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ENVIRONMENTAL MANAGEMENT AND ITS INFLUENCE ON THE QUALITY OF CERRADO SOILS

MANEJO DE AMBIENTES E SUA INFLUÊNCIA NA QUALIDADE DOS SOLOS DO CERRADO

GESTIÓN DE LOS AMBIENTES Y SU INFLUENCIA EN LA CALIDAD DE LOS SUELOS DEL CERRADO

Ciro Alberto de Oliveira Silva[1]
0009-0008-3396-4734
ciroalberto.23@gmail.com

Hildeu Ferreira da Assunção[2]
0000-0002-4203-6568
hildeu@ufj.edu.br

Claudio Hideo Martins da Costa[3]
0000-0002-1334-5441
c_hideo@ufj.edu.br

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[1] Mestrado em Agronomia. ORCID: https://orcid.org/0009-0008-3396-4734. E-mail: ciroalberto.23@gmail.com.

[2] Pós-Doutor em Agrometeorologia. Professor títular da Universidade Federal de Jataí. ORCID: https://orcid.org/0000-0002-4203-6568. E-mail: hildeu@ufj.edu.br.

[3] Doutorado em Agronomia. Professor Associado da Universidade Federal de Jataí. ORCID: https://orcid.org/0000-0002-1334-5441. E-mail: c_hideo@ufj.edu.br

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ABSTRACT: The objective was to evaluate the effects of different types of management of a *Latossolo Vermelho distrófico* (Oxisol) on edaphic properties, as well as identifying physical, chemical and biological indicators with greater weighting for soil quality discrimination among the managed environments. The design used was completely randomized: Native Cerrado (NC); No-tillage (NT); Forestry (F); Pasture (P); and Agroforestry (AF), in which 3 soil samples were collected, in the layer from 0 to 20 cm. Chemical, physical and biological, variables were determined and analyzed with the aid of the GENES application, subjecting them to analysis of variance and discrimination by Tukey test ($p<0.05$). After that, the multivariate technique of principal component analysis (PCA) was applied to identify the indicators and group similar environments. That physical and biological attributes form quality indicators with greater contributions in the differentiation of environments.

Keywords: *Latossolo Vermelho distrófico* (Oxisol). Soil Attributes. Sustainability. Conservation.

RESUMO: O objetivo foi de avaliar os efeitos dos diferentes tipos de manejo de um Latossolo Vermelho distroférrico sobre as propriedades edáficas, bem como identificar indicadores físicos, químicos e biológicos com maior ponderação para discriminação da qualidade do solo entre os ambientes manejados. O delineamento foi o inteiramente casualizado: Cerrado Nativo (CN); Plantio Direto (SPD); Silvicultura (S); Pastagem (P); e Agro Floresta (AF), foram tomadas 3 amostras de solo, na camada de 0 a 20 cm. As variáveis químicas, físicas e biológicas foram determinadas e analisadas pelo aplicativo GENES, submetendo-as à análise de variância e a discriminações pelo teste de Tukey ($p<0{,}05$). Aplicou-se a técnica multivariada de análises de componentes principais (ACP) para identificação dos indicadores e agrupamento dos ambientes similares. Os atributos físicos e biológicos formam indicadores da qualidade com maiores contribuições na diferenciação dos ambientes.

Palavras-chave: *Latossolo Vermelho distrófico* (Oxisol). Atributos dos solos. Sustentabilidade. Conservação.

