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Production systems and their impacts on the physical and microbiological characteristics of the soil in the Cerrado of Mato Grosso[1]

Oksana Aparecida de Lara Hungaro[2], Marco Antonio Camillo de Carvalho[3], Roberto Antonio Savelli Martinez[4], Cassiano Garcia Roque[5], Rivanildo Dallacort[6]

ABSTRACT - The physical and microbiological characteristics of the soil are indicators considered in the assessment of the conditions of anthropized areas and are tools to identify levels of degradation, define the best crops, and thus, propose actions that help the producer to choose the appropriate soil management. In this regard, the aim of this work was to analyze the physical and microbiological properties of the soil in different agricultural production systems and in a preserved area. The research was carried out at a property located in the municipality of Campo Novo do Parecis - MT, Cerrado`s Biome. For the physical analysis, samples at depths of 0-0.10 m, 0.10-0.20 m and 0.20-0.30 m in five locations were collected randomly, within each production system and in the forest fragment. To evaluate the microbial activity of the soil, soil samples were collected at the 0-0.10 m layer also in five locations. All uses showed changes in physical characteristics, when compared to natural conditions. In the microbiological analysis, the integrated systems did not present significant differences in relation to the organic matter and the basal respiration of the soil when compared with the conventional systems and the forest fragment. The carbon of the microbial biomass of the soil and the metabolic quotient showed a difference between the systems of use and the preserved area.

Key words: Agro-Livestock systems. Soil quality. Soil analysis. Indicators.

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Editor-in-Chief: Prof. Tiago Osório Ferreira - toferreira@usp.br
*Author for correspondence
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[1]PART OF MASTER'S DISSERTATION - Interdisciplinary Postgraduate Program in Environment and Agricultural Production Systems – PPGASP
[2]State University of Mato Grosso (UNEMAT), Tangará da Serra-MT, Brasil, oksana.hungaro@unemat.br (ORCID ID 0000-0003-4366-4520)
[3]State University of Mato Grosso (UNEMAT), Alta Floresta-MT, Brasil, marcocarvalho@unemat.br (ORCID ID 0000-0003-4966-1013)
[4]State University of Mato Grosso (UNEMAT). Tangara da Serra-MT, Brasil, robertosavelli@unemat.br, robertosavelli@unemat.br (ORCID ID 0000-0001-8059-4280)
[5]Federal University of Mato Grosso do Sul (UFMS), Chapadão do Sul-MS, Brasil, cassiano.roque@ufms.br (ORCID ID 0000-0001-6872-0424)
[6]State University of Mato Grosso (UNEMAT), Tangará da Serra-MT, Brasil, rivanildo@unemat.br (ORCID ID 0000-0002-7634-8973)

INTRODUCTION

The state of Mato Grosso has approximately 37% of its area dedicated to agricultural production and 62% is preserved. Forty percent (40%) of the total territory belongs to the Cerrado Biome where 46% is destined for agribusiness and other activities that modify soil attributes. The state stands out in agricultural and Forty per cent production, being considered the largest soybean producer in the country in the 2020/2021 harvest, producing 35.7 million tons. (CONAB, 2021; IMEA, 2020).

To produce, the soil must have conditions to be cultivated; however, it is multifunctional, as in addition to being used for human activities such as agricultural production, it is also responsible for maintaining the survival of ecosystems. However, when the soil is used incorrectly, degradation occurs, resulting in total or partial loss of productivity, which is evidenced by erosion, soil compaction, decrease in organic matter and other factors that can cause damage depending on the characteristics of the soil biomes (MARTINS; FERNANDES, 2017).

When the soil is preserved, its characteristics do not present changes caused by anthropization, however, when it is anthropized the soil presents changes on its properties, which are unfavorable for plant development. However, systems that cultivate plants intensively, without disturbing the soil, benefit the quality and preservation of its characteristics, that is, its structure is linked to the phytomass that is made available to the system (ASSIS *et al*., 2015; MOREIRA *et al*., 2014).

The physical attributes of the soil, according to Assis *et al*. (2015), are used by researchers as indicators to analyze existing differences in the soil in areas with different land use systems. For Carvalho *et al*. (2016), integrated production systems promote improvements in the physical characteristics of the soil in the long term as they increase macroporosity in areas with pasture, and microporosity in all areas, in addition to reducing soil density. The combination of integration methods with no till planting, crop rotation and grazing with adjusted load favors soil fauna.

