IMPACT OF SUGARCANE FALLOW MANAGEMENT STRATEGIES ON WATER QUALITY AND PLANT YIELD

R.L. Bengtson[1] and K.A. Gravois[2]
[1]Biological and Agricultural Engineering Department
[2]LSU Agricultural Center, Sugar Research Station

INTRODUCTION

Sugarcane lands in Louisiana are usually managed in 4-yr rotations. The crop is usually planted in August and September. The crop grows until frost. It starts growing again in the spring and will be harvested in the October to December period. The cane starts growing after the last freeze of the spring and will be harvested in the October to December period. Two or three ratoon crops are grown and then 11 months of fallow to control weeds and diseases. The largest annual soil loss occurs during the fallow year. The annual average fallow sediment loss for the fallow years of 1996, 2001, and 2006 was 5.33 t/ac. The annual average crop year sediment loss was 2.94 t/ac (Bengtson and Selim, 2012). Three management strategies are used by sugarcane growers during the fallow year. They are fall fallow, spring fallow, and no till. With fall fallow practice, the fields are ploughed out soon after harvest in the fall. The fields are tilled when the fields dry in the spring. They are tilled periodically to control vegetation growth until the fields are planted in August and September. With the spring practice, the fields are tilled when the fields dry in the spring and are tilled periodically to control vegetation growth until the fields are planted in August and September. With no-till practices, the vegetation is controlled by spraying periodically with broad-spectrum herbicide. The fields are not tilled until they are prepared for planting in September.

The objective of this project was to compare the amount of soil and nutrient losses in the surface runoff from sugarcane fields with three management practices (fall fallow, spring fallow and no-till) on a Commerce silt loam soil. A second objective was to compare the yields of the plant year cane with the three management practices.

MATERIALS AND METHODS

The experimental site is at the Louisiana Agricultural Experiment Station's Sugar Research Station at St. Gabriel, Louisiana. Six leveed plots, 0.1 ac in size (nine rows spaced 6 ft apart and 460 ft long) and sloped 0.1% are located on Commerce silt loam soil (*Aeric Fluvaquent*, fine-silty, mixed, non-acid, thermic). (Camp, 1976; Rogers et. al., 1985). This soil has a hydraulic conductivity of 0.04 in/hr. To measure and sample surface runoff, a sump is installed on the low side of each plot. A float-controlled electric pump is installed in each sump to discharge the runoff through a water meter and into a surface drainage ditch. An automatic water sampler at each sump is used to collect runoff samples. The water samplers turn on when runoff is detected. The water samples were analyzed by the LSU Department of Agricultural Chemistry for total solids, nitrogen, phosphorus, and potassium. Nitrogen was determined by an automatic colorimetric procedure developed by Wall and Gere (1979). Phosphorus and potassium were determined by EPA Method 200.2 (Martin et al., 1991). These analyses determined the total concentration in both solution and solids. Using the amount of surface that was measured with the water meters and the concentrations provided by the LSU Agricultural Chemistry Department, total loadings were calculated for each storm. Paired t-test was used to determine significance differences between the practices (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

The sugar cane was harvested on October 31, 2012. On November 2, 2012, the fall fallowed plots were tilled. On April 12, 2013, the spring fallowed plots were tilled and the fall fallowed plots were tilled a second time. The no-till plots were sprayed with glyphosate, June 7, 2013; July 15, 2013; August 6, 2013; and September 4, 2013. The fall and spring fallowed plots were tilled on July 15, 2013. All of the plots were tilled and prepared for planting on September 20, 2013. On October 4, 2013, all of the plots were planted with sugar cane variety L 01-299. The plant year sugarcane crop was harvested on November 20, 2014.

Table 1. St. Gabriel Data from November 1, 2012 to October 30, 2014.

Treatment	Rainfall (in)	Runoff (in)	Soil Loss (t/ac)	Nitrogen Loss (lbs/ac)	Phosphorus Loss (lbs/ac)	Potassium Loss (lbs/ac)
Fall Fallow	104.14	42.79	25.62	20.75	34.95	140.46
Spring Fallow	104.14	44.47	19.49	17.16	24.97	120.64
No-Till	104.14	47.70	14.30	33.23	53.50	148.90

Data were collected from October 31, 2012, when the last ration crop was harvested to October 30, 2014, when the plant cane crop was harvested. The rainfall for this period was 104.14 in., which was 98% of normal. Fall fallow produced 42.79 in. of runoff, 25.62 t/ac of soil loss, 20.75 lbs/ac of nitrogen loss, 34.95 lbs/ac of phosphorus loss, and 140.46 lbs/ac of potassium loss. Spring fallow produced 44.47 in. of runoff, 19.49 t/ac of soil loss, 17.16 lbs/ac of nitrogen loss, 24.97 lbs/ac of phosphorus loss, and 120.64 lbs/ac of potassium loss. No-till fallow produced 47.70 in. of runoff, 14.30 t/ac of soil loss, 33.23 lbs/ac of nitrogen loss, 53.50 lbs/ac of phosphorus loss, and 148.90 lbs/ac of potassium loss.

