# USLE "C" VALUES FOR LOUISIANA SUGARCANE[1]

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## ABSTRACT

Universal Soil Loss Equation cropping and management "C" values were calculated by crop stages for Louisiana sugarcane. Measured soil loss and rainfall erosion indices were used in the calculation of the "C" values. The winter crop stage "C" value was 0.107. The first quarter was 0.126, second quarter was 0.096, third quarter was 0.047, fourth quarter was 0.031, and fall crop stage was 0.100. The annual average was 0.084. Conservationists can use these "C" values to assign design values for conservation cropping management practices in the Universal Soil Loss Equation.

## INTRODUCTION

USLE cropping and management "C" values were calculated by crop stages for Louisiana sugarcane. Conservationists can use these "C" values to assign design values for conservation cropping management practices in the Universal Soil Loss Equation.

The cropping and management "C" factor for the Universal Soil Loss Equation (USLE) is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled continuous fallow land (Wischmeier and Smith, 1965). Some soils erode more easily than others; therefore, the loss for fallow conditions must be evaluated for the same type soil as on land cropped under specified conditions. The distribution of rainfall erosion index "R" factor by crop stages must be considered in computing "C" values as described by Wischmeier and Smith (1965). The erosion index of a given storm is defined as the product: kinetic energy of the storm in MJ/ha times the 30-minute intensity in mm/hr times $10^{-2}$.

## SITUATION ON THE LAND

Sugarcane lands in Louisiana are usually managed in 4-yr rotations. The crop is usually planted in September. The crop starts growing and grows until frost. It starts growing again in the spring and will be harvested in the October to December period. In January the residue left on the field after harvest is burned. The cane starts growing after the last spring freeze and will be harvested in the October to December period. Two ratoon crops are grown and then 11 months of fallow to control weeds and diseases. Throughout the 11 months fallow period, the land is bare and unprotected; tillage operations are frequent, so as to reduce weed growth and

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decrease weed and disease problems during the next cycle sugarcane production. The old rows are broken out to cover stubble in middles about 4 months before turn-plowing, which leaves the field flat. Three months later the rows are formed for sugarcane planting.

## PROCEDURE

The USLE factors are described by Wischmeier and Smith (1965). The USLE takes the form:

$$A = RKLSCP \quad [1]$$

where
- A = the soil loss per unit area per year,
- R = the rainfall erosion index factor,
- K = the soil erodibility factor,
- L = the slope-length factor,
- S = the slope-gradient factor,
- C = the crop management factor,
- P = the erosion-control practice factor.

The value of "C" for any crop stage, t, can be calculated by:

$$C_t = A_t / (R_t \, K \, L \, S \, P) \quad [2]$$

## MATERIALS AND METHODS

The experimental site was at the Louisiana Agricultural Experiment Station's St. Gabriel Research Station located 20 km south of Baton Rouge. Six leveed plots (140 m by 18 m) 0.25 ha in size (nine rows spaced 1.8 m apart and 140 m long and sloped 0.25%) were located on a Commerce silt loam soil (Aeric Fluvaquent, fine-silty, mixed, non-acid, thermic) (Camp 1976 and Rogers et al. 1985). This soil has a hydraulic conductivity of 5 mm/hr. The water table rises to the bottom of the rows during the winter rains. During the summer, the water table falls to 4m below the rows. To measure and sample surface runoff, a sump was installed on the low side of each plot. The sump was a corrugated metal pipe 1.2m in diameter and 3m in depth. A float-controlled electric sump pump was installed in each sump to discharge the runoff through a water meter and into a surface drainage ditch. The pump was ½ HP with a flow rate of 80 l/min. An automatic water sampler at each sump was used to collect runoff samples at 20 minute intervals during runoff. Runoff samples were analyzed by the Department of Agricultural Chemistry for total solids. Using the amount of surface runoff that was measured with the water meters and concentrations provided by the Department of Agricultural Chemistry, total loadings were calculated.