Among the biological properties, microbial activity can be highlighted, which, like other metabolic processes, is dependent on the physiological state of the microbial cell and influenced by several soil factors, such as humidity, temperature, structure, nutrient availability, texture, C/N ratio and the presence of organic residues. Integrated systems have positive characteristics that can reduce these likely damages to the soil (STEINKE, 2016).

Soil Basal Respiration – SBR and metabolic quotient – qCO2 are also considered sensitive indicators capable of providing accurate information about microorganisms. SBR can be defined as the sum of all metabolic functions that produce CO2. This production occurs during the process of degradation of organic matter present in the soil, that is, the two indicators are interconnected and vary together (SILVA *et al*., 2007).

Considering the efficiency of the aforementioned indicators, this research aimed to analyze the physical properties of the soil, the organic matter content and the microbial characteristics in different agricultural production systems in relation to natural conditions on a property located on the Mato Grosso savanna.

MATERIAL AND METHODS

The experiment was conducted on a property located in the municipality of Campo Novo do Parecis – MT, located at 450 km from the state capital, Cuiabá, between the coordinates -13°49’00.18916” S and -57° 39’20 .46096” W (Figure 1). The average altitude of the property is 588 m, it is located in the Cerrado Biome, with an annual rainfall average of 1900 mm, an annual temperature average of 33 ºC. The property’s soil classification is predominantly as RED OXISOL with a medium-clay texture, which comprises the sandy clay loam textural class and flat relief.

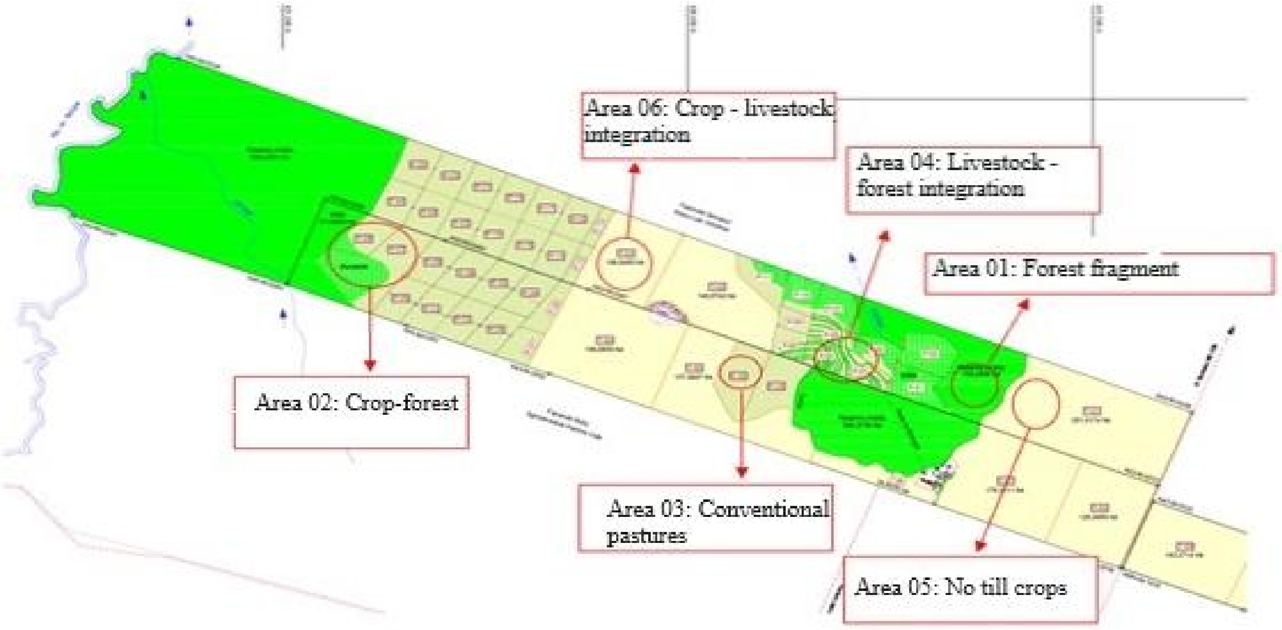
The research unit works with the cultivation of crops, livestock and forestry, where crops are explored individually and integrated, in addition to the integration involving the systems of “Forest-Livestock Integration”, “Crop-Forest Integration”, agricultural planting in the “No Tillage Cropping System” and “Conventional Livestock Farming”. The integrated production system was implemented on the property in 2012, with 650 ha of “Crop-Livestock Integration”.

