Journal of Agricultural Science; Vol. 15, No. 4; 2023
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Physical Attributes of an Ultisol Under Different Uses in the North of Espírito Santo

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Received: November 5, 2022 Accepted: December 24, 2022 Online Published: March 15, 2023

doi:10.5539/jas.v15n4p1 URL: https://doi.org/10.5539/jas.v15n4p1

Abstract

The evaluation of the physical attributes of the soil is of fundamental importance for the understanding of the impacts caused by the different uses in the agricultural systems. In this sense, the objective of this work was to evaluate the changes in physical attributes of the soil in an area with different uses located in the north of Espírito Santo. The experiment followed a randomized block design (DBC), in a 4 × 2 factorial scheme, represented by 4 areas (coffee, fruit, pasture and native forest) and 2 depth classes (0-10 and 10-20 cm), resulting in a total of 8 treatments with 5 replications. The physical attributes evaluated were: texture, Ds (soil density); Dp (particle density); Ma (macroporosity); Mi (microporosity) and Pt (total porosity). The data obtained were submitted to analysis of variance and the comparison of means was performed using the Tukey test at 5%, using the statistical program R© 4.2. Then, the physical attributes data were grouped into a similarity dendrogram, using the Euclidean distance method. The area with native forest presented the best physical attributes of the soil, followed by: coffee, fruit and pasture, not differing in depth. As for the analysis by grouping, native forest was similar to coffee growing and fruitful showed the greatest dissimilarity between land uses, especially in relation to forest.

Keywords: soil quality, soil degradation, sustainability

1. Introduction

Agricultural soils work as a complex system that retains and transfers water, heat, air and nutrients to plants, with a physical environment favorable to root growth and development being essential, maximizing crop production. However, depending on the use and management, degradation of its physical quality may occur.

In recent years, studies on soil quality have evolved significantly, almost always justified by the need to evaluate the behavior of different soil attributes in cultivated areas (Spera et al., 2009), as inadequate soil use and management can cause an increase in soil density, a decrease in macroporosity and total porosity, among other damages (Mantovanelli et al., 2015).

The physical attributes are used to estimate the structuring condition of the soils, in relation to the leaching potential, productivity and erosive aspects, being affected by several factors, such as the management system, type of cultivation, type of vegetation cover, amount of residues, on the surface and organic matter content (Spera et al., 2006). Soil density is a widely used measure because it is easy to determine and presents a good correlation with compaction, in addition to this variable, porosity contributes to the estimation of the structural quality of soils.

Studies related to soil quality monitoring by physical attributes are important to assess and maintain the sustainability of agricultural systems, in addition to signaling the proper management of the environment, aiming at conservation and productivity (Mota et al., 2013). In current agriculture it is not possible to talk about cultivation and productivity without talking about sustainability, the evaluation of physical attributes becomes an important ally in this aspect, it is through its evaluation that it is possible to know the characteristics of a certain soil, and how the different uses or handling have affected it over the years, both in positive and negative aspects.

Understanding and evaluating the damage caused by different forms of use is of fundamental importance for improving soil quality. According to Carneiro et al. (2009), the evaluation must be carried out according to a set of specific indicators (attributes) and their interrelationships. Since, studies have shown that isolated indicators are not enough to explain the potential loss or gain of crops in a given soil (Mantovanelli et al., 2015). Given the above, the objective of this work was to evaluate the attributes of a soil under different forms of use in the northern region of Espírito Santo.

2. Method

The work was carried out at the Experimental Farm of the Centro Universitário do Norte do Espírito Santo-CEUNES, belonging to the Federal University of Espírito Santo (UFES), located in the municipality of São Mateus, state of Espírito Santo-Brazil, with geographic coordinates 18º42′58″ S and 39º51′21″ E, the altitude of about 35 meters. The soil used in the experiment is classified as Yellow Argisol (Santos et al., 2018). According to the Köppen classification, the climate of the region is Aw, tropical humid, with well-defined seasons, dry winter and maximum rainfall in summer, with rainfall concentrated in the months of November and January (Alvares et al., 2013).

