SUGAR CROPS PRODUCTION MANAGEMENT RESEARCH AT THE IBERIA RESEARCH STATION

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SUMMARY:

Field trials consisted of **1)** N-rate application evaluations for both newly released (L01-299, L03-371 and HoCP04-838) and some of the leading commercial sugarcane varieties (HoCP96-540, L99-226 and L01-283); **2)** continuation of evaluating the long-term effects of post-harvest residue management on sugarcane; **3)** assess the efficacy of nutritional products (Agrotain®Plus and SumaGrow®) on sugarcane; **4)** completion of the appraisal of sunn hemp as a fallow period cover crop; and **5)** a determination of sweet sorghum feedstock logistics for bio refinery sustainability. Typical of the insensitivity to inputs of plant cane neither L03-371 nor HoCP 04-838 responded to N fertilizer application. HoCP96-540, L99-226 and L01-283 in the stubble phase, however, required for optimal yield the rate of 80 lb N per acre. L01-299 required only 40 lb N per acre. In the long-term residue management study yield recovery was measured in the plant-cane crop of production cycle number four, once again demonstrating that the debilitating effects of residue retention are not cumulative across production cycles. The addition of Agrotain®Plus to recommended N fertilizer rates tended to increase sugar per acre yield, but the only significant contrast (P=.09) was the 2X rate of Agrotain®Plus with 120 lb N/acre vs. 120 lb N/acre. SumaGrow®, a combination of over 30 soil microbes, soil applied with both 60 and 120 lb N per acre gave inconsistent results, with a tendency to increase (P=.05) tonnage at the 120 lb N per acre rate but decrease (P=.07) tonnage at the 60 lb N per acre rate. Sweet sorghum hybrids varying in maturity from approximately 100 to 135 days were planted in mid-April and early and late May to assess the possibility of providing a continuous supply of feedstock for processing. Highest yields of fresh weight and fermentable sugar occurred at the early May planting, as dry soil conditions and Hurricane Isaac affected the early and late planting dates, respectively.

I. NITROGEN RATE TESTS:

Both newly released and leading commercial varieties were evaluated for response to fertilizer N on heavy-textured soil. For each trial a 0 lb N per acre check was compared to 40, 80 and 120 lb N per acre application rates. Plant cane L03-371 and HoCP 04-838 did not respond to N fertilizer, as shown in figure 1. Averaged over the three varieties grown as second stubble, HoCP96-540, L99-226 and L01-283, sugar per acre yields were 6980, 7995, 9249 and 8743 lb sugar per acre, respectively, for the 0, 40, 80 and120 lb N per acre application rates (figure 2). This indicates that the 80 lb N rate was sufficient for these three varieties, whereas, first stubble L01-299 optimized yield at only 40 lb N per acre (figure 3). The varied response to applied N fertilizer demonstrated by the six commercial varieties evaluated in these tests indicates the difficulty in determining appropriate N rates and in predicting the response by sugarcane.

II. LONG-TERM RESIDUE MANAGEMENT STUDY:

A post-harvest residue management study was initiated in 1997 and has continued through the plant cane crop of production cycle number four. The study has clearly confirmed what other investigations have found, that post-harvest residue generated from green cane

