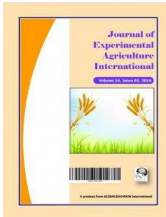

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Performance of Pyroxasulfone to Control *Amaranthus palmeri* and *Salsola kali* in Peanut

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Authors' contributions

This work was carried out in collaboration between all authors. Author PAD designed the studies and performed the statistical analysis. Author WJG wrote the first draft of the manuscript while authors PAD, TAB and JEW reviewed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Determine weed efficacy and peanut tolerance to pyroxasulfone in the Texas High Plains peanut growing area.
Study Design: Randomized complete block design with 3 replications.
Place and Duration of Study: Weed efficacy studies were conducted during 2013 and 2014 at the Texas A&M AgriLife Research and Extension Center near Halfway (34.188° N, 101.952° W) and near Seagraves (32.9369° N, 102.5409° W). Peanut tolerance studies were conducted during 2014 and 2015 near Brownfield (33.1042° N, 102.1615° W).
Methodology: Plots were four rows wide spaced 102 cm apart and 9.5 m long. Herbicides were applied with a CO_2 compressed-air backpack sprayer using Teejet Turbo Tee 11002 flat fan nozzles which delivered 140 L ha^{-1} at 207 kPa. In the weed efficacy studies, field plots were naturally

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infested with moderate Palmer amaranth (*Amaranthus palmeri* S. Wats.) populations while Russian thistle *(Salsola kali* L.*)* populations were low to moderate. Weed control and peanut injury was visually estimated on a scale of 0 indicating no control and 100 indicating complete control or plant death, relative to the untreated control. In the variety tolerance study, pyroxasulfone alone at 0.09 and 0.18 kg ha^{-1} was compared with flumioxazin + pyroxasulfone at 0.07 + 0.09 and 0.14 + 0.18 kg ha^{-1}, respectively applied PRE. This area was kept weed-free.

Results: Pyroxasulfone, applied either PRE or EPOST, provided at least 95% *A. palmeri* control while pyroxasulfone applied PRE followed by paraquat applied EPOST controlled *Salsola kali* 97%. This was as good as all other herbicide treatments with the exception of either pyroxasulfone or dimethenamid-*P* plus paraquat applied EPOST and followed by imazethapyr applied LPOST, which provided only 58% control.

Conclusion: These results indicate that pyroxasulfone can be an effective herbicide for control of *Amaranthus palmeri* and *Salsola kali* in peanut. All peanut varieties evaluated showed excellent tolerance to pyroxasulfone.

Keywords: Arachis hypogaea L; preplant incorporated; preemergence; postemergence; peanut stunting.

1. INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important legume crop for sustainable human nutrition in that it is an essential source of oil and protein in many countries around the world [1,2]. Production systems vary considerably depending on geography, climate and weather, and access to production resources [3,4]. The widespread use of herbicides in crops grown throughout the US has resulted in yield increases, savings for growers, and reduced soil erosion [5]. For most crops, the US herbicide treated acreage exceeds 85% and for peanut 97% of the hectarage is treated [5]. Without herbicides, hand weeding and cultivation would be needed and would take more time and be more costly. The national costs of these alternatives tops $14 billion annually, more than double what the nation's growers are spending on herbicides and their application [5]. Yields for peanut would be reduced more than 50% without the use herbicides [5]. Although variation exists depending upon infestation of weeds, incidence of disease, and fluctuations in insect populations, pesticide expenditures for weed control exceed those for insects control but are less than costs for disease control. Success of weed management practices can be influenced by the ability of peanut to compete with weeds, cultural practices that minimize the soil seed bank and weed infestation, cultivation during the growing season and primary tillage prior to planting, and efficacy of herbicides [6].

