CHANGES IN SOIL ORGANIC CARBON STOCKS RESULTING FROM SUGARCANE CROPPING IN THE HUMID TROPICAL CLIMATE OF MAURITIUS: RESULTS FROM ^{13}C NATURAL ABUNDANCE

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Abstract

A DECLINE in productive capacity of soils as a consequence of long-term sugarcane monoculture, combined with an intensification of the production system, has become a major issue in several sugarcane producing countries. Maintenance of adequate levels of soil organic carbon (SOC) is crucial for the biological, chemical and physical functioning of soils. This study was conducted to determine the impact of long-term sugarcane monoculture on SOC stocks and to quantify the loss of native SOC and accretion of sugarcane-derived C following the adoption of new management practices namely derocking/landgrading and mechanised harvesting. Five study sites representing the five major soil groups under sugarcane in Mauritius were studied and a classical 'paired-plot' design was adopted where two sites with similar starting conditions were developed in different ways over time, with one representing the reference soil (virgin land with predominantly C_3 type vegetation) and the other representing the following cropping treatments: (i) fields continuously cultivated with sugarcane for more than 25 or 50 years without derocking or land grading, (ii) fields under long-term sugarcane but having undergone derocking and land grading for mechanised harvesting in the last 3 years. Soil samples were taken to a depth of 50 cm and analysed for total organic C, ^{13}C abundance, bulk density and stone content. Long-term sugarcane cultivation reduced SOC stocks in the surface 0–15 cm layer compared to uncultivated virgin soil but increased subsoil organic C indicating a redistribution of SOC in the deeper layers of the soil profile. Changes in total C stock in the 0–50 cm profile, following 50 years of cane cropping were not significant ($P< 0.05$) compared to virgin land at any site. Data from ^{13}C abundance measurements revealed that long-term sugarcane cultivation in fact resulted in a depletion of original SOC by 34 to 70%. However, this loss was fully compensated by C input from sugarcane residues at all sites studied, resulting in no net change in SOC stock. Moreover, adoption of mechanised cropping, which entails intensive derocking and land grading, did not have any detrimental effect on SOC stocks due to C inputs from crop residues.

Introduction

In recent years, there has been increasing evidence of a decline in productive capacity of soils as a consequence of long-term sugarcane (*Saccharum officinarum* L.) monoculture combined with intensification of the production system (Garside *et al.*, 1997a; Meyer and van Antwerpen, 2001). Excessive tillage at time of planting, severe compaction resulting from mechanised cultural operations as well as practices that deplete organic matter have also been identified as major factors contributing to the yield decline (Pankhurst *et al.*, 2003). Collectively, these management practices result in degradation of the soil in chemical, physical and biological properties as evidenced by reduced levels of SOC, lower CEC and pH, high bulk density, less microbial biomass and a build-up of detrimental soil organisms (Garside *et al*, 1997b).

In Mauritius, analysis of the trend in productivity expressed as the average annual yield of sugar per hectare also showed a decline during the last 30 years in spite of the introduction of higher yielding cane varieties and the adoption of improved management practices.

While research examining the link between the observed declining productivity trend and soil degradation is lacking for the sugarcane industry in Mauritius, the management practices adopted are in many ways similar to those that are known to have contributed to yield decline elsewhere.

In this context sugarcane cropping in Mauritius is strongly monoculture-based and in order to facilitate mechanisation of cultural operations, land preparation involves deep tillage and derocking of the topsoil and subsoil followed by levelling of the soil surface through cut and fill method. As a result of this monoculture and soil disturbance, it is feared that the SOC levels may have declined.

Indeed as reviewed by Haynes and Hamilton (1999), most studies on the long-term effects of sugarcane production have reported a decline in SOC, the magnitude of this loss varying widely depending on soil type, period of cropping and management practices.

The determination of losses of original SOC from native vegetation and its replacement by C derived from sugarcane origin is thus of capital importance to understand the dynamics of organic carbon in soils of Mauritius.

The use of ^{13}C technique was preferred as it enables the separation of organic C pools into that of old and new vegetation so long as the two types of vegetation have contrasting photosynthetic pathways (C_3 versus C_4) (Balesdent *et al.*, 1987).

The cultivation of a C_4 crop such as sugarcane in a soil developed under C_3 natural vegetation can provide information on the turnover of the original organic matter as well as the contribution of the C_4–C to the SOM pool.

A study was therefore initiated to evaluate the impact of long-term sugarcane monoculture and of changed management practices on SOC stocks in Mauritius by means of natural ^{13}C natural abundance measurements.

