PATHOLOGY RESEARCH

Jeffrey W. Hoy, Carolyn F. Savario, and Raghuwinder Singh
Department of Plant Pathology and Crop Physiology

Pathology research addresses the important diseases affecting sugarcane in Louisiana. The overall program goal is provide farmers with practices to minimize losses to diseases in a cost-effective manner. Projects receiving emphasis during 2011 included: improving control methods for brown rust, support of healthy seedcane programs to manage ratoon stunting disease (RSD) and other systemic diseases, improving the evaluation of resistance to leaf scald, identifying potential parents with resistance to smut, evaluating disease resistance in the variety selection program, and billet planting. Research results on billet planting are reported separately.

BROWN RUST

Cold winter conditions resulted in low brown rust severity during 2011. Therefore, it was not possible to compare the ability of commercial and experimental fungicides to control the disease.

Spores of the brown rust pathogen, *Puccinia melanocephala*, were collected and used to evaluate the potential of inoculation under controlled conditions to determine and compare resistance levels in parent and seedling populations. Plants grown in the greenhouse were inoculated with brown rust spores, placed in a chamber with mist generators overnight, and placed on shelves under artificial light for 2 weeks for symptoms to develop. Differences in susceptibility were detected among parental clones. In a repeat experiment, variability occurred in infection severity for a few clones; however, infection severity averages for both experiments were similar to known resistance ratings. Additional research is being conducted to evaluate reaction variability following inoculation under controlled conditions. Inoculation of seedlings with a high concentration of spores under favorable conditions for infection resulted in severe disease and high mortality rates in all crosses regardless of parent rust resistance ratings. An experiment was conducted to determine the optimum spore concentration for inoculation, and the experiment will be repeated during 2012.

HEALTHY SEEDCANE PROGRAM SUPPORT

Disease testing was conducted by the Sugarcane Disease Detection Lab for the 16th year during 2011. Kleentek and SugarTech seedcane production was monitored for RSD, and no disease was detected. A total of 2,198 stalk samples from research farms, variety increase plots, and grower fields were tested for RSD with no positives detected (Table 1). Limited testing was conducted on commercial farms. A total of 45 fields with 1,135 stalks were tested, and no RSD was detected (Table 2). A total of 10,069 leaf samples were tested for yellow leaf (Table 3). Commercial tissue-culture seedcane sources were tested as part of the LDAF seedcane certification program. No field failed to certify due to virus infection. The Local Quarantine supplied healthy plant material of promising experimental varieties to the seedcane companies.

Table 1. RSD testing summary for 2011.

Source	Location	No. of fields	No. of varieties	No. of samples
Louisiana growers	State-wide	49	7	1,135
Variety Release Program	1° & 2° stations	-	11	725
Helena SugarTech®	Foundation stock	-	7	48
Kleentek®	Foundation stock	-	16	78
Kleentek®	Other than foundation	-	-	114
Local Quarantine	LSUAC	-	21	98

Table 2. Sugarcane yellow leaf virus testing summary for 2011.

Source	Location	No. of fields	No. of varieties	No. of samples
LDAF	Seed Certification	192	-	6767
Helena SugarTech®	Foundation stock	-	7	59
Kleentek®	Foundation stock	-	9	68
Local Quarantine	LSUAC	-	21	98
Research	LSUAC	-	-	3085