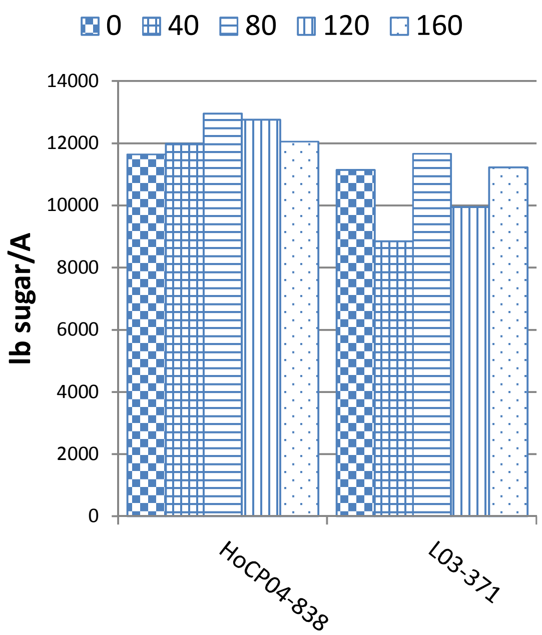

Fig. 1 – Response of plant cane varieties to N rates

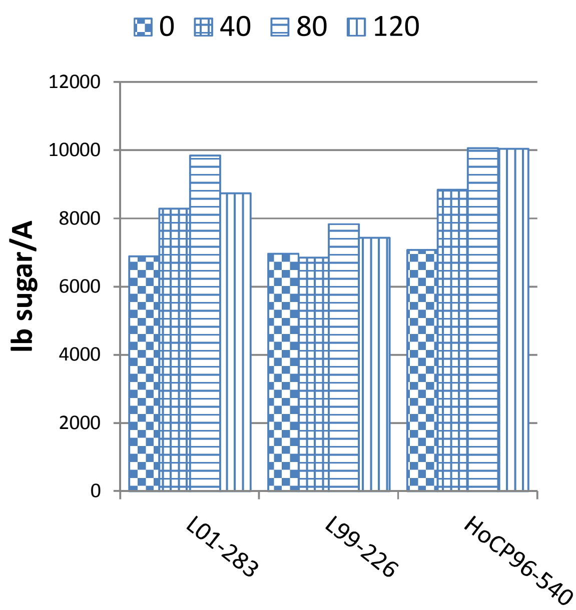

Fig. 2 – Response of 2nd stubble varieties to N rates

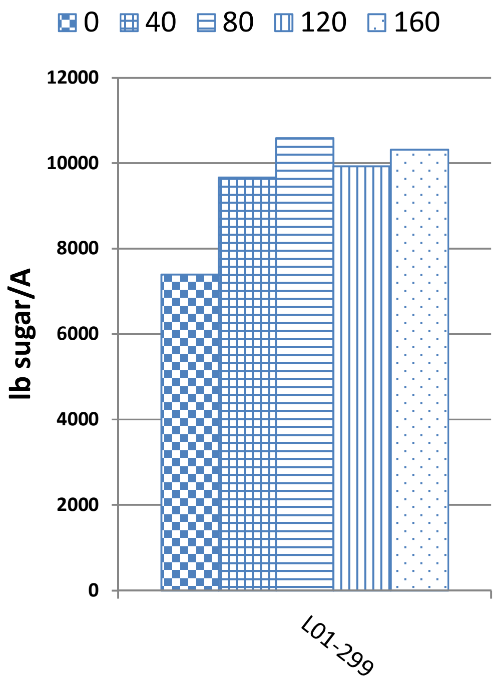

Fig. 3 - Response of L01-299 1st stubble to N rates

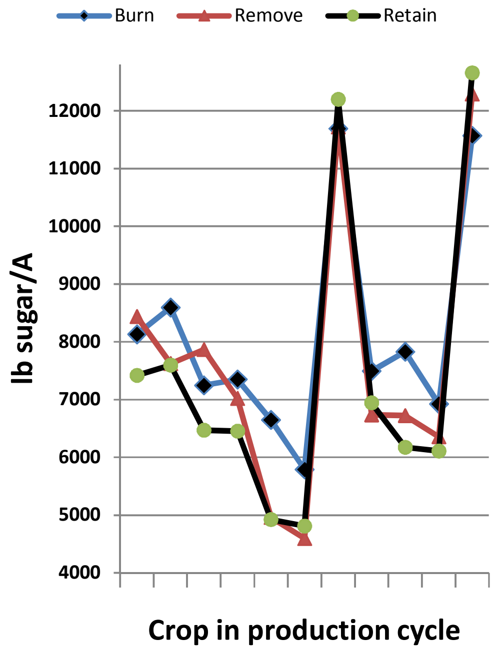

Fig. 4 - Long-term residue management study

harvesting under Louisiana conditions has a negative effect on the cane and sugar yield of ratoon crops within a production cycle. Generally, burning produces higher cane yield than retaining the residue, with sweeping the residue to the middles producing intermediate yields. What was known only anecdotally was that the negative effects of residue retention did not carry over to the plant cane crop of subsequent cycles of production. This study consistently demonstrates yield recovery with the initiation of the plant cane crop of each production cycle, as shown by the spikes in plant cane sugar yield in figure 4.

III. EFFICACY OF AGROTAIN®PLUS ON STUBBLE SUGARCANE:

Sugarcane in south Louisiana is widely produced on heavy-textured soil in a high rainfall environment, a situation conducive to potential N losses after fertilizer is applied in the spring. A product, Agrotain® Plus, formulated as an additive for UAN solution to slow N losses by retarding nitrification and inhibiting ammonia volatilization was evaluated in 2012 on first stubble L99-226. Because of the high nitrification potential of the soil Agrotain® Plus was evaluated at both the 1x rate (15 lb of Agrotain® Plus for each ton of UAN applied) and the 2x rate of Agrotain® Plus mixed with both 60 and a 120 lb N per acre application rates. The treatments were arranged in a RBD with four replications of plots that were 3 rows wide and 80 ft. in length. The soil type was typical of the sugarcane region, a Baldwin silty clay loam. As shown in the table 1 below, the only significant difference (P=0.09) among the treatment means was the 900 lb increase in sugar per acre yield due to the addition of the 2x rate of Agrotain® Plus to the 120 lb N per acre UAN rate. The material for the 2x rate of Agrotain® Plus is reported to cost $24 per acre, which is affordable should the positive yield results measured in this field trial prove repeatable.