Materials and methods

Study sites

The study was carried out at five locations representing the five major soil types of Mauritius. The soils at the study sites fall into two main soil groups: the mature ferralitic soils also known as Ferralsols (FAO-ISRIC-IUSS, 2006) or Oxisols (Soil Survey Staff, 1999) derived from highly weathered basalt and the immature latosolic soils also known as Cambisols (FAO-ISRIC-IUSS, 2006) or Inceptisols (Soil Survey Staff, 1999) derived from moderately weathered basalt rock. The main characteristics of the soils are given in Table 1.

The cropping systems studied at each of the five sites were:

(1) natural vegetation (treatment NV)

(2) continuous sugarcane for > 50 years under conventional practice (treatment 50Y) and

(3) continuous sugarcane for > 50 years under conventional practice followed by recent (three years) derocking and mechanisation (treatment 3M).

In addition, a fourth treatment consisting of 25 years sugarcane under conventional practice (treatment 25Y) was included at two sites (Riche Terre and Médine).

Table 1—Soil characteristics at experimental sites.

Location	Climatic zone (Rainfall mm/yr)	Classification (FAO WRB, 2006)	Treat-ment	Silt (%)	Clay (%)	C:N ratio
Riche Terre	Sub-humid 1000–1500	Ferralsol	NV	13.8±0.8	75.1±1.3	8–10
			50Y	19.8±1.8	66.4±2.6	10–11
			3M	18.0±1.7	70.0±2.3	9–11
			25Y	21.1±1.2	63.1±2.1	9–10
Beau Champ	Humid 1500–3200	Ferralsol	NV	21.2±0.6	62.4±2.5	11–14
			50Y	18.8±0.4	66.2±0.9	11–12
			3M	31.0±1.4	41.7±3.8	11–13
Mon Désert Alma	Super-humid 2500–3800	Ferralsol	NV	27.2±0.7	32.0±1.2	13–14
			50Y	27.4±0.7	34.5±1.3	12–13
			3M	30.6±0.9	30.8±1.1	12–13
Médine	Sub-humid 750–1500	Cambisol	NV	17.8±0.6	62.9±2.0	9–10
			50Y	21.2±0.7	49.8±3.3	10–11
			3M	21.4±0.9	58.6±2.8	10–12
			25Y	19.7±0.9	59.1±2.7	9–11
Savannah	Super-humid 2000–3200	Cambisol	NV	29.2±1.6	27.8±2.2	11–12
			50Y	25.8±0.5	47.1±1.7	9–11
			3M	25.0±0.4	53.1±2.2	10–12

The natural vegetation plots consisted of native trees and shrubs (C_3 photosynthetic pathway) but could at times have included some exotic C_4 grasses and had never been tilled or cultivated with sugarcane.

The conventional practice for sugarcane consisted of tillage to a depth of 20–30 cm and replanting of sugarcane every seven to 10 years with N, P, K fertilisation at recommended rates, and manual harvesting with trash retention, though at times pre-harvest burning of some fields might have been practised.

Derocking of soils (treatment 3M) involved tillage to more than 50 cm depth, raking of surface and subsurface rocks and boulders which were then removed from the field, followed by the levelling of the soil through cut and fill.

The study plots at any site were located one to two kilometres apart and were thus subjected to the same climatic and drainage conditions.

Soil sampling and analysis

For each cropping treatment, there were three field replicates of one hectare each and within each field replicate there were four sampling plots of 50 m^2. At each sampling plot, two trenches 1.5 m long, 0.3 m wide and 0.5 m deep were dug, extending from the middle of one cane interrow across the row to the middle of the next interrow.

Soil samples were collected from the trenches in four different depth layers namely 0–5, 5–15, 15–30 and 30–50 cm. All samples were air dried and sieved to pass a 2 mm screen.

Total C and $\delta^{13}C$ were determined on a Europa Model 2020 ANCA-SL continuous flow isotope ratio mass spectrometer with a triple collector (Europa Scientific, Crewe, UK) and expressed as per mil deviation from V-PDB standard (Peterson and Fry, 1987).

Calculation of C derived from C_3 and C_4 vegetation

Fraction of total soil organic C derived from sugarcane (*f*) was calculated using the following isotope mass balance equation (Balesdent and Mariotti, 1996):

$$f = \frac{\delta\,\text{sample} - \delta\text{reference}}{\delta\text{sugarcane} - \delta\text{reference}} \qquad \text{(Equation 1)}$$

where δsample is the average $\delta^{13}C$ value of the sample for a given depth layer from sugarcane soil, δreference is the average $\delta^{13}C$ value of the corresponding sample from natural vegetation (reference) soil and δsugarcane is the average $\delta^{13}C$ value of sugarcane crop residues (–12.05 $^0/_{00}$). Total SOC stocks (t/ha) were calculated using the following equation:

Total SOC stocks (t/ha) = % C × Z × B × (100–S) (Equation 2)

where % C is the carbon content of sample (percent), Z is the layer thickness (m), B is the bulk density (t/m^3) and S is the stone content of soil (percent). Soil C stocks were corrected to an equivalent mass basis according to Solomon *et al*. (2002).

