Peanut Response to Postemergence Application of Pyroxasulfone

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ABSTRACT

Field experiments were conducted from 2009 through 2011 to evaluate peanut tolerance to postemergence (POST) applications of pyroxasulfone applied alone or in combination with commonly used foliar herbicides. Hherbicide treatments were arranged in a factorial arrangement that included three pyroxasulfone rates (0, 240, and 480 g ai/ha) and four POST application timings [10, 30, 60, and 90 days after planting (DAP)]. Pyroxasulfone applied at 240 or 480 g ai/ha 10 DAP caused 24 and 33% stunting 2 weeks after treatment (WAT), respectively. Regardless of pyroxasulfone rate, peanut stunting following application 30, 60, or 90 DAP was less than 3%. Peanut yield was not influenced by POST applied pyroxasulfone applied alone. In a second experiment, herbicide treatments were applied in a factorial treatment arrangement that included two pyroxasulfone rates (0 and 240 g ai/ha) and six POST herbicide systems [none; paraquat (140 g ai/ha); paraquat (210 g ai/ha) plus bentazon (280 g ai/ha); paraquat (210 g ai/ha) plus bentazon (560 g ai/ha) plus acifluorfen (280 g ai/ha); imazapic (70 g ai/ha); and lactofen (220 g ai/ha)]. Stunting 2 WAT with paraquat applied 10 DAP ranged from 33 to 37% while less injury was observed with lactofen or imazapic. Peanut stunting 9 WAT ranged from 3 to 6% regardless of weed management system. Pyroxasulfone applied in combination with POST herbicides did not reduce peanut yield.

Key Words: Crop injury, crop tolerance, yield, postemergence, KIH-485.

Over 428,000 ha of peanut were harvested in the United States in 2013 (Anonymous 2013a). Although economically important in the southern region, peanut acreage is significantly lower than many row crops grown in the United States. Consequently, secondary labels are often the only opportunity to obtain new herbicide labels for peanut growers. For example, lactofen was registered for use in soybean in 1989, and later labeled for use in peanut in 2004 (Anonymous 2004; Hagwood and Wilcut 1989; Wilcut *et al.* 1990). Similarly, pyroxasulfone, a preemergence (PRE) herbicide currently labeled for use in corn and soybean is being developed for use in wheat (*Triticum aestivum* L.) and sunflower (*Helianthus annus* L.). While research concerning peanut tolerance to pyroxasulfone is limited, Prostko *et al.* (2011) reported excellent tolerance when it was applied POST at 44 to 51 days after emergence. Pyroxasulfone may potentially have utility in peanut but manufacturers may never explore this use without third party research efforts.

Pyroxasulfone, is a member of the isoxazoline herbicide class and inhibits very-long-chain-fatty acid synthesis in susceptible plants (Tanetani *et al.* 2009). Other members with this mode of action used in peanut include dimethenamid-p and *S*-metolachlor (Johnson *et al.* 1994; Grichar *et al.* 1996; Baumann *et al.* 1999). Pyroxasulfone provides residual control of troublesome annual broadleaf weeds and grasses, including; browntop millet (*Urochloa ramose* L.), barnyardgrass (*Echinochloa crus-galli* L.), green foxtail (*Setaria viridis* L.), *Amaranthus* spp., velvetleaf (*Abutilon theophrasti* Medik.), large crabgrass (*Digitaria sanguinalis* L.), Italian ryegrass (*Lolium multiflorum* L.), and kochia (*Kochia scoparia* L.) (Geier *et al.* 2006; Gregory *et al.* 2005; Hulting *et al.* 2012; King and Garcia 2008; Koger *et al.* 2008; Nurse *et al.* 2011). Pyroxasulfone applied at 209 g ai/ha controlled broadleaf signalgrass (*Urochloa platyphylla* L.) similar to dimethenamid-p and *S*-metolachlor; however, dimethenamid-p and *S*-metolachlor provide poor residual control of Texas millet (*Urochloa texana* Buckl.) (Mueller and Steckel 2011). Pyroxasulfone applied at 208 g ai/ha resulted in greater than 90% control of Texas millet 4 weeks after treatment (WAT) (Gregory *et al.* 2005). At pyroxasulfone rates of 120 g ai/ha or less, Texas millet control is inconsistent. Originally, Knezevic *et al.* (2009) proposed that pyroxasulfone use rates range from 200 to 300 g ai/ha. Due to high manufacturing costs, pyroxasulfone use rates are projected to be between 60 and 120 g ai/ha.

