

Pyrithiobac Combinations Control Red Morningglory (*Ipomoea coccinea*) and Devil's-claw (*Proboscidea louisianica*) in Non-Transgenic Cotton (*Gossypium hirsutum*)

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ABSTRACT

Standard and reduced rates of pyrithiobac, prometryn, and diuron applied preemergence (PRE) alone and in combination and followed by pyrithiobac POST were evaluated for red morningglory and devil's-claw control in non-transgenic cotton. Preemergence applications of prometryn or diuron controlled red morningglory no more than 27% and devil's-claw no more than 47%. Preemergence combinations of prometryn or diuron plus pyrithiobac controlled red morningglory and devil's-claw as much as 75%. Prometryn or diuron plus pyrithiobac followed by pyrithiobac postemergence (POST) controlled red morningglory 88 to 91% and devil's-claw 81 to 100%. Red morningglory control was similar with reduced rates (0.8 lb ai/A) of prometryn or diuron plus pyrithiobac PRE followed by a reduced rate (0.047 lb ai/A) of pyrithiobac POST. Cotton yields were greatest when PRE combinations were followed by pyrithiobac POST.

KEYWORDS: cotton 'Paymaster HS-26', devil's-claw, diuron, *Gossypium hirsutum* L., preemergence herbicide combinations, *Proboscidea louisianica* (Mill.) Thellung, prometryn, pyrithiobac, red morningglory, weed management

INTRODUCTION

Morningglory (*Ipomoea* spp.) infests approximately 1,000,000 acres of Texas cotton and may cause complete crop loss at populations of one or more plants per 6 feet of row (Keeley et al. 1986). Savoy et al. (1993) reported that no single herbicide treatment provided season-long morningglory control in cotton. In addition, herbicides

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applied preplant incorporated (PPI) did not control morningglory (Holshouser and Chandler 1988, Savoy et al. 1993) and PRE herbicides only provided early-season control or suppression (Smith and Chandler 1991). Applications of MSMA plus methazole, fluometuron, or cyanazine applied postemergence-directed (PDIR) following a soil-applied herbicide program has effectively controlled most morningglories (Savoy et al. 1993, Thullen and Keeley 1994, Wilcut et al. 1997); however, methazole and cyanazine are not currently registered for use in cotton and fluometuron has a history of cotton injury on lighter soils. In addition, Wilcut et al. (1996) reported that producers prefer to make POST applications instead of PDIR applications in small cotton.

Devil's-claw is a problem weed in Southwestern cotton production (Dowler 1992). Lack of devil's-claw control resulted in stripper harvest complications and reduced lint yield by 74% when populations reached 1 plant per foot of row (Mercer et al. 1987). Herbicides applied PRE in cotton have limited activity on devil's-claw, and POST herbicides lose effectiveness once this weed reaches 4 inches in height (Smith et al. 1973). Although there are PDIR herbicides available that effectively control many difficult to control broadleaf weeds in cotton (Buchanan 1992), often the necessary height differential between the crop and weed is difficult to establish.

Pyrithiobac has POST activity on devil's-claw (Prostko and Chandler 1998) and morningglory spp. (Keeling et al. 1993a, Jordan et al. 1993), but control has been inconsistent on the Texas Southern High Plains (Light et al. 1999). Developing a weed-control strategy that provides consistent control of these weed species would be of considerable benefit to cotton producers in the Texas Southern High Plains. Therefore, research was conducted to evaluate standard and reduced rates of pyrithiobac, prometryn, and diuron applied PRE alone and in combination and followed by pyrithiobac POST for red morningglory and devil's-claw control in non-transgenic cotton.

MATERIALS AND METHODS

Field experiments were conducted in 1997 and 1998 on the Texas Agricultural Experiment Station near Lubbock, TX and on private land near Hart, TX. Soils at Lubbock and Hart were an Acuff sandy clay loam (fine-loamy, mixed, superactive, thermic Aridic Paleustolls) with 0.8% organic matter and a pH of 7.8 and a Pullman clay loam (fine, mixed, superactive, thermic, Torrtic Paleustolls) with 1.5 % organic matter and a pH of 7.5, respectively. The Lubbock site contained natural infestations of devil's-claw estimated 60 days after planting (DAP) at 2 plants/ft² in non-treated control plots, while the Hart location contained natural infestations of red morningglory estimated 60 DAP at 6 plants/ft² in the non-treated control plots. Trifluralin at 0.8 lb ai/A was applied preplant and incorporated over all test areas to control annual grasses and Palmer amaranth (*Amaranthus palmeri* S. Wats.). Cotton, Paymaster HS-26, was planted in 40-inch rows at a seeding rate of 12 lb/A at each location in 1997 and 1998. Planting dates near Lubbock were May 8, 1997 and May 7, 1998 and May 15, 1997 and May 4, 1998 near Hart. Traditional production practices were implemented at each location.

