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Weed Management–Major Crops

Glyphosate-Resistant Giant Ragweed (*Ambrosia trifida*) Control in WideStrike® Flex Cotton

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A field study was conducted in 2009, 2010, and 2011 on a grower's field with a known population of glyphosate-resistant giant ragweed to determine potential control options utilizing a WideStrike® cotton variety. Glyphosate-resistant giant ragweed control and cotton response to herbicide applications were both assessed. Few herbicide treatments provided greater than 80% control. Glufosinate followed by glufosinate was the only treatment that provided greater than 90% control at each assessment timing. Other effective treatments were glufosinate alone, glufosinate plus glyphosate, glyphosate plus pyrithiobac, and glufosinate plus fluometuron. Results from this study indicate that few of the studied herbicide treatments provide effective control of glyphosate-resistant giant ragweed without reducing yield in WideStrike cotton. Treatments that had the highest level of giant ragweed control at all ratings and also had the highest yield included glufosinate followed by glufosinate, glufosinate plus pyrithiobac, and glufosinate plus fluometuron at either rate. However, glufosinate followed by glufosinate was the only treatment that resulted in greater than 90% control of giant ragweed without reducing crop yield.

Nomenclature: Fluometuron; glufosinate; glyphosate; pyrithiobac; giant ragweed, *Ambrosia trifida* L.; cotton, *Gossypium hirsutum* L.

Key words: Glyphosate resistance, herbicide resistance.

Se realizõ un estudio de campo en 2009, 2010 y 2011 en el campo de un productor que tenĩa una poblaciõn de *Ambrosia trifida* resistente a glyphosate, para determinar opciones potenciales de control utilizando una variedad WideStrike® de algodõn. Se evaluõ el control de *A. trifida* resistente a glyphosate y la respuesta del algodõn a aplicaciones de herbicidas. Pocos tratamientos con herbicidas brindaron un control superior al 80%. Glufosinate seguido de glufosinate fue el ũnico tratamiento que brindõ un control superior al 90% en cada momento de evaluaciõn. Otros tratamientos efectivos fueron glufosinate solo, glufosinate más glyphosate, glyphosate más pyrithiobac, y glufosinate más fluometuron. Los resultados de este estudio indican que pocos de los tratamientos con herbicidas estudiados proveen un control efectivo de *A. trifida* resistente a glyphosate sin reducir el rendimiento del algodõn WideStrike. Los tratamientos que tuvieron los mayores niveles de control de *A. trifida* en todas las evaluaciones y además tuvieron los mayores rendimientos incluyeron: glufosinate seguido de glufosinate, glufosinate más pyrithiobac y glufosinate más fluometuron en cada dosis. Sin embargo, glufosinate seguido de glufosinate fue el ũnico tratamiento que resultõ en un control de *A. trifida* superior al 90% sin reducir el rendimiento del cultivo.

Giant ragweed is a problematic summer annual weed in agronomic crops throughout the eastern United States (Baysinger and Sims 1991; Harrison et al. 2001; Johnson et al. 2006; Webster et al. 1994). It is a member of the Asteraceae family that can reach greater than 5 m in height (Bryson and DeFelice 2009). Giant ragweed primarily is known for being a weed in floodplains, fence rows, and ditch banks but, in the past few decades, has adapted to become competitive in agronomic crops (Bassett and Crompton 1982; Bryson and DeFelice 2009; Hartnett et al. 1987; Johnson et al. 2006; Steckel 2007).