Table 1. Contrast Analysis of Sugarcane Fertilized at Two Rates of N and Two Rates of Agrotain® Plus	
Treatment	Sugar Yield, lb/A
Contrast Analysis	
60 lb N/acre	6788
60 lb N/acre + 1x rate	7166
P value	***0.46***
60 lb N/acre	6788
60 lb N/acre + 2x rate	7029
P value	***0.64***
120 lb N/acre	6473
120 lb N/acre + 1x rate	6427
P value	***0.93***
120 lb N/acre	6473
120 lb N/acre + 2x rate	7362
P value	***0.09***
CV%	10.3

IV. EFFICACY OF SUMAGROW® ON STUBBLE SUGARCANE:

SumaGrow® is marketed as a unique combination of soil microbes (Bacillus, Enterobacter, Pseudomonas, Stenotrophomonas, Rhizobium, Azorhizobium and Trichoderma) designed to enhance soil health to influence crop growth and development. A field trial was conducted in 2012 to evaluate the efficacy of SumaGrow® applied at two rates (1 gallon and ½ gallon of product) in combination with two rates of fertilizer N (120 and 60 lb N per acre) to second stubble of the sugarcane variety HoCP96-540. SumaGrow® was applied in 32% UAN solution at spring fertilization to 3-row plots 50 ft in length. Plots were replicated four times in a randomized complete block design. The soil type was an Iberia silty clay. Means for cane tonnage are shown in table 2, as TRS was not available for all plots because juice quality was not determined. The response to the addition of SumaGrow® to UAN at the full rate was inconsistent, with tonnage being depressed at the 60 lb N per acre rate but increased at the 120 lb N per acre application. The coefficient of variation was relatively high, which tends to undermine the validity of the data.

Table 2. Contrast Analysis of Sugarcane Fertilized at Two Rates of N and Two Rates of SumaGrow®	
Treatment	Cane Yield, tons/A
Contrast Analysis	
60 lb N/acre	35.5
60 lb N/acre + 1/2 x rate	32.2
P value	***0.39***
60 lb N/acre	35.5
60 lb N/acre + 1x rate	28.2
P value	***0.07***
120 lb N/acre	32.3
120 lb N/acre + 1/2x rate	33.3
P value	***0.81***
120 lb N/acre	32.3
120 lb N/acre + 1x rate	40.1
P value	***0.05***
CV%	15.7

V. EVAUATION OF SUNN HEMP AS A COVER CROP FOR SUGARCANE:

'Tropic Sun' sunn hemp (*Crotalaria juncea* L.) is a tropical legume capable of producing high amounts of biomass containing considerable N. A field trial was conducted in 2011-12 to evaluate its suitability as a N-fixing cover crop for production during the fallow period prior to plant cane establishment. Sunn hemp seed was double drilled on sugarcane rows at the rate of 40 lb of seed per acre on April 19, 2011. While the intent was to incorporate the biomass into the soil after 60 days of growth, emergence was initially suppressed by dry soil conditions and shredding was delayed by wet soil conditions resulting in an August shredding. After approximately two weeks were allowed for residue desiccation, the residue was incorporated and sugarcane variety L99-226 was planted on September 9, 2011. Sunn hemp sampling revealed an average dry matter yield of 6 tons per acre, which contributed an average of 190 lb N per acre. Treatments compared were: 1) unfertilized plant cane following a conventional fallow period; 2) plant cane fertilized with 40 lb N per acre following fallow; 3) plant cane fertilized with 80 lb N per acre following fallow; 4) unfertilized plant cane following ploughed down sunn hemp; 5) plant cane fertilized with 40 lb N per acre following sunn hemp; and 6) plant cane fertilized with 80 lb N per acre following sunn hemp. As shown in table 3 below, there were no differences between the treatments at the P=0.05 level. While the expectation that plant cane benefitting from the additive effects of sunn hemp residue plus additional fertilizer N would exhibit highest yields did not meet the generally accepted standard for significance, there was a trend for plant cane following sunn hemp and receiving fertilizer N to yield greater than fertilized plant cane following a conventional fallow period. Regardless, the results are not strong enough to conclude that the N contained in the ploughed down sunn hemp could substitute for spring applied N fertilizer on plant cane. This test is being repeated.

