SOIL CARBON AND NUTRIENT CONTENTS UNDER CACAO AGROFORESTRY SYSTEMS IN BAHIA, BRAZIL

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INTRODUCTION

In Brazil, cacao (*Theobroma cacao*) agroforestry systems (AFS) are established mostly in highly weathered soils with acidic pH and low fertility. The high amount of plant litter that is deposited (estimated to be ca 10 Mg ha-1 yr-1) is believed to have an important role in maintaining nutrient cycling and microbial activity to support sustainable cacao production in these AFS. Information on the extent of nutrient store and mineralization rates in the soils and their microbial biomass is important but scanty.

Microbial populations are primarily responsible for the decomposition of organic residues, the nutrients cycle and the flow of energy inside of soil. The present study was undertaken to link soil microbiological and soil biochemical parameters with soil and litter quality conditions in the surface layer from five sites differing in plant cover, in stand age, and in land use history.

The soil microbial biomass is a labile fraction of soil organic matter and plays a crucial role in the maintenance of soil fertility and availability of plant nutrients. The microbial biomass is a sensitive indicator of organic matter dynamics because the microbial fraction changes comparatively rapidly, and differences are detectable before they occur in total organic matter.

OBJECTIVES

To determine the soil carbon (C), nitrogen (N), and phosphorus (P) contents; soil microbial biomass C, N, and P contents; extent of soil C and N mineralization; and total and labile (fast mineralization) soil organic P in different cacao AFS in southern Bahia, Brazil.

MATERIALS AND METHODS

Study Area:

The study was conducted on the Center of Cocoa Science, Itajuípe, located in the southern region of Bahia, Brazil (14o 0' S and 39o 2' W). The research farm is situated in a humid tropical climate with a well-distributed rainfall of 1500 mm per year.

Soil samples were collected under six land-use systems in two soil orders, in Bahia, Brazil. The land-use systems were:

(1) Natural forest next to the agroforestry systems to serve as reference, in Oxisol.

(2) 30-year-old stands of cacao with Erythrina (*Erythrina glauca*) as shade trees, in Oxisol.

(3) 30-year-old stands of cacao under natural forest (*Cabruca*), in Oxisol.

(4) 70-year-old stands of cacao under natural forest (*Cabruca*), in Oxisol.

(5) 30-year-old stands of cacao with Erythrina (*Erythrina glauca*), in Inceptsol.

(6) 15-year-old stands of cacao germoplasm collection area, in Inceptsol

Soil Sampling:

Soil samples collected from four depth classes (0 – 5, 5 – 15, 15 – 30, and 30 – 50 cm) were analyzed for C, N, total and labile organic P. Microbial activity and microbial biomass C and N were measured using samples from 0 – 10 cm depth and microbial biomass P using samples from 0 – 5 cm depth. Three sets of composite soils per depth class of each land-use, each prepared from four sampling spots, were used.

Elemental Analysis:

The following procedures were used for the various analyses: Soil organic C and total N: Anderson and Ingram (1996); total P and total organic P: Bowman, (1989); labile P: Bowman and Cole (1978); microbial biomass C: Tate et al. (1988); microbial biomass N: Jorgensen and Brookes (1990); microbial biomass P: Brooks et al. (1984); microbial activity: Jenkinson and Powlson (1976); and N mineralization: Stanford and Smith (1972).

RESULTS

Table 1. Organic C, total N and P, total organic P (Po) and labile organic P in soils (0 - 50 cm) under cacao agroforestry systems in Bahia, Brazil

Cover	Org C	Total N	Total P	Total Po	Labile Po
	kg ha^{-1}				
Forest	113,077	9,667	781	135 (17)[1/]	53 (39)[2/]
Cacao-*Erythrina*	92,651	8,088	1,243	187 (15)	47 (25)
Cacao - Cabruca	99,403	9,619	869	68 (8)	39 (57)
Cacao - Cabruca	91,147	8,808	1,489	540 (36)	33 (6)
Cacao - *Erythrina*	72,475	8,268	5,225	1,446 (28)	51 (4)
Cacao germoplasm	74,450	9,083	4,130	1,271 (31)	62 (5)
Cacao AFS' average	86,025	8,773	2,591	702 (27)	46 (7)

[1/] % total P. [2/] % total organic P.

Table 2. Microbial biomass C (MBC), N (MBN) and P(MBP), microbial activity (MA) and N mineralized (Nm) in soils under cacao agroforestry systems in Bahia, Brazil

Cover	MBC	MBN	MA	Nm	MBP	Seed-N[1/]	Seed-P
	kg ha^{-1}						
Forest	262	155	99	87	2	-	-
Cacao-*Erythrina*	174	142	49	65	3	25	5
Cacao - Cabruca	357	134	37	72	4	23	5
Cacao - Cabruca	298	212	22	81	4	24	5
Cacao - *Erythrina*	229	151	61	63	6	25	6
Cacao germoplasm	218	117	52	60	9	23	5
Cacao AFS' average	255	151	44	68	5	24	5

[1/] N and P content in cacao seed.

Table 3. Pearson correlation coefficients between the P fractions and some chemical and physical soil properties

Parameters	TOP	LOP	MBP	TP	P	TOC	pH	Clay
TOP	1,00	0,44	**0,84****	**0,84***	**0,63***	**- 0,92***	**0,85***	**- 0,92***
LOP		1,00	-	**0,56***	**0,65***	- 0,44	0,08	- 0,33
MBP			1,00	-	**0,91****	**- 0,67****	-	**- 0,87****
TP				1,00	**0,92***	**- 0,70***	**0,85***	**- 0,93***
P					1,00	- 0,42	**0,63***	**- 0,74***
TOC						1,00	**- 0,73***	**0,82***
pH							1,00	**- 0,96***
Clay								1,00

* significant at 5% level ** significant at 1% level

TOP = total organic P; LOP = labile organic P; MBP = microbial biomass P; TP = total P; P = P extracted by Mehlich - 1; TOC = total organic C; pH = pH water.

SUMMARY AND CONCLUSIONS

(1)Cacao agroforestry systems store relatively high amounts of C in the soil and consequently have a potential to increase the soil quality and reduce the atmospheric CO_2 emission.

(2) Furthermore, the high amounts of soil microbial biomass, N mineralized, and organic P could be relevant for cacao nutrition considering the low amount of N and P exported through cacao seed harvest

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Acknowledgments: This work was developed in collaboration with USDA-ARS-Sustainable Perennial Crops Lab and MARS-Center of Cocoa Science and financially supported by CNPq to the first author.

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