Giant ragweed's rapid growth, extended emergence window, and ability to grow in a variety of environments have contributed to its success as a major competitor in corn (*Zea mays* L.), soybean [*Glycine max* (L.) Merr.], and cotton (Abul-Fatih and Bazzaz 1979b; Harrison et al. 2001). Once established, giant ragweed continues to thrive in its environment, with rapid growth producing large amounts of biomass and eventually suppressing all other plant species (Abul-Fatih and Bazzaz 1979a; Jurik 1991). Giant ragweed's growth varies based on crop and environment, but it typically grows 0.3 to 1.5 m taller than the crop with which it is competing (Johnson et al. 2006). Giant ragweed is certainly one of the most competitive weeds in corn and soybean. In corn, one giant ragweed plant per 10 m^2 can reduce yields by 13.6% (Harrison et al. 2001), and in soybean, one study indicated two giant ragweed plants per 9 m^{-1} per row could reduce yields by as much as 50%, and another study determined that 1 plant/m^{-2} of giant ragweed could reduce yields 45 to 77% (Baysinger and Sims 1991; Webster et al. 1994).

Additionally, giant ragweed's emergence window has evolved over the years, making it more challenging for

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growers to control. In the 1960s and 1970s, studies in Illinois indicated that giant ragweed seedlings started emerging in the beginning of March and continued through the first part of May (Abul-Fatih and Bazzaz 1979a; Stoller and Wax 1973). Now, giant ragweed in agronomic fields can emerge starting in mid-March and continue through mid-July (Harrison et al. 2001; Steckel 2007). This extended emergence window makes it difficult to control because early-germinating plants could become established before effective weed control measures can be taken, and plants that germinate in late June through July might escape POST weed control measures (Harrison et al. 2001; Schutte et al. 2008).

Giant ragweed has long been considered a common issue for growers in Midwestern corn and soybean fields, with Ohio and Indiana growers considering it one of the worst weed problems since the early 1990s (Gibson et al. 2005; Loux and Berry 1991). The introduction of glyphosate-resistant (GR) crops, including corn, cotton, and soybean, has provided POST options for difficult-to-control weeds. Glyphosate has been used heavily in cotton production since its introduction in 1997 because of its broad-spectrum control of most grass and broadleaf species (Askew et al. 2002; Baylis 2000; Duke and Powles 2009; Gianessi 2005; Owen and Zelaya 2005). However, GR giant ragweed can now be found in several states throughout the United States. Although GR giant ragweed is found primarily in Midwest corn and soybean states, such as Indiana, Iowa, Kansas, Minnesota, Missouri, and Ohio, it is also prevalent in cotton-growing states throughout the south, including Arkansas, Mississippi, and Tennessee (Heap 2011; Norsworthy et al. 2010, 2011). GR giant ragweed was first confirmed in Tennessee in 2007 and has continued to become problematic throughout the state (Norsworthy et al. 2010).

Currently, few POST herbicides provide effective control of GR giant ragweed (UT Extension 2011). Norsworthy et al. (2010) evaluated several potential options for control of GR giant ragweed in cotton. Trifloxysulfuron was determined to be effective on two-node giant ragweed, but provided only 55% control of six-node giant ragweed. Glufosinate was one of the most effective herbicide options for GR giant ragweed control. This herbicide provided greater than 90% control of GR giant ragweed when applied to two-node, four-node, or six-node GR giant ragweed. The opportunity and necessity to apply glufosinate POST in cotton is increasing with the adaptation and spread of GR weeds, as well as crops resistant to glufosinate. In 2011, 63% of Tennessee cotton acres were planted to cotton with tolerance to glyphosate and glufosinate in the form of WideStrike® (Dow AgroSciences, Indianapolis, IN) varieties (USDA-AMS 2011). With no known glufosinate-resistant broadleaf species in the world at this time (Heap 2011), glufosinate is an excellent option for controlling GR weeds such as giant ragweed. With the exception of herbicides that can be used as postdirected applications, no other herbicide provided control comparable to glufosinate.