Statistical analysis

Statistical analysis of the data was carried out using the linear model analysis of variance (ANOVA) procedure of SAS statistical package (Enterprise Guide 4, SAS International 2006). Post hoc comparisons among treatment means were done using the Tukey test at P=0.05.

Results and discussion

Effect of long-term cane cultivation on total C stocks

In the Ferralsols, SOC stocks in the 0–50 cm profile under native vegetation increased from 98.7 t C/ha at Riche Terre (subhumid zone) to 117.6 and 160.2 t C/ha respectively at Mon Desert Alma (superhumid zone) and Beau Champ (humid zone) (Figure 1).

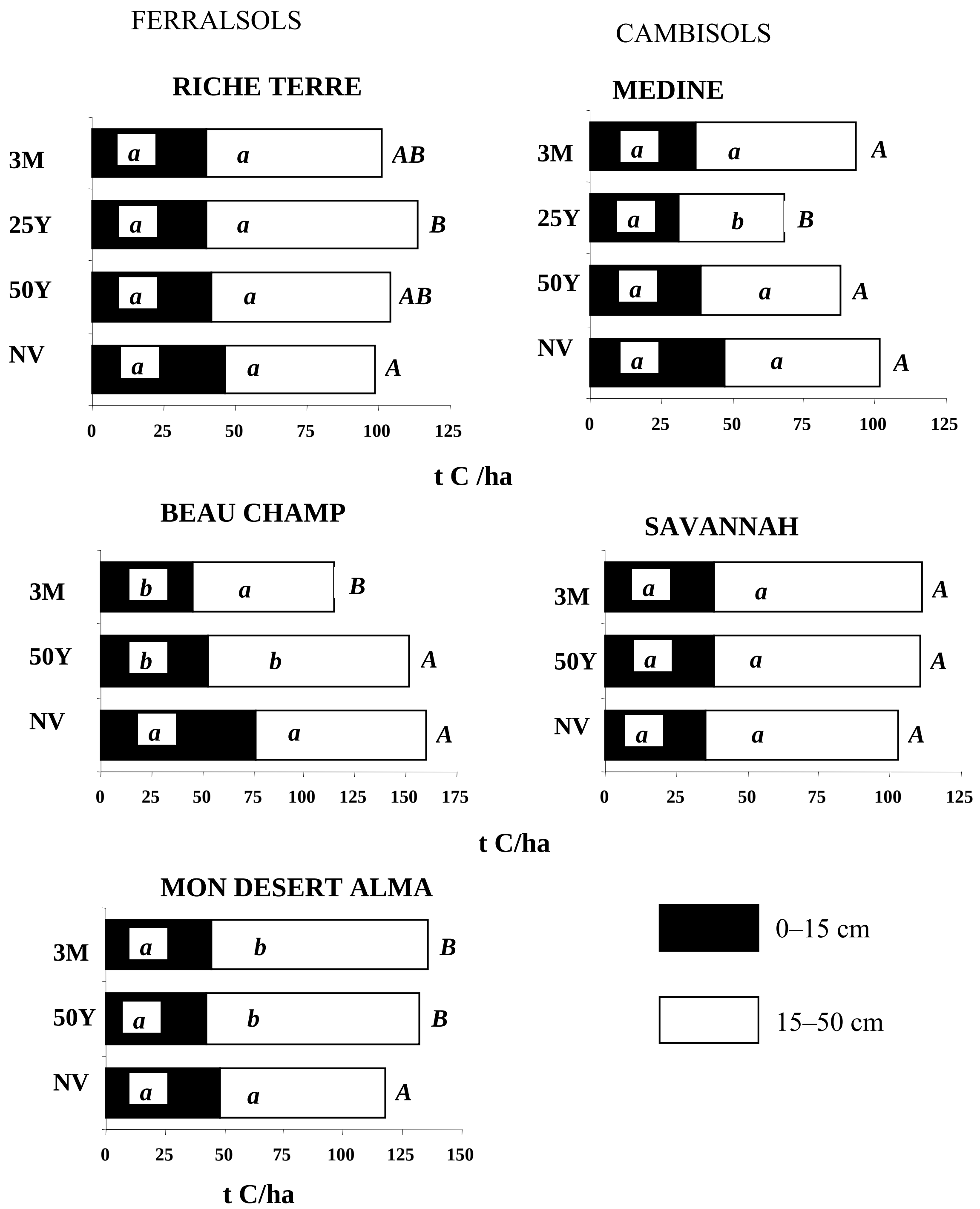
Although the soil at Mon Desert Alma has developed under the superhumid zone, its lower SOC stock compared to Beau Champ could be attributed to its lower silt plus clay content (59% at Mon Desert Alma v/s 83% at Beau Champ).

