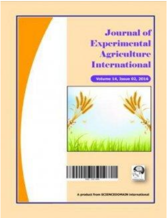

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Weed Control and Peanut Tolerance Using Pyroxasulfone in Oklahoma

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Authors' contributions

This work was carried out in collaboration between all authors. Author TAB designed the study, wrote the protocol, carried out the studies, and performed the statistical analysis. Author WJG wrote the first and final draft of the manuscript and made corrections to manuscript as suggested by authors PAD and TAB. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the spectrum of weed control and peanut tolerance with pyroxasulfone in Oklahoma.

Study Design: Randomized complete block design with four replications.

Place and Duration of Study: Oklahoma State University Caddo Research Station near Ft. Cobb (35.091° N, 98.275° W) in southwestern Oklahoma during the 2013-2014 growing seasons.

Methodology: Herbicides were applied with a CO_2 compressed air backpack sprayer using Teejet 110015XR nozzles that delivered 93 L ha^{-1} at 180kPa. Weed control and peanut injury were visually estimated on a scale of 0 indicating no control or plant death to 100 indicating complete control or plant death, relative to the untreated control. Peanut yields were obtained by digging each plot

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separately, air-drying in the field for 4 to 7 d, and harvesting peanut pods from each plot with a combine. Visual estimates of weed control and peanut yield were subjected to analysis of variance to test effects of postemergence (POST) herbicide and application timing and means were compared with Fisher's Protected LSD test (0.05).

Results: In 2013, only treatments that controlled *Urochloa texana* > 85% were those that included pendimethalin plus pyroxasulfone applied preemergence (PRE) and imazapic applied late postemergence (LPOST). *Ipomoea hederacea* control using either pendimethalin applied preplant incorporated (PPI) or flumioxazin applied PRE and imazethapyr applied POST was $\geq$ 75%. In 2014, herbicide systems that included imazapic applied POST controlled *I. hederacea* at least 98% while no other herbicide systems provided better than 78% control. Peanut stunting (4 to 13%) was observed in 2013 with all PPI and PRE treatments. In 2013 and 2014, pyroxasulfone plus pendimethalin systems applied PRE followed by imazapic applied LPOST produced the greatest peanut stunting.

Conclusion: These results indicate that pyroxasulfone is an effective herbicide for weed control in Oklahoma peanut production. Although no peanut yield reductions were observed, the early season stunting in isolated instances should be noted.

Keywords: Preplant incorporated; preemergence; postemergence; Texas millet; ivyleaf morningglory.

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a crop with very challenging weed management issues. First, most peanut cultivars grown in the U.S. require a fairly long growing season of 140 to 160 d depending on cultivar and geographical region [1,2]. Because of this requirement, soil-applied herbicides may not provide season-long control, which can result in mid to late season weed problems. Secondly, peanut has a prostrate growth habit, a relatively shallow canopy, and are slow to shade row middles allowing weeds to be more competitive [2,3]. Additionally, peanut fruit develops underground on pegs that originate from stems and grow along the soil surface. The prostrate growth habit and pattern of fruit development limits cultivation to an early season control option [2,4].

Urochloa texana Buckl., previously known as Texas panicum but now called Texas millet, is a large seeded, vigorous, fast growing annual grass commonly found in peanut fields in parts of Alabama, Arkansas, Georgia, Oklahoma and Texas [5]. It is listed as one of the most troublesome weeds in all peanut growing states except Alabama and Arkansas [5]. During the digging operation, the peanut plant is lifted out of the ground and inverted. A heavy stand of *U. texana* can reduce the effectiveness of the process. The tight fibrous root system becomes intertwined with the peanut plant, causing peanut pods to be stripped from the vine during digging. Peanuts that become detached from the plant remain unharvested in or on the soil surface [6].

Ipomoea hederacea (L.) Jacq (ivyleaf morningglory) is an annual low growing vine that twines up and around the peanut plant for support as they exhibits positive phototropism to intercepted sunlight [7]. *Ipomoea* spp. have shown to have varying effects on crop yields depending on limiting resources, such as light, nutrients, and water [8-11]. This weed can reduce harvested peanut quality and under moderate-to-high plant populations reduce harvest efficiency in peanut and many other crops [12-14].

