Soil Organic Matter Impacts on Sugarcane Production on Florida Mineral Soils[1]

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Introduction

Mineral soils account for approximately 29% of Florida sugarcane (*Saccharum* spp.) acreage (VanWeelden et al. 2019). The percentage of sugarcane grown on mineral soils has increased from 20% in the 2011 crop year (Rice et al. 2012). These are sands with low organic matter content (typically ≤ 2%) and very little clay within the root zone. Therefore, these soils have low capacity for holding water and nutrients. Intensive management of irrigation, drainage, and fertilization is required to maintain an economically sustainable level of crop production. Drainage and irrigation are accomplished primarily through manipulation of seepage irrigation to manage water table depth using field ditches typically spaced from 150 to 300 feet apart. Split applications of nitrogen (N) and potassium (K) are required, and controlled-release N and K are sometimes applied to reduce the number of applications and provide a more continuous supply of nutrients to the crop. Application of calcium silicate has been shown to be beneficial for sugarcane production on these soils because soluble soil silicon (Si) tends to be low before amendment (McCray and Ji 2018).

The difficulty of managing water and nutrients is compounded by a high degree of spatial variability in these soils. In previous evaluations of growth-limiting factors, higher soil organic matter content and higher soil concentrations of calcium (Ca), magnesium (Mg), and K were correlated with good sugarcane growth on mineral soils (Muchovej et al. 2000). This document discusses research evaluating soil organic matter content as a limitation to sugarcane production and suggests alternatives for increasing soil organic matter content.

Influence of Soil Organic Matter on Sugarcane Yield

Generally poor and highly variable sugarcane growth was observed in three small-plot experiments in two adjacent fields on sand soils in south Florida. Trial 1 was a phosphorus (P) rate trial. The plots with the three lower P rates in this trial were eliminated from this evaluation because of significantly lower sugarcane yields with these treatments. Trial 2 was a P experiment evaluating rates and fertilizer sources. Although there were no significant differences in sugarcane yield among treatments, plots with the zero P rate of this experiment were eliminated from this evaluation. Trial 3 was a controlled-release N and K experiment in which all plots received N and K fertilizer. All plots were included in this evaluation because there were no significant differences in sugarcane yield among treatments. After inadequately fertilized treatments were removed, combined data from these experiments (81 plots) were evaluated for factors influencing sugarcane yield.

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Relative sugar yield was used to combine data from the three experiments. Relative sugar yield was positively correlated with soil concentrations of Ca and Mg but was most strongly related to soil organic matter content (Figure 1). Substantially lower sugar yields were associated with soil organic matter content less than 1.1%.

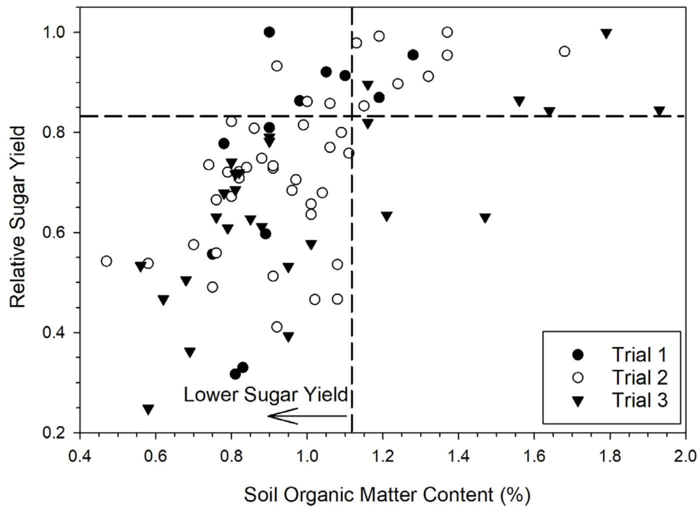

Figure 1. Relationship between soil organic matter content (depth of 0–6 inches) and relative sugar yield (cumulative plant and first ratoon) across three adjacent trials on Florida mineral soils. In the Cate-Nelson analysis (Cate and Nelson 1965), the vertical and horizontal lines are placed to maximize the number of points in the upper right and lower left quadrants.
Credits: McCray and Ji (2019)

The authors assessed paired soil samples for nematode risk that could damage root systems and reduce yield within the three experimental areas. These soil samples were collected in pairs to compare sugarcane of relatively good and poor growth. All samples were rated as either moderate or high risk for damaging sugarcane based on their nematode populations. However, all severely stunted sugarcane was associated with high nematode populations. This suggests that nematodes were a factor in poor sugarcane growth in the evaluation area. Nematode damage to sugarcane can be greater in low-organic-matter sands due to higher nematode populations compared to soils with higher organic matter content (Crow and Dunn 2010; Hall and Irey 1992). In addition to reducing nematode populations, increased soil organic matter content can improve the tolerance of sugarcane to nematodes by increasing the water- and nutrient-holding capacities of the soil (Crow and Dunn 2010).

