The *Journal of Cotton Science 30:1–7* (*2026*)
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WEED SCIENCE

Impact of Reduced Rates of Trifludimoxazin + Saflufenacil on Early-Season Cotton (*Gossypium hirsutum* L.) Growth and Yield

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ABSTRACT

Trifludimoxazin + saflufenacil is a premix protoporphyrinogen oxidase-inhibiting herbicide with both PRE and POST activity pending U.S. Environmental Protection Agency registration for burndown application ahead of planting corn, soybean, grain sorghum, and wheat. Early-season cotton emergence and growth often coincide in the Mid-South with preplant herbicide application in later planted soybean, thereby increasing opportunity for off-target herbicide movement from adjacent fields. Field studies were conducted in 2024 to identify any deleterious impacts of reduced rates of trifludimoxazin + saflufenacil (1/8-1/256x of the lowest proposed labeled application rate of 38.3 g ai ha^{-1}) applied to one- to two-leaf cotton. Visual injury one week after treatment (WAT) with 1/8, 1/16, 1/32, and 1/64x rate of trifludimoxazin + saflufenacil was 93, 84, 66, and 40%, respectively; whereas at four WAT these respective rates resulted in visual injury of 55, 30, 11, and 4%. Trifludimoxazin + saflufenacil at these rates reduced cotton height 30 to 72% and 21 to 60%, two and four WAT, respectively, and reduced seed cotton yield 64, 26, 6, and 1%. Application of trifludimoxazin + saflufenacil directly adjacent to cotton in early vegetative growth should be avoided as severe visual injury will occur. In cases where off-target movement does occur, impacted cotton should not be expected to fully recover and negative impact on growth and yield will be observed at the three highest reduced rates evaluated.

Conservation Tillage. A 2024 National Agricultural Statistics Service (NASS) and USDA Natural Resources Conservation Services (NRCS) Conservation Effects Assessment Project (CEAP) survey of 6,245 producers across the U.S. indicted that approximately 81% of respondents used conservation practices on their cropland (USDA-NASS, 2024). Also, 83.3% reported using no-till or minimum tillage to manage pests applied to almost 73% of the cropland surveyed. These findings continued a trend based on results from a CEAP II survey conducted from 2013 through 2016, which indicated that approximately 87% of U.S. cultivated cropland acres used some form of conservation tillage for at least one crop in a crop rotation (USDA-NRCS, 2022). Conservation tillage use in crop production can lead to a potential 2888-million-liter reduction in diesel equivalents per year as well as a 7.7-million-metric-ton yearly reduction in associated emissions (Creech, 2022). Realized benefits of conservation tillage systems can include improved soil health or capacity of the soil as a living system to sustain plants, decreased erosion, maximized water infiltration, improved nutrient cycling, and a build-up in organic matter (Creech, 2022; Farmaha et al., 2021; Lal, 2015).

Conservation tillage systems rely on herbicides for effective preplant weed management. Numerous herbicides or combinations of herbicides are currently labeled and recommended for preplant or burndown control of many common and troublesome winter weed species encountered in corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), and soybean (*Glycine max* [L.] Merr.) production fields (Anonymous, 2026; Barber et al., 2026; Bond et al., 2026; Steckel et al., 2026). Weed resistance issues

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and difficult-to-control species have necessitated identification of novel strategies and herbicides for continued successful preplant weed management in these production systems (Flessner and Pittman, 2019; Johanning et al., 2016; Vollmer et al., 2019; Westerveld et al., 2021a, b; Zimmer et al., 2018).

