

PREPLANT HERBICIDES FOR WEED CONTROL IN CONSERVATION-TILLAGE COTTON (*GOSSYPIMUM HIRSUTUM* L.)

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INTRODUCTION

Conservation-tillage cotton production is becoming more common in Arkansas and throughout the Cotton Belt because of increased production efficiency and for soil conservation under federal compliance guidelines. The term "conservation tillage" encompasses several practices of reduced tillage, including stale seedbed, minimum or reduced tillage, ridge tillage, strip tillage, mulch tillage and no-till. Several of these terms are briefly described as methods of residue management in a review article by Locke and Bryson (1997). In most of these systems, however, no tillage is performed for several weeks or months before planting (Locke and Bryson, 1997; Hydrick and Shaw, 1995; Webster and Shaw, 1997). Weed control at planting, therefore, is a major concern (McWhorter and Jordan, 1985; Worsham and Lewis, 1985). Cotton is a poor competitor early in the season, and it is important that vegetation be controlled during the seedling stage of growth.

Postemergence herbicides, such as Roundup, that can be used over-the-top of transgenic cotton cultivars and control a wide spectrum of winter and early-spring annual weeds are becoming an option for producers who choose to use this emerging technology. However, heavy infestations of green vegetation can interfere with planting, in which case it is advisable to achieve weed-free conditions prior to cotton emergence to successfully produce a conservation-tillage cotton crop.

The burndown herbicides Gramoxone Extra and Roundup are currently the foundation of most burndown programs in conservation-tillage cotton. However, these herbicides often do not control all emerged weeds, and neither Roundup nor Gramoxone Extra provides residual weed control to suppress new weed emergence (Baughman et al., 1995; Frans et al., 1994; Guy, 1995a; Reynolds et al., 1994).

Some winter weeds, such as horseweed [*Conyza canadensis* (L.) Cronq.], Pennsylvania smartweed (*Polygonum pensylvanicum* L.), cutleaf eveningprimrose and Italian ryegrass (*Lolium multiflorum* Lam.), may persist into the cotton growing season and are difficult to control with a single, burndown herbicide (Fairbanks et al., 1995; Guy, 1995a; Guy and Ashcraft, 1995). Roundup

has been good for controlling small horseweed, but control of cutleaf eveningprimrose has been erratic (Guy and Ashcraft, 1995). Tank-mixing a residual herbicide with Roundup or Gramoxone Extra can increase control of many weeds over control with either of the herbicides alone (Baughman et al., 1995; Frans et al., 1994), although antagonism of these mixtures on some weeds has been reported (Hydrick and Shaw, 1995; Webster and Shaw, 1997). Residual herbicides can also extend control into the early season. If weeds are not controlled prior to or soon after cotton emergence, they have the potential to interfere with crop production and decrease cotton yields. The objective of these experiments was to evaluate several herbicide combinations for preplant weed control in reduced-tillage cotton.

MATERIALS AND METHODS

Field experiments were conducted in 1994 through 1996 at the Cotton Branch Experiment Station, Marianna, Arkansas, on a Calloway silt loam to evaluate activity of burndown herbicides on natural winter weed infestations. Plot areas were fallow the year prior to establishment of each experiment and were not disturbed by tillage before spraying preplant treatments. Plot size was 6 by 25 ft, and each treatment was replicated four times.

Herbicides were applied 18 March 1994, 21 March 1995 and 17 March 1996, with a backpack sprayer in 20 gal/acre at 20 to 40 psi. All herbicide rates are expressed as lb of active ingredient per acre (lb ai/acre). Non-ionic surfactant (Induce) at 0.5% by volume was added to each treatment.

Average weed sizes and densities of prevalent weeds at the time of planting are presented in Table 1. Because of the different growth habits of winter weeds, size information is very general. Weeds were rated visually by species for percent control (0 = no control and 100 = death or absence of plants) compared to an untreated check plot. A rating of "total burndown," which was percentage control of total vegetation in the plots, was also evaluated. Miscellaneous species, including pineappleweed, shepherds-purse, sibara, white clover, wild garlic, henbit, annual bluegrass, horseweed, common chickweed, mouseear chickweed, paleseed plantain and various grass (*Graminaea*) species, present at low infestations or controlled with all treatments or rated individually only one year, are reported as part of the total burndown. At 6 weeks after treatment

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(WAT), summer annual weeds such as morningglory, pigweed and goosegrass were emerging, but little biomass had accumulated. Gramoxone Extra was applied at cotton planting to control emerging weeds, so these species were rated only as part of the total burndown rating. Plots were rated 2 and 4 WAT in 1994 and 2, 4 and 6 WAT in 1995 and 1996. Because the 2 WAT rating of cutleaf eveningprimrose is representative of total control at that time, only 4 and 6 WAT ratings are presented for total control.

