Microbial Biomass in Upland Soils of the Central Amazon under Different Plant Covers

Adônis Moreira[1]* and Nand Kumar Fageria[2]

1. CPPSE-EMBRAPA, Caixa Postal 339, 13560-970, São Carlos, SP, Brazil.
2. CNPAF-EMBRAPA, Caixa Postal 179, 75375-000, Santo Antônio de Goiás, GO, Brazil.
* Corresponding author: fageria@ cnpaf. embrapa. br

ABSTRACT

The objective of this study was to evaluate the microbial activity of carbon, nitrogen and phosphorus resulting from the replacement of the primary forest with *Brachiaria brizantha*, *Hevea*, cupuaçu, citrus and secondary forest. There was no increase in soil fertility under secondary forest, but in the pasture had an increase in the stock of C and N and high C/N ratios, the inverse occurred with C-microbial biomass. The primary forest had the highest values of C, N and P of the microbial biomass and the lowest metabolic quotient. The *Hevea* was the plant cover with the smallest changes of C in the soil.

INTRODUCTION

The Amazon region in South America has largest tropical forest. In the Central Amazon, the natural vegetation is typically rainforest. The land use consists mainly of deforestation by logging the commercially valuable timber, felling and (in the case of mechanized agriculture) windowing the remaining material and then burning for subsequent planting of annual and perennial crops, and particularly for formation of pastures. Most soils of the Amazon region are characterized as acidic and infertile (Moreira and Malavolta, 2002). When the Amazon forest land is cleared for agricultural use by burning the vegetation, the efficient nutrient recycling mechanism is disrupted. However, nutrient contents in the deforested burn land increased temporarily. The objective of this study was to evaluate the microbial activity of carbon (C), nitrogen (N) and phosphorus (P) resulting from the replacement of the primary forest with pasture, commercial plantations of rubber (*Hevea* spp.), cupuaçu, citrus trees (*Citrus sinensis*) in a Xanthic Ferralsol and secondary forest in an Acrisols Dystric Nitosols.

MATERIALS AND METHODS

The studies were conducted in a Xanthic Ferralsol localized in the geographic coordinates 3°8′ 25″ SL and 59°52′ WL, in the municipality of Manaus, Amazon State, Brazil, and the Acrisols Dystric Nitosols is located at 4°53′ SL and 65°11′ WL, in the municipality of Coari, Amazonas State. The natural vegetation is a tropical rainforest. The predominant climate in both areas is humid tropical, classified as Afi by the Köppen system, with relatively abundant rainfall throughout the year with average of 2250 mm (Vieira and Santos, 1987). The rainfall during the dry months (July to September) is always above 60 mm, and during the wet months March to June (Table 1). The average temperature is approximately 26℃ during the same period. These soils are predominantly dystrophic, with exchangeable Ca and Mg lower than 1.5 $cmol_c \cdot kg^{-1}$. In most of these soils, Al saturation is higher than 50% and the base saturation is lower than 50%. The C, N and P microbial biomass were determined and to estimate the C, N and P, we used K_{EC}, K_{EN} and K_{EP} correction factors of 0.45, 0.54 and 0.40, respectively. Due to similarity of soil fertility in the areas, the six plant covers were compared in a separate analyses for a completely randomized complete design with ten replicates. We submitted the data to variance analysis (ANOVA), the F-test at $p \leq 0.05$ and comparison of the means by the Tukey test at 5% probability (Pimentel Gomes and García, 2002). For the statistical analyses, we defined each point sampled as a replicate and considered each sample as the mean of the duplications.

RESULTS AND DISCUSSION

The results showed that the conversion of primary forest into the other types of plant cover studied here left the soil fertility little changed, with high acidity and exchangeable aluminum and low levels of available P and K and exchangeable Ca and Mg (Table 2). The management of the cultivated areas under secondary forest, but in the pasture there was a significant increase in the stock of organic C and total N and high C/N ratios, the inverse of what occurred with the carbon of the microbial biomass (Table 3). The primary forest had the highest values of C, N and P of the microbial biomass and the lowest metabolic quotient (Table 4). The lower release of CO_2 in the secondary forest ecosystem indicates less biological activity, except in soils with high SOM levels, which did not occur in this condition (Table 3), its being directly related with the C of the organic matter. Of the successions studied, the rubber trees were the plant cover with the smallest changes in terms of quality of the organic matter in the soil.

