





## GLYPHOSATE AND PYRITHIOBAC (STAPLE™) COMBINATIONS IN ROUNDUP READY™ COTTON

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### RESEARCH PROBLEM

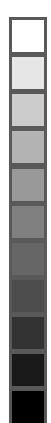


The Roundup Ready™ (glyphosate-tolerant) system has provided cotton producers versatility in their weed management programs and allows the reduction of soil-applied herbicides in some situations. However, glyphosate (Roundup UltraMax™, Touchdown I.Q.™, Glyphomax™, and others) does not have residual activity, and some weeds, such as the morningglory species, are difficult to control with glyphosate alone. Staple™ (pyrithiobac) appears to be a good choice as a tank-mix partner for glyphosate because it does have some residual activity and is active on pitted and entireleaf morningglories. The objective of this research was to determine if adding Staple to glyphosate would increase weed control in Roundup Ready cotton and provide residual control lacking in glyphosate alone.



### BACKGROUND INFORMATION

Glyphosate programs without residual, soil-applied herbicides can be used effectively under some conditions, although application timing is important and some weeds are difficult to control with glyphosate alone. Studies have been conducted to determine if applying Staple with glyphosate can enhance weed control over that with glyphosate alone (Reynolds et al., 1998; Webster and Baughman, 1998). Miller et al. (1999) reported that pyrithiobac increased control of barnyardgrass, hemp sesbania, and pitted morningglory over that with low rates of glyphosate (0.188 lb active ingredient [ai]/acre). However, sicklepod, smooth pigweed, and entireleaf morningglory were controlled equally by all treatments. Entireleaf morningglory and common cocklebur were controlled as well with two applications of glyphosate at 1 lb ai/acre as with sequential treatments of Staple plus glyphosate (Webster and Baughman, 1998). A combination package of Staple and glyphosate (Staple Plus™) was introduced by



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DuPont in 2000. Gillham et al. (2001) claimed that studies in 2000 showed that control with the mixture was better than control with either herbicide alone, although comparisons with sequential glyphosate treatments were not reported.

## RESEARCH DESCRIPTION

Two sets of experiments were conducted. The first set, glyphosate formulation experiments, was conducted in 2001 at Marianna and Fayetteville, AR, to evaluate single applications of Staple with four glyphosate formulations. The experiment at Marianna was a randomized complete block (RCB) design with 13- by 40-ft plots and four replications. Cotton (Paymaster 1218BR) was planted 14 May, and postemergence (POST) treatments were applied 6 June (two-leaf cotton, ~one-leaf weeds). At Fayetteville, fourteen species – cotton (Paymaster 1218BR), soybean (Roundup Ready), barnyardgrass, seedling johnsongrass, large crabgrass, sunflower, velvetleaf, sicklepod, hemp sesbania, prickly sida, entireleaf and pitted morningglory, smooth pigweed, and Palmer amaranth – were planted in a multispecies design in 6.5-ft wide plots. Treatments were applied 6 July (one-leaf cotton stage). Glyphosate formulations were Roundup™ (no surfactant), Roundup Ultra™, and Roundup UltraMax™ at 0.75 lb ai/acre, and Touchdown™ at 0.56 lb acid equivalent/acre. Each formulation was applied alone and with Staple (0.031 lb ai/acre).

The second set of experiments, Staple Plus experiments, were conducted in 2000 and 2001 at Marianna and Fayetteville to evaluate Staple Plus (Staple + Roundup without surfactant) programs. Paymaster 1218 Roundup Ready cotton was planted in mid-May. Each experiment was an RCB design with four replications. Plots were 13 by 40 ft. at Marianna and 3 by 27 ft at Fayetteville. Treatments, rates, and timing are shown in Table 1.

Standard field-plot techniques were used. Plots were rated for weed control and cotton injury, and cotton yield was taken at Marianna in 2001. Data were analyzed by analysis of variance, and means were separated with Fisher's protected LSD at the 0.05 level of probability.

## RESULTS

### Formulation Experiments

Glyphosate formulations generally did not differ in activity in the formulation experiments (data not shown), and only data for Staple with Roundup Ultra and Touchdown are shown (Table 2). The benefits of adding Staple to glyphosate were evident with these single-application treatments. Control of prickly sida (*Sida spinosa*), morningglory species (*Ipomoea lacunosa* and *I. hederacea* var. *integriscula*), pigweed species (*Amaranthus palmeri* and *A. hybridus*), and annual grasses (*Digitaria*

*sanguinalis*, *Eleusine indica*, and *Brachiaria platyphylla*) at 4 weeks after treatment (WAT) at Marianna was 89 to 100% with all treatments. By 13 WAT, however, control with glyphosate alone was significantly lower for all species. Control with glyphosate alone also declined at Fayetteville for most species as weed regrowth and late emergence occurred (Table 3). Because of good soil moisture and high temperatures, plant growth and herbicide activity were rapid, and control was evident even by 1 WAT. Regrowth of species was rapid as well, and weed control had declined by 4 WAT.

