Weed Science 2013 61:482–490

Integrated Management of Bermudagrass (*Cynodon dactylon*) in Sugarcane

Caleb D. Dalley, Ryan P. Viator, and Edward P. Richard, Jr.*

Bermudagrass is a difficult perennial weed to manage in Louisiana sugarcane. Research was conducted to compare interrow tillage practice, postharvest residue management, and herbicide placement on bermudagrass proliferation and sugarcane yield. Tillage frequencies included conventional (four tillage operations per season), reduced (two tillage operations), and no-till. Residue management practices included removal by burning, sweeping from row top into the wheel furrow, and not removed. Spring herbicide placement treatments included broadcast, banded, or no herbicide application. With conventional tillage, broadcast and banded herbicide applications resulted in similar bermudagrass cover in the first and second ratoon crops, but bermudagrass cover was greater when using banded applications (22%) compared with broadcast application (15%) in the third-ratoon crop. Bermudagrass cover was greatest with no-till. When herbicides were banded, bermudagrass cover was greater in reduced tillage than conventional tillage in all three ratoon crops. Postharvest residue management did not affect bermudagrass ground cover. In plant cane, sugarcane yields were lowest when herbicide was not applied. In ratoon crops, sugarcane and sugar yield were reduced when herbicide was not applied regardless of tillage practice. Cane and sugar yield were generally equal when comparing reduced and conventional tillage. Total sugarcane yield (4 crop yr) for the no-till program was reduced 11, 15, and 25%, respectively, when herbicides were broadcast, banded, and when herbicide was not applied, compared with conventional tillage. Failure to remove residue reduced sugarcane yield by 5, 7, and 10% in first, second, and third ratoons, respectively, compared with burning. Eliminating unnecessary tillage practices can increase profitability of sugarcane through reduced costs, but it will be imperative that herbicide programs be included to provide adequate bermudagrass control and that postharvest residue is removed to promote maximum sugarpostane yield.

Nomenclature: Metribuzin; pendimethalin; bermudagrass, *Cynodon dactylon* (L.) Pers.; sugarcane, *Saccharum* interspecific hybrid.

Key words: Banded herbicide application, postharvest crop residue, tillage.

Bermudagrass is ubiquitous to the sugarcane production region of south Louisiana (Holm et al. 1977; Richard 1997). The interference of bermudagrass with sugarcane reduces yield and can reduce the longevity of a stand of sugarcane, often requiring sugarcane to be replanted earlier than desired (Richard and Dalley 2007). Within sugarcane, bermudagrass is very difficult to manage, because currently there is no postemergence herbicide that will selectively control bermudagrass in sugarcane (Richard 1998). Some herbicides can be used to suppress bermudagrass to reduce its interference and slow its spread, but none can provide season-long control (Richard 1993, 2000). Controlling bermudagrass in fallowed sugarcane fields, therefore, becomes an important priority for sugarcane farmers (Miller et al. 1999; Richard 1997).

At the end of the sugarcane production cycle, following the final harvest, fields are disked to a depth of approximately 20 cm. This destroys existing stands of sugarcane and disrupts perennial weeds, such as bermudagrass. Rows are then marked, raised beds formed, and fields either left fallow or planted to an annual seeded crop such as soybean [*Glycine max* (L.) Merr.] This period between crops is essential to managing perennial grasses such as johnsongrass [*Sorghum halepense* (L.) Pers.] and bermudagrass through multiple applications of glyphosate in combination with tillage. Tillage is typically done using a rolling disk cultivator to till the row side in combination with a shovel-type plow to till the row top.

Sugarcane in Louisiana is planted in raised beds with a commonly used row spacing of 1.8 m. These wide rows allow for passage of harvesting equipment and provide furrows for drainage of excess water after heavy rainfall events. The wheel furrows and row sides are cultivated as many as four times each spring to control weeds, incorporate leaf residue from the previous crop, fill in ruts created during the previous harvest, to soften the soil to facilitate the injection of fertilizers, incorporate certain preemergence herbicides, and replace soil lost from the top of the row during the harvest or from movement with rainfall. Reducing the number of tillage operations each spring would reduce costs in fuel and equipment wear and repair (Etheredge et al. 2009; Judice et al. 2006; Salassi and Diliberto 2012). However, reducing the frequency of tillage can reduce the effectiveness of this as a cultural practice for managing weeds, especially perennial grasses such as bermudagrass (Buhler 1995; Buhler et al. 1994; Triplett and Lytle 1972; Webster et al. 2000).

Green harvesting of sugarcane in Louisiana deposits 6 to 24 Mg ha^{-1} of leaf residue onto the soil surface (Viator et al. 2008). In regions having a distinct dry season, residue has been shown to benefit sugarcane growth by preserving soil moisture (Ball-Coelho et al. 1993; Wood 1991). The retention of leaf residue can also suppress weed growth because the layer of mulch may can reduce germination and emergence of weeds due to the resulting physical barrier, through changes in soil microclimate (temperature, moisture), and possibly through allelopathic chemicals leached from the leaf residue (Correia and Durigan 2004; Ferreira et al. 2010; Martins et al. 1999; Viator et al. 2006). However, in regions lacking a distinct dry season, the retention of postharvest leaf residue has been shown to be detrimental to the growth and yield of ratoon crops (Kingston 2000; Viator et al. 2006, Viator et al. 2009). This practice can also interfere with the coverage and therefore the efficacy of soil-applied preemergence herbicides (Carbonari et al. 2010; Foloni et al. 2011; Negrisoli et al. 2007).

Martins et al. (1999) demonstrated that germination of several weed species was inhibited by the presence of

DOI: 10.1614/WS-D-12-00124.1

* Agronomist, Research Agronomist, and Former Supervisory Research Agronomist (retired), USDA–ARS Sugarcane Research Unit, 5883 USDA Road, Houma, LA 70360. Corresponding author's E-mail: caleb.dalley@ars.usda.gov

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

sugarcane leaf residue, but only with leaf residue of 15 Mg ha^{-1} or more. Correia and Durigan (2004) showed that germination of spreading liverseed grass [*Urochloa decumbens* (Stapf.) R. Webster], prickly sida (*Sida spinosa* L.), and Jamaican crabgrass (*Digitaria horizontalis* Willd.) was reduced when soil was covered with sugarcane residue. However, beach morningglory [*Ipomoea grandifolia* (Dammer) O'Donell], and ivyleaf morningglory (*Ipomoea hederifolia* L.) were not affected by the presence of sugarcane residue and the emergence of cypressvine morningglory (*Ipomoea quamoclit* L.) increased when the soil was covered with sugarcane residue. The suppression of emergence and growth might be due to leaf residue acting as a physical barrier or leaching of allelopathic chemicals from the leaf residue (Sampietro et al. 2006; Viator et al. 2006).