Pyroxasulfone is an isoxazoline herbicide with the same mode of action as the chloroacetamide herbicides [7] and has potential for use in peanut. It is a group 15 herbicide that limits the production of very long chain fatty acids (VLCFA) through interference with VLCFA elongases [7]. Pyroxasulfone is a soil-applied preemergence (PRE) herbicide registered for use in corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), soybeans (*Glycine max* L.), and wheat (*Triticum aestivum* L.) that recently received labeling for early postemegence use in peanut in the US [8,9]. Like other soil-applied herbicides, pyroxasulfone efficacy and use rates can be affected by edaphic factors [10]. Pyroxasulfone has a log K_{ow}, octanol/water partition co-efficient, of 2.39 and a moderate K_{oc}, soil/organic carbon sorption co-efficient, of 113 mL g^{-1}, indicating that it is relatively water-soluble and has high mobility potential in soil water [10]. It has an estimated half-life in the soil of between 8 and > 71 day [11]. There is a strong correlation between organic matter and soil adsorption of pyroxasulfone, indicating that organic matter content and soil moisture can cause variable efficacy between years, locations, and weed species [10]. Soil organic matter increases pyroxasulfone binding to soil colloids thus decreasing herbicide efficacy [10].

The current distribution of Palmer amaranth (*Amaranthus palmeri* S. Wats.) is the southern half of the US [12]. In Texas, Palmer amaranth can be found in all areas of the state [13]. It is a severe problem in many fields in the southern part of the state when not properly controlled [14]. Monoculture production systems and the repeated use of the same or similar herbicides have led to herbicide resistance in weeds [15-18]. *Amaranthus* species are very sensitive to ALS-inhibiting herbicides and possess characteristics that predispose them to have herbicide resistant biotypes such as high genetic variability, prolific seed production, and efficient pollen and seed distribution [19]. The use of soil-applied and POST herbicides with alternative sites of action is necessary to reduce the rate of development of herbicide-resistant weed populations [20].

Russian thistle (*Salsola kali* L.) is not a new weed, per se; however, it has rarely been studied in agronomic crops other than in chemical weed control experiments reported in regional proceedings. It is an exotic, annual, erect, xerohalophytic forb which is highly branched and rounded in form growing from 0.3 to 1 m in height and from 0.3 to 1.5 m in diameter and is a highly effective reproducer [21,22]. After seeds mature in the late fall, the plant stem separates from the root and the plant is blown by the wind [23]. Seeds, held in the leaf axils, fall to the ground as the plant tumbles [23]. Further dispersal is accomplished when wind scatters the winged seeds. One plant typically produces about 250,000 seeds, which remain viable for less than a year [24]. Russian thistle competes with crop plants for space, water, and nutrients [25]. It is the primary host for the beet leafhopper (*Circulifera tennellus*) that vectors the curly-top virus of sugar beets, tomatoes, and curcubitis [23,26], as well as root-knot nematodes (*Meloidogyne incognita*) [27].

Previous research in other peanut growing areas of the US has shown that pyroxasulfone has good peanut tolerance and provides control of problem weeds in each production area. For those reasons, research was undertaken in the High Plains of Texas peanut growing area to determine peanut tolerance and control efficacy of two problem weeds, Palmer amaranth and Russian thistle, found in that area.

2. MATERIALS AND METHODS

Two separate studies were conducted during the 2013 through 2015 growing seasons in the Texas High Plains peanut growing region: 1) weed efficacy study where various herbicide treatments which included pyroxasulfone were evaluated for Palmer amaranth and Russian thistle control, and 2) peanut tolerance studies where pyroxasulfone alone was compared with flumioxazin plus pyroxasulfone for peanut growth and yield. For both studies, the factors discussed below are virtually the same unless otherwise noted.

2.1 Field Studies

Field studies for weed efficacy were conducted during the 2013 and 2014 growing seasons at the Texas A&M AgriLife Research and Extension Center near Halfway (34.188ºN, 101.952ºW) and near Seagraves (32.9369ºN, 102.5409ºW) in the Texas High Plains. There were two locations in 2013 (Location 1 and 2) near Halfway and one location (Location 3) in 2014 near Seagraves.