Trifludimoxazin + Saflufenacil Herbicide. Trifludimoxazin, a new protoporphyrinogen oxidase (PPO)-inhibiting herbicide developed by BASF that is awaiting registration by the U.S. Environmental Protection Agency (EPA), has demonstrated PRE and POST activity on a number of grass and broadleaf weeds including annual ryegrass (*Lolium perenne* [L.] ssp. *multiflorum* [Lam.] Husnot), giant foxtail (*Setaria faberi* Herrm), junglerice (*Echinochloa crus-galli* [L.] P. Beauv), johnsongrass (*Sorghum halepense* [L.] Pers.), green foxtail (*Setaria viridis* [L.] P. Beauv.), hairy crabgrass (*Digitaria sanguinalis* [L.] Scop.), horseweed (*Conyza canadensis* [L.] Cronquist), redroot pigweed (*Amaranthus retroflexus* L.), common ragweed (*Ambrosia artemisiifolia* L.), and kochia (*Bassia scoparia* [L.] A.J. Scott) (Rapado et al., 2025). Additionally, the herbicide has been reported to inhibit the PPO2 enzyme that carries target-site mutations that could be used to mitigate widespread occurrence of PPO target-site resistance and resistance to other modes of action (Porri et al., 2023). Saflufenacil, also a PPO-inhibiting herbicide commercialized by BASF, is labeled for preplant application in crops including soybean, corn, cotton, and rice (*Oryza sativa* L.) and exhibits good activity on a number of common broadleaf winter weeds (Anonymous, 2024; 2026; Barber et al., 2026; Bond et al., 2026; Steckel et al., 2026). Improved burndown weed control and longer soil residual activity have been reported with combinations of trifludimoxazin and saflufenacil (Findley, 2020; Grey et al., 2020; Rapado et al., 2025). Registration is pending by the EPA for a premix herbicide containing both trifludimoxazin and saflufenacil for burndown application ahead of planting corn, soybean, grain sorghum (*Sorghum bicolor* [L.] Moench ssp. *bicolor*), and wheat (*Triticum aestivum* L.).

Cotton and Off-Target Herbicide Impacts. Cotton was estimated to be planted on more than 4 million hectares in the U.S. in 2025 (USDA-NASS, 2025). Cotton emergence and early-season growth often coincide with preplant herbicide applications made in preparation for later planting of cotton or soybean and often occur in adjacent fields, thereby increasing opportunity for off-target herbicide movement. Drift or off-target movement was identified previously by survey respondents from two states as the biggest herbicide application challenge they face (Butts et al., 2021; Virk and Prostko, 2022). Additionally, severe crop injury from off-target herbicide movement is possible upwards of 60 m downwind from both ground and aerial applications, which can negatively impact yield, environmental stewardship, and other beneficial species (Butts et al., 2022). As a result, it is imperative to understand the implications on crop growth and development if the crop were to be exposed to a herbicide drift event.

Serious deleterious effects of simulated off-target movement of selective and nonselective herbicides to cotton at various growth stages have been demonstrated (Johnson et al., 2012; Manuchehri et al., 2020). Hurst (1982) investigated impacts of foliar application of normal use rates (0.2-0.6 kg ai ha^{-1}) and below normal use rates (0.07-0.1 kg ai ha^{-1}) of acifluorfen, a contact PPO-inhibiting herbicide similar to trifludimoxazin and salflufenacil, to cotton at the cotyledon, 5-, or 8-node growth stage. It was reported that acifluorfen at all rates above 0.07 kg ha^{-1} applied at the cotyledon stage severely reduced cotton stands. Additionally, Miller et al. (2024) reported that the PPO-inhibiting herbicide tiafenacil applied to one- to two-leaf cotton resulted in visual injury one week after treatment (WAT) with 1/8, 1/16, 1/32, and 1/64x rate of 72, 54, 36, and 22%, respectively; whereas at four WAT these respective rates resulted in visual injury of 73, 67, 48, and 20%. Tiafenacil at these rates reduced cotton height 26 to 38% and 12 to 36%, one and four WAT and seed cotton yield by 58, 38, 20, and 9%.

RESEARCH OBJECTIVES

With the potential use of trifludimoxazin + saflufenacil for preplant application, the opportunity for off-target movement to young cotton plants growing in proximity to later planted soybean fields exists. To our knowledge there exists no published information on the impact of trifludimoxazin + saflufenacil on cotton growth and yield following foliar application at sublethal rates that might be encountered in off-target movement events. Therefore, the objective of this research was to determine any negative impacts of foliar application of trifludimoxazin + saflufenacil to cotton.

