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Microbiological Attributes of a Cohesive Yellow Latosol Under Different Land Use Systems

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Abstract

The objective of this study was to evaluate the microbiological attributes of a Cohesive Yellow Latosol. Collections were carried out in three land use systems (LUS). The first, with natural rainforest (NR), the second with sugarcane (SC) cultivated since 2009, and the third under *Mimosa cesalpiniifolia* (MC) introduced in 1999. Microbiological analyzes were carried out by determining the carbon from microbial biomass, readily mineralizable carbon, microbial respiration, metabolic quotient, total organic carbon, microbial C/total organic C ratio, and occurrence of cellulolytic and ammonifiers microorganisms. Analysis of variance

was performed to verify the different measures of microbiological attributes. The variation obtained from CMB was from 3.06 to 4 µg.C.g^{-1} in NR, 3.02 to 3.92 µg.C.g^{-1} in MC, and 3.14 to 3.24 µg.C.g^{-1} in SC. For accumulated CO_2, no differences were found between environments, with values ranging from 77 to 55.70 µg.Kg^{-1} for NR, 80.30 to 49.56 for MC, and 80.30 to 49.56 for SC. *q*CO_2 had no significant effect, and in relation to total organic carbon the forest soil (NR). These results demonstrate that the microbiological attributes of the soil are influenced by cover, environmental standards and soil management, and the sampling time. The forest soil showed superior microbial biomass when compared to other soils. The metabolic control detected a difference between the collection times. For the accumulated CO_2 resources, no changes were observed.

Keywords: carbon from biomass, basal respiration, cellulolytic fungi, ammonifers bacteria, metabolic quocient

1. Introduction

Soil microbiota is the principal responsible by organic residue decomposition and nutrient cycle, influencing in organic matter, carbon, and mineral stock. The natural fertility depends on the dynamics of these compounds. The microbial diversity in soil is an important indicator of soil quality (Silva et al., 2019). Comparative studies about biological properties of soils between native and cultivated vegetation are important parameters for sustainable evaluation of soils use systems.

Different plant species, in turn, determine the quantity, quality and persistence of residues, and change the growth of the microbial community in the soil. The size of the microbial community and its activity determine the intensity with which the biochemical processes take place. Microbial activity and biomass, in turn, are influenced, by other factors, such as temperature, humidity, aeration and availability of substrates in the soil.

The choice of microbiological indicators to define soil quality has been adopted since edaphic organisms have the ability to respond quickly to changes in the environment, especially anthropic changes derived from the crop management (Barroso et al., 2012; Eleftheriadis & Turrion, 2014; Silva et al., 2019).

Microbial biomass plays a fundamental role in the productivity and maintenance of ecosystems, acting as a catalyst for important chemical transformations in the soil and constitutes a reservoir of nutrients available to plants, as it belongs to the labile component of soil organic matter and has activity influenced by biotic and abiotic conditions. Its monitoring reflects possible changes in the soil, being considered a good indicator of changes resulting from management (Souza et al., 2008).

Microbial biomass responds quickly to the addition of C and N applied to the soil, determining the decomposition of organic matter, the C:N ratio, mineralization, and immobilization of nutrients (Hatch et al., 2000). And it is influenced by seasonal variations in humidity and temperature, soil management, cultivation, and plant residues. Soil management also interferes with the microbial biomass carbon, promoting its decrease in intensive soil preparation, such as plowing, harrowing, and subsoiling (Perez et al., 2005).

The carbon in microbial biomass (CMB), which represents the living and most active part of the organic matter of the soil, is more sensitive to the removal of native vegetation cover than the mineral part of the organic matter. For this reason, the microbial biomass carbon has been pointed out by several authors (Mendes & Vivaldi, 2001) as a quality indicator, with sensitivity to detect changes in the soil, even before the organic matter contents are significantly changed.

Soil respiration, also known as readily mineralizable C, can be understood as the sum of all metabolic functions in which carbon dioxide (CO_2) is produced being one of the most used methods to evaluate the metabolic activity of the soil microbial population. Breathing can be quantified baseline or induced (Alef et al., 1995). While basal respiration simply quantifies the CO_2 evolved during soil incubation, estimating the heterotrophic activity on the substrates present in the system, a readily available carbon source is added to the induced, in order to quantify the maximum heterotrophic activity of an edaphic system (Moreira & Siqueira, 2006).