RESISTANCE TO LEAF SCALD

A comparative proteomic analysis identified differentially expressed proteins that suggested mechanisms for the sugarcane resistance response to infection by *X. albilineans*. Protein expression was compared for inoculated and mock-inoculated plants of two resistant and two susceptible varieties during a time-course encompassing the responses to initial and systemic infection. Differential expression also was compared across cultivars with and without infection. The number of up- and down-regulated proteins increased in the resistant cultivars during systemic infection. Identified, differentially expressed proteins were mostly in the chloroplast (67%), and 48% were involved in photosynthesis. Identified proteins were homologous to cyclophilin, translationally controlled tumor protein (TCTP), thylakoid ascorbate peroxidase (tAPOD), germin-like protein (GLP), and thioredoxins. All are proteins that have been associated with induced defense responses. Down-regulation of APOD and the thioredoxins and up-regulation of GLP could result in accumulation of reactive oxygen species, particularly H_2O_2, in the cytoplasm and the apoplast. In addition, proteins involved in ethylene biosynthesis, another key signaling molecule in induced systemic resistance (ISR), were differentially expressed in resistant cultivars. Differences found between the two resistant cultivars indicate that resistance mechanisms can vary between genotypes, but the suggested resistance mechanisms for both were inducible responses. Finally, some differentially expressed proteins were involved in primary metabolism that could represent a plant fitness mechanism to provide energy needed for ISR.

Multiple lines of evidence from the proteomic analysis suggest a triggering of ISR that would result in the limited colonization of the new xylem developing above the apical meristem and lack of symptom development that is evident in leaf scald resistant sugarcane genotypes. Research is now underway to develop molecular markers for resistance to leaf scald and determine their utility in breeding for resistance.

The quantitative polymerase chain reaction (qPCR) assay developed for the detection and quantification of *X. albilinean* in infected plants previously showed potential to provide an alternative screening method to determine leaf scald resistance levels by distinguishing three resistant and three susceptible varieties. During 2011, the qPCR assay was evaluated with more varieties with known resistance levels and experimental varieties in both field and greenhouse experiments. Bacteria were present in inoculated leaves for both resistant and susceptible varieties; however, the bacterial level detected by qPCR was correlated with the 2-week resistance rating for two inoculation dates in the field experiment (Spearman’s Rank correlations of 0.44 and 0.38). Agreement between ratings based on the severity of systemic infection symptoms and bacterial levels detected by qPCR was highest in systemically infected leaves at 8 weeks after inoculation in the first inoculation (Spearman’s Rank correlation 0.57), but the there was no significant agreement comparing ratings and qPCR results for the second inoculation (Spearman’s Rank correlation 0.24). By 12 weeks after inoculation, bacterial levels were erratic in systemically infected leaves of some susceptible varieties. Bacteria were present in the stalk base of both susceptible and resistant varieties by 12 weeks. Additional experiments are in progress to determine whether qPCR can provide an alternative leaf scald resistance screening method.

SMUT RESISTANT PARENT DEVELOPMENT

In recent years, varieties with low to moderate smut susceptibility have been released to provide alternatives to replace LCP 85-384. Susceptibility to smut has been a recurrent problem for the breeding program. Therefore, an attempt to select more resistant parents through resistance screening of clones earlier in the selection program was initiated during 2011. Single stalks were collected from clones in the second line trial, dip-inoculated in a suspension of $5x10^6$ smut teliospores, cut in half, and planted in un-replicated plot along with the parents from each cross. Results will be determined during 2012.

VARIETY SELECTION

Disease susceptibility in experimental varieties in the Variety Selection Program was determined. Resistance ratings for smut and leaf scald were determined for experimental varieties in the selection program in the annual inoculated test (Table 3). Rust severity resulting from natural infection was not adequate in nurseries and outfield tests to identify rust susceptible experimental varieties. This lack of results again demonstrates the limitation of relying on natural infection to determine brown rust resistance levels and indicates the need to evaluate inoculation methods to assess resistance.

Table 3. Smut and leaf scald resistance ratings determined in an inoculated test for commercial and experimental sugarcane varieties during 2011.