MATERIALS AND METHODS

Field experiments were conducted in 2024 at the LSU AgCenter Northeast Research Station near St. Joseph, LA; the University of Arkansas System Division of Agriculture Lon Mann Cotton Research Station in Marianna, AR; and the University of Tennessee AgResearch and Education Center in Milan, TN to determine the impact of reduced rates of trifludimoxazin + saflufenacil on cotton growth and yield. Experiments were conducted in a randomized complete block design with treatments replicated three or four times. Treatments were applied via compressed air or CO_2 backpack sprayer at 140 liters ha^{-1}. Treatments included trifludimoxazin + saflufenacil at 0, 1/8, 1/16, 1/32, 1/64, 1/128, or 1/256x rate applied to one- to two-leaf cotton. The 1x rate basis for reduced rate calculation was 38.3 g ai ha^{-1}. Unpublished research indicated that this rate in combination with glyphosate provides effective control of most common winter weed species prior to planting (Donnie K. Miller, personal observation). Methylated seed oil (MSO) was added at 1% v/v to all treatments. A comparison 1% MSO-alone treatment was included but resulted in no impact on parameters measured in comparison to the 0x rate and was excluded from statistical analysis.

Trifludimoxazin + saflufenacil at designated rates was applied to one- to two-leaf cotton variety DP2127 B3XF near St. Joseph on 21 May, variety DP2127 B3XF on 30 May in Marianna, and variety NG4343BTXF on 14 June in Milan. This timing was selected as being the most likely to exist when burndown of late-planted soybean ground normally occurs in the Mid-South. Plots were maintained weed free at St. Joseph with as needed application of glyphosate at 1120 g ai ha^{-1} plus glufosinate at 450 g ai ha^{-1}. Plots at Marianna were kept weed free with a PRE application of fluometuron at 1680 g ai ha^{-1} plus fluridone 1120 g ai ha^{-1}. Plots at Milan were kept weed free by hand-weeding. Parameter measurements included visual injury on a scale of 0 to 100 (0 = no injury; 100 = plant death) 1, 2, and 4 WAT, plant height at 2 and 4 WAT, and yield.

The four-parameter log-logistic model was fit to cotton injury (1, 2, and 4 WAT), cotton height injury (2 and 4 WAT), and yield data averaged across locations:

$$Y = c + \frac{d - c}{1 + \exp\left[b(\ln(x) - \ln(e))\right]}$$

where Y is injury (%), height (cm), and yield (kg ha^{-1}), b is the slope at the inflection point, c is the lower limit, d is the upper limit, e is the dose of herbicide corresponding to the midpoint of plant injury response observed between the upper and lower limits, and x is the fraction of the labeled rate of the premixture of saflufenacil and trifludimoxazin tested (Tables 1, 2, 3). All curve fittings were accomplished using the nonlinear least squares regression (nls) function in R version 4.1.2 (R-Core Team, 2024).

Table 1. Nonlinear regression parameters for cotton visual injury 1, 2, and 4 weeks after treatment following application of trifludimoxazin + saflufenacil at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024

Timing	Parameter estimates			
Weeks after application	c	d	b	e
1	1.673311123	98.68660383	-1.585703683	0.020555716
2	1.27499043	100	-1.491247983	0.046496553
4	1.27499043	84.47447385	-1.775398015	0.087905507

Table 2. Nonlinear regression parameters for cotton height 2 and 4 weeks after treatment following application of trifludimoxazin + saflufenacil at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024

Timing	Parameter estimates			
Weeks after application	c	d	b	e
2	-6.605875665	49.4921213	0.756509979	0.060885981
4	19.56527912	77.21908334	1.11580963	0.03580917

Table 3. Nonlinear regression parameters for seed cotton yield after treatment following application of trifludimoxazin + saflufenacil at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024

Parameter estimates			
c	d	b	e
0	3607.536	2.358024	0.097935

Prior to fitting the equation, model assumptions were assessed using different statistical tests. A lack-of-fit test was used to compare the chosen nonlinear regression model to a more general ANOVA model (Ritz and Streibig, 2008). Variance homogeneity was evaluated using Levene's test. The Shapiro-Wilk test was used to assess whether residuals were normally distributed.

