QUANTIFYING THE EFFECT OF SUGARCANE BORER INJURY ON YIELD IN CONVENTIONAL AND BIO-ENERYGY SUGARCANE AND SORGHUM IN LOUISIANA

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The U.S. Gulf Coast is among the geographic regions with the highest potential for production of dedicated cellulosic bioenergy crops, especially energycane and high-biomass sorghum. The most destructive pest of sugarcane in Louisiana is the sugarcane borer (SCB), *Diatraea saccharalis*, which also attack graminaceous bioenergy crops. However, the potential of this pest to cause yield losses in bioenergy crops remains unknown. This study examines the effect of SCB injury under natural pest pressure and associated yield loss in sugarcane, energycane, high-biomass sorghum, and sweet sorghum in two locations in Louisiana.

Cultivars which were evaluated include resistant sugarcane (HoCP 85-845), susceptible sugarcane (HoCP 00-950), two energycanes (L 79-1002 and Ho 02-113), sweet sorghum (M81E), and two high-biomass sorghums (ES 5200 and ES 5140). Cultivars were evaluated in replicated field studies in Rapides Parish (diverse agricultural production) in 2011 and 2012 and St. Mary Parish (predominately sugarcane production) in 2012 and 2013. Plots of each variety were divided into protected (biweekly applications of tebufenozide) and unprotected (no insecticides) subplots.

Natural populations of SCB in Rapides Parish in 2011 were very low and percentage of bored internodes averaged < 1.0% in all cultivars (data not shown). SCB infestations in unprotected plots in Rapides Parish in 2012 (1.2–7.1% bored internodes) were slightly higher than in 2011, and significant differences were detected among cultivars (Table 1). Mean borer injury was greater than 5-fold higher at the St. Mary Parish location than in Rapides Parish in 2012. SCB injury to unprotected plots in St. Mary Parish in 2012 (Table 2) ranged from 3.4% (HoCP 85-845) to 17.7% bored internodes (HoCP 00-950). Differences were detected ($P < 0.001$) in both percentage of bored internodes and number of adult emergence holes among cultivars. Injury in protected plots was <1% bored for all cultivars evaluated and was used to calculate yield loss attributable to SCB injury. Yield loss was based on the difference in mean stalk weight between protected and unprotected plots of each cultivar. Yield loss (Table 2) was greatest in sweet sorghum M81E (26.1%) and least in energycane Ho 02-113 (5.9%). High-biomass sorghums suffered yield losses of 22–24%. Energycane Ho 02-113 is relatively resistant to SCB. SCB injury in 2013 (1.8–10.0% bored internodes) was less than that of 2012. However, yield losses attributable to SCB damage were observed for all cultivars evaluated.

Results from these studies demonstrate that natural levels of SCB infestations have potential to cause substantial yield loss in bioenergy crops. In areas where SCB is a problem in sugarcane it will be a problem in bioenergy crops as well. Host plant resistance will continue to be important to SCB management in bioenergy and conventional crops. Levels of resistance are crop- and cultivar-specific. Insecticidal protection including development of cultivar-specific thresholds will be required to achieve maximum yields in bioenergy crops. Additionally, a landscape approach must be used to assess the interactive role of pest management in conventional and bioenergy crops.

Table 1. SCB injury under natural infestations. Rapides Parish, 2012.

		% Bored internodes	**Emergence Holes/Stalk**
High-biomass Sorghum	ES 5140	1.7 b	0.08
	ES 5200	1.2 b	0.07
Sweet Sorghum	M81E	7.1 a	0.33
Energycane	L 79-1002	2.8 ab	0.14
	Ho 02-113	1.2 b	0.05
Sugarcane	HoCP 00-950	3.5 ab	0.12
	HoCP 85-845	1.4 b	0.02
F-value P > F		F = 3.20 P = 0.0170	F = 2.40 P = 0.0590

*Means followed by the same a letter are not different (Tukey's HSD, α = 0.05).

Table 2. SCB injury under natural infestations and associated yield loss. St. Mary Parish, 2012 and 2013.