In the Cambisols, SOC stocks of uncultivated soils were similar, Medine (101.4 t C/ha) and Savannah (103.0 t C/ha), in spite of differences in rainfall regime and could be attributed to the higher silt plus clay content at Medine (81%) compared to Savannah (57%). Although a positive correlation between silt plus clay content and native SOC levels has been widely reported (Feller and Beare, 1997; Barthes *et al*., 2008), such a relationship was not consistent over all the soil groups of Mauritius.

In order to assess changes in SOC stocks between cropping systems, the SOC data for individual depth layers sampled were summed over two depth ranges (0–15 cm representing the topsoil and 15–50 cm representing the subsoil. In the Ferralsols, long-term sugarcane cropping decreased SOC stocks in the surface 0–15 cm layer by 24 t C/ha compared to the uncultivated virgin soil (representing 31% of the initial C stock) at Beau Champ. Similarly, surface C stock at Mon Desert Alma and Riche Terre declined by 6.3 and 4.9 t C/ha although these losses were not significant at P<0.05.

Further, the decline in topsoil organic C was accompanied by an increase in subsoil organic C of 15.3, 20.8 and 10.5 t C/ha respectively at Beau Champ, Mon Desert Alma and Riche Terre. These observations concord with the findings of McGarry *et al.,* (1996) and Skjemstad *et al.,* (1999) who reported a decline in organic carbon content in surface horizons but an increase in subsurface horizons after different periods of sugarcane cultivation in Australia. An accumulation of SOC in deeper soil layers under sugarcane has been attributed to rhizodeposition and continual turnover of root material at lower depth as evidenced by a higher proportion of sugarcane-derived C in the subsoil compared to topsoil organic matter as reported by De Resende *et al.,* (2006).

However, our data on measurements of $\delta^{13}C$ in the present study showed that the topsoil was more depleted in native organic C than the subsoil (Table 2) suggesting that repeated ploughing resulted in a greater loss of original SOC and hence lower SOC stock.



Fig—1. Soil organic carbon stocks (t C/ha) in 0-15 and 15-50 cm depths under different cropping systems at the five study sites. (NV: land under natural vegetation; 50Y: >50 years sugarcane conventional practice; 25Y: 25 years sugarcane conventional practice; 3M: >50 years sugarcane conventional practice with recent mechanisation). For a given site and soil depth, bars with the same lower case letter were not significantly different at P= 0.05; bars with the same upper case letter indicate that SOC for the 50 cm profile were not significantly different at P= 0.05.

It could also be due to a downward redistribution of organic matter-rich topsoil due to tillage and disk harrowing carried out at the time of replanting (Masilica *et al.*. 1986; McGarry *et al.*, 1996) or to a vertical migration of organomineral complexes (Basile-Doelsch *et al.*, 2009). In the Cambisols (Medine and Savannah), changes in SOC stocks in topsoil and subsoil resulting from long-term cane cultivation were not significant (P< 0.05).

Site	Depth (cm)	50Y	3M	25Y	50Y	3M	25Y
		% C derived from sugarcane			% loss of original C		
CAMBISOLS							
Medine	0–15	68.56aA	69.55aA	33.50aB	74.13aA	76.24aA	55.95aB
	15–50	62.79aA	63.77aA	32.80aB	66.40aA	62.17bA	54.48aB
	Profile	65.3A	66.0A	33.1B	69.99A	68.71A	55.16B
Savannah	0–15	40.94aA	41.95aA		36.50aA	37.52aA	
	15–50	27.57bA	23.41bA		22.15bA	18.14bA	
	Profile	32.2A	30.4A		27.08A	24.80A	
FERRALSOLS							
Riche Terre	0–15	31.01aA	53.47aB	21.30aA	38.25aA	56.08aB	32.16aA
	15–50	35.91aA	48.89aB	33.30bA	16.12aA	29.64bB	15.10bA
	Profile	30.5A	50.6B	28.9A	26.52A	42.07B	23.12A
Beau Champ	0–15	60.45aA	63.58aA		72.85aA	78.38aA	
	15–50	44.32bA	37.99bA		34.15aA	48.67bB	
	Profile	49.9A	48.1A		52.62A	62.85A	
Mon Desert Alma	0–15	56.37aA	51.22aA		62.11aA	55.48aA	
	15–50	38.43aA	36.79aA		19.97aA	16.75bA	
	Profile	44.2A	41.5A		37.31A	32.68A	