Four rows of cotton 'DPL 51' were planted across all plots 20 May 1994, 17 May 1995 and 9 May 1996 to evaluate cotton tolerance to the preplant burndown herbicide treatments. Gramoxone Extra was applied over the entire area at planting to control emerged summer annual weeds and vegetation not controlled by the burndown treatments. Cotton was rated visually for percent injury approximately three weeks after planting. Data were analyzed by analysis of variance, and means were separated by protected LSD at the 0.05 level of significance.

RESULTS AND DISCUSSION

Because cutleaf eveningprimrose was the predominant species each year, discussion will center around its control and total burndown. Tank mixtures containing Roundup and Gramoxone Extra generally controlled winter weed species such as chickweed species, shepherdspurse, henbit and annual bluegrass (data not shown). Control of these species was usually less with Roundup or Gramoxone Extra alone than with a tank mixture containing a residual herbicide.

Cutleaf Eveningprimrose Control

A heavy, uniform population of cutleaf eveningprimrose was present at Marianna all years (Table 1). Activity of Gramoxone Extra on cutleaf eveningprimrose was faster than activity of Roundup (Table 2). At the 2 WAT rating, control with Roundup was 10% to 38% compared with 61% to 100% control with Gramoxone Extra. However, control with Roundup had increased by 4 WAT.

In 1994 at 4 WAT, all tank mixtures with Roundup controlled primrose better than Roundup alone. Of the Gramoxone Extra mixtures, those that equalled control of Roundup mixtures were Staple, Bladex, Karmex, Caparol and Lorox. These Gramoxone Extra treatments also gave fair to good primrose control (75 to 88%) at 4 WAT in 1995. By 6 WAT in 1995, treatments that controlled primrose better than Roundup alone (75%) were Banvel, 2,4-D, Staple, Karmex plus Roundup, 2,4-D plus Gramoxone Extra and the three-way mixtures (2,4-D plus Gramoxone Extra plus Bladex, Karmex or Caparol). The large decrease in cutleaf eveningprimrose control at 6 WAT with Gramoxone Extra alone and in some mixtures was the result of regrowth from plants that were not completely

controlled with this contact herbicide. Activity of Roundup was much slower than that of Gramoxone Extra, but because Roundup is readily translocated, regrowth was less.

In 1996, primrose control tended to be better with Gramoxone Extra than with Roundup treatments (Table 2). The only tank-mix herbicides that added to Roundup activity by 4 WAT in 1996 were Bladex, Karmex and Goal. By 6 WAT, control with Goal had declined dramatically, but control with 2,4-D and Caparol had increased to 85 and 73%, respectively. Although antagonism has been reported for several herbicides in tank mixture with Roundup (Webster and Shaw, 1997), that is probably not the explanation for low control in 1996 since control with Roundup alone was extremely low. Climatological conditions, including frost after treatment in 1996, probably resulted in activity differences among years.

Roundup or Gramoxone Extra plus 2,4-D gave at least 85% control of cutleaf eveningprimrose at 6 WAT (2,4-D was not mixed with Gramoxone Extra in 1994). Activity of 2,4-D plus Roundup appeared to be slower in 1996 than in 1994 and 1995. Control of primrose with 2,4-D plus Gramoxone Extra was not significantly enhanced by the addition of Bladex, Karmex or Caparol, although there was a numerical trend for higher control with the three-way mixture in 1996. Guy (1995b) also reported that 2,4-D, either alone or mixed with Roundup, controlled cutleaf eveningprimrose. There is, however, a question of safety to the cotton crop with 2,4-D. 2,4-D can injure cotton significantly if applied 2 weeks or less before cotton planting, but cotton was tolerant to applications made 4 weeks or more before planting (Guy 1995b).

Fairbanks et al. (1995) reported that 0.012 or 0.024 lb/acre of the package mixture of Harmony Extra with Gramoxone Extra increased control of cutleaf eveningprimrose over that of Gramoxone Extra alone, but control with Roundup was not enhanced. In our study, however, control with Gramoxone Extra was not enhanced by the addition of Harmony Extra except for a slight increase in control at 4 WAT in 1996 (Table 2). Control from Roundup, however, was increased from 78% when applied alone to 99% with the addition of Harmony Extra in 1994 and from 25 to 60% in 1996. In 1995, the addition of Harmony Extra did not significantly increase primrose control over that with Roundup alone.

