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Crop Tolerance and Weed Management with Pyroxasulfone in Cotton

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ABSTRACT

Field studies were conducted in 2013 and 2014 on the Texas Southern High Plains to evaluate cotton response and Palmer amaranth control following applications of Zidua (pyroxasulfone). Herbicide treatments were applied early-preplant (EPP), preemergence (PRE) and postemergence-directed (PDIR). Early-preplant and PRE applications of Zidua, Warrant, and Dual Magnum were applied at Halfway (clay loam soil) and Lamesa (sandy loam soil). Cotton injury was observed ranging from 20% to 65% following Zidua applied EPP and PRE with greatest injury observed on coarse textured soils. Zidua applied EPP and PRE at either location provided excellent residual control of Palmer amaranth and cotton yield was not reduced by any Zidua application. Postemergence-directed treatments of Zidua and Warrant were applied at Lamesa and Lubbock. No injury or yield reduction was observed following Zidua applied PDIR and excellent residual Palmer amaranth control was achieved.

KEYWORDS: cotton; *Gossypium hirsutum*; weeds; palmer amaranth; resistant; control; zidua; pyroxasulfone; chemical control; herbicide resistance

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an economically important crop in the United States and the most important agronomic crop on the Texas Southern High Plains. In 2015, 12.9 million bales of Upland cotton were produced on 3.4 million hectares (NASS 2015). One of the many factors that contribute to profitable cotton yields is an effective weed management system. Environmental conditions that are favorable for cotton growth also provide ample opportunities for weeds to emerge and compete with cotton for water, nutrients and light (Rushing et al. 1985).

One of the most detrimental weeds to profitable cotton production is Palmer amaranth (*Amaranthus palmeri* S. Wats.). Palmer amaranth is an aggressive summer annual that can reach heights exceeding three meters. Female Palmer amaranth plants are prolific seed producers capable of producing thousands of seeds each year (Keeley

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et al. 1987). Morgan et al. (2001) found that Palmer amaranth competition with cotton reduced lint by 54% when populations averaged one plant per m.

Herbicides are an integral part of cotton production and can be applied as preplant incorporated (PPI), preemergence (PRE), postemergence-topical (POST) or postemergence-directed (PDIR) (Chapman and Carter 1976). The commercialization of glyphosate-tolerant cultivars in the mid 1990s gave producers an effective means of weed control by allowing POST applications of glyphosate to be made up to the four leaf stage of cotton and PDIR applications for the rest of the season. The commercialization of Roundup Ready® Flex cotton in 2006 allowed season-long POST applications of glyphosate. Glyphosate was so effective at controlling weeds in glyphosate-tolerant crops that many growers reduced or eliminated the use of residual herbicides and cultivation (Green 2007). The wide-spread use of glyphosate throughout the United States has created intensive selection pressure for the evolution of glyphosate-resistant weeds (Culpepper 2006). Weed management has been a challenge for cotton producers, and will be an even greater challenge with the development of glyphosate-resistant weeds. To manage herbicide resistant weeds, producers will need to utilize a combination of herbicides employing multiple modes of action.