Variety	Smut rating[x]	Scald rating[x]	Variety	Smut rating[x]	Scald rating[x]
CP 65-357	8	4	L 01-299	9	3
CP 70-321	1	3	Ho 02-113	1	-
CP 73-351	9	2	L 03-371	4	2
LCP 82-89	1	4	HoCP 04-838	2	4
LCP 85-384	1	2	HoCP 05-961	3	2
HoCP 85-845	4	4	L 07-57	2	1
CP 89-2143	1	2	HoCP 07-613	1	2
HoCP 89-846	1	4	L 08-75	1	2
HoCP 91-555	2	-	L 08-88	3	1
Ho 95-988	8	2	L 08-90	1	3
HoCP 96-540	1	2	HoCP 08-706	1	3
L 97-128	6	3	HoCP 08-709	1	3
L 99-226	5	4	HoCP 08-711	6	1
L 99-233	5	3	HoCP 08-717	1	1
HoCP 00-950	1	3	HoCP 08-723	2	2
L 01-283	1	2	HoCP 08-726	4	2

[x]Resistance ratings assigned on a 1-9 scale in which 1-3 = resistant, 4-6 = moderately susceptible, and 7-9 = highly susceptible.

BERMUDAGRASS CONTROL PROGRAMS IN FALLOWED SUGARCANE FIELDS: ECONOMICS AND EFFECT ON THE PLANT CANE CROP

J. L. Griffin, M. E. Salassi, J. R. Mite, J. M. Boudreaux, and M. A. Deliberto
School of Plant, Environmental, and Soil Sciences and
Department of Agricultural Economics and Agribusiness

A study was initiated in 2010 at the Sugar Research Station, St. Gabriel, LA, in a fallowed sugarcane field heavily infested with bermudagrass. Fallow programs for bermudagrass control included: Treatment 1 - Bottom plow, chisel plow, disk, bed up, and two applications of Roundup OriginalMax at 46 oz/A; Treatment 2 – same as Treatment 1 with bottom plow omitted; Treatment 3 - Chisel plow, disk, bed up, re-hip beds, and one application of Roundup OriginalMax at 46 oz/A; and Treatment 4 - Chisel plow, disk, chisel plow, disk, bed up, and one application of Roundup OriginalMax at 46 oz/A (Table 1).

Variable treatment cost for the fallow programs, which included charges for tillage (fuel and labor) and herbicide (material and application), was $81.22, $76.95, $55.83, and $59.12 for treatments 1, 2, 3, and 4, respectively (Table 1). Comparing Treatments 1 and 2, the bottom plow operation increased variable cost $4.27/A. The greater variable cost for Treatments 1 and 2 compared with 3 and 4 was related primarily to an additional Roundup OriginalMax application. Sencor was applied at planting on September 10 and again in late February of 2011. Sugarcane shoot population was determined on March 24, 2011 and differences among treatments were not observed (Table 1). Bermudagrass control on May 19 was 91 to 93 for Treatments 1, 2, and 4 and was 85% for Treatment 3. Reduced sugarcane shoot population and weed control observed for Treatment 3 was reflected in reduced sugar yield. Although Treatment 3 fallow program was less costly compared with Treatment 2 ($21.12/A less), the greater sugar yield for Treatment 2 (1,490 lb/A) would more than offset the higher fallow program cost. Additionally, it is likely that the greater bermudagrass control observed for Treatment 2 would carry into the stubble crops resulting in increased yield.

In a fallow program the choice of specific tillage operations and herbicide has a direct impact on the variable cost per acre. A collaborative effort between weed scientists and agricultural economists has resulted in development of the *Sugarcane Fallow Weed Control Program - Producer Decision Aid* (see attached Producer Decision Aid example representing cost analysis for Treatment 1). The Excel-based spreadsheet model can be used as a farm planning tool for producers to determine costs of current fallow programs and to compare costs for alternative fallow programs. The model can handle any combination of tillage and herbicide programs. The user directly enters fuel price ($/gal) and labor cost ($/hr). Drop down menus are used to enter passes over field as well as herbicides applied, and herbicide prices can be changed as needed. When a herbicide is selected from the drop down menu, the user is automatically provided with the recommended application rate based on the LSU AgCenter Weed Management Guide. Based on the data entered, total variable cost per acre for a fallow program is estimated to include charges for fuel, labor, and herbicide materials for operations performed. The *Sugarcane Fallow Weed Control Program - Producer Decision Aid* and users guide is available on the sugarcane crop page of the LSU AgCenter web page (www.lsuagcenter.com). An explanation of how the model can be used along with worksheets is provided.