RESUMEN: El objetivo fue evaluar los efectos de los diferentes tipos de manejo de un Latosol Rojo distroférrico sobre las propiedades edáficas, así como identificar indicadores físicos, químicos y biológicos con mayor peso para la discriminación de la calidad del suelo entre ambientes manejados. El diseño utilizado fue completamente al azar: Cerrado Nativo (CN); Siembra Directa (SPD); silvicultura (S); pasto (P); y Agro Floresta (AF), en las que se tomaron 3 muestras de suelo, en el estrato de 0 a 20 cm. Las variables químicas, físicas y biológicas fueron determinados y analizados mediante la aplicación GENES, sometiéndolos a análisis de varianza y discriminación por prueba de Tukey ($p<0.05$). Posteriormente, se aplicó la técnica multivariada de análisis de componentes principales (ACP) para identificar indicadores y agrupar ambientes similares. Los atributos físicos y biológicos forman indicadores de calidad con mayores aportes en la diferenciación de ambientes.

Palabras clave: Latosol Rojo Distrófico (Oxisol). Atributos del suelo. Sostenibilidad. Conservación.

INTRODUCTION

Soil is a fundamental component of the various terrestrial ecosystems (WELC *et al*., 2012), housing physical, chemical and biological processes and reactions with action in several key functions in the environments (Chaer *et al*., 2009). Soil balance has been constantly disturbed by inadequate anthropic actions, which cause accelerated degradation and reduction of natural characteristics (Claassens *et al.,* 2008; Kaschuk, Alberton, Hungria, 2010).

A consequence of the conversion of native forests and pastures to cultivated areas is the overexploitation of agroecosystems (Qi *et al*., 2009), exerting an important influence on the intrinsic properties of the soil (Rahmanipour *et al*., 2014).

A better knowledge of attributes that are indicators of the quality of a soil is important to improve sustainable land use management (McGrath, Zhang, 2003). The essentiality in the evaluation of edaphic conditions is based on the capacity of the land for production, conservation and environmental management purposes (Pieri *et al*., 1995; Stamatiadis *et al*., 1999).

With this, it is stimulated by the awareness that soil is a vital resource for humanity (Doran *et al*., 1996), as well as by the realization that processes of soil degradation caused by changes in natural environments resulting from agricultural, forest and livestock management systems have intensified due to the use of inadequate operations in a considerable portion of the Cerrado biome soils.

Thus, the objective of this work was to evaluate the effects of no-tillage, pasture, forestry and agroforestry environments in a *Latossolo Vermelho distrófico* (Oxisol) on chemical, physical and biological attributes, as well as identifying the attributes that are indicators of edaphic quality with greater contribution to environmental discrimination.

MATERIAL AND METHODS

This study was conducted in the experimental area of the Federal University of Goiás, at the Jataí Regional Unit/ Jatobá Campus - University City, where the *Latossolo Vermelho distrófico* (Oxisol) of clayey texture predominates (Santos *et al*., 2018).

The climate of this region is characterized, according to Köppen's classification, as Aw or Tropical Savannah, with rains concentrated in summer and persistent drought in winter (Alvares *et al.,* 2013).

For experimental sampling in the environments, we previously surveyed the history of use and occupation of the areas, and then adopted the Completely Randomized Design with 5 treatments: Native Cerrado (NC); No-tillage (NT); Forestry (F); Pasture (P); and Agroforestry (AF), in 3 repetitions.

The sampling spaces of the experiment were delimited in plots of 1 hectare. Within each management system, 3 soil samples were collected at depth of 0-20 cm. Sample points per plot were spatially randomized and georeferenced.

Table 1. History of environments under different land uses and managements in a *Latossolo Vermelho distrófico* (Oxisol).