Herbicide treatments were applied to plots 4 rows by 30 feet in length using a tractor-mounted, compressed-air sprayer equipped with Teejet¹ 80015VS flat-fan nozzles calibrated to deliver 10 gallons per acre. Prometryn at 0.8 and 1.2 lb ai/A (reduced and standard rates, respectively), diuron at 0.8 or 1.2 lb ai/A (reduced and standard rates,

¹Spraying Systems Co., North Avenue and Schmale Road, Wheaton, IL 60188.

respectively), and pyriithiobac at 0.032, 0.047, and 0.063 lb ai/A (reduced and standard rates) were applied PRE alone. Tank-mix combinations of prometryn at 0.8 or 1.2 lb ai/A or diuron at 0.8 or 1.2 lb ai/A plus pyriithiobac at 0.032 or 0.047 lb ai/A also were applied PRE. Tank-mix combinations of prometryn or diuron (0.8 or 1.2 lb ai/A) plus pyriithiobac at 0.032 lb ai/A were applied PRE and followed by pyriithiobac applied POST at 0.047 or 0.063 lb ai/A. Pyriithiobac applied PRE alone at 0.032 lb ai/A was also followed by pyriithiobac POST at either 0.047 or 0.063 lb ai/A. All POST pyriithiobac treatments included crop oil concentrate² at 1% (v/v). Pyriithiobac was applied POST to 1 to 3-leaf devil's-claw (1 to 4 inches in height) or to 1 to 3-leaf red morningglory (2 to 4 inches in height). Cotton size at the POST application was 2 to 3-leaf (3 to 5 inches in height). Rainfall totaled approximately 20 inches in 1997 and 13 inches in 1998 at both locations. Due to the more adequate rainfall in 1997, no supplemental irrigation was applied at either location that year. However, each experiment was furrow irrigated in May, June, and July 1998 totaling approximately 12 inches.

The experimental design was a randomized complete block with three replications. Weed control and crop injury were estimated visually on a scale of 0 to 100% (where 0 = no control or injury and 100 = complete control or cotton death). Weed control was estimated 41 and 73 days after planting (equivalent to 2 and 7 weeks after POST treatments) at both locations. Crop injury (stunting and chlorosis) was estimated at 14 and 30 days after POST applications. Yields were obtained by hand-harvesting 2 rows by 13 feet in length within the center of each plot. Harvested samples were ginned and lint yield determined. Percentage data were subjected to arcsine square root transformation before performing analysis of variance. Non-transformed data are presented in the tables based on the analyses of transformed data for weed control. Data were not combined over years because treatment by year interactions occurred for both red morningglory and devil's-claw. Means were separated using Fisher's Protected LSD test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Red Morningglory Control. In 1997, cool and wet soil conditions increased the soil activity of PRE herbicides and perhaps the residual activity of pyriithiobac POST compared to 1998. However, individual treatments of prometryn, diuron, or pyriithiobac applied PRE still did not effectively control red morningglory (30 to 62%) early-season (41 DAP) in 1997 (Table 1). Combinations of prometryn plus pyriithiobac were more effective at controlling red morningglory than most combinations of pyriithiobac plus diuron. Prometryn plus pyriithiobac (regardless of rates) controlled red morningglory 83 to 87%, in contrast to 62 to 67% control from preemergence combinations of diuron plus pyriithiobac at 0.032 lb ai/A. Excellent red morningglory control (92 to 98%) was observed when PRE combinations (prometryn or diuron plus pyriithiobac) were followed by pyriithiobac POST.

²Agri-Dex, 83% paraffin based petroleum oil with 17% polyol fatty acid esters and polyethoxylated derivatives thereof. Helena Chemical Co., 6075 Poplar Ave., Suite 500, Memphis, TN 38119.

Table 1. Effects of prometryn, diuron, and pyriithiobac on red morningglory control in cotton near Hart, TX, 1997 and 1998.

