EFFECT OF THE SOIL PHYSICAL PROPERTIES ON PASTURE DEGRADATION IN THE AMAZON REGION (BRAZIL)

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INTRODUCTION

Key words In the Brazilian Amazon region, half of the 50 million hectares where the forest has been replaced by pastures, are degraded. The forage resource has practically disappeared. Phytossanitary problems and low soil fertility have been used to explain this degradation. Today, the agronomist accuse the bad management practices performed by the farmers, specially the incorrect control of weeds that compete with the pastures and the insufficient herd load. Can we, on the other hand, not consider the soil, and say that its properties, specially the physical ones, have not evolved after deforestation, limiting the suitability to satisfy the water and nutrient necessities for the cultivated plants? We have tried to answer this question studying a clayey Oxisol in the Manaus region.

MATERIAL AND METHODS

The clayey Oxisols of central Amazon ("Latossolos Amarelos álicos argilosos", according to the Brazilian classification, "Ferralsols" according to the World Reference Base for Soil Resources), are kaolinitic (>80%), occupy plateaus with low declivities and an area of more than 10% of the Amazon region. The physical properties of various soils under pastures were compared to soils under forest. Soil structure and its dynamics were observed and measured taking into account the history of the plot and climatic and biological factors. To complement the cultural profile morphological descriptions and the classical soil physical measurements (densities and water content), the pore size distribution was analyzed using a mercury porosimeter (Lawrence, 1977). The consequences of the changes in soil structure on the hydrodynamic properties and the soil water dynamics, were also evaluated. Water retention curves were done in the laboratory using undeformed soil samples. Hydraulic conductivity was measured in the field using a tension infiltrometer (Ankeny *et al.*, 1991). The soil water potentials were measured continuously during rainstorms using tensiometers.

RESULTS AND DISCUSSION

Under forest, the structure of the Oxisol, poliedric and microaggregate, is favorable to infiltration and to water storage. The clayey microaggregates have a biological origin and are fragile due to the lack of metallic oxyhidroxides in their structure, when compared to the red Oxisols developed on basalt or sedimentary rocks in southern Brazil. The structure becomes lamellar or massive due to the coalescence and deformation of the microaggregates, induced by the pressures exerted by livestock and by the machines used for deforestation. The volume and continuity of the macropores (fissures, vughs and packing voids) are strongly reduced by compaction (Table 1, Grimaldi et al., 1993). The decrease in the macroporal volume in the degraded pastures frequently reaches 80% in relation to the forest soil. The available water for the cultivated plants is also reduced due to the decrease in hydraulic conductivity and the available water retention capacity (Table 2). On the other hand, the elementary clayey particle organization is not modified. The water retained by the micropores, preserved by this unmodified particle organization, is not available because the necessary suction for its extraction is higher than the suction at wilting point (Chauvel *et al.*, 1991).

Summing up to the mechanical and hydric strains suffered by the soils after deforestation, the compacting action of certain species of soil invertebrates drastically increase the soil density in the pastures, while the biodiversity diminishes. An extreme case was observed in a pasture where a species of earthworm dominates, *Pontoscolex corethrurus*. This specie ejects very wet castings on the soil surface, these form a continuous layer, with width of a few cm, in which the poral space is practically uniquely formed by very fine pores between the kaolinite particles (Table 1, Chauvel *et al.*, 1999). This layer favors the apparition of anoxic conditions and develops, after a few years, a pseudo-gley morphology: gray colors and indurated ochre stains on the border of the aggregates, whereas, under the forest, the soil is reddish yellow, homogeneous and plastic. In the pastures, the tensiometric measurements, during rainstorms, showed the formation of a more or less superficial water table, whereas, under forest, the saturation is rarely reached during the rainy season, thanks to the microaggregate structure that favors the vertical drainage of the water.

CONCLUSION

The introduction of the pastures cause an important and rapid change in the superficial structure of the clayey Oxisols, mainly due to physical and/or biological mechanisms. This change affects the vegetation, at least locally and temporally. Finally, when no significant change in the soil structural state is evidenced, only the study of the soil functioning on the field together with the state and productivity of the vegetation permits to confirm the soil's aptitude to satisfy the plant's needs.

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Table 1: Macropores and micropores volumes deduced of mercury porosimetry measurements (means of 2 to 4 replicates.

Origin of the samples	Depth (cm)	Macropores (100µm to 0.1µm) volume ($cm^3.100g^{-1}$)	Micropores (0.1µm to 3.75nm) volume ($cm^3.100g^{-1}$)
Primary forest	0 -2	21.3	21.6
	2 -5	12.0	23.7
	5 -10	7.8	24.1
	10 -20	8.5	25.2
Three years old pasture (manual deforestation)	0 -2	24.1	20.7
	2 -5	18.3	21.5
	5 -10	4.1	25.0
	10 -20	6.8	25.6
Pasture disused since 5 years	0 -5	2.5	19.6
	5 -10	4.2	20.4
	10 -20	5.5	21.2
15 years old pasture	0 -5	9.4	24.9
	5 -10	8.2	26.2
	10 - 15	8.0	26.0
Casts of *Pontoscolex corethrurus*	-	1.6	20.3
Mechanical compression (10^3 kPa)	-	2.7	23.4
Recent mechanical deforestation	0 - 5	2.6	25.2

Table 2: Water retention properties of soil samples (means of 5 to 10 replicates ± 95 % confidence interval)

Origin of the samples	Depth (cm)	Water storage at -1 kPa matric potential (cm^3/100g) **(1)**	Water storage at -1600 kpa matric potential (cm^3/100g) **(2)**	Maximum available water volume (cm^3/100g) **(1) - (2)**
Primary forest	5 -10	46.0 (± 4.9)	33.8 (± 0.7)	12.2
	10 -20	41.0 (± 1.4)	33.4 (± 0.4)	7.6
Pasture disused since 5 years	0 -5	28.2 (± 0.5)	23.6 (± 0.5)	4.6
	5 -10	34.1 (± 0.3)	25.3 (± 0.4)	8.8
	10 -20	34.3 (± 0.9)	27.7 (± 0.2)	6.6
15 years old pasture	5 -10	39.9 (± 4.6)	30.5 (± 0.9)	9.4
Mechanical compression (1 MPa)	-	39.6 (± 0.6)	33.4 (± 0.5)	6.2