Evaluation of Billet Planting Tolerance in Commercial and Experimental Sugarcane Varieties in Louisiana

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The potential is greater for stand establishment problems and lower yields with billet compared to whole stalk planting in Louisiana. However, circumstances, such as severe lodging of seedcane sources or the lack of labor, sometimes result in farmers planting billets. Therefore, whole stalk and billet plantings of commercial and near-release experimental sugarcane varieties were compared in field experiments at the Sugar Research Station of the Louisiana Agricultural Experiment Station at St. Gabriel, LA to determine varietal tolerance to billet planting. Results have been determined for two 3-year crop cycles, one experiment through first ratoon, and one experiment with plant cane only. Typical commercial planting rates for each method are compared rather than planting with each method using the same amount of seedcane. Whole stalks are machine cut and hand planted; billets are machine cut and machine planted. Yields from billet and whole stalk plantings have been compared for LCP 85-384, Ho 95-988, HoCP 96-540, L 97-128, L 99-226, L 99-233, L 01-283, and L 01-299. Tolerance to billet planting assessed as yield production equivalent to whole stalk planting has varied among varieties and within varieties compared in different plantings. Lower yields in billet plantings were manifested most strongly in the plant cane crop. Yield reductions were greater when stressful environmental conditions occur during the planting season and/or following winter. Large differences in plant cane yield between billet and whole stalk plantings persisted into first ratoon in some experiments for some varieties. A significant yield reduction was only detected in second ratoon for Ho 95-988 in one experiment. Varieties with poor tolerance to billet planting exhibited lower yield even in plant cane crops that did not experience environmental stress conditions following planting. These included Ho 95-988, L 97-128, and L 99-226. Varieties that had lower plant cane yield in billet plantings when exposed to environmental stress were LCP 85-384, HoCP 96-540, and L 99-233. The two most recently selected clones, L 01-283 and L 01-299, did not exhibit any differences in yield between billet and whole stalk plantings in three successive plant cane crops suggesting they currently possess tolerance to billet planting.

Soybean Planting Configurations on Fallowed Sugarcane Beds

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In Louisiana, sugarcane stubble is destroyed following the multi-year crop cycle, and fields are fallowed during the summer months in preparation for replanting in August and September. Because conventional tillage and herbicide fallow weed control programs impose a cost with no direct return, planting an alternative crop during the fallow period may provide additional income to producers. Interest in growing soybean in fallowed sugarcane fields has further increased as early maturing varieties have become available that allow for earlier harvest and timely planting of sugarcane. Research was initiated to evaluate growth response and yield of maturity Group IV soybean planted on 6 foot-wide sugarcane beds using the same seeding rate per acre and several planting configurations; two drills per bed spaced 18, 24, or 30 inches apart and three drills per bed spaced 15 inches apart. Differences in soybean height among the planting configurations were not observed from 8 weeks after planting (WAP) through the remainder of the growing season. Maximum soybean height was attained 11 WAP for 2 drills at 24 or 30 inch spacing and for 3 drills at 15 inches, but 13 WAP was needed to maximize height for 2 drills at 18 inch spacing. Soybean canopy closure on the top of the bed between drills was attained 7 WAP when drills were 15 or 18 inches apart, 9 WAP when drills were 24 inches apart, and 11 WAP when drills were 30 inches apart. Canopy closure in the row middles was determined by measuring the area not covered by soybean foliage between the two outermost drills for adjacent sugarcane beds. When 2 drills were planted 30 inches apart and when 3 drills were planted 15 inches apart, canopy closure in the row middles occurred by 11 WAP. Complete canopy closure in the row middles was not attained by 13 WAP for 2 drills at 18 or 24 inch spacing. In 2006 when planting was delayed beyond the optimum date, yield was 14% greater when 3 drills were planted 15 inches apart compared with 2 drills planted 30 inches apart, both with 30 inches between the two outside drills. In 2007 when total rainfall was 1.6 times that of the previous year and when soybean was planted at the optimum date, yield differences among the various planting configurations were not observed.

Investigation of Factors Affecting Suspension of Metribuzin DF in Spray Solution

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Use of metribuzin products for weed control in sugarcane has increased. Producers have reported problems with the metribuzin DF (dry flowable) formulation related to mixing and clogging of main filter and nozzle screens. A DF formulation is in an agglomerated state and when added to water in the spray tank, particles should completely wet, fall apart, and disperse in the spray solution. Any factor affecting ability of DF metribuzin to wet and disperse can result in formation of sediment which contributes to spray problems. In 2008, analysis of five water sources where problems had occurred showed ranges of 7.5 to 8.3 pH, 127 to 508 alkalinity, and 46 to 120 hardness (Ca and Mg). In 2009, research was conducted in the laboratory to

investigate various factors including water source, metribuzin product, spray volume, agitation time, surfactant, and addition of another herbicide that may contribute to the sediment problem. In all experiments, water sources from the Carmouche Farm in Assumption Parish where serious mixing problems had occurred (8.3 pH, 366 alkalinity, and 46 hardness) and from St. Gabriel municipal water (7.8 pH, 181 alkalinity, and 4 hardness) were compared. Formulated metribuzin products were added to water to correspond to a field rate of 2 lbs product per acre applied in 10, 15, or 20 gallons per acre spray volume. Erlenmeyer flasks containing water and herbicide were agitated using a shaker for 1, 5, 15, 30, 60, or 90 minutes and spray solution was filtered through Whatman #1 (11 micron) filter paper. Collected sediment was dried and weighed.