In the Staple Plus experiments, cotton was injured slightly by Staple applied preemergence (PRE) alone or with fluometuron (Fig. 1). Although early symptoms (3 to 7 DAT) included slight chlorosis, injury at 2 WAT manifested primarily as stunting. No visual injury was noted later in the season except at Marianna in 2000 from Staple + fluometuron PRE *fb* a full rate of Staple postemergence [12% at 6 weeks after late over-the-top (LOT) treatment]. Seedcotton yield (Marianna 2001) did not differ among treatments (data not shown).

Prickly sida control was 95% at 2 WAT with all treatments (Fig. 2). By 7 WAT, control with Roundup Ultra alone was lower than control with treatments containing pyriithobac. The decline was due to decreased control at Marianna (72% at 7 WAT), whereas control at Fayetteville did not differ among treatments (data not shown).

Staple Plus applied alone LOT gave the poorest morningglory control initially at both Fayetteville and Marianna (Fig. 3). By 7 WAT, control had increased with single LOT applications and decreased with early over-the-top (EOT) applications. Morningglories treated at EOT apparently had sufficient regrowth to avoid complete shading from the growing cotton, whereas those treated at LOT were further shaded by the cotton. Control also declined with Roundup Ultra applications and was lower than treatments in which Staple or Staple Plus was applied LOT. For this difficult-to-control species, the residual activity of Staple helped maintain control later into the season.

Pigweed species were controlled 99 to 100% at 2 weeks after LOT treatments and 96% at 7 WAT (data not shown). Miller et al. (1999) reported 98 to 100% control at 7 WAT with sequential applications of Roundup Ultra alone or with single or sequential applications of Roundup Ultra + Staple.

Annual grass was controlled 100% at 2 weeks after LOT treatments with all treatments (data not shown). At 7 weeks after LOT treatments, control was 93% except with the sequential application of Roundup Ultra, which gave only 84% at Marianna. Staple, although generally weak on grasses, appeared to have enough residual activity to help maintain grass control. At Fayetteville, however, control was 100% with Roundup Ultra alone, and later-emerging grass was shaded by the cotton canopy.

### PRACTICAL APPLICATION

Adding Staple to glyphosate postemergence (Staple Plus), or applying Staple preemergence prior to glyphosate application, may be advantageous for difficult-to-control species such as morningglories, especially with high-density infestations and

with single applications prior to late post-directed or layby treatments. The cost of the additional Staple will have to be balanced with the benefits of possible increased and residual control from Staple and will depend on the species and density of weeds present or anticipated in the crop.

### LITERATURE CITED

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- Reynolds, D., C. Rowland, R. Cobill, and K. Bloodworth. 1998. Evaluation of Staple use in transgenic cotton. Proc. Beltwide Cotton Conf., National Cotton Council, Memphis, TN. (vol. 1) p. 846.
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**Table 1. Treatments in Staple Plus experiments, Marianna and Fayetteville, 2000-2001.**

Treatment designation	Herbicide <sup>z</sup>	Rate (lb ai/acre)	Application timing <sup>y</sup>
St/fl	Staple +	0.031 +	PRE <i>fb</i>
St LOT	fluometuron <i>fb</i>	0.94 <i>fb</i>	
	Staple +	0.063 +	LOT
	Assure (quizalofop)	0.063	
St/fl	Staple +	0.031 +	PRE <i>fb</i>
St+ LOT	fluometuron <i>fb</i>	0.94 <i>fb</i>	
	Staple Plus	0.031 + 0.75	LOT
St	Staple <i>fb</i>	0.031 <i>fb</i>	PRE <i>fb</i>
St+ LOT	Staple Plus	0.031 + 0.75	LOT
St+ EOT	Staple Plus	0.031 + 0.75	EOT
St+ LOT	Staple Plus	0.031 + 0.75	LOT
St+ EOT/LOT	Staple Plus	0.031 + 0.75	EOT <i>fb</i> LOT
RU/RU	Roundup Ultra(Max)	0.75	EOT <i>fb</i> LOT

<sup>z</sup> Staple = pyriithiobac + NIS (surfactant); Staple Plus + pyriithiobac + glyphosate + NIS; *fb* = followed by.

<sup>y</sup> PRE = preemergence; EOT = cotyledon- to 3-leaf; LOT = 4-leaf cotton.

**Table 2. Control of prickly sida, morningglory species (pitted and entireleaf), and annual grasses at 4 and 13 weeks after treatment (WAT) at 2-leaf cotton and seedcotton yield, Marianna, 2001.**

Treatment <sup>z</sup>	Prickly sida		Morningglory spp.		Annual grass		Lint yield (lb/acre)
	4 WAT	13 WAT	4 WAT	13 WAT	4 WAT	13 WAT	
	----- (%) -----						
St + RU	100 a <sup>y</sup>	98 a	96 a	87 ab	99 a	92 a	1518 a
St + TD	100 a	100 a	95 ab	94 a	98 a	92 a	1424 a
RU	89 b	40 b	88 c	69 b	96 a	92 a	1467 a
TD	89 b	53 b	91 bc	70 b	96 a	85 b	1480 a

<sup>z</sup> St = Staple; RU = Roundup UltraMax; TD = Touchdown. RU and TD are glyphosate formulations.