The main agricultural crops worked in the company are soybeans and corn, however, in 2019, cotton began to be planted. Millet cultivation was also used as a cover crop in 2019 and is eventually used for this purpose. Livestock farming began on the property in 2014, and the company only operates in the rearing and fattening phases. The pastures are formed by Zuri grass (*Panicum maximum* cv. Zuri) and Piatã grass (*Urochloa brizantha* cv. Piatã). Forestry production has existed for eight years and is made up of eucalyptus forests, with the hybrids *Urocam* (*E. urophylla x E. camaldulensis*) and *Urograndis* (*E. grandis x E. urophylla*) being cultivated.

Figure 1 shows the floor plan of the property, generating a sketch where each research area is identified with the nomenclature of the treatments.

In order to have greater knowledge about the areas under study, a historical survey of the areas researched was carried out (Table 1), considering the period of the last four years, corresponding to the period between 2016 and 2020.

Figure 1 - Sketch of the property demarcating the sample collection areas for soil analysis



Source: Property data adapted by the author, 2020

Table 1 - History of the areas used as treatments in the research

Areas	Year 2020 (February)	Year 2019	Year 2018	Year 2017	Year 2016
Área 01 – Forest fragment	Native forest	Native forest	Native forest	Native forest	Native forest
Área 02 – Crop forest	Soybean crop (renovating pasture) + eucalyptus forest.	Livestock (piatã grass).	Livestock (piatã grass)	Livestock (piatã grass).	Livestock (piatã grass).
Área 03 – Conventional pastures	Livestock Zuri grass.	Livestock Zuri grass	Livestock Zuri grass	Soybean	Soybean
Área 04 – Livestock forest integration	Livestock (piatã grass) eucalyptus forest.	Livestock (piatã grass) eucalyptus forest	Livestock (piatã grass) eucalyptus forest	Livestock (piatã grass) eucalyptus forest	Livestock (piatã grass) eucalyptus forest
Área 05 – No till crops	Soybean harvest, 2nd corn harvest in intercrop with sunn hemp.	Soybean harvest, 2nd cotton harvest.	Soybean harvest, 2nd corn harvest.	Soybean harvest, 2nd corn harvest.	Soybean harvest, 2nd corn harvest.
Área 06 – Crop livestock integration	Crop Integration soybean harvest, Livestock 2nd harvest.	Crop Integration soybean harvest, Livestock 2nd harvest.	Crop Integration soybean harvest, Livestock 2nd harvest..	Crop Integration soybean harvest, Livestock 2nd harvest.	Crop Integration soybean harvest, Livestock 2nd harvest.

Source: Property data, adapted by the author, 2020

The experiment was carried out in a completely randomized experimental design (DIC). Was executed in a 6 x 3 factorial scheme, with six areas with different uses as study factors: (1) Forest Fragment – FF; (2) Crop-Forest - CF; (3) Conventional Livestock - L; (4) Forest-Livestock - FL; (5) No tillage cropping system - NTCS and (6) Crop-Livestock - CL and three sampled soil depths (0-0.10 m, 0.10-0.20 m and 0.20-0.30 m).

Table 2 - Characterization of treatments and numbers of samples

nº of treatments.	Land use and occupation (treatment)	Number of samples for analysis
1	Forest Fragment – FF	5
2	Crop-Forest – CF	5
3	Conventional Livestock – L	5
4	Forest Livestock – FL	5
5	No Tillage Cropping System – NTCS	5
6	Crop-Livestock– CL	5

Source: by the author, 2020

The physical characteristics of the soil determined were macroporosity (Ma), microporosity (Mi), total porosity (Pt) and soil density (Ds). For each use, aiming to determine the physical characteristics of the soil, five replications were collected at three different depths, totaling 90 samples. The collection of undisturbed samples was carried out manually, with the aid of a soil core sampler and volumetric rings measuring 0.05 m in height and 0.05 m in diameter.

