Research Article

Weed Control and Grain Sorghum (*Sorghum bicolor*) Tolerance to Pyrasulfotole plus Bromoxynil

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Field studies were conducted during the 2008 and 2009 growing seasons at five locations in the Texas grain sorghum producing regions to evaluate pyrasulfotole plus bromoxynil combinations for weed control and grain sorghum response. All pyrasulfotole plus bromoxynil combinations controlled *Amaranthus palmeri*, *Cucumis melo*, and *Proboscidea louisianica* at least 94% while control of *Urochloa texana* was never better than 69%. Pyrasulfotole plus bromoxynil combinations did result in early season chlorosis and stunting; however, by the end of the growing season no visual injury or stunting differences were noted when compared to the untreated check. Early season grain sorghum chlorosis and stunting with pyrasulfotole plus bromoxynil combinations did not affect grain sorghum yields with the exception of pyrasulfotole at 0.03 kg ai/ha plus bromoxynil at 0.26 kg ai/ha plus atrazine at 0.58 kg ai/ha applied early postemergence followed by pyrasulfotole plus bromoxynil applied mid-postemergence which reduced yield at one of two locations in 2008. Grain sorghum yield increased following all pyrasulfotole plus bromoxynil treatments compared to the untreated check in 2009.

1. Introduction

Weed control in grain sorghum is a challenge because of the limited number of herbicides available to growers, rotational crop restrictions following a number of herbicides registered for use in grain sorghum, and because of the increased presence of herbicide resistant weeds. Competition from broadleaf weeds reduced grain sorghum yields more than grass species competition or mixtures of broadleaf and grass weeds [1–3]; however, weed competition the first 2 wks after crop emergence has not reduced grain sorghum yields regardless of the weeds studied [3, 4]. Duration of weed growth beyond 2 wks after grain sorghum emergence reduced yields depending on the weed species and environmental conditions [1–5]. Yield reductions primarily were due to the reduced seed/panicle [4–6], but reduced seed weight or panicles/plant also were important [1, 7].

Bromoxynil is a postemergence (POST) herbicide that is used for weed control in many crops and controls a broad

spectrum of annual broadleaf weeds including *Ipomoea* spp., *Sesbania exaltata* (Raf.) Coryl, *Chenopodium album* L., *Ambrosia artemisiifolia* L., *Sida spinosa* L., and *Anoda cristata* L. [8–12]. It does not effectively control grass species [8] and only controls *Amaranthus* spp. with properly timed applications [11, 13, 14]. Bromoxynil applications may control numerous broadleaf weed; however, many weed species may not be adequately controlled [8, 10, 12–14].

Pyrasulfotole is a new herbicidal active ingredient, belonging to the bleaching class of herbicides, and its action is based on the inhibition of the enzyme 4-hydroxyphenylpyruvate dioxygenase (HPPD) [15]. It controls a wide range of broadleaf weeds including *Stellaria media*, *C. album*, *Solanum* spp., *Amaranthus* spp., and *Abutilon theophrasti* in wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and triticale (*Triticosecale* spp.) [16]. Crop tolerance with pyrasulfotole is guaranteed through the inclusion of mefenpyr-diethyl, which ensures crop safety in all cereal varieties [16]. It has been suggested that

pyrasulfotole be included in mixtures with bromoxynil and fenoxaprop to improve control of broadleaf weeds and grasses, respectively [16].

The use of pyrasulfotole plus bromoxynil combinations has been investigated in a number of crops including various cereal crops [17–19] and grain sorghum [20]. Paulsgrove et al. [17], Thorsness et al. [18], and Watteyne et al. [20] reported that this combination controlled *Kochia scoparia* L., *Amaranthus* spp., *Polygonum convolvulus* L., *Chenopodium album* L., *Thlaspi arvense* L., *Salsola iberica* Sennan & Paul, *Lactuca serriola* L., and *Solanum* spp. They reported that the best control was achieved when this combination was applied to weeds at the 1- to 8-leaf stage and included ammonium sulfate in the mix. Geier and Stahlman [19] reported that pyrasulfotole plus bromoxynil combinations controlled *Descurainia sophia* L. greater than 95% and fall applications controlled *Lamium amplexicaule* L. 100%. All wheat plots treated with herbicides yielded 3020 to 3290 kg/ha more grain than nontreated wheat. Thompson et al. [21] reported that all treatments which contained pyrasulfotole plus bromoxynil combinations controlled *A. retroflexus* L., *A. palmeri* L., *C. album*, *Abutilon theophrasti* L., *Helianthus annuus* L., and *Ipomoea hederacea* L. regardless of stage of application, while Brandon and Bean [22] reported that this combination controlled *Amaranthus* spp. 85% one week after application, but control was reduced to 61% by the end of the season.

