Dynamic of organic matter in the conversion of primary forest in rubber tree stand in the central amazon region

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Abstract

The removal of primary forest causes a significant reduction of the microbial biomass of C and soil fertility. With the introduction of stands of rubber trees, there can be a continuous recovery of the amount of organic matter and of carbon sequestration. The aim of this work was to study the dynamic of the organic matter and microbial biomass of C after reforestation with rubber trees. The trees were planted in 1999, 1988, 1986, 1985, 1984 and 1960. The results show that with the clearing of the primary forest and introduction of other vegetation, the content and quality of the organic matter was seriously affected, and even where rubber trees were planted in 1960, the regrowth has not been sufficient to replace the amounts found in the original system.

Introduction

The Amazon Basin covers approximately 4.5 million km^2 of Brazilian territory. Roughly 75% of the region's soils have low fertility, which poses a problem for any type of cultivation. Normally the land use consists of deforestation, with the removal of salable timber. Then the remaining plant cover is burned off to "prepare" and "fertilize" the soil for agricultural uses. These can include planting annual or perennial crops or formation of pastures for livestock (Andreux & Cerri, 1989). Various studies have reported an increase in soil pH and the content of exchangeable cations, along with a reduction in exchangeable acidity because of clearing and burning of natural forest.

Deforestation also significantly affects the C and N content of soil. The removal of the forest to introduce a crop upsets the balance of organic matter. Regarding ecological sustainability, stands of rubber trees planted 20 years ago in the Ivory Coast enabled the ratio between fulvic acid (relatively unstable) and humic acid (stable) to return to levels similar to those in the native forest, with reconstitution of the capacity to exchange cations, while at this same age the organic matter content of the area planted with rubber trees was 70% of that found in the forest (Bi & Omont, 1987). This represents high carbon sequestration, suitable for the requirements of the Clean Development Mechanism (CDM) established under the Kyoto Protocol. Measurements of microbial mass have been used in studies of the flow of C and N, cycling of nutrients and productivity of plants in different land ecosystems. These measurements allow quantifying the live microbial biomass in the soil at a determined time. Since the microbial biomass constitutes the greatest part of the active fraction of organic matter, it is more sensitive than organic C and total N as a means to assess changes in the levels of organic matter in the soil caused by land management and cultivation practices.

The objective of this work was to diagnose the effects of changed land use with conversion of forest into rubber tree stands, through chemical (organic carbon) and microbiological (C-microbial biomass, basal respiration, flow of CO_2) analyses of the soil.

Material and Methods

The areas studied are characterized by dystrophic Yellow Latosol (Brazilian classification) - Xanthic Ferralsol, with clayed texture and kaolinitic mineralogy and are located at the geographic coordinates 3°8'25" LS and 59°52' LW, in the county of Manaus, Amazonas State, Brazil. The climate is low land humid tropical, of the Afi type in the Köppen classification, with abundant year-round rainfall (average of 2600 mm year^{-1}). Even in the driest month, rainfall is always above 60 mm (July to September). The average temperature is approximately 26°C. A chronosequence was studied formed of a primary forest next to six stands of rubber trees (*Hevea* spp.), planted in 1999 (crown of hybrids of *Hevea brasilienses* x *Hevea pauciflora*), 1988 (crown of *Hevea pauciflora*), 1986 (crown of *Hevea pauciflora*), 1985 (crown of *Hevea brasiliensis*), 1984 (crown of *Hevea pauciflora*) and 1960 (crown of *Hevea brasiliensis*).

In each of these areas, five samples were removed, the first in the center of the area and the others 25 meters away in the four cardinal directions. The readings were made at a depth of 0-10 cm. The organic C was analyzed by the dry combustion method (CHN auto-analyzer), and the microbial biomass of carbon was determined indirectly. The induced respiration was transformed into microbial biomass through the formula: biomass in μg C g^{-1} solo = (respiration in □L CO_2 min^{-1} g^{-1} x 40.04) + 0.37 (Anderson & Domsch, 1978). The flow of CO_2 (mL min^{-1}) was determined in the induced samples with 0.24 grams of glucose + 0.50 grams of inert talcum. The basal respiration (□g g^{-1} dia^{-1} of C-CO_2 in soil) was determined in the same samples before induction, reflecting the microbial activity.

Results and Discussion

The forest removal caused an average reduction of 46% in the stock of organic matter in the soil. This figure reached 66% when compared with the area where the trees were planted in 1999. The reduction in the microbial biomass of carbon (BM-C) was 32%, regardless of the age of the rubber trees. The basal respiration varied widely in relation to the plant cover and age of the rubber trees, but this did not occur with the flow of CO_2 (Table 1), indicating less metabolic activity, and was directly related to the content of the organic matter in the soil. These results show that regardless of the culture introduced after deforestation, the cycling process and activity of the organic matter components are severely affected.

Table 1. Organic carbon, microbial biomass of C, basal respiration and flow de CO_2 in a Xanthic Ferralsol (dystrophic Yellow Latosol) under a primary forest and rubber tree with ages different, 0-10 cm of depth.

Vegetable cover	Organic carbon g kg^{-1}	C-microbial biomass □g g^{-1} C in soil	Basal respiration □L h^{-1} g^{-1}	Flow of CO_2 mL min^{-1}
Primary forest	41.3±4.1	265.3±35.0	1.4±0.3	420.4±70.4
Rubber tree				
1960	19.5±2.6	189.8±33.8	1.3±0.4	478.5±30.8
1984	20.7±2.9	178.2±78.4	0.7±0.2	434.0±49.0
1985	23.5±2.2	169.1±16.8	1.5±0.4	431.5±17.6
1986	26.8±2.3	179.1±14.3	1.9±0.3	440.7±35.0
1988	29.5±1.5	215.9±19.9	1.6±0.5	454.3±17.9
1999	13.9±1.9	136.8±16.0	2.0±0.1	416.1±47.5
CV%	10.65	21.34	19.48	12.56

These results corroborate the findings of Moreira & Costa (2004), in studies of the organic matter dynamic in recuperation of cleared areas of the Amazon Forest. That study also found that even 10 years after reforestation, there was an average reduction of 68% in the stock of carbon in the soil when compared with primary forest.

Conclusions

The results obtained by biological and biochemical indicators to assess the effect of removing primary forest and replacing it with crops or pasturage demonstrate that the impact on the content and quality of the organic matter was seriously affected, and even stands of rubber trees planted in 1960 (± 47 years ago) were not able to restore the original situation.

References

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