These studies were in the same general area, but different parts of the field in each year. Soils at Halfway were a Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll) with less than 1% organic matter and pH 7.7 while soil at Seagraves were Brownfield fine sand (loamy, mixed, superactive, thermic Arenic Aridic Paleustalfs) with less than 1% organic matter and pH 7.4. The experimental design for the weed efficacy and peanut tolerance studies were a randomized complete block with three replications. An untreated check was included each year in all studies.

The peanut tolerance studies were conducted during the 2014 and 2015 growing seasons (Locations 4 and 5) near Brownfield at the Birdsong Peanut Company research site (33.1042ºN, 102.1615ºW). Three studies evaluating Spanish, runner, and Virginia market types were conducted in 2014 while two studies evaluating runner and/or Virginia market types were conducted in 2015 (Table 1). Soils at Brownfield were also a Brownfield fine sand with less than 1% organic matter and pH 7.6.

2.2 Plot Size and Weed Populations

Each plot was four rows wide spaced 102 cm apart and 9.5 m long. Peanut varieties, planting dates, and herbicide application timings for the weed efficacy and peanut tolerance studies are shown in Table 1. For the weed efficacy studies, all field plots were naturally infested with moderate populations of Palmer amaranth (4 to 6 plants m^2) while Russian thistle populations were low to moderate (2 to 4 plant m^2). For the peanut tolerance studies, the test area was maintained weed-free throughout the growing season. All plots received a dinitroaniline herbicide (pendimethalin at 1.12 kg ha^{-1}) applied preplant incorporated (PPI) and were cultivated and hand-weeded throughout the growing season to maintain weed-free conditions.

Table 1. Peanut variety, planting date, and herbicide application dates for the various studies using pyroxasulfone in the Texas High Plains[a]

	2013		2014
	Location 1	**Location 2**	**Location 3**
Weed efficacy studies			
Peanut variety	OLin	OLin	OLin
Planting date	April 29	April 29	May 3
Application			
PRE	April 29	April 29	May 3
EPOST	May 20	May 20	May 14
LPOST	July 3	July 3	June 16
Peanut tolerance studies	2014		2015
	Location 4		**Location 5**
Peanut varieties			
Runner	TamRun OL11		Tam Run OL11
Spanish	AT 9899		-
Virginia	Florida Fancy		Florida Fancy
Planting date	April 29		May 12
PRE application	April 29		May 12

[a]*Abbreviations: PRE, preemergence; EPOST, early postemergence; LPOST, late postemergence*

2.3 Herbicide Application

Herbicides were applied with a CO_2 compressed air backpack using Teejet Turbo Tee 11002 flat fan nozzles that delivered 140 L ha^{-1} at 207 kPa. In the weed efficacy studies, the early POST (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 late POST (LPOST) applications were made when both Palmer amaranth and Russian thistle were 20 to 40 cm tall. 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, Peanut Injury, 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 was visually estimated on a scale of 0 to 100 (0 indicating no control and 100 indicating complete control or plant death), relative to the untreated control [28]. In the weed efficacy studies, weed control evaluations were recorded 42 to 120 d after PRE application (DAT) depending on the study.

In the peanut tolerance studies, injury evaluations were recorded 3 to 20 wks after the PRE application. 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 commercial combine modified with a sacking attachment. Weights were recorded after soil and trash were removed from plot samples. Peanuts were not dug for yield in the weed efficacy studies due to the difficulty of digging heavily infested weed plots [29].

2.5 Data Analysis

Weed control data were arcsine transformed prior to analysis of variance; however, because the transformation did not alter treatment means original data are presented. 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

3.1 Weed Efficacy Studies

Since herbicide treatments varied from location-to-location no attempt was made to combine data over years.

3.1.1 Palmer amaranth control

In 2013 at Location 1, all herbicide systems provided at least 97% Palmer amaranth control when evaluated 42 DAT; however, when evaluated late-season control varied from 75 to 99% (Table 2). Dimethenamid-*P* alone applied PRE provided only 75% control while all treatments containing pyroxasulfone, applied either PRE or EPOST, provided at least 95% control. This was better than the local standard of *S*-metolachlor applied PRE or EPOST which controlled Palmer amaranth less than 85%.

