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RESEARCH ARTICLE

DYNAMICS OF CHEMICAL ATTRIBUTES OF SOIL IN DIFFERENT LAND USE SYSTEMS IN THE MUNICIPALITY OF SANTA BARBARA DO PARA, BRAZIL

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ABSTRACT

Concern about the quality of the soil and quantification of changes in its attributes is of great importance for the monitoring of soil productivity in order to improve the management of the sustainability of agricultural systems. Soil quality is the capacity in this act positively in the regulation of energy flow in a particular ecosystem, whether natural or agricultural. Thus, the study aimed to assess the dynamics of soil chemical properties in four different land use systems in two sampling periods, dry and rainy in the municipality of Santa Bárbara do Pará, Brazil. The study was conducted in the municipality of Santa Barbara-PA in four land use systems: agroforestry system (SAF), cassava crop cultivation (Manihot esculenta Crantz) and witness the natural forest vegetation in a completely randomized design in a factorial 4 x 2 (four systems and two periods collect). The soil quality was obtained by determining soil chemical properties. The use of SAF system showed higher Ca, Mg, P, and the lower acidity of the soil, while the forest showed higher levels of K, Al and increased soil acidity. The dry period showed higher exchangeable Al and P values compared to the rainy season. But the K showed higher levels in the rainy season compared to the dry. The highest Ca values, Mg, P and lower acidity in the SAF, compared to other systems use this system gives better sustainability.

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INTRODUCTION

Concern about the quality of the soil and quantification of changes in its attributes is of great importance for the monitoring of soil productivity in order to improve the management of the sustainability of agricultural systems (NEVES *et al.*, 2007; CUNHA *et al.*, 2012). According to Dantas *et al.*(2012), soil quality is the ability of this act positively in the regulation of energy flow in a particular ecosystem, whether natural or agricultural; performing functions that interfere with plant productivity and maintaining the quality of the environment (ARAUJO; MONTEIRO., 2007, ARAUJO *et al*, 2008). The study of the spatial variability of soil chemical characteristics is an important step in agriculture (ZANÃO JR *et al.*, 2010).

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Considering that knowledge of soil fertility is one of the key factors for achieving success in farming, various authors have quantified the soil chemical properties under different uses and management in order to identify those considered sustainable in the medium and long term (FRAZÃO *et al.*, 2008). The main soil properties may include the cation exchange capacity (CEC), sum of bases (BS), base saturation (%) the aluminum saturation (m%) and pH, which indicates the amount of hydrogen ions (H^+) on the ground (RONQUIM, 2010). However, improper use of soil, especially through the use of conventional systems, has led to degradation of physical, chemical and biological properties (SA *et al.*, 2004), for example, the disintegration and compaction, reduced fertility, accelerated oxidation of organic matter and reduction of the quantity and diversity of soil organisms (MOURA, 2004; LEITE *et al*, 2010).

