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Low carryover risk of late-season soybean herbicides to newly planted sugarcane

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Research Article

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Abstract

Numerous annual and perennial weeds infest sugarcane. End-season weed infestations are managed before sugarcane is replanted by fallowing (cultivation and sequential glyphosate applications) or by rotating to glyphosate-tolerant soybean in Louisiana. With the occurrence of perennial grasses and glyphosate-resistant weeds, growers need to utilize alternative late POST (LPOST) herbicide programs in soybean to reduce weed infestations in newly planted sugarcane (soybean-sugarcane rotation). Current rotational restrictions limit the use of acifluorfen, clethodim, fomesafen, and quizalofop to control troublesome weeds before soybean harvest and the subsequent planting of sugarcane. However, there is a lack of information on the carryover effects of these soybean herbicides on newly planted sugarcane. Field experiments were conducted at Schriever, LA, and St. Gabriel, LA, in 2017 to 2018 and in 2020 to 2021 to determine sugarcane injury and yield component response to herbicides labeled for LPOST applications in soybean, including acifluorfen, clethodim, fomesafen, lactofen, and quizalofop, applied at the field-use rates (1X) 45 d prior to or immediately after sugarcane planting. Separate field experiments were conducted at those two locations in Louisiana in 2018 to 2019 and in 2020 to 2021 to determine sugarcane injury and yield component response to five rates of fomesafen applied immediately after sugarcane planting. Results of the herbicide screening experiment showed no reductions in sugarcane shoot and stalk population, stalk height, sugarcane yield, sucrose content, or sucrose yield from the selected herbicides at either application timing. Fomesafen applied at 790 (2X) and 1,580 (4X) g ha^{-1} resulted in 7% and 13% average visible injury to sugarcane at 27 d after treatment (DAT), respectively; injury symptoms persisted until 62 DAT. Transient injury observed at 62 DAT did not correspond to reduced sugarcane stalk population, height, sucrose content, sugarcane yield, or sucrose yield. This research indicates a potentially low risk of carryover and yield loss in newly planted sugarcane from late-season applications of selected soybean herbicides.

Introduction

Louisiana is the top sugarcane-producing state in the United States. In 2023, sugarcane was commercially produced on 215,297 ha in Louisiana (Gravois 2024). Sugarcane is a perennial crop and is harvested annually three to five times from a single planting. In Louisiana, sugarcane is ideally planted from early August through September on raised beds and harvested 16 (plant cane), 28 (first ratoon), 39 (second ratoon), and 50 (third ratoon) mo after planting (Gravois 2014). Sugarcane yield loss is affected by numerous factors, including crop genotype, disease pressure, weed infestation level, and harvest timing (Gravois et al. 2011; Grisham et al. 2009; Richard and Dalley 2005; Viator et al. 2010). The crop should be terminated and fallowed for 6 to 8 mo once sugarcane yield is reduced to a level where net returns are not maximized over the crop cycle (Salassi and Breaux 2002). Crop termination is accomplished primarily by mechanical tillage that uproots and destroys the sugarcane stool following the final harvest. However, fields not rutted during the final harvest and where water drainage is acceptable provide an option to chemically terminate the crop and retain the raised-bed row profile.

The fallow period provides an opportunity for releveling the sugarcane beds, which often become rutted during harvest, and is an opportune time to control problematic perennial weeds. Perennial weeds, particularly grasses, are among the most problematic and yield-limiting weeds in sugarcane production in the southern United States (Griffin et al. 2001). Bermudagrass [*Cynodon dactylon* (L.) Pers.], johnsongrass [*Sorghum halepense* (L.) Pers.], and purple nutsedge (*Cyperus rotundus* L.) frequently infest sugarcane fields in Louisiana. Control of perennial weeds during the fallow period is a fundamental practice due to the limited and moderately effective in-crop POST chemical control options for managing bermudagrass and johnsongrass in sugarcane (Etheredge et al. 2009). Furthermore, the planted row area (row top) is not cultivated during the production cycle (Anonymous 2024; Dalley and Richard 2008; Etheredge et al. 2009; Richard 1990). Pluralistic approaches to managing perennial weeds during the fallow period are superior to singular methods. For instance, Miller et al. (1999) reported that glyphosate application interspersed between tillage operations during the fallow period resulted in greater bermudagrass control than did multiple tillage operations without glyphosate. Similarly, Etheredge et al. (2009) showed improved bermudagrass and johnsongrass control when glyphosate applications were interspersed with a conventional tillage program as compared to tillage alone.