In another study in 2013 (Location 2), the only treatment that controlled Palmer amaranth at least 98% late-season was pendimethalin plus pyroxasulfone applied PRE, followed by the three-way mix of aciflurofen plus bentazon plus paraquat applied EPOST and imazapic applied LPOST (Table 3). In 2014 (Location 3), pyroxasulfon in combination with either pendimethalin or flumioxazin applied PRE and followed by an EPOST application of aciflurofen plus bentazon plus paraquat controlled Palmer amaranth at least 98% when evaluated late-season. The addition of a LPOST application of imazapic did not improve control over the above-mentioned combinations. None of the other herbicide treatments provided greater than 77% Palmer amaranth control (Table 3).

In a 2-yr cotton study, Cahoon et al. [30] reported that pyroxasulfone at 0.06 to 1.2 kg ha^{-1} controlled Palmer amaranth at least 85% when rated late-season and a rate response was generally noted. In corn, Stephenson et al. [31] reported that in absence of a POST herbicide, pyroxasulfone or pyroxasulfone plus atrazine control of Palmer amaranth was 93 to 96% at all evaluations. Pyroxasulfone must be applied prior to weed emergence or used in combination with a postemergence herbicide like paraquat to assist controlling emerged weeds [32].

3.1.2 Russian thistle control

The dinitroaniline herbicides are effective on Russian thistle and paraquat applied either preplant, EPOST, or up to 28 d after emergence will effectively control this weed in peanut (author's personal observations).

In 2013, when rated 42 DAT, pyroxasulfone alone applied PRE, dimethenamid-P and *S*-metolachlor alone applied EPOST, and herbicide systems which included dimethenamid-P applied EPOST followed by pyroxasulfone plus imazethapyr applied LPOST, or flumioxazin applied PRE followed by either imazethapyr alone or imazethapyr plus dimethenamid-P applied LPOST controlled this weed at least 90% (Table 2).

In 2014, Russian thistle control was 100% with several herbicide systems. This included flumioxazin plus pyroxasulfone applied PRE followed by aciflurofen plus bentazon plus paraquat applied EPOST, dimethenamid-P applied PRE followed by pyroxasulfone plus paraquat applied EPOST, pendimethalin plus pyroxasulfone applied PRE followed by aciflurofen plus bentazon plus paraquat applied EPOST followed by either imazethapyr or imazapic applied LPOST, pyroxasulfone applied PRE followed by paraquat applied EPOST followed by either imazethapyr or imazapic applied LPOST, and pyroxasulfone applied PRE followed by paraquat applied EPOST followed by pyroxasulfone plus either imazethapyr or imazapic applied LPOST (Table 3).

3.2 Variety Tolerance Studies

3.2.1 Peanut stunting

In 2014, the high dose of pyroxasulfone alone or flumioxazin plus pyroxasulfone resulted in significant peanut stunting when compared with the untreated check for all market types (Table 4). Additionally, the low dose of flumioxazin plus pyroxasulfone caused stunting to the Spanish and runner market types when evaluated 20 weeks after treatment (WAT). Significant stunting was also observed 20 WAT with the low dose of pyroxasulfone alone or flumioxazin plus pyroxasulfone.

In 2015, similar trends were noted with the high doses of pyroxasulfone alone or flumioxazin plus pyroxasulfone with runner and Virginia market types (Table 4). However, pyroxasulfone alone at the low dose resulted in 12% stunting when evaluated 3 WAT with the runner market type while all treatments caused at least 17% stunting when evaluated 3 WAT and 5 to 9% stunting with the Virginia market type when evaluated 9 WAT.

Baughman et al. [33] reported that peanut stunting of all preplant incorporated (PPI) and PRE treatments with pyroxasulfone ranged from 1 to 13%. Pyroxasulfone is not labeled for PPI or PRE applications in peanut due to potential peanut injury [34]. In other crops, injury has been noted with pyroxasulfone and flumioxazin plus pyroxasulfone combinations [8, 35-37]; whereas, McNaughton et al [37] reported that there was a variety response to either of those herbicides in soybean. Flumioxazin plus pyroxasulfone applied PRE at 0.16 kg ha^{-1} did not cause significant injury; however, when the dose was increased to 0.32 kg ha^{-1} injury was observed with all soybean varieties. Futhermore, increased soybean injury has been reported in soils with high moisture after flumioxazin application [38].