Land use and management	Description
Native Cerrado (NC)	Area (20 hectares) with closed forest with thick litter, without anthropic intervention. Average contents of Sand, Silt and Clay: 332.6, 196.2 and 471.2 g kg^{-1}
No-Tillage (NT)	Since 2004, the area (14.9 hectares) has been used with crop rotation, soybean + sorghum and soybean + corn in a no-tillage system. In 2014 and 2016, liming was performed in total area, using 2 Mg ha^{-1} of dolomitic limestone, in addition to corrective fertilization with 30 kg ha^{-1} of K_2O and 50 kg ha^{-1} of P_2O_5. Average contents of Sand, Silt and Clay:189.5, 192.6 and 617.9 g kg^{-1}
Forestry (F)	Until 2011 the area (3 hectares) was cultivated with pasture with signs of degradation; in this area the previous pasture of the genus Brachiaria (Syn. Urochloa) was desiccated and, in November 2012, eucalyptus crop was planted in a subsoiling and system. Fertilization at planting consisted of the NPK formulation 04-14-08 (with 12% Ca and 10% S) in the amount of 150 grams per hole. Subsequently, 12 months after planting, top-dressing fertilization was performed with Nitrogen, Potassium and Boron, at the respective doses of 60, 40 and 3 kg ha^{-1}. Average contents of Sand, Silt and Clay: 184.2, 224 and 591.8 g kg^{-1}
Pasture (P)	Previously, in 2004 the area (10.2 hectares) was used with succession (Soybean + Corn); from 2005 on, the area was limed with 2 Mg ha^{-1} of dolomitic limestone, 40 kg ha^{-1} of K_2O and 50 kg ha^{-1} of P_2O_5, harrowed, planted with Brachiaria (Syn. Urochloa) decumbens, which was sown broadcast, and then received the herd of cattle at the average density of 1.5 AU per hectare. In 2014, 1 Mg ha^{-1} of dolomitic limestone was applied broadcast on the pasture already formed, in order to correct the acidity of the area. In 2017, the area was prepared in 30-to-30-meter contour lines according to the slope of the terrain. Average contents of Sand, Silt and Clay: 261.3, 251.1 and 487.6 g kg^{-1}
Agroforestry (AF)	From 2004 to 2015, the area (4.3 hectares) had pasture with signs of marked degradation. Then, the agroforestry system with soil turning (formation of beds) was implemented and several fruit tree species were planted, in addition to annual crops (e.g., Eucalyptus, Baru, Cassava, Banana, Papaya, Peanut, Pepper) in order to promote the stratification of the productivity of the area. After soil analysis, the soil was turned and mineral fertilization with 4 Mg ha^{-1} of rock powder + Yoorim thermal-phosphate (175 P_2O_5, 280 CaO, 145 MgO) in the proportion of 2 Mg ha^{-1} and organic fertilization with 3 m^3 ha^{-1} of manure + plant remains) were incorporated. Average contents of Sand, Silt and Clay: 255.3, 233.5 and 511.2 g kg^{-1}

Source: The authors (2023).

For the determination of the edaphic fauna, arthropods were extracted by modified Berlese-Tüllgren funnels, according to the methodology proposed by Rodrigues *et al.* (2008), subsequently screened, and the total number of individuals larger than 2 mm in diameter was counted for further determination of the density of individuals per cubic meter.

The variables used as a parameter for the present study, as well as the methodology and references used in their determination are presented in Table 2.

Table 2. Physical, chemical and biological attributes of the soil and methodologies applied for their determination.

Soil attributes	**Units**	**Methodology Used**	**References**
Physical			
Bulk density (BD)	$kg \cdot dm^{-3}$	Volumetric ring	EMBRAPA (2017)
Mean weight diameter (MWD)	mm	Wet sieving	Salton *et al.* (2012).
Soi penetration resistance (PR)	MPa	Digital penetrometer	Molin *et al*. (2012)
Total pore volume (TPV)	$m^3 m^{-3}$	Indirect method	EMBRAPA (2017)
Chemical			
Base saturation (V%)	%	Base saturation	EMBRAPA (2017)
Phosphorus (P-labile) and Potassium (K)	$Kg\ ha^{-1}$	Mehlich-1 extractant	EMBRAPA (2017)
CEC	$mmolc\ dm^{-3}$	C.E.C	EMBRAPA (2017)
Total acidity (pH) in H_2O	-	Water, 1:2.5 ratio	EMBRAPA (2017)
Total Nitrogen (TN)	$Kg\ ha^{-1}$	Kjeldahl method	EMBRAPA (2017)
Aluminum saturation (m%)	%	Aluminum saturation	EMBRAPA (2017)
Biological			
Total organic carbon (OC)	$g \cdot kg^{-1}$	Walkley & Black method	EMBRAPA (2017)
Microbial biomass carbon (MBC)	$\mu g\ g^{-1}$	Extraction-fumigation	Vance *et al*. (1987)
Edaphic fauna (EF)	N° m^3	Modified Berlese Tullgren	Rodrigues *et al.* (2008)
Soil organic matter (OM)	$g \cdot kg^{-1}$	Colorimeter method	EMBRAPA (2017)