To carry out the soil porosity analysis, the tension table method was used, adapted from Kiehl (1979).

Referring to macropores, they were determined using the following equation (EMBRAPA, 1997):

$$MAC\left(m^3m^{-3}\right)=\frac{Msaturado-M\,60cm}{Vanel} \quad (1)$$

The volume of soil micropores was obtained using the following equation (EMBRAPA, 1997):

$$MIC\left(m^3m^{-3}\right)=\frac{M\,60cm-M\,\sec o}{Vanel} \quad (2)$$

To analyze the total porosity of the soil, the formula was used:

$$Ptot\left(m^3m^{-3}\right)Mac+Mic \quad (3)$$

To determine soil density, the mass of the sample completely dried in an oven at 105º C was used. To obtain this information, the following equation was used (EMBRAPA, 1997):

$$Ds\left(Mgm^{-3}\right)=\frac{M\,\sec o}{Vanel} \quad (4)$$

The results obtained in all determinations were subjected to variance analysis (F test) and means test, using the Scott-Knott at 5%, with the aid of the Sisvar Statistical Program (FERREIRA, 2011).

For microbiological analysis, the experimental design used was also completely randomized (DIC), used in the six areas with different uses. In Table 2, there is a list of treatments that were analyzed with their respective numbers of samples collected for experimental determinations.

For each use, aiming to determine the microbiological characteristics (basal soil respiration - SBR, organic-C, qCO2 and soil organic matter) samples were collected at a depth of 0-0.10 m at five different points in each area. The area called forest fragment – F, was used as a control for the other treatments, as it was considered an area that has no apparent anthropization.

The analyzes were carried out at the Soil and Leaf Analysis Laboratory University of the State of Mato Groso – UNEMAT, Alta Floresta Campus, adopting the procedures proposed by Silva *et al*. (2007) to determine SBR, organic-C and qCO2 and for soil organic matter, the methodology proposed by (EMBRAPA, 2009) was followed.

The results obtained were subjected to a variance analysis using the F test, and when significant, the Skott Knott mean test was applied with the aid of the statistical software SISVAR (FERREIRA, 2011).

RESULTS AN DISCUSSION

Soil Physical Analysis

In Table 3, it is possible to identify that there was a difference for all the variables analyzed for use and depths, as well as a significant interaction between them.

The unfoldings obtained for the physical characteristics of the soil between uses and depths are found in Table 4.

Macroporosity at the 0-0.10 m and 0.10-0.20 m layers was greater in the forest fragment (Table 4), indicating that all other uses presented lower values for this indicator at these depths, a result similar to that of Sales *et al*. (2016) who identified the highest macroporosity in native forest in red-yellow latosol. There are changes in the size of soil pores resulting from management, where there is a reduction in macropores. This factor generally occurs due to the decrease in organic matter in the soil (MAGALHÃES, 2018), a fact that normally happens with the use of soil for agriculture and/or livestock.

Table 3 - Mean square values and coefficient of variation (CV%) for macroporosity (Macro), microporosity (Micro), total porosity (Total) and soil density as a function of different uses and depth

	Macro	Micro	Total	Density
Uses (u)	389.36**	939.14**	802.39**	0.65**
Depth (p)	13.67*	46.31**	15.09*	0.01*
u x p	15.10**	9.23**	8.88*	0.01**
CV(%)	17.53	6.57	5.17	4.41

Note: * and ** correspond respectively to 5% and 2% significance using the f test

Table 4 - Unfoldings of the interaction between land uses and depth for macroporosity, microporosity, total porosity and soil density. Campo Novo do Parecis (2020)