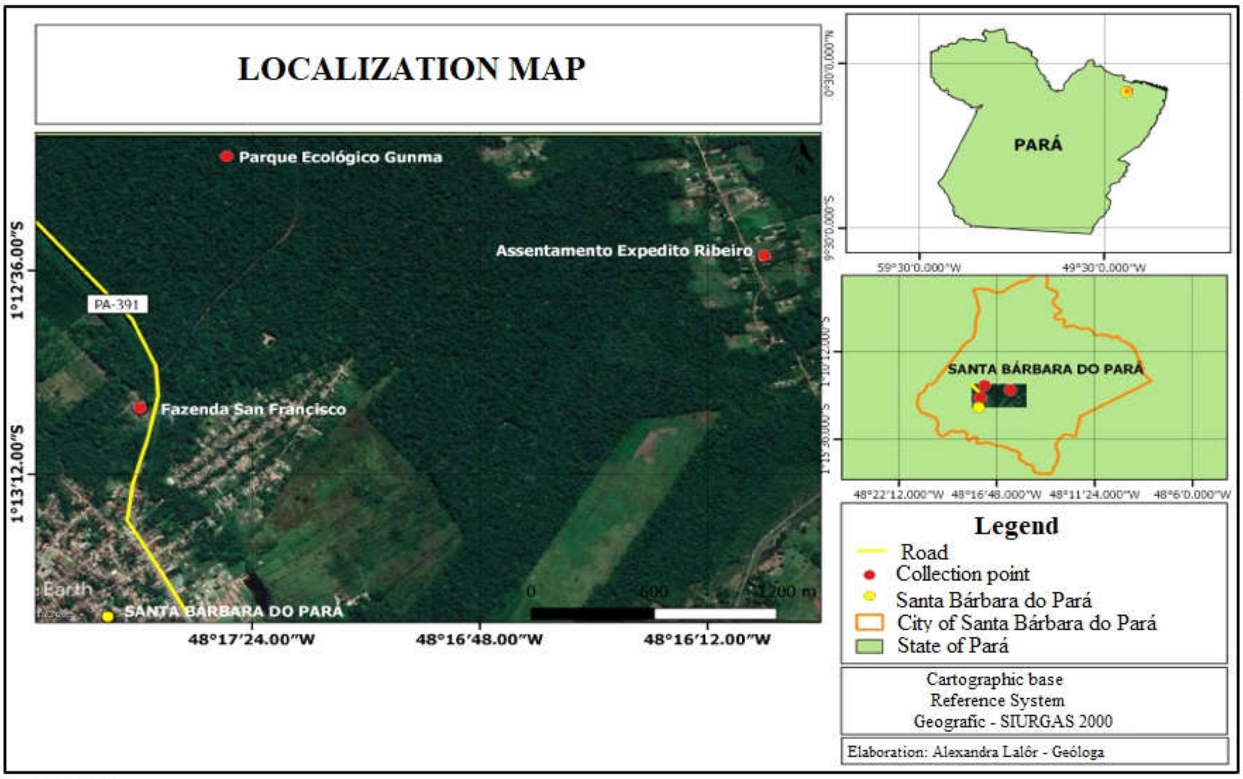

Figure 1. Study area, located in Santa Barbara, Para, Brazil

Currently, many studies have been conducted with the objective of identifying management systems that promote increased soil quality (SALMI *et al*., 2009), such as agroforestry systems (SAF's), which are characterized mainly by the combination of forest species crops and added or not to livestock activities (LIMA *et al*., 2010). In this sense, the study aimed to assess the dynamics of soil chemical properties in four different land use systems in two sampling periods, dry and rainy in the municipality of Santa Bárbara do Pará, Brazil.

MATERIALS AND METHODS

The study area is in the highway Augusto Meira Filho (PA-391), Belém-sense Mosqueiro, municipality of Santa Bárbara, between the approximate coordinates of 01º13'00.86 "S and 48º17'41.18" W (Figure 1). Soil samples were collected and evaluated in four land use systems: agroforestry system composed of banana (*Musa sp*.), cocoa (*Theobroma cacao* L.), acai (*Euterpe oleracea* Mart.), andiroba (*Carapa guianensis* Aubl) and Jatoba (*Hymenaea sp.* L.), cassava agricultural crop (*Manihot esculenta* Crantz), grassland cultivation species kikuio (*Brachiaria humidicola* (Rendle.) Schweickerdt), and witness the natural forest vegetation with over 30 years of age. Soil samples of agro forestry and cassava were collected on settlement Expedited Ribeiro, one being the SAF planting 2.5 years with lime and NPK fertilization and cassava one planting 3 years old fertilized, pasture cultivation The Farm San Francisco is located, PA-391, already the forest vegetation is located on the banks of the PA-391, the Ecological Park Gunma, all situated in the municipality of Santa Bárbara do Pará. The local climate is humid tropical type Afi, according to Köppen climate classification, with annual rainfall of 2,500 and 3,000 mm, and is characterized by having rainfall greater than or equal to 60 mm in the driest month of the year. The annual average temperature is 26.0 ° C. The annual average relative humidity is 85% (SUDAM, 1984).