Traditionally, sugarcane is grown in a monoculture production system in southern parishes along the Mississippi River and Bayou Lafourche, as well as in the Bayou Teche region of Louisiana. More recently, these traditional sugarcane producers in Louisiana have adopted glyphosate-resistant (GR) soybean as a rotational crop during the fallow period (Viator and Griffin 2001; White et al. 2011). Early Group IV soybean is planted on raised, 1.8-m-wide sugarcane beds in two or three equally spaced drills on the top of the row from late March to late April to ensure a timely harvest and so as not to delay sugarcane planting (Boudreaux and Griffin 2009; Morgan et al. 2017). Soybean production practices in soybean-sugarcane systems differ in many aspects from soybean production systems in the Midwest and Midsouth. Most notably, grasses like itchgrass [*Rottboellia cochinchinensis* (Lour.) W.D. Clayton], johnsongrass, and bermudagrass are the primary weeds in soybean-sugarcane systems and are managed primarily POST in soybean with glyphosate at 840 or 1,120 g ha^{-1} (Griffin et al. 2006; Viator and Griffin 2001), as opposed to the GR broadleaf weeds that commonly infest Midwest soybean-corn (*Zea mays* L.) and Midsouth soybean-cotton (*Gossypium hirsutum* L.) production systems and are managed with PRE and POST herbicides and cover crops (Loux et al. 2017; Wiggins et al. 2017).

Low grain commodity prices in recent years, coupled with stable sugar prices, have resulted in more sugarcane hectares planted in northern and central parishes (Avoyelles, Concordia, Pointe Coupee, St. Landry, and Rapides), which have historically been planted to grain crops (K. Gravois, personal communication, June 12, 2024). Expansion into northern areas, once limited by low tolerance of sugarcane to cooler climates, can largely be credited to high-sucrose, cold-tolerant cultivar selection (Hale et al. 2017). Considering increased sugarcane cultivation in northern and central Louisiana in recent years, where soybean is typically grown in rotation with corn, it is important to evaluate the potential carryover effects of soybean herbicides on newly planted sugarcane. Furthermore, GR weeds, including Palmer amaranth (*Amaranthus palmeri* S. Watson), waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer], johnsongrass, and Italian ryegrass [*Lolium perenne* L. var. *multiflorum* (Lam.) Parnell], are widespread in Louisiana production fields (Heap 2024), which necessitates the use of late POST (LPOST) herbicides (alternative to glyphosate) in soybean to manage late-season infestations of those problematic GR weeds, in addition to perennial grasses. However, current rotational crop restrictions limit the use of certain LPOST soybean herbicides if sugarcane production is planned following soybean harvest. Therefore the objectives of this research were (1) to determine sugarcane injury and yield component response to herbicides labeled for LPOST applications in soybean, including acifluorfen, clethodim, fomesafen, lactofen, and quizalofop (applied at field-use rates), 45 d before (carryover scenario) or immediately after sugarcane planting (to simulate the greatest possible carryover injury potential) and (2) to determine sugarcane injury and yield component response to five rates of fomesafen (0, 198 [1/2X], 395 [1X], 790 [2X], and 1,580 [4X] g ha^{-1}) applied immediately after sugarcane planting, where 1X is the field-use rate in soybean.

Table 1. Herbicide treatments and rates evaluated in the soybean herbicide and timing experiments conducted in Schriever and St. Gabriel, LA, in 2017 to 2018 and 2020 to 2021.