Results showed consistently greater sediment for the Carmouche water source compared with St. Gabriel and for Sencor DF® (Bayer Crop Protection) compared with TriCor® (United Phosphorus Industries). Sediment was reduced when agitation time increased and when spray volume equivalent increased. At a spray volume equivalent of 15 gallons per acre, collected sediment increased when Sencor or TriCor was used in combination with crop oil concentrate compared with nonionic surfactant or no surfactant and in combination with Brash® (dicamba plus 2,4-D). Laboratory research is underway to evaluate addition of buffer and ammonium sulfate to mitigate the negative effect of water pH, alkalinity, and hardness on re-suspension of metribuzin DF. Research will also evaluate the various factors using grower spray equipment.

Potential Use of Eptam in Sugarcane

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EPTC herbicide, trade name Eptam, was used extensively at one time in corn. Its strength was the control of nutsedge and suppression of rhizome johnsongrass and bermudagrass, but its weakness was that it required immediate incorporation into the soil to prevent loss due to volatilization. In sugarcane the most prevalent weeds are johnsongrass, bermudagrass, and nutsedges. During the fallow year when fields are prepared for replanting, efforts are made to reduce population of troublesome weeds. Glyphosate is used extensively in fallowed fields but is not highly effective on bermudagrass and nutsedges. In 2008 Eptam was labeled for use in fallow ground when applied at least 45 days before planting. In 2007 and 2008 Eptam was evaluated at 2, 3, 4, and 5 pt/A incorporated on pre-formed sugarcane beds using a Lilliston® rolling cultivator or a hipper/bedder. Bermudagrass control at 30 and 45 days after treatment (DAT) did not differ among Eptam rates or between the application methods either year. In 2007 Eptam reduced bermudagrass ground cover an average of 78% 30 DAT and 73% 45 DAT, but a reduction in ground cover between Eptam and the nontreated control was not evident in 2008. Because Eptam suppressed bermudagrass growth, the follow up application of glyphosate both years was delayed 14 days compared with a glyphosate alone treatment. Glyphosate was equally effective on bermudagrass whether or not Eptam was used. Johnsongrass control with Eptam was evaluated in 2008 and as observed for bermudagrass, control was not affected by rate or application method. Johnsongrass control with Eptam averaged 83% 30 DAT and 68% 45 DAT. In 2007 when Eptam was incorporated with a bedder, purple nutsedge ground cover was reduced an average of 77%. This level of control is significant considering that glyphosate is not effective on purple nutsedge.

An Eptam rate of 2 pt/A was as effective as the higher rates and at a cost of around $10/A would be an economical component of a fallow program utilizing glyphosate products. The two-week delay in the initial glyphosate application when Eptam was used would allow the grower more flexibility in making applications. Eptam is also effective on many vining weeds which could be beneficial. Eptam applied in all fallow experiments did not negatively affect stand establishment of sugarcane. Research is ongoing to determine the value of Eptam application in fallowed fields in regard to weed control in the planted crop. In 2008 Eptam was also evaluated for sugarcane tolerance and weed control when applied at-planting at 3, 5, and 7 pt/A. Treatments were incorporated with a Lilliston® cultivator after sugarcane was planted and covered with 3 to 4 inches of soil and rows were packed. Sugarcane shoot population in 2009 was not negatively affected by Eptam.

Effects of Glyphosate Ripener Timing and Rate on Cane and Sugar Yields

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The Louisiana sugarcane industry is dependent on the use of glyphosate ripener applications to increase sucrose levels. Initially these applications began in late-August and were limited to the second-ratoon crop harvested at the start of the growing season. Currently, applications have been extended to include all ratoon crops and harvests through November and early December. There have been a number of new varieties released in Louisiana. Unfortunately, the response of many of these varieties to the standard rate (0.188 lb ae/A) of glyphosate has been inconsistent and higher rates are being applied to elicit a response. Glyphosate, formulated with surfactant, was applied at 0.188 lb /A in the first week of August, September, October, and November of 2006 and 2007 to a first-ratoon crop of the cultivar 'HoCP 96-540'. Sugarcane was hand-harvested at 4, 5, 6, and 7 weeks after treatment (WAT) and theoretical sugar recovery (TRS) was determined. Increases in TRS were obtained with all application timings and sampling intervals except the November application date. Increases of 5 to 16% in TRS occurred in all sections of the stalk, but the greatest increase (29 to 94%) occurred in the top two-thirds of the stalk where sugar accumulation was still occurring at the time of the glyphosate application. In a second study, application of glyphosate at 0.25 and 0.312 lb/A in September 2007 to a plant-cane crop of the cultivar 'L 97-128' resulted in a 33-

38% increase in TRS over the non-treated check but did not increase TRS levels over the standard 0.188 lb/A rate. At 6 WAT, the increase in TRS resulted in a 19 to 34% increase in sugar yields for all rates based on estimated yields calculated from stalk weights and populations. However, at 8 WAT the percent increase in TRS was less, 9 to10%, and there was no significant increase in per acre sugar yields as cane yields were further reduced. Use of the 0.312 lb/A rate of glyphosate resulted in increased bleaching of the leaves, stunting and reduction in spring shoot numbers in the subsequent first-ratoon crop which translated into a 14% reduction in first-ratoon sugar yields. To take full advantage of glyphosate as a ripener for enhancing sugar levels at harvest and reducing the impact of the application on the subsequent ratoon crop, growers should not apply glyphosate beyond mid-October. Further, they should avoid using higher rates in the hopes of eliciting a ripening response in varieties that don't respond to the standard rate.