Limited data is available on the use of pyrasulfotole plus bromoxynil combinations in the Texas grain sorghum producing regions and the weed spectrum controlled. Therefore, the objectives of this research were to determine if combinations of pyrasulfotole plus bromoxynil applied POST could control multiple broadleaf weeds and some grass species and to investigate grain sorghum tolerance to these tank-mix combinations and systems.

2. Materials and Methods

2.1. Field Studies. Studies were conducted during the 2008 and 2009 growing seasons at the Texas AgriLife Research site near Yoakum in south-central Texas and at the Texas AgriLife Research and Extension Center near Lubbock in the Texas High Plains, and in 2008 at the Texas AgriLife Research and Extension Center near Corpus Christi in the Coastal Bend area, to evaluate weed control and grain sorghum response to POST applications of bromoxynil plus pyrasulfotole. However, due to extremely dry conditions during the 2009 growing season at Corpus Christi, this study was not planted. Soil type near Yoakum was a Denhawken sandy loam (fine-silty, carbonitic, hyperthermic Fluventic Ustochrepts) with less than 1.0% organic matter and pH 7.6 while soil type near Corpus Christi was a Victoria clay (fine, montmorillonitic, thermic Udic Pellusterts) with less than 1.0% organic matter and pH 7.5. Soil type at Lubbock in 2008 was an Acuff clay loam (fine-loamy, mixed, superactive thermic Aridic Paleustolls) with less than 0.8% organic matter and pH 7.7, while in 2009 soil type was an Olton clay loam (fine, mixed, thermic Aridic Paleustolls) with less than 1.0% organic matter and pH 7.4.

A randomized complete-block experimental design was used and herbicide treatments and rates were replicated three times. Plot size was two rows (97 cm apart) by 9.5 m at Yoakum, four rows (97 cm apart) by 11.1 m at Corpus Christi, and four rows (102 cm apart) by 7.3 m near Lubbock. At the Lubbock location, the two middle rows per plot were sprayed and the other rows were left untreated to serve as buffers while at the Corpus Christi location all four rows were sprayed. All pyrasulfotole plus bromoxynil combinations included ammonium sulfate at 3.9 kg/378 L. All POST herbicides at the Corpus Christi and Yoakum locations included a crop oil concentrate (Agri-Dex, a blend of 83% paraffin-based petroleum oil and 17% surfactant; Helena Chemical Company, Suite 500, 6075 Poplar Avenue, Memphis, TN 38137) at 1% v/v while at the Lubbock locations all POST herbicides included a nonionic surfactant (R-11, 90% alkylphenol ethoxylate, butyl alcohol dimethylpolysiloxane; Wilbur-Ellis Company, P.O. Box 16458, Fresno, CA 93755) at 0.25% v/v. Herbicides were applied in water using a CO₂-pressurized backpack sprayer with TeeJet 11002 DG (Spraying Systems Company, P.O. Box 7900, North Avenue, Wheaton, IL 60188) nozzles calibrated to deliver 190 L/ha at 180 kPa at Yoakum, TeeJet 8003XR calibrated to deliver 117 L/ha at 193 kPa at the Corpus Christi location, and TurboTee 110015 nozzles calibrated to deliver 140 L/ha at 207 kPa at the Lubbock locations. In 2008, at the Yoakum and Corpus Christi locations, all plots with the exception of the untreated check received S-metolachlor at 1.11 kg/ha applied preemergence. Herbicides and rates for each year are shown in Tables 1 and 2. Atrazine was used as a standard comparison in 2008 while atrazine plus bromoxynil was used as the standard in 2009.

Natural infestations of *Urochloa texana* (Buckl.) L. were present at the Yoakum location at the population density of 4 to 6 plants/m² in both years while, in 2009, *Cucumis melon* and *A. palmeri* were present at the density of 6 to 10 plants/m² and 5 to 8 plants/m², respectively. Natural infestations of *A. palmeri* were present at the Lubbock location at the population density of 4 to 6 plants/m² in both years while *Protoparce louisianica* L. was present in 2008. Due to dry conditions at the Corpus Christi location in 2008, weed populations were not uniform enough to provide an accurate assessment. Desired plant heights for early postemergence (EPOST) applications were 5 to 10 cm tall for all weeds and grain sorghum while weed heights at the mid-postemergence (MPOST) applications were 10 to 20 cm tall and grain sorghum was 30 to 41 cm tall.