Treatment	Product	Rate	Herbicide manufacturer
		g ai ha^{-1}	
Acifluorfen	ULTRA BLAZER®	280	United Phosphorous, King of Prussia, PA, USA
Clethodim	Select Max®	272	Valent USA, Walnut Creek, CA, USA
Fomesafen[a]	Flexstar®	395	Syngenta Crop Protection, Greensboro, NC, USA
Lactofen	Cobra®	175	Valent USA
Quizalofop	Assure® II	93	Dupont, Wilmington, DE, USA

[a]Fomesafen was applied at 0, 198, 395, 790, and 1,580 g ai ha^{-1} in the fomesafen herbicide rate experiment.

Materials and Methods

Soybean Herbicide and Timing Experiment

Field experiments were conducted at the U.S. Department of Agriculture Agricultural Research Service (USDA-ARS) Sugarcane Research Unit Ardoyne Farm in Schriever, LA (29.637°N, 90.84°W), and at the Louisiana State University (LSU) AgCenter's Sugar Research Station in St. Gabriel, LA (30.268°N, 91.105°W), in 2017 to 2018 and in 2020 to 2021. The experimental design was a randomized complete block with four replicates, and the plot size was 5.4 m (three sugarcane rows spaced 1.8 m apart) × 9 m. Treatments consisted of a two-way factorial of Herbicide Treatment × Application Timing. Herbicides, product names, and application rates are listed in Table 1. A nontreated control was included for comparison. Application timings included 45 d prior to planting sugarcane (to simulate carryover) and immediately following sugarcane planting. Herbicide treatments were broadcast applied to raised sugarcane beds with a tractor-mounted compressed-air sprayer calibrated to deliver 140 L ha^{-1} at 170 kPa using TeeJet® AI 11002 flat-fan nozzles (TeeJet® Technologies, Collierville, TN, USA).

Sugarcane variety 'L 01-299' was hand planted on September 11, 2017, and August 7, 2020, at Schriever, LA, on a Cancienne silty clay loam (fine-silty, mixed, superactive, nonacid, hyperthermic Fluvaquentic Epiaquepts) soil and on September 12, 2017, and September 3, 2020, at St. Gabriel, LA, on a Commerce silt loam (fine-silty, mixed, superactive, nonacid, thermic Fluvaquentic Endoaquepts) soil. Shoot density was recorded 78 d after planting (DAP). Sugarcane visible injury was recorded at 28 DAP and was assessed on a scale of 0% to 100%, with 0% being no injury and 100% being complete plant death. Sugarcane stalk population and stalk height were measured on July 6, 2018, and July 23, 2021, at Schriever and on July 2, 2018, and July 23, 2021, at St. Gabriel. Stalk population was determined by counting all millable stalks (stalks at least 1.2 m to the uppermost node) per plot, and stalk height was determined by measuring ten random stalks per plot from the soil surface to the uppermost node. Plots were machine harvested and loaded into a wagon equipped with load cells, and the weight of cane stalks from each plot was recorded on November 6, 2018, and November 17, 2021, at Schriever and on November 28, 2018, and November 9, 2021, at St. Gabriel. A hand-cut ten-stalk sample from each plot was used to calculate theoretically recoverable sucrose (TRS; g kg^{-1}). The sum of the plot weights and hand-cut sample weights was used to calculate sugarcane yield (Mg ha^{-1}). Sucrose yield (kg ha^{-1}) was calculated as the product of TRS and sugarcane yield.

Fomesafen Herbicide Rate Experiment

A separate field experiment was conducted at the USDA-ARS Sugarcane Research Unit Ardoyne Farm in Schriever, LA, and at the LSU AgCenter's Sugar Research Station in St. Gabriel, LA, in 2018 to 2019 and in 2020 to 2021 to investigate sugarcane tolerance to different rates of fomesafen applied at planting. Among all soybean herbicides screened, fomesafen was chosen because it has the longest rotational interval to sugarcane (18 mo). Fomesafen rates and sources of material are listed in Table 1. The experimental design was a randomized complete block with four replicates, and the plot size was 5.4 m (three sugarcane rows spaced 1.8 m apart) × 9 m. Treatments were broadcast applied with a tractor-mounted compressed-air sprayer calibrated to deliver 140 L ha^{-1} at 170 kPa using TeeJet® AI 11002 flat-fan nozzles (TeeJet® Technologies).

