, *115*(5), 1693–1702.

Lawton, C. B., Pokhrel, A., Lee, J. M., Chalise, D. P., Virk, G. K., Snider, J. L., Roberts, P., Chee, P., & Hand, L. C. (2023). Evaluating the impacts of wide row upland cotton (*Gossypium hirsutum* L.) production in Georgia. *Agronomy Journal*, *115*(6), 2867–2876.

Li, C., Knowlton, A., Brown, S., & Ritchie, G. (2011). A comparative study of a microgin with a lab gin stand and commercial gins in the southeast United States. *Applied Engineering in Agriculture*, *27*, 167–175.

Li, C., Wang, C., Dong, N., Wang, X., Zhao, H., Converse, R., Xia, Z., Wang, R., & Wang, Q. (2012). QTL detection for node of first fruiting branch and its height in upland cotton (*Gossypium hirsutum* L.). *Euphytica*, *188*, 441–451.

Li, X., Grey, T., Vencill, W., Freeman, J., Price, K., Cutts, G., & Price, A. (2018). Evaluation of cotton responses to fomesafen-based treatments applied preemergence. *Weed Technology*, *32*(4), 431–438.

Mailhot, D., Dunn, D., Sutton, A., & Arrington, J. (2025). *Georgia 2024 peanut and cotton performance tests*. University of Georgia Griffin Campus. https://swvt.uga.edu/content/dam/caes-subsite/statewide-variety-testing/docs/performance-trials/2024/peanut-cotton-2024.pdf

Main, C. L., Faircloth, J. C., Steckel, L. E., Culpepper, A. S., & York, A. C. (2012). Cotton tolerance to fomesafen applied preemergence. *Journal of Cotton Science*, *16*, 80–87.

Mills, C. I., Bednarz, C. W., Ritchie, G. L., & Whitaker, J. R. (2008). Yield, quality, and fruit distribution in Bollgard/Roundup Ready and Bollgard II/Roundup Ready Flex cottons. *Agronomy Journal*, *100*(1), 35–41.

Reay-Jones, F. P., Greene, J. K., Herbert, D. A., Jacobson, A. L., Kennedy, G. G., Reisig, D. D., & Roberts, P. M. (2017). Within-plant distribution and dynamics of thrips species (*Thysanoptera: Thripidae*) in cotton. *Journal of Economic Entomology*, *110*(4), 1563–1575.

Roberts, P., Toews, M., Culpepper, S., Herbert, A., Greene, J., Marshall, M., Reed, T., & Smith, R. (2015, January 5–7). *Potential interaction of thrips management and PRE herbicides in cotton*. [Paper presentation]. 2015 Beltwide Cotton Conferences, San Antonio, TX, USA.

Shannon, W. (2023, October 9). ThryvOn technology: Changing the way we manage cotton. *FarmProgress*. https://www.farmprogress.com/cotton/thryvon-technology-changing-the-way-we-manage-cotton-

Song, Z., Yu, X., & Fan, L. (2005). Genetic analysis of main agronomic traits in short season upland cotton. *Journal of Cotton Science*, *17*, 94–98.

Stewart, S. D., & Lentz, G. L. (2010). *Cotton insects: Thrips* (W026). The University of Tennessee Agricultural Extension Service.

USDA-NASS. (2024). *Quick stats*. USDA-NASS. https://www.nass.usda.gov/Quick_Stats/

Wang, H., Kennedy, G. G., Reay-Jones, F. P., Reisig, D. D., Toews, M. D., Roberts, P. M., Herbert, D., Jr., Taylor, S., Jacobson, A., & Greene, J. K. (2018). Molecular identification of thrips species infesting cotton in the Southeastern United States. *Journal of Economic Entomology*, *111*(2), 892–898.

Whitfield, A. (2023). *Evaluation of thresholds, control, and behavioral responses of tobacco thrips, Frankliniella fusca (Hitch), and tarnished plant bugs, Lygus lineolaris (Beauvoris), in ThryvOn cotton* [Master's thesis]. University of Arkansas.

York, A. C., Jordan, D. L., Batts, R. B., & Culpepper, A. S. (2000). Cotton response to imazapic and imazethapyr applied to a preceding peanut crop. *Journal of Cotton Science*, *4*, 210–216.

How to cite this article: Wortman, L., Kimbrell, M. M., Lawton, C., Hobby, S., Graham, S., Brown, S., Roberts, P., Snider, J., & Hand, L. C. (2026). Determining if preemergent herbicide injury on ThryvOn cotton alters management strategies. *Agronomy Journal*, *118*, e70452. https://doi.org/10.1002/agj2.70452