The *Journal of Cotton Science 23:262–269 (2019)*
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WEED SCIENCE

LibertyLink®, WideStrike® and XtendFlex® Tolerance to Late Postemergence Applications of Glufosinate and *S*-Metolachlor

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ABSTRACT

Glufosinate remains an important postemergence (POST) herbicide for controlling glyphosate-resistant *Amaranthus palmeri* (S. Wats) in auxin-tolerant trait systems. Although visual injury from glufosinate applications to WideStrike cultivars is expected, concerns have been raised on the visual injury noted in XtendFlex cultivars, particularly with sequential late-POST glufosinate applications or when *S*-metolachlor is tank-mixed with glufosinate. Field trials were established in Jackson, TN during 2015 and 2017 and in Huntersville, TN during 2016. Herbicide treatments included an untreated; one, two, and three sequential applications of glufosinate; and glufosinate + *S*-metolachlor followed by (FB) glufosinate FB glufosinate + *S*-metolachlor. Applications began 40 days after planting and sequential applications were made every 10 to 14 days. Cultivars included DP 1522 B2XF (DeltaPine, Bayer CropScience, St. Louis, MO), PHY 333 WRF (Phytogen, Corteva Agriscience, Indianapolis, IN), and ST 4946 GLB2 (Stoneville, BASF Corp., Florham Park, NJ). Visual injury ratings varied across timing, treatment, cultivar, and site-year. Three sequential applications of glufosinate with two applications of *S*-metolachlor caused 7 to 20%, 2 to 15%, and 1 to 8% injury 10 days after the last application in PHY 333 WRF, DP 1522 B2XF, and ST 4946 GLB2, respectively. Cultivar lint yield and fiber quality did not vary by herbicide treatment. Producers who apply glufosinate should expect increasing visual injury from LibertyLink to XtendFlex to WideStrike cultivars, with a sharp increase in visual injury from XtendFlex to WideStrike cultivars; however, sequential, labeled applications of glufosinate with or without two applications of *S*-metolachlor will likely not impact yields of LibertyLink, WideStrike, or XtendFlex cultivars.

Over-reliance on glyphosate for weed control in glyphosate-tolerant cropping systems has resulted in glyphosate resistance in many weed species in the U.S. (Heap, 2019). Glyphosate-resistant Palmer amaranth (*Amaranthus palmeri*, S. Wats) has spread across the Mid-South and Southeast U.S. (Nichols et al., 2009). Prior to the introduction of 2,4-D- and dicamba-tolerant cotton (*Gossypium hirsutum*, L.) cultivars, the commercialization of glufosinate-tolerant cropping systems led to glufosinate becoming the preferred postemergence (POST) herbicide for producers in combatting glyphosate-resistant Palmer amaranth (Sosnoskie and Culpepper, 2014). Glufosinate can provide effective control of some annual grasses and broadleaf species when timely applications are made (Anonymous, 2016; Steckel et al., 1997), but sequential applications of glufosinate are occasionally necessary to achieve acceptable levels of control of large *Amaranthus* species (Coetzer et al., 2002). The current Liberty 280 SL label (Bayer CropScience, Research Triangle Park, NC) allows three sequential applications of 594 g ai ha^{-1} to be applied prior to early bloom for a total-season use rate of 1,784 g ai ha^{-1} (Anonymous, 2016). Although the introduction of 2,4-D-tolerant and dicamba-tolerant cotton cultivars likely will result in a reduction of the use of glufosinate, glufosinate will remain a critical component of a resistance management strategy; Palmer amaranth susceptibility to dicamba and 2,4-D recently has been shown to decline within three generations (Tehranchian et al., 2017).