When herbicides are applied to fields covered with sugarcane leaf residue, the herbicides must move through the layer of mulch into the soil in order to provide weed control. Negrisoli et al. (2007) found that when amicarbazone was applied to soil covered with 5 Mg ha^{-1} of sugarcane leaf residue, some weeds were controlled only when applications were followed by simulated rainfall. Foloni et al. (2011) reported no difference in the control of four annual weed species when 12 different herbicide treatments were applied to soil covered with sugarcane leaf residue when compared to soil where leaf residue was removed. No studies have been conducted on the efficacy of herbicides applied to sugarcane fields infested with a perennial grass such as bermudagrass when leaf residue is not removed. However, it has been reported that sugarcane leaf residue alone might have little or no impact on the growth of bermudagrass in sugarcane (Manechini 2000). Consequently, additional research is needed to determine the impact of sugarcane leaf residue on the growth and development of bermudagrass and on the efficacy of herbicides applied to suppress this weed in sugarcane.

Bermudagrass interference with sugarcane has been shown to reduce sugarcane yield by 20% or more (Richard and Dalley 2005, 2007). Interference is greatest during the spring months when sugarcane is emerging from the winter dormant period up until row closure, when shade-induced dormancy of bermudagrass occurs. Management practices that reduce growth of bermudagrass during this period should reduce the degree of interference from this weed. Therefore, studies were conducted to determine the impact of sugarcane management practices on the level of bermudagrass infestation and the resulting impact on sugarcane yield. Management practices evaluated included spring tillage practice, herbicide placement, and postharvest residue management. These practices were evaluated during a 4-yr sugarcane cropping cycle.

Materials and Methods

Field studies were conducted at the USDA–ARS Sugarcane Research Unit's Ardoyne Farm near Houma, LA on a Cancienne silty clay loam (fine-silty, mixed, superactive, nonacid, hyperthermic Fluvaquentic Epiaquepts). Sugarcane 'HoCP 96-540' was hand-planted in both experiments with the first experiment planted in September 2005 and the second in September 2006. Sugarcane was planted in fields with a history of bermudagrass infestation. However, to aid in obtaining a uniform bermudagrass infestation throughout the evaluations, greenhouse-grown bermudagrass plugs were transplanted in March 2006 and 2007 at a rate of one per meter row throughout the entire study. These bermudagrass plugs were propagated by sprigging stolons into 5 by 5 cm cell trays using bermudagrass collected at the USDA Ardoyne Farm that was growing in a flat in the greenhouse. Sugarcane was fertilized in late March of each year by injecting 112 kg ha^{-1} of N, 15 kg ha^{-1} of P, and 56 kg ha^{-1} of K approximately 15 cm deep on both sides (0.9 m apart) of the planted sugarcane row.

Plots were arranged in a split-plot design with the whole plot being tillage practice, and subplots being a factorial arrangement of herbicide placement and postharvest residue management treatments. Subplots were three rows wide (5.3 m) by 14 m long. Treatments were replicated five times for each experiment.

Tillage treatments included conventional, reduced, and no-tillage. The conventionally tilled plots were cultivated four times each spring using a rolling-disk cultivator. This included two off-bar cultivations, where soil on the row sides were cut away with one set of disks and then another set of disks lifts soil back onto the row side with shields in place to prevent soil deposition on the emerging row of sugarcane shoots, leaving the 0.6-m row top undisturbed. The first off-bar cultivation was completed in mid-March each year, and the second cultivation coincided with fertilizer application in mid-April. A third cultivation was completed in mid-May with shields removed and disks angled to place some soil onto the row top. The fourth cultivation (the layby cultivation) was completed in early June; row sides were reworked and 2 to 5 cm of soil was placed on top of the row around the sugarcane shoots. For the reduced tillage practice, plots were cultivated twice during the spring; one off-bar cultivation coinciding with fertilization and a second cultivation was conducted at layby. In the no-tillage, plots were not cultivated during the entire crop cycle.

The herbicide placement treatments were broadcast, banded, and nontreated control. Pendimethalin (2.8 kg ai ha^{-1}) and metribuzin (2.8 kg ai ha^{-1}) were applied over the entire plot (broadcast) or over the row top in a 90-cm band (banded). These treatments coincided with the first off-bar cultivation with herbicide being applied immediately after the cultivation. No herbicide was applied to the nontreated plots during the entire crop cycle. Following the layby cultivation, pendimethalin (2.8 kg ha^{-1}) and metribuzin (2.2 kg ha^{-1}) were applied postdirected underneath the crop canopy to plots where herbicide was either banded or broadcast-applied previously. Treatments were applied using a tractor-mounted sprayer equipped with 8002 flat-fan nozzles (Spraying Systems Co., Wheaton, IL 60187) at a spray volume of 187 L ha^{-1}, with compressed air (221 kPa) used as the propellant.

Postharvest residue management treatments included complete removal by burning (burn), repositioning of residue by sweeping from row top into wheel furrow (sweep), and no removal. Residue generated during the sugarcane harvest consisted mostly of sugarcane leaves and tops. In plots designated to be burned, residue was raked from the front and back of plots (to prevent fire from spreading to adjacent plots), and then ignited using a mixture of gasoline and diesel in a drip torch. In plots designated for row top sweeping, a modified rotary street sweeper was used to remove residue from the row top into the wheel furrow. In plots designated for no removal, residue was left in place. Residue was removed

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Table 1. ANOVA for mixed procedure analysis of data collected from experiments at two locations on the effects of tillage practice, herbicide placement, and residue management in sugarcane.

