Original Research Article

The effect of soil use and management on the chemical properties of an Ultisol

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ABSTRACT

The use of vegetation cover to protect the soil and increase the soil organic matter content available to plants is a good practice to minimize loss of soil quality. The effect of soil management practices on the objective of this study was to evaluate the soil quality under different types of management. A completely randomised experimental design was used with three treatments as; area of natural vegetation; Area of perennial crop cultivation and degraded pasture area; with five replications. Chemical soil properties evaluated were: phosphorus, potassium, magnesium and calcium contents by extraction with ion exchanger resin. The content of organic matter was determined by the colorimetric method and the pH, in calcium chloride, as well as the acidity potential of the pH 7.0. The sums of bases, cation exchange capacity and base saturation were calculated. Under the treatment of natural vegetation the soil depths: 0.00-0.10; 0.10-0.20 and 0.20-0.40m. Data were analyzed statistically using the Tukey test at 5% for comparison of means. In the treatment, there was an accumulation of exchangeable bases, organic matter and phosphorus, as well as reducing potential acidity. The results show that soil use in spite of its management interferes with the chemical quality of the soil.

Keywords: organic matter*, soil acidity, phosphorus.*

1. INTRODUCTION

Sustainable use of natural resources, especially soil and water, has become a topic that is increasingly relevant, due to the increase of anthropogenic activities. Consequently there is, increases the concern with the quality and sustainable use of these resources (Araújo et al., 2007).

The introduction of agricultural systems to replace the forests causes an imbalance in the ecosystem in which the removal of the original vegetation and the deployment of crops, combined with inadequate management practices, lead to the disruption of the balance between the soil and the environment. In this way, the modification of soil chemical, physical and biological properties, limits the soils their agricultural use (Richart et al., 2005).

The quality to attributes provides suitable conditions for the growth and development of plants and the maintenance of the diversity of organisms that inhabit the soil (Doran & Parkin, 1994). The current research challenge is the assessment of quality soil restored. According to Doran & Parkin (1994), it can be measured by quantifying to attributes, i.e., physical, chemical and biological properties have been used to monitor medium and long term changes, in the quality of the soil. Soil quality must be monitored to detect changes that may be mediated at a certain time and can be done on the farm or on a larger scale, such as watersheds and regions.

According to Araujo et al. (2007), management practices and soil conservation and water must be planned and executed attempting to maintain or even improve their attributes, in order to increase the soil's ability to sustain a competitive biological productivity. The conventional management systems (plowing and harrowing), results in intensified processes of erosion and soil compaction which in the medium and long term, may lead to physical, chemical and biological degradation of the soil (Leite et al., 2003; Araújo et al., 2004). In these conditions, the absorption of nutrients available to the root system is hampered and the amount of oxygen in the rhizosphere can become limiting in several metabolic processes (Beulter & Centurion, 2004).

Islam & Weil (2000) proposed the use of data of physical, chemical and biological characteristics of soil collected in an area of undisturbed natural forest, as a reference for assembling a general index of soil quality. According to Brookes (1995), the relationship between the physical, chemical and biological properties of the soil vary in time and space. And these changes can be beneficial or harmful to production systems. Proper management promotes gain in soil quality and crop productivity. Consequently, the variation of these attributes, determined by management and soil use, and its evaluation are important for better management aiming at sustainability of the system (Carneiro et al., 2009).

Works performed by Souza & Alves (2003) in dystrophic Oxisol, show that soil management systems with less or no soil disturbance led to significant accumulation of organic matter, phosphorus, potassium, magnesium and calcium and decrease of exchangeable aluminum and potential acidity. With soil disturbance as a result of cropping, the effects were a reduction of the levels of organic matter, phosphorus, potassium, calcium and magnesium and increased potential acidity and exchangeable aluminum.

Studies conducted in Oxisol, in the region north of the state of Pará, found that the sum of bases and cation exchange capacity (CEC) were the most sensitive variables to changes in the use and management (primary forest, explored forest, grassland, scrub, juquira of typical Brazilian vegetation), and the pH and potential acidity and soil pH were influenced by the replacement of forest by pasture (Ferreira et al., 2011).