The microbial quotient (*q*Mic) calculated by the ratio between CMB and total organic carbon (TOC), expressed in micrograms of C-CO_2 per microgram of Cmic is an index widely used to provide indications about the dynamics of organic matter, expressing the efficiency of biomass microbial use of soil organic carbon (Cardoso et al., 2009).

The soil microbial community is influenced by the environment. Such variations are directly linked to the water regime and climate of the region, to the structure and management of the soil, and to the content and quality of the vegetable residues contributed. Soil with a high content of organic matter tends to keep the microbial population more stable throughout the year, probably due to the wealth of ecological niches and the heterogeneity of carbon sources (Fede et al., 2001; Mesquita, 2014).

In view of above, the aim of this study was to evaluate and to characterize the microbiological attributes that act as indicator of soil quality in different using system in a cohesive Yellow Latosol.

2. Method

2.1 Experimental Area and Soil Sampling

The soil in the experimental areas is classified as a Cohesive Yellow Latosol. The climate of the region is As in the Koeppen Classification (Koeppen, 1948), with mean annual rainfall of 2,363 mm, relative humidity of 93.02%, minimum average temperature of 18.9 ºC, and maximum of 27.1 ºC, with a dry season in summer.

Soil sampling were carried out in three land use systems (LUS), described below: the first, with natural rainforest (soil cover condition) (NR), the second with sugarcane crop (SC) cultivated since 2009, having received the recommendations for the culture (CNA, 2007), and the third under *Mimosa caesalpiniifolia* (MC) that was introduced replacing the natural forest in 1999. In each soil cover system, four 1000 m^2 areas were subdivided.

Five collections were made, 10 samples were collected at a depth of 20 cm by zigzag walking,

packed in plastic bags. In the laboratory, sieving was performed (opening = 4 mm), manual removal of roots and vegetable remains.

2.2 Microbiological Analysis

Microbiological analyzes were performed by determining the carbon of the microbial biomass, readily mineralizable carbon, microbial respiration, metabolic quotient, total organic carbon, microbial C/total organic C ratio, and the most probable number (MPN.g^{-1}) of cellulolytic fungi and ammonifying bacteria.

A 10 g sub-samples were taken from each composite soil sample which was suspended in 90 ml of saline solution. After stirring, serial dilutions were made. From the 10^{-1} to 10^{-5} dilutions 1 ml aliquots were transferred to test tubes containing 9 ml of liquid medium for cellulolytic fungi. A strip of sterile filter paper measuring 7 x 1 cm was placed in each tube so that the paper is 2 cm above the level of the culture medium. The cultures were incubated in the dark at 28 ° C for 28 days. Counting was done according to the McGrady table of the most likely number of microorganisms for 5 repetitions (Jenkinson & Powlson, 1976). From the 10^{-1} to 10^{-5} dilutions, 1 ml aliquots were transferred to test tubes containing 4 ml of liquid culture medium for ammonifying bacteria. The cultures were incubated in the dark at 28 °C for five days. The tubes with ammonia production showed a color change from orange to pink. The count was made according to the McGrady table of the most likely number of microorganisms for 5 repetitions (Jenkinson & Powlson, 1976).

2.2.1 Basal Respiration (BR)

Soil microbial respiration was determined by the fumigation-incubation method proposed by Jenkinson and Polwson (1976). For this, 20g of soil were sampled with 25 ml of ethanol-free chloroform under a vacuum of approximately 600 mm Hg for 2 min after the start of boiling in a wet desiccator, remaining for 24 hours in contact with the steam of this fumigant, in a dark place and temperature of 27 ± 2 ºC.