Glufosinate tolerance in cotton has been achieved with the insertion of either the *bar* or *pat* gene. The *bar* gene, present in LibertyLink (BASF Corp., Florham Park, NJ) and XtendFlex (Bayer CropScience, Research Triangle Park, NC) cotton, confers resistance to glufosinate (Car-

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bonari et al., 2016; Perez-Jones et al., 2018). The *pat* gene, which confers low levels of resistance to glufosinate, is inserted as a marker gene in WideStrike (Corteva Agriscience, Indianapolis, IN) for the confirmation of the successful insertion of an insect resistance trait. Visual injury is often observed when POST applications of glufosinate are made to WideStrike cotton due to lower levels of resistance compared to LibertyLink cotton, but this injury is minimal or nonexistent by 21 days after application (DAA) (Ducar and Price, 2017; Inman et al., 2014).

Although timely applications of glufosinate alone can control many weed species, it is often recommended to make applications with the addition of residual herbicides (Steckel et al., 2019). Glufosinate is often tank-mixed with a chloroacetamide (WSSA Group 15) herbicide, but this combination commonly results in greater injury (Culpepper et al., 2009; Ducar and Price, 2017). Culpepper et al. (2009) observed a significant increase in crop injury (average of 6.5% 5 DAA) when glufosinate was tank-mixed with *S*-metolachlor than when glufosinate was applied alone. Barnett et al. (2013) also observed an increase in crop injury when fluometuron was tank-mixed with glufosinate (25%) than glufosinate alone (10%).

POST glufosinate applied to WideStrike cultivars, particularly in combination with other products, often causes greater cotton injury than that caused by other POST herbicides; however, it is rare to observe yield loss due to glufosinate injury early in the season, even when 11 to 27% injury is noted after the application (Barnett et al., 2013; Cahoon et al., 2015b; Culpepper et al., 2009; Whitaker et al., 2011). Dodds et al. (2011) observed an increase in cotton injury from 15 to 47% as glufosinate application rate increased from 590 to 2,380 g ai/ha^{-1}, but observed no yield differences.

In contrast, cultivars that contain the *bar* gene are often characterized as nonresponsive to glufosinate. Blair-Kerth et al. (2001) evaluated the tolerance of a transformed Coker 312 line and noted no visual injury, no plant height reductions, and no impacts on lint yield or fiber quality from single applications of glufosinate beginning at the cotyledon stage and terminating at 50% open boll. Wallace et al. (2011) observed no visual injury or impact on lint yield and fiber quality from up to four sequential applications of glufosinate applied up to 50% cracked boll to LibertyLink cotton. Although Dodds et al. (2015) was able to elicit a node above cracked boll (NACB) response from a LibertyLink cultivar with the application of 2,400 g ai ha^{-1}, the application did not significantly impact lint yield or fiber quality.

Although growers in Tennessee expect visual injury from glufosinate applications to WideStrike cultivars and negligible to no injury from glufosinate applications to LibertyLink cultivars, concerns have been raised on the level of injury observed in XtendFlex cultivars following glufosinate applications. Therefore, the objectives of this experiment were to: (1) evaluate the impacts of late-POST sequential applications of glufosinate and glufosinate + *S*-metolachlor on visual crop response, growth, maturity, and yield, and (2) determine if the impacts vary among cultivars containing the LibertyLink, WideStrike, and XtendFlex traits.

MATERIALS AND METHODS

Field trials were established at the West Tennessee Research and Education Center during 2015 and 2017, and at Huntersville, TN during 2016. Soil type, planting dates, application dates, rating dates, and harvest dates are summarized in Table 1. Each trial was designed as a split-plot trial with four replications. Main plot units consisted of herbicide treatments and were eight 97-cm rows wide and 9 m in length. Subplots consisted of cultivar treatments and were two rows wide and 9 m in length. The first and eighth row of each main plot unit served as border rows.