Pyroxasulfone is a soil-applied herbicide that inhibits very long chain fatty acid synthesis in plants and is the sole active ingredient in Zidua®. Zidua® is currently labeled for use PPI, PRE, and early postemergence (EPOST) in corn, PDIR in cotton, PPI, PRE, and EPOST in soybean (*Glycine max* L.) and delayed preemergence (DPRE) and EPOST in wheat (*Triticum aestivum* L.) (CDMS 2015). Lawson (2013) reported no injury to corn (*Zea maydis* L.) when pyroxasulfone was applied PRE at the 1x rate (89 g ai/ha), while pyroxasulfone applied at 2x (178 g ai/ha) resulted in stunting. Pyroxasulfone provided grass and broadleaf weed control comparable to *S*-metolachlor (Lawson 2013). Pyroxasulfone PRE at 1x caused 16% plant height reduction in cotton (Doherty et al. 2014). Pyroxasulfone controlled Palmer amaranth 98% 25 days after treatment (DAT), which was greater than the 55% control following acetochlor PRE at 1x (1050 gai/ha) at this same observation period (Doherty et al. 2014). When applied in tank mix combinations to soybean, pyroxasulfone caused no crop injury when applied early-preplant (EPP) or POST. At 20 DAT, horseweed (*Conyza canadensis* L.) and common dandelion (*Taraxacum officinale* Weber in Wiggers) were controlled 98%, while giant foxtail (*Setaria faberi* Herrm.) was controlled 99% with pyroxasulfone applied EPP (Owen et al. 2012). Pyroxasulfone in combination with flumioxazin injured winter wheat seedlings at least 64% at the 1x field use rate (89 and 72 g ai/ha). Pyroxasulfone accounted for 20% injury when applied alone at the same rate. Seedling injury increased two-fold as the rate of pyroxasulfone increased from 1 to 4x (Refsell, 2013). Pyroxasulfone applied PRE or POST in wheat controlled Italian ryegrass (*Lolium multiflorum* L.) more effectively than pyroxsulam applied POST. However, no significant yield differences were observed (Lyon et al. 2014). Pyroxasulfone applied at 90 g ai/ha controlled Italian ryegrass 88%, while 120 g ai/ha provided 4% to 7% better control (Mize et al. 2014).

Limited information is available as to the potential use of pyroxasulfone in cotton. The studies herein were conducted to evaluate cotton tolerance and Palmer amaranth efficacy with pyroxasulfone applied PRE, POST, and PDIR in cotton. In both 2013 and 2014, cotton tolerance and Palmer amaranth control with pyroxasulfone was compared to cotton tolerance and Palmer amaranth control with acetochlor and *S*-metolachlor.

MATERIALS AND METHODS

Field sites and experimental design. Field experiments were conducted in 2013 and 2014 at the Texas A&M AgriLife Research and Extension Center at Halfway, TX Latitude 34.184, Longitude -101.946 the AG-CARES research farm in Lamesa, TX, Latitude 32.775, Longitude -101.943 to evaluate cotton tolerance and Palmer amaranth response to pyroxasulfone at PRE, POST, and PDIR application timings. In 2014, additional field experiments were conducted at the Texas A&M AgriLife Research and Extension Center near Lubbock, TX and the AG-CARES research farm in Lamesa, TX to evaluate cotton tolerance to pyroxasulfone applied PDIR. In both 2013 and 2014, cotton tolerance and Palmer amaranth control with pyroxasulfone was compared to cotton tolerance and Palmer amaranth control with acetochlor and *S*-metolachlor.

Field experiments were established using a randomized complete block design with three replications. Cotton was planted approximately 38 mm deep, centered on 102 cm rows, and planted at a density of four plants per 30 cm. Plots were four rows in width by 9.1 m in length for all PRE and POST experiments. For postemergence-directed experiments, plots were four rows in width by 15.2 m in length. Lubbock and Lamesa experiments were planted with cotton variety 'FiberMax 2011 GT', while Halfway experiments were planted with cotton variety 'Deltapine 0912 B2RF'. Planting dates for Halfway were May 16, 2013 and May 16, 2014. Planting date for Lubbock was June 2, 2014. Planting dates for Lamesa were May 8, 2013 and May 14, 2014.