For all studies, fertilizer was applied based on the soil test recommendations provided by the Texas AgriLife Extension Service Soil and Plant Testing Laboratory. At Corpus Christi, grain sorghum hybrids were planted on a flat seedbed while at the other locations hybrids were planted on a slightly raised seedbed. The grain sorghum hybrid planted at the Corpus Christi location was DK 53–67 at 135,800 seed/ha. Pioneer 85G01 was planted at Lubbock in 2008 and DK 44–20 was planted in 2009, each at 96,800 seed/ha. At Yoakum, Pioneer 85G50 was planted in 2008 and Pioneer 84G60 was planted in 2009, each at the rate of 197,600 seed/ha. Grain sorghum was planted on March 17, 2008 at

TABLE 1: Weed control at Lubbock and Yoakum as influenced by pyrasulfotole plus bromoxynil combinations in 2008, 4 weeks after MPOST applications.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Weed control ⁴		
			<i>A. palmeri</i>	<i>U. texana</i> %	<i>P. louisianica</i>
Untreated	—	—	0	0	0
Pyrasulfotole (P)	0.03				
+Bromoxynil (B)	0.20	EP	100	33	100
+Atrazine (A)	0.58				
P	0.04				
+B	0.24	EP	100	23	100
+A	0.58				
P	0.03				
+B	0.20	EP	100	33	100
+A	0.58				
+2, 4-D	0.27				
P	0.03				
+B	0.20	EP	100	33	100
+A	0.58				
+dicamba	0.13				
Atrazine	0.58	EP	98	20	100
P	0.03				
+B	0.20	MP	100	47	100
+A	0.58				
P	0.04				
+B	0.24	MP	100	50	100
+A	0.58				
P	0.03				
+B	0.20	MP	100	33	100
+A	0.58				
+2,4-D	0.27				
P	0.03				
+B	0.20	MP	100	55	100
+A	0.58				
+dicamba	0.13				
Atrazine	0.58	MP	100	30	100
P	0.03				
+B	0.18	EP + MP	100	45	100
+A	0.58				
P	0.03				
+B	0.21	EP			
+A	0.58		100	47	100
P	0.03	MP			
+B	0.18				

TABLE 1: Continued.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Weed control ⁴		
			<i>A. palmeri</i>	<i>U. texana</i> %	<i>P. louisianica</i>
P	0.04	EP	100	33	100
+B	0.26				
+A	0.58				
P	0.03	MP	100	50	100
+B	0.18				
P	0.03	EP	100	50	100
+B	0.26				
+A	0.58				
P	0.03	MP	100	50	100
+B	0.26				
LSD (0.05)			1	12	NS

¹At Yoakum, all herbicide treatments with the exception of the untreated check included S-metolachlor at 1.11 kg ai/ha applied preemergence. At both locations, all herbicide treatments with the exception of atrazine alone include ammonium sulfate at the rate of 3.9 kg/378 L.

²Agridex at 1.0% v/v added to all treatments at Yoakum while R-11at 0.25% was added to all treatments at Lubbock with the exception of the atrazine only treatments which included Agridex at 1.0% v/v.

³Abbreviations: EP (early postemergence), weeds 5 to 10 cm tall; MP (mid postemergence), weeds 10 to 20 cm tall; *A. palmeri*, *Amaranthus palmeri*, S. Wats; *P. louisianica*, *Prosochloa louisianica* (Mill.) Thellung; *U. texana*, *Urochloa texana* L.

⁴Weed rating scale: 0: no control; 100: complete control. *A. palmeri* was present at both locations while *U. texana* was present at Yoakum and *P. louisianica* was present at Lubbock. *A. palmeri* ratings were combined over locations due to a lack of interaction.

the Corpus Christi location, May 22, 2008, and May 21, 2009 at the Lubbock locations, and March 27, 2008 and April 2, 2009 at the Yoakum locations. Visual grain sorghum injury (chlorosis and stunting) due to POST herbicides was evaluated based on a scale of 0 (no chlorosis or stunting) to 100 (complete plant death). Visual weed control ratings were based on a similar scale with 0 (no control) to 100 (complete weed control). Chlorosis and stunting observations were recorded approximately 10 d after herbicide application while weed control ratings were taken approximately 4 weeks after MPOST applications. A final observation of herbicide stunting was taken prior to harvest.