Uses	Depth (p) (m)		
	0-0.10	0.10-0.20	0.20-0.30
	Macroporosity (cm^3 cm^{-3})		
F	0.185 a A	0.184 a A	0.144 b B
CF	0.156 b A	0.159 b A	0.163 a A
L	0.068 c B	0.117 c A	0.129 b A
FL	0.065 c A	0.083 d A	0.074 c A
NTCS	0.056 c A	0.055 d A	0.064 c A
CL	0.052 c A	0.065 d A	0.048 c A
	Microporosity (cm^3 cm^{-3})		
F	0.328 c A	0.320 b A	0.338 a A
CF	0.178 f A	0.150 e B	0.139 d B
L	0.218 e A	0.179 d A	0.178 c A
FL	0.337 b A	0.312 b B	0.305 b B
NTCS	0.371 a A	0.343 a B	0.332 a B
CL	0.292 d A	0.277 c A	0.297 b A
	Porosity Total (cm^3 cm^{-3})		
F	0.503 a A	0.504 a A	0.483 a A
CF	0.334 d A	0.310 d B	0.303 d B
L	0.286 e A	0.296 d A	0.308 d A
FL	0.402 c A	0.395 b A	0.379 b A
NTCS	0.427 b A	0.398 b B	0.396 b B
CL	0.344 d A	0.342 c A	0.346 c A
	Density (g cm^{-3})		
F	0.98 a A	1.06 a B	1.17 a C
CF	1.56 c A	1.60 d A	1.62 d A
L	1.68 d A	1.64 d A	1.58 d A
FL	1.39 b A	1.46 c A	1.44 c A
NTCS	1.33 b A	1.37 b A	1.37 b A
CL	1.54 c A	1.55 d A	1.54 d A

Note: Averages followed by the same letter, uppercase in the row and lowercase in the column do not differ from each other at the 5% level using the Scott-Knott test. Forest Fragment – F; CF – Crop-Forest; L – conventional Livestock Farming; FL – Forest Livestock; NTCS – No Tillage Crop System and CL – Crop- Livestock

For the depth of 0.20-0.30 m, the greatest macroporosity was observed in the use of crop-forestry, a fact that may have occurred due to the root development of the trees in this system, litter decomposition produced by the trees and/or the soil preparation carried out when the crop was planted, since pasture was already cultivated in the area until 2019 and the crop was implemented in 2020. This can also be seen at the 0-0.10 m and 0.10-0.20 m layers where in CF there was also the presence of a greater amount of MAC compared to all other systems (L, FL, NTCS and CL).

In the CF, FL, NTCS, and CL systems, there was equality in macroporosity between depths, a fact not observed in the forest fragment, in which the first two depths are similar and higher than the greatest depth. The lowest macroporosity in the 0.20-0.30 m layer observed in F occurs naturally, as soil density increases from this layer onwards.

In conventional livestock farming, the lowest macroporosity was observed in the most superficial layer. The results obtained in this experiment are similar to those of Centurion *et al*. (2007), who comment that this difference in behavior between the uses and the forest fragment can be explained by the fact that there was soil preparation in the uses when it was implemented. This must have caused the homogenization of the layers, and the smaller macroporosity in the surface layer in conventional livestock farming due to animal trampling.

The results corroborate those obtained by Sales *et al*. (2016), who stated that the reduction in macroporosity in cultivated soils can be caused by machine traffic, a decrease in total organic carbon and other activities that cause anthropization. Such compaction was also evidenced by the increase in density in the use systems in relation to the forest fragment, since according to Oliveira and Moniz (1975), preserved dystroferric and eutroferric Red Oxisols must present density values between 0.98 and 1. 13 kg dm^{-3} at depths of 0–0.30 m.

In relation to microporosity, at the three depths the use of CF presented the lowest values, indicating a large loss of micropores in that use. Regarding the depth values for each land use, it was noted that for forest fragments, conventional livestock farming and Crop-Livestock, there was no difference between depths.

For the CF, FL and NTCS, the largest volume of micropores was found in the most superficial layer, with a decrease of that microporosity in depth, indicating a loss of quality in those uses. On the other hand, it can be observed that the greatest microporosity was present in the NTCS. Although there is a high anthropic process in this production system, there is a process of crop rotation and mulch production, in addition to not disturbing the soil, which allows for a greater accumulation of organic matter throughout the entire soil profile, thus maintaining better soil structure throughout the profile when compared to all other uses, including the forest fragment.

According to Silva and Kay (1997), soil microporosity is intensely influenced by the texture and organic C content and little influenced by the increase in soil density, caused by the traffic of machines, implements and animal trampling, indicating that in the uses that differed of the forest fragment may be experiencing a loss of organic matter.

For total porosity, there was no difference between the depths in the forest fragment, conventional livestock, crop-forest and crop-livestock, while for forest farming and no tillage cropping system the greatest porosity was observed in the most superficial layer, which may have occurred due to crops cultivation in both areas.