Table 2—Proportion of sugarcane-derived C and loss of native C in 0–15, 15–50 and 0–50 cm depth layers after 25 years, > 50 years of sugarcane monoculture and recent mechanisation. Within one site, values along the same column followed by the same lower case letter were not significantly different at P> 0.05. Within one site, values along the same row followed by the same upper case letter were not significantly different at P> 0.05. 50Y: >50 years sugarcane monoculture; 25Y: 25 years sugarcane monoculture; 3M: >50 years sugarcane monoculture with recent mechanisation.

In this study, long-term sugarcane production resulted in a decline in SOC in the top 15 cm layer but not in total SOC stock in the 0–50 cm profile at any of the sites studied. Most previous reports of a decline in SOC under sugarcane cultivation have been based on measurements of SOC changes in the surface 10–20 cm depth layer only (Cerri and Andreux, 1990; Blair, 2000; Dominy *et al*, 2002) or over a short period of cane cultivation (e.g. Hartemink, 1998). On the other hand, Skjemstad *et al.,* (1999) showed that SOC stock in the 0–80 cm profile did not decline as a result of long-term sugarcane cultivation in Australia.

Loss of original native C and incorporation of sugarcane-derived C

Although total SOC stocks in the 50 cm profile did not decline after long-term sugarcane cultivation, there was a marked depletion of the native SOC at all the study sites (Figure 2). The amount of native C lost ranged from 35 to 70% of the native C stock in the corresponding virgin soils (Table 3) and represented between 26 and 84 t C/ha. The highest loss of 70% was measured at Medine and could only partly be attributed to a decrease in soil clay content from an initial 63% in the virgin soil to 50% after >50 years of cane cropping. Although it is generally reported that clay and silt contents play an important role in the protection of SOC against mineralisation (Bationo and Buerkert, 2001; Bationo *et al*, 2007), a consistent relationship between the proportion of C lost and the soil clay content was not observed for all sites in the present study. Instead, factors such as climatic variations, mainly temperature, and cultural practices such as the frequency and intensity of tillage operations could have influenced the loss of native SOC.

Most of the loss in native C occurred in the surface 15 cm of soil, indicating that repeated tillage of topsoil at planting resulted in enhanced mineralisation of native C stocks. The measured losses of native carbon in this study were generally similar to values reported earlier. Thus Cerri *et* *al.* (1985) showed that 50% of the original C_3–C in a Brazilian Ferralsol was lost during 12 years after conversion of forest to sugarcane production. The loss of native SOC was fully compensated by C inputs from sugarcane at all sites studied (Figure 2). This is in contrast to the generally reported net loss of total SOC due to a slower accretion of crop–derived C than the loss of native C (e.g. Dominy *et al.,* 2002; Solomon *et al.*, 2002).