Sugarcane Brown and Orange Rusts: Their Impact in Florida and the USDA-ARS Sugarcane Field Station Response

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Sugarcane brown rust has been present in Florida since 1978 and orange rust, caused *Puccinia kuehnii*, was confirmed in Florida in 2007 by morphological and molecular techniques. Both brown and orange rusts have impacted both the commercial production and cultivar development programs in Florida. Since July 2007, orange rust caused severe symptoms on CP 80-1743, a cultivar that occupied 25 % of the acreage. CP 72-2086, occupying 4 % of the acreage was also moderately susceptible. Furthermore, the high orange rust spore load threatens CP 89-2143 a major cultivar that did not have orange rust symptoms originally but *P. kuehnii* pustules are now occurring on the variety. A status of the impact of brown and orange rusts on the selection and cultivar development program will be given. In the 2008 crossing season, approximately 45 % of the parental clones were resistant to either orange or brown rust. Overall 30% of the clones in Stage II were resistant to both sugarcane rust pathogens but depending on the specific female parent the resistance of their progeny varied dramatically. Rust resistance of clones advanced to Stage III improved in 2008 compared to those of 2007. The level of rust resistance of clones in Stage IV and the increase program appears to be improving. Changes in the program to develop rust resistant progeny will be discussed.

Evaluation of Fungicides for Control of Orange Rust on Sugarcane

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Orange rust of sugarcane, incited by *Puccinia kuehnii*, was first observed in Florida during June 2007 on one of the industry's most important commercial cultivars, CP 80-1743. This was the first report of this disease in the Western Hemisphere. It has since been reported in several other Central American and Caribbean Countries. Trials were initiated to investigate the feasibility of fungicides serving as an interim or supplementary management strategy until replacement of CP 80-1743 was completed. Thirteen different fungicide treatments were examined for their efficacy in controlling orange rust during the 2008/2009 growing season. Experimental units consisted of two rows of cane 15 m in length, replicated four times. Fungicide treatments consisted of select candidates from two major classes of fungicides, the strobilurins (FRAC group 11) and triazoles (FRAC group 3), alone, and in combination or alternation. Fungicide applications were made using a CO_2 backpack sprayer and were initiated following canopy closure (approx. 1.5-m ht) at 21 day intervals. Rust severity in the trial area was moderately severe, with severities in excess of 30% on the distal third of the fourth leaf beneath the top-visible-dewlap leaf in the untreated check. Results indicate that the strobilurin fungicides provided the highest level of control, followed by strobilurin/triazole combinations, and finally, the triazole fungicides alone. In separate trials using the strobilurin fungicide, pyraclostrobin, fungicide treatments were demonstrated capable of reducing orange rust to levels sufficient to significantly reduce yield losses by as much as 40%. While economic factors will ultimately be an important consideration, levels of orange rust control obtained in these studies show promise regarding prospects for fungicides as a potential management tool.

Potential Effect of *Sugarcane yellow leaf virus* Infection on Yield of Leading Sugarcane Cultivars in Louisiana

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Field experiments were conducted to determine the potential effect of *Sugarcane yellow leaf virus* (ScYLV) infection on cane and sucrose yield of four sugarcane cultivars (LCP 85-384, Ho 95-988, HoCP 96-540 and L 97-128) that occupied a combined total of 93% of the sugarcane production area in Louisiana in 2007. Although natural infection has been found to occur in commercial fields of each of these cultivars; visual symptoms of sugarcane yellow leaf disease

caused by ScYLV have been rarely observed. Similarly, visual symptoms of sugarcane yellow leaf disease were not observed among the ScYLV-infected experimental plants in this study. Seed cane for the field experiments was obtained from stools (plants with multiple stalks) of each cultivar that were analyzed by leaf print immunoassay for natural infection by the ScYLV. Experimental plots were planted with stalks from stools that tested either positive or negative for ScYLV infection. Three, annual crops (plant-cane, first-ratoon, and second-ratoon) were harvested utilizing a single-row, chopper harvester (Cameco CH3500, John Deere, Thibodaux, LA) and the total weight of harvested cane in each plot was determined using a single-axle high dump billet wagon containing three electronic load sensors (John Deere, Thibodaux, LA). Three sub-samples of the billeted cane were collected from each plot as it was harvested for juice and fiber analysis by the pre-breaker, core press method. Cane yield was reduced in ScYLV-infected plants of LCP 85-384 across the crop cycle (plant-cane, first-ratoon, and second-ratoon crops); however, sucrose yield was not reduced because of an increase in the percent sucrose content of infected plants. Cane and sucrose yields were reduced in ScYLV-infected plants of cultivars HoCP 96-540 by approximately 10 and 11 percent, respectively, and in L 97-128 by approximately 9 and 12 percent, respectively, across the crop cycle. The only observed effect of ScYLV-infection in cultivar Ho 95-988 was an increase in percent sucrose content of the cane. The results of this study indicate that ScYLV-infection can cause loss of cane and sucrose yields in LCP 85-384, HoCP 96-540, and L 97-128 even when visual symptoms are not present; while Ho 95-988 appears to be tolerant to ScYLV infection. To minimize the potential for yield loss from ScYLV infection, growers should plant seed cane free of the virus infection.