All sites were maintained under rain-fed conditions with the exception of the Yoakum location in 2009 which received supplemental irrigation (50.8 mm) for the first 60 d after planting and the 2009 location near Lubbock which was planted under a center-pivot irrigation system and received 341 mm of irrigation during the growing season. Rainfall was below normal for both 2008 and 2009 with above normal temperatures at all locations [23]. Rainfall during the growing season was 145.5 mm at Yoakum in 2008 and 275.6 mm in 2009; at Corpus Christi in 2008, 160 mm was received; and at the Lubbock locations, 436.4 mm was received in 2008 and 393.7 mm in 2009.

2.2. Plot Harvest and Statistical Analysis. Crop yield was determined by harvesting plots with a small plot combine and crop weights were adjusted to 14% moisture. Data for grain sorghum chlorosis, stunting, and percentage of weed control were transformed to the arcsine square root prior to analysis; however, nontransformed means are presented because arcsine transformation did not affect interpretation of the data. Data were subjected to ANOVA and treatment

means were separated using Fisher's Protected LSD at $P < 0.05$. The untreated check was used for yield calculation comparison and a visual comparison for grain sorghum chlorosis and stunting and weed control and was only included in yield data analysis.

3. Results and Discussion

No attempt was made to combine data over years due to different treatments in both years. Data were not combined over locations, with the exception of *A. palmeri* data in 2008 and 2009, due to a treatment by location interaction for grain sorghum chlorosis, stunting, and yield.

3.1. Weed Control. Weed control was recorded approximately one month after MPOST applications. In 2008, control of *A. palmeri* and *P. louisianica* was 100% for all pyrasulfotole plus bromoxynil treatments (Table 1). This was as good as or better than atrazine alone applied EPOST, which controlled *A. palmeri* 98% and *P. louisianica* 100%. *U. texana* control was poor with all pyrasulfotole plus bromoxynil combinations and control was no greater than 55% at any rate or application timing while atrazine alone controlled *U. texana* 20 and 30% with EPOST and MPOST applications, respectively. The MPOST applications of pyrasulfotole plus bromoxynil combinations did provide slightly better control of *U. texana* than EPOST applications.

In 2009, all EPOST treatments of pyrasulfotole plus bromoxynil controlled *A. palmeri* 100% and atrazine plus bromoxynil also provided 100% control (Table 2). The MPOST applications of pyrasulfotole plus bromoxynil controlled *A. palmeri* at least 94% while atrazine plus bromoxynil applied MPOST provided 77% control. *Amaranthus* spp. are among

TABLE 2: Weed control at Lubbock and Yoakum as influenced by pyrasulfotole plus bromoxynil combinations in 2009, 4 weeks after MPOST applications.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Weed control ^{4,5}		
			<i>A. palmeri</i>	<i>U. texana</i> %	<i>C. melo</i>
Untreated	—	—	0	0	0
Pyrasulfotole (P)	0.03				
+Bromoxynil (B)	0.20	EP	100	64	100
+Atrazine (A)	0.58				
P	0.04				
+B	0.25	EP	100	66	100
+A	0.58				
P	0.03				
+B	0.20	EP	100	69	100
+A	0.58				
+2,4-D Amine	0.22				
P	0.03				
+B	0.20	EP	100	59	100
+A	0.58				
+dicamba	0.13				
Atrazine	0.58	EP	100	66	100
+bromoxynil	0.21				
P	0.03				
+B	0.20	MP	100	54	100
+A	0.58				
P	0.04				
+B	0.25	MP	94	43	100
+A	0.58				
P	0.03				
+B	0.20	MP	100	58	100
+A	0.58				
+2,4 Amine	0.22				
P	0.03				
+B	0.20	MP	100	38	100
+A	0.58				
+dicamba	0.13				
Atrazine	0.58	MP	77	69	100
+bromoxynil	0.21				
P	0.03				
+B	0.20	EP + MP	100	68	100
+A	0.58				
LSD (0.05)			13	18	NS

¹ All herbicide treatments with the exception of atrazine + bromoxynil included ammonium sulfate at the rate of 3.9 kg/378 L.