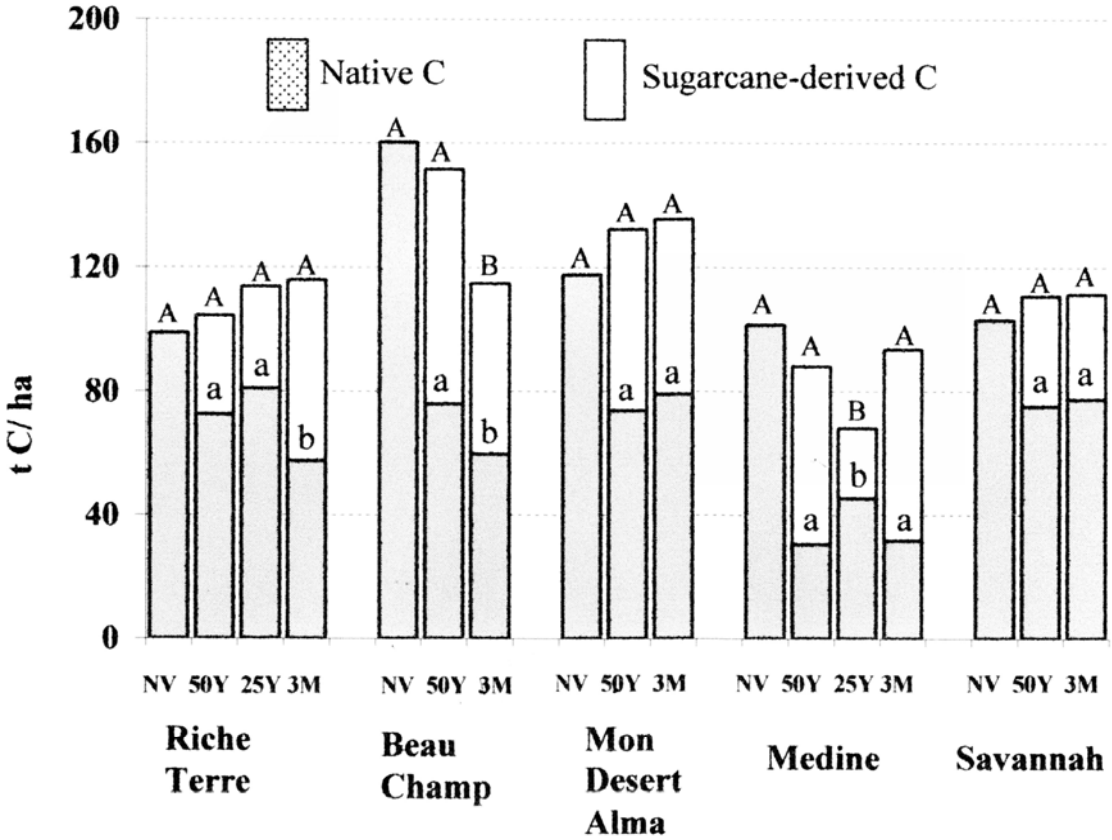


Fig. 2—Native and sugarcane-derived soil carbon stocks in the surface 50 cm of soil at five sites. (NV: land under natural vegetation; 50Y: >50 years sugarcane conventional practice; 25Y: 25 years sugarcane conventional practice; 3M: >50 years sugarcane conventional practice with recent mechanisation). For a given site, bars with the same lower case letter indicate no significant difference (P> 0.05) in native C; bars with the same upper case letter indicate no significant difference (P> 0.05) in total C.

After >50 years of sugarcane cultivation, sugarcane–derived C constituted between 31 and 68% of the existing C in topsoil (0–15 cm), the remaining 32 to 61% being attributed to native C (Table 2). The proportion of sugarcane–derived C decreased with depth in the humid and superhumid soils, but was more uniformly distributed in the 50 cm profile of the subhumid zone. Roots constitute an important source of C in sugarcane farming systems (Suman *et al.*, 2009) and the size and distribution of the root system is strongly influenced by the distribution and availability of soil water (Baran *et al.*, 1974). The observed differences in distribution of sugarcane-derived C were presumably due to a lower root density in the generally water saturated layer of humid and superhumid soils at lower depths, compared to a more uniform distribution of roots down to the 50 cm depth in the subhumid soils.

Over the 50 cm profile, percent contribution of sugarcane-derived C to the total SOC stock varied from 32% at Riche Terre to 65% at Medine (Table 3). Cerri and Andreux (1990) found that sugarcane-derived C constituted 20% and 45% of the total SOC after 12 and 50 years respectively of sugarcane cultivation in a Brazilian Ferralsol. The data in Figure 2 suggest that accretion of sugarcane-derived C was dependent on the amounts of original C lost and tended to continue until the initial level of SOC is restored.

The effects of period of sugarcane cultivation on SOC changes were studied at Medine and Riche Terre. At Medine, SOC declined by 33% (33.5 t C/ha) relative to the uncultivated land after 25 years of sugarcane (Table 3). With a longer period of cultivation (>50 years), native SOC declined further to reach about 31% of the initial value. Sugarcane-derived C represented about 33% of the total C stock after 25 years and increased to 65% after >50 years of sugarcane cultivation so that loss of native C was nearly totally compensated.

Table 3—Amounts of native SOC and sugarcane-derived SOC (t C/ha) under soils cropped for different lengths of time at Medine and Riche Terre.

Cropping system	*Native C*			*Sugarcane-C*		
	0–15	15–50	0–50	0–15	15–50	0–50
Virgin soil	47.17a	54.22a	101.39a	–	–	–
25 years	20.78b	24.68b	45.46b	10.45a	12.02a	22.47a
50 years	12.20b	18.22b	30.42b	26.62b	30.75b	57.37b
Virgin soil	46.39a	52.32a	98.71a	–	–	–
25 years	31.47b	49.42ab	80.89b	8.52a	24.37a	32.89a
50 years	28.65b	43.88b	72.53b	12.87a	18.96a	31.83a

Within one site, values along the same column followed by the same letter were not significantly different at P= 0.05.