At all depths, the loss of total porosity with the use of the soil was noticed, where in the forest fragment there was the greatest porosity. Total porosity can be considered ideal when the soil presents 50% (0.5 m^3 m^{-3}) of its total volume as porous space (LIMA *et al*., 2007), so it was noted that only the forest fragment presented values considered optimal for total porosity at the three depths analyzed

Among the systems where there is anthropization, the NTCS was the one that showed the least change in the total porosity of the soil, which allows for greater retention of water and solutes in the soil. The result may be linked to the fact that this soil is exploited by different types of root systems due to the diversity of crops used in it. That diversity can promote increased porosity in that use system.

Among the systems where there is anthropization, the NTCS was the one that showed the least change in the total porosity of the soil, which allows for greater retention of water and solutes in the soil in that use. The result may be linked to the fact that that soil is exploited by different types of root systems due to the diversity of crops used in it. That diversity can promote increased porosity in that use system.

The large decrease in total porosity in conventional livestock stands out, this fact can be attributed to the lack of soil disturbance, animal trampling and the absence of crop rotation (RESENDE *et al*., 2012). The crop in a no tillage cropping system showed a higher porosity index compared to other managements, such result can be attributed to the crop rotation existing in this use (soybeans, corn and cotton).

Following the same behavior of total porosity, the lowest soil density, at all depths, was observed in F, probably due to this area not being anthropized, having a diversity of plant species and micro and macrofauna, factors that, according to Resende *et al*. (2012) promote greater aeration and soil structuring, thus showing that this area has less compact soil than the others treatments, since soil density is used as an indicator of compaction, taking into account changes in structure and porosity of the soil.

Density showed an increase in all uses and all depths when compared to F. The uses with anthropization that resulted in lower density were FL and NTCS. In FL, the density was lower at the first depth and increased at depths of 0-0.20 and 0-0.30. The resulting increase in depth may be linked to the number of plants roots in the surface layer (0 – 0.10 m), since root development increases the number of pores and decreases density. These results corroborate the study by Abreu *et al*. (2015) who, in their research, found that the density was lower in the most superficial layer (0-0.20) and gradually increased according to depth.

For the NTCS use, the density was positive when compared to other uses, since in addition to being lower than all, it did not increase with depth, which corroborates the study carried out by Lima *et al*. (2007) in which the authors point out that the no tillage cropping system causes heterogeneity in the soil surface. The use of NTCS also has the positive fact of providing the soil with a greater accumulation of plant residues on the surface and in the depths, which, in turn, favors soil restructuring (SPERA *et al*., 2009).

Another relevant fact about density is that according to (OLIVEIRA; MONIZ, 1975) all use systems present altered density, since the result considered ideal for dystroferric and eutropherric Red Oxisols is between 0.98 and 1.13 kg dm^{-3} at depths of up to 0–0.30 m. However, the FF presented values considered adequate. In the study, it is possible to note that in the forest fragment there was an increase in density with increasing depth, while for other uses the density did not differ between depths, indicating the presence of compaction up to the deepest layer in systems with production.

Of the three treatments that include livestock farming in the production system, the one with the highest density was conventional livestock, followed by crop-livestock and forest-livestock, degressively. This fact is in line with research results by Abreu *et al*. (2015) and Carvalho *et al*. (2016) who point out that the density in traditional livestock systems is greater than in integrated production systems, since in the integrated systems there is the presence of legumes wich have a deeper root system.

Analyzing the soil organic matter content (Table 5) of the uses researched, it is possible to verify that there was no significant difference between them. The type of fractionation of this organic matter may have an influence on this result, in addition to the C/N ratio of this organic matter being different for each use (COTTA *et al*., 2006).