Sugarcane variety 'L 01-299' was hand planted on August 15, 2018, and August 7, 2020, at Schriever and on August 21, 2018, and September 3, 2020, at St. Gabriel. The soil types at the two sites were similar to those previously mentioned in the soybean herbicide and timing experiment. Visual sugarcane injury was recorded at 27 and 62 DAT and was based on a scale of 0% to 100%, with 0% being no injury and 100% being complete plant death. A Crop Circle™ model ACS-430 active crop canopy sensor (Holland Scientific, Lincoln, NE, USA) was used to measure Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge Index (NDRE) values following the 27 DAT injury rating. The model can sense three specific wave bands (near infrared, red, and red edge). Sugarcane shoot density was recorded at 27, 62, and 204 DAT, and stalk population and stalk height were measured on July 7, 2019, and July 23, 2021, at Schriever and on July 10, 2019, and July 26, 2021, at St. Gabriel. Stalk population and stalk height measurements were determined as previously described in the soybean herbicide and timing experiment. Plots were machine harvested and weighed, as previously mentioned, on November 19, 2019, and December 3, 2021, at Schriever and on November 11, 2019, and November 2, 2021, at St. Gabriel. A hand-cut ten-stalk sample from each plot was hand harvested to calculate TRS, and the sum of the plot weights and hand-cut sample weights was used to calculate sugarcane yield. Sucrose yield was calculated as the product of TRS and sugarcane yield.

Statistical Analysis

Data for both studies were subjected to the MIXED procedure in SAS (version 9.4; SAS Institute, Cary, NC, USA). For the soybean herbicide and timing experiment, site-year, herbicide, application timing, and their interactions were considered fixed effects in the model, while replication nested within site-year and all possible interactions were considered random effects. For the fomesafen herbicide rate experiment, site-year, rate, and their interactions were considered fixed effects, while replication nested within site-year and all possible interactions were considered random effects in the model. Sugarcane visible injury and shoot density data in the fomesafen herbicide rate experiment were arranged as repeated measures. Type III statistics were used to test all possible interactions of fixed effects. Means were separated using Fisher's protected least significant difference (LSD) at $P < 0.05$. Letter groupings were derived using the PDMIX macro in SAS to denote significant treatment differences (Saxton 1998). The UNIVARIATE procedure was used to check residuals for normality and homogeneity of variance for all variables measured. Sugarcane visible injury data were arcsine square root transformed to improve normality and homogeneity of variance, and means were back-transformed for discussion. All other data, including sugarcane shoot density, stalk population, stalk height, sugarcane yield, sucrose content, and sucrose yield data, were not transformed. The relationship between visible sugarcane injury and NDVI or NDRE at 27 DAT for the fomesafen herbicide rate experiment was analyzed in SAS software using the Pearson PROC CORR procedure.

Table 2. Rotational crop restriction period for sugarcane planting following application of soybean herbicides[a].

Herbicide	Crop rotational interval for sugarcane
Acifluorfen	100 d
Clethodim	30 d
Fomesafen	18 mo
Lactofen	0 d
Quizalofop	120 d

[a]Rotational intervals were obtained from product labels.