Similar results have been reported by Dominy *et al* (2002) who found that sugarcane-derived C in a Cambisol in South Africa increased over time until it accounted for 61% of total SOC in the surface soil after 50 years of sugarcane cultivation. However, in their study, the newly added C did not compensate the loss of original C. At Riche Terre, on the other hand, original SOC declined at a much slower rate so that, at 25 years, 82% of the existing SOC still had the original C signature, and this value decreased only slightly to 74% after more than 50 years of cane cultivation.

The difference in loss of original C between the two sites could be attributed to the lower initial clay content at Medine (63% compared to 75% at Riche Terre), which declined further with increasing period of cane cultivation. The importance of clay-organic matter associations as a mechanism for organic matter protection has been reported by a number of authors (e.g. Hassink, 1997; Feller and Beare 1997; Dieckow *et al.*, 2009). Carbon inputs from sugarcane represented 29% of existing SOC after 25 years and adequately replaced the loss of native C at the Medine site.

While these results demonstrate that long-term sugarcane cultivation under the conditions in Mauritius does not have any detrimental effect on overall SOC stock, they also emphasise the importance of sugarcane crop residues in the rehabilitation of SOC under intensive sugarcane copping. Although several studies have shown the beneficial effects of sugarcane trash retention on SOC (Graham *et al*, 2002; Robertson and Thorburn, 2007), few studies have quantified the actual contribution of sugarcane-derived C to the total SOC stock.

Effect of mechanised sugarcane cropping on soil carbon stocks

It was expected that the physical impact caused by intensive derocking and aggressive tillage in preparation for mechanisation would lead to a decline in SOC, as this will favour microbial activity through enhanced aeration and the exposure of formerly aggregate-protected SOC fractions (Wright and Hons, 2005; Zotarelli *et al.*, 2007). However, mechanised cropping generally had no significant effect on topsoil or subsoil SOC stocks except at Beau Champ where total SOC declined by 37 t C/ha compared to the conventional practice (Figure 1).

The change from conventional to mechanised practice at this site was also accompanied by a decrease in the clay content from 66 to 42%. The lower SOC stock in the mechanised cropping system was presumably due to the lower clay content rather than mechanisation *per se*. Moreover, measurements of ^{13}C natural abundance showed that land preparation activities generally did not influence the loss of native C relative to the conventional practice except at Riche Terre and Beau Champ where land under mechanised cropping lost 24 and 16 t C/ha more C than under conventional practice (Figure 2 and Table 3). Likewise, mechanised cropping generally did not impact negatively on replacement of lost carbon by sugarcane-derived C except at Beau Champ where about 20 t C/ha less sugarcane-C was incorporated relative to the conventional practice.

Conclusion

Using the ^{13}C natural abundance technique, this study has demonstrated that long-term sugarcane cropping under the humid tropical climate of Mauritius resulted in significant decline in native SOC. However, losses of native SOC were adequately compensated by SOC input from sugarcane crop residues and root C turnover so that total SOC stocks in the profile generally remained unchanged.

The results further emphasise the importance of trash retention in restoring SOC under sugarcane farming systems in Mauritius. The adoption of mechanised cropping in recent years did not have any detrimental effect on soil organic carbon.

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EVOLUTION DES STOCKS DE CARBONE ORGANIQUE DU SOL SOUS CULTURE DE CANNE À SUCRE EN CLIMAT TROPICAL HUMIDE A L'ILE MAURICE: RÉSULTATS DE l'ABONDANCE NATURELLE de ^{13}C

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MOTS CLÉS : Carbone Organique Du Sol, Delta ^{13}C, Production Durable De Canne à Sucre.