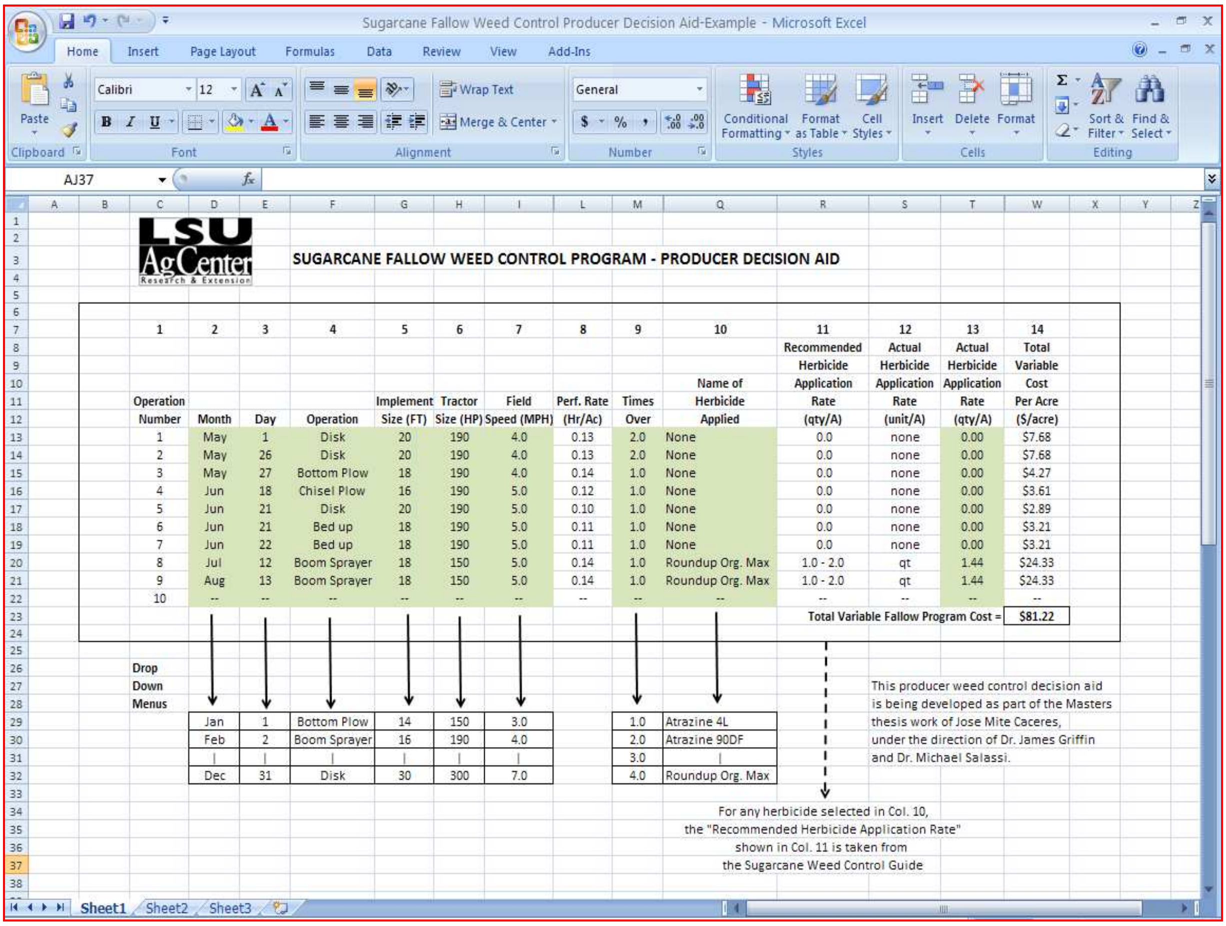
Table 1. Variable cost, sugarcane shoot population, bermudagrass control, and sugar yield in 2011 as influenced by fallow programs implemented in 2010 at the Sugar Research Station, St. Gabriel, LA.