No-Till produced the smallest amount of soil loss. Spring Fallow was second and was 36% larger than the No-Till. The Fall Fallow had the largest soil loss, which was 79% larger than the No Till. Since the No Till is not tilled until just before planting, the plant roots hold the soil. Fall Fallow is tilled in the fall. The roots decay over the winter and there is nothing to hold the soil when spring rainfall arrives. No-Till has the largest nutrient losses with Fall Fallow second and Spring Fallow the lowest.

Table 2. St. Gabriel Biomass and Sugar Yields for 2014 Crop Year.

Treatment	Biomass (t/ac)	Sugar Yield (lbs/ac)
Fall Fallow	42.57 a[1]	10,318 a
Spring Fallow	44.68 a	11,229 a
No-Till	47.91 a	12,782 a

[1] Means followed by the same letter are not significantly different (P=0.05)

No-Till produced the largest biomass yields with 47.91 t/ac and 12,782 lbs/ac sugar yields. Spring Fallow was second with 44.68 t/ac biomass and 11,229 lbs/ac sugar yield. Fall Fallow was the smallest with 42.57 t/ac biomass and 10,318 lbs/ac sugar yields.

CONCLUSIONS

The No-Till fallow program produced the largest biomass and sugar yields with the smallest soil loss by 79%. However, No-Till produced the largest nutrient losses. Fall Fallow produced the smallest biomass and sugar yields with the largest soil loss. Spring Fallow was in between No-Till and Fall Fallow. The management strategy had the largest effect on soil loss. There were no significant difference among crop yields. The management strategy did not affect crop yields.

REFERENCES

Bengtson, R. L. and H.M. Selim. 2012. USLE "C" values for Louisiana sugarcane. ASABE Paper No. 12-1336859. St. Joseph, MI. ASABE. 16 pgs.

Camp, C.R. 1976. Determination of hydraulic conductivity for a Louisiana alluvial soil. In: *Proc. of the Third National Drainage Symposium.* Pp. 104-108. St. Joseph, MI. ASAE.

Martin, T.D., C.A. Brockhoff, J.T. Creed, and S.E. Long. 1991. Method 200.2, Determination of metals and trace elements by indirectly coupled plasma-atomic emission spectrometry. In: *USEPA. 1991. Methods for the determination of metals in environmental samples.* ESEPA 600/4-91/010. June.

Rogers, J.S., V. McDaniel, and C.E. Carter. 1985. Determination of saturated hydraulic conductivity of a Commerce silt loam soil. *Trans. ASAE* 28(4):1141-1144.

Steel, R.G.D. and Torrie, J.H. 1960. Principle and procedures of statistics. McGraw-Hill Book Co., INC.

Wall, L.L. and C.W. Gehrke. 1979. Automated ureasechromous method (AUCM) for nitrogen in fertilizers. Missouri Agricultural Experiment Station Bulletin, Columbia, MO.

DISTRIBUTIONS OF CARBON AND NITROGEN IN THE SOIL PROFILE UNDER DIFFERENT SUGARCANE MANAGEMENTS

H. Magdi Selim, April Newman
Liyun Zhang, Allen Arceneaux, Brenda Tubaña, and Lewis A. Gaston
School of Plant, Environmental and Soil Science

The focus of this long-term investigation was to study the influence of different residue management practices on carbon and nitrogen in soils grown to sugarcane. The project was initiated in 2001 with the main objective of studying the influence of different residue management strategies on sugarcane yield, and the impact of the residue on soil physical and chemical properties. The three treatments were; (i) burning the mulch after harvest, off-barring and cultivating in the spring; (ii) sweeping the mulch off the top of the row after harvest, offbarring and cultivating in the spring; and (iii) leaving the mulch on the field after harvest, offbarring and cultivating in the spring. The last treatment where the mulch is not removed may be best regarded as a no-till treatment which is a commonly used soil conservation measure. The objective of this study was to quantify the influence of the no-burn with the conventional burn treatments on SOC and N in the soil to a depth of at least 1 m. Sampling was carried out in 2012 and 2013, and other parameters quantified include cation exchange capacity (CEC). bulk density, and pH.