Results and Discussion

Soybean Herbicide and Timing Experiment

Sugarcane rotational restriction for the soybean herbicides evaluated in the experiment ranged from 0 to 18 mo (Table 2). There was no significant effect ($P > 0.05$) of site-year or interaction of site-year with any of the parameters (shoot density, stalk population, stalk height, sugarcane yield, sucrose content, and sucrose yield) measured. The soybean Herbicide Treatment × Application Timing interaction was also insignificant for any of those parameters, and herbicide treatment means were averaged across application timings (Table 3). Despite soybean herbicide treatments, sugarcane showed no visible injury at 28 DAP (data not shown). Treatment means for shoot density, stalk population, stalk height, sugarcane yield, sucrose content, and sucrose yield did not differ across herbicides tested and were comparable to the nontreated plots (Table 3). These results suggest that acifluorfen, clethodim, fomesafen, lactofen, and quizalofop (tested at rates labeled for LPOST weed control in soybean) applied immediately after sugarcane planting, to simulate the greatest possible carryover injury potential, do not compromise sugarcane yield components when the sugarcane is harvested approximately 15 mo later. However, all herbicides evaluated, with the exception of lactofen, require a 30-d or more preplant interval before planting sugarcane. Previous research has shown a differential response among sugarcane varieties to various herbicides registered for use in sugarcane. Richard (1989) evaluated the tolerance of eight sugarcane cultivars to fall (after planting) and spring applications of metribuzin, terbacil, and hexazinone and reported that sugarcane shoot density and plant height were not reduced with fall applications; however, stalk population and sugar yield were reduced with the spring application of hexazinone for several

Table 3. Soybean herbicide treatment means averaged across application timings, sites, and years for newly planted sugarcane[a,b,c].

Herbicide treatment	Rate	Shoot density	Stalk population	Stalk height	Sugarcane yield	Sucrose content	Sucrose yield
	g ai ha^{-1}	——— no. ha^{-1} × 103	———	cm	Mg ha^{-1}	g kg^{-1}	kg ha^{-1} × 10^2
Acifluorfen	280	120	102	142	96	105	100
Clethodim	272	115	107	140	94	106	100
Fomesafen	395	114	109	143	93	104	96
Lactofen	175	112	104	141	92	101	93
Quizalofop	93	120	106	144	93	104	96
Nontreated	—	118	105	142	94	101	95
P-value		0.110	0.826	0.993	0.650	0.128	0.561

[a]Application timings evaluated were 45 d prior to planting sugarcane and immediately following sugarcane planting at each of the two sites in 2017 and 2020.
[b]Shoot density was determined 78 d after planting sugarcane.
[c]Sugarcane stalk populations and heights were recorded on July 7, 2019 (Schriever, LA) and July 10, 2019 (St. Gabriel, LA) and on July 23, 2021 (Schriever, LA) and July 26, 2021 (St. Gabriel, LA), respectively.

cultivars. A similar experiment reported sugarcane varietal sensitivity to 1.65 kg ha^{-1} of diuron absorbed by plant foliage and roots when applied in the spring (Millhollon and Matherne 1968). In a previous experiment, sugarcane variety 'CP 44-101' had 48% less sucrose yield than the nontreated, but greater tolerance was reported for diuron-treated 'N Co 310' when sucrose yield was compared with the nontreated (Millhollon and Matherne 1968).

Yields of newly planted sugarcane and radiation use efficiency are generally greatest in the plant cane crop and decrease with plant age (Park et al. 2005). Gravois et al. (2011) characterized newly planted 'L 01-299' as a slow-emerging cultivar, but crop growth and canopy development were more vigorous in ratoon crops, which contributed to greater stalk population and yield in subsequent harvests when compared with the plant cane crop. Fields planted to slower-emerging cultivars are susceptible to weed infestation because of limited crop vegetation to shade competing weeds and are excellent candidates for PRE herbicide sensitivity evaluation, as PRE herbicides may further slow crop development and growth when compared to other commercial sugarcane cultivars that emerge quickly and in high densities.

Fomesafen Herbicide Rate Experiment

Site-year and the interaction of Site-Year × Fomesafen Rate were not significant ($P > 0.05$) on sugarcane shoot density evaluated at 24, 62, and 204 DAP (Table 4). Furthermore, increasing rates (1/2X to 4X) of fomesafen did not influence sugarcane shoot density at any of the evaluation dates and did not differ from the nontreated check (Table 4). Sugarcane shoot density ranged from 47,000 to 55,000 shoots ha^{-1} at 27 DAT averaged across site-years.