Pyroxasulfone is a newly registered herbicide in the U.S. for either preplant (PP), preplant incorporated (PPI), preemergence (PRE), or early postemergence (EPOST) to be used in corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), peanut, soybean (*Glycine max* L.), and wheat (*Triticum aestivum* L.) [15-17]. Application timing is crop specific. It controls *Amaranthus* spp., *Lolium* spp., *Urochloa* spp., *Eleusine indica* L., *Dactyloctenium aegyptium* L., and *Digitaria* spp. [18-21]. Although pyroxasulfone has a similar weed control spectrum as *S*-metolachlor and dimethenamid-P, it has a higher specific activity allowing for use doses approximately eight times lower than dimethenamid-P [22]. Pyroxasulfone inhibits very long chain fatty acid synthesis similar to chloroacetamide, oxyacetamide, and tetrazolinone herbicides [18].

Previous research in the southeast has determined that pyroxasulfone has good peanut crop tolerance and provides control of problem weeds [23]. Pyroxasulfone applied PRE to peanut has been documented to cause early-season stunting but no yield loss [23]. For those reasons research was undertaken in the Oklahoma peanut growing region to determine crop tolerance and weed control efficacy with pyroxasulfone when applied PPI, PRE, EPOST or late POST (LPOST).

2. MATERIALS AND METHODS

2.1 Field Studies

These were conducted at the Oklahoma State University Caddo Research Station near Ft. Cobb (35.091º N, 98.275º W) in southwestern Oklahoma during the 2013 and 2014 growing seasons to determine the weed efficacy of pyroxasulfone in Southwestern U.S. peanut growing areas. There were two locations in both 2013 (Location 1 and 2) and 2014 (Location 3 and 4). These were in the same general area but different parts of the field.

Soils were a Binger fine sandy loam with less than 1% organic matter and a pH of 7.0 to 7.5. The experimental design was a randomized complete block with four replications. An untreated check was included each year at all locations.

2.2 Plot Size and Weed Populations

Each plot was two rows wide spaced 91 cm apart and 9.1 m long. Peanut variety, planting date, and herbicide application timing are shown in Table 1. All field plots were naturally infested with moderate to severe (3 to 15 plants m^2) populations of *U. texana* while *I. hederacea* populations were low to moderate (3 to 6 plants m^2).

2.3 Herbicide Application

Herbicides were applied with a CO_2 compressed air backpack sprayer equipped with Teejet 110015XR nozzles that delivered 94 L ha^{-1} at 131 kPa. Listed beds were sprayed and PPI herbicides were incorporated with a rolling cultivator equipped with disk gangs and furrow sweeps prior to planting. The EPOST herbicide applications (also referred to as peanut cracking) were made when the peanut plants had begun to emerge or were no bigger than saucer size. All weeds at this stage were less than 5 cm tall. The LPOST applications were made when *U. texana* was 20 to 50 cm tall and *I. hederacea* was 15 to 40 cm in length. All POST treatments included a crop oil concentrate (Agridex®) at 1.25% v/v or a non-ionic surfactant (Induce®) at 0.25% v/v.

2.4 Irrigation, Weed Control, and Peanut Harvest

Sprinkler irrigation was applied on a 2- to 3-wk schedule throughout the growing season as needed. Weed control and peanut injury were visually estimated on a scale of 0 to 100 (0 indicating no control or plant death and 100 indicating complete control or plant death), relative to the untreated control [24]. Peanut injury evaluations were recorded 16 to 22 days after PRE herbicide treatment (DAT) while weed control evaluations were recorded 37 to 120 DAT. Peanut injury consisted of stunting (reduced vine size). Peanut yields were obtained by digging each plot separately, air-drying in the field for 4 to 7 d, and harvesting peanut pods from each plot with a combine. Weights were recorded after soil and trash were removed from plot samples.

2.5 Data Analysis

Visual estimates of weed control and peanut yield were subjected to analysis of variance to test effects of herbicide treatments. Means were compared with Fisher's Protected LSD test at the 5% probability level. The untreated control was not included in weed control or peanut injury analysis but was included in the yield analysis.

3. RESULTS AND DISCUSSION

No attempt was made to combine data over years since weather conditions varied from location-to-location and year-to-year. Also, in some instances, herbicide treatments varied from year-to-year depending on location.

3.1 Weed Control

3.1.1 *Urochloa texana* (Texas millet) control

In 2013, at Location 1 (Table 2) and Location 2 (Table 3), no herbicide treatment provided acceptable control of *U. texana* when rated late-season. At Location 3 in 2014, the only treatments that controlled *U. texana* greater than 85% was those that included pendimethalin plus pyroxasulfone applied PRE, aciflurofen plus bentazon plus paraquat applied EPOST, and imazapic applied LPOST (Table 4). At Location 4 when evaluated early-season (37 DAT), all PPI or PRE only herbicide systems controlled *U. texana* no greater than 80% while those systems that included an EPOST or LPOST herbicide application provided at least 93% control (Table 5). When evaluated late-season (104

DAT), only herbicide systems that included a PPI application of either pendimethalin or pyroxasulfone followed by a EPOST and LPOST herbicide applications provided at least 80% control.