Cell Wall Components of Tropical Grasses as Determined by an ANKOM^{2000} Fiber Analyzer

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The potential of sugarcane (*Saccharum spp.*) and its tropical relatives as dedicated energy crops for the production of biofuels from lignocellulosic biomass has generated interest in the cell wall composition of these grasses, as the relative proportions of cellulose, hemicellulose, and lignin are a major factor in determining the appropriate biomass to biofuel conversion technology. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were determined on 48 tropical grasses (42 *Saccharum spp.*; 4 *Miscanthus spp.*; and 2 *Erianthus spp.*). These measurements represent the whole of the lignocellulosic fraction of the cell wall and enable the quantification of the two major cell wall sugars, cellulose and hemicellulose. To determine NDF and ADF, 0.5 g samples were sealed in filter bags and refluxed sequentially in 24-sample batches in an ANKOM^{2000} Fiber analyzer in 2000 ml detergent solutions for 1 h at 100°C, followed by hot water and acetone rinses. For NDF, α-amylase and sodium sulfite were added during refluxing to solubilize starches and proteins. To determine ADL, filter bags containing ADF residue were stirred in 1000 ml 72% sulfuric acid for 3 h at room temperature, followed by water and acetone rinses. Hemicellulose was calculated as the difference between NDF and ADF, cellulose as the difference between ADF and ADL, and lignin as the difference between ADL and ash. The analyses showed interesting differences in the concentrations of cell wall components, which could be incorporated into the breeding program to identify varieties with specific traits for energy conversion. For example, varieties with high lignin concentrations would be better suited for thermochemical conversions, whereas those with high cell wall sugars would be more appropriate for biological conversions.

Evaluation of Variable-rate Lime Application for Sugarcane

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Precision agriculture may offer sugarcane growers a management system that decreases costs and maximizes profits, while minimizing any potential negative environmental impact. Variable rate (VR) application of lime and fertilizers is one area in particular in which significant advantages may be realized. A series of experiments were initiated in the summer of 2006 to determine the utility of VR lime application to Louisiana sugarcane production systems and to investigate alternate methods to estimate lime requirements for sugarcane. Soil electrical conductivity (EC_a) mapping techniques were also evaluated as potential tools to develop management zones for VR lime application. Soil samples (0-15-cm) were collected from a nine ha field on a 0.3-ha grid to map variability in soil pH and lime requirement. Both shallow (0-30-cm) and deep (0-90-cm) soil EC_a data were also collected at this time. Soil samples were analyzed for soil pH, and lime requirement was determined by the standard Shoemaker-McLean-Pratt (SMP) procedure, in addition to the Adams-Evans (AE) and Woodruff (WD) lime requirement methods, respectively. VR application maps were prepared utilizing variogram analysis and kriging of the grid soils data. Treatments compared the SMP, AE and WD lime requirement estimates in both VR and uniform scenarios and a no lime control. Plots were seven rows wide (15-m) by ~85-m and there were six replications. Lime treatments were applied with a Newton Crouch VR lime applicator equipped with a Mid-Tech VR controller. Soil pH was found to vary from 4.1 to 8.1 prior to lime application and the corresponding lime recommendations were also variable with the calculated lime rates ranging from 0-7.84, 0-7.39 and 0-3.36 Mg ha^{-1} for the Shoemaker-McLean-Pratt, Adams-Evans and Woodruff lime requirement methods, respectively. Soil EC_a measurements were correlated with soil pH levels from grid soil samples, with pH increasing with soil EC_a levels. Sugarcane yield results from this study showed a significant advantage in the theoretically recoverable sugar (TRS) levels with VR lime application. The Adams-Evans VR treatment resulting in the highest TRS of all methods; however, sugar yield was highest with the Woodruff VR method. These results are

promising, because if similar yields can be obtained with the VR system while actually applying fewer inputs, then Louisiana sugarcane producers can experience an overall increase in profitability. These combined data suggest that sufficient variability exists in both soil properties and cane and sugar yields to justify a precision management approach.

An Assessment of Cold/Freeze Tolerance in Sugarcane

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The complexity of tolerance mechanisms of crops to environmental stresses requires a multipronged approach to decipher the genetics of and breed for stress resistance. Field tests and a proteomics analysis were carried out on sugarcane genotypes to assess the time-course deterioration of sucrose in the juice after freeze events and to identify the proteins or genes that confer tolerance. The field trials were conducted in 2007-2009 in Florida at Hague, Alachua (latitude: 29^{o}45’0”N/longitude: 82^{o}25’48”W) and at Canal Point, Palm Beach (latitude: 26^{o}51’50”N/longitude: 80^{o}37’32”W) to obtain the sucrose profiles of 15 sugarcane (*Saccharum* spp.) genotypes in the final stage of selection in the Canal Point breeding program (CP03 Series) along with three reference cultivars. Freezes occurred in both years at Hague and in the second year at Canal Point. Repeated measures analyses were used to model the covariance structures of the data and to discriminate the genotypes in terms of tolerance or susceptibility by way of different stress indices. The proteins of two genotypes (CP 65-357 and SES 234) were extracted and sequenced to capture the nature of their differential response to cold/freeze temperatures. Specific proteins associated with cold or abiotic stress in plants were identified, such as dehydrins, heat shock proteins, and pyruvate phosphate dikinase. Proteins that are known to be associated with specific metabolic processes (PPDK, CYP450), transport (ABC transporter, proteasome complex), photosynthesis (ATP synthase F0), and protein protection and destruction (HSP, proteasome complex) were detected at dissimilar levels in the two genotypes and used to construct and link the different pathways (TCA cycle, water-water cycle, xantophyll cycle) involved in cold stress in sugarcane.