Sub-samples of 20g of fumigated soil were placed in 2 L flasks together with another flask containing 10 ml of NaOH 0.05 mol.L^{-1} to capture the C-CO_2 released from the soil. These samples were incubated for 10 days. The control consisted of flasks containing only NaOH. After incubation, the captured CO_2 was precipitated as barium carbonate, after the addition of 5 ml barium chloride (0.5 mol.L^{-1}), and the excess of NaOH was titrated with HCl solution (0.5 mol.L^{-1}) in the presence of phenolphthalein 0.1%). The rate of evolution of CO_2 in each sample was calculated using the following formula:

$$CO_2(mg.kg^{-1}\ soil)=((Vb-Va) \times 1.1 \times 1000)/DSW \quad (1)$$

Vb = volume of HCl (ml) used in NaOH titration of control;

Va = volume of HCl (ml) used in NaOH titration of the sample;

1,1 = conversion factor (1 ml of NaOH 0,05M = 1mg of CO_2)

DSW = Dry Soil Weight

2.2.2 Carbon of Microbial Biomass (CMB)

The determination of the biomass carbon was performed using the fumigation-extraction and oxidation method of organic carbon by potassium dichromate ($K_2Cr_2O_7$) (Vance et al., 1987). For this, 20g of soil were fumigated with 25 ml of ethanol-free chloroform under a vacuum of approximately 600 mm Hg for 2 min after the start of boiling in a wet desiccator, remaining in contact for 24 hours with the steam of this fumigant, in a dark place and at a temperature range of 27 ± 2 ºC.

The organic carbon was extracted by 50 ml of a 0.5 M potassium sulfate solution (K_2SO_4) added to the fumigated and non-fumigated samples, under stirring for 30 min, after which the extract was filtered on Whatman 42 filter paper. An 8 ml aliquot of the filtrate, along with 2 ml of 66.7 mM $K_2Cr_2O_7$, 10 ml of concentrated sulfuric acid (H_2SO_4, 98%) and 5 ml of phosphoric acid (H_3PO_4, 88%) were heated on a reflux plate by 3 min after the first bubble appears, when the oxidation reaction of the carbon present in the soil samples occurs. After cooling the mixture, residual $K_2Cr_2O_7$ was quantified by titration with 33.3 mM ferrous sulfate ($Fe(NH_4)_2(SO_4)26H_2O$) and 1% diphenylamine in an acid medium as indicator. A blank was added with 50mL of potassium sulfate 0.5 $mol.L^{-1}$ (without the soil). The carbon of the microbial biomass was calculated using the formulas:

Oxidizable C :($mg.g^{-1}$C of soil) =

$$((Br-A)xN0{,}003x50x106)/(8xP) \quad (2)$$

where:

Br = volume used in titration of the control

A = volume used in titration of the sample

N = exact normality of ammoniacal ferrous sulphate

0,003 = meq of C

50 = extrator volume

8 = aliquot volume

DW = dry wheight of the sample

106 = conversion factor to mg C

Carbon of Microbial Biomass (CMB) ($mg.g^{-1}$ C)

$$Cmic=(CF-CNF).kc \quad (3)$$

where:

FC = Fumigated carbon

NFC = Non fumigated carbon

Kc = 2,78 (correction factor)

2.2.3 Total Organic Carbon

The organic C of the soil was determined by the method described by Embrapa (1997). This principle is based on the oxidation of organic matter in a humid way with potassium dichromate ($K_2Cr_2O_7$, 0.4N) in a sulfuric medium, using the heat given off by the sulfuric acid and/or heating as an energy source. The excess dichromate after oxidation was titrated with a standard solution of ammoniacal ferrous sulfate [(Fe (NH4) 2 (SO4) 2.6H2O, 0.1N] (Mohr's salt).

20g of soil were sieved through an 80 mesh sieve and 0.5g of that soil was removed and placed in a 250 ml conical flask. 10ml of 0.4N potassium dichromate solution was added. A blank with 10ml of the potassium dichromate solution (without the soil) was included. Erlenmeyers were taken to the condenser and on an electric plate until the boil was mild, for 5 minutes. It could cool and 80 ml of distilled water, 2 ml of orthophosphoric acid and 3 drops of the diphenylamine indicator were added. It was titrated with 0.1N ammoniacal ferrous sulfate solution. Organic C was calculated using the formula:

$$C\ (g.kg^{-1}) = [40 - (\text{volume used} \times f)] \times 0.6 \quad (4)$$

where:

f = 40/volume of ferrous sulfate used in white

2.2.4 Metabolic Quocient (qCO_2) and Microbial Quocient (qMic)

From the results of the basal respiration of the soil, samples and of the Cmic, the metabolic quotient (qCO_2) that represents the amount of C-CO_2 evolved per unit of microbial C (mg C-CO_2.hour^{-1}.mg C-biomass.g^{-1} dry soil) was calculated (Anderson & Domsch, 1993). The microbial quotient was calculated according to Anderson and Domsch (1993), by the relationship between carbon of microbial biomass and total organic carbon, expressed in micrograms of C-CO_2 per microgram of Cmic.