		2012			2013		
		% Bored	**Emergence Holes/Stalk**	**% Yield Loss**	**% Bored**	**Emergence Holes/Stalk**	**% Yield Loss**
High-biomass Sorghum	ES 5140	10.1 abc	0.34 b	22.4 ab	4.4 ab	0.04 a	6.9
	ES 5200	16.2 a	0.90 b	24.3 a	7.6 b	0.16 a	13.7
Sweet Sorghum	M81E	14.6 ab	0.75 b	26.1 a	6.4 ab	0.14 a	17.6
Energycane	L 79-1002	11.1 abc	0.79 b	10.5 bc	6.1 ab	0.19 a	14.9
	Ho 02-113	5.1 bc	0.39 b	5.8 c	1.8 a	0.05 a	7.1
Sugarcane	HoCP 00-950	17.7 a	1.90 a	18.8 abc	10.0 b	0.48 b	11.1
	HoCP 85-845	3.4 c	0.22 b	9.0 bc	1.9 a	0.09 a	7.7
	F =	6.00	9.10	7.60	5.51	8.47	1.25
	P =	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.2963

*Means followed by the same a letter are not different (Tukey's HSD, $\alpha = 0.05$).

ESTIMATING YIELD LOSS FROM THE MEXICAN RICE BORER IN SUGARCANE, ENERGYCANE, AND SORGHUM

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The Mexican rice borer (MRB), *Eoreuma loftini*, is an invasive stem-borer, which poses a threat to crops grown for biofuel production in the Gulf Coast Region. An experiment was conducted in 2012 and 2013 at the Texas A&M Research Center in Beaumont, TX to evaluate yield-loss by the MRB among varieties of sugarcane, energycane, and bioenergy sorghum. Two sugarcanes (HoCP 04-838, *MRB susceptible*, and HoCP 85-845, *MRB resistant*) and two energycanes (L 79-1002 and Ho 02-113) were evaluated. Two high-biomass sorghums (ES 5200 and ES 5140) and one sweet sorghum (M81E), which have potential for biofuel production, were also evaluated. The experiment was arranged using a split-plot design with four replications. Crop varieties were randomized to 3-row plots (72 ft long, 1.6 m row spacing). Plots were further divided into four, subplots (18 ft long) and subjected to one of four MRB infestation levels: suppressed (biweekly applications of tebufenozide), natural infestation, enhanced infestation, and highly-enhanced infestation. To achieve enhanced infestation levels, MRB egg masses (~30 eggs) were clipped to the basal leaves of each plant throughout the growing season. Four-stalk samples were collected from each row of each subplot at the end of each season and the no. bored internodes no. total internodes, and no. emergence holes recorded. Stalks were then weighed and crushed to extract juices for determining Brix and ethanol output. In 2012, stalk weights and Brix measurements were used to calculate ethanol from sucrose using methods described by Vasilakoglou *et al.* (2011, Field Crops Res. 120: 38-46). All data were compared using two-way ANOVAs with crop variety and MRB infestation level as fixed effects.

In 2012 and 2013, differences were detected in the percentage of bored internodes across variety and infestation level, however an interaction between variety and infestation level was evident only in 2012 (Tables 1 and 2). Applications of tebufenozide were successful in suppressing injury to < 1.0% bored in all varieties. In subplots with highly-enhanced infestations, the percentage of bored internodes ranged from 9.1–26.8% and 7.9–19.9% in 2012 and 2013, respectively, with energycane Ho 02-113 and sweet sorghum M81E expressing higher levels of resistance. Injury to HoCP 04-838 was approximately 100% greater when compared to HoCP 85-845 in 2013. Differences in stalk weight were detected across variety and infestation level in both years. Higher infestations were associated with decreases in stalk weight for all varieties. In 2012, the negative impact in yield was also evident in terms of theoretical ethanol output. In highly-enhanced infestations, decreases in ethanol production ranged from 12–42% when compared to suppressed subplots. For all varieties, maximum ethanol productivity was achieved in MRB-suppressed subplots. In 2013, differences in Brix were detected by variety, infestation level, and variety by infestation level. Decreases in Brix were most prevalent in ES 5200 and M81E.