Materials and Methods

This study was carried out at the St. Gabriel Sugar Research Station of the LSU AgCenter The experimental site was described earlier and covered approximately 1.5 ha of a Commerce silt loam soil and was in sugarcane for over 50 years. Sugarcane, a ratoon crop, is typically planted in the fall followed by ~~3~~ three or ~~4~~ four ratoons. The land was rowed where six plots (3 treatments x 2 replications) running east to west were established. Each plot consisted of 9 rows 150-m long with 1.82-m row spacing. The three treatments were: (i) burning the mulch after harvest, (ii) leaving the mulch on the field after harvest (no-burn), and (iii) sweeping the mulch off the top of the row after harvest. These management treatments were implemented on sugarcane grown on this site since 2001.

Two sets of soil samples were collected on transacts of the burn and no-burn plots on April 30, 2012, and August 1, 2013 In 2012, core sampling was carried out at a spacing of 1.8 m to a depth of 1 m. Each of thirty soil cores per transect were divided into 10 cm sections for a total of 300 samples per plot. Each sample was oven-dried, ground, and analyzed for soil moisture content and bulk density determined. Each sample was further analyzed for percent total C and percent total N using a dry combustion method. In 2013, core sampling was carried such that for the burn and no-burn treatments, three cores were sampled. The cores were at 5 m spacing to a depth up to 2.7 m dependent on the soil wetness. The purpose of this sampling was to examine the changes of C and N distribution versus depth at different times.

Results and Discussion

Results of 2012 of soil C content versus depth from the burn and no-burn treatments are given in Fig. 1. The solid curve represents the average carbon content versus soil depth. The carbon content was remarkably similar with overall averages of 0.61 and 0.65 % for the burn and no-burn treatments, respectively. The associated variances were 0.029 and 0.027 %, respectively.

Inorganic C was undetectable in all samples tested; therefore all total C measurements were interpreted as representing soil OC. The range of SOC in the two treatments were somewhat lower than those found in other soils in the region which ranged from 1.0 to 2.4 % in South Louisiana sugarcane fields and from 1.1 to 22.6 % in non-agricultural floodplain soils of the Atchafalaya River Basin, Louisiana. Nevertheless, highest SOC was encountered in the top zone with a decrease with depth, which is typically encountered for most soils.

Results from 2013, shown in Fig. 2, indicated no significant differences for SOC ($t = -1.622$, $p = 0.109$) or N ($t=1.588$, $p=0.166$) between the burn and no-burn treatments. However, a comparison of 2012 data versus 2013 indicated significant differences for SOC and N. Such differences between year of sampling is not easy to explain. Lack of differences in C stock between the burn and no-burn treatments is in agreement with the conclusion reached by others.

It is recognized that datasets from 2012 and 2013 represent snap shots that capture the SOC and N distributions at each particular time. One way to address this concern is to compare the SOC and N data with a "control" dataset. We designated cores sampled in areas outside the experimental plot area as control since the area was not cropped and did not receive fetilizers or other managent other than frequent mowing of predominantly bermudagrass (Cynodon spp.) for over 50 years. Results from the control treatments along with those from 2012 and 2013 are shown for SOC in Fig 3. It obvious that data for the top 10 cm of the control were higher in SOC and N when compared to plots under crop management. Moreover, at depth below 10 cm, a decrease in SOC and N were found in the control area but this decrease did not resemble that of exponential decay. Based on paired t-test analyses, there were significant difference of SOC and N between the control and the results from two treatments, for 2012 and 2013. In order to test whether there was a build up of C stock at lower depth, we performed the test for signicance when the top 10 cm zone was excecluded. The results indicated a sigifıcant difference beweeen the control profiles and those from two treatments for depth between 10 to 90 cm. For example, the paired t-statistics for the burn versus control were ($t=-2.64$, $p = 0.009$ and $t=-20.67$, $p < 0.001$, for the 2012 burn and no burn treatments, respectively. This is an important finding and implies that a continuous sugarcane cropping system resulted in lower C stock in the soil when compared to the control plots under bermudagrass. For example, in 2012, the average SOC over the entire soil profile were 0.608%, 0.653%, and 0.694% for the burn, no-burn and control plots, respectively.

