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WEED SCIENCE

Pyrithiobac and Bromoxynil Combinations with MSMA for Improved Weed Control in Bromoxynil-Resistant Cotton

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INTERPRETIVE SUMMARY

Pyrithiobac (Staple herbicide) and bromoxynil (Buctril herbicide) were registered for weed control in cotton in the mid-1990s. Pyrithiobac can be applied pre-emergence or post-emergence to any variety of cotton, whereas bromoxynil can be applied post-emergence only to bromoxynil-resistant cotton. Both herbicides are options for post-emergence control of several troublesome broadleaf weeds in Georgia and Florida cotton.

Bromoxynil and pyrithiobac do not control sicklepod, a common weed in cotton in Georgia and Florida. Prickly sida must be small (three or fewer leaves) for effective control. Sicklepod control can be improved by post-emergence-directed application of MSMA, but successful post-emergence-directed herbicide application requires a height differential between the cotton and the weeds, and this is often difficult to obtain with sicklepod.

Experiments were conducted in Georgia and Florida to determine whether control of sicklepod by bromoxynil or pyrithiobac could be increased by mixing these herbicides with MSMA at rates suitable for overtop application, and to determine whether control by these mixtures would be adequate for cotton.

MSMA at 0.5 to 0.75 lb a.i. acre^{-1} mixed with bromoxynil or pyrithiobac increased control of sicklepod and yellow and purple nutsedge compared with bromoxynil or pyrithiobac applied alone and did not adversely affect cotton yield. Sicklepod control often was as good with MSMA alone as with the combinations. However, MSMA alone has a more limited spectrum of control than the combinations.

ABSTRACT

Field studies were conducted to determine the tolerance of bromoxynil (3,5-dibromo-4-hydroxybenzonitrile)-resistant cotton (*Gossypium hirsutum* L. 'BXN 57') and weed control with pyrithiobac {2-chloro-6-[(4,6-dimethoxy-2-pyrimidinyl)thio]benzoic acid}, bromoxynil, pyrithiobac plus MSMA (monosodium methylarsonate), and bromoxynil plus MSMA applied post-emergence to one- to three-leaf cotton. MSMA at 0.6 to 0.8 kg a.i. ha^{-1} added to pyrithiobac at 70 g a.i. ha^{-1} or bromoxynil at 0.6 kg a.i. ha^{-1} increased control of sicklepod [*Senna obtusifolia* (L.) H. S. Irwin & Barneby], yellow nutsedge (*Cyperus esculentus* L.), and purple nutsedge (*Cyperus rotundus* L.) compared with pyrithiobac or bromoxynil applied alone without adversely affecting cotton yield. MSMA did not improve prickly sida (*Sida spinosa* L.) control by pyrithiobac or bromoxynil.

Cotton plantings in Georgia and Florida have doubled since 1994 (Dowler, 1995; Webster, 1998; NASS, 2001). The success of the boll weevil (*Anthonomus grandis* Boheman) eradication program and the reduced economic viability of alternative crops have increased interest in cotton.

Weed control, especially during the early stages of cotton development, is essential. Cotton typically emerges and grows very slowly during the first 2 to 4 wk after planting. Hence the crop is vulnerable to early-season weed competition (Buchanan and Burns, 1971).

Cotton weed control systems historically have relied on a number of tactics, including use of preplant incorporated herbicides such as pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] or trifluralin [2,6-dinitro-*N*,*N*-

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dipropyl-4-(trifluoromethyl)benzenamine] for control of annual grasses and small-seeded broadleaf weeds, and pre-emergence herbicides such as fluometuron {*N*,*N*-dimethyl-*N'*-[3-(trifluoromethyl)phenyl]urea}, norflurazon {4-chloro-5-(methylamino)-2-[3-(trifluoromethyl)phenyl]-3(2*H*)-pyridazinone}, or prometryn [*N*,*N'*-bis(1-methylethyl)-6-(methylthio)-1,3,5-triazine-2,4-diamine] for control of broadleaf weeds (Wilcut et al., 1995). Prior to registration of pyrithiobac and bromoxynil, no herbicides were available that could safely be applied post-emergence to cotton to control broadleaf weeds escaping soil-applied herbicides. Most cotton-producing states have special registrations allowing post-emergence application of reduced rates of MSMA or DSMA (disodium methylarsonate), but MSMA or DSMA applied in this manner can delay cotton maturity and reduce yield (Monks et al., 1999). Fluometuron is registered for post-emergence application to cotton, but it also can delay maturity and reduce yield (Snipes and Byrd, 1994). Hence weed control efforts after crop emergence shifted to cultivation and use of post-emergence-directed sprays (Buchanan, 1992; Wilcut et al., 1995).