3.2.2 Peanut yield

In 2014, pyroxasulfone alone or flumioxazin plus pyroxasulfone at any dose had no effect on peanut yield when compared with the untreated check with the Spanish market type (Table 4). With the runner market type, the high dose of flumioxazin plus pyroxasulfone reduced yield when compared with the untreated check while with the Virginia market type yields were not reduced from the untreated check with any herbicide treatment. In fact, the low dose of pyroxasulfone alone and the high dose of flumioxazin plus pyroxasulfone resulted in greater yields than the untreated check. In 2015, none of the herbicide treatments had any effect on yield when compared with the untreated check.

Eure et al. [34] reported that 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%. Additionally, Prostko et al. [32] reported that pyroxasulfone applied PRE did not result in a reduction in yield when compared with the untreated check. In soybean, McNaughton et al. [37] reported that PRE applications of pyroxasulfone alone or flumioxazin plus pyroxasulfone did not affect soybean yield.

Table 2. Comparisons of dimethenamid-*P*, flumioxazin, *S*-metolachlor, and pyroxasulfone combinations for weed control near Halfway during the 2013 growing season (Location 1)[a]

Treatment[b,c]	Timing	Dose	AMAPA[d]		SASKR
			DAT		
			42	86	42
		Kg ai ha^{-1}	%		
Dimethenamid-*P*	PRE	0.84	100	75	83
Pyroxasulfone	PRE	0.09	100	95	97
S-Metolachlor	PRE	1.08	100	82	75
Dimethenamid-*P*	EPOST	0.84	100	87	92
Pyroxasulfone	EPOST	0.09	100	97	75
S-metolachlor	EPOST	1.08	98	84	90
Dimethenamid-*P*	EPOST	0.84			
Imazethapyr	LPOST	0.07	97	89	58
Dimethenamid-*P*	EPOST	0.84			
Pyroxasulfone+imazethapyr	LPOST	0.09 + 0.07	100	95	90
Flumioxazin	PRE	0.11			
Imazethapyr	LPOST	0.07	100	87	97
Flumioxazin	EPOST	0.11			
Imazethapyr+dimethenamid-*P*	LPOST	0.07+0.84	100	94	100
Pyroxasulfone	EPOST	0.09			
Imazethapyr	LPOST	0.07	100	99	58
Untreated	--	--	0	0	0
LSD (0.05)			3	9	33

[a]Abbreviations: DAT, days after PRE treatment; PRE, preemergence; EPOST, early postemergence (ground cracking); LPOST, late postemergence.
[b] All herbicide treatments included paraquat at 0.21 kg ai ha^{-1} + Induce at 0.25 % v/v applied EPOST.
[c] Induce included in all LPOST treatments at 0.25 % v/v.
[d] Bayer code for weeds: AMAPA (Palmer amaranth), Amaranthus palmeri; SASKR (Russian thistle), Salsola kali var. Ruthenica.

Table 3. Late-season weed control with pyroxasulfone combinations near Halfway during the 2013 (Location 2) and near Seagraves during the 2014 growing seasons (Location 3)