In summary, in 2012 and 2013, SOC and N were measured along two transacts in a long-term study of burn and no-burn management of sugracane residue. Vertical distribution of SOC and N indicated appreciable levels throughout the soil profile up to 1 m. Siginficant correlations were observed between CEC and SOC. For individual soil depths, semivariogram analysis indicated that there was a lack of spatial variation for all properties measured. Semivariograms for the entire data set indicated extensive spatial structure for SOC and N. For the burn treatment, greatest spatial structure was observed for SOC and CEC. Results from 2012 indicated that that the no-burn treatmnet stored significantly more SOC and N than the burn treatament. In contrast, in 2013, SOC and N results indicated no significant differences between the burn and no-burn treatments. Results from a control area under bermudagrass indicated higher SOC and N near the soil surface compared to both the burn and no-burn treatments, but lower levels were observed at depth below 60 cm. Total SOC to a depth of 1 m was 6% and 14% higher in the control compared to the burn and no-burn treatments, respectively. Based on two years of data, the influence of no burn (no-till) management of sugarcane residue on C stock in the soil profile is inconclusive.

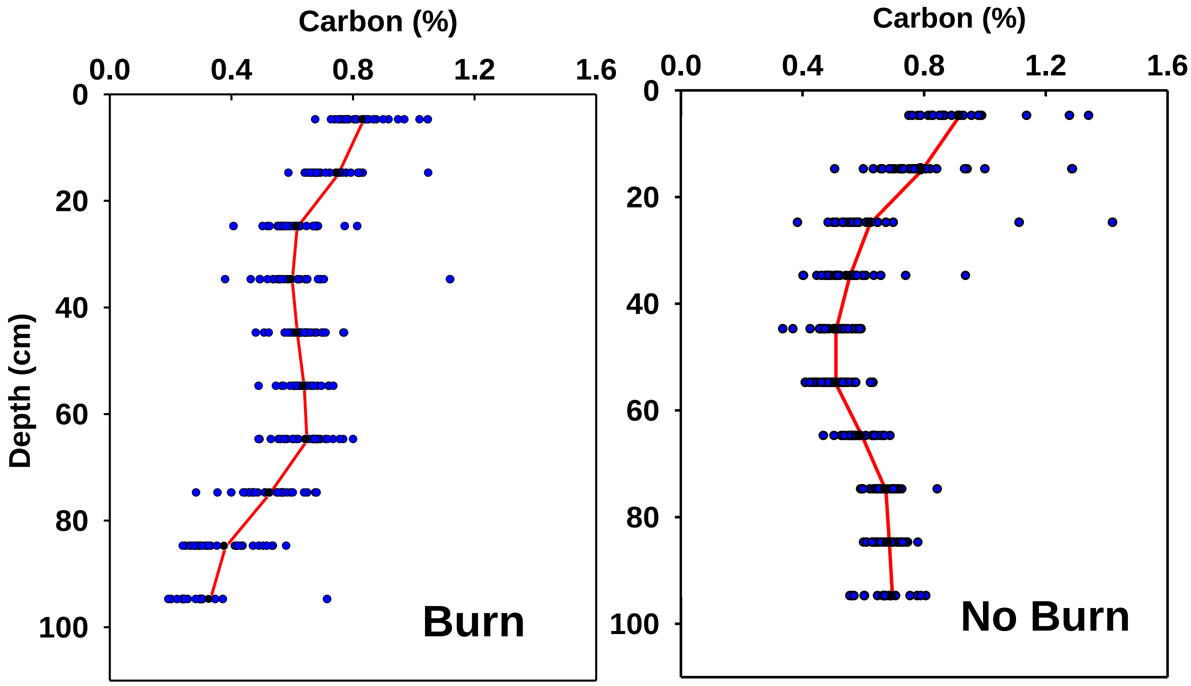

Fig. 1. Soil organic carbon (SOC) versus depth for the burn and no burn treatments from 2012 sampling. Continuous lines represent averages for each depth.