Source	Probability values				
	Plant cane	First ratoon	Second ratoon	Third ratoon	Average
Bermudagrass ground cover					
Tillage (T)		< 0.0001	< 0.0001	< 0.0001	
Residue (R)		0.3732	0.4531	0.2758	
T by R		0.9575	0.8452	0.6500	
Herbicide (H)		< 0.0001	< 0.0001	< 0.0001	
T by H		< 0.0001	0.0359	0.0003	
R by H		0.8384	0.0657	0.8922	
T by R by H		0.5876	0.2447	0.8490	
Sugarcane stalk population					
Tillage (T)	0.2398	0.0001	0.0002	< 0.0001	< 0.0001
Residue (R)	0.8120	0.0069	0.0193	< 0.0001	< 0.0001
T by R	0.1046	0.3046	0.0030	0.0110	0.0007
Herbicide (H)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
T by H	0.4942	0.0002	0.0594	< 0.0001	< 0.0001
R by H	0.5411	0.2081	0.3220	0.3702	0.3103
T by R by H	0.6465	0.5889	0.5041	0.4701	0.3809
Sugarcane yield					
Tillage (T)	0.0586	0.0005	< 0.0001	< 0.0001	< 0.0001
Residue (R)	0.4620	0.0192	0.0008	< 0.0001	0.0001
T by R	0.6411	0.1073	0.5041	0.4974	0.3692
Herbicide (H)	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
T by H	0.0641	0.0177	0.0006	0.0442	< 0.0001
R by H	0.2847	0.3228	0.1896	0.0094	0.0309
T by R by H	0.9305	0.8483	0.6627	0.5539	0.5161
Sugar yield					
Tillage (T)	0.0592	0.0004	< 0.0001	< 0.0001	< 0.0001
Residue (R)	0.7021	0.0104	0.0166	< 0.0001	0.0019
T by R	0.8363	0.0637	0.7062	0.3448	0.2530
Herbicide (H)	0.0018	< 0.0001	< 0.0001	< 0.0001	< 0.0001
T by H	0.0149	0.0212	0.0004	0.0813	< 0.0001
R by H	0.3240	0.6902	0.0886	0.0345	0.1232
T by R by H	0.7886	0.7274	0.5583	0.4263	0.4547

each year after harvesting was completed and when the residue had sufficiently desiccated. Removal was completed in either December or January each year when the sugarcane was dormant.

Sugarcane stalk population was determined in mid-summer (July or early August) each year by counting the number of stalks within each row of each plot. Bermudagrass infestation was also determined simultaneously with stalk counts each year through a visual estimate of the percent of each 1.8 m row of sugarcane that was covered with bermudagrass, using a scale of 0 to 100, with 0 being no ground cover and 100 being complete ground cover.

Sugarcane was harvested each year (plant cane, and three ratoon crops) using a sugarcane chopper harvester (CAMECO® 3500 Chopper Harvester, John Deere Thibodaux, Inc., 244 Highway 3266, Thibodaux, LA 70301). Sugarcane was harvested from the first experiment on December 20, 2006, December 3, 2007, November 14, 2008, and October 2, 2009. Sugarcane was harvested from the second experiment on December 14, 2007, November 20, 2008, December 7, 2009, and October 21, 2010. Weights from each row of each plot were measured using a dump wagon with load cells on each axle and tongue. Stalk samples (billets) were collected randomly from each plot as it was being harvested using a sampler attached to the dump wagon. Billets were passed though a shredder to create a nearly homogonous mixture. A 1,000-g sample of the shredded cane was then placed into a hydraulic press at 21 MPa for 2 min to extract juice. Juice was analyzed for brix (% soluble solids) and pol (% apparent sucrose by weight) using a refractometer (RFM 190 Refractometer, Bellingham and Stanley, Ltd., Longfield Rd., North Farm Industrial Estate, Tunbridge Wells, Kent, United Kingdom) and polarimeter (Autopol 880 automated saccharimeter, Rudolph Research Analytical, 55 Newburgh Rd., Hackettstown, NJ 07840), respectively. Stalk fibers remaining after pressing were weighed wet, placed in paper bags, and then dried in a forced-air dryer for a minimum of 72 h at 66 C. Dried fiber samples were then reweighed, and percent fiber was determined. Theoretically recoverable sugar (TRS, kg sugar per Mg cane) was calculated from Brix, Pol, and fiber measurements using standard methodologies (Legendre 1992; Legendre and Henderson 1972).

Data were analyzed as a split-plot factorial using PROC MIXED in SAS (Version 9.2, SAS Institute, Inc., 100 SAS Campus Drive, Cary, NC 27513), where the whole plot was tillage practice and subplots were herbicide placement and postharvest residue management in a factorial arrangement. Replication, location, and their interactions were treated as random factors; all other factors were treated as fixed (Table 1). Arcsine square-root transformed data were used for the analysis of visual evaluation of bermudagrass; however, actual values for observations are reported. Means were separated using the PROC MIXED lsmeans macro as described by Saxton (1998).

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Table 2. Bermudagrass ground cover as affected by tillage practice and herbicide placement during a sugarcane 'HoCP 96-540' cropping cycle. Average of two locations,[a] and three residue management treatments.[b]

Tillage practice[c]	Herbicide placement[d]	Crop age[e]					
		First ratoon		Second ratoon		Third ratoon	
		% cover					
No-till	Nontreated	89	a	90	a	94	a
	Banded	58	c	62	bc	78	b
	Broadcast	40	d	48	d	62	cd
Reduced	Nontreated	75	b	70	b	65	c
	Banded	25	e	29	e	30	e
	Broadcast	17	f	20	f	21	fg
Conventional	Nontreated	72	b	53	cd	52	d
	Banded	17	f	14	f	22	ef
	Broadcast	16	f	12	f	15	g

[a] Sugarcane was planted at the USDA–ARS Ardoyne Farm in 2005 at one location with bermudagrass cover measurements taken in the summers of 2007 to 2009, and planted at a second location in 2006 with measurements taken in 2008 to 2010.

[b] Three sugarcane leaf residue management treatments included in this study were: no removal, sweep, and burn.

[c] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.

[d] Herbicide placement treatments were: no herbicide application; banded, 90-cm band of pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) on 180-cm row; and broadcast, complete coverage using pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}).