Pyrithiobac, a pyrimidinyl thiobenzoate herbicide that inhibits acetolactate synthase, was registered in 1996 for pre-emergence and post-emergence application to cotton (Hatzios, 1998). Applied post-emergence, pyrithiobac controls several broadleaf weeds common to U.S. cotton with minimal crop response (Jordan et al., 1993a,c; Culpepper and York, 1997). Pyrithiobac applied post-emergence controls pigweed species (*Amaranthus* spp.), morning-glory species (*Ipomoea* spp.), velvetleaf (*Abutilon theophrasti* Medik.), hemp sesbania [*Sesbania exaltata* (Raf.) Rydb. ex A.W. Hill], and common cocklebur (*Xanthium strumarium* L.).

Bromoxynil is registered for post-emergence application to bromoxynil-resistant cotton. Tolerance of bromoxynil-resistant cotton to bromoxynil applied post-emergence is excellent (Culpepper and York, 1997; Paulsgrove and Wilcut, 1999). Bromoxynil controls numerous broadleaf weed species (Jordan et al., 1993d; Culpepper and York, 1997; Treadaway et al., 1997; Paulsgrove and Wilcut, 1999).

Pyrithiobac and bromoxynil are important options for post-emergence broadleaf weed control in cotton. However, sicklepod is not controlled by pyrithiobac (Jordan et al., 1993c; Monks et al., 1999) or bromoxynil (Jordan et al., 1993d; Paulsgrove and Wilcut, 1999). Bromoxynil and pyrithiobac must be applied post-emergence to small prickly sida (three-leaf or less) for effective control (Culpepper and York, 1997). Otherwise, delaying the time of application results in decreased prickly sida control for both herbicides (Jordan et al., 1993b; Paulsgrove and Wilcut, 1999).

Sicklepod consistently ranks among the two most troublesome weeds in Georgia and Florida cotton (Dowler, 1995, 1998). It is a vigorous competitor if emergence occurs within a few weeks of the crop (Buchanan and Burns, 1970). Densities of eight sicklepod per 7.3 m of row emerging with cotton can reduce yieldup to 40%. Similarly, prickly sida continues to be common and troublesome throughout the southeastern cotton-production belt (Dowler, 1998). Depending upon density and period of competition, prickly sida can reduce cotton yield (Buchanan et al., 1977, 1980). Sicklepod can be controlled by fluometuron, MSMA, or DSMA applied post-emergence, but successful directed application requires a height differential between cotton and weeds (Monks et al., 1999).

The objective of this research was to determine if weed control by pyrithiobac and bromoxynil could be improved by mixing each of these herbicides with MSMA at rates suitable for post-emergence application.

MATERIALS AND METHODS

Experiments were conducted in 1995 and 1996 in different areas of the same field at the Southwest Georgia Branch Experiment Station near Plains, GA, and at the West Florida Research and Education Center near Jay, FL. Soils were a Faceville sandy loam (fine, kaolinitic, thermic Typic Kandiudults) with 71% sand, 13% silt, 16% clay, 1% organic matter, and pH 6.5 at Plains and a Red Bay fine sandy loam (fine-loamy, kaolinitic, thermic Rhodic Kandiudults) with 77% sand, 14% silt, 9% clay, 2% organic matter, and pH 5.8 at Jay. All experiments received trifluralin at 0.8 kg a.i. ha^{-1} preplant incorporated for annual grass control and aldicarb {2-methyl-2-(methylthio)propanal *O*-[(methylamino)carbonyl]oxime} in the seed furrow for early-season insect control. Fertility and other pest-control practices were according to extension recommendations in the area.

Cotton BXN 57 seed was planted 3 cm deep and spaced 7 to 8 cm apart in 91-cm and 76-cm rows at Plains and Jay, respectively. Plots were four rows by 7.6 m long at both locations. The experimental design was a randomized complete block with treatments replicated four times. Planting dates were 17 May 1995 and 9 May 1996 at Plains and 16 May 1995 and 8 May 1996 at Jay. All locations were infested with sicklepod at densities of 5 to 15 plants m^{-2}. The Plains locations were infested with prickly sida at 2 to 5 plants m^{-2}. Purple nutsedge and yellow nutsedge were present at Jay in 1995 and 1996, respectively, at densities of 1 to 3 plants m^{-2}.