Use of a Remote Controlled Plane to Identify Cold Tolerant Clones from Early Stages of a Selection Program

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Stress tolerance is one of the most important selection traits for sugarcane. However, it is a time consuming and laborious process to identify stress tolerant clones from among the thousands of clones in the early stages of a selection program. Additionally, some of the weather-related stress events occur infrequently and unpredictably and data must be gathered quickly to take advantage of the weather events as they occur. On January 22, 2009 an industry-wide killing freeze event occurred in Florida with temperatures below 26°F for 3 hours in some places in the cane-growing region. Traditionally, ground-based assessments are made on a periodic basis in order to identify freeze tolerant clones. In the work presented here, CH-E05, a remote controlled aerial imaging device developed by AgFly R&D was used to see if cold tolerant clones could be quickly identified from the air. CH-E05 is a ground piloted drone that uses electric power and has a flight time of 20 – 40 minutes depending on the weather and flight pattern. The plane is designed to be hand launched and can be belly landed in the field. On February 13, 21 days following the freeze event, a digital camera with a ground link was used to record aerial images of the approximately 1500 clones in Stage 2 of the USDA Canal Point program. Visual assessments of freeze damage from the aerial images were made and then compared to analytical data collected March 3 during ground-based assessments and October 22-24 sampling. Clones identified as susceptible to cold damage in the aerial images averaged a 3.4% increase for sucrose content from late October to early March. Similarly, clones identified as cold tolerant based on the aerial images averaged an 18.8% increase for sucrose content during the same period based on the ground-based milling data. Thus the use of aerial imagery is a means of quickly collecting large amounts of visual cold tolerance data in a short period of time. In the future, infrared imagery will be used in CH-E05 to determine if other types of stress tolerance can be identified using this tool.

Databasing Molecular Identities of Louisiana, Florida and Texas Sugarcane Clones

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Sugarcane (*Saccharum* spp. hybrids) clones (cultivars and superior breeding lines) are routinely exchanged across geographic locations for field-testing or crossing. It is crucial to maintain the genetic identity of these clones during field collection, shipping, and quarantine. Traditionally, sugarcane researchers identify clones using gross morphological traits. Although this may work well for the breeders who developed the clones, others may not be able to identify mislabeled clones because morphological traits are known to change across years and locations. Since the early 2000s, a sugarcane molecular genotyping technology was developed which uses the leaf tissue DNA and fluorescence-based capillary electrophoresis for definitive identification of sugarcane clones. Using this technology, 21 polymorphic microsatellite (SSR) markers generated 144 distinctive DNA fingerprints from the U.S. sugarcane clones. The 144 DNA

fingerprints are arranged in an affixed linear order and the presence (denoted by A) or absence (C) of each fingerprint in a clone being genotyped is recorded into an Excel spreadsheet to generate a unique sequence of As or Cs. This unique sequence was converted into a DNAMAN® file to define the molecular identity of that clone. All the resulting DNAMAN® files were stored in a molecular identity database at the USDA-ARS, SRL in Houma, LA, which may be retrieved for clone identity verification using the DNAMAN® multiple sequence alignment program. Since 2005, a total of 689 leaf tissue samples from Florida, Texas, and Louisiana have been genotyped (222 in 2005; 183 in 2006; 249 in 2007; and 35 in 2008). A few important Louisiana clones have been sampled multiple times across years and locations to confirm the genetic identity. If any sample were mislabeled, then it would produce a different molecular identity than the rest of the samples of that same clone. The database and the DNAMAN® program were then used to correctly identify the sample of the mislabeled clone. The molecular identity database of newly designated clones is updated yearly, providing molecular descriptions for cultivar registrations, tools for enhancing breeding efficiency by maintaining the right clones in the crossing programs to ensure the desired crosses, identifying male parent in a polycross, and verifying that growers have the correct cultivars.

Repeatability and Genotype x Environment Interaction of Intermediate Stage Sugarcane Selection Conducted on Sand and Organic soils

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The Florida cooperative sugarcane cultivar development program conducts all of its early selection stages on muck (organic) soils at the USDA-ARS Sugarcane Field Station in Canal Point. About 25% of the locations in the final two stages (Stages 3 and 4) are conducted on sand soils, after a reduction in the number of genotypes from about 100,000 seedlings to 135 in Stage 3. This strategy might be overlooking the best sand-adapted genotypes earlier in the breeding scheme. To test this hypothesis an intermediate stage (Stage 2), with the same 1500 genotypes and a nested subset of replicated genotypes, was grown on a muck soil (Canal Point) and on a sand soil (United States - Sugar Corp. Townsite Farm, near Clewiston, FL). Genotype x environment interaction was significant for tons cane acre^{-1} (TCA), theoretical recoverable sucrose (TRS) (lb Ton^{-1}), and tons sucrose acre^{-1} (TSA). Spearman correlations among traits measured on sand and muck were highly significant ($p < 0.01$), although low in value (r = 0.26 across traits), suggesting that specific selection is needed to target genotypes to the sand or muck environment. Means of TCA and TSA were higher for the muck location (75.5 ± 10.5 and 7.20 ± 1.1) than for the sand location (36.1 ± 16.1 and 4.6 ± 2.2). TRS was higher and less variable on sand (297.5 ± 9.5) than on muck (203.0 ± 20.5). Repeatability (R) was higher on muck than on

sand soils for all traits, with R values 0.48 ± 0.1, 0.63 ± 0.08 and 0.46 ± 0.1 for TCA, TRS, and TSA respectively compared with respective R values 0.43 ± 0.1, 0.47 ± 0.1 and 0.42 ± 0.11 on sand. Of 135 clones selected for advancement to Stage 3, 51 selections were common to both soil types, suggesting that some outstanding sand genotypes may be lost when intermediate selections are performed only on muck soils.