Table 5 - F values, coefficient of variation, organic matter (OM) content. Campo Novo do Parecis – MT (2020)

Uses	OM Content (g kg^{-1})
FF	32.46a
CF	26.06a
L	35.69a
FL	29.79a
NTCS	37.18a
CL	32.58a
F Value	2.13^{ns}
CV(%)	23.22

Note: Means followed by the same letter do not differ from each other at the 5% level using the Scott-Knott test. FF – Forest Fragment; CF – Crop-Forest; L – Conventional Livestock; FL – Forest Livestock; NTCS – No Tillage Cropping System; and CL – Crop-Livestock. *Data transformed into $\sqrt{x}$

In relation to the organic matter content of the soil presented in Table 5, no significant difference was observed between the land use systems, demonstrating that no significant losses of organic matter are occurring. Those results prove that the use of integrated soil management can contribute to improving biological, physical and chemical attributes, noting that they promote an increase in carbon and nitrogen, especially in areas that work with no tillage cropping system (SALES *et al*., 2016). In the study by Souza *et al*. (2009), the authors found that integrated crop-livestock systems under no tillage cropping systems promote an increase in CO and N stocks in soil organic matter, thus increasing the soil's productive capacity.

Microbiological analysis

It was observed that basal respiration – SBR did not present significant variation between the production systems and the forest fragment (Table 6). However, even though there were no significant differences, the forest fragment - FF and farming in no tillage cropping system - NTCS stood out. The area of the FF was considered intact, that is, it was not disturbed, however this area is located next to the area destined for farming in a no tillage cropping system – NTCS and may be being affected indirectly.

The basal respiration of microorganisms, that is, the energy expenditure they have to keep the population active, was not interfered by the integrated systems. Basal respiration refers to the activity of microorganisms in decomposing residues present in the soil and the convertion or immobilization into living cells (BELO *et al*., 2012). High values characterize energy loss and stressful conditions, while lower values indicate biomass efficiency in conversion and immobilization (CARNEIRO *et al*., 2008).

Table 6 - F values, coefficient of variation, organic matter content (MO), basal respiration (SBR), microbial biomass carbon (BMS-C) and metabolic quotient (qCO2) of the soil under different uses. Campo Novo do Parecis – MT (2020)

Uses	OM Content	SBR	BMS-C	qCO_2^*
	($g\ kg^{-1}$)	(mg $C\text{-}CO_2$ kg¹ soil)	(mg de C kg^{-1} soil)	(mgC-CO_2 kg^{-1} BMS-C)
FF	32.46a	107.75a	63.75 b	1.78 a
CF	26.06a	77.30a	138.75 a	0.58 c
L	35.69a	76.71a	161.25 a	0.48 c
FL	29.79a	98.97a	97.50 b	1.01 b
NTCS	37.10a	126.49a	90.00 b	1,55 a
CL	32.58a	87.25a	86.25 b	1.04 b
F Value	2.13^{ns}	2.29^{ns}	13.97**	9.39**
CV(%)	23.22	29.89	20.50	18.35

Note: Means followed by the same letter do not differ from each other at the 5% level using the Scott-Knott test. FF – Forest Fragment; CF – Crop-Forest; L – Conventional Livestock; FL – Forest Livestock; NTCS – No Tillage Cropping System; and CL – Crop-Livestock. *Data transformed into $\sqrt{\chi}$

When analyzing the BMS-C (Table 6), it was observed that the results were higher for CF and L, where there was no significant difference. The similar result for those two treatments may be linked to the fact that the area destined for crop-forest had been used for coventional livestock in previous years. The fact that the soil is not disturbed for preparation favors the preservation of the fungi that make up the majority of the soil's microbiota (REIS JÚNIOR; MENDES, 2007).

The treatments, FL, NTCS and CL, presented microbial biomass carbon considered indifferent to that of the FF used as control, and lower than CF and L. It was also observed that BSM-C presented the highest values for L and CF, a fact that may be linked to microbiota activity that seeks to balance itself depending on the time of adoption of the systems, where it can maintain or increase BSM-C values and reduce the values for SBR (BALBINO; BARCELLOS; STONE, 2011; STIEVEN, *et al*., 2020).

A contradictory fact was observed in relation to BMS-C in the forest fragment, where the result was inferior only for the CF and L and was equal to the other treatments. The result does not corroborate other studies related to analyzes and areas where no anthropization occurred, however, a study developed by Embrapa Cerrados in an area already deforested showed that after a year of deforestation the BMS-C reduced by 76% in relation to the area that it was in natural conditions (REIS JÚNIOR; MENDES, 2007).