Treatments at Plains consisted of bromoxynil at 0.6 kg ha^{-1}, pyrithiobac at 70 g ha^{-1}, and MSMA at 0, 0.6, 0.8, or 1.1 kg ha^{-1} applied post-emergence alone and all combinations of bromoxynil plus MSMA and pyrithiobac plus MSMA. Treatments at Jay were bromoxynil at 0.6 kg ha^{-1} or pyrithiobac at 70 g ha^{-1} applied post-emergence alone and in combination with MSMA at 0.6, 0.8, or 1.1 kg ha^{-1}. A nonionic surfactant (Chem Nut 80/20, Chem Nut, Albany, GA) was added to each treatment at 0.25% (v v^{-1}). A no-post-emergence herbicide check was also included.

Herbicides were applied with a backpack sprayer in Georgia and with a tractor-mounted boom sprayer in Florida. Sprayers were calibrated to deliver 187 L ha^{-1} at 210 kPa. Herbicides were applied when cotton was in the one- to three-leaf stage, sicklepod was in the cotyledonary to two-leaf stage, yellow and purple nutsedge was in the spike to three-leaf stage, and prickly sida was in the one- to three-leaf stage. Application dates were 9 June 1995 and 4 June 1996 at Plains and 6 June 1995 and 30 May 1996 at Jay. Weed control was visually estimated using a scale of 0 (no control) to 100% (complete control). Nutsedge control was determined during June to reflect control after post-emergence application but before canopy closure. Prickly sida control was evaluated in July (prior to cultivation and post-emergence application) to reflect mid-season control prior to sicklepod becoming the dominate weed. Sicklepod control was evaluated during August at Jay in 1995 and 1996 and in August 1995 and September 1996 at Plains to reflect late-season control. Cotton injury was estimated visually 7 to 10 d after the post-emergence treatments using a scale of 0 (no injury) to 100 (plant death). Injury was not recorded in 1995 at Plains. Cotton was cultivated approximately 40 d after planting (19 July 1995 and 1 July 1996) at Plains. After cultivation (19 July 1995 and 11 July 1996), cyanazine {2-[[4-chloro-6-(ethylamino)-1,3,5-triazin-2-yl]amino]-2-methylpropanenitrile} at 0.8 kg a.i. ha^{-1} plus MSMA at 2.2 kg ha^{-1} was applied as a post-emergence-directed spray. No follow-up treatments were made at Jay. The center two rows of each plot were mechanically harvested in October. A subsample of seed cotton from each plot was collected and used to determine lint percentage.

Cotton injury, weed control, and yield data were subjected to analysis of variance, and means were separated using Fisher's protected LSD test at the 5% level of probability. Variation in nutsedge species by year and significant location by treatment interactions were noted for cotton injury, sicklepod control, and lint yield. Therefore, data are presented for individual experiments. The location by year interaction was not significant for prickly sida control in Georgia, and data were combined.

RESULTS AND DISCUSSION

Sicklepod control varied by locations and years, but trends were similar. MSMA alone was applied only at Plains, where control ranged from 66 to 81% (Table 1). There was no response to rate of MSMA in 1995 and only a minor response in 1996. Pyrithiobac applied alone controlled sicklepod only 29 to 47%. Jordan et al. (1993c) reported similar results, with 36 and 38% control of sicklepod by pyrithiobac at 60 and 80 g ha^{-1}, respectively. Bromoxynil applied alone did not control sicklepod at Plains in either year or at Jay in 1995. Bromoxynil controlled sicklepod 40% at Jay in 1996.

Mixing MSMA with pyrithiobac did not affect sicklepod control at Jay in 1996 (Table 1). At the other three locations, sicklepod control by pyrithiobac plus MSMA was 23 to 51% greater than control by pyrithiobac alone. Sicklepod control by pyrithiobac plus MSMA was greater than control by either herbicide applied alone at Plains in 1995. Control by the herbicide combination also was greater than control by pyrithiobac alone at Plains in 1996, but not greater than control by MSMA alone.

Table 1. Sicklepod control with combinations of pyrithiobac plus MSMA and bromoxynil plus MSMA.