WideStrike varieties were developed to confer resistance to lepidopteran insects through the insertion of two genes that express the Cry1Ac and Cry1F insecticidal proteins (Castle et al. 2006; Dow Chemical Company 2006). A *pat* gene was used as a selectable marker to determine the presence of the Cry1Ac and Cry1F genes, but this *pat* gene also confers tolerance to glufosinate. However, when the *pat* gene is used as a selectable marker, there are lower levels of pat activity, so the level of glufosinate tolerance is incomplete when compared with Liberty Link varieties (OECD 2002; Tan et al. 2006). One to two glufosinate applications to WideStrike varieties can cause crop injury ranging from 5 to 25% without decreasing yields (Barnett et al. 2011; Culpepper et al. 2009; Dodds et al. 2011; Whitaker et al. 2011). WideStrike varieties have performed well in Tennessee (USDA-AMS 2011), and the flexibility of being able to apply both glufosinate and glyphosate POST is appealing to growers. Although neither the manufacturer of glufosinate, nor the marketers of this cotton seed support POST application of glufosinate, many growers choose to use it as a tool for control of Palmer amaranth (*Amaranthus palmeri* S. Wats) (author's personal experience).

The development of herbicide-resistant biotypes of giant ragweed has led to fewer options for effective control in cotton. The objectives of this research were to (1) evaluate current control options for GR giant ragweed in WideStrike Flex cotton and (2) determine cotton response to herbicide treatments.

Materials and Methods

A field study was established to examine current control options for GR giant ragweed in WideStrike Flex cotton. In 2007, GR giant ragweed was first confirmed in Tennessee on a grower's field near Rutherford, TN (Norsworthy et al. 2010). This field had been planted to continuous cotton for at least 15 yr, and glyphosate was the primary POST product used during that time. Giant ragweed at this location had a 5.3 level of glyphosate resistance when compared with the susceptible biotype. This study was conducted at that same location with a present population of GR giant ragweed in 2009, 2010, and 2011. The experimental design was a randomized complete block design with three replications. Soil type at this location was a Lexington silt loam (fine silty, mixed, thermic Aeric Orchraqualfs) with 1% organic matter and soil pH 7.0. Row spacing was 97 cm, and plots measured two rows by 6 m. Phytogen 375 WRF (Dow AgroSciences, Indianapolis, IN) was planted at a population of 20,000 seed ha^{-1} on May 7, 2009, May 5, 2010, and May 31, 2011. A no-tillage system was used, and standard production practices were followed, with the exception of herbicide treatments. Treatments with application rates are listed in Table 1. Herbicides included glyphosate (Roundup PowerMax, Monsanto Co., St. Louis, MO), glufosinate (Ignite, Bayer CropScience, Research Triangle Park, NC), pyrithiobac (Staple LX, DuPont Crop Protection Co., Wilmington, DE), trifloxysulfuron (Envoke, Syngenta Crop Protection Inc., Greensboro, NC), and fluometuron (Cotoran, MANA of North America Inc., Raleigh, NC). The pyrithiobac alone or glyphosate plus trifloxysulfuron

Table 1. Response of WideStrike cotton to herbicide treatments applied at the one and five-leaf stages.[a]

Herbicide treatment	Rate	Application timing	Cotton injury[b]	
		Cotton stage, lf	7 DAA[c]	7 DAB[d]
	kg ai ha^{-1}			
Glufosinate	0.59	1	7 c[f]	5 a
Glyphosate	0.84[e]	1	1 a	4 a
Glufosinate + glyphosate	0.59 + 0.84[e]	1	9 cd	6 a
Pyrithiobac	0.11	1	3 ab	8 ab
Glyphosate + pyrithiobac	0.84[e] + 0.11	1	6 bc	10 ab
Glyphosate + glufosinate + pyrithiobac	0.84[e] + 0.59 + 0.11	1	11 d	12 bcd
Glufosinate + fluometuron	0.59 + 0.56	1	8 cd	11 abc
Glufosinate fb glufosinate	0.59 fb 0.59	1 + 5	8 cd	11 ab
Glyphosate + trifloxysulfuron	0.84[e] + 0.01	5	—	18 de
Glufosinate + pyrithiobac	0.59 + 0.11	5	—	21 e
Glufosinate + fluometuron	0.59 + 0.56	5	—	18 cde
Glufosinate + fluometuron	0.59 + 1.12	5	—	30 f

[a] Abbreviations: lf, leaf; DAA, days after first application; DAB, days after second application; fb, followed by.