Table 1 The bimonthly minimum and maximum temperature and rainfall data of municipality of Manaus and C Amazonas State, Brazil (2003)

Months	Manaus			Cos		
	Temperature (℃)		Rainfall	Temperature (℃)		Rainfall
	Minimum	Maximum	(mm)	Minimum	Maximum	(mm)
Jan/Feb	17.8	35.1	239.4	17.7	36.2	281.2
Mar/April	14.2	34.1	323.0	14.0	35.5	410.2
May/June	10.1	34.1	321.2	9.9	35.2	469.2
July/August	13.8	35.1	77.8	14.0	36.0	124.2
Sep/Oct	17.0	36.5	129.4	16.0	36.5	248.0
Nov/Dec	18.8	35.9	122.8	19.0	35.4	197.2

Table 2 Soil fertility data from the study area on a Xanthic Ferralsol (a) and an Acrisols Dystric Nitosols different plant covers in western Amazonia[1,2]

Plant Covers	pH in water	K	Ca	Mg	Al	H + Al
		(mg · kg^{-1})		(cmol$_c$ · kg^{-1})		
Primary forest (a)	4.28	2.59	20.70	0.17	0.17	1.41	7.18
Secondary forest (b)	4.34	1.53	34.89	0.07	0.04	4.25	10.06
Rubber trees (a)	3.79	3.09	26.75	0.15	0.10	1.24	7.75
Cupuacu (a)	4.40	4.51	41.39	0.47	0.32	1.13	7.28
Citrus (a)	4.03	1.52	54.17	0.08	0.07	0.86	7.20
Pasture (a)	4.23	2.04	17.63	0.20	0.12	1.09	7.00

1. 0 – 10 cm soil depth, n = 20 samples.
2. Available P and K—Mehlich 1 extractant; exchangeable Ca, Mg and Al – KCl 1.0 mol · L^{-1} extractant, exchangeable H Al-calcium acetate 0.01 mol · L^{-1}.

Table 3 Carbon (CMB), nitrogen (NMB) and phosphorus (PMB) of the microbial biomass in soil under different pl covers in western Amazonia[1,2]

Plant covers	CMB[3]		NMB	PMB		C/N
	MR	IRGA				
	(kg · ha^{-1})				(Mg · ha^{-1})	
Primary forest	652.84 a	265.25 a	98.58 a	5.46 a	24.81 b	1.87 bc
Secondary forest	222.18 d	94.90 d	43.84 c	2.18 c	15.87 b	1.51 c
Rubber trees	401.60 c	169.08 bc	102.06 a	4.54 b	23.52 b	2.26 b
Cupuaçu	495.83 bc	148.68 bc	77.34 b	2.01 c	24.29 b	1.66 c
Citrus	508.40 b	126.42 d	58.70 c	2.32 c	19.68 b	1.83 bc
Pasture	169.91 d	183.20 b	71.24 b	3.66 b	42.56 a	3.09 a

1. 0 – 10 cm soil depth, n = 10 samples.
2. Values followed by similar letters in the same column are not significantly different at $p \leq 0.05$ by Tukey test.
3. Methods of Microwave Radiation (MR) and indirectly measuring the increase in the rate of respiration caused by adding gluc the soil, employing an infrared gas analyzer (IRGA).

Table 4 Basal respiration flow of CO_2 metabolic quotient (qCO_2) and Cmic/Corg ratio under different plant cove western Amazonia[1,2]

Plant Covers	Basal Respiration	Flow of CO_2	Metabolic Quotient	Cmic/Corg
	(μg g^{-1} dia^{-1} de C-CO_2)	(mL · min^{-1})	(μg CO_2/μgCmin h^{-1}) × 10^{-4}	(%)
Primary forest	1.39 b	494.99 a	2.18 e	2.63 a
Secondary forest	1.19 b	415.77 ab	5.22 cd	1.40 b
Rubber trees	1.60 b	432.76 ab	3.94 d	1.70 b
Cupuaçu	3.23 a	420.44 ab	9.05 a	2.04 ab
Citrus	1.57 b	374.38 b	5.17 cd	2.58 a
Pasture	3.16 a	385.327 b	7.19 b	0.40 c

1. 0 – 10 cm soil depth, n = 10 samples.
2. Values followed by similar letters in the same column are not significantly different at $p \leq 0.05$ by Tukey test.

REFERENCES

Moreira A, Malavolta E. 2002. Variação das propriedades químicas e físicas do solo e na matéria organica em agroecossistemas da Amazônia Ocidental (Amazonas). Piracicaba: CENA/USP.

Pimentel Gomes F, Garcia CH. 2002. Applied statistic elementary agronomy and forestry. Piracicaba: FEALQ

Vieira LS, Santos PCTC. 1987. Amazon, its soils and ot natural resources. São Paulo: Agronômica Ceres.