All evaluated environments are located in land areas classified as Alic yellow latosol (RADAMBRASIL, 1974). The soil sampling, for determining the fertility were performed using the a soil auger in each land use system depths 10-20 cm between rows of crops and discarding litter layer covering the soil. Collected were held in September 2014 (dry season) and March 2015 (rainy season).

The soil quality was obtained by determining the following chemical attributes: 1) calcium (Ca), magnesium (Mg) and exchangeable aluminum (Al), obtained by extraction KCl 1 mol L-1 solution with EDTA-Na 0.025 N and 0.025 N NaOH; 2) Potassium (K) by extraction in H2SO4 + HCl solution to determine by flame photometry; 3) Phosphorus (P) for extracting second extraction solution Mehlich (1984), consisting of a double acid (0.05 N hydrochloric acid + 0.025 N sulfuric acid) at a ratio: 1 solution to 10, where the phosphorus determined colorimetrically by the molybdenum blue method, with ascorbic acid as a reductant and potassium by flame photometry; 4) pH in water, determined by potentiometry, using a soil: water 1: 2.5, according to the procedures contained in soil analyzes Methods Manual (EMBRAPA, 2009). The experiment will be performed using the design entirely randomized in a 2 x 4 factorial, four combinations result of land use systems (SAF, crop, Pasture and forestry), two periods of (dry and rainy) and three replications totaling 24 samples. The variables were evaluated by analysis of variance and the mean are compared by Tukey's test at 5%.

RESULTS AND DISCUSSION

As for soil calcium levels (Figure 2A), the value found in cassava planting (1.03 cmolc / dm3) did not differ significantly from the SAF (0.93 cmolc / dm3), but exceeded the values found in the forest (0 , 51 cmolc / dm3) and the pasture (0.40 cmolc / dm3). When the main effect was considered the period

(Figure 2B), there was no significant effect ($p < 0.05$) in the soil calcium, or ignore when the usage type of system, the period did not influence the calcium. In general, the exchangeable calcium levels found in soil, regardless of the sampling time, are classified as low (PREVEDELLO; KRIGER; MOTTA, 2003).

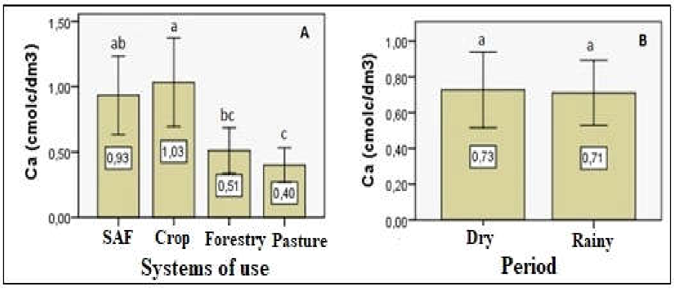

Figure 2. Mean concentration of calcium under different use of Systems (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present significant difference at 5% Tukey test

According to Figure 3A, it can be seen that the higher magnesium values (0.45 and 0.43 cmolc / dm3) were obtained, respectively, with APS and cassava not differ significantly, while smaller values they were presented in the forest (0.22 cmolc / dm3) and grazing system (0.20 cmolc / dm3), which also showed no significant differences. Since the magnesium content in soil showed no significant difference between the systems (Figure 3B) with respect to periods. According Malavolta (2002), values in the soil magnesium ≤ 2 cmolc / dm3 are considered low for the development of crops.