Sugarcane Genotype Selection for Sand Soils in Florida

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Selection of high yielding sugarcane (*Saccharum* spp.) genotypes in Florida has been more successful for organic (muck) soils than for sand soils. The purpose of this study was to compare the performance of sugarcane genotypes on sand soils and on sand soils with mill mud added at the rate of 1510 m^3 ha^{-1}. Mill mud, a by-product organic waste produced from the clarification of sugarcane juice, is rich in N, P, K, Ca, and Mg. In Florida, mill mud is made up largely of the muck soils that come through the mill with the sugarcane. In a field test, 31 sugarcane genotypes were planted as subplots in a sand soil with two soil treatments (with or without mill mud) as main plots. Commercial recoverable sucrose (CRS) (g kg^{-1}), cane yield (Mg cane ha^{-1}), and sucrose yield (Mg sucrose ha^{-1}) were determined about 1 year after planting. Genotype repeatability for sucrose yield was 0.70 with mill mud compared with 0.32 on the sand soil without mill mud. This difference was probably due to the increased variability on the soil treatment that did not have added mill mud. The mill mud caused a decrease in CRS from 136 g kg^{-1} without to 116 g kg^{-1} with added mill mud. However, the mill mud increased cane yields by 113 Mg ha^{-1} (103 Mg ha^{-1} without mill mud vs. 216 Mg ha^{-1} with mill mud) which resulted in an increase of 11 Mg ha^{-1} in sucrose yield (14 Mg ha^{-1} without mill mud vs. 25 Mg ha^{-1} with mill mud). Genotype x soil interactions were not significant (P = 0.05), but because interactions were nearly significant for cane yield (P = 0.08) and sucrose yield (P = 0.06), yields of each genotype were compared with the mean yields of all genotypes on each soil treatment. Cane and sucrose yields of 6 of the 31 genotypes were significantly influenced by soil treatment. CL 90-4725, CP 00-1446, and CP 01-1372 had higher than average cane and sucrose yields with added mill mud, but mediocre yields without mill mud. CP 01-2390 had moderately high yields with added mill mud, but was one of the two highest yielding genotypes on the sand soil without mill mud. CP 78-1628, the most widely grown sugarcane cultivar on sand soils in Florida, had mediocre yields without mill mud, but ranked among the lowest yielding genotypes with added mill mud. CP 78-1628 yields on both treatments were probably substantially reduced by heavy brown rust (*Puccinia melanocephala*) infestations. CPCL 01-0877 was one of the higher ranking genotypes on the sand soil without mill mud and one of the lower ranking genotypes with added mill mud. Previous research indicated that CL 90-4725, CP 00-1446, CP 01-1372, and CPCL 01-0877 yielded well on sand soils. However, perhaps due to the increased variability on the sand soil without mill mud, the added mill mud in this study was necessary to identify CL 90-4725, CP

00-1446, and CP 01-1372 as high yielding. Conversely, the added mill mud detracted in the identification of CPCL 01-0877 as a high-yielding genotype on sand soils.

Multivariate Repeated Measures Analysis of Sugarcane Variety Trials

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In sugarcane variety trials, data from several variables are collected from the same individual plants or plots over several crop cycles. When several variables are measured on the same plots, this creates a multivariate data structure. Also, variables measured every year for several crop-years create a repeated measures data structure. Combining these characteristics to account for correlations between variables (multivariate) and between crop-years (repeated measures) during data analysis may foster correct interpretation of data. Univariate analysis assuming a split-plot in time data structure is commonly used to analyze data from sugarcane variety trials. Univariate analysis assumes independence between variables and crop-years and ignores possible correlations between variables and crop-years, potentially underestimating experimental errors and increasing the likelihood of Type I errors. In this presentation, we will demonstrate the use of the multivariate repeated measures analysis to analyze data from sugarcane variety trials using the Proc Mixed Procedure of SAS. We will demonstrate how to determine multivariate effects, the appropriate covariance structure for crop-years, and apply a data set to compare the univariate and the multivariate repeated measures analysis analytical approaches.

Biology and Cultural Control of Lesser Cornstalk Borer in Sugarcane

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Lesser cornstalk borer, *Elasmopalpus lignosellus* Zeller (Lepidoptera: Pyralidae) is an important sugarcane pest in south Florida. To determine development thresholds, lesser cornstalk borer development was observed at constant temperatures of 13, 15, 18, 21, 24, 27, 30, 33, and 36°C under laboratory conditions. Development rate increased with increase in temperature from 13 to 33°C and then decreased in all immature growth stages. Lower and upper development thresholds estimated by linear and non-linear regression models ranged from 9.2°C to 11.2°C and 37°C to 39°C, respectively. As the average annual soil temperature in South

Florida falls within these thresholds, this insect can develop and reproduce throughout the year. Lesser cornstalk borer larvae cause dead hearts and symmetrical rows of holes in the leaves, during early growth stage of sugarcane. Plant response to the damage in three varieties with different emergence rates (CP78-1628, CP89-2143, and CP88-1762) was evaluated in green house studies. CP78-1628 compensated for lesser cornstalk borer damage well by producing more secondary shoots compared to the other two varieties. Therefore, due to difference in tillering and response to damage, variety selection is an important tool in lesser cornstalk borer control. In other cultural control practices, green cane harvesting was evaluated under field conditions for lesser cornstalk borer damage. Damage was significantly less in green cane harvested field compared to burnt cane field. Growers cultivate fields to break down sugarcane trash to improve percolation and fertilizer availability in green cane harvested fields. Therefore, tillage levels (no-till, conventional, and intermediate tillage) were evaluated for their effect on lesser cornstalk borer damage. Green cane harvesting with intermediate tillage greatly reduced lesser cornstalk borer damage to sugarcane and increased yield.

What Makes Sugarcane Varieties Resistant to the Sugarcane Aphid?