The soil at Lubbock is classified as an Acuff clay loam [fine-loamy, mixed, thermic Aridic Paleustolls (39% sand, 28% silt, and 33% clay)] with less than 1.0% organic matter and pH of 7.9. The soil at Halfway is classified as a Pullman clay loam [fine, mixed, thermic Torrertic Paleustoll (31% sand, 36% silt, and 33% clay)] with less than 1.0% organic matter and pH of 7.7. The soil texture at Lamesa was an Amarillo fine sandy loam [fine-loamy, mixed, superactive, thermic Aridic Paleustalfs (67% sand, 14% silt, and 19% clay)] with less than 1.0% organic matter and pH of 7.7. Rainfall, which varied between locations and year to year, is summarized in Table 1. Halfway rainfall totaled 416 mm in 2013 and 363 mm in 2014 and received an additional 161 mm of irrigation in 2013 and 142 mm in 2014. Lubbock rainfall totaled 572 mm in 2014 and no supplemental irrigation was applied. Lamesa rainfall totaled 395 mm in 2013 and 521 mm in 2014 and received an additional 224 mm of irrigation in 2013 and 236 mm in 2014.

Chemical treatments. Pyroxasulfone was applied EPP, PRE, EPOST, late-postemergence (LPOST) and PDIR. Early-preplant, PRE, EPOST and LPOST applications were made using a CO_2-pressurized sprayer and calibrated to deliver 91 L/ha with a two row spray boom using Turbo Tee 110015 nozzles on 0.5 m centers. Postemergence-directed applications were made using a tractor mounted Redball 420 Lay-By hooded sprayer (Redball LLC, 140 30th Avenue SE, Benson, MN 56215-0159) pressurized with CO_2 and calibrated to deliver 182 L/ha with 8001 Flat-fan and 11004 AIXR nozzles.

Table 1. Monthly rainfall distribution for the years 2013 and 2014, and the 30 year average for Lubbock, Lamesa, and Halfway, TX.[a,b]

Month	--------2013--------			--------2014--------			30 year avg.
	Lubbock	Halfway	Lamesa	Lubbock	Halfway	Lamesa	
	------------------------------mm-------------------------------						
January	23	28	19	0	0	0	17
February	33	10	44	4	26	4	23
March	0	0	10	4	5	8	32
April	1	0	1	15	6	14	38
May	29	19	3	133	96	112	64
June	42	63	57	66	61	123	85
July	37	76	124	67	28	67	57
August	34	29	42	14	9	28	52
September	14	83	27	176	169	106	82
October	29	52	42	10	0	15	43
November	14	6	23	75	32	41	25
December	15	50	4	8	14	4	22
Total	271	416	396	572	446	522	540

[a]Abbreviations: avg, average; yr, year.
[b]Thirty year average reported by National Weather Service 2015

Injury ratings and yield measurements. Visible cotton injury and Palmer amaranth control were recorded on a scale of 0% to 100% as described by Frans et al. (1986). Plots exhibiting no cotton injury and no Palmer amaranth control received a rating of 0, while complete injury or control was rated at 100. Visual evaluations were made at approximately 7, 14, 21, 42, and 56 (DAT). In both 2013 and 2014, field experiments were conducted at Halfway and Lamesa to evaluate cotton injury and Palmer amaranth control following pyroxasulfone applied PRE (Table 2). Plots were weed-free at time of application and PRE applications were made following planting. Cotton injury and Palmer amaranth control were evaluated 14 to 28 days after planting (DAP) (early), 28 to 56 DAP (mid), and 56 to 72 DAP (late). Plots were harvested with a John Deere 7445 two-row cotton stripper and cotton lint yields calculated. In both 2013 and 2014, field experiments were conducted at Halfway and Lamesa to evaluate cotton injury and Palmer amaranth control using pyroxasulfone applied POST (Table 2). All POST treatments received a blanket application of glyphosate between PRE and EPOST applications. Postemergence applications were made to 4 and 6 node cotton and 2 to 9 cm Palmer amaranth. Cotton injury and Palmer amaranth control were evaluated 7, 14, and 21 (DAT). Plots were harvested with a John Deere 7445 two-row cotton stripper and cotton lint yields calculated. In 2014, field experiments were conducted at Lubbock and Lamesa to evaluate cotton injury with pyroxasulfone applied PDIR (Table 3). Palmer amaranth populations were not uniform enough to accurately evaluate control.