Treatment ^a	Application		Days after planting			
	Rate	Timing ^b	1997		1998	
			41	73	41	73
	- lb ai/A-		-----%-----			
Prometryn	0.8	PRE	37	8	29	2
Prometryn	1.2	PRE	52	27	38	5
Diuron	0.8	PRE	30	10	34	5
Diuron	1.2	PRE	32	10	38	5
Pyrithiobac (pyr)	0.032	PRE	45	29	34	17
Pyrithiobac	0.047	PRE	58	40	38	18
Pyrithiobac	0.063	PRE	62	48	47	2.5
Prometryn + pyr	0.8+0.032	PRE	83	62	49	28
Prometryn + pyr	0.8+0.047	PRE	83	75	57	38
Prometryn + pyr	1.2+0.032	PRE	85	64	57	41
Prometryn + pyr	1.2+0.047	PRE	87	73	61	47
Diuron + pyr	0.8+0.032	PRE	67	50	42	20
Diuron + pyr	0.8+0.047	PRE	78	66	49	30
Diuron + pyr	1.2+0.032	PRE	62	42	44	23
Diuron + pyr	1.2+0.047	PRE	80	63	47	42
Pyr fb pyr	0.032 fb 0.047	PRE fb POST	86	80	98	84
Pyr fb pyr	0.032 fb 0.063	PRE fb POST	92	88	98	85
Prometryn + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	92	85	100	90
Prometryn + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	93	85	99	89
Prometryn + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	96	90	99	89
Prometryn + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	98	88	100	91
Diuron + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	98	90	97	87
Diuron + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	96	91	100	88
Diuron + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	97	90	98	88
Diuron + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	98	89	99	89
LSD (0.05)			8	10	8	8

^aAbbreviations: fb, followed by; POST, postemergence; PRE, preemergence; Pyr, Pyriithiobac.

^bAll POST pyriithiobac treatments included crop oil concentrate at 1% (v/v).

Overall, late-season (73 DAP) red morningglory control was greater from preemergence combinations that included the higher rate of pyriithiobac (0.047 lb ai/A) compared to combinations that included the lower rate. Pyriithiobac combinations with prometryn were generally more effective than pyriithiobac combinations with diuron. Red morningglory was controlled 73 to 75% by combinations of prometryn plus pyriithiobac at 0.047 lb ai/A. Less control (62 to 64%) was observed from prometryn plus the reduced rate of pyriithiobac (0.032 lb ai/A), which was similar to control from diuron plus the full rate of pyriithiobac (63 to 66%). Pyriithiobac PRE followed by pyriithiobac POST at 0.063 lb ai/A controlled red morningglory 88%, which was greater than any PRE combination alone. Red morningglory control from PRE combinations followed by pyriithiobac POST was similar (85 to 91%) to pyriithiobac PRE followed by pyriithiobac POST.

In 1998, PRE treatments of prometryn, diuron, or pyriithiobac applied individually did not provide effective early-season red morningglory control (29 to 47%) 41 DAP. Preemergence combinations of diuron plus pyriithiobac were similar to pyriithiobac applied PRE alone at 0.063 lb ai/A. Increased red morningglory control (57

to 61%) was observed from PRE combinations of prometryn and pyrithiobac (when either was applied at their higher rate) compared to other PRE treatments.

In contrast to 1997, no PRE treatment controlled red morningglory greater than 47% at 73 DAP. However, all PRE treatments followed by pyrithiobac POST controlled red morningglory at least 84% in 1998.

Devil's-claw Control. Prometryn, diuron, or pyrithiobac (0.032 and 0.047 lb ai/A) PRE did not effectively control devil's-claw (37 to 60%) early-season in 1997 (Table 2). Increasing the rate of pyrithiobac to 0.063 lb ai/A increased devil's-claw control to 70% 41 DAP. Similar control (63 to 77%) was observed from PRE combinations of prometryn or diuron plus pyrithiobac. All PRE treatments followed by pyrithiobac POST (regardless of rate) increased devil's-claw control $\geq$ 99% 41 DAP (2 weeks after the pyrithiobac POST treatment).

Table 2. Effects of prometryn, diuron, and pyrithiobac on devil's-claw control in cotton near Lubbock, TX, 1997 and 1998.