Field operations[1]	Date performed	Variable cost $/A[2] 2010 fallow period	Sugarcane shoot population (no./row) 3/24/11	Bermudagrass control 5/19/11	Sugar yield lb/A
Treatment 1		$81.22	157 a[3]	93 a	7470 ab
Bottom plow (10 -12 inches deep)	May 27				
Chisel plow	June 18				
Disk	June 21				
Bed up (2 operations)	June 21,22				
Roundup OriginalMax @ 46 oz/A	July 12				
Roundup OriginalMax @ 46 oz/A	August 11				
Treatment 2		$76.95	143 a	91 a	7800 a
Chisel plow	June 18				
Disk	June 21				
Bed up (2 operations)	June 21,22				
Roundup OriginalMax @ 46 oz/A	July 12				
Roundup OriginalMax @ 46 oz/A	August 11				
Treatment 3		$55.83	133 a	85 b	6310 b
Chisel plow	June 18				
Disk	June 21				
Bed up (2 operations)	June 21,22				
Re-hip beds	July 12				
Roundup OriginalMax @ 46 oz/A	August 11				
Treatment 4		$59.12	142 a	92 a	6970 ab
Chisel plow	June 18				
Disk	June 21				
Chisel plow, disk, bed up	July 16				
Roundup OriginalMax @ 46 oz/A	August 11				

[1] Prior to implementation of treatments stubble was destroyed by disking (2 passes each) on May 1 and May 26, 2010.

[2] Variable treatment cost includes charges for tillage (fuel and labor) and herbicide (material and application). Fallow treatment input prices used: diesel at $2.30/gal.; labor at $9.60/hr.; herbicide at $57.60/gal.

[3] Means within each column followed by the same letter are not significantly different ($P \leq 0.05$).



SUGARCANE FALLOW WEED CONTROL PROGRAM - PRODUCER DECISION AID

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Operation Number	Month	Day	Operation	Implement Size (FT)	Tractor Size (HP)	Field Speed (MPH)	Perf. Rate (Hr/Ac)	Times Over	Name of Herbicide Applied	Recommended Herbicide Application Rate (qty/A)	Actual Herbicide Application Rate (unit/A)	Actual Herbicide Application Rate (qty/A)	Total Variable Cost Per Acre ($/acre)
1	May	1	Disk	20	190	4.0	0.13	2.0	None	0.0	none	0.00	$7.68
2	May	26	Disk	20	190	4.0	0.13	2.0	None	0.0	none	0.00	$7.68
3	May	27	Bottom Plow	18	190	4.0	0.14	1.0	None	0.0	none	0.00	$4.27
4	Jun	18	Chisel Plow	16	190	5.0	0.12	1.0	None	0.0	none	0.00	$3.61
5	Jun	21	Disk	20	190	5.0	0.10	1.0	None	0.0	none	0.00	$2.89
6	Jun	21	Bed up	18	190	5.0	0.11	1.0	None	0.0	none	0.00	$3.21
7	Jun	22	Bed up	18	190	5.0	0.11	1.0	None	0.0	none	0.00	$3.21
8	Jul	12	Boom Sprayer	18	150	5.0	0.14	1.0	Roundup Org. Max	1.0 - 2.0	qt	1.44	$24.33
9	Aug	13	Boom Sprayer	18	150	5.0	0.14	1.0	Roundup Org. Max	1.0 - 2.0	qt	1.44	$24.33
10	--	--	--	--	--	--	--	--	--	--	--	--	--
												Total Variable Fallow Program Cost =	$81.22