The aim of this work was to evaluate the chemical quality of the soil of an Ultisol under different uses and management.

2. MATERIALS AND METHODS

The experiment was conducted at the experimental area of farm Teaching and Research at the University Camilo Castelo Branco - UNICASTELO, Fernandópolis city, São Paulo (SP) (Santa Rita farm), located between coordinates 20°16'50" south latitude and 50°17'43" west longitude and 20°18'05" south latitude and 50°16'26 "west longitude (Figure 1).

The climate of the region, according to the Koppen classification, is humid subtropical, Aw, with winter (dry and mild) and summer (hot and rainy) (Rolim et al., 2007). According to the Embrapa (2007) region is characterized by a period of 6 months of the year with water deficit and average temperature of 23.5°C or 74,3º F (Table 1).

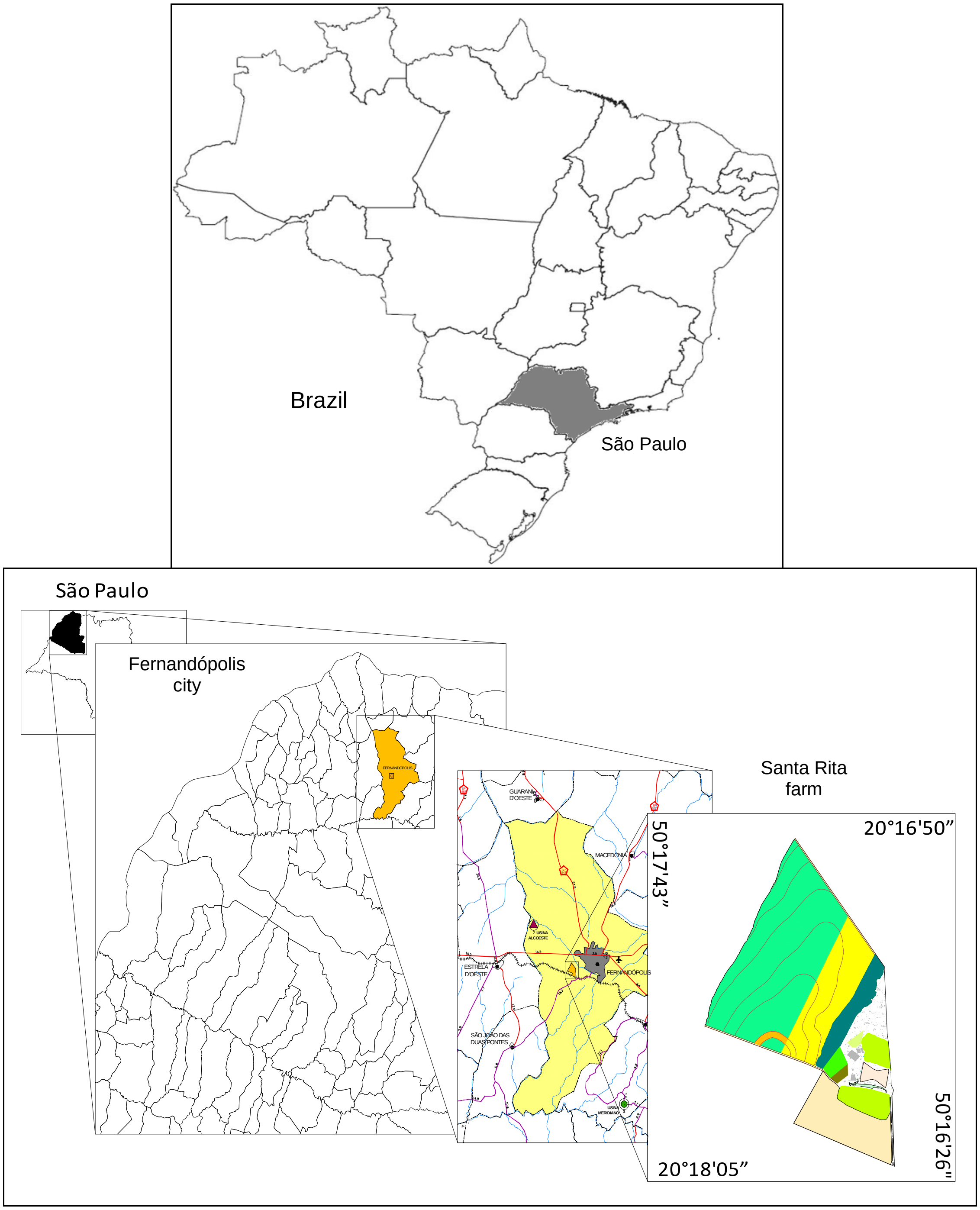

Figure 1: Location of the Santa Rita farm, Fernandópolis city, SP, Brazil

According to Soil Survey Staff (1999) soils of Santa Rita farm consist of Ultisol. The experimental design used was a completely randomized, with three treatments and five replications, totaling 25 experimental plots. The treatments were: Natural vegetation area (Figure 2); Area of cultivation of perennial crops (implanted 15 years ago, spacing 1 x 2 m, area without management of manuring) (Figure 2) and Degraded pasture area (3 ha) (Figure 2).

Table 1: Water balance of the Fernandópolis city, SP.

Month	AT (℃)	AT (ºF)	P (mm)	PE (mm)	WS (mm)	AE (mm)	DE (mm)	EXC (mm)
January	25.2	77.4	242	130	100	130	0	84
February	25.3	77.5	193	120	100	120	0	73
March	25.0	77.0	131	124	100	124	0	7
April	23.4	74.1	65	94	74	91	4	0
May	21,2	70.2	47	70	59	62	8	0
June	20.2	68.4	37	57	48	48	9	0
July	20.1	68.2	13	58	31	30	27	0
August	22.3	72.1	20	80	17	34	46	0
September	24.1	75.4	35	101	9	43	58	0
October	24.8	76.6	126	119	16	119	0	0