Steele [17] found that pyroxasulfone at doses above 0.125 kg ha^{-1} controlled *U. texana* 90 to 96% when evaluated 4 weeks after treatment (WAT). In comparison, 0.125 kg ha^{-1} to 0.5 kg/ha of pyroxasulfone controlled more *U. texana* than 1.1 to 1.8 kg ha^{-1} of *S*-metolachlor; however, control generally declined by 6 and 9 WAT. They also reported at 9 WAT, pyroxasulfone at 0.5 kg ha^{-1} controlled *U. texana* 90% which was better than all doses of *S*-metolachlor. They attributed the better weed control with pyroxasulfone to longer residual activity despite an almost 10-fold lower dose than *S*-metolachlor.

3.1.2 *Ipomoea hederacea* control

In 2013 at Location 1, the only treatments that controlled *I. hederacea* at least 75% were those that included either pendimethalin applied PPI or flumioxazin applied PRE plus an EPOST application which included paraquat or pyroxasulfone and a LPOST application which included imazethapyr (Table 2). No other herbicide systems effectively controlled this weed. At Location 2, no herbicide system effectively controlled (< 48%) *I. hederacea* (Table 3).

In 2014 at Location 3, all herbicide systems that included imazapic applied LPOST controlled *I. hederacea* at least 98% while no other herbicide systems provided better than 78% control (Table 4). At Location 4, when evaluated 37 DAT, the PRE combination of dimethenamid-P plus pyroxasulfone applied PRE was the only PPI or PRE treatments without a POST treatment to control *I. hederacea* at least 90% (Table 4). All EPOST treatments controlled this weed at least 95%, 37 DAT. This evaluation was 21 days after these EPOST treatments were applied. When evaluated 104 DAT, systems that included imazapic applied LPOST controlled *I. hederacea* at least 98% while EPOST herbicide applications without imazapic provided 68 to 83% control. Herbicides applied PPI or PRE without any POST applications provided less than 70% control.

Pyroxasulfone is not considered an outstanding herbicide for *Ipomoea* spp. control [15]; however, Hardwick [25] reported in corn that pyroxasulfone at 0.15 kg ha^{-1} alone applied PRE controlled *I. hederacea* at least 89% and *Ipomoea lacunose* (L.) no better than 70% throughout the growing season.

3.2 Peanut Stunting

Peanut stunting was observed with all PPI and PRE treatments in 2013 and 2014 (Tables 2-5). Stunting with pyroxasulfone PPI or PRE combinations ranged from 1 to 13%. In 2013, pyroxasulfone alone applied PPI at Location 1 (Table 2) and applied PRE at Location 2 (Table 3) stunted peanut 8% when evaluated 21 or 22 DAT. Stunting with pendimethalin applied PPI was 5% or less while systems which included flumioxazin caused 5 to 8% stunting (Table 2).

In 2014 at Location 3, most all treatments resulted in greater peanut stunting than the untreated check (Table 4). In 2014 as well as 2013, pyroxasulfone plus pendimethalin systems applied PRE followed by imazapic applied LPOST produced the greatest peanut stunting. At Location 4 peanut stunting was most severe (13%) with the PRE combination of dimethenamid-*P* plus pyroxasulfone while pyroxasulfone at 0.09 and 0.18 kg ha^{-1} and dimethenamid-*P* alone caused 5% or less stunting (Table 5).

Research in other crops has shown greater crop injury from pyroxasulfone applied PRE on course-textured soils than on fine-textured or organic soils [26-30]. *Zea mays* var. saccharata injury has been documented to be greater than 10% following pyroxasulfone at 0.25 kg ha^{-1} on soils with 82% sand [28] while no injury has been observed on soils high in organic matter [30]. In cotton, Koger et al. [29] reported only transient injury on a silt loam soil following pyroxasulfone applied PRE.