Resume

LE DÉCLIN de la capacité productive des sols suite à une monoculture à long terme de canne à sucre, associé à une intensification du système de production, est devenu le problème principal de plusieurs pays producteurs de canne à sucre. Le maintien du carbone organique de sol (SOC) à des niveaux adéquats est crucial pour le fonctionnement biologique, chimique et physique des sols. Cette étude a été entreprise pour déterminer l'impact de la monoculture à long terme de canne à sucre sur les stocks de SOC, pour mesurer la perte de SOC naturel et l'augmentation de C provenant de la canne à sucre suite à l'adoption des nouvelles pratiques culturales, notamment l'épierrage, le nivellement et la récolte mécanique. Cinq sites représentatifs des cinq principaux groupes de sol cultivés en canne à sucre à l'île Maurice ont été étudiés et un dispositif classique de parcelles appariées a été adopté. Pour chaque site, deux emplacements ayant des conditions initiales semblables ont été traités de différentes manières dans le temps, avec un emplacement représentant le sol de référence (terre vierge avec principalement une végétation de type C3) et l'autre emplacement constitué des traitements suivants (i) champs cultivés sans interruption avec de la canne à sucre pendant plus de 25 ou 50 ans sans épierrage et nivellement, (ii) champs contenant de la canne à sucre cultivée sans interruption mais épierrés et nivelés pour permettre une récolte mécanique les 3 dernières années. Sur des échantillons de sol prélevés jusqu'à une profondeur de 50 centimètres ont été analysés le C organique total, l'abondance en ^{13}C, la densité apparente et la teneur en pierre ou refus. La culture à long terme de canne à sucre a diminué les stocks de SOC dans la couche 0–15 cm par rapport au sol vierge non cultivé, mais a augmenté C organique du sol sous-jacent, indiquant une redistribution de SOC dans les couches plus profondes du profil de sol. Sur tous les sites, les évolutions des stocks totaux de C dans le profil 0–50 centimètres, après 50 ans de culture de canne n'étaient pas significativement différentes ($P<0.05$) de celles relatives à la terre vierge. Les mesures de l'abondance C^{13} ont indiqué que la culture à long terme de canne à sucre a en fait eu comme conséquence un épuisement de SOC original de 34 à 70%. Cependant, cette perte a été entièrement compensée par les entrées de C issues des résidus de canne à sucre sur tous les sites étudiés, avec pour résultat aucun changement net des stocks de SOC. De plus, l'adoption de la culture mécanisée, qui nécessite l'épierrage et le nivellement, n'a eu aucun effet néfaste sur les stocks de SOC à cause des entrées de C provenant des résidus de récolte.

CAMBIOS EN LOS CONTENIDOS DE CARBÓNO ORGÁNICO DEL SUELO RESULTANTE DEL CULTIVO DE LA CAÑA DE AZÚCAR EN EL CLIMA TROPICAL HÚMEDO DE MAURITIUS: RESULTADOS DE ABUNDANCIA NATURAL DE ^{13}C

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PALABRAS CLAVE: Carbono Orgánico del Suelo, Delta ^{13}C, Producción Cañera Sostenible.

Resumen

LA DISMINUCIÓN en la capacidad productiva de los suelos como consecuencia del monocultivo de la caña de azúcar a largo plazo, combinada con una intensificación del sistema de producción, se ha convertido en un problema grave en varios países productores de caña de azúcar. El mantenimiento de niveles adecuados de carbono orgánico del suelo (COS) es crucial para el funcionamiento biológico, químico y físico de los suelos. Este estudio se realizó para determinar el impacto a largo plazo del monocultivo de caña de azúcar en los niveles COS y cuantificar las pérdidas de COS nativo y la acumulación de C derivado de la caña de azúcar a causa de la adopción de nuevas prácticas de manejo como la eliminación de piedras, la nivelación y la cosecha mecanizada. El estudio se realizó en cinco sitios que representan los cinco principales grupos de suelos cañeros de Mauricio mediante la utilización de un diseño de parcela pareada. En cada una de las experiencias se evaluaron dos sitios con similares características iniciales, que se desarrollaron en forma diferente, uno en representación el suelo de referencia (campo virgen con predominio de vegetación de tipo C3) y el otro que representa los siguientes tratamientos de cultivo: (i) campos continuamente cultivada con caña de azúcar por más de 25 o 50 años sin eliminación de piedras o nivelación de los terrenos, (ii) campos de caña de azúcar a largo plazo, pero que hayan sido sometidos a la eliminación de piedras o nivelación de los terrenos para la cosecha mecanizada en los últimos 3 años. Se tomaron muestras de suelo a una profundidad de 50 cm y se analizó C orgánico total, abundancia de ^{13}C, densidad aparente y el contenido de piedra. A largo plazo el cultivo de la caña de azúcar redujo las existencias de COS en la capa superficial de 0–15 cm en comparación con el suelo virgen sin cultivar, pero aumentó de C orgánico del subsuelo lo que indica una redistribución de la COS en las capas más profundas del perfil del suelo. Cambios en las existencias de C total en el perfil de 0-50 cm, después de 50 años de cultivo de caña no fueron significativas ($P < 0{,}05$) en comparación con la tierra virgen en todos los sitio. Los datos de mediciones de la abundancia ^{13}C revelaron que a largo plazo, el cultivo de caña de azúcar dio lugar a un agotamiento de COS original entre el 34 al 70%. Sin embargo, esta pérdida fue totalmente compensada por la entrada C de los residuos de la caña de azúcar en todos los sitios estudiados, sin cambio neto de las cantidades de COS en el suelo. Por otra parte, la adopción de la mecanización de cultivo, lo que implica la eliminación intensiva de piedras y nivelación de los terrenos, no tiene ningún efecto perjudicial sobre las cantidades de COS, debido al ingreso del C proveniente de residuos de la cosecha.