November	24.8	76.6	120	120	16	120	0	0
December	25.0	77.0	187	131	72	131	0	0
Totals	-		1.216	1.205	642	1.053	152	163
Average	23,5	74.2	-	-	-	-	-	-

NOTE: AT (average temperature); P (precipitation); PE (potential evapotranspiration); WS (water storage in the soil); AE (actual evapotranspiration); DE (disability); EXC (excess).

The native vegetation is composed mainly by the respective species: *Stylosantes capitata, Talisia esculenta, Hymenaea stilbocarpa, Matayba elaeagnoides, Anadenanthera falcata. Peltophorum dubium, Tabebuia serratifolia, Mimosa caesalpiniaefolia*. As a floristic composition heterogeneous and rich in species.

In the area with perennial crop is basically composed by species of *Eucaliptus grandis*, without ground vegetation, i.e., as the area is already being cultivated for 15 years, the canopy of trees shades the whole area, hindering the onset of ground vegetation on site. The planting was done with cuttings. The sampling in this treatment was performed at 0.50 m from the plant row. The degraded area is cultivated by the grasses *Panicum maximum*.

The samples were collected with the aid of exchange of mug, in three soil depths: 0.00-0.10; 0.10-0.20 and 0.20-0.40 m (Figure 3). For each treatment soil samples were obtained in duplicate for better data reliability, in may to 2012.

Chemical soil properties were evaluated according to the methodology described by Raij & Quaggio (1983) and the composition of phosphorus, potassium, magnesium and calcium by extraction with an ion exchange resin were evaluated. The organic matter (OM) was determined by the colorimetric method and the pH, in calcium chloride, as well as the potential acidity (hydrogen + aluminum) at pH 7.0. Were calculated sums of bases (SB = Ca + Mg + K), cation exchange capacity (CEC = SB + (H + AL)) and base saturation (V% = (100 x SB) / CEC).

Natural vegetation.