Drop Down Menus

Month	Day	Operation	Implement Size (FT)	Tractor Size (HP)	Field Speed (MPH)	Times Over	Name of Herbicide Applied
Jan	1	Bottom Plow	14	150	3.0	1.0	Atrazine 4L
Feb	2	Boom Sprayer	16	190	4.0	2.0	Atrazine 90DF
|	|	|	|	|	|	3.0	|
Dec	31	Disk	30	300	7.0	4.0	Roundup Org. Max

This producer weed control decision aid is being developed as part of the Masters thesis work of Jose Mite Caceres, under the direction of Dr. James Griffin and Dr. Michael Salassi.

For any herbicide selected in Col. 10, the "Recommended Herbicide Application Rate" shown in Col. 11 is taken from the Sugarcane Weed Control Guide

NEW HERBICIDES/HERBICIDE FORMULATION RESEARCH

J. L. Griffin and M.J. Bauerle
School of Plant, Environmental, and Soil Sciences

Herbicides labeled for use in corn were evaluated for johnsongrass control and sugarcane tolerance. In Patterson, LA, herbicide treatments were applied when johnsongrass was 14 to 28 inches and sugarcane was 18 to 24 inches. At two weeks after application, johnsongrass control with Corvus (thiencarbazone-methyl and isoxaflutole) was 59% and with Laudis (tembotrione) was 65% compared with 47% for Asulox plus Envoke. By six weeks after treatment, control was 53% with Corvus, 32% with Laudis, 45% with Capreno (thiencarbazone-methyl and tembotrione), 12% with Callisto (mesotrione), and 75% with Asulox plus Envoke. Sugarcane injury was 55 and 67% for Capreno and Corvus, but was no more than 8% for Laudis, Callisto, and Asulox plus Envoke. At St. Gabriel, LA, application to 12 to 18 inch sugarcane resulted in injury six weeks after application around 70% for Corvus and Capreno, but injury was no more than 15% for Laudis, Callisto, and Asulox plus Envoke. Zidua (pyroxasulfone), a BASF product being evaluated in soybeans and corn, injured sugarcane 13%. At both locations sugarcane injury with Corvus and Capreno was reflected in reduced plant height in August.

2,4-D formulations Unison (2,4-D acid) and Weedar 64 (2,4-D amine salt); dicamba formulations Vision (acid) and Clarity (amine salt); and 2,4-D plus dicamba combinations, Latigo and Brash, were evaluated for red morningglory control. At three weeks after treatment of red morningglory with 8 to 16 inch runners, Unison at 1.5 pt/A provided less control than Weedar 64 at 2 pt/A (68 vs. 89%). Latigo and Brash at 1 and 1.5 pt/A provided equivalent red morningglory control of around 75%. Both Vision and Clarity at 8 and 16 oz/A provided poor control of red morningglory (35 to 42%). In a herbicide volatility test Unison and Vision were less injurious to sensitive crops compared with salt formulations.

SPRING APPLICATION PROGRAMS FOR BERMUDAGRASS CONTROL

J. L. Griffin and M.J. Bauerle
School of Plant, Environmental, and Soil Sciences

A study was conducted at two sites and treatments consisted of Sencor (3 lb/A), Command plus Direx (3 pt + 2.5 qt/A), Prowl plus Sencor (2 qt + 3 lb/A), and Command plus Sencor (3 pt + 1 lb/A). Herbicides were applied on February 15, March 1, or March 15. Bermudagrass and sugarcane were not emerged at the February application but were actively growing at the March applications. Four weeks after the February application, bermudagrass control was 45% for Sencor, 68% for Command plus Direx, 33% for Prowl plus Sencor, and 50% for Command plus Sencor; six weeks after treatment control was 10 to 40% (Table 1). For the March 1 application, bermudagrass control four weeks after treatment was 28% for Sencor, 63% for Command plus Direx, 48% for Prowl plus Sencor, and 50% for Command plus Sencor; six weeks after treatment control was 35 to 58%. For the March 15 application, bermudagrass control four weeks after treatment was 38% for Sencor, 70% for Command plus Direx, 43% for Prowl plus Sencor, and 75% for Command plus Sencor; six weeks after treatment control was 30 to 58%.