Table 3. Cover crop effects of sunn hemp on plant cane L99-226				
Fallow period treatment	N fertilizer lb/A	Cane yield tons/A	TRS lb/ton	Sugar yield lb/A
Fallow	0	42	249	10469
Fallow	40	39	245	9881
Fallow	80	40	239	9745
sunn hemp	0	37	247	9166
sunn hemp	40	45	259	11661
sunn hemp	80	43	237	10203
***P* =**		***0.08***	***0.43***	***0.08***

VI. A REGIONAL PROGRAM FOR PRODUCTION OF MULTIPLE AGRICULTURAL FEEDSTOCKS AND PROCESSING TO BIOFUELS AND BIOBASED CHEMICALS:

The LSUAgCenter received its largest grant ever, a $17.2 million award from the U.S. Department of Agriculture's National Institute of Food and Agriculture for a project to investigate energy cane and sweet sorghum for the production of biofuels and chemicals. The broad mission of the sweet sorghum research group is to "evaluate sweet sorghum hybrids for agronomic performance, inclusive of their ability to maintain juice quality into the fall season, produce commercial yields on marginal soil, respond to low-input sustainable production practices and deliver quantities of feedstock on a schedule that sustains the viability of the bio-refinery". While it is broad in scope and involves multiple disciplines and research stations, personnel at the Iberia Research Station are responsible for investigating and demonstrating the logistics of feedstock delivery. The test location was the Sugar Research Station because of its lab facilities and close proximity to the Audubon Sugar Institute, where plant samples were sent for fiber and sugar analyses. Ceres® Inc. hybrids of varying maturity were planted in early-April, mid-May and early-June and harvesting with a John Deere combine was initiated when grain reached the hard-dough stage of development. The test was designed to provide a sustained feedstock supply from the initiation of harvest in July to mid-November, which is typically the time for the occurrence of the first frost. Harvesting commenced with the early-maturity hybrids in late July and continued until the June planting of the late-maturity hybrids were combine harvested on October 11. Expectation that the late-maturity hybrids would reach hard-dough in approximately 150 days was not realized, as maturation was earlier due to issues of day length and temperature for the site chosen. This earlier than expected maturation, therefore, created an overlap in maturity between the mid- and late-maturity hybrids. Averaged over the three planting dates, the early-, mid- and late-maturity hybrids required 98, 123 and 130 days, respectively, to reach maturity. Hybrid performance by planting date is shown in table 4. The ranking of fermentable sugar yields was consistent for each planting date, with the medium-maturity hybrids producing the most for each planting. Averaged over planting dates the early, medium and late maturing hybrids yielded 1.70, 3.08 and 2.44 tons per acre of fermentable sugar, respectively. The hybrids in the first planting were adversely affected by dry soil conditions and for the last planting by Hurricane Isaac. Greatest yields were achieved with the May 7 planting, 2.79 tons of fermentable sugar per acre as an average of the three maturity groups. Yields measured in this study suggest that a 1,000 metric ton per day bio-refinery would require approximately 6,000 acres to operate from July 15 to October 15. Bio-refinery viability based on sweet sorghum is particularly feasible in south Louisiana when included in a model with energy cane, as sweet sorghum and energy cane can be grown in sequence to sustain feedstock availability. Sorghum's competitive advantage in Louisiana is that it can be grown on fallow land of the energy cane production cycle and can be harvested and transported with existing sugarcane equipment.

Table 4. Influence of planting date on sweet sorghum production at Sugar Research Station

Planting date	Maturity group	Fermentable Sugar tons/A	Fresh weight tons/A	Brix
April 11	Early	2.22	18.6	16.5
	Medium	2.98	31.5	15.4
	Late	2.29	26.3	14.6
May 7	Early	1.45	21.7	12.9
	Medium	3.85	42.9	14.3
	Late	3.06	38.9	13.4
May 30	Early	1.55	19.7	13.1
	Medium	2.24	32.1	11.1
	Late	1.97	30.0	10.9

EVALUATION OF BIOWASH ON SUGAR YIELD

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In 2012, the LSU AgCenter was approached to test the effect of BioWash™ on sugarcane growth and development. Product information can be obtained at the following web site: http://www.fertilizerboosters.com/ (accessed April 11, 2013).