Table 1. Agronomic information and application details for each location during the 2015-2017 growing seasons

Year	Location	Soil Type	Planting	Application			Late-season Data Collection	Harvest
				A	B	C		
2015	**Jackson, TN**	**Grenada silt loam**	**19-May**	**30-Jun**	**14-Jul**	**24-Jul**	**15-Sep**	**3-Nov**
2016	**Huntersville, TN**	**Calloway silt loam**	**11-May**	**20-Jun**	**30-Jun**	**11-Jul**	**12-Sep**	**24-Oct**
2017	**Jackson, TN**	**Grenada silt loam**	**16-May**	**27-Jun**	**7-Jul**	**17-Jul**	**27-Sep**	**18-Oct**

Five herbicide treatments were established and included: (1) an untreated; (2) one application of glufosinate; (3) two sequential applications of glufosinate; (4) three sequential applications of glufosinate, and (5) glufosinate + *S*-metolachlor FB glufosinate FB glufosinate + *S*-metolachlor. Glufosinate was applied as Liberty 280 SL and *S*-metolachlor was applied as Dual Magnum (Syngenta Corp., Wilmington, DE). Application rates of glufosinate and *S*-metolachlor were 594 g ai ha^{-1} and 1,070 g ai ha^{-1}, respectively. Applications were made with a high-clearance multi-boom compressed air sprayer (LeeAgra, Inc., Lubbock, TX). Spray volume for each application was 140 L ha^{-1}. Spray tips used were TeeJet XR8002VS tips (TeeJet Technologies, Wheaton, IL). Each glufosinate application was made within 3 h of solar noon to avoid lower levels of injury that have been noted near dawn or dusk (Montgomery et al., 2017). The first applications were applied approximately 40 d after planting when the cotton had entered the squaring stage. The initial application timing was selected to maximize the leaf area of the cotton plant that would be impacted by the herbicide without pushing sequential applications outside the labeled application window. Sequential applications were made 10 to 14 d after the initial application. During 2015 and 2017, flowers were present at the time of the final application. During 2016, the field was within approximately 5 d of flower at the time of the final application. Environmental conditions prior to, during, and after each application are reported in Table 2.

Cultivars included DP 1522 B2XF (DeltaPine, Bayer CropScience), PHY 333 WRF (Phytogen, Corteva Agriscience), and ST 4946 GLB2 (Stoneville, BASF Corp.). All varieties were planted at 118,610 seed ha^{-1}. Cotton was cone-planted into no-till ground each year and managed in accordance with University of Tennessee Extension recommendations (Raper, 2018). Paraquat dichloride (1,1'-dimethyl-4,4'-bipyridinium dichloride) + fluometuron (1,1-dimethyl-3-(a,a,a-trifluoro-m-toyl) urea) + prometryn (2,4-bis(isopropylamino)-6-(methyltio)-s-triazine) + nonionic surfactant were applied at planting at 700, 841, and 841 g ai ha^{-1} and 0.25% volume surfactant per volume spray solution (v/v), respectively. Weeds that emerged after this application were either managed with blanket applications of glyphosate at 840 g ai ha^{-1} or removed by hand.

Table 2. Environmental conditions at the time of application

DOA[z]	Relative humidity, %	Daily Temperature, °C		Precipitation, mm						
		Max	Min	3 DPA[y]	2 DPA	1 DPA	DOA	1 DAA[x]	2 DAA	3 DAA
				2015						
30-Jun	72	31	21	0	0	7	0	0	5	9
14-Jul	79	36	22	0	0	0	5	0	0	0
24-Jul	76	34	23	0	4	28	0	0	0	0
				2016						
20-Jun	70	32	21	0	0	0	0	0	0	0
30-Jun	69	31	16	1	1	0	0	0	0	0
11-Jul	86	30	22	0	2	0	0	0	0	2
				2017						
27-Jun	77	28	17	0	0	0	4	0	2	4
7-Jul	82	32	22	12	20	13	0	9	0	0
17-Jul	73	33	18	0	0	0	0	0	0	0

[z] Day of application (DOA).

[y] Day(s) prior application (DPA).

[x] Day(s) after application (DAA).