There was no significant interaction of Fomesafen Rate × Site-Year ($P > 0.238$) on visible injury at 27 and 62 DAT. Visible sugarcane injury was influenced by fomesafen rate, and injury persisted to 62 DAT (Table 4). Sugarcane visible injury averaged 14% and 13% at 27 and 62 DAT, respectively, when treated with 1,580 g ha^{-1} of fomesafen (4X rate) at planting (Table 4). Injury was noted as leaf chlorosis and stunted crop growth. Griffin and Lencse (1992) applied fomesafen at 600, 800, and 1,100 g ha^{-1} to emerged sugarcane in March, and maximum injury averaged 7% for the 800 g ha^{-1} treatment for the sugarcane hybrid 'CP 72-370', whereas 'CP 70-321' showed no injury regardless of fomesafen rate. Sugarcane injury did not exceed 3% when fomesafen was applied at 395 g ha^{-1}, which corresponded to a labeled 1X use rate for soybean in Louisiana.

Site-year and interaction of Site-Year × Fomesafen Rate were not significant ($P > 0.05$) on stalk population, stalk height,

Table 4. Sugarcane shoot density and visible injury 27, 62, and 204 d after fomesafen treatment at different rates averaged across sites and years[a,b,c].

Fomesafen rate	Shoot density 27 DAT	Shoot density 62 DAT	Shoot density 204 DAT	Visible injury 27 DAT	Visible injury 62 DAT
g ai ha^{-1}	——— no. ha^{-1} × 10^3		———	——— %	———
198	52	101	177	2 c	0 d
395	55	107	181	3 c	1 c
790	51	105	173	7 b	4 b
1,580	47	97	167	14 a	13 a
Nontreated	53	104	172	0 d	0 d
P-value	0.211	0.137	0.139	<0.0001	<0.0001

[a]Abbreviation: DAT, days after treatment.
[b]Fomesafen treatments were immediately applied following sugarcane planting at each of the two sites in 2018 and 2020.
[c]Means within a column that are followed by the same letter are not statistically different according to Fisher's protected LSD test at $\alpha < 0.05$.

sugarcane yield, sucrose content, and sucrose yield. Furthermore, those variables were not influenced by fomesafen rates (0 to 4X) when applied at sugarcane planting (Table 5). Griffin and Lencse (1992) also reported that sugarcane stalk height and stalk population were similar to those of the untreated check for 'CP 72-370' and 'CP 70-321' when measured 6 mo after fomesafen treatment. Although in the present experiment, crop injury observed with fomesafen rates greater than 395 g ha^{-1} may have been concerning to a grower, injury symptoms were not detrimental to yield parameters at sugarcane harvest. Herbicide degradation is greatly influenced by soil characteristics, including pH, organic matter content, and cation exchange capacity. The edges and wheel furrows of raised sugarcane beds are not mechanically cultivated for approximately 6 mo after planting. The lack of soil aggregate shattering following sugarcane planting may have reduced fomesafen degradation by preventing microorganisms from penetrating hardened soil aggregates (Paul and Clark 1996). Furthermore, there may be enhanced herbicide degradation in the spring and summer months, when sugarcane bed edges were cultivated to reestablish eroded row edges and remove winter annual weeds. Subsequent cultivation passes during the cropping cycle are necessary to incorporate liquid fertilizer and remove summer annual weeds.

Sugarcane injury ratings 27 DAT were compared to plant vigor using handheld active crop canopy sensors for making standard comparisons between field locations and ambient conditions, because a sensor with its own light source does not have

Table 5. Sugarcane stalk population, stalk height, sugarcane yield, sucrose content, and sucrose yield across fomesafen rates applied at planting and averaged across sites and years[a,b].