## ANALYTICAL DATA

The soil loss "A" in MT/ha was measured for a specific cropping practice by sampling the runoff water and calculating the soil loss load. Rainfall was measured by a universal recording rain gauge and the rainfall erosion index factor “R” in MJ*mm/ha*h was calculated for each storm. The method used for calculating “R” was described in Wishmeier and Smith (1978). The “R” was calculated in English units. This value was multiplied by 17.02 (Foster et. al. 1981) to transfer the “R” into metric units of MJ*mm/ha*h.

The soil erodibility factor “K” was 0.083 t*ha*h/ha*MJ*mm for Commerce silt loam soil. This was determined by Barnett et al. (1978) using a rainfall simulator.

The slope length factor “L” was 1.39. This was calculated for a slope length of 170 m using the procedure in Wischmeier and Smith (1965).

The slope steepness factor “S” was 0.08. This was calculated for a slope steepness of 0.25% using the procedure in Wischmeier and Smith (1965).

The support practice factor “P” was 1.0 for up and down tillage. This was from Wischmeier and Smith (1965).

## CROP STAGES

The sugarcane season was divided into the following crop stages.

Winter: From January 1st to last spring freeze. The fields are bare because the residue left on the field after the harvest has been burned in January.

First Quarter: This is from the last freeze date to ¼ of the way through the growing season. The plants are short and only cover ¼ of the soil surface.

Second Quarter: This is from ¼ to ½ of the way through the growing season. Plants are of medium height and cover ½ of the soil surface.

Third Quarter: This is from ½ to ¾ of the way through the growing season. Plants are tall and cover ¾ of the soil surface.

Fourth Quarter: This is from ¾ of the way through the growing season to harvest. Plants are very tall (over 3 m) and cover all of the soil surface.

Fall: From harvest to December 31st. The field is covered with residue.

## RESULTS AND DISCUSSION

The average annual rainfall for St. Gabriel, Louisiana, from 1994 to 2010 was 1383 mm (54.45 in) (91% of normal). The year 1997 had the maximum rainfall of 1790 mm (70.47 in) (119% normal). The year 2000 had the least rainfall with 1023 mm (40.28 in) (68% normal). June was the wettest month with 178 mm (7.00 in) and May was the driest with 87 mm (3.42 in).

The average annual runoff was 476 mm (18.74 in) (31% of rainfall). The year 1997 had the maximum runoff with 840 mm (33.07 in). The year 2000 had the least runoff with 146 mm (5.75 in). June had the maximum monthly runoff with 70 mm (2.75 in). August had the least with 18 mm (0.70 in).

The average annual USLE "R" Factor was 10548 MJ*mm/ha*h. The year 1997 had the maximum "R" with 18702 MJ*mm/ha*h. The year 2008 had the minimum "R" with 5000 MJ*mm/ha*h. June had the maximum "R" with 2258 MJ*mm/ha*h. February had the minimum "R" with 403 MJ*mm/ha*h.

The average annual soil loss from 1994 to 2010 was 7.51 MT/ha (3.35 t/a). The maximum soil loss occurred in 1994 with 20.83 MT/ha (9.30 t/a). The year 2008 had the minimum soil loss with 1.24 MT/ha (0.55 t/a). The year 2008 had a very small soil loss because it was a drought year with only 73% normal rainfall and 38% of annual average runoff. June had the maximum monthly soil loss with 1.29 MT/ha (0.58 t/a) and August had the minimum monthly soil loss with 0.15 MT/ha (0.07 t/a).

From 1994 to 2010, the winter stage had a total of 3675 mm (144.68 in) of rain and 2031 mm (79.96 in) of runoff. This resulted in 19.388 MT/ha (8.63 t/a) soil loss and an USLE "R" of 19707 MJ*mm/ha*h to equal an USLE "C" of 0.107. This stage is from January 1$^{st}$ to the last spring freeze. The fields are bare and the water table is at the bottom of the rows during this season.

For the first quarter stage, a total of 2288 mm (90.08 in) of rain resulted in 1187 mm (46.73 in) of runoff and 22.713 MT/ha (10.13 t/a) soil loss. With a USLE "R" of 19582 MJ*mm/ha*h, this equaled an USLE "C" of 0.126. This stage is the first quarter of the growing season starting with the last spring freeze date. The cane is less than 1 m (3.28 ft) tall during this period.