[e] Means within columns with the same letter are not significantly different ($P < 0.05$).

Results and Discussion

For comparisons of bermudagrass ground cover, there was an interaction between tillage practice and herbicide placement in all three ratoon crops. Bermudagrass cover in the plant-cane (first year) crop was not evaluated, because this was the establishment year and initial bermudagrass cover was similar for all treatments. No differences in bermudagrass cover occurred due to differences in postharvest residue management (data not shown). Previous research had shown that leaving residue in place reduced emergence and growth of winter annual weeds (Judice et al. 2007; Richard 1999). We did not find this to be the case with bermudagrass, which emerges later in the spring after a period of winter dormancy and after natural decomposition of residue during the winter months.

No-till management practices increased the amount of bermudagrass cover in all three ratoon crops compared to reduced and conventional tillage for all three herbicide treatments (Table 2). When no-till was practiced along with broadcast spring herbicide applications, percent bermudagrass cover was 40, 48, and 62%, respectively for the first, second, and third ratoons. This was much greater than what was observed when conventional tillage was practiced and broadcast spring herbicide applications where percent bermudagrass cover was 16, 13, and 15%, respectively, in the first, second, and third ratoon. Under no-till practices, bermudagrass is better able to establish, which reduces the effectiveness of herbicides used for suppressing this perennial weed. Judice et al. (2006) cautioned against the adoption of no-till practices in sugarcane fields where bermudagrass or other perennial grasses are problematic. The results of our research support their assertions.

Reduced tillage practices generally resulted in increased bermudagrass cover when either no herbicide was applied or when herbicides were banded, compared to broadcast herbicide application (Table 2). No differences in bermudagrass cover were observed when comparing reduced and conventional tillage, when herbicides were broadcast-applied. Buhler et al. (1994) showed that in corn (*Zea mays* L.) one or two interrow cultivations were needed to control the perennial weeds dandelion (*Taraxacum officinale* G. H. Weber ex Wiggers) and quackgrass [*Elymus repens* (L.) Gould] when no preemergence herbicide was used. In our study, up to four springtime cultivations without herbicide application were not adequate to achieve satisfactory control of bermudagrass in sugarcane. It is noteworthy that for none of the cultivations was the top of the row disturbed. Otherwise, sugarcane injury would have resulted.

Broadcast application of herbicides reduced bermudagrass cover compared to a banded application only under reduced tillage or no tillage in the first- and second-ratoon crops and regardless of tillage practice in the third-ratoon crop (Table 2). When no herbicide was applied, both reduced and conventional tillage reduced bermudagrass cover compared to the no-till practice. Generally, conventional tillage reduced bermudagrass cover more than reduced tillage when herbicides were banded or when herbicides were not applied, but not when broadcast-applied.

Sugarcane stalk population was affected by both tillage practice and herbicide placement, with an interaction between these parameters in all but the plant-cane crop (Table 1). In the plant-cane crop, population density was affected only by herbicide placement, with increasing population density when herbicide placement increased from no herbicide to banded application and from banded application to broadcast application (Table 3). Bermudagrass control in the plant-cane crop is critical in this establishment phase of sugarcane. Any competition from weeds or other stresses can reduce the number of tillers produced (Ali et al. 1986; Lencse and Griffin 1991; Viator et al. 2008). In the ratoon crops, herbicide placement was more critical when using a no-till or reduced tillage program. Stalk population increased when herbicides were applied broadcast or banded compared to when no herbicide was applied when practicing either no-till or reduced tillage in all three ratoon crops. Additionally, broadcast herbicide application increased sugarcane stalk populations when compared to banded application in all three ratoon crops when either no-till or reduced tillage was practiced. When conventional tillage was used, there was no increase in stalk population when comparing banded herbicide application with broadcast application, although

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Table 3. Sugarcane stalk population as affected by tillage practice and herbicide placement each year of a 4-yr sugarcane cropping cycle. Averages of two locations,[a] and three residue management treatments.[b]

Tillage practice[c]	Herbicide placement[d]	Crop age[e] Plant cane		First ratoon		Second ratoon		Third ratoon	
		stalks m^{-2}							
No-till	Nontreated	7.8		5.7	e	5.9	f	4.3	e
	Banded	8.4		7.7	d	7.7	e	6.5	d
	Broadcast	8.6		8.4	c	8.2	cd	7.2	c
Reduced	Nontreated	8.3		7.7	d	7.5	e	7.0	cd
	Banded	8.6		8.8	bc	8.7	bc	8.3	b
	Broadcast	8.9		9.2	a	9.1	a	8.8	a
Conventional	Nontreated	8.3		7.5	d	7.7	de	7.0	cd
	Banded	8.7		9.1	ab	9.1	a	8.4	ab
	Broadcast	8.8		9.0	ab	9.2	a	8.4	ab
Mean	Nontreated	8.1	c	7.0		7.0		6.1	
	Banded	8.6	b	8.5		8.5		7.7	
	Broadcast	8.8	a	8.9		8.8		8.1	

[a] Sugarcane was planted at the USDA–ARS Ardoyne Farm in 2005 at one location with stalk population measurements taken in the summers of 2006 to 2009, and planted at a second location in 2006 with measurements taken in the summers of 2007 to 2010.

[b] Three sugarcane leaf residue management treatments included in this study were: no removal, sweep, and burn.

[c] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.

[d] Herbicide placement treatments were: no herbicide application; banded, 90-cm band of pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) on 180-cm row; and broadcast, complete coverage using pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}).

[e] Means within columns with the same letter are not significantly different ($P < 0.05$).

both application methods had higher stalk population compared to no herbicide application (Table 3). The multiple tillage operations in the conventional tillage treatments helped reduce bermudagrass competition, thereby reducing the need for herbicides. This program would provide the sugarcane grower an option to either increase the number of tillage operations while reducing herbicide applications through use of banded application, or to reduce tillage applications and increase herbicides through use of a broadcast application. This decision would need to be based on a cost analysis of herbicides vs. tillage practices.