Treatments		Plains	Plains	Jay	Jay
Post-emergence herbicides†	MSMA rate	1995	1996	1995	1996
	kg ha^{-1}	------------%------------			
None	--	0	0	0	0
MSMA	0.6	66	76	--	--
MSMA	0.8	66	79	--	--
MSMA	1.1	66	81	--	--
Pyrithiobac	-	44	29	47	33
Pyrithiobac + MSMA	0.6	90	71	70	50
Pyrithiobac + MSMA	0.8	93	80	57	33
Pyrithiobac + MSMA	1.1	92	79	77	52
Bromoxynil	-	0	0	0	40
Bromoxynil + MSMA	0.6	63	68	60	30
Bromoxynil + MSMA	0.8	68	73	57	33
Bromoxynil + MSMA	1.1	69	78	62	77
LSD (0.05)		7	4	19	20

† Bromoxynil and pyrithiobac applied at 0.6 kg ha^{-1} and 70 g ha^{-1}, respectively.

Table 2. Prickly sida and purple and yellow nutsedge control with combinations of pyrithiobac plus MSMA and bromoxynil plus MSMA.

Treatments		Prickly sida	Purple nutsedge	Yellow nutsedge
Post-emergence herbicides†	MSMA rate	Plains‡	Jay 1995	Jay 1996
	kg ha^{-1}	-------------%-------------		
None	--	0	0	0
MSMA	0.6	19	--	--
MSMA	0.8	24	--	--
MSMA	1.1	30	--	--
Pyrithiobac	-	76	43	60
Pyrithiobac+MSMA	0.6	77	73	57
Pyrithiobac+MSMA	0.8	81	80	63
Pyrithiobac+MSMA	1.1	78	85	67
Bromoxynil	-	81	47	3
Bromoxynil+MSMA	0.6	86	77	7
Bromoxynil+MSMA	0.8	81	77	75
Bromoxynil+MSMA	1.1	82	83	80
LSD (0.05)		10	4	4

† Bromoxynil and pyrithiobac applied at 0.6 kg ha^{-1} and 70 g ha^{-1}, respectively.
‡ Data pooled over years.

Similarly, Jennings et al. (1998) reported similar control of sicklepod by MSMA alone and pyrithiobac plus MSMA. Other researchers (Monks et al., 1999) have reported greater sicklepod control when MSMA or DSMA was mixed with pyrithiobac.

Sicklepod control by bromoxynil plus MSMA was much greater than control by bromoxynil alone in both years at Plains (Table 1). However, the combination was no more effective than MSMA alone. At Jay, bromoxynil plus MSMA at any rate controlled sicklepod better than bromoxynil alone in 1995. In 1996, control by the combination exceeded control by bromoxynil alone only when MSMA was applied at 1.1 kg ha^{-1}.

Prickly sida was controlled 30% or less by MSMA applied at any rate (Table 2). Pyrithiobac and bromoxynil controlled prickly sida 76 and 81%, respectively, and MSMA added to either of these herbicides did not improve control. These results are similar to those observed in North Carolina (Culpepper and York, 1997; Paulsgrove and Wilcut, 1999).

Purple nutsedge was controlled 43% by pyrithiobac and 47% by bromoxynil (Table 2). Pyrithiobac plus MSMA and bromoxynil plus MSMA controlled purple nutsedge 73 to 85% and 77 to 83%, respectively. Yellow nutsedge was controlled 60% by pyrithiobac and 3% by bromoxynil. Yellow nutsedge control by pyrithiobac plus MSMA was similar to control by pyrithiobac alone. However, MSMA at 0.8 and 1.1 kg ha^{-1} mixed with bromoxynil increased yellow nutsedge control to 75 to 80%.

Cotton injury 7 to10 d after treatment was insignificant at Plains in 1996 (Table 3). At Jay, no injury was observed with bromoxynil applied alone in 1995 or with bromoxynil or bromoxynil plus MSMA in 1996. Cotton was injured 13 to 23% by bromoxynil plus MSMA in 1995. Pyrithiobac alone or combinations of pyrithiobac plus MSMA injured cotton 18 to 25% at Jay in 1995 and 23 to 30% in 1996. Injury was transient, and cotton recovered quickly.