For the second quarter, a total of 2250 mm (88.58 in) of rain resulted in 1098 mm (43.22 in) of runoff, 25.596 MT/ha (11.42 t/a) of soil loss, and a USLE "R" of 30551 MJ*mm/ha*h. This equaled an USLE "C" of 0.091. The second quarter of the growing season is a period of early summer high intensity convective storms. The cane is less than 2 m (6.56 ft) tall.

For the third quarter, a total of 2345 mm (92.32 in) of rain resulted in 734 mm (28.90 in) of runoff, 10.598 MT/ha (4.73 t/a) of soil loss, and a USLE "R" of 24236 MJ*mm/ha*h. This equaled an USLE "C" of 0.047. The water table is approximately 1.2 m deep during the third quarter of the growing season. The cane is less than 3 m (10 ft) tall.

For the fourth quarter, a total of 1941 mm (76.42 in) of rain resulted in 732 mm (28.82 in) of runoff, 4.308 MT/ha (1.92 t/a) of soil loss, and a USLE "R" of 15225 MJ*mm/ha*h. This equaled an USLE "C" of 0.031. This fourth quarter of the growing season is hurricane season. This season is usually very dry unless there is a hurricane, and then it can be very wet. The cane is more than 3 m (10 ft) tall and the canopy completely covers the ground.

For the fall period, a total of 2359 mm (92.87 in) of rain resulted in 1247 mm (49.09 in) of runoff, 11.472 MT/ha (5.12 t/a) of soil loss, and a USLE "R" of 12486 MJ*mm/ha*h. This equaled an USLE "C" of 0.100. This is the period from harvest to December 31st. The field is covered with residue. Rainfall increases as the end of the year nears with the start of winter rains. The winter rains are low intensity and long duration storms.

Every fifth year the sugarcane fields were fallowed from the time the fields are dry enough to cultivate in the spring until the new crop of sugarcane is planted in the first part of September. The St. Gabriel sugarcane plots were in fallow during 1996, 2001, and 2006. A total of 1300 mm (51.18 in) of rain resulted in 509 mm (20.04 in) of runoff and 7.318 MT/ha (3.26 t/a) of soil loss, and an USLE "R" of 21903 MJ*mm/ha*h. This equaled a USLE "R" of 0.036. The fallowing operation reduces the percentage of rainfall that becomes runoff.

The plant period goes from when the sugarcane is planted the first part of September until December 31$^{st}$. The cane grows and establishes itself until is killed with the first fall freeze. The cane may grow to 0.5 m (1.6 ft) during this period. Sugarcane was planted in the St. Gabriel plots in September 1996, September 2001, and August 2006. A total of 1041 mm (40.98 in) of rain resulted in 376 mm (14.80 in) of runoff, 26.630 MT/ha (11.88 t/a) of soil loss, and an USLE "R" of 11296 MJ*mm/ha*h. This equaled a USLE "R" of 0.255. During this period the soil is loose from the planting operation and erodes very easily. A large amount of the soil loss (14.18 MT/ha) (6.32 t/a) was caused by 107 mm (4.21 in) of rainfall in October 2001.

Table 1 is a summary table of the USLE "C" values for Louisiana Sugarcane. The average annual "C" value was 0.084. It varied from 0.126 during the first quarter to 0.031 for the fourth quarter.

## CONCLUSIONS

The "C" values presented in this study were derived from field measurements of soil loss and rainfall erosion index. These items were measured from instrumented runoff sugarcane plots located at St. Gabriel, Louisiana. The winter crop stage "C" value was 0.107. The first quarter was 0.126, second quarter was 0.091, third quarter was 0.047, fourth quarter was 0.031, and fall crop stage was 0.100. The average annual "C" value was 0.084. Values were also calculated for the fallow and plant periods of the sugarcane cycle. The values were 0.036 for the fallow period and 0.255 for the plant period.