Cotton injury ratings were collected between 7 and 10 DAA. Tissue necrosis and chlorosis was visually rated, with 0% representing no injury and 100% representing complete cotton death (Frans et al., 1986). Approximately 125 d after planting, plant height, total nodes, and NACB data were collected from six plants within each plot. The trial was defoliated when the uppermost harvestable boll developed seedcoat color, was difficult to cut with a knife, and did not contain jelly within the seed (Dodds et al., 2018). Approximately 14 DAA of the defoliant, plots were harvested with a spindle picker (Case IH 1822, CNH Industrial America LLC, Racine, WI) outfitted with automated load cells. Approximately 2 kg of seed cotton was collected from each treatment to determine lint turnout and fiber quality. Subsamples were ginned at the University of Tennessee MicroGin in Jackson, TN. Due to the small seed cotton sample sizes, turnouts were averaged across cultivar each year. Fiber samples from each treatment were classed on high volume instrumentation (HVI) at the USDA Classing Office in Memphis, TN.

Data were subjected to the PROC MIXED procedure in SAS v9.4 (SAS Institute Inc., Cary, NC). Visual injury rating data was analyzed by site-year and by rating timing to capture variability of observed injury noted in variable environmental conditions and timings. Least square means (p = 0.05) were calculated in SAS with a macro written by Saxton (2012). Site-year, replication nested within site-year, and all subsequent interactions were considered random effects (Carmer et al., 1989) for total node, plant height, NACB, lint yield, and fiber quality data. Total node, plant height, NACB, lint yield, and fiber quality means were separated using Fishers's protected Least Significant Difference (LSD) at an alpha level equal to 0.1 when treatment effects were identified to be significant by the ANOVA test.

RESULTS

Visual Injury Ratings. Visual injury ratings varied across timing, treatment, cultivar, and site-year. During the 2015 and 2017 seasons, the greatest levels of visual injury were noted after the first application and visual ratings declined after the second and third applications (Table 3). In contrast, the 2016 visual injury ratings declined only slightly from the first to second applications and then increased after the third application timing.

Whereas DP 1522 B2XF was typically characterized by greater levels of visual injury than ST 4946 GLB2 when three sequential applications of glufosinate with the first and third containing *S*-metolachlor were applied, differences between these cultivars were rarely significant when only single or sequential applications of glufosinate were applied. In contrast, PHY 333 WRF was commonly characterized by greater levels of visual injury to glufosinate applied alone than DP 1522 B2XF or ST 4946 GLB2. Three sequential applications of glufosinate with two applications of *S*-metolachlor caused 7 to 20%, 2 to 15%, and 1 to 8% injury 10 d after the last application within PHY 333 WRF, DP 1522 B2XF, and ST 4946 GLB2, respectively (Table 3). The greatest levels of visual injury were noted in PHY 333 WRF that received three sequential glufosinate applications with the first and third containing *S*-metolachlor (24% after POST 1 in 2015; 23% after POST 1 in 2016; 20% after POST 3 in 2016).

The recovery of the single and two sequential glufosinate treatments over time is captured in Table 3. By the last rating date, injury from single or two sequential glufosinate treatments ranged from 0 to 8%, 0 to 3%, and 0 to 1%, for PHY 333 WRF, DP 1522 B2XF, and ST 4946 GLB2, respectively. The reported injury maximum likely would have been lower if dry environmental conditions had not occurred during the 2016 season (Table 2).

Growth Measurements. Total nodes, plant height, and NACB were not significantly impacted by herbicide application but were significantly impacted by cultivar (Table 4). Cultivar DP 1522 B2XF had significantly more total nodes and NACB than PHY 333 WRF but did not have significantly more total nodes or NACB than ST 4946 GLB2. Cultivar PHY 333 WRF was significantly taller than ST 4946 GLB2 but was similar in height to DP 1522 B2XF.