² Agridex at 1.0% v/v added to all treatments at Yoakum while R-11 at 0.25% was added to all treatments at Lubbock.

³ Abbreviations: EP (early postemergence), weeds 5 to 10 cm tall; MP (mid postemergence), weeds 10 to 20 cm tall. *A. palmeri*, *Amaranthus palmeri* S. Wats; *U. texana*, *Urochloa texana* (Buckl.) L.; *C. melo*, *Cucumis melo* L.

⁴ Rating scale (% weed control), 0: no control, 100: complete control.

⁵ All weeds present at Yoakum while *A. palmeri* was present at Lubbock. *A. palmeri* ratings combined over locations due to a lack of interaction.

the ten most common and ten most troublesome weeds in grain sorghum in 12 southern states including Puerto Rico [24]. In Texas, *Amaranthus* spp. ranks as the most common and troublesome weed in grain sorghum [24]. Moore and Murray [25] reported that grain sorghum yields decreased 97 kg/ha for each increase of one *A. palmeri* plant per 15 m of row and decreased 392 kg/ha for each increase of 1 kg of dry matter of the weed per 15 m of row. Shipley and Wiese [26] reported that one *Amaranthus* plant per 30 cm² of row in irrigated grain sorghum reduced grain yield approximately 48%. *U. texana* control with pyrasulfotole plus bromoxynil combinations or atrazine plus bromoxynil was no greater than 69% with any application timing (Table 2). *C. melo* control with pyrasulfotole plus bromoxynil or atrazine plus bromoxynil was 100% regardless of application timing.

3.2. Grain Sorghum Chlorosis. In 2008 at Corpus Christi, grain sorghum chlorosis was present with EPOST and EPOST plus MPOST applications of pyrasulfotole plus bromoxynil but not MPOST only applications (Table 3). All EPOST and EPOST plus MPOST applications of pyrasulfotole plus bromoxynil resulted in greater chlorosis than atrazine alone applied either EPOST or MPOST. The greatest chlorosis was noted with pyrasulfotole at 0.03 kg ai/ha plus bromoxynil at 0.26 kg ai/ha applied EPOST and MPOST (Table 3). At Yoakum, all pyrasulfotole plus bromoxynil combinations, with the exception of pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg ai/ha plus atrazine at 0.58 kg ai/ha applied EPOST or the four-way combination of pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg/ha plus atrazine at 0.58 kg/ha plus either dicamba or 2,4-DB applied MPOST resulted in chlorosis that was greater than atrazine alone. At Lubbock, all pyrasulfotole plus bromoxynil combinations resulted in greater chlorosis than atrazine alone applied EPOST (Table 3).

In 2009 at Yoakum, chlorosis was 5% or less with EPOST applications of pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg/ha plus atrazine at 0.58 kg/ha plus either 2,4-D or dicamba, and atrazine plus bromoxynil while only the MPOST application of pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg/ha plus atrazine at 0.58 kg/ha plus dicamba resulted in grain in grain sorghum chlorosis which was not different than the untreated check (Table 4). At Lubbock, all EPOST applications with the exception of pyrasulfotole at 0.04 kg ai/ha plus bromoxynil at 0.25 kg ai/ha plus atrazine at 0.58 kg/ha resulted in 5% or less chlorosis. All MPOST applications caused at least 12% chlorosis with less chlorosis with pyrasulfotole plus bromoxynil combinations that include either 2,4-D or dicamba (Table 4).

Other studies have noted crop chlorosis and injury with pyrasulfotole plus bromoxynil combinations. Thompson et al. [21] found that sorghum injury (they did not state the type of injury) ranged from 0 to 24% 5 to 9 days after herbicide application. They reported that the addition of 2,4-D amine or dicamba to pyrasulfotole plus bromoxynil combinations reduced sorghum injury 4 to 5% compared to pyrasulfotole plus bromoxynil treatment alone. However, Brandon and Bean [22] reported increased injury with

greater rates of pyrasulfotole plus bromoxynil or when atrazine or dicamba was added. Geier and Stahlman [19] noted that wheat chlorosis was generally greater with fall applications of pyrasulfotole plus bromoxynil compared to spring applied. However, this had no effect on wheat maturity or yield as pyrasulfotole plus bromoxynil-treated wheat matured one day earlier than nontreated wheat and the pyrasulfotole plus bromoxynil treated wheat yielded over 3000 kg/ha more than nontreated wheat.