Stalk population was also affected by postharvest residue management. During the plant-cane year, there was no residue to manage because sugarcane had not yet been harvested. In the first ratoon, main effects for both residue management and tillage practice were significant, although the interaction between these effects was not significant (Table 1). However, in both the second- and third-ratoon crops, this interaction was significant. Therefore, the interaction between residue management and tillage practice is only compared in the final two ratoon crops (Table 4). The interaction between residue management and herbicide placement was not significant in any of the ratoon crops (data not shown).

In the first-ratoon crop, stalk population was reduced 5 and 4%, respectively, when residue was not removed compared to burning and sweeping (Table 4). In the second-ratoon crop, stalk density was reduced 8 and 11% when residue was not removed compared to sweeping or burning, respectively, only when no-till was practiced. In the third-ratoon crop, leaving residue on the field reduced stalk density in both the no-till and reduced tillage treatments compared with sweeping and burning of residue; differences among residue management treatments were not observed when conventional tillage was practiced. When no-till was practiced and residue was not removed, stalk densities were reduced 13 and 21%, respectively, compared with the sweep and burn treatments. When reduced tillage was practiced and residue was not removed, stalk population was reduced by 10% compared with both sweep and burn treatments. Burning to remove residue increased stalk density compared to sweeping only in the no-till treatments of the third-ratoon crop. The 3-yr average for stalk population also showed that removal of residue was more critical when using reduced tillage or no-till (Table 4).

When residue was swept into the row furrows, tillage to incorporate residue into the soil likely increased the speed of residue degradation, which could lessen the impact of the residue on the crop as it is emerging from the winter dormant period. Previous studies have shown that sugarcane leaf residue contains phytotoxic compounds that have autotoxic properties on sugarcane (Viator et al. 2006). Additional studies have shown that postharvest residue can reduce sugarcane stalk densities if they are not removed (Viator et al. 2008; Viator et al. 2009). These reductions were greater when sugarcane had also been treated with glyphosate as a ripener prior to harvest (Viator et al. 2011). No ripener application was made to sugarcane in our study. In other climates where sugarcane is grown, leaving harvest residue in place has been shown to be beneficial due to increases in soil moisture retention and a decrease in the emergence of weed seedlings (Ball-Coelho et al. 1993; Lorenzi et al. 1989). In the present study, leaving residue in place did not provide any measured benefit, and in some cases led to reductions in stalk population. Soil moisture was not limiting during the years this study was conducted. Also, the fields were primarily infested with bermudagrass, a perennial weed, and retention of residue did not impact its growth in this study.

Retention of harvest residue also impacted sugarcane yield (Table 5). Averaged over herbicide placement and tillage practice, sugarcane yield was reduced in the first- and second-ratoon crops when residue was not removed, compared to removal by sweeping or burning. There were no differences between sweeping and burning. For third ratoon, there was an interaction with herbicide placement and residue management for sugarcane yield. Removal of residue by sweeping or burning increased yield when herbicide was not applied and

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Table 4. Sugarcane stalk populations as affected by tillage practice and postharvest residue management in the three ratoon crops of a 4-yr sugarcane cropping cycle. Averages of two locations[a] and three herbicide placement treatements.[b]

Tillage practice[c]	Residue mangement[d]	Crop age[e]							
		First ratoon		Second ratoon		Third ratoon		3-yr average	
		stalks m^{-2}							
No-till	None	6.9		6.8	c	5.2	f	6.3	d
	Sweep	7.4		7.4	b	6.1	e	7.0	c
	Burn	7.5		7.6	b	6.7	d	7.3	c
Reduced	None	8.4		8.4	a	7.5	c	8.1	b
	Sweep	8.7		8.7	a	8.3	a	8.6	a
	Burn	8.6		8.3	a	8.3	a	8.4	a
Conventional	None	8.5		8.7	a	7.7	bc	8.3	ab
	Sweep	8.6		8.6	a	8.0	abc	8.4	a
	Burn	8.6		8.7	a	8.1	ab	8.4	a
Mean	None	7.9	b	7.9		6.8		7.6	
	Sweep	8.2	a	8.2		7.5		8.0	
	Burn	8.3	a	8.2		7.7		8.1	

[a] Sugarcane was planted at the USDA–ARS Ardoyne Farm in 2005 at one location with stalk population measurements taken in the summers of 2006 to 2009, and planted at a second location in 2006 with measurements taken in 2007 to 2010.
[b] Herbicide (pendimethalin plus metribuzin at 2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) placement treatments included in this study were: no herbicide, banded (90 cm), and broadcast on 180-cm row.
[c] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.
[d] Residue management treatments were: none, leaf mulch was left undisturbed following harvest; sweep, leaf mulch was repositioned off of the row top into the row furrows; and burn, leaf mulch was removed by burning.
[e] Means within columns with the same letter are not significantly different ($P < 0.05$).

when herbicide was banded, but an increase in yield was not observed when herbicide was broadcast. Comparing total yield over the 4-yr can cycle, removing residue by sweeping and burning increased yield by 12 (3%) and 17 (5%) Mg ha^{-1}, respectively, compared to no residue removal, averaged across herbicide treatments.

In a study reported by Viator et al. (2008), postharvest residue was shown to reduce sugarcane yield by 2.3 Mg ha^{-1} when it was not removed, compared to partial removal through use of a tractor-mounted serrated tooth sweep. This level of yield increase is comparable to what was observed in the present study where residue was removed from the row-top using a rotary sweeper. Sugarcane yield losses in our trial were comparable to those observed by Viator et al. (2008) with a 3.3 Mg ha^{-1} reduction in the first ratoon and a 3.7 Mg ha^{-1} reduction in the second ratoon when comparing no removal with partial removal by sweeping (Table 5). In Australia, Kingston (2000) found that retaining postharvest residue in areas of high rainfall and clay soils reduced sugarcane yield. Yield losses were attributed to a reduction in bud development, resulting in fewer stalks when residue was retained compared to removal by burning or raking. In Louisiana, a 10-yr trial conducted over three consecutive sugarcane production cycles showed that burning residue improved sugarcane yield in ratoon crops compared to when harvest residue was retained, and that sweeping residue into the row middles generally resulted in intermediate yields (Viator and Wang 2011). Results from the present study support those findings.