Residual herbicides are often applied topically to peanut in combination with POST herbicides such as paraquat, bentazon, acifluorfen, imazapic, and lactofen. Bentazon and acifluorfen are com-

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Table 1. The effect of POST applied pyroxasulfone rate and application timing on peanut stunting 2 and 8 WAT.[a,b]

Pyroxasulfone rate	Application timing following planting	Peanut Stunting	
		2 WAT[d]	8 WAT[e]
g ai/ha	DAP[c]	%	
240	10	24 b	3
240	30	3 c	2
240	60	0 c	0
240	90	0 c	0
480	10	33 a	3
480	30	2 c	2
480	60	0 c	0
480	90	0 c	0

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD at a $P \leq 0.05$.
[b]Data pooled over 2 locations.
[c]DAP = days after planting.
[d]WAT = weeks after treatment.
[e]Means not significantly different at $P = 0.6890$.

monly tank-mixed with paraquat to increase control of prickly sida (*Sida spinosa* L.), smallflower morningglory (*Jacquemontia tamnifolia* L.), sicklepod (*Senna obtusifolia* L.), and coffee senna (*Senna occidentalis* L.) (Wehtje *et al.* 1992). Peanut tolerance to imazapic is excellent (Faircloth and Prostko 2010; Richburg *et al.* 1994; Warren and Coble 1999; Wilcut *et al.* 1996). Following application of paraquat, peanut foliage becomes stunted and necrotic. Peanut tolerance to paraquat or in mixture with bentazon and/or acifluorfen has been thoroughly studied (Carley *et al.* 2009; Grichar and Dotray 2012; Johnson *et al.* 1993; Knauft *et al.* 1990; Tubbs *et al.* 2010; Wehtje *et al.* 1991; Wilcut and Swann 1990; Wilcut *et al.* 1994). Bentazon tank-mixed with paraquat has been documented to reduce paraquat injury in peanut (Wehtje *et al.* 1992). The addition of *S*-metolachlor to paraquat systems has shown to increase peanut stunting (Grichar and Dotray 2012). However, peanut yield loss has only been documented following a 3x rate of *S*-metolachlor (Grichar *et al.* 1996). Limited information is available regarding peanut tolerance to pyroxasulfone applied POST. Therefore, the objectives of this research were to determine the influence of pyroxasulfone applied POST from emergence to podset and to evaluate peanut response to pyroxasulfone applied POST with and without herbicide tank-mix partners.

Table 2. The influence of POST applied pyroxasulfone rate on peanut yield.[a]

Pyroxasulfone rate	Pod yield[b]
g/ha	kg/ha
0	5,555*
240	5,560
480	5,360

[a]Data pooled over 4 application timings and 2 locations.
[b]Pod yield adjusted to 10% moisture.
*Means not significantly different at $P = 0.32$.

Materials and Methods

Field experiments were conducted from 2009 through 2011 at the University of Georgia Ponder Research Station near Ty Ty, GA on a Tifton loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) with 93% sand, 2% silt, 4% clay, 1% organic matter, and pH 6.0. The cultivar 'Georgia-06G' was planted in freshly tilled seed beds at a rate of 13 seed/m of row, in twin rows spaced 23 cm apart on a 91 cm center. Production, irrigation, and pest management practices other than specific treatments were held constant over the entire experiment to optimize peanut growth and development (Anonymous 2013b). Plots were maintained weed-free throughout the season using a tank-mixture of commonly applied PRE herbicides [pendimethalin (1 kg ai/ha) plus diclosulam (25 g ai/ha) plus flumioxazin (105 g ai/ha)] in combination with cultivation between plots and hand-weeding. All treatments were applied using a CO_2-pressurized backpack sprayer calibrated to deliver 140 L/ha at 275 kPa with 11002DG nozzle tips. At maturity, peanut were inverted and harvested using commercial equipment. Peanut yields were adjusted to 10% moisture. Data were subjected to ANOVA using the PROC MIXED procedure in SAS (SAS Institute

Table 3. The influence of POST applied pyroxasulfone timing on peanut yield.[a]

Pyroxasulfone application timing	Pod yield[c]
DAP[b]	kg/ha
10	5,460*
30	5,520
60	5,545
90	5,450

[a]Data pooled over 3 pyroxasulfone application rates and 2 locations.
[b]DAP = days after planting.
[c]Pod yield adjusted to 10% moisture.
*Means not significantly different at P = 0.94.