2.2.5 Chemical Analisys

The chemical analyzes were carried out at the Soil Physics and Fertility Laboratory by the methods of Embrapa (1997).

2.2.6 Experimental Design and Statistical Analysis

Analysis of variance (ANOVA) was performed to verify the differences between the means of the microbiological attributes of the soil and, when these occurred, the Scott-Knott test (5%) was applied (Ferreira, 2014). Pearson's correlation test (Sigmaplot 11.0) was performed with the average values of chemical and biological attributes.

3. Results and Discussion

3.1 Carbon of Microbial Biomass

The variation obtained in the CMB contents in the soils were 3.06 to 4.00 mg of C.g^{-1} for NR,

3.02 to 3.42 for MC and 3.14 to 3.27 for SC (Table 1). For the accumulated results, there was a higher value for NR. The observed levels probably reflect better environmental conditions for the development of the microbial population.

Table 1. Carbon of microbial biomass (μg.C.g^{-1}) in a cohesive Yellow latosol under different land use systems

LUS[2]	Collects				
	1	2	3	4	5
NR[3]	4.00 aA[1]	3.06 aB	3.27 aB	3.37 aB	3.21 aB
MC[4]	3.22 bA	3.02 aA	3.42 aA	3.38 aA	3.29 aA
SC[5]	3.15 bA	3.27 aA	3.19 aA	3.19 aA	3.14 aA

[1]Means followed by the same letter do not differ statistically by Tukey test ($p<0.05$). [2]Land Use Systems. [3]Native Rainforest. [4]*Mimosa Cesalpiniifolia*. [4]Sugarcane.

In areas under native vegetation, among the factors responsible for conditions more favorable to microbial biomass, the following stand out: lack of soil preparation and greater floristic diversity. In addition to favoring the preservation of fungal hyphae, and the accumulation of litter on the soil surface, the absence of soil disturbance also results in a greater presence of roots, which increase the entry of carbon substrates into the system, via root exudates (Moreira & Siqueira, 2006). The floristic diversity of native areas and the presence of vegetation throughout the year influence the quantity and quality of litter, the sum of these factors contributes to the occurrence of higher levels of biomass in these areas.

In addition, there is a greater diversity of organic compounds deposited in the rhizosphere, which is a factor favorable to the survival and growth of different groups of soil microorganisms. In this sense, the abundance of decomposing microorganisms can contribute to further stimulate their saprophytic and predatory microfauna.

In this way, the different conditions of the soil under forest vegetation, together with the absence of disturbances resulting from anthropic activity, make it possible to have greater amounts of CBM, indicating the greater balance of the soil microbiota in this ecosystem (Pôrto et al., 2009; Ferreira et al., 2010; Silva et al., 2019). Nunes et al. (2009) and Ferreira et al. (2010) verified, through multivariate analysis, that among the biological attributes of the soil, CMB was the one that most contributed to the separation of the forest from areas under different uses.

3.2 Basal Respiration and Metabolic Quociente qCO_2

The F test at 5% probability detected significant differences between the collection times. For the results accumulated CO_2 evolution, there were no differences between areas, the observed

variations occurred between collections (Figure 1). The values ranged from 77.00 to 55.70 µg.kg-¹ CO_2 for NR, 80.30 to 55.20 for the MC, and while in the area under SC the values ranged from 80.30 to 49.56 µg.kg^{-1} CO_2 (Figure 1). Q-CO_2 remained practically stable throughout the collection periods; however, a significant effect of the interaction was observed (Table 2).

Figure 1. Basal respiration in a cohesive Yellow latosol under different land use systems.