Lint Yield and Fiber Quality. The response of lint yield and fiber quality to herbicide treatment was not significant, but cultivar significantly impacted lint yield and fiber quality parameters of micronaire, length, and strength (Table 4). Cultivars DP 1522 B2XF and PHY 333 WRF produced similar quantities of lint but more lint than ST 4946 GLB2. Fiber quality results closely match those reported in variety testing publications (Raper et al., 2016, 2017).

Table 3. Visual injury response of cotton cultivars to herbicide treatment observed 7-10 days after– application during 2015, 2016, and 2017

Treatment	2015			2016			2017		
	Percent visual injury rating collected 7 d after								
	POST 1[z]	POST 2	POST 3	POST 1	POST 2	POST 3	POST 1	POST 2	POST 3
DP 1522 B2XF									
Untreated	0 e[W]	0 f	0 d	0 g	0 de	0 c	0 ef	0 e	0 d
Glufosinate[Y]	8 cd	4 de	0 d	3 ef	1 cde	0 c	3 cde	0 e	1 cd
Glufosinate FB Glufosinate	8 cd	7 c	0 d	4 def	1 cde	3 bc	0 ef	2 cde	0 d
Glufosinate FB Glufosinate FB Glufosinate	8 cd	6 cd	2 c	4 cde	3 c	5 bc	1 ef	2 cde	0 d
Glufosinate + S-metolachlor[X] FB Glufosinate FB Glufosinate + S-metolachlor	16 b	9 b	4 b	7 c	1 cde	15 a	5 cd	4 c	2 c
PHY 333 WRF									
Untreated	0 e	0 f	0 d	0 g	0 de	0 c	0 ef	0 e	0 d
Glufosinate	14 b	8 bc	0 d	11 b	2 cd	3 bc	9 b	3 cd	2 c
Glufosinate FB Glufosinate	16 b	14 a	0 d	12 b	9 b	8 b	10 b	7 b	2 cd
Glufosinate FB Glufosinate FB Glufosinate	16 b	13 a	6 a	12 b	14 a	18 a	10 b	11 a	5 b
Glufosinate + S-metolachlor FB Glufosinate FB Glufosinate + S-metolachlor	24 a	14 a	7 a	23 a	12 a	20 a	17 a	10 a	7 a
ST 4946 GLB2									
Untreated	0 e	0 f	0 d	0 g	0 de	0 c	0 ef	0 e	0 d
Glufosinate	5 d	3 e	0 d	3 ef	0 e	0 c	0 f	0 e	1 cd
Glufosinate FB Glufosinate	5 d	4 de	0 d	3 ef	0 de	0 c	0 ef	0 e	0 d
Glufosinate FB Glufosinate FB Glufosinate	6 cd	4 de	0 d	2 fg	0 cde	0 c	2 def	0 e	1 cd
Glufosinate + S-metolachlor FB Glufosinate FB Glufosinate + S-metolachlor	10 c	7 c	1 c	6 cd	3 c	8 b	6 c	1 de	1 cd

[Z] Postemergence (POST) 1, POST 2, and POST 3 targeted 40, 50 and 60 days after planting, respectively.

[Y] Glufosinate was applied as Liberty 280 SL (Bayer CropScience, Research Triangle Park, NC) at 594 g ai ha^{-1} at each application timing.

[X] *S*-metolachlor was applied as Dual Magnum (Syngenta Corp., Wilmington, DE) at 1070 g ai ha^{-1} at each application timing.

[W] Values not sharing any letter within the same column among all three varieties are significantly different by the Fisher's protected Least Significant Difference at the 5% level of significance.