3.3. Grain Sorghum Stunting. Grain sorghum stunting was evident early season; however, by the end of the growing season the grain sorghum had outgrown any early season injury and there were no noticeable differences (data not shown). In 2008, no noticeable stunting was noted at Corpus Christi (data not shown) while at Yoakum, pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg/ha plus atrazine at 0.58 kg/ha applied MPOST or pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.26 kg/ha plus atrazine at 0.58 kg/ha applied EPOST followed by pyrasulfotole plus bromoxynil applied MPOST resulted in stunting that was greater than 20% (Table 3). No other herbicide treatments resulted in stunting that was greater than the untreated check. At Lubbock, atrazine applied MPOST resulted in 4% grain sorghum stunting and only the pyrasulfotole plus bromoxynil treatment that included 2,4-D applied EPOST or MPOST resulted in grain sorghum stunting that was greater than atrazine.

In 2009 at Yoakum, stunting was greatest with pyrasulfotole plus bromoxynil treatment which included dicamba applied EPOST or two applications of pyrasulfotole plus bromoxynil plus atrazine applied EPOST plus MPOST (Table 4). At Lubbock, the greatest stunting was noted with pyrasulfotole plus bromoxynil plus atrazine plus 2,4-D applied EPOST and the two applications of pyrasulfotole plus bromoxynil plus atrazine applied EPOST and MPOST.

3.4. Grain Sorghum Yield. Due to dry conditions at Lubbock in 2008 and Yoakum in 2009 no attempt was made to harvest the grain sorghum and in 2008 at Yoakum, yields were extremely low due to the drought conditions [23]. In 2008 at Yoakum, pyrasulfotole plus bromoxynil plus atrazine plus 2,4-D applied MPOST and pyrasulfotole pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.26 kg/ha plus atrazine at 0.58 kg/ha applied EPOST followed by pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.26 kg/ha applied MPOST treatment resulted in grain sorghum yields that were lower than the untreated check while at Corpus Christi there were no differences in yields (Table 3). In 2009 near Lubbock, all herbicide treatments, with the exception of pyrasulfotole at 0.03 kg/ha plus bromoxynil at 0.2 kg/ha plus atrazine at 0.58 kg/ha plus 2,4-D at 0.22 kg/ha, increased grain sorghum yields over the untreated check (Table 4). The EPOST plus MPOST application of pyrasulfotole plus bromoxynil plus atrazine produced the greatest yield. Early season grain sorghum chlorosis and stunting did not have any effect on yield as the grain sorghum quickly recovered.

TABLE 3: Grain sorghum injury and yield as influenced by pyrasulfotole plus bromoxynil combinations in 2008.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Chlorosis ^{4,5}				Stunting		Yield Kg/ha	Corpus
			Corpus	Yoakum	Lubbock %	Yoakum	Yoakum	Lubbock		
Untreated	—	—	0	0	0	0	0	0	2072	3465
Pyrasulfotole (P)	0.03									
+Bromoxynil (B)	0.20	EP	13	3	6	3	3	0	2539	3385
+Atrazine (A)	0.58									
P	0.04									
+B	0.24	EP	13	8	7	3	3	0	2333	3253
+A	0.58									
P	0.03									
+B	0.20									
+A	0.58	EP	8	12	13	7	7	6	2268	3375
+2,4-D	0.27									
P	0.03									
+B	0.20									
+A	0.58	EP	8	10	7	3	3	2	2430	3266
+dicamba	0.13									
Atrazine	0.58	EP	0	0	0	0	0	0	2051	3521
P	0.03									
+B	0.20	MP	0	20	12	23	23	0	1639	3411
+A	0.58									
P	0.04									
+B	0.24	MP	0	20	13	10	10	0	1486	3582
+A	0.58									
P	0.03									
+B	0.20									
+A	0.58	MP	4	6	5	0	0	10	1344	3527
+2,4-D	0.27									
P	0.03									
+B	0.20									
+A	0.58	MP	0	5	5	0	0	0	1758	3134
+dicamba	0.13									
Atrazine	0.58	MP	0	0	8	0	0	4	1583	3267
P	0.03									
+B	0.18	EP + MP	8	17	15	3	3	0	2203	3493
+A	0.58									
P	0.03									
+B	0.21	EP	10	15	16	2	2	3	2430	3237
+A	0.58									
P	0.03									
+B	0.18	MP								