RESULTS AND DISCUSSION

Cotton Injury. Cotton visual injury was characterized by necrotic speckling of leaves contacted at time of application and population reduction due to plant death at higher rates. Cotton was injured 93% at the highest trifludimoxazin + saflufenacil rate applied (1/8x), with each successive rate reduction resulting in 84, 66, 40, 19, and 8% visual injury 1 WAT (Fig. 1). At 2 WAT visual injury was 82, 61, 36, 18, 8, and 4% at these same rates (Fig. 2). By 4 WAT, visual injury for each successive reduced rate was 55, 30, 12, 4, 1, and 0% (Fig. 3). Hurst (1982) reported the PPO-inhibiting herbicide acifluorfen

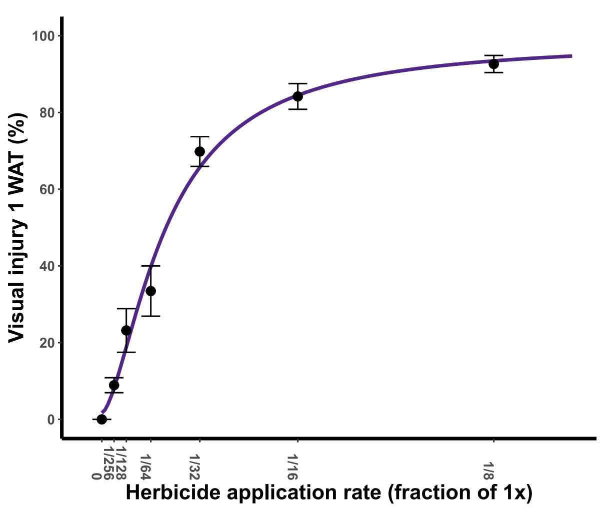

Figure 1. Cotton visual injury 1 week after treatment (WAT) as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha-1 use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024.

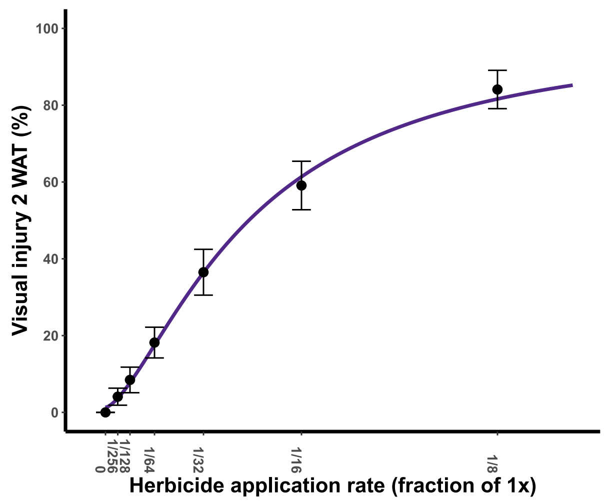

Figure 2. Cotton visual injury 2 week after treatment (WAT) as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024

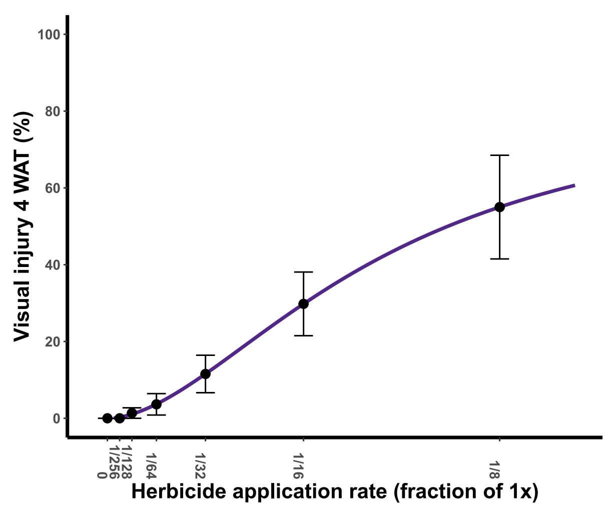

Figure 3. Cotton visual injury 4 week after treatment (WAT) as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024.