Perennial crop – Eucalyptus *grandis*

Degraded pasture.

Figure 2: View of the experimental area

For data analysis, was performed the analysis of variance (F test) and applied the Tukey test (5%), for comparison of means, using SISVAR program (Ferreira, 2008).

Soil collected

Trench to collect soil

Figure 3: Composite sample of soil was used for the determination of soil fertility and collecting.

3. RESULTS AND DISCUSSION

The results for the chemical properties of the soil are presented in Table 1. For all properties and soil depths studied, the F test was significant at 5% of probability.

Table 1: Effect of soil use and management on the chemical properties of an Ultisol.

Soil property	Soil use and management and soil depth (A: 0.00-0.10; 0.10-0.20 and 0.20-0.40m)								
	Natural Vegetation			Perennial Crops			Degraded Pasture		
	A	B	C	A	B	C	A	B	C
OM (g dm^{-3})	18 a	18 a	16 a	14 a	13 c	13 b	16 ab	15 b	15 ab
P (mg dm^{-3})	18 a	15 a	10 a	6 c	4 c	3 b	14 b	12 b	11 a
pH	5,6 a	5,2 a	5,1 a	4,8 a	4,7 b	4,5 b	5,4a	5,4 a	5,3 a
K (mmolc dm^{-3})	1,6 a	1,5 a	1,3 a	1,1 b	1,1 b	0,8 b	1,3 b	1,2 b	1,3 a
Ca (mmolc dm^{-3})	17 a	16 a	14 a	6 c	5 c	5 c	12 b	11 b	10 b
Mg (mmolc dm^{-3})	6 a	6 a	5 a	3 b	2 c	2 b	5 a	4 b	4 a
H+Al (mmolc dm^{-3})	23 c	24 c	26 c	34 a	35 a	36 a	28 b	30 b	31 b
SB (mmolc dm^{-3})	24,6 a	23,4 a	20,6 a	10,1 c	8,1 c	7,9 c	18,3 b	15,9 b	15,3 b
CEC (mmolc dm^{-3})	47,6 a	47,5 a	45,7ab	44,1 b	44,1 c	43,9 b	47,3 a	46,2 b	46,6 a
V%	52 a	49 a	44 a	23 c	18 c	18 c	39 b	35 b	33 b

Soil property	F Test, SDM - significant difference minimum 5%, VC- variation coefficient (%) (A: 0.00-0.10; 0.10-0.20 and 0.20-0.40m)								
	F			SDM(5%)			VC(%)		
	A	B	C	A	B	C	A	B	C
OM (g dm^{-3})	5.471*	57.00*	7.63*	3.943	1.445	2.397	11.30	4.35	7.54
P (mg dm^{-3})	384.00*	134.08*	66.07*	1.352	2.184	2.314	4.92	9.67	13.34
pH	384.00*	13.00*	14.182*	31.912	0.433	0.479	15.71	3.92	4.45
K (mmolc dm^{-3})	16.28*	15.97*	35.48*	0.270	0.237	0.194	9.35	8.69	7.92
Ca (mmolc dm^{-3})	78.00*	166.50*	25.11*	2.704	1.770	1.198	10.69	7.78	5.82
Mg (mmolc dm^{-3})	12.92*	72.00*	11.19*	1.843	1.022	2.068	18.21	11.79	26.31
H+Al (mmolc dm^{-3})	111.76*	164.58*	18.00*	2.257	1.946	1.616	3.66	3.03	2.40
SB (mmolc dm^{-3})	668.38*	732.43*	35.29*	1.222	1.224	1.467	3.19	3.57	4.64
CEC (mmolc dm^{-3})	165.22*	225.44*	9.288*	0.654	0.495	1.976	0.65	0.50	2.01
V%	585.3*	24.21*	98.14*	0.817	1.371	1.777	1.00	1.84	2.58

abc Values with different superscripts are significantly different at (P< .05). * Significant at 5%, ns no significant.