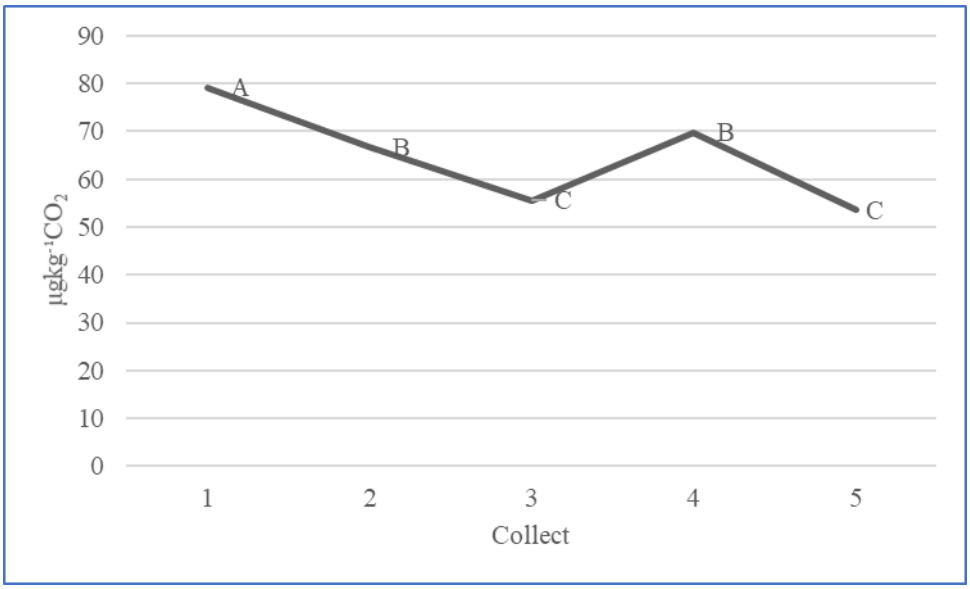

Table 2. qCO_2 in a cohesive Yellow latosol under different land use systems

LUS[2]	Collect				
	1	2	3	4	5
NR[3]	2.75 bB[1]	7.18 aA	5.75 aA	5.61 aA	5.96 aA
MC[4]	7.09 aA	8.48 aA	4.34 aB	5.45 aB	5.46 aB
SC[5]	7.59 aA	6.29 aA	6.59 aA	6.74 aA	5.98 aA

[1]Means followed by the same letter do not differ statistically by Tukey test ($p<0.05$) – Capital letters in the lines, lower case letters in the columns. [2]Land Use Systems. [3]Native Rainforest. [4]*Mimosa cesalpiniifolia*. [4]Sugarcane.

The different types of residues in the soil, in different amounts, alters the behavior of the microbiota, being able to stimulate or inhibit its activity, mainly in relation to the processes of transformation of organic matter and the cycling of nutrients and the exchange interactions with most of the plant species, especially those of agricultural importance (Moura et al., 2015).

The qCO_2 resulting from the specific respiration of the soils represents the amount of CO_2 released per unit of microbial biomass in a time, low values of qCO_2 indicate more stable agroecosystems, providing more favorable conditions for the development of microorganisms, related to the non-overturning of the soil. Soil and mulching, such as less disruption of the fungi hyphae, protection of microbial habitat, increased soil moisture content and less extreme temperature conditions (Rhoton, 2000; Pereira et al., 2007). Higher qCO_2 values indicate higher losses of C in the system in the form of CO_2 per unit of microbial C (Melloni

et al., 2001). According to Martins et al. (2010), increases in qCO_2 values are related to the response to microbial biomass mineralization.

The greater release of qCO_2 is generally associated with greater biological activity, which in turn is directly related to the amount of labile carbon in the soil. However, the interpretation of the values of biological indicators must be made with discretion, since high microbial activity does not always indicate desirable conditions: in the short term it can mean release of nutrients from the plants and, in the long term, loss of organic carbon from the soil into the atmosphere. Thus, high basal respiration values can indicate disturbance situations as well as a high level of system productivity.

Pereira et al. (2007) and Ferreira et al. (2010) observed a higher qCO_2 in the soil under conventional tillage than in no-tillage. As microbial biomass becomes more efficient in the use of ecosystem resources, less CO_2 is lost through respiration and a higher proportion of carbon is incorporated into microbial tissues, resulting in a decrease in qCO_2 lower values of qCO_2 indicate more stable LUS. Direct seeding provides more favorable conditions for the development of microorganisms, related to the non-revolving soil and mulching, such as less disruption of the fungi hyphae, protection of the microbial habitat, increased soil moisture content and extreme soil conditions (Rhoton, 2000; Pereira et al., 2007), such as water and temperature.