[b] Cotton injury was rated on a scale of 0 (no injury) to 100 (plant death).

[c] Cotton injury rated at 7 d after the one-leaf application.

[d] Cotton injury rated at 7 d after the five-leaf application.

[e] Glyphosate rate listed in kg ae ha^{-1}.

[f] Means followed by the same letter are not significantly different according to Fisher's Protected LSD at $P \leq 0.05$.

treatments also contained non-ionic surfactant (NIS) at 0.25% (v/v). Applications with fluometuron were only applied in 2010 and 2011. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 94 L ha^{-1}. Treatments were applied to one- or five-leaf cotton, with the exception of a glufosinate application to one-leaf cotton followed by another glufosinate application to five-leaf cotton. The five-leaf application was made approximately 7 to 10 d after the one-leaf application. Giant ragweed height at the one-leaf application was approximately 20 to 25 cm and 30 to 51 cm at the five-leaf application. A nontreated control was also included in 2009; however, the glyphosate-treated plot was considered the main comparison for control because of the presence of GR giant ragweed.

Data were subjected to analysis of variance using the PROC MIXED model in SAS (ver. 9.2; SAS Institute, Cary, NC). Herbicide treatment and cotton growth stage were considered fixed main effects. Replication and year were treated as random effects as well as any interactions containing these random effects. Means were separated using Fishers Protected LSD at a significance level of 0.05.

Cotton response was evaluated approximately 7 d after the first application (A) and 7 d after the second application (B). Giant ragweed control was evaluated 7 d after the first application (DAA) and 7, 21, and 30 d after the second application (DAB). These evaluations were completed on a scale of 0 (no plant injury) to 100 (plant death) (Frans et al. 1986). Giant ragweed counts were recorded, and giant ragweed fresh weights were collected for two 0.3-m^2 sections and normalized to 1.0-m^2 sections for each plot. Plants 3 m from the center of each plot were harvested by hand and collected to determine lint percentage. Seed cotton was ginned on a laboratory gin without lint cleaning.

Results and Discussion

Cotton Injury. Seven days after the first application, crop injury ranged from 0 to 11% (Table 1) with visual estimates of injury ($P < 0.0001$). All treatments resulted in higher crop injury than glyphosate alone (0%) or pyrithiobac alone (3%). However, cotton injury was less than 11% for each of these applications.

Crop response to five-leaf applications ranged from 4 to 30% for crop injury (Table 1). Of all of the treatments applied at the five-leaf stage, glufosinate plus fluometuron at 1.12 kg ai ha^{-1} resulted in the highest crop injury (30%). Glyphosate plus trifloxysulfuron, glufosinate plus pyrithiobac, and the one-leaf application of glufosinate plus fluometuron at 0.56 kg ha^{-1} resulted in statistically lower injury, but values were still high and ranged from 18 to 21%. Glufosinate applied at the one- and five-leaf stages had the least injury of any application made to five-leaf cotton (11%) and was similar to all applications at the one-leaf stage. Injury from one-leaf applications increased from the first rating for some applications; however, all one-leaf applications had less than 13% injury. Three weeks after the five-leaf application, there was no visible crop injury (data not shown).