Plots were harvested with a John Deere 7445 two-row cotton stripper and cotton lint yields calculated.

Statistical analysis. Data was subjected to ANOVA using the GLM procedure.A significant year by treatment and year by location interaction was observed for all field experiments except pyroxasulfone preemergence and postemergence on coarse textured soil at Lamesa; therefore, data were analyzed separately by year.

Table 2. Application description for pyroxasulfone preemergence and postemergence at Halfway and Lamesa TX.

	EPP[a]	PRE	EPOST	LPOST
Halfway				
2013	April 16	May 16	June 7	July 21
2014	April 17	May 16	June 17	July 21
Lamesa				
2013	April 18	May 8	June 7	July 22
2014	April 16	May 14	June 11	July 9

[a] Abbreviations: EPOST, early-postemergence; EPP, early-preplant; LPOST, late-postemergence; PRE, preemergence.

Table 3. Application description for pyroxasulfone postemergence-directed at Lubbock and Lamesa TX.

	A	B	C	D
Lubbock				
2014	July 9	July 18	July 28	August 5
Lamesa				
2014	July 9	July 17	July 29	-

RESULTS

Pyroxasulfone preemergence and postemergence on fine textured soils at Halfway. In 2013, no cotton injury was observed following all treatments regardless of application timing (Table 4). When pyroxasulfone was applied EPP, Palmer amaranth was controlled 68%, 36 DAP. Similar Palmer amaranth control was observed following acetochlor EPP (68%), but less effective control was observed following *S*-metolachlor (38%) applied EPP. At 53 DAP, pyroxasulfone and acetochlor controlled Palmer amaranth 60% to 70%; whereas, control from *S*-metolachlor was < 40%. At 68 and 81 DAP, no EPP treatment controlled Palmer amaranth > 51%.

Pyroxasulfone applied PRE controlled Palmer amaranth 46% at 36 DAP, which was similar to *S*-metolachlor (53%) and acetochlor (56%) (Table 4). At 53 DAP, pyroxasulfone, acetochlor and *S*-metolachlor provided similar levels of Palmer amaranth control, ranging from 33% to 46%. At 68 and 81 DAP no PRE treatment controlled Palmer amaranth > 43%.

When pyroxasulfone, acetochlor and *S*-metolachlor were applied EPOST with glyphosate, Palmer amaranth control 36 and 53 DAP was not different across treatments and ranged from 89% to 98% and 81% to 91%, respectively (Table 4). End of season control (81 DAP) ranged from 60% to 85%, and no differences were observed among treatments. Palmer amaranth control 14 days after late-postemergence (LPOST) treatments ranged from 88% to 91%, 68 DAP (Table 4). At 81 DAP, Palmer amaranth was controlled at least 85% and control was similar for all LPOST treatments. Palmer amaranth control was not sufficient to produce harvestable cotton with EPP, PRE, and EPOST treatments. Cotton lint yield ranged from 990 to 1,097 kg/ha with LPOST tank-mix combinations that received an EPOST glyphosate application.

In 2014, cotton injury was observed with all pyroxasulfone treatments at every evaluation date (Table 5). Injury with pyroxasulfone applied EPP was < 20% at each evaluation date. Greatest injury (48%) was observed at 28 and 76 DAP with pyroxasulfone applied PRE. Cotton injury was observed with acetochlor (15%) and *S*-metolachlor (13%) applied PRE at 28 DAP. Injury with pyroxasulfone applied EPOST ranged from 11% to 15%. Pyroxasulfone applied LPOST injured cotton 15% 36 DAT. Pyroxasulfone was the only herbicide to cause visual stunting to cotton, which was similar to results reported by Doherty et al. (2014).

Palmer amaranth control following pyroxasulfone applied EPP ranged from 90% to 93% at all evaluation dates (Table 5). Palmer amaranth control following acetochlor and *S*-metolachlor was < 76% at all evaluation dates. Preemergence applications of pyroxasulfone or acetochlor provided similar control and were more effective than *S*-metolachlor at all evaluation dates. Palmer amaranth control following EPOST and LPOST treatments was similar at all evaluation dates. Palmer amaranth control ranged from 88% to 95% following EPOST treatments and 95% to 99% following LPOST treatments.