Tillage practice and herbicide placement also impacted sugarcane yield (Table 6). In all 3 ratoon crop yr there was a significant interaction between these two treatment factors. In plant cane, yield was reduced only when herbicide was not applied. Although there were no reductions in yield due to tillage practice, using no-till in the plant cane might encourage proliferation of perennial weeds such as bermudagrass that

Table 5. Sugarcane yield as affected by postharvest residue management[a]. Average of two locations, three tillage frequencies,[b] and three herbicide placement[c] treatments. In the third ratoon, an interaction between residue mangement and herbicide placement was significant and shown.

Residue management	Crop age[d]											
					Third ratoon							
					Herbicide placement							
	First ratoon		Second ratoon		None		Band		Broad		Total	
	Mg ha^{-1}											
None	87.7	b	83.3	b	50.2	e	66.8	cd	71.2	bc	348	b
Sweep	91.0	a	87.0	a	54.7	c	76.4	a	73.9	ab	360	a
Burn	92.1	a	89.9	a	62.3	d	71.7	ab	75.0	ab	365	a

[a] Residue managment treatments were: none, leaf mulch was left undisturbed following harvest; sweep, leaf mulch was repositioned off of the row top into the row furrows; and burn, leaf mulch was removed by burning.
[b] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.
[c] Herbicide (pendimethalin plus metribuzin at 2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) placement treatments included in this study were: no herbicide, banded (90 cm), and broadcast on 180-cm row.
[d] Means within columns with the same letter are not significantly different ($P < 0.05$).

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Table 6. Sugarcane 'HoCP 96-540' yield in response to tillage practice and herbicide placement during a 4-yr sugarcane cropping cycle. Average of two locations,[a] and three residue management treatments.[b]

Tillage practice[c]	Herbicide placement[d]	Crop age[e] Plant cane		First ratoon		Second ratoon		Third ratoon		Total	
		Cane yield (Mg ha^{-1})									
No-till	Nontreated	105	b	71	e	50	d	37	f	262	d
	Banded	113	a	86	d	77	c	56	e	331	c
	Broadcast	116	a	90	bc	84	b	61	de	350	b
Reduced	Nontreated	114	a	89	cd	81	bc	61	d	345	bc
	Banded	117	a	99	a	102	a	79	ab	396	a
	Broadcast	116	a	98	a	100	a	77	b	391	a
Conventional	Nontreated	112	a	86	cd	83	bc	68	c	350	b
	Banded	115	a	96	ab	101	a	80	ab	393	a
	Broadcast	114	a	98	a	103	a	83	a	399	a

[a] Sugarcane was planted at the USDA–ARS Ardoyne Farm in 2005 at one location with stalk population measurements taken in the summers of 2006 to 2009, and planted at a second location in 2006 with measurements taken in the summers of 2007 to 2010.
[b] Three sugarcane leaf residue management treatments included in this study were: no removal, sweep, and burn.
[c] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.
[d] Herbicide placement treatments were: no herbicide application; banded, 90-cm band of pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) on 180-cm row; and broadcast, complete coverage using pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}).
[e] Means within columns with the same letter are not significantly different ($P < 0.05$).

would have to be dealt with in the ratoon crops. Further research is needed to determine economic benefits of adopting this practice.

In the first ratoon, differences between treatments became more apparent. For no-till, yield losses ranged from 17 to 20% when herbicide was not applied compared with 10 to 13% when herbicide was banded and 8% when herbicide was broadcast. When comparing banding with broadcast herbicide applications, banding resulted in reduced yield only under no-till practices. This pattern continued in the second ratoon, only that yield losses were even greater, as much as 40% when herbicide was not applied in no-till, compared to reduced or conventional tillage. This shows that both herbicide application and tillage are important for reducing the impact of bermudagrass on sugarcane. However, it became apparent that reducing tillage frequency would be a viable option in that yields were similar when comparing two and four tillage practices.

Only in the third ratoon were there any yield differences when comparing reduced and conventional tillage. When no herbicide was applied, sugarcane yielded 7 Mg ha^{-1} less under reduced tillage than conventional tillage. When herbicides were applied broadcast, sugarcane yielded 6 Mg ha^{-1} less under reduced tillage compared with conventional. However, sugarcane yielded similarly when herbicides were banded when comparing reduced and conventional tillage. This shows that there might be some benefit to a conventional tillage practice in later ratoon crops, where the stand of sugarcane is diminishing; however, the evidence is not conclusive.

Sugar yield was determined from the product of cane yield and sugar content (TRS) of harvested sugarcane (Table 7). There were no differences in TRS due to treatments except in the third ratoon (data not shown). In the third ratoon, TRS was lower when no herbicide was applied compared to banded or broadcast applications (data not shown).

When combining yields from all four crops, there was no advantage in sugarcane yield (Table 6) or sugar yield (Table 7) to using conventional over reduced tillage. Yields, however, were reduced when no-till was practiced, regardless

Table 7. Sugar yield in response to tillage practice and herbicide placement during a 4-yr sugarcane 'HoCP 96-540' cropping cycle. Average of two locations,[a] and three residue management treatments.[b]

Tillage practice[c]	Herbicide placement[d]	Crop age[e] Plant cane		First ratoon		Second ratoon		Third ratoon		Total	
		Sugar yield (Mg ha^{-1})									
No-till	Nontreated	11.6	b	8.7	f	5.5	d	3.0	f	28.8	d
	Banded	12.7	a	10.5	e	8.5	c	4.7	e	36.5	c
	Broadcast	13.0	a	11.2	bcd	9.3	b	5.1	e	38.6	b
Reduced	Nontreated	12.9	a	10.9	cde	9.0	bc	5.1	e	37.9	bc
	Banded	13.3	a	12.0	ab	11.4	a	6.7	bc	43.1	a
	Broadcast	13.1	a	12.1	a	11.0	a	6.4	c	42.6	a
Conventional	Nontreated	12.7	a	10.7	de	9.1	bc	5.8	d	38.4	bc
	Banded	13.0	a	11.6	abc	11.3	a	7.0	ab	42.9	a
	Broadcast	12.7	a	12.1	a	11.1	a	7.3	a	43.3	a

[a] Sugarcane was planted at the USDA–ARS Ardoyne Farm in 2005 at one location with stalk population measurements taken in the summers of 2006 to 2009, and planted at a second location in 2006 with measurements taken in the summers of 2007 to 2010.
[b] Three sugarcane leaf residue management treatments included in this study were: no removal, sweep, and burn.
[c] Tillage frequencies were: no-till, no cultivation of row-sides during crop cycle; reduced, two cultivations of row-sides each spring; and conventional, four cultivations of row sides each spring.
[d] Herbicide placement treatments were: no herbicide application; banded, 90-cm band of pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}) on 180-cm row; and broadcast, complete coverage using pendimethalin plus metribuzin (2.8 kg ha^{-1} plus 2.8 kg ha^{-1}).
[e] Means within columns with the same letter are not significantly different ($P < 0.05$).