Glufosinate injury of less than 20% for one to two applications to WideStrike cotton was consistent with other research (Culpepper et al. 2009; Steckel et al. 2011; Whitaker et al. 2011). Applications that contained glufosinate plus fluometuron had the highest amount of crop injury. Previous studies have reported similar stunting and chlorosis symptomology from POST applications of fluometuron alone (Arle and Hamilton 1976; Guthrie and York 1989). Fluometuron has been observed to result in cotton injury ranging from 14 to 28% (Snipes and Byrd 1994), whereas studies by Byrd and York (1987) observed fluometuron injury of 22%. Several studies have also

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Table 2. Glyphosate-resistant giant ragweed control with herbicide treatments applied at the 1-lf and 5-lf stages to WideStrike cotton.[a]

Herbicide treatment	Rate	Application timing Cotton stage, lf	Giant ragweed control[b] 7 DAA[c]	7 DAB[d]	21 DAB[e]	30 DAB[f]
	kg ai ha^{-1}					
Glufosinate	0.59	1	85 ab[h]	76 bcd	83 ab	75 ab
Glyphosate	0.84[g]	1	31 c	31 h	57 cd	30 d
Glufosinate + glyphosate	0.59 + 0.84[g]	1	88 a	66 def	82 ab	69 abc
Pyrithiobac	0.11	1	31 c	41 gh	51 d	45 cd
Glyphosate + pyrithiobac	0.84[g] + 0.11	1	34 c	56 ef	73 bc	67 abc
Glyphosate + glufosinate + pyrithiobac	0.84[g] + 0.59 + 0.11	1	86 a	70 cde	74 b	63 bc
Glufosinate + fluometuron	0.59 + 0.56	1	69 b	57 ef	83 ab	86 ab
Glufosinate fb glufosinate	0.59 fb 0.59	1 + 5	88 a	94 a	94 a	93 a
Glyphosate + trifloxysulfuron	0.84[g] + 0.01	5	—	53 fg	78 ab	64 bc
Glufosinate + pyrithiobac	0.59 + 0.11	5	—	87 ab	84 ab	70 abc
Glufosinate + fluometuron	0.59 + 0.56	5	—	84 abc	89 ab	86 ab
Glufosinate + fluometuron	0.59 + 1.12	5	—	89 ab	78 ab	85 ab

[a] Abbreviations: lf, leaf; DAA, days after first application; DAB, days after second application; fb, followed by.
[b] Cotton injury was rated on a scale of 0 (no injury) to 100 (plant death).
[c] Giant ragweed control rated at 7 d after the one-leaf application.
[d] Giant ragweed control rated at 7 d after the five-leaf application.
[e] Giant ragweed control rated at 21 d after the five-leaf application.
[f] Giant ragweed control rated at 30 d after the five-leaf application.
[g] Glyphosate rate listed in kg ae ha^{-1}.
[h] Means followed by the same letter are not significantly different according to Fisher's Protected LSD at $P \leq 0.05$.

observed similar cotton injury from trifloxysulfuron applications, with injury ranging from 7 to 24% (Koger et al. 2005; Richardson et al. 2007; Thomas et al. 2006). Pyrithiobac injury was minimal in our studies, unless applied with glufosinate. This was similar to several studies across the mid-South that reported little pyrithiobac injury to cotton (Harrison et al. 1996; Keeling et al. 1993; Shankle et al. 1996). Injury from these applications was similar to what is previously reported in the literature, but the application of some of these herbicides in combination with glufosinate increased injury.

GR Giant Ragweed Control. Herbicide treatments applied to cotton at the one-leaf stage resulted in varying levels of control ($P < 0.0001$). None of the treatments provided greater than 88% control of GR giant ragweed 7 DAA

Table 3. Glyphosate-resistant giant ragweed counts and fresh weights 30 d after the five-leaf application, and cotton lint yield with varying POST herbicide applications.[a]