Treatments had no effect on lint percentage (data not shown). Few treatments affected cotton yield at Plains in 1995 (Table 4). Only bromoxynil plus MSMA at 0.8 or 1.1 kg ha^{-1} increased yield relative to the no-post-emergence herbicide check. The soil-applied herbicides, cultivation, and the post-emergence-directed herbicides applied to all plots apparently controlled weeds well enough to avoid yield reductions. Yield was reduced with pyrithiobac plus MSMA at 1.1 kg ha^{-1}.

Weed populations were greater and conditions for weed growth were more favorable during 1996 at

Table 3. Cotton injury with combinations of pyrithiobac plus MSMA and bromoxynil plus MSMA.†

Treatments		Plains	Jay	Jay
Post-emergence herbicides‡	MSMA rate	1996	1995	1996
	kg ha^{-1}	----------% ----------		
None	--	0	0	0
MSMA	0.6	0	--	--
MSMA	0.8	0	--	--
MSMA	1.1	0	--	--
Pyrithiobac	-	0	25	23
Pyrithiobac + MSMA	0.6	0	18	30
Pyrithiobac + MSMA	0.8	0	23	30
Pyrithiobac + MSMA	1.1	0	23	30
Bromoxynil	-	0	3	0
Bromoxynil + MSMA	0.6	0	13	5
Bromoxynil + MSMA	0.8	0	23	10
Bromoxynil + MSMA	1.1	5	22	10
LSD (0.05)		5	7	14

† Cotton injury determined 7 to 10 d after post-emergence herbicide application.

‡ Bromoxynil and pyrithiobac applied at 0.6 kg ha^{-1} and 70 g ha^{-1}, respectively.

Table 4. Cotton lint yield with combinations of pyrithiobac plus MSMA and bromoxynil plus MSMA.

Treatments		Plains	Plains	Jay	Jay
Post-emergence herbicides†	MSMA rate	1995	1996	1995	1996
	kg ha^{-1}	----------kg ha^{-1} ----------			
None	--	1000	420	120	280
MSMA	0.6	1010	680	--	--
MSMA	0.8	1030	750	--	--
MSMA	1.1	1000	810	--	--
Pyrithiobac	-	1040	920	320	730
Pyrithiobac + MSMA	0.6	1140	940	400	630
Pyrithiobac + MSMA	0.8	1090	940	420	740
Pyrithiobac + MSMA	1.1	810	860	400	720
Bromoxynil	-	1130	630	210	850
Bromoxynil + MSMA	0.6	1130	900	420	630
Bromoxynil + MSMA	0.8	1190	900	380	710
Bromoxynil + MSMA	1.1	1170	890	410	1040
LSD (0.05)		150	160	210	230

† Bromoxynil and pyrithiobac applied at 0.6 kg ha^{-1} and 70 g ha^{-1}, respectively.

Plains. All post-emergence herbicides increased cotton yield (Table 4). Yields were similar regardless of rate of MSMA applied alone. MSMA did not increase yield when mixed with pyrithiobac. However, regardless of rate, MSMA increased yield 41 to 43% when mixed with bromoxynil. This result was probably due to improved sicklepod control with bromoxynil plus MSMA compared with bromoxynil alone. Yield of cotton treated with pyrithiobac exceeded yield of cotton treated with bromoxynil. However, yields were similar with bromoxynil plus MSMA and pyrithiobac plus MSMA.

Cotton yields were generally lower at Jay than at Plains (Table 4). This may be due to no follow-up treatments (cultivation or post-emergence-directed herbicides) after post-emergence applications. In 1995, two hurricanes also passed through the area, further reducing cotton yield potential. In 1995, neither pyrithiobac nor bromoxynil applied alone increased cotton yield. All combinations of pyrithiobac plus MSMA and bromoxynil plus MSMA increased yield similarly. This result was probably due to increased control of both sicklepod and purple nutsedge. All treatments increased cotton yield similarly in 1996.

These results indicate that MSMA at 0.6 to 0.8 kg ha^{-1} applied in combination with bromoxynil or pyrithiobac can increase control of sicklepod and yellow and purple nutsedge without adversely affecting cotton yield. As was the case at Plains, these herbicide combinations can control weeds sufficiently to allow cotton to establish the height differential with weeds needed for cultivation and subsequent post-emergence-directed herbicide application. MSMA alone may control sicklepod as well as combinations of pyrithiobac plus MSMA or bromoxynil plus MSMA. However, MSMA applied alone will control a more limited spectrum of weeds than the herbicide combinations. Further, pyrithiobac may provide residual control of susceptible weeds.