Table 4, Effects of cultivar and herbicide application on total nodes, height, node above cracked boll, and cotton lint yield averaged across the 2015, 2016, and 2017 seasons

	Total nodes	Height cm	NACB[Z]	Lint yield kg ha^{-1}	Micronaire units	Length mm	Strength kN m kg^{-1}	Uniformity %
			Herbicide					
Untreated	16.9 ns[V, U]	104 ns	4.3 ns	1391 ns	4.8 ns	29.8 ns	316 ns	83.0 ns
Glufosinate[Y]	17.1 ns	105 ns	3.9 ns	1452 ns	4.7 ns	29.8 ns	310 ns	83.0 ns
Glufosinate FB[X] Glufosinate	17.1 ns	104 ns	4.1 ns	1424 ns	4.7 ns	30.0 ns	313 ns	83.3 ns
Glufosinate FB Glufosinate FB Glufosinate	17.3 ns	103 ns	4.3 ns	1429 ns	4.7 ns	30.3 ns	316 ns	83.1 ns
Glufosinate + S-metolachlor[W] FB Glufosinate FB Glufosinate + S-metolachlor	17.5 ns	103 ns	4.7 ns	1345 ns	4.7 ns	30.2 ns	314 ns	83.4 ns
			Cultivar					
DP 1522 B2XF	18.0 a	105 ab	4.6 a	1430 a	4.9 a	29.7 b	307 b	83.1 ns
PHY 333 WRF	16.6 b	107 a	3.9 b	1440 a	4.5 b	30.4 a	310 b	83.0 ns
ST 4946 GLB2	17.0 b	100 b	4.3 ab	1354 b	4.8 a	29.9 b	324 a	83.3 ns

[Z] Node above cracked boll measurement (NACB).

[Y] Glufosinate was applied as Liberty 280 SL (Bayer CropScience, Research Triangle Park, NC) at 594 g ai ha^{-1} at each application timing.

[X] Followed by (FB).

[W] *S*-metolachlor was applied as Dual Magnum (Syngenta Corp., Wilmington, DE) at 1,070 g ai ha^{-1} at each application timing.

[V] Not significantly different at the 5% level of significance (ns).

[U] Values not sharing any letter are significantly different by Fisher's protected Least Significant Difference at the 10% level of significance.

DISCUSSION

Visual Injury Ratings. Visual injury ratings captured from the WideStrike (PHY 333 WRF) treatments are consistent with injury reported by Steckel et al. (2012) and Culpepper et al. (2009), slightly higher than those observed by Barnett et al. (2015), and lower than those observed by Stewart et al. (2013). Steckel et al. (2012) reported 18 and 23% average injury from glufosinate and glufosinate plus *S*-metolachlor, respectively. Applied glufosinate rates reported by Steckel et al. (2012) are identical to rates applied within this research. Culpepper et al. (2009) reported 14% and 20% injury from a single application of glufosinate and an application of glufosinate plus *S*-metolachlor, respectively, but application rates of glufosinate in their studies were lower (430 g ai ha^{-1} instead of 594 g ai ha^{-1}). Barnett et al. (2015) applied glufosinate at similar application rates but noted less injury (11% max at 5 DAA). Differences in injury could be due to differences in tested cultivars and environmental conditions surrounding the application timing or the growth stage; in this study, sequential applications were stacked at the end of the application window. Although other studies have examined the response to glufosinate applications in similar application windows, few applied sequential applications in such a short interval.

Visual injury ratings captured from the LibertyLink cultivar are consistent with data collected from Sweeney and Jones (2015), who noted a range of 1 to 6% injury (addition of chlorosis and necrosis ratings) in LibertyLink cultivars and approximately 14% injury in WideStrike cultivars. Similarly, Dodds et al. (2015) observed 1% injury in LibertyLink and 12% injury in WideStrike cultivars 7 DAA of 600 g ai ha^{-1}.

Visual injury ratings captured from XtendFlex cultivars are consistent with data collected by Vann et al. (2017), who noted < 4% injury in XtendFlex cotton when several mixtures and timings of glufosinate and dicamba were applied. Similarly, Cahoon et al. (2015a) noted 3 to 6% injury when glufosinate was applied alone or with dicamba in North Carolina and 9 to 14% injury in Georgia, but authors concluded this injury was “transitory and did not affect cotton yield.”