Source: The authors (2023).

To evaluate the effect of the environments on the physical, chemical and biological attributes of the soil, the data were subjected to analysis of variance and Tukey's mean discrimination test ($p<0.05$).

To identify the representative indicators of edaphic quality with greater relevance in the discrimination of management environments, principal component analysis (PCA) was used and subsequently the environments were grouped based on Mahalanobis generalized distance (D^2), optimized by the Tocher's method.

RESULTS AND DISCUSSION

In the analysis of physical variables, a significant difference ($p<0.05$) was observed for total pore volume (TPV) and penetration resistance (PR), evidencing that the managements adopted promoted changes in these characteristics (Table 3).

Table 3. Indicator physical, biological and chemical attributes, BD - Bulk density; TPV - total pore volume; PR - soil resistance to mechanical penetration; MWD - Mean weight diameter of aggregates; OC - organic carbon; OM - Organic matter; MBC - Microbial Biomass Carbon; and EF - Edaphic Fauna; pH - hydrogen potential, V% - base saturation; m% - aluminum saturation, P-labile - phosphorus content; K - potassium content; TN - Total nitrogen; CEC - cation exchange capacity in the layer from 0 to 20 centimeters.

Land Use	BD	TPV	PR	MWD	OC	OM	MBC	EF
	Kg dm-3	m^3 m-3	MPa	mm	g kg-1		µg g-1	n°m-3
NC	1.42 a	0.62 ab	0.98 b	2.18 a	15.60 ns	36.90 ns	620 ab	27,500ns
NT	1.81 a	0.51 b	1.69 a	2.00 a	14	31.43	335 b	19,722.22
F	1.43 a	0.59 ab	1.76 a	2.15 a	14.67	31.77	331 b	14,722.22
P	1.54 a	0.63 a	1.57 a	1.96 a	14	30.69	401 b	14,444.44
AF	1.46 a	0.66 a	0.98 b	2.16 a	16.67	36.2	743 a	23,611.11
CV%	9.29%	6.42%	14.22%	4.36%	11.33%	15.64%	23.79%	43.23%
MEAN	1.53	0.507	1.4	2.09	15.02	30.77	485.84	20,000
Physical					Biological			

	pH	V%	m%	P-labile	K	TN	CEC
	H2O	%		kg ha-1			cmolcdm³
NC	4.7 bc	10.1 c	4.2 ab	4.30 b	82 b	410 ns	8.0 ns
NT	5.1 bc	31.8 bc	3.4 ab	21.0 a	143 ab	371	9.8
F	4.7 c	24.8 bc	5.3 a	13.1 ab	217 a	376	8.4
P	5.3 b	40.0 ab	2.6 bc	4.40 b	176 ab	336	10
AF	6.0 a	64.3 a	0.8 c	14.9 ab	197 a	463	8.3
CV%	4.49%	28.20%	27.64%	41.61%	21.55%	8.31%	11.46%
MEAN	5.18	34.21	3.29	5.77	163	391	8.91
Chemical							

Source: The authors (2023).