Inc., Cary, NC 27513) with years and replications as random effects. Means of significant main effects and interactions were separated using Fisher's Protected LSD test at $P \leq 0.05$.

Pyroxasulfone Application Timing

A field experiment was conducted twice during 2010 and 2011. Herbicide treatments were arranged in a factorial treatment arrangement including three pyroxasulfone rates (0, 240, and 480 g ai/ha) and four POST application timings [10, 30, 60, and 90 days after planting (DAP)]. The experimental design was a randomized complete block with each treatment replicated 4 times. Treatments applied at 10, 30 60 and 90 DAP were applied at the V2 to V3, R1, R3 and R6 stages, respectively, as described by Boote et al. (1982). Visual estimates of peanut stunting were made 2 and 8 WAT using a scale of 0 to 100% where 0 = no stunting and 100 = complete plant death.

Pyroxasulfone Tank-Mixtures

Two field experiments were conducted during 2009 and 2010. Herbicide treatments were arranged in a factorial arrangement that included two pyroxasulfone rates (0 and 240 g ai/ha) and six POST herbicide systems [none; paraquat (140 g ai/ha); paraquat (210 g ai/ha) plus bentazon (280 g ai/ha); paraquat (210 g ai/ha) plus bentazon (560 g ai/ha) plus acifluorfen (280 g ai/ha); imazapic (70 g ai/ha); and lactofen (220 g ai/ha)]. All herbicide treatments included non-ionic surfactant (80/20) at 0.25% v/v. Paraquat rate was increased from 140 g ai/ha to 210 g ai/ha when mixed with products containing bentazon due to antagonism (Wehtje et al. 1992). The experimental design was a randomized complete block with each treatment replicated 4 times. Treatments were applied 10 DAP to peanuts 5 to 10 cm in height at growth stages V4 to V5 (Boote 1982). Visual estimates of peanut stunting were made 2 and 9 WAT using methods previously discussed.

Results and Discussion

Pyroxasulfone Application Timing

Peanut stunting (2 and 9 WAT) and yield were not influenced by the interaction of pyroxasulfone rate, application timing, and experiment. Peanut stunting 2 WAT was influenced by the interaction of pyroxasulfone rate and application timing. Pyroxasulfone applied at 240 g ai/ha 10 DAP caused 24% stunting 2 WAT (Table 1). Increasing the pyroxasulfone rate to 480 g ai/ha increased stunting to 33%. Regardless of pyroxasulfone rate, peanut stunting 2 WAT following pyroxasulfone applied 30, 60, or 90 DAP was less than 3%. By 8 WAT, peanut stunting was minimal, ranging from 0 to 3%. Peanut yield was not influenced by pyroxasulfone rate or application timing (Tables 2 and 3). These results are similar to Prostko *et al.* (2011), who reported excellent peanut tolerance to pyroxasulfone applied 44 to 51 days after emergence. These data provide evidence that pyroxasulfone may be applied throughout the peanut growing season with little concern of negative yield effects. However, application of pyroxasulfone 10 DAP may result in stunting following higher use rates.

Table 4. The influence of POST (14 to 20 days after planting) applied pyroxasulfone rate on peanut canopy stunting 2 and 9 weeks after treatment and pod yield.[a,b]

Pyroxasulfone rate	Stunting 2 WAT[c]	Stunting 9 WAT	Pod yield[d]
g/ha	%	%	kg/ha
0	22 b	2 b	6985*
240	26 a	5 a	6570

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD at a $P \leq 0.05$.
[b]Data pooled over 6 POST herbicide applications and 2 locations.
[c]WAT = weeks after treatment.
[d]Pod yield adjusted to 10% moisture.
*Means not significantly different at P = 0.64.