It is suspected the slight variations in observed injury ratings across trials are not a function of humidity or temperature, but instead a function of crop condition before, during, and after each application timing. Although increases in relative humidity have been associated with increased levels of herbicide efficacy (Coetzer et al., 2001; Ramsey et al., 2002), relative humidity levels varied slightly (69-86%) across all application timings (Table 2). Range of relative humidity during application timings was narrower than reported by Culpepper et al. (2009), who reported a range of humidity from less than 67% to greater than 90%. Furthermore, the narrow range of observed temperatures at the time of application (28.3-35.6 °C) fall well within the predicted thermal range of glufosinate tolerance predicted by Mahan et al. (2006). Additionally, time of day varied only slightly from application to application with no applications occurring within 3 h of dawn or dusk.

It is hypothesized the variability in injury levels, most notably at the final visual rating date in 2016 compared to the 2015 and 2017 season, was due to a lack of rainfall prior to and after the 2016 applications (Table 2). Variation in cultivar injury observed from year to year and application to application are suspected to be a function of cultivar-specific leaf physiological and gene expression responses to the environment and their subsequent impacts on absorption and metabolism of the herbicide(s). The impact of environment on cuticle thickness and its impact on herbicide efficacy was identified by Oosterhuis et al. (1991) as a parameter that might need to be considered in herbicide rate selection.

Growth Measurements. Failure of glufosinate applications to significantly impact total nodes, plant height, and NACB measurements has been noted previously. Maturity is often not impacted by glufosinate applications to *bar*-containing cultivars (Blair-Kerth et al., 2001; Dodds et al., 2015; Wallace et al., 2011) and occasionally not impacted by glufosinate applications to *pat*-containing cultivars (Dodds et al., 2015). In contrast to results noted here, Barnett et al. (2015) noted slight increases in maturity (reductions in NACB) from one and two sequential applications of glufosinate, whereas Steckel et al. (2012) noted delays in maturity (increases in NACB) when glufosinate replaced glyphosate in tank mixes of dimethoate or *S*-metolachlor.

Lint Yield and Fiber Quality. Data from this study suggest sequential late POST glufosinate applications with or without *S*-metolachlor likely will not impact lint yield. Previous research has shown glufosinate applications of $\leq$600 g ai ha^{-1} to cultivars containing the *bar* or *pat* genes might not impact lint yield; Sweeney and Jones (2015) did not observe yield decreases when glufosinate applications were applied to WideStrike and LibertyLink cultivars.

Dodds et al. (2015) also observed no yield reductions when glufosinate was applied at 600 g ai ha^{-1} to WideStrike and LibertyLink cultivars. Furthermore, Wallace et al. (2011) noted no significant yield reduction when four sequential applications of glufosinate were applied to a LibertyLink cultivar. Conversely, yield increases not associated with weed control reported with single applications of glufosinate (Cahoon et al., 2015b; Sweeney and Jones, 2015) were not observed within this work. Similar to findings of Dodds et al. (2015), Sweeney and Jones (2015), Steckel et al. (2012), and Wallace et al. (2011), our results suggest fiber quality will not be impacted by sequential applications glufosinate with or without *S*-metolachlor.

CONCLUSIONS

Late-POST glufosinate applications will likely result in increases in visual injury from LibertyLink to XtendFlex to WideStrike cultivars, with a sharp increase in visual injury from XtendFlex to WideStrike cultivars. These data agree with previous research on older germplasm suggesting sequential applications of glufosinate will not significantly impact yields of LibertyLink, WideStrike, or XtendFlex cultivars, given gene expression within platform does not vary from the cultivars tested. Results indicate up to three sequential, labeled late-POST applications of glufosinate with the first and third containing *S*-metolachlor could be used with no impact on lint yield or fiber quality. Subsequently, results indicate producers should continue to use sequential applications of glufosinate and *S*-metolachlor to reduce herbicide resistance selection pressure on dicamba in the XtendFlex system with the understanding that slight visual injury observed after the application likely will not impact lint yield or fiber quality.

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