Herbicide treatment	Rate	Application timing Cotton stage, lf	Giant ragweed Count	Giant ragweed Biomass[b]	Cotton lint yield[c]
	kg ai ha^{-1}		Plant density m^{-2}	g m^{-2}	kg ha^{-1}
Glufosinate	0.59	1	3.1[e]	203 abc[f]	994 a[g]
Glyphosate	0.84[d]	1	3.3	1,240 d	601 b
Glufosinate + glyphosate	0.59 + 0.84[d]	1	2.8	307 abc	979 a
Pyrithiobac	0.11	1	3.9	595 bc	625 b
Glyphosate + pyrithiobac	0.84[d] + 0.11	1	1.7	610 bc	619 b
Glyphosate + glufosinate + pyrithiobac	0.84[e] + 0.59 + 0.11	1	1.4	718 cd	931 a
Glufosinate + fluometuron	0.59 + 0.56	1	1.1	657 c	792 ab
Glufosinate fb glufosinate	0.59 fb 0.59	1 + 5	0.6	9.5 a	1,029 a
Glyphosate + trifloxysulfuron	0.84[d] + 0.01	5	3.6	501 abc	513 b
Glufosinate + pyrithiobac	0.59 + 0.11	5	1.7	586 bc	984 a
Glufosinate + fluometuron	0.59 + 0.56	5	0.8	222 abc	922 a
Glufosinate + fluometuron	0.59 + 1.12	5	0.5	56.7 ab	790 ab

[a] Abbreviations: fb, followed by; lf, leaf.
[b] Giant ragweed biomass collected and weighed in grams for 1.0 m^2 in each plot, 30 d after the five-leaf application.
[c] Cotton yield collected from 3 m of one row for each plot.
[d] Glyphosate rate listed in kg ae ha^{-1}.
[e] Means were not statistically significant using Fisher's Protected LSD at $P \leq 0.05$.
[f] Means followed by the same letter are not different according to Fisher's Protected LSD at $P \leq 0.05$.
[g] Means followed by the same letter are not different according to Fisher's Protected LSD at $P \leq 0.05$.

(Table 2). Glufosinate alone, glufosinate plus glyphosate, and glufosinate plus glyphosate plus pyrithiobac provided the most complete control (85 to 88%). The application of glufosinate plus fluometuron resulted in 69% control, which was lower than all treatments with the highest level of control, with the exception of the glufosinate alone application. All other herbicide treatments provided less than 40% control and did not differ from glyphosate (31% control).

GR giant ragweed control ranged from 31 to 94% ($P < 0.0001$) 7 DAB. Glufosinate applied at the one-leaf stage followed by glufosinate at the five-leaf stage resulted in the highest level of control at 94%. Glufosinate plus fluometuron (1.12 kg ha^{-1}), glufosinate plus fluometuron (0.56 kg ha^{-1}), and glufosinate plus pyrithiobac also had similar control, at 84 to 89%. All applications made to one-leaf cotton had less than 75% control approximately 7 DAB. Glufosinate followed by glufosinate continued to provide excellent control (92%) of GR giant ragweed at 21 DAB (Table 3). Glufosinate plus fluometuron (all applications), glufosinate plus pyrithiobac, glufosinate plus trifloxysulfuron, glufosinate plus glyphosate, and glufosinate alone also provided similar levels of control (78 to 89%), and these treatments continued to provide similar levels of control to the glufosinate followed by glufosinate application (93% control) 21 DAB.

The level of control observed with applications of pyrithiobac or trifloxysulfuron on giant ragweed was consistent with observations made by Norsworthy et al. (2010), where control ranged from between 55% and 64% for trifloxysulfuron and pyrithiobac, respectively. The addition of glufosinate to pyrithiobac increased control to 87% 7 DAB and 84% control 21 DAB (Table 2). Trifloxysulfuron appears to be a more effective POST option for seedling giant ragweed control (Norsworthy et al. 2010) and therefore demonstrated lower control of larger giant ragweed in our study. Although Norsworthy et al. (2010) determined that glufosinate alone provided greater than 90% control with one application, our results indicated that glufosinate alone provided only 75 to 85% control. However, glufosinate followed by glufosinate provided the greatest level of control of GR giant ragweed. This application resulted in greater than 90% control, even 30 DAB. Applying sequential applications will most likely be necessary because of the continued emergence of giant ragweed throughout the growing season. However, from a resistance management perspective, the use of multiple modes of action is recommended to delay the development of glufosinate-resistant weeds. Additionally, treatments such as glufosinate plus pyrithiobac or glufosinate plus fluometuron add a residual component to applications that only include glufosinate.