A yield trial was conducted during 2013 at the Sugar Research Station in St. Gabriel, Louisiana. A field of L 01-299 was used as the test site. The experimental design was a randomized complete block (four replications). Treatments included nitrogen (N) rates of 30, 60, 90, and 120 lbs N/acre with two foliar applications of Biowash twice at 30 day intervals at a rate indicated by the company. Another treatment of 60 lbs. N/acre with Biowash applied to the soil was also included. The final treatment included was 120 lbs. N/acre with no application of Biowash, which served as a control to evaluate all other treatments.

Standard cultural practices were followed during the 2013 growing season. Several traits important to sugarcane yield were measured: plant height (inches, May 30th), plant height (inches, July 5th), and stalk population (#/acre, recorded August 1st). The trial was harvested on November 13, 2012. Plots were harvested with a mechanical sugarcane combine and the cane was weighed in a wagon fitted with three load cells to record plot weight. Prior to harvest, eight-stalk samples were cut from each plot and taken to the sucrose laboratory to assess sucrose content (lbs. sugar/ton of cane). Stalk weight (lbs.) was also estimated by weighing the eight-stalk bundles. From the plot weights, tons of cane/acre was estimated. Sugar per acre was estimated as the product of sucrose content and tons of cane/acre.

Data were analyzed with SAS (v9.2) software. Replication was considered a random effect; treatments were considered a fixed effect. Least square means were estimated and tested for statistical significance (P=0.05) with the PDIFF option of PROC MIXED.

Table 1. Summary of a field trial conducted at the Sugar Research Station in St. Gabriel, LA in 2013 testing the product BioWash on sugar yield and yield components.

Nitrogen Rate (lbs. N/acre)	Biowash Application	Foliar or Soil	Height-July 30 cm	Height-July 30 inches	Significance Letter Grouping*
120 (Control Treatment)	NO	NO	87.8	34.6	AB
120	YES	FOLIAR	91.9	36.2	A
90	YES	FOLIAR	87.8	34.6	AB
60	YES	FOLIAR	91.7	36.1	A
30	YES	FOLIAR	81.5	32.1	B
60	YES	SOIL	83.8	33.0	B

Nitrogen Rate (lbs. N/acre)	Biowash Application	Foliar or Soil	Height - July 5 cm	Height - July 5 inches	Significance Letter Grouping*
120 (Control Treatment)	NO	NO	176	69.3	A
120	YES	FOLIAR	180	70.9	A
90	YES	FOLIAR	170	66.9	A
60	YES	FOLIAR	176	69.3	A
30	YES	FOLIAR	170	66.9	A
60	YES	SOIL	173	68.1	A

Nitrogen Rate (lbs. N/acre)	Biowash Application	Foliar or Soil	Tons/acre	TRS (lbs/ton)*	lbs Sugar/acre	Stalk Weight (lbs)	Population (#/acre)
120 (Control Treatment)	NO	NO	38.7	239 A	9259	2.00	24502
120	YES	FOLIAR	38.7	238 A	9208	2.02	25229
90	YES	FOLIAR	37.8	241 A	9132	2.13	25809
60	YES	FOLIAR	39.6	242 A	9613	2.06	23922
30	YES	FOLIAR	38.3	238 A	9131	2.09	24321
60	YES	SOIL	36.4	224 B	8153	1.97	25047
		Pr > F	0.7351	0.0484	0.2261	0.8845	0.8838

* Means having the same letter are not significantly different from each other (Prob <0.05).

RESPONSE OF DIFFERENT CANE VARIETIES TO NITROGEN AND SILICON FERTILIZATION

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In Cooperation with
Sugar Research Station

Summary

Three field trials were conducted in 2012 to evaluate the performance of recent cane varieties as affected by different application rates of nitrogen (N) and silicon (Si). Nitrogen applied at the rate of 80 lbs ac^{-1} significantly increased cane yield of 2nd ratoon cane varieties HoCP96-540, L99-226 and L01-283. The effect of N on sugar yield was not consistent among these three varieties. Both L99-226 and HoCP96-540 sugar yield were maximized at 80 lbs N ac^{-1} while L01-283 required 120 lbs N ac^{-1}. Calcium silicate ($CaSiO_3$) application improved sugar yield of cane varieties L01-283, LCP85-384, and HoCP96-540 planted on Sharkey clay soil. The increased in sugar yield was attributed to increased cane tonnage. On Commerce silt loam, theoretical recoverable sugar (TRS) and juice quality across varieties were significantly (P<0.05) increased by applying 2 ton ac^{-1} of $CaSiO_3$ however there were minimal increases in cane tonnage, thus overall sugar yield was not significantly increased.