In 2013, EPP, PRE, and EPOST treated plots were not harvested due to intense Palmer amaranth competition that reduced yield to essentially zero. Cotton was harvested from LPOST treatments and no treatment adversely affected yield. In 2014, EPP and EPOST plots treated with acetochlor and *S*-metolachlor produced similar yield, which was less than the yield harvested from pyroxasulfone treated plots. Cotton yields ranged from 797 kg/ha to 1,182 kg/ha and were different among PRE and LPOST treatments. In 2014, above average rainfall (9.6 cm) occurred in late May and likely contributed to the injury observed in pyroxasulfone treated plots. Olson et al. (2011) reported 17% injury to sunflowers (*Helianthus* spp.) when 18 mm of precipitation occurred within one week of pyroxasulfone applications.

Pyroxasulfone preemergence and postemergence on coarse textured soils at Lamesa. Cotton injury was observed with pyroxasulfone applied EPP or PRE at all evaluation dates with the level of injury ranging from 49% to 62% (Table 6). When acetochlor and *S*-metolachlor were applied EPP and PRE, injury was < 7% at early season evaluations (June 6, 2013 and June 6, 2014). No injury was observed from any EPOST or LPOST treatment at any evaluation date.

Table 4. Effects of pyroxasulfone preemergence and postemergence on cotton growth and Palmer amaranth control on fine textured soil at Halfway, TX in 2013.

Treatment	Rate	Application Timing	Cotton injury (DAP)[a]				Palmer amaranth control (DAP)				Yield
			36	53	68	81	36	53	68	81	
	------kg ai/ha------		------------%-----------				----------------%----------------				kg/ha
non-treated	-	-	0 a	0 a	0 a	0 a	0 d	0 e	0 e	0 e	0 c
pyroxasulfone[b]	0.089	EPP	0 a	0 a	0 a	0 a	68 b	70 ab	43 cd	31 cd	0 c
acetochlor	1.05	EPP	0 a	0 a	0 a	0 a	68 b	60 bc	51 c	45 bc	0 c
S-metolachlor	1.4	EPP	0 a	0 a	0 a	0 a	38 c	36 d	16 de	16 de	0 c
pyroxasulfone	0.089	PRE	0 a	0 a	0 a	0 a	46 c	33 d	43 cd	38 bcd	0 c
acetochlor	1.05	PRE	0 a	0 a	0 a	0 a	56 bc	36 d	25 de	21 cde	0 c
S-metolachlor	1.4	PRE	0 a	0 a	0 a	0 a	53 bc	46 cd	16 de	15 de	0 c
glyphosate fb pyroxasulfone + glyphosate	0.84, 0.089 + 0.84	EPOST	0 a	0 a	0 a	0 a	98 a	91 a	88 ab	85 a	0 c
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	EPOST	0 a	0 a	0 a	0 a	89 a	83 a	61 bc	60 ab	0 c
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.40 + 0.84	EPOST	0 a	0 a	0 a	0 a	91 a	81 a	81 ab	75 a	0 c
glyphosate fb pyroxasulfone + glyphosate	0.84, 0.089 + 0.84	LPOST	-	-	0 a	0 a	-	-	88 ab	85 a	990 ab
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	LPOST	-	-	0 a	0 a	-	-	91 a	88 a	1097 a
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.40 + 0.84	LPOST	-	-	0 a	0 a	-	-	88 ab	85 a	912 ab

[a]Abbreviations: DAP, days after planting; EPOST, early-postemergence; EPP, early preplant; LPOST, late-postemergence; PRE, preemergence.
[b]0.25% v/v of NIS was added to all pyroxasulfone treatments; 1% w/v of ammonium sulfate was added to all pyroxasulfone treatments.