Giant Ragweed Counts and Biomass. Giant ragweed counts ranged from 0 to 3.8 plants m^{-2} but were not different from one another ($P = 0.09$). However, giant ragweed biomass proved to be a better indicator of differences between treatments ($P = 0.0094$). Giant ragweed biomass ranged from 8.3 to 1,288 g m^{-2} (Table 3). Consistent with the level of control observed with the glufosinate followed by glufosinate application, this treatment had the least amount of giant ragweed biomass of any treatment (9.5 g). Glufosinate plus fluometuron (1.12 kg ha^{-1}) also resulted in less than 100 g of giant ragweed biomass. Other treatments provided similar levels of biomass, but ranged from 203 to 500 g. The glyphosate treatment had the highest level of giant ragweed biomass at 1,242 g m^{-2}.

Effect of Herbicide Applications on Yield. Crop loss due to giant ragweed competition and crop injury from herbicide applications was evident ($P = 0.0001$). Several treatments were statistically similar, indicating that although crop injury might have been evident, yield was not affected. The highest yielding treatments included glufosinate followed by glufosinate, glufosinate alone, glufosinate plus pyrithiobac, glufosinate plus glyphosate, glyphosate plus glufosinate plus pyrithiobac, and all applications of glufosinate plus fluometuron (Table 3). Despite increased crop injury with applications of glufosinate plus fluometuron, lint yield was not reduced. Byrd and York (1987) determined that lint yield could be reduced by fluometuron applications. However, our results coincide with other studies that determined that fluometuron does not reduce yield (Arle and Hamilton 1976; Guthrie and York 1989; Snipes and Byrd 1994). Pyrithiobac alone, glyphosate plus pyrithiobac, glyphosate plus trifloxysulfuron, and glyphosate alone statistically reduced yields when compared with all other treatments except glufosinate plus fluometuron at 0.56 kg ha^{-1} at the one-leaf stage and glufosinate plus fluometuron at 1.12 kg ha^{-1}. These treatments did not effectively control GR giant ragweed, so yields were reduced as a result of weed interference. The glyphosate-treated plot resulted in a yield of 601 kg ha^{-1} compared with the glufosinate followed by glufosinate treatments, which resulted in 1,029 kg ha^{-1}. However, this was still considerably better than the nontreated control (in 2009), which had no harvestable bolls at harvest.

These data demonstrate that effective POST options for GR giant ragweed include treatments that contain glufosinate. Not only was GR giant ragweed control increased with applications containing glufosinate, but lint yields were also increased when compared with the glyphosate-treated application. Previous work has shown that one to two applications of glufosinate to WideStrike cotton do not reduce yields, and our results coincide with this work as well (Culpepper et al. 2009; Steckel et al. 2011; Whitaker et al. 2011). Sequential applications of glufosinate will most likely be necessary to control larger GR giant ragweed and to control plants that emerge later in the growing season. Crop yields were reduced with certain applications because of either competition from poor control of GR giant ragweed or crop injury from herbicide treatments. Despite visible necrosis with applications that contained fluometuron or pyrithiobac, with injury ranging from 18 to 30% 7 DAB, crop yields were not reduced at the end of the growing season. Using fluometuron or pyrithiobac with glufosinate applications not only maintained yields but also provided effective control of GR giant ragweed. These options could be good

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for tank-mixed applications with glufosinate because they will add residual control of giant ragweed. Currently there are no known glufosinate-resistant broadleaf weeds, but growers will have to continue to use multiple modes of action, in addition to glufosinate, to prevent this from occurring.

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