Treatment [a,b]			Weed control		
			AMAPA[d]		SASKR
	Appl. timing	Dose	2013	2014	2014
		Kg ai ha^{-1}		%	
Dimethenamid-P	PRE	0.84			
Pyroxasulfone + paraquat	EPOST	0.09 +0.21	--	77	100
Dimethenamid-*P*	PRE	0.84			
Pyroxasulfone + imazapic/imazethapyr	LPOST	0.09 +0.07	--	67	57
Flumioxazin + pyroxasulfone	PRE	0.11+ 0.09			
Aciflurofen + bentazon + paraquat	EPOST	0.29 + 0.56 + 0.29	92	100	100
Pendimethalin + pyroxasulfone	PRE	0.84 +0.06			
Aciflurofen + bentazon + paraquat	EPOST	0.29 +0.56 + 0.29	83	98	83
Pyroxasulfone	PRE	0.09			
Aciflurofen + bentazon + paraquat	EPOST	0.29 + 0.56 + 0.21	88	65	83
Pendimethalin + pyroxasulfone	PRE	0.84 + 0.06			
Aciflurofen + bentazon + paraquat	EPOST	0.29 + 0.56 + 0.21			
Imazapic/imazethapyr	LPOST	0.07	98	100	100
Pyroxasulfone	PRE	0.09			
Paraquat	EPOST	0.21			
Imazapic/imazethapyr	LPOST	0.07	--	62	100
Pyroxasulfone	PRE	0.09			
Paraquat	EPOST	0.21			
Pyroxasulfone + imazapic/imazethapyr	LPOST	0.07	--	63	100
Untreated			0	0	0
LSD (0.05)			5	7	30

[a] *All EPOST and LPOST treatments included Induce at 0.25 % v/v.*
[b] *LPOST treatment in 2013 at Location 2 was imazapic while at Location 3 the LPOST treatment in 2014 was imazethapyr.*
[c] *Abbreviations: PRE, preemergence; EPOST, early postemergence (ground cracking); LPOST, late postemergence.*
[d] *Bayer code for weeds: AMAPA (Palmer amaranth), Amaranthus palmeri; SASKR (Russian thistle), Salsola kali var. Ruthenica*

Table 4. Peanut variety response, according to market types, to pyroxasulfone and flumioxazin plus pyroxasulfone applied preemergence in 2014 and 2015

2014		**Market type[a]**								
		Spanish			**Runner**			**Virginia**		
		WAT[b]			**WAT**			**WAT**		
Herbicide	**Dose**	**5**	**20**	**Yield**	**5**	**20**	**Yield**	**5**	**20**	**Yield**
	Kg ha^{-1}		**%**	**Kg ha^{-1}**		**%**	**Kg ha^{-1}**		**%**	**Kg ha^{-1}**
Pyroxasulfone	0.09	2	2	2483	0	2	4395	0	6	4176
Pyroxasulfone	0.18	8	15	2483	12	5	5046	25	8	3522
Flumioxazin + pyroxasulfone	0.07+ 0.09	2	5	2523	0	12	4070	3	6	3340
Flumioxazin + pyroxasulfone	0.14+ 0.18	15	22	2565	13	12	3663	18	8	4248
Untreated	--	0	0	2972	0	0	4721	0	0	3304
LSD (0.05)		6	5	NS	6	5	861	7	3	804
2015					**Runner**			**Virginia**		
					WAT			**WAT**		
Herbicide	**Dose**				**3**	**9**	**Yield**	**3**	**9**	**Yield**
	Kg ha^{-1}					**%**	**Kg ha^{-1}**		**%**	**Kg ha^{-1}**
Pyroxasulfone	0.09				12	8	2088	25	5	3783
Pyroxasulfone	0.18				18	20	3255	17	7	4516
Flumioxazin + pyroxasulfone	0.07+ 0.09				0	3	2726	20	7	5412
Flumioxazin + pyroxasulfone	0.14+ 0.18				32	22	2359	17	9	4741
Untreated	--				0	0	2637	0	0	4842
LSD (0.05)					10	14	NS	11	5	NS

[a] Peanut varieties used in each market type:
2014: Spanish, AT9899; Runner, Tamrun OL01; Virginia, Florida Fancy.
2015: Runner, Tamrun OL01; Virginia, Florida Fancy.
[b]Abbreviation: WAT, weeks after treatment.