Table 1: USLE "C" Values for Louisiana Sugarcane

| Crop Stage | USLE "C" Factor |
|---|---|
| Winter | 0.107 |
| First Quarter | 0.126 |
| Second Quarter | 0.091 |
| Third Quarter | 0.047 |
| Fourth Quarter | 0.031 |
| Fall | 0.100 |
| Annual Average | 0.084 |

## REFERENCES

Barnett, A.P., A.E. Dooley, and G.A. Smith. 1978. Soil erosion and sediment loss under sugarcane culture on the flat lands of Southern Louisiana. *Trans. ASAE* 21(6):1144-1150.

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

Foster, G.R., D.K. McCool, K.G. Renard, and W.C. Mouldenhauer. 1981. Conversion of the universal soil loss equation to SI metric units. Journal of Soil & Water Conservation. Nov-Dec. 355-360.

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.

Wishmeier, W.H. and D.D. Smith. 1965. Predicting rainfall erosion losses from cropland east of the Rocky Mountains. Agriculture Handbook 282. U.S. Department of Agriculture, Washington, D.C. 47p.

Wishmeier, W.H. and D.D. Smith. 1978. Predicting rainfall erosion losses-a guide to conservation planning. Agriculture Handbook No. 537. U.S. Department of Agriculture, Washington, D.C. 58p.

# IMPACT OF SUGARCANE MANAGEMENTS ON CARBON SEQUESTRATION IN SOILS

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In the southern climate region of the United States, potential rates of carbon sequestration in soils are largely not quantified. Recently, the soil organic carbon (SOC) pool has been recognized as an important contributor to global carbon sequestration, and agricultural systems in particular have been identified as an area in which soil organic carbon may be increased appreciably when managed for that objective. Although a growing body of work has emerged to quantify the carbon sequestration potential of various cropping systems and climates, there have been few studies in the southern climate region. Because controls on SOC dynamics vary with climate, vegetation type, soil texture, and soil structure, regional sequestration potentials vary. The aim of this study is to quantify carbon sequestration and its spatial variability under two long-term management systems in sugarcane (Saccharum Spp. Hyb.) cropping systems.

## OBJECIVES

The focus of this long-term investigation was to study the influence of different residue management practices on carbon sequestration 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, off-barring and cultivating in the spring; and (iii) leaving the mulch on the field after harvest, off-barring 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. In this present study, the focus was on two treatments; namely the burn or conventional treatment (i) and the no-till treatment (iii).

## MATERIALS AND METHODS

This investigation was carried out at the Louisiana Agriculture Experiment Station's Sugar Research Station located 19 km south of Baton Rouge. Six levied plots 0.25 ha in size (nine rows spaced 1.77 m apart and 138 m long) were located on a Commerce silt loam (Fine-silty, mixed, superactive, nonacid, thermic, Fluvaquentic Endoaquepts). Three cycles of sugarcane were located on the Commerce site. The sugarcane variety HoCP 91-555 was hand planted with whole stalks on September 19, 2001. In the second planting, sugarcane variety L97-128 was hand planted with whole stalks August 15, 2006. In the third planting, sugarcane variety L01-283 was hand planted with whole stalks August 29, 2011.

Soil sampling to a depth of 1 m (>4 ft) was carried out along two 60-m transects; one in the no-till plot treatment and the other on the burn or conventional treatment. A Giddings probe was used to collect all core samples on April 25-26, 2012. The samples were obtained from the edge of the top of the center row for each treatment at spacing interval of 1.8 m (6 ft). Each soil core was divided into 10 cm depth increment for a total of 10 samples per core (300 samples per treatment). All samples were oven dried and analyzed for soil moisture content and bulk density. Soil sample was homogenized and analyzed for percent total carbon and percent total nitrogen using the dry combustion method (Elementar Americas Inc., Mount Laurel, NJ). Soil pH and cation exchange capacity were also measured. To determine if differences between treatments were significant, paired t-tests on the entire data set as well as all samples at each soil depth were carried out.