applied to cotyledon cotton at sublethal rates ranging from 0.1 to 0.8 kg ha^{-1} resulted in stands of 8 to 59% of that for an untreated control. Miller et al. (2003) reported that the nonselective contact herbicide glufosinate applied to 2-node non-glufosinate tolerant cotton resulted in 20 to 32% and 6 to 16% injury at a 1/8 and 1/16x reduced rate 14 days after treatment (DAT), respectively. In addition, the 1/8x rate reduced final plant population 9 to 14%. The PPO-inhibiting herbicide tiafenacil applied at 1/8, 1/16, 1/32, and 1/64x injured one- to two-leaf cotton 72, 54, 36, and 22%, respectively; whereas at four WAT these respective rates resulted in visual injury of 73, 67, 48, and 20% (Miller et al., 2024).

Cotton Height. At 2 WAT, the highest rate of trifludimoxazin + saflufenacil applied reduced cotton height 72%, whereas successive rate reductions resulted in height reductions of 57, 43, 30, 26, and 13% (Fig. 4). At 4 WAT, height was reduced for each successive reduced rate 60, 49, 35, 21, 12, and 6% (Fig. 5). The non-selective contact herbicide glufosinate reduced 2-node non-glufosinate cotton height 6 to 17% and 3 to 9% 30 DAT when applied at the 1/8 and 1/16x reduced use rates, respectively (Miller et al., 2003). Previous research has shown that tiafenacil at the reduced rates used in the current research reduced cotton height 43 to 3% and 36 to 4%, 1 and 4 WAT, respectively (Miller et al., 2024). These results and results from the current research indicate greater sensitivity of early-season cotton growth to off-target movement of trifludimoxazin + saflufenacil compared to glufosinate and tiafenacil.

Seed Cotton Yield. Cotton yield following exposure to trifludimoxazin + saflufenacil at the 1/8x rate was reduced 64% (Fig. 6). Trifludimoxazin + saflufenacil applied at 1/16 and 1/32x rates resulted in reduced yield of 26 and 6%, respectively; whereas lower rates reduced yield no greater than 1%. Negative impact of reduced rates of a contact

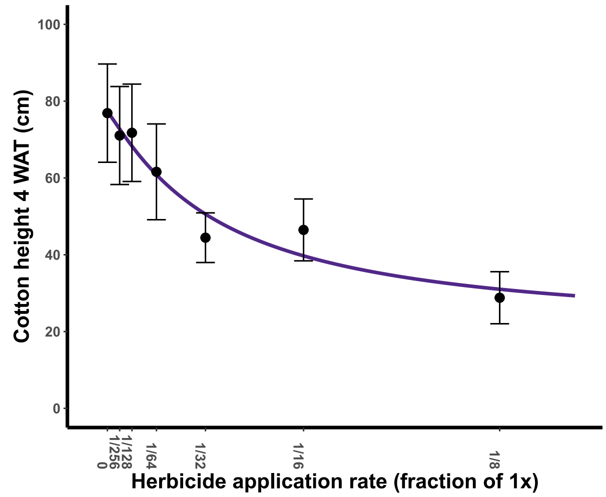

Figure 5. Cotton height 4 week after treatment (WAT) as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024.