Objective

This research was designed to provide information on N fertilizer management and potential benefits of Si fertilization to sugarcane to help growers maximize both economic yields and profitability of sugarcane production. This annual progress report is presented to provide the latest available data on certain practices and not as final recommendation for growers to use all of these practices.

Results

Sugarcane Response to Nitrogen Fertilization

Cane and sugar yield responses of 2nd ratoon cane varieties L01-283, HoCP96-540 and L99-226 to different N rates (0, 40, 80, and 120 lbs N ac^{-1}) were evaluated along with TRS and juice quality (Table 1; Figure 1). There were varietal differences on % Brix, sucrose content, and TRS. The effect of N on TRS and juice quality was not significant however, there were significant differences on mean cane tonnage among N rates (P<0.001). For sugar yield, the effect of N was not consistent among varieties. Sugar yield of both L99-226 and HoCP96-540 was maximized with an application rate of 80 lbs N ac^{-1} increasing yield by more than 2000 lbs ac^{-1} when compared with the check plot. Variety HoCP96-540 required 120 lbs N ac^{-1} to maximize sugar yield; sugar yield was more than twice the yield of the check plot.

Response of Sugarcane to Calcium Silicate Fertilization

This study was established on Sharkey clay and Commerce silt loam soils at the Sugar Research Station in St. Gabriel, LA. The treatments consisted of three cane varieties (L01-283, LCP85-384, and HoCP96-540) and four rates of $CaSiO_3$ slag (0, 1, 2, and 4 ton ac^{-1}). The effect of $CaSiO_3$ application was consistent across varieties for both soils (Tables 2 and 3). For Sharkey clay soil, while there were significant differences on mean TRS among $CaSiO_3$ rates ($P<0.05$), there was no clear relationship between $CaSiO_3$ rates and TRS levels (Table 2). Cane yield was significantly affected by $CaSiO_3$ application however, there were no significant differences on cane yield among the $CaSiO_3$ rates. Plots which received 4 ton $CaSiO_3$ ac^{-1} consistently obtained the highest level of TRS and cane yield hence sugar yield ($P<0.05$). For Commerce silt loam soil, the application of $CaSiO_3$ had an increasing effect on TRS, % Brix, and sucrose content ($P<0.05$) but with very minimal impact on cane yield, the resulting sugar yield among $CaSiO_3$ rates was found to be statistically similar (Table 3). Figures 2 shows that among the varieties tested, L01-283 on Sharkey clay soil obtained the highest increase (about 1000 lbs ac^{-1}) in sugar yield with only 1 ton $CaSiO_3$ ac^{-1} application rate. HoCP96-540 required 4 ton $CaSiO_3$ ac^{-1} to raise sugar yield by about 600 lbs ac^{-1}; at the same $CaSiO_3$ rate, smaller increase in yield (about 400 lbs ac^{-1}) was recorded for LCP85-384. For Commerce silt loam, the increase in sugar yield was numerically highest at 2 ton $CaSiO_3$ ac^{-1} for both L01-283 and LCP85-384, and 4 ton ac^{-1} for HoCP96-540. This study showed the potential of $CaSiO_3$ application on sugarcane quality and yield. Field response trials should be continued to build a strong database to confirm the benefits of $CaSiO_3$ application and develop the corresponding Si fertilization guidelines for sugarcane.

Acknowledgement
The authors wish to express appreciation for the financial support of American Sugar Cane League.

Table 1. Effect of nitrogen on cane yield and juice quality parameters of three cane varieties (2^{nd} ratoon) planted on a Commerce silt loam soil at the Sugar Research Station, St. Gabriel, LA, 2012.

Treatment		Brix %	TRS lbs ton^{-1}	Sucrose %	Cane Yield ton ac^{-1}
Variety					
	L99-226	20.9	209	15.8	29.3
	L01-283	22.0	221	16.6	31.1
	HoCP96-540	20.7	208	15.6	31.0
	Pr>F	***<0.001***	***<0.001***	***<0.001***	***0.207***
Nitrogen Rate, lb/ac					
	0	21.1	212	16.0	22.0
	40	21.4	214	16.2	28.7
	80	21.1	212	16.0	35.0
	120	21.2	212	16.0	36.2
	Pr>F	***0.5231***	***0.8943***	***0.8121***	***<0.001***
Variety x N	***Pr>F***	***0.8834***	***0.8247***	***0.8547***	***0.0503***