**Results and Discussion**

Soil organic carbon (SOC) ranged from 0.20 - 1.1 % in the soil profiles from the burn treatment and from 0.34 - 1.4 % in the no-till treatment (Figure 1). Overall averages were 0.61 and 0.65 % for the burn and no-till treatments respectively (Table 1). In addition, differences in SOC between the two treatments were significant ($t = 2.35$, $p = 0.019$).This indicates that during the study period, significantly greater SOC was sequestered in the soil profile of the no-till plots when compared to the burn plots. Furthermore, for soil depth below 60 cm, measured SOC was significantly higher in the no-till plots when compared to the burn plots. Such finding illustrates the mobility of SOC to lower soil depths.

Soil nitrogen content ranged from 0.03 - 0.14 % in soil profiles from the burn plots and from 0.03 - 0.13 in the no-till plots (Figure 2 and Table 1). Overall averages were 0.07 and 0.08 % for the burn and no-till treatments respectively. Differences between the two treatments were significant ($t = 4.73$, $p<0.001$) and indicate that during the study period, the no-till plots accumulated a higher amount of nitrogen than the burn plots. Similar to SOC, increased amount of nitrogen was accumulated at depth below 60 cm.

Table 1. Average and standard deviation of measured percent soil organic carbon and nitrogen with depth for the no-till and burn or conventional treatments. Averages are based on 30 samples for each soil depth.

| | Soil Organic Carbon | | | | Soil Nitrogen | | | |
|---|---|---|---|---|---|---|---|---|
| | No-Till | | Conventional Burn | | No-Till | | Conventional Burn | |
| Depth (cm) | Average (%) | Standard Deviation (%) | Average (%) | Standard Deviation (%) | Average (%) | Standard Deviation (%) | Average (%) | Standard Deviation (%) |
| 0-10 | 0.91 | 0.14 | 0.83 | 0.09 | 0.102 | 0.010 | 0.085 | 0.010 |
| 10-20 | 0.79 | 0.17 | 0.75 | 0.09 | 0.090 | 0.015 | 0.079 | 0.009 |
| 20-30 | 0.62 | 0.19 | 0.62 | 0.08 | 0.073 | 0.016 | 0.069 | 0.011 |
| 30-40 | 0.55 | 0.10 | 0.60 | 0.13 | 0.064 | 0.012 | 0.071 | 0.017 |
| 40-50 | 0.51 | 0.06 | 0.62 | 0.13 | 0.059 | 0.009 | 0.077 | 0.010 |
| 50-60 | 0.51 | 0.06 | 0.64 | 0.06 | 0.060 | 0.011 | 0.079 | 0.007 |
| 60-70 | 0.60 | 0.05 | 0.65 | 0.08 | 0.072 | 0.010 | 0.071 | 0.007 |
| 70-80 | 0.67 | 0.05 | 0.53 | 0.09 | 0.086 | 0.007 | 0.058 | 0.007 |
| 80-90 | 0.69 | 0.05 | 0.38 | 0.1 | 0.084 | 0.008 | 0.048 | 0.009 |
| 90-100 | 0.70 | 0.08 | 0.33 | 0.13 | 0.075 | 0.010 | 0.041 | 0.009 |

