DISTRIBUTION OF OXIDIZABLE ORGANIC C FRACTIONS IN SOILS UNDER CACAO AGROFORESTRY SISTEMS IN SOUTHERN BAHIA, BRAZIL

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INTRODUCTION

The importance of organic carbon to the physical, chemical, and biological aspects of soil quality is well recognized. Accumulating evidence suggests that certain fractions of soil organic matter are more important in maintaining soil quality and are, therefore, more sensitive indicators of the impact of management practices. Most conventional methods used in soil organic carbon determination have been developed to maximize oxidation and recovery of C. However, total organic carbon measurements might not be sensitive indicators of changes in soil quality. Adoption of procedures that can extract the more labile fraction preferentially might be a more useful approach for the characterization of soil organic carbon resulting from different management practices.

Agroforestry systems (AFS) are recognized as a strategy for soil carbon sequestration and are quite important in mitigation of atmospheric CO_2. Specifically, traditional cacao AFS with diverse and structurally complex shade canopies are expected to have great soil C sequestration potential based on the premise that tree components can be significant “atmospheric carbon sinks” due to large long-term biomass stock and extensive root systems, large amounts of plant litter and also because are no tillage systems. Attempts have been made to identify soil organic matter fractions that have different susceptibility to microbial decomposition and represent the basis of understanding soil C dynamics.

OBJECTIVE

Evaluate distribution of C in different soil organic fractions according to clay content in soil profile under cacao agroforestry systems.

MATERIALS E METHODS

Study area: The study was conducted on the Center of Cocoa Science - MARS, Itajuípe, in the southern region of Bahia, Brazil (14º 0’ S and 39º 2’ W); the region has a humid tropical climate with a well-distributed rainfall of 1500 mm per year. Soil samples were collected from two soil orders: Oxisol and Inceptsol with clay and loam texture, respectively.

Cacao Agroforestry Systems: Thirty five-year-old and twenty five-year-old stand of cacao with Erythrina (Erythrina glauca) as shade trees: Erythrina and cacao were planted in alternating rows, with 3 m between rows of cacao and 3 m between cacao plants within a row; 1111 cacao plants per ha.

Fig 1. Cacao agroflorestry system with eritrina

Soil Sampling and Analysis: Soil samples collected from four depth classes (0 – 5, 5 – 10, 10 – 30, and 30 – 50 cm); soil bulk density for each depth interval measured by the core method. Three sets of composite samples were prepared for each soil depth under each cacao AFS

Modified Walkley-Black Method (Chan et al. 2001): The determination of oxidizable carbon was done using 5 and 10 mL of concentrated sulphuric acid instead of the 20 mL specified by Walkley and Black (1934). The resulting three acid-aqueous solution ratios of 0.5:1, 1:1, and 2:1 (which corresponded respectively to 12 N, 18 N, and 24 N of H_2SO_4) allowed comparison of oxidizable organic carbon extracted under increasing oxidizing conditions (Walkley, 1947). The amount of oxidizible organic carbon determined using 5, 10, and 20 mL of concentrated sulphuric acid when compared with total carbon concentration allowed separation of total organic carbon into four fractions of decreasing oxidizability:

Fraction 1 (12N H_2SO_4) – organic carbon oxidizible under 12N H_2SO_4;
Fraction 2 (18N – 12N H_2SO_4) – the difference in oxidizible organic carbon extracted between 18N and 12N H_2SO_4;
Fraction 3 (24N –18N H_2SO_4) – the difference in oxidizible organic carbon extracted between 24N and 18N H_2SO_4. The 24N H_2SO_4 is equivalent to the standard Walkley-Black method; and
Fraction 4 (TOC – 24N H_2SO_4) – residual organic carbon after reaction with 24N H_2SO_4 when compared with the total carbon determined by the Leco combustion method.

RESULTS

Table 1. Stocks of C and total N in different depths of two soils under cacao AFS

Depth	Oxisol	Inceptsol
cm	**TOC**[(1)] (Mg ha^{-1} cm^{-1})	
0-5	3,76 a[(2)]	2,93 b
5-15	2,23 a	1,57 b
15-30	1,68 a	0,94 a
30-50	1,35 a	0,81 a
	N total (Mg ha^{-1} cm^{-1})	
0-5	0,35 a	0,34 a
5-15	0,22 a	0,21 a
15-30	0,17 a	0,15 a
30-50	0,13 a	0,13 a

(1) TOC- Total Organic Carbon;
(2) Values within a row followed by the same letter (s) are not significantly different according to the Tukey test (P = 0.05).

Table 2. Stocks of Fractions of the organic carbon in different depths of two soils under cacao AFS

Depth cm	**Fractions**	**TOC** Mg ha^{-1} cm^{-1}	
		Oxisol	Inceptsol
0-5	F_1	1,99 a	1,63 b
	F_2	0,61 a	0,31 b
	F_3	0,22 a	0,26 a
	F_4	0,93 a	0,72 b
5-15	F_1	1,23 a	0,97 b
	F_2	0,44 a	0,23 b
	F_3	0,29 a	0,20 a
	F_4	0,27 a	0,18 a
15-30	F_1	0,92 a	0,53 b
	F_2	0,28 a	0,14 a
	F_3	0,19 a	0,23 a
	F_4	0,29 a	0,03 b
30-50	F_1	0,72 a	0,48 b
	F_2	0,20 a	0,11 a
	F_3	0,18 a	0,25 a
	F_4	0,27 a	0,03 b

•Values within a row followed by the same letter (s) are not significantly different according to the Tukey test (P = 0.05).

DISCUSSION

The stock of C was higher in Oxisol than Inceptsol.
Significantly a higher stock of C was found in the surface soil (0-15 cm).
The majority of the differences between Oxisol and Inceptsol were found in the two most easily oxidizible fractions (Fraction 1 and Fraction 2). These two fractions together extracted more than half of the total organic carbon content (72%).
The total organic carbon was significantly correlated with clay content ($r = 0,96$; $p < 0,05$);
The oxidizible organic carbon fractions were significantly correlated to clay content (F_1: $r = 0,92$, F_2: $r = 0,91$, F_4: $r = 0,73$; $p<0,05$)

CONCLUSIONS

1. Oxisol, with high amount of clay, showed highest stock of C and N and amount of carbon in Fraction 1 and Fraction 2, mainly in soil surface (0-15 cm).
2. Fraction 1 and Fraction 2 were more sensitive indicator of changes in the quality of organic C;
3. Most of the organic carbon in soils under cacao AFS were of the more labile forms.

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