TABLE 3: Continued.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Corpus	Chlorosis ^{4,5} Yoakum	Lubbock %	Yoakum	Stunting Lubbock	Yoakum	Yield Kg/ha
P	0.04								
+B	0.26	EP							
+A	0.58		13	22	20	7	5	2137	3724
P	0.03	MP							
+B	0.18								
P	0.03								
+B	0.26	EP							
+A	0.58		25	25	20	23	0	1324	3668
P	0.03	MP							
+B	0.26								
LSD (0.05)			5	7	4	10	2	678	NS

¹At Corpus Christi and Yoakum, all herbicide treatments with the exception of the untreated check included S-metolachlor at 1.11 kg ai/ha applied preemergence. Also, all treatments with the exception of atrazine alone include ammonium sulfate at the rate of 3.9 kg/378 L.

²Agrindex at 1.0% v/v added to all treatments at Corpus and Yoakum while R-11 at 0.25% was added to all treatments at Lubbock with the exception of the atrazine only treatments which included Agrindex at 1.0% v/v.

³Abbreviations: EP (early postemergence), grain sorghum 5 to 10 cm tall; MP (mid postemergence), grain sorghum 30 to 41 cm tall.

⁴Rating scale: 0: crop injury; 100: crop death.

⁵Chlorosis and stunting ratings taken 10 days after herbicide application.

TABLE 4: Grain sorghum response and yield as influenced by pyrasulfotole plus bromoxynil combinations in 2009.

Herbicide ^{1,2}	Dose Kg ai/ha	Timing ³	Chlorosis ⁴		Stunting	Yield	
			Yoakum	Lubbock	%	Yoakum	Lubbock
Untreated	—	—	0	0	0	0	0
Pyrasulfotole (P)	0.03						5312
+Bromoxynil (B)	0.20	EP	8	5		8	7
+Atrazine (A)	0.58						7963
P	0.04						
+B	0.25	EP	10	9		9	7
+A	0.58						7389
P	0.03						
+B	0.20						
+A	0.58	EP	4	2		2	27
+2,4-D Amine	0.22						7547
P	0.03						
+B	0.20						
+A	0.58	EP	5	4		18	7
+dicamba	0.13						7896
Atrazine	0.58						
+bromoxynil	0.21	EP	2	2		3	1
P	0.03						8058
+B	0.20	MP	9	27		7	10
+A	0.58						8093
P	0.04						
+B	0.25	MP	12	30		8	13
+A	0.58						7928
P	0.03						
+B	0.20	MP	8	14		6	2
+A	0.58						6816
+2,4 Amine	0.22						
P	0.03						
+B	0.20						
+A	0.58	MP	5	12		9	5
+dicamba	0.13						7165
Atrazine	0.58						
+bromoxynil	0.21	MP	15	17		1	10
P	0.03						7135
+B	0.20						
+A	0.58	EP + MP	19	38		19	20
+dicamba	0.13						8588
LSD (0.05)			7	4		9	6
							1709

¹ All herbicide treatments with the exception of atrazine + bromoxynil included ammonium sulfate at the rate of 3.9 kg/378 L.² Agridex at 1.0% v/v added to all treatments at Yoakum while R-11 at 0.25% was added to all treatments at Lubbock.³ Abbreviations: EP (early postemergence), grain sorghum 5 to 10 cm tall; MP (mid postemergence), grain sorghum 30 to 41 cm tall.⁴ Rating scale, 0: no chlorosis or stunting, 100: plant death. Chlorosis and stunting ratings taken 10 days after herbicide application.

4. Conclusions

The results of these studies indicate that grain sorghum has adequate tolerance to pyrasulfotole plus bromoxynil combinations and although grain sorghum chlorosis and stunting was evident early in the growing season, the grain sorghum quickly grew out of it and this did not result in yield reductions. Excellent control of several problem weeds is an indication of the enhanced value this herbicide combination can bring to a weed control program in grain sorghum. Thorsness et al. [18] also noted that pyrasulfotole plus bromoxynil inhibited second flushes of select weeds including *A. retroflexus* L., *Kochia scoparia* L., and *Chenopodium album* L. Also, since pyrasulfotole plus bromoxynil has an excellent crop rotation profile, this makes it an attractive herbicide to use in grain sorghum.

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