Means followed by the same letter in the column do not differ from each other by Tukey test at 5% probability level. NC - Native Cerrado; NT - No-tillage; F- forestry; P - cultivated pasture; AF - Agroforestry. CV% - coefficient of variation; Soil moisture content (%): NC- 17.3%; NT-14.8%; F - 20.63%; P- 19.3% and AF- 18.4%

In the present study, the area under NT had the lowest value for the attribute and was statistically similar to F and NC. This observed reduction can be explained in part by the successive use of the area in soybean and corn crops (without crop rotation), with the movement of machines and implements throughout the period of use of the environment.

For the attribute penetration resistance (PR), the Native Cerrado (NC) and Agroforestry (AF) environments had the lowest values (0.98 MPa), followed by Pasture, No-Tillage and Forestry (1.57; 1.69; 1.76). The areas with lower intensities of use in cultural practices showed conditions of lower penetration resistance similar to those of natural areas. However, in soils under pasture and no-tillage with a history of use conditioned by intensive use in the last 14 years, PR values were higher. This is in part explained by cultural practices such as planting, harvesting and spraying for no-tillage and animal displacement and trampling for pastures, which contribute to the compaction process of these areas.

Soil penetration resistance increases with soil compaction, being restrictive to root growth above certain values of mechanical potential ranging from 1.5 to 3.0 MPa, according to Grant and Lafond (1993). The formation of a compacted layer at different depths, with land use and management is quantified by values greater than 2.0 MPa, a critical limit suggested by Tormena (1996) in a *Latossolo* (Oxisol) with clayey characteristic.

Moreira and Siqueira (2006) state that soils under poorly managed (degraded) pastures show an increase in bulk density and penetration resistance. This factor in the present study may be related to the excess of animal load caused by different stockings on the pastures after grass sowing and cattle placement, increasing the subsurface resistance caused by the movement of animals in the area. However, the values presented are lower than the critical levels for the attribute.

The attributes Bulk density (BD) and Mean Weight Diameter (MWD) did not show statistically significant differences between the studied management environments.

Finally, the intensification of management in these environments that promotes physical changes in the soil compared to the areas of native Cerrado, over the years without the use of mitigating and sustainable measures that reduce the pressure of use on these soils, result in degradation processes such as compaction, disaggregation and water erosion in the layer from 0 to 20 centimeters, which can reduce quality and increase physical frailty.

Significant differences for chemical attributes (Table 3) were already expected between the managed areas and the natural environment due to their preliminary history of use, since they were subjected to fertility corrections to suit their respective production systems.

Chemical properties of soils are significantly modified with the removal of natural vegetation and cultivation, mainly in the arable layer, due to the addition of correctives and fertilizers and agricultural operations (Freitas, 2017).

Among the chemical attributes analyzed, the effect of the environments on CEC and total nitrogen (TN) did not promote significant changes in these attributes by the F test ($p<0.05$) (Table 3). Soil CEC in the present study showed values above adequate (≥ 6.1 cmolc dm^{-3}) for clay soils of the Cerrado (Souza, Lobato, 2004). Therefore, for the present study, the absence of statistical difference between the environments can be explained in part by the high OC stock of the soil.

For the properties, pH (H_2O), base saturation (V%), aluminum saturation (m%), and nutritional contents of phosphorus (P) and potassium (K), it was observed that the environments and management practices promoted differences in these variables. Environments under agroforestry had the highest results for pH, V%, and high nutrient contents, while native Cerrado had the lowest values. This behavior has been found in studies on the Cerrado in relation to the low natural fertility of most soils under the biome. In the work of Carneiro *et al.* (2009), the areas under Cerrado vegetation had higher levels of H + Al and Al^{3+} and lower concentrations of Ca, Mg and P compared to the managed areas.

In the forest, the low nutrient contents (4.3 and 85 kg ha^{-1}) for Phosphorus and Potassium, respectively, are partly explained by the fact that in this environment most of the nutrients are allocated in the vegetation, in addition to the chemical poverty of the Oxisol and the high degree of weathering in the environment (Santos *et al.*, 2007; Portugal *et al.*, 2008; Freitas, 2017).