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Sugarcane in Louisiana is infested with two aphid species; the sugarcane aphid, *Melanaphis sacchari* (Zehntner), and the yellow sugarcane aphid, *Sipha flava* (Forbes). The sugarcane aphid is the main vector of sugarcane yellow leaf virus disease and is distributed throughout Louisiana's sugarcane growing regions. Five commercial sugarcane varieties produced in Louisiana (LCP 85-384, HoCP 91-555, Ho 95-988, HoCP 96-540, and L 97-128) were screened in the greenhouse as well as under field conditions for resistance to the sugarcane aphid. In both greenhouse and field experiments, L 97-128 was found to be the most susceptible and HoCP 91-555 the most resistant variety. The differences in susceptibility were additionally confirmed by studying the feeding behavior of the sugarcane aphid on LCP 85-384, L 97-128, and HoCP 91-555 using the electrical penetration graph (EPG) technique. Differences among varieties were not detected in the time for aphids to initiate sieve element feeding, and in the frequency of cell punctures (potential drops) prior to sieve element feeding. However, the sugarcane aphid spent significantly more time ingesting phloem sap of L 97-128 as compared to that of HoCP 91-555. Phloem sap extracts of L 97-128 and HoCP 91-555 were analyzed for free amino acids (FAAs) using HPLC. Two essential FAAs (histidine and arginine) were absent in the phloem sap of HoCP 91-555. Analyses of honeydew collected from aphids feeding on both varieties indicated that two essential (leucine and isoleucine) and two non-essential (tyrosine and proline) FAAs were present only in the honeydew of aphids on L 97-128. These studies indicate

that amino acids significantly affect behavior as well as performance of the sugarcane aphid on resistant and susceptible varieties.

Establishing the Components of a Remote Sensor-Based Nitrogen Decision Tool for Sugarcane Production

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The success in relating canopy reflectance to crop nitrogen (N) status has resulted in the development of remote sensor-based N decision tools for wheat and corn production. Relating canopy reflectance to sugarcane N status may pose a challenge as sugarcane is a tall-growing perennial plant with canopy architectures that highly vary with variety and crop age. This study was initiated in 2008 to evaluate the feasibility of using early- to mid-season canopy reflectance to establish the important components and information required for the development of a remote sensor-based N decision tool for sugarcane production: 1) the optimal sensing dates, 2) predictive equation for sugarcane yield potential, and 3) mid-season canopy reflectance estimate of actual boost in cane and sugar yields attributed to N fertilization (N response index). Collection of normalized difference vegetation index (NDVI) readings using the GreenSeeker™ handheld sensor from multiple soil fertility trials located at the LSU AgCenter Sugar Research Station, St. Gabriel, LA was conducted from mid-April to first week of July in 2008. A total of 12 sensing dates were conducted from sugarcane plots planted with different varieties (LCP 85-384, HoCP 96-540, Ho 95-988, L 97-128, L 99-233, and L 99-226) of different crop age (plant cane, and first- and second-stubble cane). Regression analysis was performed to determine the relationships of NDVI with cane and sugar yield, and the association between the NDVI-estimated N response index and the actual sugarcane response to spring N fertilization. The NDVI readings collected in early May showed the highest association with actual cane and sugar yields with r^2 values of 0.46 and 0.50, respectively. Early season estimates of sugarcane N response index using NDVI were also correlated with increases in cane ($r^2 = 0.74$) and sugar ($r^2 = 0.62$) yields attributed to spring N fertilization. The initial findings of this study showed that the optimum sensing dates fell within the timeframe where spring N fertilization is commonly done. Further, the use of early- to mid-season NDVI readings to predict sugarcane yield potential and actual boost in sugarcane yield in response to N fertilization is feasible. The opportunities exist to refine the components of this remote sensor-based N decision tool through introduction of correction procedures that will allow the combination of sensor data from different sites and year.

Sugarcane Production Responses Related to Soil and Leaf Silicon

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Silicon (Si) is not classified as an essential plant nutrient, but it is considered a beneficial nutrient for sugarcane production. Substantial production responses to application of calcium silicate have been demonstrated on soils low in available Si. Florida growers now routinely apply this amendment before planting sugarcane on sands and low-mineral organic soils. While there has been much previous work by UF/IFAS and the sugarcane industry in examining sugarcane response to Si in Florida, we are still in need of a calibration for the acetic acid soil test for Si. In addition, the relationship between leaf Si and sugarcane production needs to be defined so that leaf analysis can be used to complement soil testing in determining Si amendment needs. A small-plot field study of calcium silicate rates was conducted at three locations, with two sites on organic soils and one site on a mineral soil. Each test was set up as a randomized complete-block design with six replications. In addition, a survey of leaf Si concentration in 205 commercial sugarcane fields (389 samples) was conducted in 2004-2006. Strong responses of sugar ha^{-1} to calcium silicate application were determined at two of the three small-plot test locations. Initial acetic acid-extractable soil Si values for responsive and nonresponsive organic soil sites were 3 and 17 mg dm^{-3}, respectively, and initial soil Si value for the responsive mineral soil site was 17 mg dm^{-3}. Using a boundary line technique with the leaf survey data, it was determined that a minimum of 0.6% leaf Si would provide for optimum sugarcane production, with 10% and 25% production losses occurring at 0.45 and 0.20% leaf Si concentrations, respectively.

Sulfur Application Effects on Soil Properties in a Calcareous Soil and on Sugarcane Growth and Yield

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High pH soils limit availability of pH sensitive nutrients including P, even though abundant levels are present. Application of such nutrients to the soil is ineffective because they quickly get tied up in unavailable forms. Elemental S application in a narrow band to lower root zone pH and increase nutrient availability to the crop is a possible economically feasible solution. A four year field study was conducted in which S was applied to sugarcane at rates up to 1120 kg S ha^{-1} each of the 1st three years in a band using different application methods. Sulfur application effects on soil pH were gradual, causing only a slight reduction in the application zone after one year; but was long lasting, resulting in continuing substantial declines in soil pH in an adjacent zone four years after the first S application. Soil available P, SO_4-S, and salinity levels increased with increasing S applied. Sugarcane plant growth, as indicated by leaf area index during the grand growth period responded to moderate S application levels. Sugarcane yields increased linearly in the plant crop, but showed quadratic responses to S applications in the 1st through 3rd ratoon crops. Initial soil available P levels prior to the first treatment application were at the critical level considered adequate for crop requirements, yet growth and yield increases in response to S application suggest that the critical available soil P levels for sugarcane may be higher than previously established. Sulfur application at rates beyond those necessary to produce maximum yields resulted in salinity problems which probably reduced yields. The ‘stool splitter’ application method which slices the plant stool using a coulter and places the fertilizer directly in the middle of the furrow caused crop damage and stand loss which persisted for the remainder of the sugarcane crops. Based on the results of this study, a single application of elemental S at up to 1120 kg S ha^{-1} directly below the seed cane at planting is recommend for sugarcane on a calcareous soil, with no additional applications in later crops.