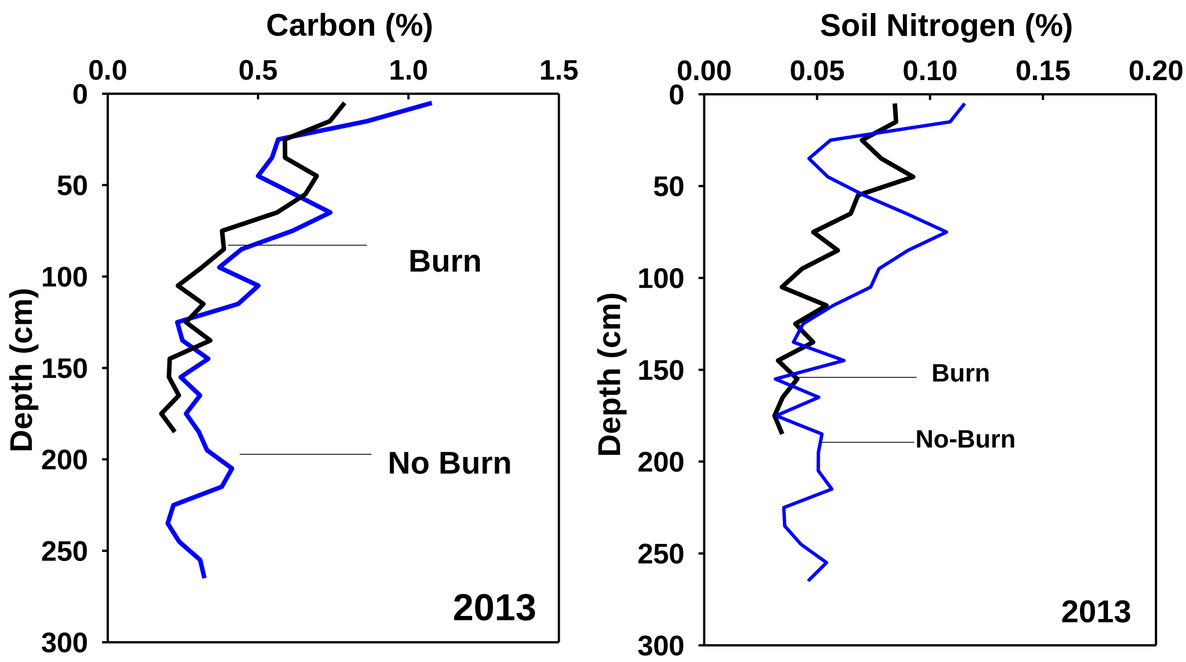

Fig. 2. Soil organic carbon (SOC) and soil nitrogen content versus depth for the burn and no burn treatments from 2013 sampling.

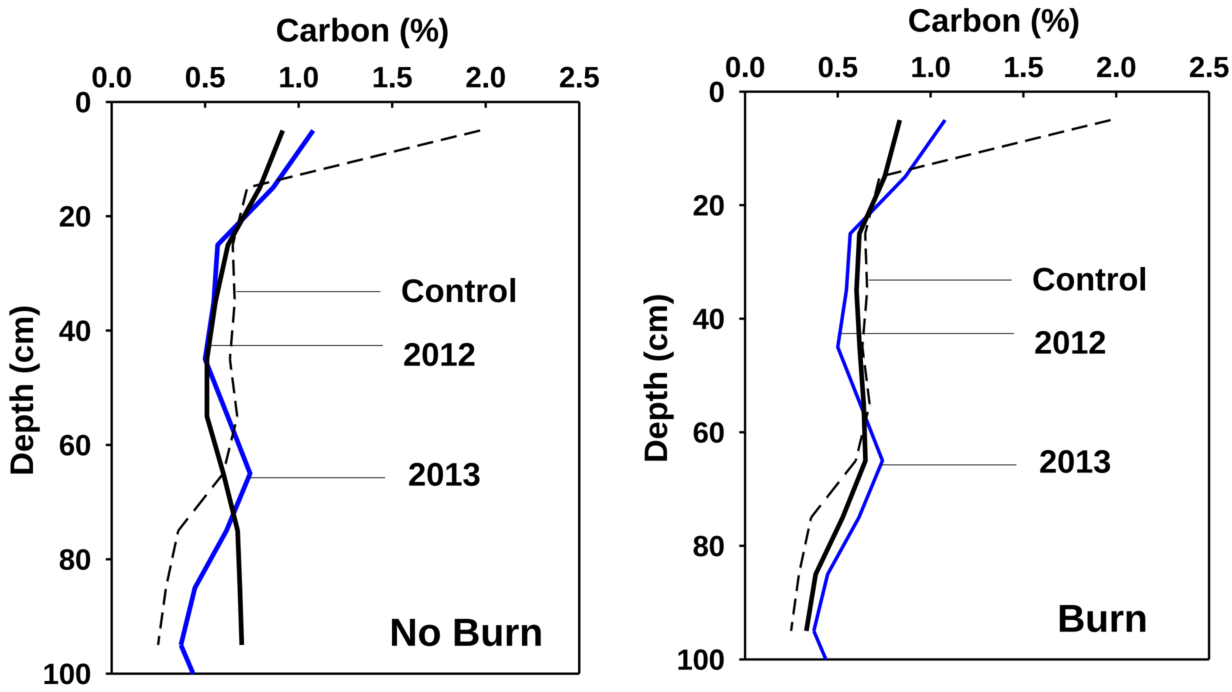

Fig. 3. Soil organic carbon (SOC) versus depth for control and the burn and no burn treatments.