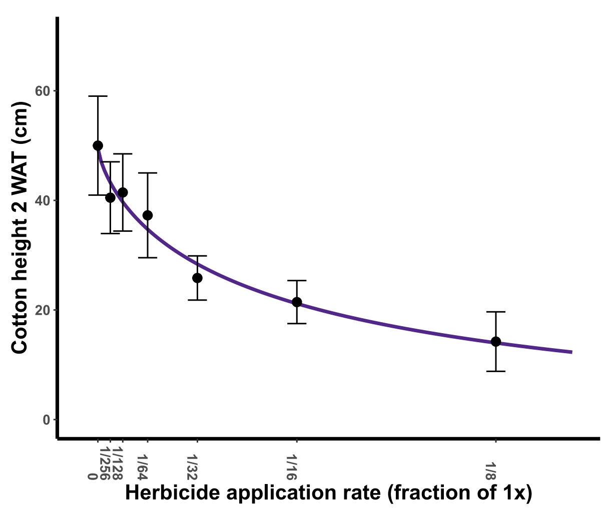

Figure 4. Cotton height 2 week after treatment (WAT) as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024.

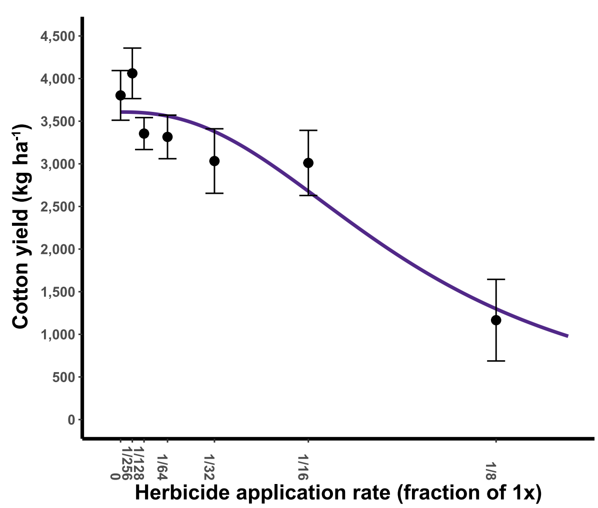

Figure 6. Seed cotton yield as impacted by reduced trifludimoxazin + saflufenacil rate at 0, 1/8, 1/16, 1/32, 1/64, 1/128, and 1/256x of a 38.3 g ai ha^{-1} use rate applied to one- to two-leaf cotton for data collected at St. Joseph, LA; Marianna, AR; and Milan, TN in 2024.

PPO-inhibiting herbicide on cotton yield has been previously reported. Hurst (1982) found that the PPO-inhibiting herbicide acifluorfen applied at 1/2 and 1/3 of the lower end of a normal use rate range (0.2-0.6 kg ha^{-1}) resulted in cotton yield of only 42 and 84% of nontreated control plants. Conversely, although resulting in significant early season injury, height reduction, and reduced final plant population, non-glufosinate resistant cotton treated with rates as high as 1/8 of an effective use rate of 420 g ai ha^{-1} was able to yield equal to that of a control. Tiafenacil applied at the four highest fractional reduced rates was reported to reduce seed cotton yield 58, 38, 20, and 9% (Miller et al., 2024). These results in addition to previous research with acifluorfen and the current research indicate that cotton is more sensitive to off-target movement from PPO-inhibiting herbicides at reduced rates in comparison to the non-selective contact herbicide glufosinate.

PRACTICAL IMPLICATIONS

In summary, severe visual cotton injury including plant death was observed early season in response to trifludimoxazin + saflufenacil rates ranging from 1/8 to 1/256x of the lower end of the proposed labeled rate range (38.3 g ai ha^{-1}) and slightly lessened over time. This visual injury was also manifested in significant height and yield reduction. In comparison to previous research conducted on the PPO-inhibiting herbicides acifluorfen (Hurst, 1982) and tiafenacil (Miller et al., 2024), season-long cotton response to trifludimoxazin + saflufenacil applied at rates evaluated would be similar among the compounds. Application of trifludimoxazin + saflufenacil directly adjacent to cotton in early vegetative stages of growth should be avoided. In cases where off-target trifludimoxazin + saflufenacil movement occurs before the two-leaf stage, injured cotton should not be expected to fully recover and negative impact on growth and yield will be observed at the three highest reduced rates evaluated.

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