Table 5. Effects of pyroxasulfone preemergence and postemergence on cotton growth and Palmer amaranth control on fine textured soil at Halfway, TX in 2014.

Treatment	Rate	Application Timing	Cotton injury (DAP)[a]				Palmer amaranth control (DAP)			Yield
			28	76	84	102	76	84	102	
	----kg ai/ha----		--------------%-------------				---------------%--------------			--kg/ha--
non-treated	-	-	0 c	0 d	0 d	0 c	0 d	0 e	0 e	0 e
pyroxasulfone[b]	0.089	EPP	20 b	16 c	13 c	13 b	93 a	91 ab	90 a	967 cd
acetochlor	1.05	EPP	0 c	0 d	0 d	0 c	63 c	61 d	56 b	849 d
S-metolachlor	1.4	EPP	0 c	0 d	0 d	0 c	75 b	71 c	65 b	797 d
pyroxasulfone	0.089	PRE	48 a	48 a	45 a	43 a	94 a	93 ab	89 a	878 d
acetochlor	1.05	PRE	15 b	0 d	0 d	0 c	88 a	88 b	86 a	1074 bcd
S-metolachlor	1.4	PRE	13 b	0 d	0 d	0 c	71 b	66 cd	66 b	840 d
glyphosate fb pyroxasulfone + glyphosate	0.84, 0.089 + 0.84	EPOST	-	15 c	6 d	11 b	94 a	95 ab	93 a	1324 a
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	EPOST	-	0 d	0 d	0 c	88 a	88 b	85 a	1057 bcd
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.4 + 0.84	EPOST	-	0 d	0 d	0 c	91 a	95 ab	91 a	1281 ab
glyphosate fb pyroxasulfone + glyphosate	0.84, 0.089 + 0.84	LPOST	-	23 b	23 b	15 b	99 a	99 a	99 a	959 cd
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	LPOST	-	0 d	0 d	0 c	97 a	96 ab	95 a	1182 abc
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.4 + 0.84	LPOST	-	0 d	0 d	0 c	96 a	97 ab	97 a	1034 bcd

[a]Abbreviations: DAP, days after planting; EPOST, early-postemergence; EPP, early preplant; LPOST, late-postemergence; PRE, preemergence.
[b]0.25% v/v of NIS was added to all pyroxasulfone treatments; 1% w/v of ammonium sulfate was added to all pyroxasulfone treatments.

Table 6. Effects of pyroxasulfone preemergence and postemergence on cotton growth on coarse textured soil at Lamesa, TX in 2013 and 2014.

Treatment	Rate	Application Timing	Cotton injury Early	Mid	Late	Yield 2013	Yield 2014
	----kg ai/ha----		------------------%-----------------			-------kg/ha-------	
non-treated	-	-	0 c	0 c	0 b	1039 a	610 a
pyroxasulfone[a]	0.089	EPP	59 a	62 a	50 a	920 a	702 a
acetochlor	1.05	EPP	5 bc	0 c	0 b	934 a	648 a
S-metolachlor	1.4	EPP	6 b	0 c	0 b	1180 a	673 a
pyroxasulfone	0.089	PRE	56 a	56 b	49 a	864 a	521 a
acetochlor	1.05	PRE	2 bc	0 c	0 b	971 a	764 a
S-metolachlor	1.4	PRE	5 bc	0 c	0 b	970 a	692 a
glyphosate fb pyroxasulfone +glyphosate	0.84, 0.089 + 0.84	EPOST	0 c	0 c	0 b	1187 a	651 a
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	EPOST	0 c	0 c	0 b	979 a	625 a
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.4 + 0.84	EPOST	0 c	0 c	0 b	1098 a	670 a
glyphosate fb pyroxasulfone + glyphosate	0.84, .089 + 0.84	LPOST	0 c	0 c	0 b	876 a	641 a
glyphosate fb acetochlor + glyphosate	0.84, 1.05 + 0.84	LPOST	0 c	0 c	0 b	990 a	642 a
glyphosate fb *S*-metolachlor + glyphosate	0.84, 1.4 + 0.84	LPOST	0 c	0 c	0 b	808 a	704 a

[a]Abbreviations: DAP, days after planting; EPOST, early-postemergence; EPP, early preplant; LPOST, late-postemergence; PRE, preemergence.
[b]0.25% v/v of NIS was added to all pyroxasulfone treatments; 1% w/v of ammonium sulfate was added to all pyroxasulfone treatments.