REFERENCES

Buchanan, G.A. 1992. Trends in weed control methods. p. 47-72. *In* C.G. McWhorter and J.R. Abernathy (ed.) Weeds of cotton: Characterization and control. The Cotton Foundation, Memphis, TN.

Buchanan, G.A., and E.R. Burns. 1970. Influence of weed competition on cotton. Weed Sci. 18:149-154.

Buchanan, G.A., and E.R. Burns. 1971. Weed competition in cotton: I. Sicklepod and morningglory. Weed Sci. 19:576-579.

Buchanan, G.A., R.H. Crowley, and R.D. McLaughlin. 1977. Competition of prickly sida with cotton. Weed Sci. 25:106-110.

Buchanan, G.A., J.E. Street, and R.H. Crowley. 1980. Influence of time of planting and distance from the cotton row of pitted morningglory (*Ipomoea lacunosa*), prickly sida (*Sida spinosa*), and redroot pigweed (*Amaranthus retroflexus*) on competitiveness with cotton. Weed Sci. 28:568-572.

Culpepper, A.S., and A.C. York. 1997. Weed management in no-tillage bromoxynil-tolerant cotton. Weed Technol. 11:335-345.

Dowler, C.C. 1995. Weed Survey - Southern states. p. 290-305. *In* 48th Proc. South. Weed Sci. Soc., Memphis, TN. 16-18 Jan. 1995. South. Weed Sci. Soc., Champaign, IL.

Dowler, C.C. 1998. Weed Survey - Southern states. p. 299-313. *In* 51st Proc. South. Weed Sci. Soc., Birmingham, AL. 26-28 Jan. 1998. South. Weed Sci. Soc., Champaign, IL.

Hatzios, K.K. 1998. Herbicide handbook. Suppl. 7th ed. Weed Sci. Soc. Am., Champaign, IL.

Jennings, K.M., A.C. York, A.S. Culpepper, and R.B. Batts. 1998. Staple/MSMA combinations for sicklepod control in cotton. p. 843-844. *In* Proc. Beltwide Cotton Conf., San Diego, CA. 5-9 Jan 1998. Natl. Cotton Counc. Am., Memphis, TN.

Jordan, D.L., R.E. Frans, and M.R. McClelland. 1993a. Cotton response to DPX-PE350. Weed Technol. 7:156-162.

Jordan, D.L., R.E. Frans, and M.R. McClelland. 1993b. Total post-emergence herbicide programs in cotton with sethoxydim and DPX-PE350. Weed Technol. 7:196-201.

Jordan, D.L., R.E. Frans, and M.R. McClelland. 1993c. Influence of application rate and timing on efficacy of DPX-PE350 applied POST. Weed Technol. 7:216-219.

Jordan, D.L., M.C. Smith, M.R. McClelland, and R.E. Frans. 1993d. Weed control with bromoxynil applied alone and with graminicides. Weed Technol. 7:835-839.

Monks, C.D., M.G. Patterson, J.W. Wilcut, and D.P. Delaney. 1999. Effect of pyrithiobac, MSMA, and DSMA on cotton growth and weed control. Weed Technol. 13:6-11.

National Agricultural Statistics Service. 2001. 2000 Annual summary. NASS-USDA, Washington, DC. Available online at http://www.usda.gov/nass/.

Paulsgrove, M.D., and J.W. Wilcut. 1999. Weed management in bromoxynil-resistant *Gossypium hirsutum*. Weed Sci. 47:596-601.

Snipes, C.E., and J.D. Byrd, Jr. 1994. The influence of fluometuron and MSMA on cotton yield and fruiting characteristics. Weed Sci. 42:210-215.

Treadaway, J.A., M.G. Patterson, and G.R. Wehtje. 1997. Efficacy of pyrithiobac and bromoxynil applied with low-volume spray systems. Weed Technol. 11:725-730.

Webster, E.P. 1998. Economic losses due to weeds in southern states. p. 314-322. *In* 51st Proc. South. Weed Sci. Soc., Birmingham, AL. 26-28 Jan. 1998. South. Weed Sci. Soc., Champaign, IL.

Wilcut, J.W., A.C. York, and D.L. Jordan. 1995. Weed management systems for oils seed crops. p. 344-400. *In* A.E. Smith (ed.) Handbook of weed management systems. Marcel Dekker, New York.