Thus, there are assumptions that at some point that area considered intact may have been burned, may be suffering the edge effect caused by biotic and abiotic factors that directly interfere with the population of microorganisms in the soil (REIS JÚNIOR; MENDES, 2007).

In addition to the assumption raised previously, another factor that may have changed the results for the FF is the effect of the production systems bordering the area. Pesticide residues can cause changes in the soil microbiota and can even eliminate certain species. But on the other hand, in environments with high biological diversity, functional compensation may exist on the part of other species, a phenomenon called redundancy. (TAUK, 2018). This compensation can be observed when analyzing and checking basal respiration and the highest metabolic quotient existing for both FF and NTCS.

Considering the metabolic quotient, the FF and the NTCS presented equal results and greater than the other treatments, which may have a direct relationship with basal respiration – SBR, since according to some authors, when qCO2 presents high values, it may be an indication of stress conditions, since microorganisms tend to consume more substrate, resulting in greater energy expenditure to maintain the microbial community (GOMIDE; SILVA; SOARES, 2011; MELLONI *et al*., 2013).

It was noticeable that despite having a smaller microbial mass, the FF and NTCS had statistically equal but numerically higher basal respirations, thus indicating a much higher metabolism compared to the other systems. This can be proven by checking the highest metabolic quotients. If it is analized the C/N ratios of these two systems, it can be infered a lower ratios for them, which would indicate and confirm these higher metabolic quotients despite the lower microbial mass. This could also explain the equality of MO content despite the expectation of greater content in these two systems.

The decomposition process of MO with higher C/N ratios is normally greater under these conditions;

Table 7 - Pearson correlation values between organic matter (OM), basal respiration (SBR), microbial biomass carbon (BMS-C) and metabolic quotient (qCO2) of the soil under different uses. Campo Novo do Parecis – MT (2020)

Variables	SBR	BMS-C	qCO2
OM Content	0.494^{ns}	-0.118^{ns}	0.353^{ns}
SBR		-0.713^{ns}	0.874*
BMS-C			-0.909*

Note: ns and * respectively mean non-significant and significant at 5% using the Student t test, Finally, it can be verified in both physical and microbiological analyzes that there is a direct relationship between macroporosity, microporosity, total porosity, density, soil organic matter and the variables researched for microbiological analysis

Biodiversity in the FF system and crop rotation in the NTCS could have provided these conditions, which would explain the result of this experiment; higher metabolic quotients in these systems also indicate greater stress for these microorganisms, having to consume a greater amount of substrate for their survival and thus greater energy expenditure (REIS JÚNIOR; MENDES, 2007).

Another explanation for this result may be associated with the fact that high metabolic quotients are an indication of microbial communities in early stages of development and with a higher proportion of active microorganisms compared to inactive ones (ROSCOE *et al*., 2006). Subsequently, FL and CL also presented results considered similar. The treatments that presented the lowest percentage of metabolic quotient were CF and L.

In Table 7, it can be seen that organic matter was not significantly correlated with any of the soil's microbial characteristics and only qCO2 showed a positive correlation with SBR and a negative correlation with BMS-C, demonstrating that in the native area there may be some abiotic factor, damaging microbial activity and bringing stress to that environment.

CONCLUSIONS

1. All uses studied showed changes in the physical quality of the soil in relation to natural conditions. Among the use systems analyzed, the one that had the lowest impact, in relation to the physical indicators analyzed, was the no tillage cropping system, reinforcing the potential of this system for the physical conservation of the soil;
2. The BMS-C showed a difference between the use systems and values, contrary to those observed in most literature in relation to areas of the forest fragment, thus demonstrating the need for a more in-depth analysis that covers soil chemical indicators as well as possible factors of abiotic anthropization, in addition to considering analyzes on microbiological diversity. The metabolic quotient showed differences between the treatments, confirming that in the FF, FL, NTCS and CL treatments the BMS-C may be affected and causing some type of stress for the microorganisms;
3. The use that least affected the physical and microbiological characteristics of the soil in relation to the forest fragment was the no tillage cropping system. Another use that stood out was also forestry livestock farming, since when compared the other uses with livestock was the one that presented better results, demonstrating the possibility of livestocking with less damage to soil characteristics, however, it was concluded that NTCS was the treatment that came closest to the forest fragment analyzed when considering the physical and microbiological characteristics of the soil.

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