Strategies for Reducing Soil in the Cane Supply to the Factory

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Efforts to minimize soil in the cane supply to the factory have been the subject of several research papers but none have attempted a comprehensive approach of sampling, metrics and feedback mechanisms at the commercial level. Previous efforts have also addressed individual topics but failed to look at the system as a whole. An experiment was designed to measure different harvester operational inputs and the impacts were predicted. This led to a company wide adoption of Best Management Practices that were measured at the factory level to verify the input assumptions. Feedback mechanisms were implemented to promote continuous improvements in the system. Inputs tested included harvester basecutter height, harvester basecutter angle of attack, harvester forward speed, harvester primary extractor fan speed, 24 hour harvest and green/ burnt harvest. Conclusions were drawn ranking the tested parameters as primary or secondary in the efforts to reduce soil being delivered to the mill.

Achernar Production Model:

How to Create a Simple Model to Plan the Production of Sugarcane

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The planning of sugarcane production is essential to optimize the use of milling facilities and achieve higher returns in the long run. The Achernar production model is a practical example of how to create a model that can predict sugarcane production at the farm level, based on variables commonly managed by farmers. The presentation shows the rationale for the selection of variables, it explains how to prepare the data set and shows how to run a regression and interpret the results to create a model. The final result is a worksheet that predicts for 5 years the tonnage produced by a farm based on three simple variables. The model has been proved at an industrial level in the EAA (FL) for 5 years with good results.

Comparing Production Costs and Returns between Florida Sand and Muck Sugarcane Operations

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Sugarcane production in Florida occurs primarily on organic, or muck soils. Increasing environmental pressures, particularly public interests to acquire land for Everglades restoration, may force the industry to reduce overall production from muck soils and increase production on mineral, or sandy soils. Already 20% of Florida's sugarcane production occurs on mineral soils. Enterprise budgets were developed for sugarcane production on both mineral and organic soils. Generally, unit costs of production on mineral soils are higher than on organic soils. An enterprise budget provides benchmarks for costs and returns, thereby allowing growers to assess their individual operations. More importantly, enterprise budgets are valuable inputs into evaluating the expected change in profitability from adopting new technology such as mechanical planters or shifting from pre-harvest burning to green-cane harvest. Enterprise budgets also provide a basis to assess the overall economic impact of sugarcane production in a given region and the likely changes to economic impact if production were to increase or be reduced.

Effect of Harvest Method on Microclimate and Sugarcane Yield in Florida and Costa Rica

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Sugarcane (*Saccharum* spp.) is an important economic crop due to its high sucrose content and remarkable bioenergy potential. However, as agricultural regions urbanize, sugarcane industries are coming under increasing public scrutiny. There is worldwide pressure on sugarcane industries to adopt "green cane" harvesting systems that do not involve burning. The objective of this study was to compare the effect of sugarcane harvest methods on cane productivity in both Florida and Costa Rica, since both regions are undergoing rapid urbanization and are subject to increasing environmental regulatory pressures. Our treatments included 1) burnt cane, 2) green cane, and 3) green cane with residue management, such as raking from the row or removal from the field. These treatments were implemented at three sites: A) Everglades Research and Education Center (EREC), Belle Glade, FL on a muck Histosol with high organic matter, B) Hilliard Bros. Farms, FL on an Entisol with sandy texture, and C) Azucarera El Viejo mill in Guanacaste, Costa Rica on an Inceptisol. The green cane residue provided a buffering effect on soil temperatures (15-cm depth) at the muck site, leading to higher minimum and lower maximum soil temperatures compared to the burnt treatment. Leaf area indices were higher for the burnt treatment on muck, particularly when harvested early (in December). There was a trend for higher biomass yields in burnt cane on muck soils when harvested early, and a significant cumulative 3-year difference of 22 tons cane ha^{-1} in burnt vs. green cane. However, cane yields were not different when harvested late in the season (in February). On the Florida sand site, significantly greater stalk counts were recorded in the rake and burnt treatments compared to green cane through April of the first ratoon crop. A decline in plant population, particularly in green cane, was linked to frost events in February, 2006. Air temperatures at 10-cm aboveground were lower in green cane during frosts, which led to significantly lower LAI in green cane in the first ratoon crop. Cane biomass yields on sand followed similar trends to muck yields with burnt cane recording higher yields when harvested early but not significantly different when harvested late. At the Inceptisol site in Costa Rica established in 2008, trash content, biomass and sucrose yields were not significantly different in green vs. burnt cane in the plant cane and first ratoon crops. Total green cane residue levels were 12-15 tons ha^{-1} of dry matter containing 92-115 kg ha^{-1} N and 99-119 kg ha^{-1} K. Cane residues reduced maximum soil temperatures for 3 months from harvest to canopy closure in Costa Rica at 2 and 10 cm depth by 5-10 C. Our results indicate that green cane residues have a significant effect on microclimate and that green cane harvest in Florida would be better suited for a late rather than early harvest time period.