Results from this study demonstrate that the MRB has potential to reduce yields in bioenergy crops. A varying degree of resistance to the MRB was evident between varieties, stressing the importance of host-plant resistance as a tool in managing MRB infestations. Alternative control tactics, including chemical and biological control, will be needed to reduce yield-losses in bioenergy cropping systems under high borer pressure.

Table 1. MRB injury and yield parameters for sugarcane, energycane, high-biomass sorghum, and sweet sorghum varieties with varying infestation levels (1=suppressed, 2=natural, 3=enhanced, 4=highly-enhanced). Replicated field trial, Beaumont, TX, 2012.

Variety	Infestation Level	Bored Internodes	Weight (kg)/Stalk	Ethanol Output (L/ha)
Energycane L 79-1002	1	0.4	0.45	27229.0
	2	5.3	0.32	19979.0
	3	13.5	0.28	17000.0
	4	11.8	0.28	17725.0
Energycane Ho 02-113	1	0.7	0.36	25081.0
	2	7.2	0.32	22184.0
	3	8.2	0.27	18860.0
	4	15.0	0.25	17850.0
Sugarcane HoCP 04-838	1	1.2	0.72	14175.0
	2	16.0	0.59	11609.0
	3	22.7	0.48	9584.7
	4	27.7	0.44	8723.1
Sugarcane HoCP 85-845	1	1.9	0.75	10157.0
	2	6.0	0.56	8081.1
	3	25.9	0.46	6990.8
	4	22.1	0.42	6474.3
High-biomass Sorghum ES 5200	1	0.0	0.66	39509.0
	2	23.5	0.53	28032.0
	3	16.0	0.52	30817.0
	4	23.4	0.51	29420.0
High-biomass Sorghum ES 5140	1	0.0	0.36	20465.0
	2	12.2	0.29	16299.0
	3	15.8	0.24	13712.0
	4	18.0	0.24	13263.0
Sweet Sorghum M81E	1	0.2	0.27	16509.0
	2	14.4	0.21	12598.0
	3	9.1	0.16	11100.0
	4	12.6	0.17	10713.0
Type III Test of Fixed Effects	Variety	$F = 4.93$ $P = 0.0038$	$F = 26.70$ $P < 0.0001$	$F = 172.33$ $P < 0.0001$
	Infestation Level	$F = 64.02$ $P < 0.0001$	$F = 48.42$ $P < 0.0001$	$F = 49.21$ $P < 0.0001$
	Variety* Infestation Level	$F = 3.13$ $P = 0.0004$	$F = 1.82$ $P = 0.0428$	$F = 1.74$ $P = 0.0556$

Table 2. MRB injury and yield parameters for sugarcane, energycane, high-biomass sorghum, and sweet sorghum varieties with varying infestation levels (1=suppressed, 2=natural, 3=enhanced, 4=highly-enhanced). Replicated field trial, Beaumont, TX, 2013.

Variety	**Infestation Level**	**Percent Bored Internodes**	**Brix**	**Weight (kg)/Stalk**
Energycane L 79-1002	1	0.4	12.6	0.24
	2	6.8	12.0	0.18
	3	11.3	11.8	0.18
	4	12.6	12.0	0.20
Energycane Ho 02-113	1	0.3	16.2	0.32
	2	3.1	16.2	0.27
	3	7.0	16.0	0.27
	4	8.7	15.5	0.24
Sugarcane HoCP 04-838	1	0.3	18.3	0.68
	2	7.6	17.6	0.55
	3	10.0	18.4	0.47
	4	11.7	17.7	0.48
Sugarcane HoCP 85-845	1	0.1	17.6	0.66
	2	4.1	17.3	0.53
	3	2.8	17.5	0.43
	4	7.9	17.6	0.47
High-biomass Sorghum ES 5200	1	0.0	12.3	0.57
	2	4.7	11.8	0.37
	3	3.8	11.3	0.37
	4	9.1	10.8	0.37
High-biomass Sorghum ES 5140	1	0.3	11.2	0.34
	2	7.3	10.9	0.18
	3	11.2	10.7	0.19
	4	19.9	10.4	0.18
Sweet Sorghum M81E	1	0.3	12.9	0.27
	2	3.2	9.8	0.14
	3	7.1	9.3	0.16
	4	8.6	9.0	0.12
Type III Test of Fixed Effects	Variety	$F = 5.49$ $P = 0.0022$	$F = 51.19$ $P < 0.0001$	$F = 69.93$ $P < 0.0001$
	Infestation Level	$F = 40.51$ $P < 0.0001$	$F = 8.01$ $P = 0.0001$	$F = 30.76$ $P < 0.0001$