Treatment ^a	Application		Days after planting			
	Rate	Timing ^b	1997		1998	
			41	73	41	73
	- lb ai/A-		-----%-----			
Prometryn	0.8	PRE	37	18	5	0
Prometryn	1.2	PRE	43	26	16	0
Diuron	0.8	PRE	55	47	33	0
Diuron	1.2	PRE	50	43	38	0
Pyrithiobac (pyr)	0.032	PRE	45	24	24	0
Pyrithiobac	0.047	PRE	60	55	27	0
Pyrithiobac	0.063	PRE	70	64	35	0
Prometryn + pyr	0.8+0.032	PRE	73	55	53	18
Prometryn + pyr	0.8+0.047	PRE	77	70	47	20
Prometryn + pyr	1.2+0.032	PRE	70	54	51	17
Prometryn + pyr	1.2+0.047	PRE	75	75	62	25
Diuron + pyr	0.8+0.032	PRE	63	53	53	12
Diuron + pyr	0.8+0.047	PRE	67	64	54	17
Diuron + pyr	1.2+0.032	PRE	63	56	56	15
Diuron + pyr	1.2+0.047	PRE	76	70	54	25
Pyr fb pyr	0.032 fb 0.047	PRE fb POST	100	99	96	63
Pyr fb pyr	0.032 fb 0.063	PRE fb POST	100	98	97	82
Prometryn + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	100	97	96	75
Prometryn + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	99	97	97	77
Prometryn + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	99	96	97	81
Prometryn + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	100	100	97	84
Diuron + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	99	96	98	80
Diuron + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	100	99	97	80
Diuron + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	100	100	99	82
Diuron + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	100	100	98	83
LSD (0.05)			6	9	9	5

^aAbbreviations: fb, followed by; POST, postemergence; PRE, preemergence; Pyr, Pyrithiobac.

^bAll POST pyrithiobac treatments included crop oil concentrate at 1% (v/v).

Pyrithiobac PRE applied at 0.47 or 0.63 lb ai/A controlled devil's-claw more effectively than prometryn or diuron 73 DAP. Preemergence combinations including pyrithiobac at 0.047 lb ai/A or greater controlled devil's-claw 67 to 77%, while all other

PRE combinations controlled devil's-claw $\leq 56\%$. Both the standard (0.063 lb ai/A) and reduced (0.047 lb ai/A) rates of pyrithiobac POST following any PRE treatment maintained effective devil's-claw control (96 to 100%) 73 DAP.

In 1998, individual PRE treatments did not control devil's-claw ($\leq 38\%$) 41 DAP. Early-season devil's-claw control improved to 47 to 62% when either prometryn or diuron was combined with pyrithiobac applied PRE. Preemergence combinations followed by pyrithiobac POST controlled devil's-claw 96 to 98% 41 DAP (2 weeks after the pyrithiobac POST treatment). By 73 DAP, no individual PRE treatment or PRE combination provided more than 25% devil's-claw control in 1998. However, any PRE combination followed by pyrithiobac POST (regardless of rate) controlled devil's-claw 75 to 84%.

Cotton Response. Although some reports suggest pyrithiobac can cause a transient chlorosis ("yellow flash") 5 to 7 d after POST applications (Keeling et al. 1993b), no cotton injury was observed following any individual PRE treatment, PRE combination, or sequential PRE/POST treatment in 1997 or 1998 (data not shown). Dotray et al. (1996) reported similar results.

Red morningglory site: Overall lint yields in 1997 were reduced due to damaging hail 14 d after cotton emergence. No lint was produced from plots that received a single PRE treatment of prometryn, diuron, or pyrithiobac (at 0.032 lb ai/A) due to severe weed pressure and subsequent competition (Table 3). However, plots that received pyrithiobac PRE at 0.047 or 0.063 lb ai/A produced 85 to 92 lb lint/A. Plots treated with PRE combinations of prometryn or diuron plus pyrithiobac or pyrithiobac PRE followed by pyrithiobac POST increased lint yields 16 to 170 lb/A compared to pyrithiobac alone at 0.063 lb ai/A. Combinations of prometryn or diuron plus pyrithiobac PRE followed by pyrithiobac POST increased lint yields 65 to 254 lb/A compared to PRE combinations alone.

Similar to findings by Patterson et al. (1991), higher cotton yields were associated with POST applications of pyrithiobac in 1998. Pyrithiobac PRE followed by pyrithiobac POST increased yields 99 to 221 lb/A compared to PRE combinations of prometryn or diuron plus pyrithiobac. The greatest lint yields recorded at Hart in 1998 (749 to 816 lb/A) were produced in plots treated with PRE combinations of prometryn or diuron plus pyrithiobac followed by pyrithiobac POST.