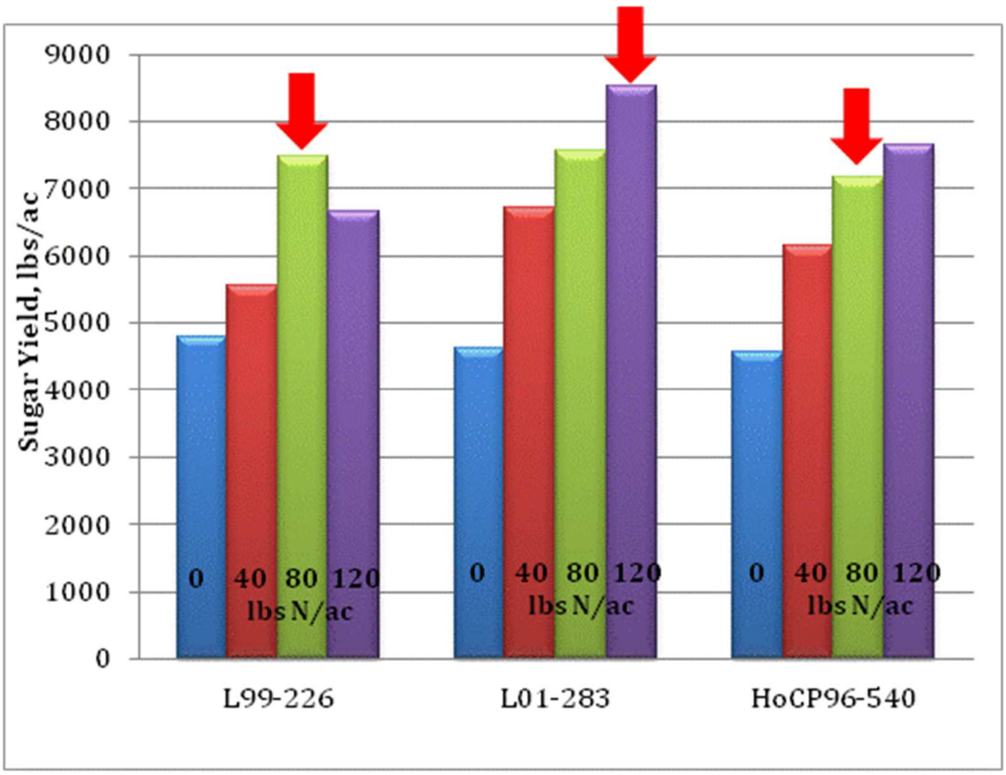

Figure 1. Effect of nitrogen rate on sugar yield of varieties L99-226, L01-283, and HoCP96-540. Arrows indicate the N rates at which the highest sugar yield was obtained for each variety (P<0.001).

Table 2. Effect of calcium silicate fertilization on yield and juice quality parameters of three cane varieties (2nd ratoon) planted on a Sharkey clay soil at the Sugar Research Station, St. Gabriel, LA, 2012.

Treatment		Brix %	TRS lbs ton^{-1}	Sucrose %	Cane Yield ton ac^{-1}	Sugar Yield lbs ac^{-1}
Variety						
	L01-283	20.4	200	15.2	34.1	6800
	LCP85-384	19.0	185	14.1	29.9	5521
	HoCP96-540	19.0	184	14.0	32.9	6028
	Pr>F	***<0.001***	***<0.001***	***<0.001***	***0.0026***	***<0.001***
Calcium Silicate Slag, ton/ac						
	0	19.6	193	14.7	30.0	5788
	1	19.4	188	14.4	32.9	6204
	2	19.1	185	14.1	32.1	5942
	4	19.7	192	14.6	34.0	6530
	Pr>F	***0.072***	***0.016***	***0.0890***	***0.0367***	***0.0214***
Variety x N	***Pr>F***	***0.0619***	***0.0934***	***0.0792***	***0.4781***	***0.3163***

Table 3. Effect of calcium silicate fertilization on yield and juice quality parameters of three cane varieties (2nd ratoon) planted on a Commerce silt loam at the Sugar Research Station, St. Gabriel, LA, 2012.

Treatment		Brix %	TRS lbs ton^{-1}	Sucrose %	Cane Yield ton ac^{-1}	Sugar Yield lbs ac^{-1}
Variety						
	L01-283	21.2	207	15.8	40.0	8265
	LCP85-384	20.2	199	15.1	32.8	6505
	HoCP96-540	20.1	198	15.0	43.2	8531
	Pr>F	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
Calcium Silicate Slag, ton/ac						
	0	20.2	197	15.0	38.4	7566
	1	20.4	200	15.2	38.2	7610
	2	20.9	206	15.7	38.6	7951
	4	20.5	201	15.3	39.5	7938
	Pr>F	***0.0056***	***0.0202***	***0.0115***	***0.7486***	***0.2063***
Variety x N	***Pr>F***	***0.4397***	***0.6951***	***0.6326***	***0.9991***	***0.9720***