Table 7. Effects of pyroxasulfone applied postemergence-directed on cotton growth at Lamesa, TX in 2014.

Treatment	Rate	Application Timing	Cotton Injury (DAP)[a]				Yield
			64	76	85	124	
	kg ai/ha		------------%-----------				kg/ha
non-treated	-	-	0 a	0 a	0 a	0 a	608 a
pyroxasulfone[b]	0.089	PDIR A	0 a	0 a	0 a	0 a	635 a
pyroxasulfone	0.18	PDIR A	0 a	0 a	0 a	0 a	646 a
acetochlor	1.05	PDIR A	0 a	0 a	0 a	0 a	588 a
pyroxasulfone	0.089	PDIR B	-	0 a	0 a	0 a	566 a
pyroxasulfone	0.18	PDIR B	-	0 a	0 a	0 a	551 a
acetochlor	1.05	PDIR B	-	0 a	0 a	0 a	588 a
pyroxasulfone	0.089	PDIR C	-	-	0 a	0 a	530 a
pyroxasulfone	0.18	PDIR C	-	-	0 a	0 a	626 a
acetochlor	1.05	PDIR C	-	-	0 a	0 a	584 a

[a]Abbreviations: DAP, days after planting; PDIR, postemergence-directed.
[b] 0.25% v/v NIS was added to all pyroxasulfone treatments.

Table 8. Effects of pyroxasulfone applied postemergence-directed and postemergence-topical on cotton growth at Lubbock, TX in 2014.

Treatment	Rate	Application Timing	Crop Injury (DAP)[a]				Yield
			44	51	64	71	
	kg ai/ha		-------------%------------				kg/ha
non-treated	-	-	0 a	0 a	0 a	0 a	370 a
pyroxasulfone[b]	0.089	PDIR A	0 a	0 a	0 a	0 a	542 a
pyroxasulfone	0.18	PDIR A	0 a	0 a	0 a	0 a	410 a
acetochlor	1.05	PDIR A	0 a	0 a	0 a	0 a	468 a
pyroxasulfone	0.089	POST A	30 a	23 a	20 b	16 ab	497 a
pyroxasulfone	0.18	POST A	20 b	15 bc	13 c	10 b	448 a
acetochlor	1.05	POST A	0 c	0 d	0 d	0 c	601 a
pyroxasulfone	0.089	PDIR B	-	0 a	0 a	0 a	492 a
pyroxasulfone	0.18	PDIR B	-	0 a	0 a	0 a	616 a
acetochlor	1.05	PDIR B	-	0 a	0 a	0 a	636 a
pyroxasulfone	0.089	POST B	-	10 cd	13 c	13 b	455 a
pyroxasulfone	0.18	POST B	-	20 ab	26 a	21 a	514 a
acetochlor	1.05	POST B	-	0 d	0 d	0 c	637 a
pyroxasulfone	0.089	PDIR C	-	-	0 a	0 a	413 a
pyroxasulfone	0.18	PDIR C	-	-	0 a	0 a	412 a
acetochlor	1.05	PDIR C	-	-	0 a	0 a	376 a
pyroxasulfone	0.089	POST C	-	-	0 d	0 c	357 a
pyroxasulfone	0.18	POST C	-	-	0 d	0 c	407 a
acetochlor	1.05	POST C	-	-	0 d	0 c	468 a
pyroxasulfone	0.089	PDIR D	-	-	-	0 a	622 a
pyroxasulfone	0.18	PDIR D	-	-	-	0 a	260 a
acetochlor	1.05	PDIR D	-	-	-	0 a	383 a
pyroxasulfone	0.089	POST D	-	-	-	0 c	641 a
pyroxasulfone	0.18	POST D	-	-	-	0 c	311 a
acetochlor	1.05	POST D	-	-	-	0 c	324 a