MEXICAN RICE BORER ESTABLISHMENT IN LOUISIANA

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Cooperative studies on the Mexican rice borer (MRB), *Eoreuma loftini*, between the LSU AgCenter, Texas A&M University AgriLIFE, the Texas Department of Agriculture, and the Louisiana Department of Agriculture and Forestry (LDAF) have been on-going since 1999 to monitor the movement of this devastating pest of sugarcane into Louisiana. As previously anticipated, MRB spread into Louisiana by the end of 2008, and was collected in two traps near rice fields northwest of Vinton, LA on December 15. Since then, extensive trapping of MRB has been conducted in southwest Louisiana by LDAF and LSU AgCenter personnel. Currently, more than 100 traps are being monitored in ten parishes in Louisiana.

To date, pheromone traps have detected MRB moths in Calcasieu, Cameron, Jefferson Davis, Beauregard, Allen, Vermillion, and Acadia Parishes (Fig. 1). LSU AgCenter Entomology personnel monitored 62 MRB pheromone traps in Calcasieu, Jefferson Davis, Cameron, Allen, and Beauregard Parishes from Feb-Dec, 2013. LDAF trapping efforts are focused near the eastern edge of the MRB range with 12 traps deployed in Acadia and Vermillion Parishes, as well as trapping near sugarcane mills during harvest. A total of 16,487 MRB males were trapped during this period. Examination of larval infestations in sugarcane and rice was conducted in addition to pheromone trap monitoring. Monitoring efforts in 2013 confirmed the presence of MRB in 30 previously unknown sites and 3 new Parishes (Allen, Acadia, and Vermillion) as well as detected the first larval infestations of MRB in Louisiana sugarcane. The first MRB infestation in sugarcane was recorded on March 29, 2013 in Calcasieu Parish. Further examination confirmed MRB infestations in roughly 300 acres of sugarcane in Calcasieu and 550 acres in Jefferson Davis; infestations reached levels as high as 11% of stalks infested with MRB larvae (Table 1). However, based on MRB distribution indicated by pheromone traps, it is probable that all Calcasieu (≈500 acres) and Jeff. Davis (≈1,000 acres) sugarcane is infested. Current known MRB distribution covers all of Calcasieu, Cameron, Jeff. Davis, and Beauregard Parishes. It stretches from the Gulf north to Deridder, LA and Oberlin, LA and east to within 5 miles from Crowley, LA. Based on its current rate of spread of roughly 15 mi/yr, MRB will likely become established throughout Vermillion (31,000 acres of sugarcane) and Acadia (1,800 acres) and may be detected in Lafayette (12,600 acres), Evangeline (200 acres), Rapides (11,400 acres), and St. Landry (6,500 acres) Parishes during the 2014 growing season.

Table 1. MRB infestations and pheromone trap captures in Louisiana sugarcane, 2013.