Table 5. The influence of POST (14 to 20 days after planting) weed management systems on peanut canopy stunting 2 and 9 weeks after treatment and pod yield.[a,b]

POST System[c]	Stunting 2 WAT[d]	Stunting 9 WAT	Yield[d]
	——%——		kg/ha
none	0 e	0 b	6,935 ab
paraquat	33 b	5 a	6,865 ab
paraquat plus bentazon	37 a	3 ab	6,760 ab
paraquat plus bentazon plus acifluorfen	33 b	6 a	6,565 b
imazapic	15 d	3 ab	7,255 a
lactofen	23 c	3 ab	7,030 ab

[a]Means within a column followed by the same letter are not significantly different according to Fisher's Protected LSD at a $P \leq 0.05$.
[b]Data pooled over 2 pyroxasulfone rates and 2 locations.
[c]Herbicide rates for POST systems included paraquat at 140 g ai/ha; paraquat at 210 g ai/ha plus bentazon at 280 g ai/ha; paraquat at 210 g ai/ha plus bentazon at 560 g ai/ha plus acifluorfen at 280 g ai/ha; imazapic at 70 g ai/ha; and lactofen at 220 g ai/ha. All treatments included non-ionic surfactant (80/20) at 0.25% v/v.
[d]WAT = weeks after treatment.
[e]Pod yield adjusted to 10% moisture.

Pyroxasulfone Tank-Mixtures

Peanut stunting (2 and 9 WAT) and yield were not influenced by the interaction of pyroxasulfone rate, foliar herbicide system, and experiment. Peanut stunting 2 and 9 WAT was influenced by the main effect of pyroxasulfone rate. Treatments that included pyroxasulfone caused greater peanut stunting 2 and 9 WAT. When pooled over foliar herbicide systems and locations, peanut stunting 2 WAT was 22% without pyroxasulfone (Table 4). The addition of pyroxasulfone to foliar herbicide systems increased peanut stunting to 26%. By 9 WAT, peanut stunting with and without pyroxasulfone was 5 and 2%, respectively. Although the addition of pyroxasulfone to weed management systems increased peanut stunting throughout the season, peanut yield was not reduced.

Peanut stunting (2 and 9 WAT) and yield were influenced by the main effect of foliar herbicide systems. Peanut treated with systems that included paraquat were stunted 33 to 37% 2 WAT, while less severe injury was observed following treatment with lactofen or imazapic (Table 5). By 9 WAT, stunting ranged from 3 to 6% regardless of foliar herbicide system. Similar peanut tolerance has been observed when paraquat was applied in combination with other residual herbicides (Carley *et al.* 2009; Grichar and Dotray 2012).

Peanut yield was not reduced using common foliar herbicide systems when compared to systems that did not include foliar herbicides (Table 5). However, peanut yield was reduced in systems using paraquat plus bentazon plus acifluorfen (6,565 kg/ha) when compared to imazapic alone (7,255 kg/ha). Paraquat may cause injury that results in yield loss; however, yield loss is sporadic and rare (Grichar and Dotray 2012; Knauft *et al.* 1990; Wilcut and Swann 1990; Wilcut *et al.* 1994). Paraquat reduced yield of the runner type peanut cultivar`York` following application 21 days after cracking while application 7, 14, or 28 days after cracking did not reduce yield (Grichar and Dotray 2012). Lactofen may also cause leaf necrosis and bronzing in peanut; however, this injury does not result in yield loss (Dotray *et al.* 2012; Ferrell *et al.* 2013; Grichar and Dotray 2011; Wilcut *et al.* 1990).

Results from these field studies suggest potential POST uses for pyroxasulfone in peanut. While significant stunting occurred when pyroxasulfone alone was applied 10 DAP, peanut recovered and yield was not reduced. Pyroxasulfone tank-mixed with POST herbicides increased peanut stunting; however, yield was not reduced. Future research should focus on weed management using pyroxasulfone in peanut and determining weed species sensitivity to projected use rates of 60 to 120 g ai/ha.

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