[a]Abbreviations: DAP, days after planting; PDIR, postemergence-directed.
[b] 0.25% v/v NIS was added to all pyroxasulfone treatment.

Cotton was harvested and yield determined for all treatments in both years. No treatment adversely affected cotton lint yield in either year. These results indicate that EPP and PRE applications of pyroxasulfone may cause injury to cotton when applied on a coarse textured soil; however, the level of injury may not be sufficient to cause yield loss. The mobility of pyroxasulfone in coarse textured soils could explain the greater injury observed at the Lamesa location compared to the Halfway location. Westra et al. (2014) reported that pyroxasulfone was more mobile in a sandy loam soil compared to a clay loam soil.

Pyroxasulfone postemergence-directed Lamesa. No injury was observed with any treatment at any evaluation date (Table 7). Palmer amaranth populations were too variable to evaluate control with PDIR applications of pyroxasulfone or acetochlor. Cotton was harvested from all treatments and no treatment adversely affected cotton lint yield. No cotton injury and no yield effects indicated that pyroxasulfone applied PDIR may be a safe herbicide to use for mid-season to late-season weed control in cotton.

Pyroxasulfone postemergence-directed and postemergence-topical Lubbock. No cotton injury was observed with any acetochlor treatment at any evaluation date (Table 8). No cotton injury was observed with pyroxasulfone applied PDIR regardless of rate. When pyroxasulfone was applied at the 1 and 2x rate, injury was similar for POSTA applications (7 DAT, 44 DAP) and POSTB applications (6 DAT, 51 DAP). Injury with pyroxasulfone applied POST ranged from 20% to 30% at POSTA and 10% to 20% at POSTB. No injury was observed from any pyroxasulfone treatment applied at the POSTC (8 DAT, 64 DAP) or POSTD (7 DAT, 71 DAP) timings at any evaluation date.

Pyroxasulfone applied POST injured cotton following early season applications; however, no injury was observed from later applications (Table 8). Injury from early applications suggest that cotton is more sensitive to pyroxasulfone in the early-season (8 to 12 nodes) compared to POST applications made late-season (12 to 16 nodes). No injury from pyroxasulfone applied PDIR at any evaluation date suggests that hooded applications can provide excellent crop safety even at a 2x rate. Cotton was harvested from all treatments and no treatment adversely affected yield.

CONCLUSION AND DISCUSSION

In 2013, cotton injury was not observed following pyroxasulfone applications on fine textured soil; however; injury was observed following all pyroxasulfone applications in 2014. In both 2013 and 2014, cotton injury was observed following pyroxasulfone applied EPP and PRE on coarse textured soils; however, no injury was observed from pyroxasulfone applied EPOST or LPOST. Cotton injury was not observed following any PDIR application of pyroxasulfone at any location. Cotton lint yields were not adversely affected by any pyroxasulfone treatment. In 2013, pyroxasulfone applied EPP controlled Palmer amaranth similar to acetochlor on fine textured soil. Pyroxasulfone applied PRE, EPOST, and LPOST controlled Palmer amaranth similar to acetochlor and *S*-metolachlor. Similar Palmer amaranth control was observed following pyroxasulfone in 2014.

This research indicates that pyroxasulfone can injure cotton when applied EPP or PRE. In some years pyroxasulfone may cause injury to cotton when applied POST;

however, no injury was observed from any PDIR application. Pyroxasulfone provided excellent control of Palmer amaranth and can be safely applied to cotton when used as a PDIR application.

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