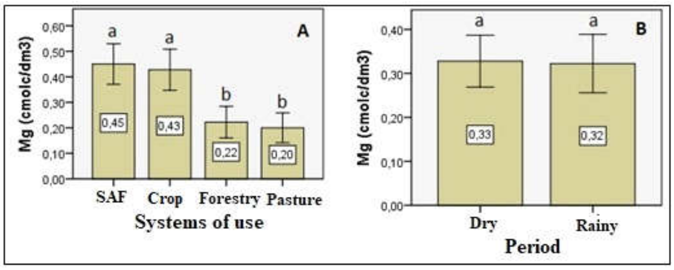

Figure 3. Average concentrations of magnesium under different use of Systems (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present significant difference at 5% Tukey test

The highest concentrations of potassium found in forest soils (11.39 mg / dm^3) And grazing system (8,33 mg / dm3), which did not statistically differ from each other. For the potassium lower values were obtained in the APS systems (5.0 mg / dm3) and cassava (4.0 mg / dm3) which were not statistically different from each other. It can be seen in Figure 4B, which during the dry period the soil was reduced potassium content when compared to the results obtained in the soil collected during the rainy season. In the rainy season, the action of soil microbes in the mineralization process is intensified, releasing the potassium contained in the organic matter to the soil solution, which can justify the higher potassium levels in the rainy season (MELLO *et al*. 1985). The mean values observed for potassium, both as the dry period for rainy are classified as low-level for all land-use systems (TOME Jr., 1997). In Figure 5A, it is seen that the forest had the highest Al amounts (1.24 cmolc / dm3) compared with the other systems of use, pasture (0.82 cmolc / dm 3) APS (0.61 cmolc / dm3) and cassava (0.60 cmolc / dm3), which were not statistically different ($p > 0.05$). The Al concentrations found in soil are considered medium toxic level for cassava (0.60 cmolc / dm3), SAF (0.61 cmolc / dm3) and pasture (0,82cmolc / dm3), and high for the forest (1.24 cmolc / dm3) according PREVEDELLO; KRIGER; MOTTA (2003).

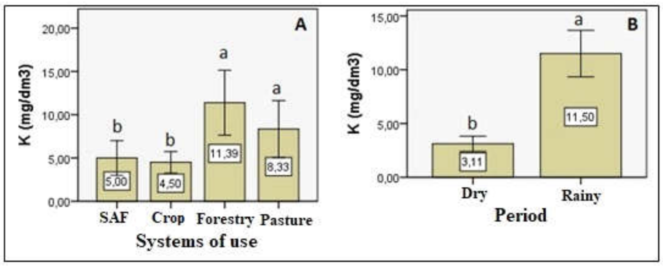

Figure 4. Medium concentrations of potassium, under different use of systems (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present significant difference at 5% Tukey test

The dry period showed higher Al concentrations (0.90 cmolc / dm3) compared to the rainy season (0.73 cmolc / dm3). According Malavolta (1976) during the rainy season is larger amount of loss of soil cations, causing increased soil acidity, causing solubilization of Al, Al^{+3} in releasing large quantities, thereby increasing the concentration of exchangeable aluminum. However in the present study we observed lower Al concentrations with lower acidity of the soil in the rainy season, which may have been influenced probably by higher concentrations of potassium in the rainy season.

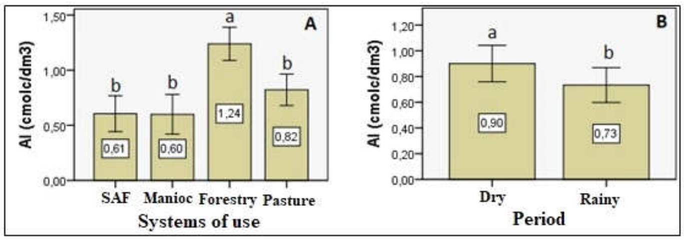

Figure 5. Means of exchangeable Al concentrations under different of use Systems (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present statistical difference by 5% Tukey test