Fomesafen rate	Stalk population	Stalk height	Sugarcane yield	Sucrose content	Sucrose yield
g ai ha^{-1}	no. ha^{-1} × 10^3	cm	Mg ha^{-1}	g kg^{-1}	kg ha^{-1} × 10^2
198	96	174	109	123	134
395	97	177	102	120	122
790	100	180	100	120	120
1,580	100	174	99	121	119
Nontreated	95	175	108	120	129
P-value	0.084	0.159	0.129	0.126	0.118

[a]Fomesafen treatments were immediately applied following sugarcane planting at each of the two sites in 2018 and 2020.
[b]Sugarcane stalk populations and heights were recorded on July 7, 2019 (Schriever, LA) and July 10, 2019 (St. Gabriel, LA) and on July 23, 2021 (Schriever, LA) and July 26, 2021 (St. Gabriel, LA), respectively.

Table 6. Pearson correlation coefficients and their significance for sugarcane injury and Normalized Difference Vegetation Index or Normalized Difference Red Edge Index measurements 27 d after treatment for the fomesafen rate experiment[a,b].

Parameter	Pearson correlation coefficient	$P > F$
Injury vs. NDVI	−0.5219	0.0182
Injury vs. NDRE	−0.6832	0.0009
NDVI vs. NDRE	0.9477	<0.0001

[a]Abbreviations: NDRE, Normalized Difference Red Edge Index; NDVI, Normalized Difference Vegetation Index.
[b]Fomesafen treatments were immediately applied following sugarcane planting.

interference from cloudiness or time of the day. Plant vigor or injury was assessed using NDVI and NDRE. Pearson correlation coefficients showed that sugarcane injury was negatively associated with NDVI and NDRE measurements (Table 6). Henry et al. (2004) also demonstrated that reflectance may be used to quantify crop injury caused by herbicide exposure. The use of sensor-based measurements may offer an opportunity to alleviate difficult management decisions, such as determining herbicide injury levels from herbicide carryover, physical drift, or tank contamination, that may warrant crop replanting and provide standard ratings for reporting crop injury in sugarcane. Similar work has been done to evaluate weed infestation with the use of sensors and image processing (Papadopoulos et al. 2018).

Practical Implications

Soybean planted during the 6- to 8-mo fallow period that is harvested can provide income to offset weed control expenses normally encountered when land remains fallow, without negatively impacting sucrose yields in newly planted sugarcane (Griffin et al. 2006; Viator and Griffin 2001; White et al. 2011). Modeled data from Australia suggest that soybean may provide adequate nitrogen to supplement the plant cane crop in a soybean-sugarcane rotation and a portion of the nitrogen needed for ratoon crops (Park et al. 2010).

Application of herbicides with soil residual activity at planting would be expected to inflict maximum crop injury; however, little to no injury was observed in sugarcane variety 'L 01-299' at labeled rates of soybean herbicides tested in this research. The rotational cropping restriction for sugarcane when acifluorfen, clethodim, fomesafen, and quizalofop are applied is 100 d, 30 d, 18 mo, and 120 d, respectively. These rotational crop restrictions limit the use of acifluorfen and quizalofop herbicides and eliminate fomesafen as an option for managing problematic perennial and herbicide-resistant weed populations LPOST in soybean if sugarcane is planted after soybean harvest. Sugarcane growth and yield parameters in the plant cane crop were not affected by acifluorfen, clethodim, fomesafen, lactofen, or quizalofop (applied at the field-use rate in soybean) 45 d or immediately following sugarcane planting. This indicates a potentially minimal risk of carryover effects from LPOST applications of these soybean herbicides to newly planted sugarcane. Growers can potentially utilize LPOST applications of fomesafen and acifluorfen in soybean to control GR Palmer amaranth and waterhemp and reduce late-season weed seed additions prior to planting sugarcane. Furthermore, clethodim and quizalofop would be valuable tools for managing grassy weeds, especially perennials like bermudagrass and GR johnsongrass, prior to planting sugarcane, considering that in-crop POST chemical control options for managing these weeds are limited in sugarcane.

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Competing interests. The authors declare no conflicts of interest.

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