In relation to m%, the native Cerrado (4.2) and forestry (5.3) environments had higher percentages of Al^{3+} saturation, different from the values found in other treatments evaluated and higher than the average found (3.29). These values can be explained by the absence of application of soil correctives, through liming, for forest planting. The history of use for Forestry shows that the forestry treatments of fertilization were carried out in the planting rows of the clonal seedlings and not in total area.

Thus, when conducting soil preparation in this in-row system, the subsoiler implement coupled to a tractor is usually used, which promotes the destructuring of the soil in the row, at a depth greater than 40.00 cm (Paiva *et al*., 2011). In conjunction with this subsoiling operation, the distribution of phosphate fertilizer is also carried out in the planting row (Paiva *et al*., 2011).

According to Oliveira *et al*. (2015), liming, for example, is an indispensable technique in Brazilian Cerrado agriculture, because it decreases the potential acidity of the soil, as it increases the pH at levels suitable for crops.

The environments evaluated did not promote significant changes in the attributes organic carbon (OC), organic matter (OM) and edaphic fauna (EF). For microbial biomass carbon (MBC), variations were observed (Table 3).

Microbial biomass carbon (MBC) showed higher values in the area subjected to Agroforestry integration and Cerrado, differing significantly from the other land use and management systems (Table 3). According to Moreira & Siqueira (2006), MBC represents about 2 to 4% of total soil organic carbon and is closely related to factors associated with the activation of decomposing microorganisms.

For Silva *et al*. (2010), the increase in MBC in areas of integration and Cerrado is the result of the deposition of easily oxidized organic substrates of varied chemical composition resulting from litter, the rhizosphere of plants, in addition to the microbial activity of the soil. In the present work, the incorporation of plant residues had relevance in the increase of MBC, and microbial biomass has also been used as an indicator of soil changes and quality, being able to quickly reflect land use changes (Matoso *et al*., 2012).

Although they did not show significant statistical differences, the managed soils obtained a density of edaphic fauna individuals lower than those of the undisturbed areas of the Cerrado. According to Baretta *et al*. (2011), when referring to land use in the search for productivity, soil fauna is a factor that receives little attention, since high amounts of chemicals are applied, usually in large monoculture areas to combat the presence of undesirable organisms (Freitas, 2007).