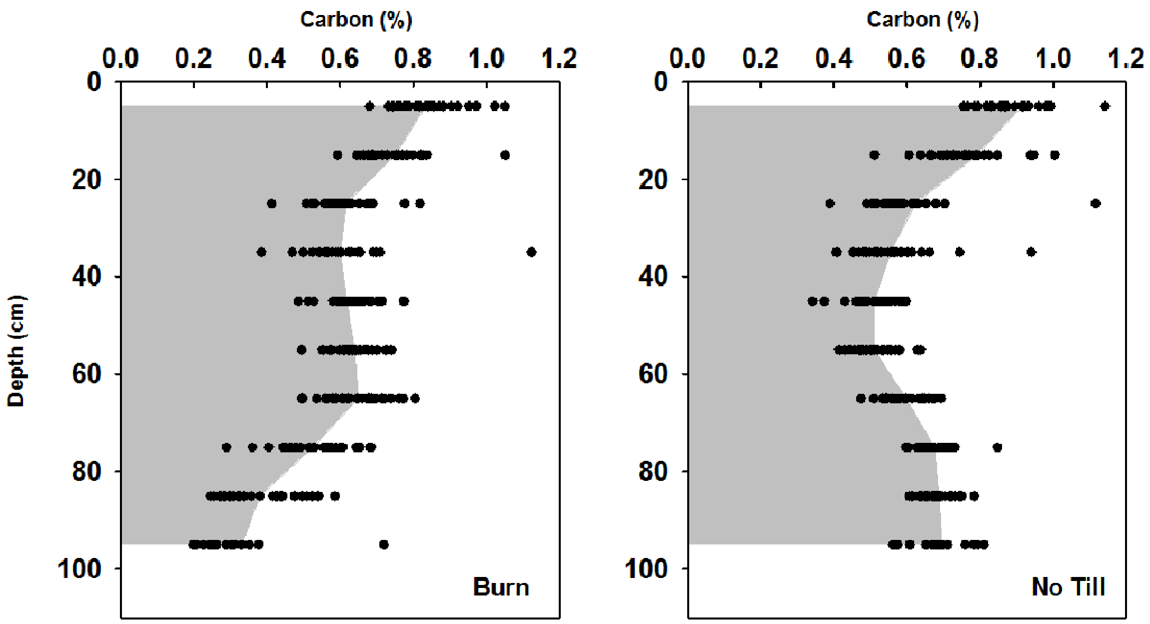


Figure 1. Percent soil organic carbon for the burn and no-till treatments versus soil depth. Shaded area indicates averages with depth.

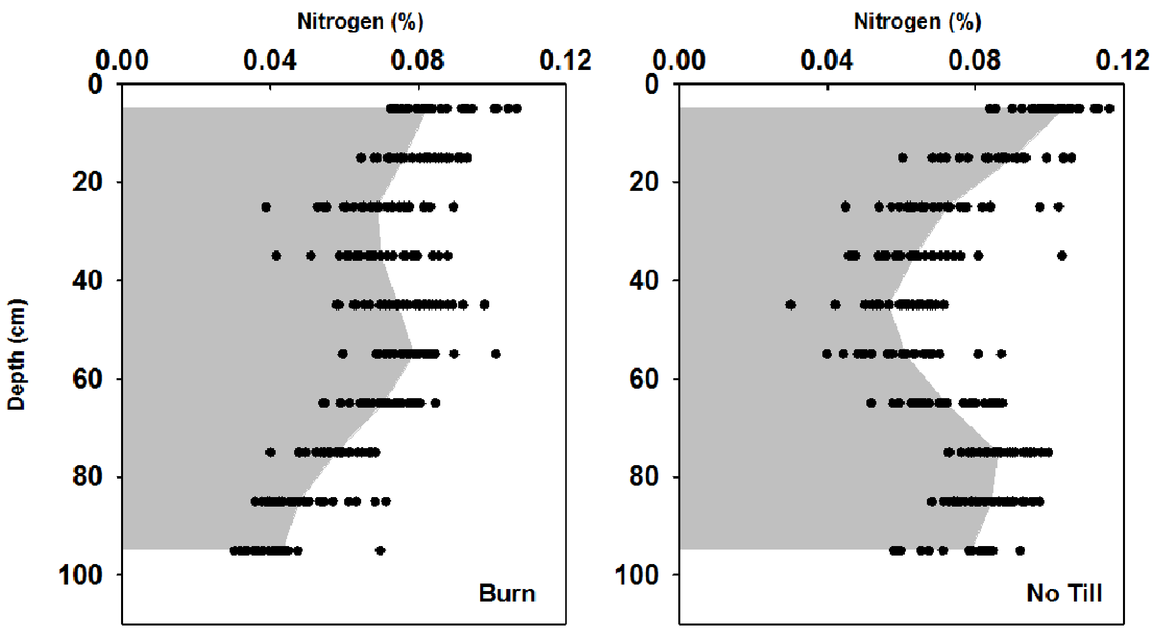


Figure 2. Percent soil nitrogen for the burn and no-till treatments versus soil depth. Shaded area indicates averages with depth.