Goal, Reflex, Cobra and Blazer (diphenylether herbicides) increased Roundup control of cutleaf eveningprimrose to at least 95% in 1994 and 82% in 1995 at 4 WAT (Table 2). In 1995, however, primrose control with the Roundup plus diphenylether treatments was generally poor by 6 WAT. In general, these herbicides did not increase control with Gramoxone Extra.

Total Burndown

As with cutleaf eveningprimrose control, total burndown ratings were generally better with Gramoxone Extra than with Roundup at 2 WAT (data not shown), primarily because of rapid activity of Gramoxone Extra. In 1994, tank-mix herbicides that enhanced total control over that with Roundup alone were Banvel, Harmony Extra, Bladex, Karmex, Caparol, Reflex, Cobra and Blazer. Total control with Roundup mixtures tended to be lower than control of cutleaf eveningprimrose, perhaps because wild garlic control with most Roundup treatments was low at 4 WAT (10 to 65%). Total control with Gramoxone Extra treatments in 1994 ranged from 61 to 89%. Gramoxone Extra plus Bladex gave higher control (89%) than Gramoxone Extra plus Karmex, Caparol and the diphenylethers.

Although total control with Roundup was enhanced slightly by diphenylether herbicides in 1994, there was no enhancement in 1995. Gramoxone Extra activity was not increased with addition of those herbicides either year. However, other studies have shown improved control of some species with the addition of Goal to Roundup or Gramoxone Extra (Baughman et al., 1995; McClelland et al., 1995). In 1995, herbicides that added to Roundup control at 4 WAT were 2,4-D, Karmex and Cobra. Gramoxone Extra mixtures that performed well in 1995 were Gramoxone Extra with Banvel, 2,4-D, Bladex, Karmex and Caparol. Horseweed was present in the 1995 experiment. Although most Roundup mixtures controlled horseweed, only Bladex and Banvel aided in horseweed control with Gramoxone Extra (data not shown). Gramoxone Extra plus Bladex, however, does not always control horseweed, and Roundup is a better burndown choice than Gramoxone Extra for horseweed (Guy, 1995b). Horseweed was not present in 1994 or 1996.

Gramoxone Extra mixtures generally gave better total weed control than Roundup mixtures in 1996. The presence of wild garlic, which was controlled better with Gramoxone Extra than with Roundup mixtures (data not shown), probably influenced total control, as did the poorer control of cutleaf eveningprimrose with Roundup that year.

Herbicides that gave greater than 70% total control for 4 to 6 WAT in all three years of experiments were Bladex and Karmex plus either Roundup or Gramoxone Extra (Table 2). Other treatments that controlled most weeds consistently included 2,4-D plus Roundup, Harmony Extra plus Roundup, Caparol plus Gramoxone Extra and Banvel plus Gramoxone Extra or Roundup.

Total burndown control was greater than 90% with the three-way mixtures of 2,4-D plus Gramoxone Extra plus Bladex, Karmex or Caparol (Table 2). Total burndown control was at least 91% at 6 WAT with the three-way mixtures compared to 70 to 80% with 2,4-D plus Gramoxone Extra. Increased total control with the three-way mixtures

is probably due to control by the residual herbicides of summer annuals, especially grass species, that were emerging by 6 WAT. However, Gramoxone Extra was always applied at cotton planting because all plots had at least a few emerging weeds.

Cotton Tolerance

Cotton was not significantly injured by any of the burndown treatments at the 5% level of significance (data not shown). Injury was generally higher in 1996 (4 to 30%) than in 1994 and 1995 (0 to 5%), probably because of difficulty planting into a rougher seedbed in 1996. Guy (1995a) reported cotton injury only from 2,4-D, Banvel and Harmony Extra if application was made within two weeks of planting. The residual herbicides such as Bladex, Karmex, Lorox and Caparol could be used safely even when applied within one week of planting. Generally, herbicides can be used safely if applied at least four weeks before planting and if rainfall occurred after application, but before planting (Guy, 1995a).

In summary, there were a number of options for pre-plant weed control in no-till cotton. Bladex and Karmex with Gramoxone Extra or Roundup gave the most consistent control for all three years of experiments. Banvel, 2,4-D, Harmony Extra, Staple and Caparol were also generally good tank-mix partners with Gramoxone Extra and Roundup for control of winter weeds, including cutleaf eveningprimrose. Three-way mixtures of Gramoxone Extra plus 2,4-D plus Bladex, Karmex or Caparol gave excellent broad-spectrum control. Even with a residual herbicide, all plots were sprayed with Gramoxone Extra at planting to control regrowth of winter weeds and emerging weeds that would otherwise interfere with emerging cotton.

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Table 1. Size and density of prevalent weeds in March at Marianna, Arkansas.