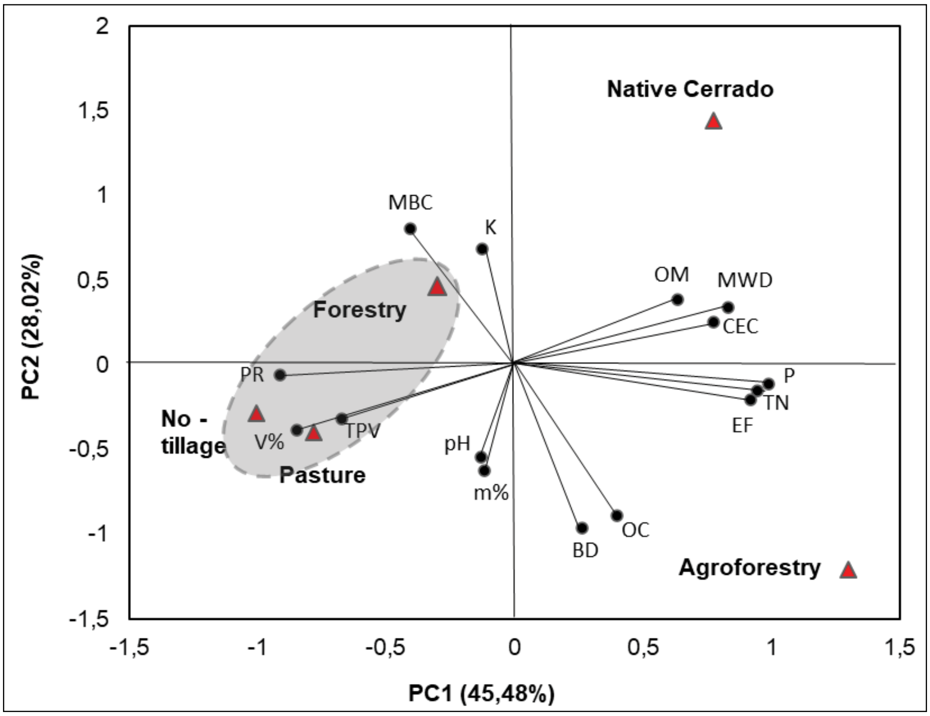
Principal Component Analysis - PCA

In the Principal Component Analysis (PCA) of the physical and chemical attributes of the soil under different environments and uses, using the input parameters of the 15 initial variables, the biplot graphic dispersion of the scores for the evaluated environments was used, as well as the correlations between eigenvectors (Figure 1).

It is observed that PC1 and PC2 (eigenvalues) participate in 45.48% and 28.02%, corresponding to 73.5% of the total variation of the data. The eigenvalue represents the highest possible level of correlation of all variables with the main axis (Hongyu, 2015). So, it is a measure of the total variation of the data set represented by the axis (Cruz, Regazzi, 2012; Cruz, 2013).

The axis PC1 was influenced by the biological and physical variables of the soil, with higher weights associated with this component. For the axis PC2, the chemical variables had a more important contribution. In the interpretation of PCA, the variables (eigenvectors) closest to the axis are the most relevant when trying to explain the total variation and the correlation between the variables.

The graph also shows the grouping of environments by the Tocher's method, based on Mahalanobis dissimilarity in: Group 1 (Pasture, No-tillage and Forestry) and also the formation of two groups, Group 2 (native Cerrado) and Group 3 (Agroforestry), where the greatest graphic distance between the environments was observed within the axis CPC1, that is, with greater influence explained by the physical and biological attributes of the soil, and the most important eigenvectors were OC, MBC, TN, PR and MWD.



Source: The authors (2023).

Figure 1. Graphic dispersion (biplot) of the initial variables in relation to the management environments for the *Latossolo Vermelho distrófico* (Oxisol); Eigenvectors - BD - Bulk density; TPV - total pore volume; PR- soil resistance to mechanical penetration; MWD - Mean weight diameter of aggregates; pH - hydrogen potential; V% - base saturation; m% - aluminum saturation; P - phosphorus content; K - potassium content; TN - Total nitrogen; CEC pH 7.0 - cation exchange capacity; OC - organic carbon; OM - Organic matter; MBC - Microbial Biomass Carbon and EF - Edaphic Fauna.

In relation to the axis PC2, we can mention the contribution of chemical eigenvectors (pH, V% and m%) to differentiate the managed environments from the areas of Native Cerrado (Table 4).

Table 4. Results of principal component analyses (PCA).

Principal components	**PC1**	**PC2**	**PC3**	**PC4**
Eigenvalue	6.82595	4.20615	2.3229	1.652373
Proportion (%)	45.484	28.02725	15.478	11.01042
Accumulated (%)	45.484	73.51124	88.99	100
Eigenvectors				
MWD	**0.8226***	-0.3466	0.0191	0.4497
PR	**-0.9102***	0.0439	-0.128	0.3925
TPV	**0.6357***	-0.4065	-0.562	-0.3439
BD	**-0.6697***	0.3269	0.6547	-0.1296
pH (H_2O)	0.3931	**0.8917***	-0.007	-0.2238
m%	-0.4001	**-0.8077***	-0.076	0.4263
V%	0.2583	**0.9608***	-0.101	-0.0028
TN	**0.9166***	0.2115	0.2943	0.1694
P	-0.1326	0.5521	**0.7224**	0.3944
K	-0.1166	0.6177	-0.483	**0.6093**
CEC	-0.85	0.3846	0.0126	-0.3611
MBC	**0.9436***	0.1573	0.0685	-0.2833
OC	**0.9902***	0.1196	0.0613	0.0614
OM	**0.7794***	-0.2448	0.5098	0.27
EF	-0.1218	-0.4807	**0.66**	-0.2938