4. CONCLUSION

These studies show that pyroxasulfone is an effective herbicide for weed control in peanut in the Texas High Plains and performs as well as dimethenamid-*P* or *S*-metolachlor at much lower use doses. Excellent peanut safety was noted at the 1X dose (0.09 kg ha^{-1}); however, considerable peanut injury was observed at the 2X dose but this did not translate to a reduction in yield.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Davis JP, Dean LL. Peanut. consumption, flavor and nutrition. Stalker HT, Wilson RF, eds. Peanuts: Genetics, processing, and utilization. AOCS Monograph Series, AOCS Press, Elsevier. 2016;289-346.
2. Valentine H. The role of peanuts in global food security. 2016;447-462.
   Stalker HT, Wilson RF, eds. Peanuts: Genetics, processing, and utilization. AOCS Monograph Series, AOCS Press, Elsevier; 2016.
3. Bullen G, Jordan D. Peanut production budgets. Jordan DL Coordinating Author, 2017 Peanut Information. North Carolina Cooperative Extension Service Pub. AG-331. 2017;13-16.
4. Bennett AC, Price AJ, Sturgill MC, Buol GS, Wilkerson GG. HADSSTM, Pocket HERBTM, and WebHADSSTM: Decision Aids for Field Crops. Weed Technol. 2003;17:412-420.
5. Gianessi LP, Sankula S. Executive Summary: The value of herbicides in U.S. crop production. National Center for Food and Agricultural Policy. Washington, DC. 2003:1-16.
6. Wilcut JW, York AC, Grichar WJ, Wehtje GR. The biology and management of weeds in peanut (*Arachis hypogaea*). In Pattee HE, Stalker HT, editors. Advances in Peanut Science, American Peanut Research and Education Society, Still-water, OK. 1995;207-244.
7. Tanetani Y, Kaku K, Kawai K, Fujioka T. Action mechanism of a novel herbicide, pyroxasulfone. Biochem. Physiol. 2009;95: 47-55.
8. Tidemann BD, Hall LM, Johnson EN, Beckie HJ, Sapsford KL, Raatz. Efficacy of fall- and spring-applied pyroxasulfone for herbicide-resistant weeds in field pea. Weed Tech. 2014;28:351-360.
9. Anonymous, Supplemental Label-for use in peanut. Zidua® herbicide, BASF Corpora-tion, Research Triangle Park, NC; 2017.
10. Westra EP. Absorption, leaching and dissipations of pyroxasilfone and two chloroacetamides. MSc thesis. Fort Collins CO. Colorado State Univ.; 2012.
11. Mueller TC, Steckel LE. Efficacy and dissipation of pyroxasulfone and three chloroacetamides in a Tennessee field soil. Weed Sci. 2011;59:574-579.
12. Anonymous. Weed identification guide. Champaign, IL. South. Weed Sci. Soc. 1990;3.
13. Correll DS, Johnston MC. Manual of vascular plants of Texas. Univ. of Texas at Dallas, Richardson, TX; 1979.
14. Grichar WJ. Control of palmer amaranth (*Amaranthus palmeri*) in peanut (*Arachis hypogaea*) with postemergence herbicides. Weed Technol. 1997;11:739-743.
15. Culpepper AS, Grey TL, Vencill WK, Kichler JM, Webster TM, Brown SM, York AC, Davis JW, Hanna WW. Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*) confirmed in Georgia. Weed Sci. 2006;54:620-626.
16. Beckie HJ. Herbicide-resistant weeds: Management tactics and practices. Weed Technol. 2006;20:793-814.
17. Putwain PD. Herbicide resistance in weeds-an inevitable consequence of herbicide use? Proc. Brighton Crop Prot. Conf.-Weeds. Farnham, UK: British Crop Protection Council. 1982;719-728.
18. Peterson DE. The impact of herbicide-resistant weeds on Kansas agriculture. Weed Technol. 1999;13:632-635.
19. Lovell ST, Wax LM, Horak MJ, Peterson DE. Imidazolinone and sulfonylurea resistance in a biotype of common waterhemp (*Amaranthus rudis*). Weed Sci. 1996;44:789-794.
20. Shaner DL, Feist DA, Retzinger EJ. SAMOA: one company's approach to