For native vegetation, the surface layer (0-0,10m) was found the highest content of organic material, and exchangeable ions (cations: Ca, K and Mg and anions: P). This behavior was observed due to the presence of an equilibrium soil-plant-water. The nutrient input has as main source, the mineralization of nutrients coming from the roots and leaf litter. This effect is the result of greater accumulation due to greater species richness of this treatment. The CEC of the soil in the same layer (0-0,10m) is almost entirely occupied by SB (Ca, Mg and K) and at lower extent by the potential acidity. As the increases the sampling depth (0.10-0.20 and 0.20-0.40m), the contents of cations and anions decreases, this behavior is explained by the best influence of leaf litter and of the roots. With the smaller influence of OM there is an increased potential acidity.

According to Souza & Alves (2003) who observed similar behavior that found in this work, claim that management systems with little or no soil disturbance, tends to accumulate exchangeable cations, phosphorus and organic matter. The same behaviour was also observed in research by Ferreira et al. (2011). This accumulation of exchangeable bases in the soil surface depth agrees with a lower potential acidity found in treatments native vegetation and grassland. Regarding the treatment eucalyptus there is a greater potential acidity and lower content of exchangeable bases, phosphorus and soil organic matter. Identical behavior was verified by Souza & Alves (2003) and Ferreira et al. (2011).

For the cultivation of eucalyptus, there was lower contents of exchangeable cations and anions in relation to the native vegetation treatment of cerrado. In the surface layer (0-0.10m) the contents were higher than in the other layers (0,10-0,20 and 0.20-0.40m) for the treatment eucalyptus.

The lowest concentration of Ca and Mg in K in eucalyptus treatment, is result of lower influence of roots and ground cover, due to the taproot system. In Eucalyptus, the growth of the root system of plants resulting of seedlings or cuttings are distinct. According Gaspar et al. (2005) cuttings produces less, primary roots, frequently without main root and have a more shallow root system. Fabião et al. (1985) states that the amount of fine roots in Eucalyptus is very low.

In grasses (treatment degraded pasture), the fibrous root system, influence in greater proportion the soil quality in the surface depth. This effect of the grasses roots was verified by Bonini (2012). The effect of roots was also verified by Beutler & Centurion (2004) and Richart et al. (2005).

Soil management by man leads to soil depletion and degradation. The sustainable management (with low soil disturbance and vegetation cover) is recommending in Brazil, due to the hot and humid climate that leads the organic matter to highest mineralization rates.

The highest levels of exchangeable bases in the treatment degraded pasture in relation to eucalyptus treatment is verified by the greatest influence of vegetation cover provided by *Brachiaria decumbens*. But these treatments have characteristics fewer beneficial for the development of plants (low CEC, SB, pH, V% and high potential acidity) in relation to native vegetation.

To soil organic matter, the highest contents found were to treatment native vegetation in any soil depth. The same behavior was observed for phosphorus, calcium, potassium and magnesium (table 1). This higher content of nutrients that are beneficial and essential for plant development was recorded in the treatment where there was no human intervention. In grasslands and eucalyptus treatments there was a gradual reduction, this due to greater soil disturbance and lower vegetation cover.

Regarding the sum of bases, cation exchange capacity and base saturation, values found in this research, are considered low compared to the values considered average by Raij et al. (1996). But even with values below of the optimal considered, was portrayed very well the difference between the treatments. The optimal saturation bases should be around 70% for most of the crops. The pH was an index with little variation among the treatments studied, this is due to no soil correction of cultivated areas and the native vegetation be slightly acidic (inherent soil characteristic). Bonini (2012) verified in Oxisol corrected higher pH than the native vegetation. Similar results were also found by Islam et al. (2000), Carneiro et al. (2009) and Souza & Alves (2003).

4. CONCLUSION

The chemical properties of the soil were good indicators of soil quality, except for the pH index. Treatment with higher accumulation of organic matter, phosphorus, exchangeable cations was the native vegetation. The worst treatment was eucalyptus. The analyzes performed indicate that the management interfere with the chemical quality of the soil.

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