*Eigenvectors with higher weight associated with the principal components 1 and 2. Bold and underlined - eigenvectors with greater weight in the latest principal components. MWD- Mean weight diameter; PR- penetration resistance; TPV - total pore volume; BD- Bulk density; pH (H_2O) - hydrogen potential in water; m% - aluminum saturation; v% - base saturation; TN - total nitrogen; P-labile - phosphorus content; K - potassium content; CEC - cation exchange capacity; MBC - microbial biomass carbon; OC- Organic carbon; OM - organic matter; EF - edaphic fauna

Source: The authors (2023).

These results may be associated with intensive use of these soils, 15 and 17 years for pasture and no-tillage and 8 years for forestry with intense movement of implements (Cavalieri *et al.*, 2011) and animal trampling in the case of livestock. (Costa *et al.*, 2009), which have changed over the years the physical and biological attributes for this grouping of environments.

According to Santana and Bahia Filho (1998), physical attributes such as aggregate stability undergo changes in the medium term and long term. And these have been considered the best indicators of differences between soils with different cultivation systems, that is, in the long term, the differences between crop managements will have a high chance of showing significant results (Araújo *et al*., 2007). This difference was found in the present study.

In line with this and also having high weighting for differentiating treatments are the biological attributes Organic carbon (OC) and microbial biomass carbon (MBC). According to Sales *et al*. (2018), organic carbon is an essential attribute in identifying more appropriate and sustainable practices, increasing productivity and reducing pressure on natural areas.

Organic carbon is directly linked to soil quality, because it is a cementing agent of the structure, acts on pH buffer, in the complexation of elements and cation exchange capacity, in addition to increasing water availability in the soil (Campos *et al*., 2016). In environments that promote the deposition of plant material, root and shoot residues, and even organic fertilization practices, it plays a major role in stimulating the activity of soil microorganisms and increasing the concentration of organic matter (Guo, Gifford, 2002).

Considering that soil quality attributes should be sensitive enough to indicate changes resulting from use, it is possible to verify that the microbial biomass carbon showed performance for this. According to Gama-Rodrigues and Gama-Rodrigues (2008), microbial biomass can be classified as the central compartment of the C cycle and represents a considerable reservoir of nutrients in soils and a fundamental attribute for the study of nutrient cycling in different ecosystems. That is why this attribute is very useful in studies on ecosystem sustainability and can be indicated as a potential component of a soil quality index.

In studies that use the principal components technique as a means of discarding variables in order to reduce labor, time and cost spent on the analysis and interpretation of experimental data, the relative importance of characteristics can be assessed by the magnitude of their weighting coefficient (Cruz, Regazzi, 2012)

The discarded variables that represent high weighting in eigenvalues that explain little of the total variation existing are: P-labile and K contents and EF (Table 4). For the works of Carneiro *et al*. (2009), the highest weightings were observed for the attributes Macropores and Micropores, Density, total pore volume and P content.

CONCLUSIONS

The results of this study show that the type of use of the management environment alters the magnitude of physical, chemical and biological indicators in the soil.

The reduction of physical and biological variables indicates the loss of soil quality for environments with intensive use through the presence of anthropic pressure.

The chemical evaluation of the soils shows increased availability of nutrients and reduction of acidity and toxicity for all environments compared to Cerrado soils.

Principal component analysis indicates that biological and physical attributes form quality indicators with greater contributions in the discrimination of management environments.

None of the built management environments has a grouping with the native Cerrado area, established as a reference.

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