Eure et al. [31] reported that peanut stunting during 2012 and 2013 ranged from 38 to 55% and 3 to 11%, respectively, depending on peanut cultivar. They reported several factors played a role in the differences observed between the two years. More rainfall occurred through the EPOST application in 2012 compared to 2013 (50.8 mm vs. 25.4 mm). Enhanced peanut stunting has been observed following the application of other PRE herbicides under cool, wet conditions [32]. In previous research, Prostko et al. [23] documented transient peanut stunting at one of two locations following pyroxasulfone applied PRE.

3.3 Peanut Yield

In 2013 at Location 1, there was no difference in yield between the untreated check and any herbicide treatment (Table 2). This was likely due to the lack of adequate *Urochloa texana* control with any treatment and *U. texana* can reduce peanut yield through direct competition and reduced harvest efficiency. The tight fibrous root system of this weed becomes intertwined with the peanut plant, causing peanut pods to be stripped from the vine during digging [1,2,4,6].

Table 1. Peanut variety, planting date, and herbicide application dates near Ft. Cobb, Oklahoma[a]

	2013		2014	
	Location 1	**Location 2**	**Location 3**	**Location 4**
Peanut variety	Tamnut OL06	Tamnut OL06	Tamnut OL06	Tamnut OL06
Planting date	May 28	May 28	May 6	May 6
Application				
PPI	May 28	-	May 6	-
PRE	May 28	May 28	May 6	May 6
EPOST	June 19	June 19	May 22	May 22
LPOST	July 17	July 17	July 10	July 10

[a]Abbreviations: PPI, preplant incorporated; PRE, preemergence; EPOST, early postemergence; LPOST, late postemergence

Table 2. Peanut stunting, late-season weed control, and yield with pyroxasulfone combinations during the 2013 growing season (Location 1)[a]

Treatment[b]	**Timing**	**Dose**	**Weed control**			
		Kg ai ha^{-1}	**Stunt[c]**	**URODE[d]**	**IPOHE**	**Yield**
				%		**Kg ha^{-1}**
Pendimethalin	PPI	1.1	4	18	18	2978
Pyroxasulfone (P)	PPI	0.09	8	11	16	2488
Pendimethalin + P	PPI	1.1 + 0.09	5	25	21	2788
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27	0	15	13	2556
P + paraquat	EPOST	0.09 + 0.27	0	13	25	3079
Dimethenamid-P/paraquat	PRE/EPOST	0.84/ 0.27	4	18	26	2736
P/paraquat	PRE/EPOST	0.09/0.27	10	21	31	2577
Pendimethalin	PPI	1.1				
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27				
P + imazethapyr (I)	LPOST	0.09 + 0.07	5	38	75	3097
Pendimethalin	PPI	1.1				
Dimethenamid-P + P	EPOST	0.84 + 0.27				
I	LPOST	0.07	1	41	89	2977
Pendimethalin	PPI	1.1				
P + paraquat	EPOST	0.09 + 0.27				
I	LPOST	0.07	3	48	84	3136
P	PPI	0.09				
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27				
I	LPOST	0.07	4	21	68	2883
Flumioxazin	PRE	0.11				
Paraquat	EPOST	0.27				
Dimethenamid-P + I	LPOST	0.84 + 0.07	5	28	93	2967
Pendimethalin/flumioxazin	PPI/PRE	1.1/0.11				
Paraquat	EPOST	0.27				
I	LPOST	0.07	8	41	93	3214
Untreated	-	-	0	0	0	2390
LSD (0.05)			4	10	9	NS

[a] Abbreviations: EPOST, early postemergence; LPOST, late postemergence; PRE, preemergence;PPI, preplant incorporated.
[b] Induce included with paraquat at 0.25 % v/v; Agridex included with imazethapyr at 1.25% v/v,[c] Stunting evaluated 22 days after herbicide treatment,[d] Bayer code for weeds: URODE (Texas millet) Urochloa texana; IPOHE (ivyleaf morningglory) Ipomoea hederacea.

Table 3. Peanut stunting, late-season weed control, and peanut yield with pyroxasulfone combinations during 2013 (Location 2)[a,b]