Alternatives for Increasing Soil Organic Matter Content

There are alternatives for increasing organic-matter content to improve sugarcane growth and yield in these low-organic matter soils. Gilbert et al. (2008) measured a 54% increase in 3-year tons sugar/acre (TSA) with a broadcast mill mud application (100 tons/acre or an approximately 1-inch layer of mill mud) compared to no mill mud after a fallow year with normal fertilization in each treatment. McCray et al. (2015) measured a 20% increase in 2-year TSA with a broadcast mill mud application (120 yd^3/acre or approximately 100 tons/acre) compared to no mill mud after a fallow year with normal fertilization in each treatment. There have been significant TSA responses to furrow-applied mill mud (15 yd^3/acre and 30 yd^3/acre) at one of two test locations (6% and 9% increases, respectively) (McCray et al. 2015); however, due to inconsistent results in these trials, broadcasting of organic amendments is the application method most likely to provide a consistent yield benefit. Broadcasting an organic amendment can enhance water and nutrient availability in a greater volume of the root zone compared to a furrow application and is the more effective approach. Broadcasting an amendment at a rate of at least 60 yd^3/acre may be needed to have a positive impact on sugarcane yield, but required rates will depend on the amendment source. Also, depending on amendment source and nutrient content, an organic amendment may allow reduced fertilizer rates for one or more seasons after application. Nitrogen fertilizer requirements with a compost/sludge amendment (60 yd^3/acre) were 34%, 76%, and 76% of that with no amendment for plant cane, first ratoon, and second ratoon crops, respectively (McCray et al. 2017).

Long-term experiments in other sugarcane-growing areas have demonstrated that green harvest is another option for increasing soil organic matter content (Graham et al. 2002). Green cane harvest has not been adopted in Florida due to management issues such as increased frost damage with the trash blanket left after harvest (Sandhu et al. 2013). There may be potential for a small benefit from using green cane harvest for the last ratoon crop of a cycle before replanting even in an otherwise preharvest burn system.

Green manure crops grown in the fallow year before replanting sugarcane have been demonstrated to increase sugarcane yield for the following plant cane crop (Gilbert et al. 2008). The primary focus of these crops is often on reducing the nitrogen requirement for the following sugarcane crop (Ambrosano et al. 2013). Increased soil organic matter content with green manure crops in a sugarcane rotation has not been demonstrated in Florida mineral soils, but green manuring has the potential to be part of a management plan for long-term increases in soil organic matter content. Green manure crops such as sunn hemp (*Crotalaria juncea* L.) and cowpeas (*Vigna unguiculata* L.) can have an added benefit of reducing nematode populations (Crow and Dunn 2010). Green harvest and green manure crops might be the best options for locations farther from sugarcane mills or other sources of organic amendments because of the high cost of hauling organic amendments over longer distances. Nematicides may also be an option for reducing nematode populations in low-organic-matter sands, but the cost-effectiveness of this approach has not been demonstrated.

Due to the cost of organic amendments or other approaches for increasing soil organic matter content, growers should prioritize fields and areas in need of improvement. Visual observation and aerial imagery can aid identification of stunted areas. These areas will need evaluation to determine whether soil organic matter content is related to the problem. Soil testing laboratories can routinely determine soil organic matter content. Areas in Florida soils with soil organic matter content less than 1.1% (by the loss-on-ignition method) can be targeted for an appropriate management plan. Growers may be able to make variable-rate applications of organic amendments based on maps of organic matter content, which are derived from soil maps (Natural Resources Conservation Service), aerial imagery, and soil samples for each management zone, in a precision agriculture approach. Organic matter content of management zones or whole fields can also be used to identify fields where green manure crops might be most beneficial. Soil samples can also be taken for nematode assay (UF/IFAS Nematode Assay Laboratory) to determine if nematodes are contributing to growth problems.

Summary of Grower Options for Evaluating and Increasing Soil Organic Matter

Soil Evaluation

- Locate areas of poor sugarcane growth using visual observations and aerial or satellite imagery.
- Collect soil samples in areas of poor sugarcane growth and analyze for organic matter content by the loss-on-ignition method.
- Consider sending selected soil samples to the UF/IFAS Nematode Assay Laboratory.