Devil's-claw site in Lubbock: Despite increased rainfall at Lubbock in 1997, below average heat-unit accumulation³ (699 fewer heat units in 1997 compared to 1998) resulted in reduced yields. No yield differences were recorded in 1997 between plots that received prometryn, diuron, or pyrithiobac applied PRE alone. Rate-dependent yield increases were recorded from PRE combinations of prometryn or diuron plus pyrithiobac compared to prometryn, diuron, or pyrithiobac alone. Preemergence treatments followed by pyrithiobac POST yielded 455 to 578 lb lint/A, which was equal to or greater than yields produced from plots which received only a PRE treatment.

In 1998, no lint was harvested from plots treated only with prometryn or diuron PRE. Pyrithiobac PRE alone produced 100 to 158 lb lint/A. Lint yields were increased 72 to 193 lb/A with the addition of prometryn or diuron to pyrithiobac PRE compared to

³Heat units obtained at <http://achilleus.tamu.edu/data/weather/weather.html> from Texas Agricultural Experiment Station, Soil Physics Department, Lubbock, TX.

pyrithiobac PRE alone. When PRE combinations of prometryn or diuron plus pyrithiobac were followed by pyrithiobac POST, lint yields increased 150 to 396 lb/A compared to sequential PRE/POST applications of pyrithiobac.

Table 3. Cotton lint yields from prometryn, diuron, and pyrithiobac treatments near Hart and Lubbock, TX, 1997 and 1998.

Treatment ^a	Application		Hart		Lubbock	
	Rate	Timing ^b	1997	1998	1997	1998
	- lb ai/A-		-----lb lint/A-----			
Prometryn	0.8	PRE	0	142	281	0
Prometryn	1.2	PRE	0	231	289	0
Diuron	0.8	PRE	0	136	264	0
Diuron	1.2	PRE	0	224	287	0
Pyrithiobac (pyr)	0.032	PRE	0	241	264	100
Pyrithiobac	0.047	PRE	85	301	290	124
Pyrithiobac	0.063	PRE	92	275	301	158
Prometryn + pyr	0.8+0.032	PRE	109	297	396	293
Prometryn + pyr	0.8+0.047	PRE	237	355	429	286
Prometryn + pyr	1.2+0.032	PRE	137	331	392	253
Prometryn + pyr	1.2+0.047	PRE	252	358	435	246
Diuron + pyr	0.8+0.032	PRE	108	272	411	243
Diuron + pyr	0.8+0.047	PRE	138	317	489	230
Diuron + pyr	1.2+0.032	PRE	150	321	337	239
Diuron + pyr	1.2+0.047	PRE fb POST	255	369	426	275
Pyr fb pyr	0.032 fb 0.047	PRE fb POST	230	468	455	356
Pyr fb pyr	0.032 fb 0.063	PRE fb POST	211	493	559	435
Prometryn + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	362	749	458	585
Prometryn + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	356	787	470	594
Prometryn + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	340	797	577	612
Prometryn + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	324	796	578	591
Diuron + pyr fb pyr	0.8+0.032 fb 0.047	PRE fb POST	320	788	489	692
Diuron + pyr fb pyr	0.8+0.032 fb 0.063	PRE fb POST	342	709	524	620
Diuron + pyr fb pyr	1.2+0.032 fb 0.047	PRE fb POST	356	806	568	608
Diuron + pyr fb pyr	1.2+0.032 fb 0.063	PRE fb POST	346	816	565	752
LSD (0.05)			71	99	153	106

^aAbbreviations: fb, followed by; POST, postemergence; PRE, preemergence; Pyr, Pyrithiobac.

^bAll POST pyrithiobac treatments included crop oil concentrate at 1% (v/v).

This research suggests that PRE combinations of prometryn or diuron plus pyrithiobac followed by pyrithiobac POST can effectively control red morningglory and devil's-claw in non-transgenic cotton. Reduced rates of prometryn or diuron plus pyrithiobac followed by reduced rates of pyrithiobac POST controlled red morningglory as effectively as standard rates. Although PRE combinations of pyrithiobac with either prometryn or diuron increased control of red morningglory and devil's-claw compared to standard rates of prometryn or diuron alone, this control was still unacceptable by most standards. Effective, season-long control of red morningglory and devil's-claw was achieved when PRE treatments were followed by pyrithiobac POST.