Treatment[c]	Timing	Dose Kg ai ha^{-1}	Stunt	Weed control		Yield
			21 DAT	IPOHE	URODE	Kg ha^{-1}
			%			
Flumioxazin + pyroxasulfone	PRE	0.11 + 0.09	5	21	25	3328
Pendimethalin + pyroxasulfone	PRE	1.1 + 0.09	4	18	18	3109
Pyroxasulfone	PRE	0.09	8	16	11	2979
Pendimethalin + pyroxasulfone	PRE	1.1 + 0.06				
Imazapic + pyroxasulfone	LPOST	0.07 + 0.06	4	25	13	3701
Pendimethalin + pyroxasulfone	PRE	1.1 + 0.09				
Imazapic	LPOST	0.07	10	31	21	3061
Pyroxasulfone	PRE	0.09				
Imazapic	LPOST	0.07	4	26	18	3289
Pyroxasulfone	PRE	0.09				
Imazapic + pyroxasulfone	LPOST	0.07 + 0.06	6	13	15	3390
Pyroxasulfone	PRE	0.09				
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27	5	48	38	3573
Pyroxasulfone	LPOST	0.06				
S-metolachlor	PRE	1.1				
Imazapic	LPOST	0.07	3	48	48	3346
Untreated			0	0	0	2226
LSD (0.05)			2	7	6	592

[a] *Abbreviations: DAT, days after PRE treatment; EPOST, early postemergence (ground cracking); LPOST, late postemergence; PPI, preplant incorporated; PRE, preemergence.*

[b] *All treatments with the exception of pyroxasulfone applied PRE followed by dimethenamid-P + paraquat applied EPOST included aciflurofen at 0.29 kg ai ha^{-1} + bentazon at 0.56 kg ai ha^{-1} + paraquat at 0.27 kg ai ha^{-1} applied EPOST.*

[c] *Induce included in all POST treatments at 0.25 % v/v.*

[d] *Bayer code for weeds: IPOHE (ivyleaf morningglory); Ipomoea hederacea; URODE, (Texas millet) Urochloa texana.*

Table 4. Peanut stunting, weed control, and yield with pyroxasulfone combinations during 2014 (Location 3)[a]

Treatment [b,c]	Timing	Dose Kg ai ha^{-1}	Peanut stunt	Weed control[d]		Yield
			16 DAT	IPOHE	URODE	
					%	Kg ha^{-1}
Flumioxazin + pyroxasulfone*	PRE	0.11 + 0.09	9	65	11	3459
Pendimethalin + pyroxasulfone*	PRE	1.1 + 0.09	8	65	2	3327
Pyroxasulfone*	PRE	0.09	9	39	5	2299
Pendimethalin	PRE	1.1				
Imazapic	LPOST	0.07	3	98	74	3984
Pendimethalin + pyroxasulfone*	PRE	1.1 + 0.06				
Imazapic + pyroxasulfone	LPOST	0.07 + 0.06	5	98	88	5306
Pendimethalin + pyroxasulfone*	PRE	1.1 + 0.09				
Imazapic	LPOST	0.07	13	98	86	4662
Pyroxasulfone*	PRE	0.09				
Imazapic	LPOST	0.07	8	98	69	4062
Pyroxasulfone*	PRE	0.09				
Imazapic + pyroxasulfone	LPOST	0.07 + 0.06	8	98	76	4134
Pyroxasulfone	PRE	0.09				
Dimethenamid-P + paraquat	EPOS	0.84 + 0.27	11			
Pyroxasulfone	T	0.06		78	10	2895
S-metolachlor*	LPOST	1.1	9			
Imazapic	PRE	0.07	0	100	83	5184
Untreated	LPOST	-	4	0	0	2458
LSD (0.05)	-			14	8	1003

[a] *Abbreviations: DAT, days after PRE treatment; EPOST, early postemergence (ground cracking); LPOST, late postemergence; PPI, preplant incorporated; PRE, preemergence.*

[b] *Induce included in all POST treatments at 0.25 % v/v.*

[c] **Aciflurofen at 0.29 kg ai ha^{-1} + bentazon at 0.56 kg ai ha^{-1} + paraquat at 0.27 kg ai ha^{-1} applied EPOST.*

[d] *Bayer code for weeds: IPOHE (ivyleaf morningglory); Ipomoea hederacea; URODE, (Texas millet) Urochloa texana.*

Table 5. Peanut stunting and weed control with pyroxasulfone combinations during the 2014 growing season (Location 4)[a]