3.3 Total Organic Carbon and microbial Quocient (qMic)

The total organic carbon under rainforest was higher than in cultivated soil (Table 3), probably due to the large contribution of organic residues, non-revolving soil, and reduced water erosion due to the greater coverage of the soil by the litter. According to Jakelaitis et al. (2008), the decrease in total organic carbon in soils under cultivation may also be due to the increase in the consumption of carbon readily available by microbial biomass and, also, by the management adopted.

Table 3. Total organic carbon in a cohesive Yellow latosol under different land use systems

LUS[2]	Collect				
	1	2	3	4	5
NR[3]	35.63 bB[1]	39.29 aA	39.37 aA	39.32 aA	38.67 aA
MC[4]	39.67 aA	39.73 aA	39.84 aA	38.67 aA	39.57 aA
SC[5]	35.47 bB	38.22 aA	39.04 aA	38.71 aA	38.47 aA

[1]Means followed by the same letter do not differ statistically by Tukey test ($p<0.05$) – Capital letters in the lines, lower case letters in the columns. [2]Land Use Systems. [3]Native Rainforest. [4]*Mimosa cesalpiniifolia*. [4]Sugarcane.

The highest *q*Mic were found in the first collection for LUS NR (Table 4). Values above those reported were found in soils under different use systems in previous studies. For example, variations from 0.76 to 1.59% were found in soils under no-tillage and conventional tillage with rotated crops (Ferreira et al., 2010), and from 1.3 to 2.5% in forest soils or under conventional and organic agricultural crops 179 (Moscatelli et al., 2007). Pôrto et al. (2009) observed values of 1.10, in soils under sugarcane cultivation. Higher values for this attribute

indicate that a greater part of organic carbon is a constituent of microbial biomass. However, these attributes are also influenced by edaphoclimatic conditions.

Table 4. *q*Mic in a cohesive Yellow latosol under different land use systems

LUS[2]	Collect				
	1	2	3	4	5
NR[3]	8.25 aA[1]	3.47 aB	5.57 aB	6.42 aB	4.60 aB
MC[4]	4.59 bA	3.15 aA	7.31 aA	6.72 aA	5.25 aA
SC[5]	4.26 bA	6.03 aA	5.95 aA	4.30 aA	3.66 aA

[1]Means followed by the same letter do not differ statistically by Tukey test ($p<0.05$) – Capital letters in the lines, lower case letters in the columns. [2]Land Use Systems. [3]Native Rainforest. [4]*Mimosa cesalpiniifolia*. [4]Sugarcane.

For LUS rainforest, *q*Mic showed significantly positive correlations with biomass (r = 0.90 and TOC (r = 0.91) (Table 5) indicating that this biological attribute is influenced by the availability of total organic C and of the microbial biomass in the soil. In fact, to carry out its metabolic processes, the soil microorganisms need nutrients and energy, which are obtained from the organic matter contained in the soil, so in soils with higher TOC levels, microbial density and activity tend to be higher. In LUS MS, biomass correlated positively with qCO_2 (r = 0.96) and, with microbial biomass (r = 0.98), which shows CMB as a good biological attribute to assess soil use conditions. Especially because this biological attribute. Especially since this biological attribute can detect differences in the two environments, including at different collection times. In fact, CMB is one of the biological parameters most sensitive to changes in the soil environment, so it has been widely used to assess the impacts of different systems of use on the soil microbiota.

Table 5. Pearson's correlation coefficients between soil microbiological attributes.

LUS	Attributes	Basal respiration	Biomass	TOC	qCO_2	*q*Mic
NR	Basal respiration	1				
	Biomass	0,8781^{ns}	1			
	TOC	0,685^{ns}	0,7322^{ns}	1		
	qCO_2	-0,3106^{ns}	-0,6963^{ns}	-0,2745^{ns}	1	
	*q*Mic	0,8640^{ns}	0,9004*	0,9158*	-0,3922^{ns}	1
MC	Basal respiration	1				
	Biomass	-0,5627^{ns}	1			
	TOC	-0,2548 ^{ns}	-0,3601^{ns}	1		
	qCO_2	0,7613^{ns}	0,9626**	0,9791**	1	
	*q*Mic	-0,5994^{ns}	0,2059^{ns}	-0,3584^{ns}	0,9487*	1
SC	Basal Respiration	1				
	Biomass	0,1451^{ns}	1			
	TOC	-0,7563^{ns}	0,3436^{ns}	1		
	qCO_2	0,8255^{ns}	-0,2737^{ns}	-0,7950^{ns}	1	
	*q*Mic	-0,2159^{ns}	-0,6799^{ns}	0,0410^{ns}	0,3378^{ns}	1