REFERENCES

- Buchanan, G. A. 1992. Trends in weed control methods. In C. G. McWhorter and J. R. Abernathy, eds. Weeds of Cotton: Characterization and Control. Memphis, TN. The Cotton Foundation: pp. 47-72.
- Dotray, P. A., J. W. Keeling, C. G. Henniger, and J. R. Abernathy. 1996. Palmer amaranth (*Amaranthus palmeri*) and devil's-claw (*Proboscidea louisianica*) control in cotton (*Gossypium hirsutum*) with pyrithiobac. Weed Technol. 10:7-12.
- Dowler, C. C. 1992. Weed survey - Southern states: Broadleaf crops subsection. Proc. South. Weed Sci. Soc. 45:392-407.
- Holshouser, D. L. and J. M. Chandler. 1988. Management systems for morningglories in cotton. Proc. South. Weed Sci. Soc. 41:87.
- Jordan, D. L., R. E. Frans, and M. R. McClelland. 1993. Total postemergence herbicide programs in cotton (*Gossypium hirsutum*) with sethoxydim and DPX-PE350. Weed Technol. 7:196-201.
- Keeley, P. E., R. J. Thullen, and C. H. Carter. 1986. Influence of planting date on growth of ivyleaf morningglory (*Ipomoea hederacea*) in cotton (*Gossypium hirsutum*). Weed Sci. 34:906-910.
- Keeling, J. W., C. G. Henniger, and J. R. Abernathy. 1993a. Broadleaf weed control in cotton with DPX-PE350. In D. J. Herber and D. A. Richter, eds. Proceedings Beltwide Cotton Conference. Memphis, TN. National Cotton Council of America. p. 1529.
- Keeling, J. W., C. G. Henniger, and J. R. Abernathy. 1993b. Effects of DPX PE350 on cotton (*Gossypium hirsutum*) growth, yield, and fiber quality. Weed Technol. 7:930-933.
- Light, G. G., P. A. Dotray, and J. R. Mahan. 1999. Thermal dependence of pyrithiobac efficacy in *Amaranthus palmeri*. Weed Sci. 47:644-650.
- Mercer, K. L., D. S. Murray, and L. M. Verhalen. 1987. Interference of unicorn-plant (*Proboscidea louisianica*) with cotton (*Gossypium hirsutum*). Weed Sci. 35:807-812.
- Patterson, M. G., B. E. Norris, Jr., and J. W. Everest. 1991. Evaluation of DPX-PE350 for weed control in cotton. Proc. South. Weed Sci. Soc. 44:76.
- Prostko, E. P. and J. M. Chandler. 1998. Devil's-claw (*Proboscidea louisianica*) and smelldelon (*Cucumis melo* var. *dudaim*) control in cotton (*Gossypium hirsutum*) with pyrithiobac. Weed Technol. 12:19-22.
- Savoy, B. R., D. L. Holshouser, K. L. Smith, and J. M. Chandler. 1993. A system for morningglory (*Ipomoea* spp.) control in cotton (*Gossypium hirsutum* L.). Weed Technol. 7:615-618.
- Smith, D. T., R. C. Berner, and A. W. Cooley. 1973. Devil's-claw - Herbicidal Control. College Station, TX: Texas Agricultural Experiment Station Prog. Rep. 3202.
- Smith, K. L. and J. M. Chandler. 1991. Effectiveness of norflurazon and prometryn combinations for preemergence control of annual morningglory. In D. J. Herber and D. A. Richter, eds. Proceedings Beltwide Cotton Conferences. Memphis, TN: National Cotton Council of America. p. 964.

- Thullen, R. J. and P. E. Keeley. 1994. Control of ivyleaf morningglory (*Ipomoea hederacea*) in cotton (*Gossypium hirsutum*) by combinations of methods. *Weed Technol.* 8:772-776.
- Wilcut, J. W., H. D. Coble, A. C. York, and D. W. Monks. 1996. The niche for herbicide-resistant crops in U.S. agriculture. In S. O. Duke, ed. *Herbicide-Resistant Crops: Agricultural, Environmental, Economic, Regulatory, and Technical Aspects*. Boca Raton, FL: CRC Press. p. 213-230.
- Wilcut, J. W., D. L. Jordan, W. K. Vencill, and J. S. Richburg, III. 1997. Weed management in cotton (*Gossypium hirsutum*) with soil-applied and post-directed herbicides. *Weed Technol.* 11:221-226.