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

of herbicide placement. This shows that tillage is a vital component of the current sugarcane production practices. However, the number of tillage practices each spring could likely be reduced without any negative consequence, as far as yield is concerned. Judice et al. (2006) found that tillage could be eliminated entirely without consequence during one growing season. In a drier than average year, they found that using a reduced tillage program or no-till increased sugarcane yield. However, they did not measure the effects of reduced tillage beyond one harvest season. Also in their study, weeds were found not to be a limiting factor because they were controlled adequately in all treatments. We found that tillage could be eliminated in the plant-cane season without reducing yield unless no herbicides were applied (Tables 6 and 7). However, continuing with no-till in subsequent years reduced total crop yield by 88 Mg ha^{-1} with no herbicides, 62 Mg ha^{-1} when herbicides were banded, and 49 Mg ha^{-1} when herbicides were broadcast (Table 6). However, reducing tillage applications from four to two per year throughout the complete crop cycle did not impact total crop yield.

Reducing the number of tillage operations performed each year would directly reduce the cost of producing sugarcane. Salasi and Diliberto (2012) estimate that each cultivation, including cleaning drains after cultivation, would cost on average \$30 ha^{-1} in Louisiana. Eliminating unnecessary tillage practices would increase profitability of growing sugarcane through reduced production costs. The benefits of cultivation include improved drainage, control of weed seedlings, control or disruption of perennial weeds, and loosening of soil to facilitate fertilizer injection. However, these benefits can still be achieved while reducing the frequency of tillage operations within the sugarcane crop. Reducing tillage also favors conservation of soil moisture, which can become limiting in seasons with below-average rainfall (Blevins et al. 1983). Reducing tillage can also reduce soil erosion, because recently tilled soil is more prone to erosion during heavy rainfall events than settled soil (Glanville et al. 1997).

No-till production of sugarcane would require adjustments to current sugarcane production practices. Adjustments would include alterations to fertilizer applicators to ensure proper penetration of injections knives, harvesting only under dry conditions to prevent rutting of fields (which might be impractical in Louisiana) and adjustments to weed control methods in order to achieve similar yields compared to use of current practices. More research on no-till sugarcane production would need to be conducted in order to determine needed modifications before recommendations for adoption could be given.

Acknowledgments

The authors would like to thank Mr. Eric Petrie, Mr. Clinton ''Frank'' Randall, Mr. Thomas Duet, and Mr. Norris Matherne for their technical assistance in the completion of this research.

Literature Cited

Ali, A. D., T. E. Reagan, L. M. Kitchen, and J. L. Flynn. 1986. Effects of johnsongrass (*Sorghum halepense*) density on sugarcane (*Saccharum officinarum*) yield. Weed Sci. 34:381–383.

Ball-Coelho, B., H. Tiessen, J.W.B. Stewart, I. H. Salcedo, and E.V.S.B. Sampaio. 1993. Residue management effects on sugarcane yield and soil properties in northeastern Brazil. Agron. J. 85:1004–1008.

Blevins, R. L., M. S. Smith, G. W. Thomas, and W. W. Frye. 1983. Influence of conservation tillage on soil properties. J. Soil Water Conserv. 38:301–307.

Buhler, D. D. 1995. Influence of tillage systems on weed population dynamics and management in corn and soybean in the Central USA. Crop Sci. 35:1247–1258.

Buhler, D. D., J. D. Doll, R. T. Proost, and M. R. Visocky. 1994. Interrow cultivation to reduce herbicide use in corn following alfalfa without tillage. Agron. J. 86:66–72.

Carbonari, C. A., E. D. Velini, M. R. Correa, E. Negrisoli, C. V. Rossi, and C. P. Oliveira. 2010. Effects of different periods of clomazone + hexazinone permanence in soil and sugarcane mulch before the occurrence of rain on weed control efficacy. Planta Daninha 28:197–205.

Correia, N. M. and J. C. Durigan. 2004. Weed emergence in soil covered with sugarcane harvest straw residue. Planta Daninha 22:11–17.

Etheredge, L. M., Jr., J. L. Griffin, and M. E. Salassi. 2009. Efficacy and economics of summer fallow conventional and reduced-tillage programs for sugarcane. Weed Technol. 23:274–279.

Ferreira, E. A., S. O. Procópio, L. Galon, A. C. Franca, G. Concenço, A. A. Silva, I. Aspiazu, A. F. Silva, S. P. Tironi, and P.R.R. Rocha. 2010. Weed management in raw sugarcane. Planta Daninha 28:915–925.

Foloni, L. L., L.P.M. Plese, C. L. Silva, and J. T. Filho. 2011. Evaluation of herbicides applied in post-emergence over and under straw in no-burn sugarcane and their environmental fate. Planta Daninha 29:447–455.

Glanville, T. J., G. Titmarsh, M. M. Sallaway, and F. Mason. 1997. Soil erosion in caneland tillage systems. Pages 254–262 *in* Proceedings of Australian Society of Sugar Cane Technologists. Brisbane, Queensland, Australia: Watson Ferguson and Company.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The World's Worst Weeds. Distribution and Biology. Honolulu, HI: University Press of Hawaii. 609 p.

Judice, W. E., J. L. Griffin, L. M. Etheredge, Jr., and C. A. Jones. 2007. Effects of crop residue management and tillage on weed control and sugarcane production. Weed Technol. 21:606–611.

Judice, W. E., J. L. Griffin, C. A. Jones, L. M. Etheredge, and M. E. Salassi. 2006. Weed control and economics using reduced tillage programs in sugarcane. Weed Technol. 20:319–325.