Weed species	1994		Year 1995		1996	
	Size	Density	Size	Density	Size	Density
Cutleaf eveningprimrose	cm	no/m ²	cm	no/m ²	cm	no/m ²
Henbit	15	10-22	10	24	20	8
Mouseear chickweed	10	<10	15	16	15	50
Annual bluegrass	5	<10	4	12	3	20
Common chickweed	7	15	4	48	3	70
	--	--	4	24	4	60

Table 2. Burndown control of weeds with herbicide mixtures at Marianna, Arkansas, 1994-1996¹.

Herbicide	Rate	Cutleaf eveningprimrose									Total burndown ²				
		1994			1995			1996			1994		1995		1996
		2 WAT ³	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT	4 WAT	6 WAT
lb ai/acre		----- % -----													
G = tank mixed with Roundup, 0.75 lb ai/a + Induce, 0.5%:															
Roundup alone	0.75	38	78	10	72	75	29	54	25	65	86	79	63	58	
Banvel + G	0.25	79	97	23	78	99	—	—	—	82	83	81	—	—	
2,4-D amine + G	0.5	65	100	45	90	96	28	48	85	66	94	88	53	54	
Harmony Extra + G	0.016	65	99	16	76	82	31	51	60	86	83	84	60	80	
Staple + G	0.062	62	96	28	81	91	—	—	—	80	88	81	—	—	
Bladex + G	1.0	84	100	36	80	75	43	78	81	90	86	81	82	87	
Karmex + G	1.0	98	100	42	92	88	30	79	95	84	94	92	78	79	
Caparol + G	1.0	92	99	48	81	76	21	45	73	84	87	79	49	53	
Lorox + G	1.0	100	100	50	83	80	—	—	—	80	89	85	—	—	
Goal + G	0.25	74	98	48	82	67	66	79	38	74	88	71	82	64	
Reflex + G	0.25	95	99	55	84	69	—	—	—	86	88	72	—	—	
Cobra + G	0.10	92	100	59	86	72	—	—	—	84	93	76	—	—	
Blazer + G	0.25	92	95	48	84	64	—	—	—	86	88	70	—	—	
P = tank mixed with Gramoxone Extra, 0.63 lb ai/a + Induce, 0.5%:															
Gramoxone Extra alone	0.63	100	69	61	61	45	86	60	49	74	71	46	71	60	
Banvel + P	0.25	— ⁴	—	79	89	78	88	79	79	—	93	82	89	86	
2,4-D amine + P	0.5	—	—	85	99	99	87	86	88	—	95	80	82	70	
Harmony Extra + P	0.016	89	79	64	65	40	89	76	52	80	74	45	82	81	
Staple + P	0.062	89	95	70	80	68	—	—	—	82	86	62	—	—	
Bladex + P	1.0	91	98	76	85	75	90	91	88	89	90	81	95	92	
Karmex + P	1.0	96	88	66	84	74	92	89	92	71	89	81	91	85	
Caparol + P	1.0	100	100	80	88	77	85	90	94	69	94	80	91	86	
P = tank mixed with Gramoxone Extra, 0.63 lb ai/a + Induce, 0.5%:															
Lorox + P	1.0	98	96	62	75	54	—	—	—	78	81	61	—	—	
Goal + P	0.25	65	46	65	62	39	94	76	68	62	72	44	86	74	
Reflex + P	0.25	71	55	59	65	42	—	—	—	61	72	50	—	—	
Cobra + P	0.10	75	36	79	71	45	—	—	—	64	78	49	—	—	
Blazer + P	0.25	77	75	72	66	44	—	—	—	63	74	74	—	—	
2,4-D +	0.5														
Bladex + P	1.0	—	—	93	100	100	95	99	100	—	100	96	97	100	
2,4-D +	0.5														
Karmex + P	1.0	—	—	92	99	99	93	99	99	—	99	97	93	91	
2,4-D +	0.5														
Caparol + P	1.0	—	—	99	100	100	94	98	98	—	100	93	93	92	
LSD (0.05)		14	16	10	8	8	16	13	18	15	6	9	10	12	

¹Treatments were applied 18 March 1994; 21 March 1995; and 17 March 1996.

²Species in 1994 were cutleaf eveningprimrose, henbit, white clover, pineappleweed, shepherdspurse, and paleseed plantain; species in 1995 were cutleaf eveningprimrose, annual bluegrass, mouseear and common chickweed, horseweed, and henbit; species in 1996 were cutleaf eveningprimrose, shepherdspurse, henbit, mouseear and common chickweed, wild garlic, and pineappleweed.

³WAT: weeks after treatment.

⁴Dash '—' in means columns indicates the treatment was not applied or data were not available in that year.