herbicide-resistant weed management. Pestic. Sci. 1997;51:367-370.
21. Allen EB, Allen MF. Facilitation of succession by the nonmycotrophic colonizer *Salsola kali* (Chenopodiaceae) on a harsh site: effects of mycorrhizal fungi. Amer. J. Botany.1988;75(2):257-266.
22. Barbour MG, Billings WD, editors. North American Terrestrial Vegetation. Cambridge; New York: Cambridge University Press; 1988.
23. DeLoach CJ, Boldt PE, Cjordo HA. Weeds common to Mexican and US rangelands: Proposals for biological control and ecological studies in Patton DR, Gonzales V CE, Medina AL, technical coordinators. Management and utilization of arid land plants: Symposium proceedings: 1985 Feb 18-22. Satillo, Mexico. Gen.Tech. Rep. RM-135. Ft. Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station. 1989;49-68.
24. Young JA. Tumbleweed. Scientific American. 1991;264(3):82-87.
25. Wallace A, Rhods WA, Frolich EF. Germination behavior of *Salsola* as influenced by temperature, moisture,depth of planting and gamma irradiation. Agron. J. 1968;60:76-78.
26. USDA. Forest service. Range Plant Handbook. Washington, DC.; 1937.
27. Manuchehri MR, Woodward JE, Wheeler TA, Dotray PA, Keeling JW. First report of Russian-thistle (*Salsola tragus* L.) as a host for the southern root-knot nematode *Meloidogyne incognita*) in the United States. Plant Health Progress; 2015. DOI: 10.1094/PHP-BR-15-0011
28. Frans R, Talbert R, Marx D, Crowley H. Experimental design and techniques for measuring and analyzing plant responses to weed control practices. In Camper ND, editor. Research methods in weed science. 3rd edition Southern Weed Science Society, Champaign, IL. 1986;29-46.
29. Buchanan GA, Murray DS, Hauser EW. Weeds and their control in peanuts. In Pattee HE, Young CT, editors. Peanut Science and Technology. Amer. Peanut Res. Educ. Soc., Inc., Yoakum, TX. 1982; 206-249.
30. Cahoon CW, York AC, Jordan DL. Cotton tolerance and Palmer amaranth control with Zidua, Warrant, and Dual Magnum herbicides. Proc. 2012 Beltwide Cotton Conferences. 2012;1535.
31. Stephenson DO, Bond JA, Griffin JL, Landry RL. Weed management programs with pyroxasulfone in field corn (*Zea mays*). Weed Technol. 2017;31:496-502.
32. Prostko EP. Weed control update. 2013 Peanut Production Update. In Beasley JP Jr., editor. Cooperative Extension Service Series CSS-12-0110. University of Georgia, Athens GA. 2013;47-65.
33. Baughman TA, Grichar WJ, Dotray PA. Weed control and peanut tolerance using pyroxasulfone in Oklahoma. Journal Expt. Agric. Internatl. 2018;21(3):1-11.
34. Eure PM, Prostko EP, Merchant RM. Peanut cultivar response to preemergence applictions of pyroxasulfone. Peanut Sci. 2015;42:39-43.
35. Soltani N, Shropshire C, Sikkema PH. Response of spring planted cereals to pyroxasulfone. Int. Res. J. Plant Sci. 2012; 3:113.
36. Hulting AG, Dauer JT, Hinds-Cook B, Curtis D, Koepke-Hill RM, Mallory-Smith C. Management of Italian ryegrass (*Lolium perenne* ssp. *multiflorum*) in western Oregon with preemergence applications of pyroxasulfone in winter wheat. Weed Technol. 2012;26:230-235.
37. McNaughton KE, Shropshire C, Robinson DE, Sikkema PH. Soybean (*Glycine max*) tolerance to timing applications of pyroxasulfone, flumioxazin, and pyroxasulfone + flumioxazin. Weed Technol. 2014;28:494-500.
38. Taylor-Lovell S, Wax LM, Bollero G. Preemergence flumioxazin and pendi-methalin and postemergence herbicide systems for soybean (*Glycine max*). Weed Technol. 2002;16:502-511.

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