Kingston, G. 2000. Climate and the management of sugarcane. Chapter 2. Pages 7–25 *In*: M. Hogarth and P. Allsopp, eds. Manual of cane growing. Indooroopilly, Queensland, Australia: Bureau of Sugar Experimental Stations.

Legendre, B. L. 1992. The core/press method of predicting the sugar yield from cane for use in payment. Sugar J. 54:2–7.

Legendre, B. L. and M. T. Henderson. 1972. The history and development of sugar yield calculations. Proc. Amer. Soc. Sugar Cane Technol. 2(NS):10–18.

Lencse, R. J. and J. L. Griffin. 1991. Itchgrass (*Rottboellia cochinchinensis*) interference in sugarcane (*Saccharum* sp.) Weed Technol. 5:396–399.

Lorenzi, H. J., M. O. Gandini, and A. L. Gazon. 1989. Trash blankets: the potential to control weeds and the effect on ratoon cane development. Proc. Int. Soc. Sugarcane Technol. 20:53–56.

Manechini, C. 2000. The impact of cane trash on weed control. Int. Cane Energy News. April 2000. 7–9. http://www.winrock.org/clean_energy/files/icen2000.pdf. Accessed May 23, 2012.

Martins, D., E. D. Velini, C. C. Martins, and L. S. de Souza. 1999. Broadleaf weed emergence in soil covered with sugar cane straw. Planta Daninha 17:151–161.

Miller, D. K., J. L. Griffin, and E. P. Richard, Jr. 1999. Summer fallow and after-planting bermudagrass (*Cynodon dactylon*) control programs for sugarcane (*Saccharum* spp. hybrids). Weed Technol. 13:127–131.

Negrisoli, E., C.V.S. Rossi, E. D. Velini, A. L. Cavenaghi, E.A.D. Costa, and R.E.B. Toledo. 2007. Weed control by amicarbazone applied in the presence of sugar-cane straw. Planta Daninha 25:603–611.

Richard, E. P., Jr. 1993. Preemergence herbicide effects on bermudagrass (*Cynodon dactylon*) interference in sugarcane (*Saccharum* spp. hybrids). Weed Technol. 7:578–584.

Richard, E. P., Jr. 1997. Effects of fallow bermudagrass (*Cynodon dactylon*) control programs on newly planted sugarcane (*Saccharum* spp. hybrids). Weed Technol. 11:677–682.

Richard, E. P., Jr. 1998. Control of perennated bermudagrass (*Cynodon dactylon*) and Johnsongrass (*Sorghum halepense*) in sugarcane (*Saccharum* spp. hybrids). Weed Technol. 12:128–133.

Richard, E. P., Jr. 1999. Management of chopper harvester-generated green cane trash blankets: a new concern for Louisiana. Pages 52–60 *in* V. Singh and V. Kumar, eds. Proceedings of the XXIII International Society of Sugar Cane Technologists. New Delhi, India, February 22–26, 1999. Volume 2. New Delhi, India: Sugar Technologist's Association of India.

Richard, E. P., Jr. 2000. At-planting herbicides for bermudagrass (*Cynodon dactylon*) control in sugarcane (*Saccharum* spp. hybrids). J. Amer. Soc. Sugar Cane Technol. 20:6–14.

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press

Richard, E. P., Jr. and C. D. Dalley. 2005. Bermudagrass interference in a three year sugarcane production cycle. Sugar Cane Int. 23:3–7.

Richard, E. P., Jr. and C. D. Dalley. 2007. Sugarcane response to bermudagrass interference. Weed Technol. 21:941–946.

Salassi, M. E. and M. A. Diliberto. 2012. Projected costs and returns—sugarcane: Louisiana, 2012. Louisiana State University Agriculture Center A.E.A. Information Series No. 282. Baton Rouge, LA. 34 p. http://www.lsuagcenter.com/en/crops_livestock/crops/sugarcane/economics/2012-Projected-Louisiana-Sugarcane-Production-Costs.htm. Accessed May 8, 2012.

Sampietro, D. A., M. A. Vattuone, and M. I. Isla. 2006. Plant growth inhibitors isolated from sugarcane (*Saccharum officinarum*) straw. J. Plant Physiol. 163:837–846.

Saxton, A. M. 1998. A macro for converting mean separation output to letter groupings in Proc Mixed. Pages 1243–1246 *in* Proceedings of the 23rd SAS Users Group International, March 1999, Nashville, TN. Cary, NC: SAS Institute.

Triplett, G. B., Jr. and G. D. Lytle. 1972. Control and ecology of weeds in continuous corn grown without tillage. Weed Sci. 20:453–457.

Viator, R. P., C. D. Dalley, and E. P. Richard, Jr. 2011. Late-season glyphosate ripener application coupled with post-harvest residue retention impacts subsequent ratoon yields. Int. Sugar J. 113:66–71.

Viator, R. P., R. M. Johnson, D. L. Boykin, and E. P. Richard, Jr. 2009. Sugarcane postharvest residue management in a temperate climate. Crop Sci. 49:1023–1028.

Viator, R. P., R. M. Johnson, C. C. Grimm, and E. P. Richard, Jr. 2006. Allelopathic, autotoxic, and hormetic effects of post-harvest sugarcane residue. Agron. J. 98:1526–1531.

Viator, R. P., R. M. Johnson, E. P. Richard, Jr., H. L. Waguespack, and W. Jackson. 2008. Influence of nonoptimal ripener applications and postharvest residue retention on sugarcane second ratoon yields. Agron. J. 100:1769–1773.

Viator, H. P. and J. J. Wang. 2011. Effects of residue management on yield after three production cycles of a long-term sugarcane field trial in Louisiana. J. Amer. Soc. Sugar Cane Technol. 31:15–25.

Webster, T. M., J. Cardina, and S. J. Woods. 2000. *Apocynum cannabinum* interference in no-till *Glycine max*. Weed Sci. 48:716–719.

Wood, A. W. 1991. Management of crop residues following green harvesting of sugarcane in north Queensland. Soil Tillage Res. 20:69–85.

Received August 23, 2012, and approved February 13, 2013.

https://doi.org/10.1614/WS-D-12-00124.1 Published online by Cambridge University Press