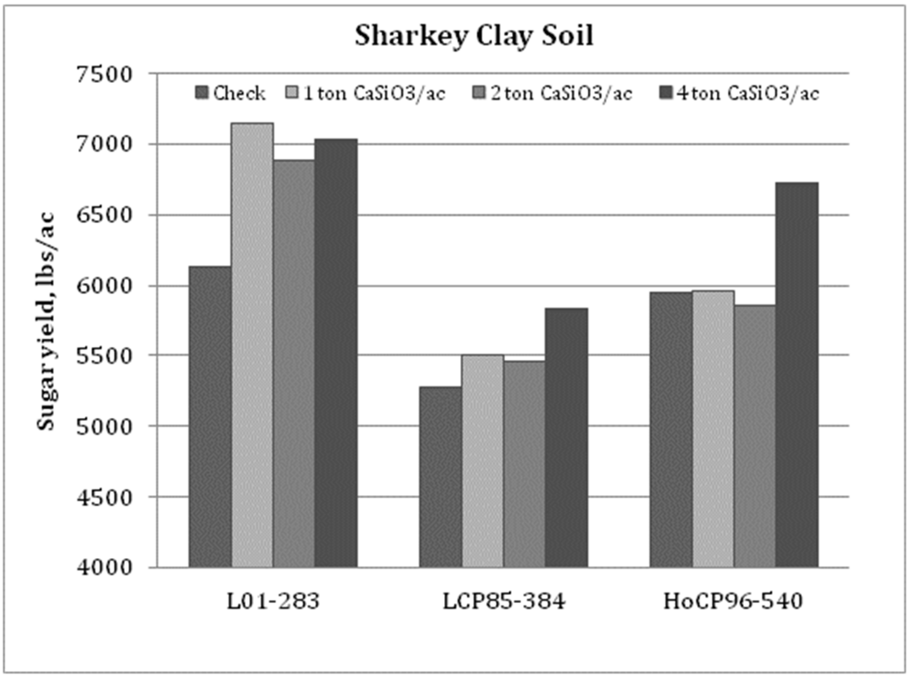

Figure 2. Sugar yield of 2nd ratoon cane varieties L01-283, LCP85-384 and HoCP96-540 planted on a Sharkey clay soil as affected by different application rates of calcium silicate slag.

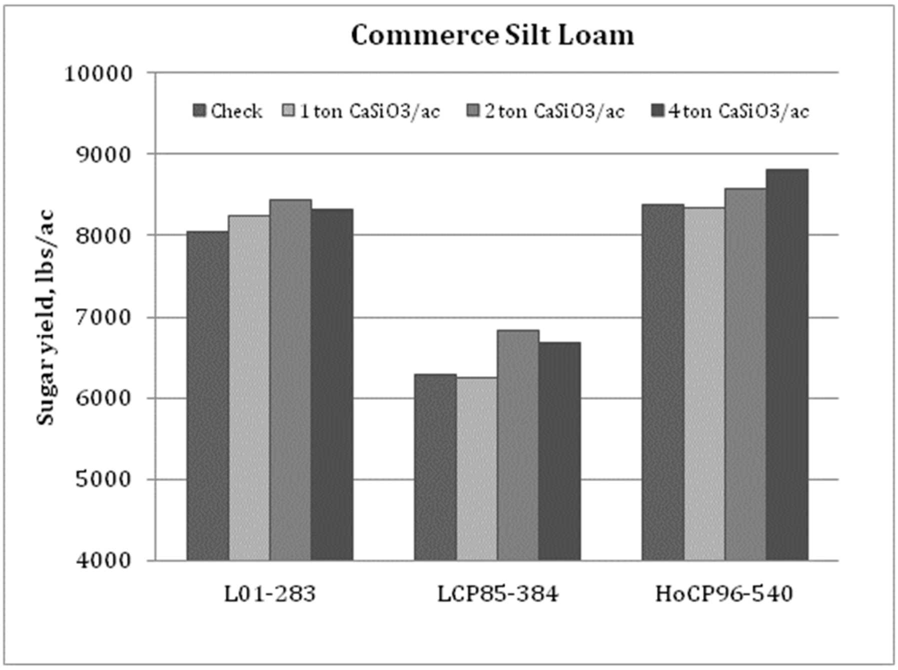

Figure 3. Sugar yield of 2nd ratoon cane varieties L01-283, LCP85-384 and HoCP96-540 planted on a Commerce silt loam as affected by different application rates of calcium silicate slag.