The results for the sugarcane (LUS SC) showed that the biological attributes of the soil

provide variable responses as a function of management practices in perennial agricultural crops such as sugarcane. The values observed for this LUS in reflect the management of the soil used in this area, where it does not occur when burning straw and is harvested without using machines (Montaldo et al., 2018). In addition, the residues of this culture are deposited on the soil, which increases the levels of organic carbon and favors microbial biomass and its metabolic processes.

Through the analyzed data it was possible to observe a higher count of ammonifying bacteria was observed in NR soil ranging from 160.883 to 42.56 MPN, decreasing from the third collection, which also reflects in the occurrence of this group of microorganisms. Greater stability was observed in sugarcane crop with 42.56 MPN, and an occurrence of 0.034 in all collections without showing variations or oscillations (Table 6).

Table 6. Most probable number and probability of occurrence of ammonifiers bacteria in a cohesive Yellow latosol under different land use systems

LUS[1]	Collect	MPN[5]x10^5.g^{-1}	Probability (%)
NR[2]	1	160.88	40.96
	2	160.88	40.96
	3	42.56	0.03
	4	42.56	0.03
	5	42.56	0.03
MC[3]	1	42.56	0.03
	2	34.53	0.35
	3	160.88	40.96
	4	21.21	0.05
	5	160.88	40.96
SC[4]	1	42.56	0.03
	2	42.56	0.03
	3	42.56	0.03
	4	42.56	0.03
	5	42.56	0.03

[1]Land Use System. [2]Native Rainforest. [3]*Mimosa cesalpiniifolia*. [4]Sugarcane. [5]Most Probable Number.

The higher N richness in the cultivated soils is associated with continuous nitrogen fertilization thereof (Wolinska et al., 2016), as observed in the sugarcane crop. Li and Lang (2014) indicating a similar trend noted in uncultivated and cultivated black soil. Similar results were showed by Zhang et al. (2013) when analyzing woodland and agricultural soils.

As for the presence and occurrence of cellulolytic fungi, the soil cultivated with sugarcane had the lowest count and occurrence, however, there was no instability throughout the collections (Table 7). This is due to the environment being highly controlled through the treatment of culture. The other two environments showed fluctuations in their counts throughout the collections, with variations from 34,531 to 1,071 MPN for NR, and 14,788 to 2,161 MPN for MC.

Table 7. Most probable number and probability of occurrence of cellulolytic fungi in a cohesive Yellow latosol under different land use systems

LUS[1]	Collect	MPN[5]x10[5].g^{-1}	Probability (%)
NR[2]	1	25.26	0.03
	2	34.53	0.35
	3	2.31	16.64
	4	1.07	10.45
	5	3.86	0.01
MC[3]	1	14.78	0.01
	2	4.52	5.20
	3	2.16	6.52
	4	10.85	11.03
	5	4.26	0.16
SC[4]	1	8.38	0.04
	2	8.38	0.04
	3	8.38	0.04
	4	8.38	0.04
	5	8.38	0.04

[1]Land Use System. [2]Native Rainforest. [3]*Mimosa cesalpiniifolia*. [4]Sugarcane. [5]Most Probable Number.

The efficiency in the production of certain enzymes by soil and rhizosphere microorganisms is of considerable importance from an ecological point of view (Almeida et al., 2020). In non-anthropized environments and with litter input from native vegetation, it is common to have greater biological activity, especially due to the existence of other edaphic organisms acting on the decomposition of organic matter. These characteristics favor the development of microorganisms with high capacity and enzymatic activity, as is the case of cellulolytic fungi presented here.

4. Conclusions

Adoption of sustainable management, such as the absence of burning, associated with the maintenance of crop residues on the soil surface favor the biological properties of the soil. Greater stability in the biological edaphic properties contributes to the maintenance of the carbon stock in the soil in these environments.

The presence and occurrence of ammonifying and cellulolytic microorganisms demonstrates the existence of functional microorganisms in the studied environments, and greater evidence in non-anthropized environments.

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