Increasing Soil Organic Matter

- Areas to target first are those with soil organic matter content below 1.1%.
- Option: Add an organic amendment such as mill mud or compost. This provides a quick increase in organic matter content. Note that amendments are expensive to transport and apply.
- Option: Plant green manure crops during the fallow year before replanting sugarcane. This has the potential for long-term increases in organic matter content with manageable costs.
- Option: Use green harvest for sugarcane, possibly only for fields with the lowest organic matter content. There is potential for long-term increases in organic matter content, but there are added harvest costs and issues with management of the sugarcane trash blanket.

References

Ambrosano, E. J., H. Cantarella, G. M. B. Ambrosano, F. L. F. Dias, F. Rossi, P. C. O. Trivelin, and T. Muraoka. 2013. "The role of green manure nitrogen use by corn and sugarcane crops in Brazil." *Agricultural Sciences* 4: 89–108. http://dx.doi.org/10.4236/as.2013.412A008

Cate, R. B., Jr., and L. A. Nelson. 1965. "A rapid method for correlation of soil test analyses with plant response data." *North Carolina Agriculture Experiment Station International Soil Testing Series Technical Bulletin 1*. Raleigh: North Carolina State University.

Crow, W. T., and R. A. Dunn. 2010. *Soil Organic Matter, Green Manures, and Cover Crops for Nematode Management*. ENY-059. Gainesville: University of Florida Institute of Food and Agricultural Sciences. https://edis.ifas.ufl.edu/vh037

Gilbert, R. A., D. R. Morris, C. R. Rainbolt, J. M. McCray, R. E. Perdomo, B. Eiland, G. Powell, and G. Montes. 2008. "Sugarcane response to mill mud, fertilizer, and soybean nutrient sources on a sandy soil." *Agronomy Journal* 100: 845–854. http://doi.org/10.2134/agronj2007.0247

Graham, M. H., R. J. Haynes, and J. H. Meyer. 2002. "Soil organic matter content and quality: Effects of fertilizer applications, burning and trash retention on a long-term sugarcane experiment in South Africa." *Soil Biology & Biochemistry* 34: 93–102. http://doi.org/10.1016/S0038-0717(01)00160-2

Hall, D. G., and M. S. Irey. 1992. "Population levels of plant-parasitic nematodes associated with sugarcane in Florida." *Journal of American Society of Sugar Cane Technologists* 12: 38–46.

McCray, J. M., and S. Ji. 2018. "Sugarcane yield response to calcium silicate on Florida mineral soils." *Journal of Plant Nutrition* 41: 2413–2424. http://doi.org/10.1080/01904167.2018.1510520

McCray, J. M., and S. Ji. 2019. "Low soil organic matter content limits sugarcane yields on Florida mineral soils." *Proceedings of the International Society of Sugar Cane Technologists* 30: 1621–1624.

McCray, J. M., S. Ji, and L. E. Baucum. 2015. "Sugarcane yield response to furrow-applied organic amendments on sand soils." *International Journal of Agronomy* 2015: 9 pp. Article ID 426387. http://doi.org/10.1155/2015/426387

McCray, J. M., S. Ji, and M. Ulloa. 2017. "Influence of compost/sludge application on sugarcane yield and nitrogen requirement on a sand soil." *Journal of Plant Nutrition* 40: 2156–2167. http://doi.org/10.1080/01904167.2017.1346672

Muchovej, R. M., Y. Luo, J. M. Shine, Jr., and J. C. Jones. 2000. "Nutritional problems associated with low yield of sugarcane on mineral soils." *Proceedings of the Soil and Crop Science Society of Florida* 59: 146–150.

Rice, R. W., L. E. Baucum, and B. Glaz. 2012. "Sugarcane variety census: Florida 2011." *Sugar Journal* 75(2): 8–15, 18–19.

Sandhu, H. S., R. A. Gilbert, G. Kingston, J. F. Subiros, K. Morgan, R. W. Rice, L. Baucum, J. M. Shine, Jr., and L. Davis. 2013. "Effects of sugarcane harvest method on microclimate in Florida and Costa Rica." *Agricultural and Forest Meteorology* 177: 101–109. http://doi.org/10.1016/j.agrformet.2013.04.011

VanWeelden, M., S. Swanson, W. Davidson, M. Baltazar, and R. Rice. 2019. "Sugarcane variety census: Florida 2018." *Sugar Journal* 82(2): 12–19.