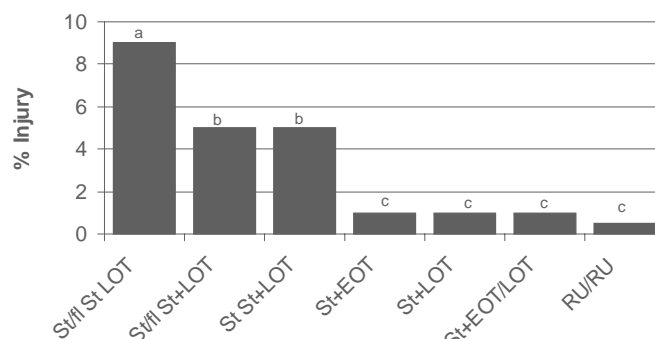
<sup>y</sup> Means for each species at each rating followed by the same letter do not differ by LSD 0.05.

**Table 3. Control of prickly sida, entireleaf morningglory, barnyardgrass, and sicklepod at 1 and 4 weeks after treatment (WAT) at 2-leaf cotton, Fayetteville, 2001.**

Treatment <sup>z</sup>	Prickly sida		Entireleaf morningglory		Barnyardgrass		Sicklepod	
	1 WAT	4 WAT	1 WAT	4 WAT	1 WAT	4 WAT	1 WAT	4 WAT
	----- (%) -----							
St + RU	100 a <sup>y</sup>	98 a	96 a	87 ab	99 a	92 a	83 a	93 a
St + TD	100 a	100 a	95 ab	94 a	98 a	92 a	80 a	87 a
RU	89 b	40 b	88 c	69 b	96 a	92 a	88 a	62 b
TD	89 b	53 b	91 bc	70 b	96 a	85 b	82 a	60 b

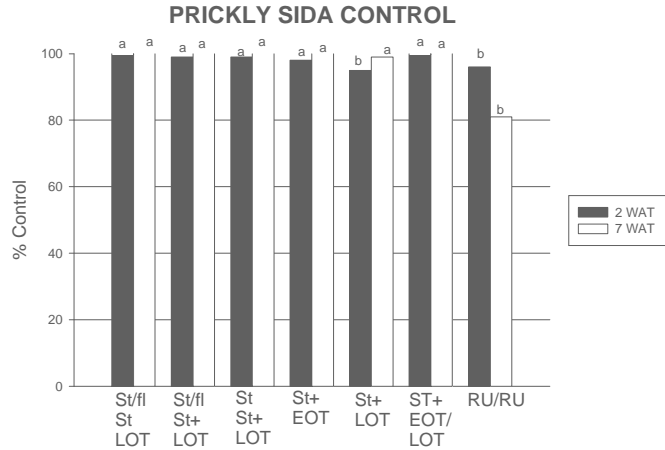
<sup>z</sup> St = Staple; RU = Roundup UltraMax; TD = Touchdown. RU and TD are glyphosate formulations.

<sup>y</sup> Means for each species at each rating followed by the same letter do not differ by LSD 0.05.

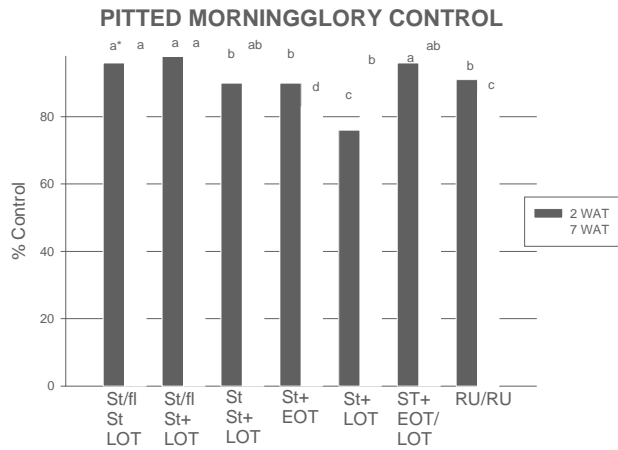


\* means with the same letter do not differ significantly.

**Fig. 1. Cotton injury 2 wks after LOT applications, mean of 2000 and 2001, Fayetteville and Marianna, AR (treatments listed in Table 1).**



**Fig. 2. Prickly sida control 2 and 7 weeks after LOT treatment (WAT), mean of 2000 and 2001, Fayetteville and Marianna, AR (treatments listed in Table 1).**



\*means at each rating time followed by the same letter do not differ by LSD (0.05)

**Fig. 3. Pitted morningglory control 2 and 7 weeks after LOT treatments (WAT), mean of 2000 and 2001 at Fayetteville and Marianna, AR (treatments listed in Table 1).**