Treatment[b]	Timing	Dose Kg ai ha^{-1}	Weed control				
			Stunt	IPOHE[c]		URODE	
			DAT				
			16	37	104	37	104
			%				
Pendimethalin	PPI	1.1	1	61	34	55	5
Pyroxasulfone	PPI	0.09	1	71	43	48	5
Pyroxasulfone	PPI	0.18	1	83	66	56	5
Pendimethalin + pyroxasulfone	PPI	1.1 + 0.09	1	86	54	55	5
Dimethenamid-P	PRE	0.84	5	60	33	55	5
Pyroxasulfone	PRE	0.09	8	88	58	65	5
Pyroxasulfone	PRE	0.18	6	80	61	74	8
Dimethenamid + pyroxasulfone	PRE	0.84 + 0.09	13	92	65	80	6
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27	0	96	68	93	6
Pyroxasulfone + paraquat	EPOST	0.09 + 0.27	0	95	83	95	11
Pyroxasulfone + paraquat	EPOST	0.18 + 0.27	0	97	83	98	34
Dimethenamid-P + pyroxasulfone + paraquat	EPOST	0.84 + 0.09 + 0.27	0	97	83	98	11
Pendimethalin	PPI	1.1					
pyroxasulfone + paraquat	EPOST	0.09 + 0.27					
Imazapic	LPOST	0.07	0	99	99	97	91
Pendimethalin	PPI	1.1					
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27					
Imazapic	LPOST	0.07	0	95	98	97	86
Pendimethalin	PPI	1.1					
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27					
Pyroxasulfone + imazapic	LPOST	0.09 + 0.07	0	98	100	97	86
Pyroxasulfone	PPI	0.09					
Dimethenamid-P + paraquat	EPOST	0.84 + 0.27					
Imazapic	LPOST	0.07	3	97	98	95	80
Untreated	-	-	0	0	0	0	0
LSD (0.05)			2	14	22	8	7

[a] *Abbreviations: DAT, days after PPI/PRE treatment; EPOST, early postemergence (ground cracking); LPOST, late postemergence; PPI, preplant incorporated; PRE, preemergence.*

[b] *Induce included in all paraquat treatments at 0.25 % v/v; Agridex at 1.25% v/v included in all imazapic treatments.*

[c] *Bayer code for weeds: IPOHE (ivyleaf morningglory); Ipomoea hederacea; URODE, (Texas millet) Urochloa texana.*

Peanuts that become detached from the plant remain unharvested in or on the soil [6]. At Location 2, all herbicide systems yielded more than the untreated check (Table 3). The herbicide system that included pyroxasulfone at 0.06 kg ha^{-1} applied PRE and LPOST provided the greatest yield.

In 2014 at Location 3, treatments that included a PRE and a LPOST treatment yielded more than the untreated check with the exception of pyroxasulfone alone applied PRE or pyroxasulfone applied PRE followed by the an EPOST application of dimethenamid-P plus paraquat and followed by an LPOST application of pyroxasulfone (Table 4). *Ipomea hederacea* and *U. texana* control was lower with this treatment and thus was reflected in yield (Table 4).

Studies in other crops have reported some yield reductions when using pyroxasulfone and results can vary by crop [16,33-37]. Winter wheat showed minimal injury or yield reductions at doses up to 0.15 kg ha^{-1} [35]. Potato (*Solanum tuberosum* L.) also showed tolerance to pyroxasulfone at doses up to 0.15 kg ha^{-1} with minor yield reduction and quality losses [36]. Pyroxasulfone at 0.125 kg ha^{-1} caused unacceptable yield losses in barley (*Hordeum vulgare* L.) as well as durum wheat and oats (*Avena sativa* L.) [37]. Sunflower (*Helianthus annus* L.) has also shown acceptable tolerance to pyroxasulfone up to 0.33 kg ha^{-1} although injury (but not yield loss) did occur at locations with heavy precipitation events shortly after application [38].

Mahoney et al. [33] reported in soybean that pyroxasulfone at 0.18 kg ha^{-1} applied PPI resulted in a 6% reduction in yield when compared with the untreated check. They also reported that pyroxasulfone plus flumioxazin should be applied prior to crop emergence as yield reductions up to 9% can occur if the product is applied at the cotyledon stage. No effect on corn yield has been noted with doses of pyroxasulfone ranging from 0.25 to 0.5 kg ha^{-1} [17,39].

Eure et al. [31] reported in peanut that treatments that included pyroxasulfone at 0.12 kg ha^{-1} yielded similar to treatments without pyroxasulfone; however, pyroxasulfone applied at 0.24 kg ha^{-1} reduced peanut yield 6%. Prostko et al. [23] did not observe a yield loss following pyroxasulfone applied PRE.

4. CONCLUSION

These results indicate that pyroxasulfone is an effective herbicide for weed control in peanut and performs as well as *S*-metolachlor and dimethenamid-P at much lower use doses. Although no peanut yield reductions were observed, the early season stunting in isolated instances should be noted. Future research should focus on determining the factors that contribute to peanut injury and document yield and peanut quality responses following pyroxasulfone applied at different application timings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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