The highest average value of P occurred in the APS (4.86 mg / dm3), while the lowest was found in the forest (2.33 mg / dm3). The pasture management systems and cassava showed intermediate values of 2.94 and 2.33 cmolc / dm 3, respectively, did not significantly differ among themselves (Figure 6A). From the results it can be inferred thatadoption of management systems in order to increase the organic matter and increased activity of soil microbes, such as SAF, can increase the content of P in soil, increasing their availability plants (HUE, 1991; FERREIRA, KATO; COSTA, 2004). In the sampling carried out during the dry period, under unfavorable conditions of humidity, phosphorus for values were higher compared to collect the rainy season (Figure 6B), being likely to be released considerable amount of phosphorus in the microbial biomass, a major source of P because due to water stress, which would justify the increased availability of the element in the dry period (NAHAS, 1999). For all systems studied using the found values of P are considered low level according RAIJ *et al*. (1996) and PREVEDELLO; KRIGER; MOTTA (2003).

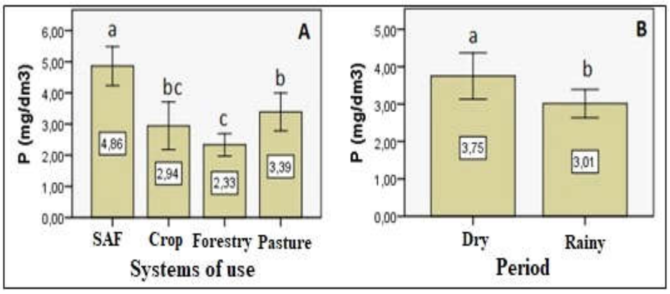

Figure 6. Average of phosphorus concentrations under different use of system (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present statistical difference by 5% Tukey test

Figure 7A shows that there is a significant effect of pH on the use of systems ground ($p < 0.05$), indicating that the types of system use significantly affect the soil pH. This clearly shows that when the period is not considered, the overall average pH is similar in APS (5.62) and cassava (5.43), but the average pH was lower in the forest (2.33) This demonstrates that the soil tends to become more acid under forest compared with use of other systems. It may be noted that also soil under SAF is less acid compared with most land-use systems, ie has less limestone requirement to correct the acidity of the soil, with greater economy to the grower.

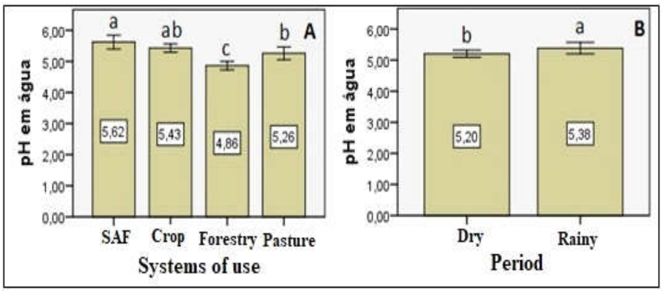

Figure 7. Mean values of pH in water under use different systems (A) and sampling period (B), Santa Barbara, PA. Columns with the same letter do not present statistical difference by 5% Tukey test

When the main effect was considered the period (Figure 7B) also observed a significant effect ($p < 0.05$), namely, when we ignore the usage type system, the time influenced the pH of the soil as soil collected in the dry period was higher acidity (5.20), when compared with the same values in the rainy season (5.38). However, the values found in both periods, are classified as medium acidity (MALAVOLTA; Pimentel-Gomes; ALACARDE, 2002).

Conclusion

The use of SAF system showed higher Ca, Mg, P, and the lower acidity of the soil, while the forest showed higher K and Al and increased soil acidity. The periods showed similar levels of Ca and Mg, K however showed higher levels in the rainy season compared to dry. The dry period showed higher exchangeable Al and P values compared to the rainy season. The adoption of management systems that increase the organic matter and soil microorganisms, such as SAF, may contribute to increased soil P and their availability to the plant. The highest Ca values, Mg, P and lower acidity in the SAF, compared to other systems use this system gives better sustainability, since they have a more efficient nutrient cycling system.

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