Sugarcane injury was greatest for Command plus Direx and injury increased as application was delayed. Regardless of herbicide treatment or application timing, bermudagrass control was no more than 70%. Control was greater when herbicide treatments were applied in March compared with February and control was equivalent with applications made on either March 1 or March 15. Reduced weed control with the February application is related to the short residual activity of herbicides and lack of crop competition. For the March applications, Command plus Sencor was less injurious to sugarcane than Command plus Direx. In early August, bermudagrass control ranged from 45 to 78% and differences in sugarcane height or stalk populations among the treatments were not observed.

Table 1. Bermudagrass control in sugarcane as affected by herbicides applied February 15, March 1, or March 15, 2011.

	Herbicide application date					
	February 15		March 1		March 15	
Herbicide treatment	4 WAT	8 WAT	4 WAT	8 WAT	4 WAT	8 WAT
Sencor 3 lb	45 a	10 a	28 a	35 a	38 b	30 a
Command 3 pt + Direx 2.5 qt	68 a	40 ab	63 a	53 a	70 ab	45 a
Prowl at 2 qt + Sencor at 3 lb	33 a	10 b	48 a	38 a	43 b	30 a
Command 3 pt + Sencor 1 lb	50 a	25 ab	50 a	58 a	75 a	58 a

NUTSEDGE FALL APPLICATION TEST

J. L. Griffin and M.J. Bauerle
School of Plant, Environmental, and Soil Sciences

A study was conducted at a site in Plaquemine, LA, where Permit was applied with Roundup in fallow and the grower was not pleased with the level of purple nutsedge control. Sugarcane was planted in September and Permit (1 and 1.33 oz/A), Yukon (6 and 8 oz/A), Authority MTZ (18, 24, and 30 oz/A), and Envoke (0.15, 0.2, and 0.3 oz/A) were applied October 18 when sugarcane was 20 to 28 inches and nutsedge was 3 to 4 inches. At 14 days after treatment (DAT) purple nutsedge was controlled 55 to 60% with Authority MTZ and control was no more than 35% with Permit, Yukon, and Envoke (Table 1). Sugarcane 14 DAT was injured 36 to 39% with Authority MTZ but injury was no more than 5% with the other herbicide treatments. At 28 DAT purple nutsedge control for all treatments was equivalent and ranged from 56 to 68%. Sugarcane injury 28 DAT was 25% for Authority MTZ treatments but no more than 9% for the other treatments. Nutsedge control for the various herbicide treatments will be evaluated in the spring of 2012.

Table 1. Purple nutsedge control and sugarcane injury as affected by herbicides applied postemergence October 18, 2011 at St. Louis Planting- Plaquemine Operation.

Herbicide treatment /	Purple nutsedge control (%)		Sugarcane injury (%)	
rate oz/A	14 DAT	28 DAT	14 DAT	28 DAT
Permit 1 oz	29 b	63 a	3 b	3 bc
Permit 1.33 oz	35 b	68 a	5 b	1 bc
Yukon 6 oz	33 b	67 a	0 b	0 c
Yukon 8 oz	35 b	65 a	0 b	0 c
Authority MTZ 18 oz	60 a	58 a	39 a	25 a
Authority MTZ 24 oz	55 a	59 a	38 a	25 a
Authority MTZ 30 oz	60 a	61 a	36 a	25 a
Envoke 0.15 oz	29 b	60 a	0 b	3 bc
Envoke 0.2 oz	33 b	56 a	0 b	3 bc
Envoke 0.3 oz	35 b	66 a	5 b	9 b
Nontreated	0 c	0 b	0 b	0 c