Parish		**May**	**June**	**July**	**Aug**	**Sept**	**Oct**
Calcasieu	No. MRB (total, 2 traps)	12	31	56	156	65	16
	Mean % infested stalks	0	0	0	11	8	8
Jefferson Davis	No. MRB (total, 3 traps)	4	40	28	39	68	51
	Mean % infested stalks	0	0	2	6	4	5

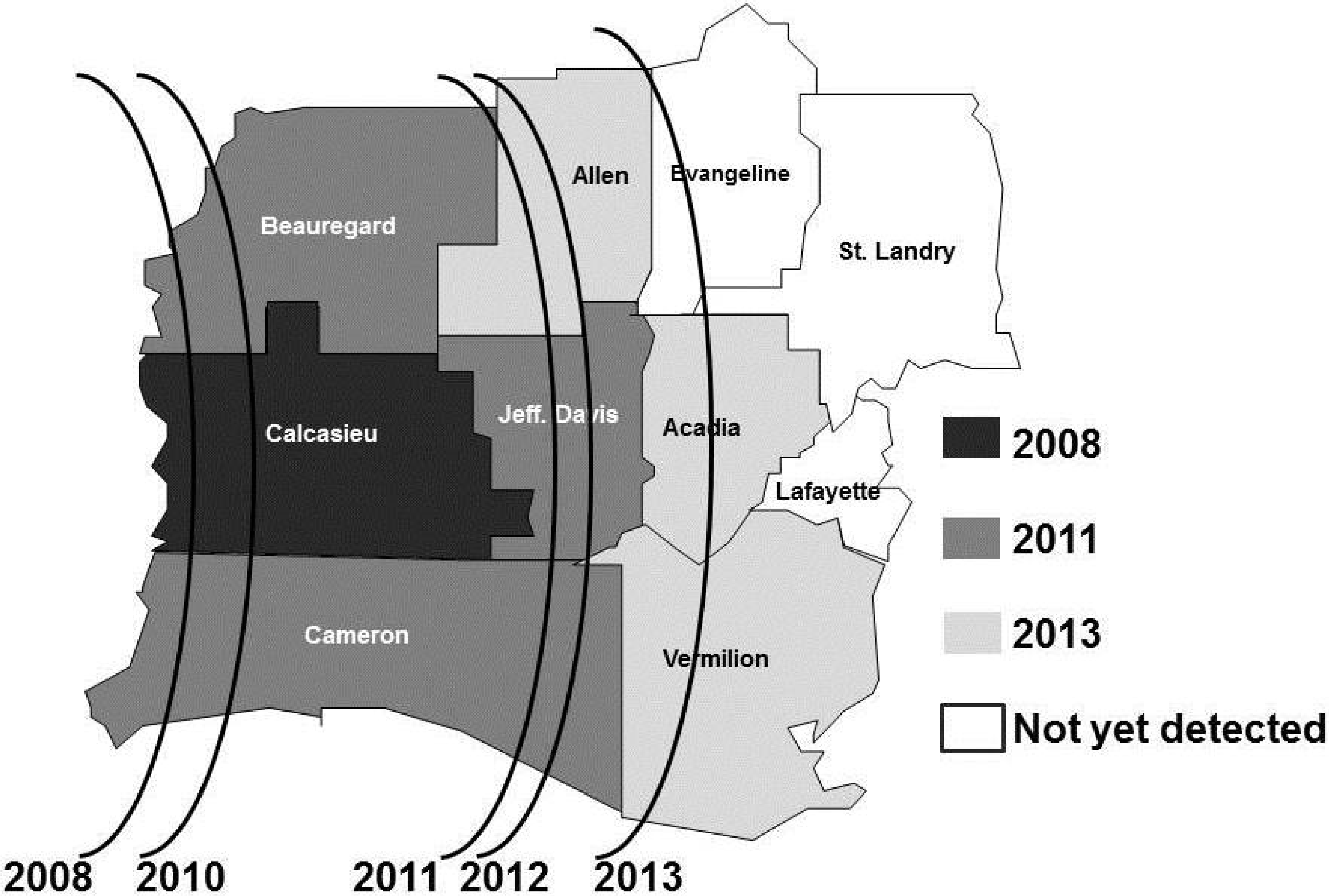

Figure 1. Mexican rice borer range expansion in SW Louisiana as of December 2013. Traps present in Rapides, Evangeline, St. Martin, St. Landry, Iberia and St. Mary Parishes have not yet detected MRB.

SMALL PLOT EVALUATION OF INSECTICIDAL CONTROL OF THE SUGARCANE BORER. JEANERETTE, LA, 2013.

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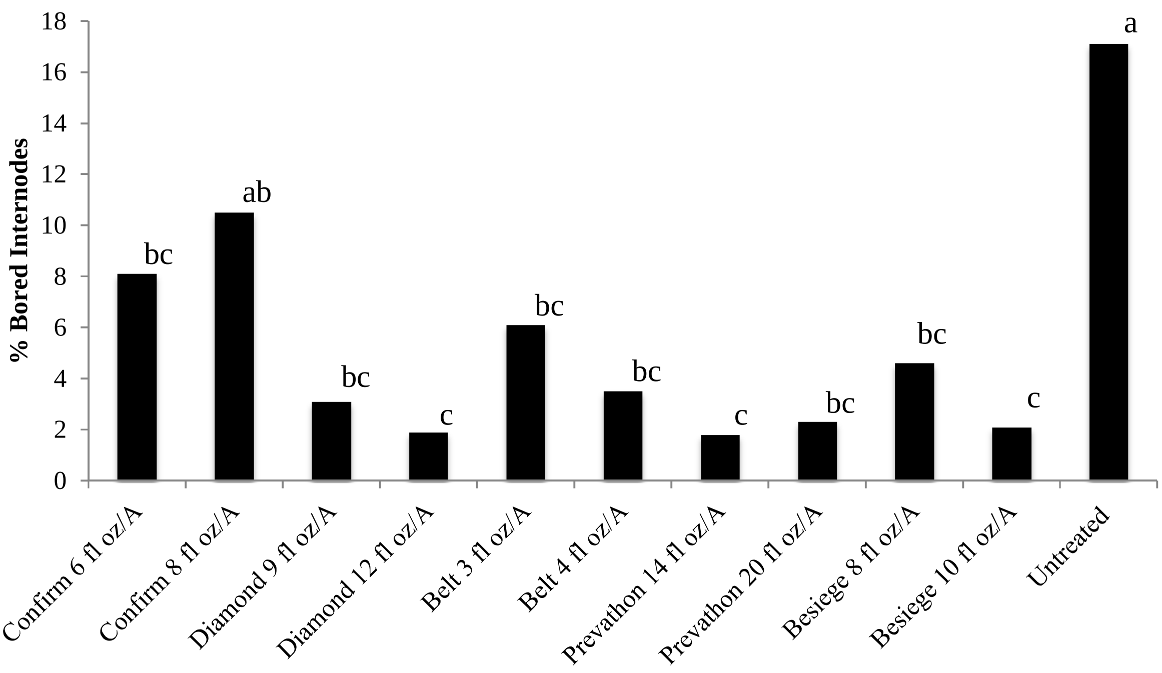
The efficacy of insecticides labeled for SCB management in sugarcane was evaluated at Enterprise Plantation in Jeanerette, LA. Ten insecticide treatments and an untreated check, replicated four times, were assessed in 4-row wide and 24-ft long plots of variety HoCP 96-540 (plant cane). One application was made on July 1, 2013 with a CO_2-pressurized backpack sprayer calibrated to deliver 10 GPA at 40 PSI. Differences between treatments were detected for percent bored internodes which ranged from 1.8% (Prevathon at 14 oz/A) to 17.1% (untreated) (Figure 1). Diamond, Belt, Prevathon, and Besiege provided successful control of SCB. However, numerical trends in the data suggest that Confirm provided less than adequate control of SCB in this test. Application timing and reduced residual of Confirm relative to other chemistries tested may have influenced the efficacy observed in this trial. However, it is possible that reduced susceptibility of SCB to Confirm is present and insecticide resistance management and utilization of alternative control strategies may be needed.

Figure 1. SCB injury, small plot insecticide trial. Enterprise Plantation, Jeanerette, LA, 2013.



*Means sharing a letter are not significantly different (Tukey's HSD, α = 0.05).