The experiment followed a randomized block design (DBC), in a 4 × 2 factorial scheme, composed of 4 areas (Coffee, fruit, pasture and native forest) evaluated at two depths: 0-10 cm and 10-20 cm, resulting in a total of 8 treatments with 5 replications. It was determined: texture, Ds (soil density); Dp (particle density); Ma (macroporosity); Mi (microporosity) and Pt (total porosity).

The collection of undisturbed samples was carried out with a castle-type auger and volumetric rings of 5 cm in height and variable diameter. In each area 10 samples were taken, divided equally between the depths 0-10 cm and 10-20 cm. In the coffee and fruitful, the collection was carried out at 20 cm from the second plant of each planting line, while in the native forest and pasture, the samples were collected randomly. With the undisturbed samples, soil density was determined by the volumetric ring method, macroporosity, microporosity and total porosity by the tension table. At each collection point, deformed soil samples were also removed at depths of 0-10 cm and 10-20 cm to determine the particle density by the volumetric flask method; the textural classification by the pipette method and the aid of Atterberg's triangular phase diagram (Embrapa, 1997).

Analysis of variance and comparison of means were performed using the Tukey test at 5%, using the statistical program R© 4.2 (R Core team, 2020). Then, the physical attributes data were grouped into a similarity dendrogram, using the Euclidean distance method.

3. Results and Discussion

3.1 Varianic Analysis

The results of the analysis of variance are presented in (Table 1), there was no statistical difference between one depth and another, however, the different areas differed statistically. For soil density, the highest values found follow the following order: (1) fruitful; (2) pasture; (2) coffee growing and (3) native forest. High soil density values limit root growth in clayey soils (Nicoloso et al., 2008). However, in this study, the fruitful area did not show the behavior mentioned by Nicoloso et al. (2008). The high value can be explained by the management, as there was the removal of the eucalyptus crop (stumps) with great soil disturbance and subsequent preparation for implantation of the area. In addition to the heterogeneity of textures found (Table 2) in small differences in depth, due to excessive revolving in the stump. Therefore, the intrinsic factors of the soil (texture and mineralogy) in conjunction with management directly interfere in the formation of soil aggregates (Vezzani & Mielniczuk, 2011). The other attributes evaluated were consistently close to the recommended value.

Table 1. Physical attributes of the soil in the different ecosystems studied

Use of the soil (Depth 0-20 cm)	Ds	Dp	Ma	Mi	Pt
	----------- g cm^{-3} ----------		--------------------- m^3 m^{-3} ---------------------		
Coffee growing	1.38b	2.64a	0.2412a	0.1720b	0.4132a
Fruitful	1.61a	2.62a	0.1810a	0.2189a	0.4000a
Pasture	1.54ab	2.59a	0.2294a	0.1216c	0.4043a
Native forest	1.16c	2.60a	0.2827a	0.1900ab	0.4193a

Note. Ds (soil density); Dp (particle density); Ma (macroporosity); Mi (microporosity) and Pt (total porosity). Means followed by the same letter in the column do not differ from each other by the Tukey test ($p < 0.05$).

Table 2. Texture analysis at two depths in different land uses

Use of the soil	Depth (cm)	Soil Texture
Coffee growing	0-10	Sandy Clay Franc
	10-20	Sandy Loam
Fruitful	0-10	Sandy Loam
	10-20	Clay Franc
Pasture	0-10	Sand
	10-20	Sand
Native forest	0-10	Sandy Clay Franc
	10-20	Sand Clay Franc

Note. * Based on the textural triangle of Atterberg (Embrapa, 1997).

Pasture and coffee growing did not differ statistically for soil density, this behavior can be explained by the difference in texture between areas (Table 2). According to Libardi (2005), sandy soils have higher density when compared to soils with higher proportions of clay. As the coffee crop presented variations in texture approaching sandy soils, it explains the behavior found. It may still be related to the effect of weeding and mowing that act on the soil structure (Effgen et al., 2012).

The native forest presented the lowest density of the soil, this physical condition is provided by the presence of leaves and branches on the soil that, when decomposing, increase the levels of organic matter, causing a reduction in density, as a result of better structuring of the soil, with its addition (Nicodemo et al., 2018). And the different root systems of the species create biopores through the colonization of the soil profile by the roots (Rosolem et al., 2010).

For particle density, macroporosity and total porosity there is no statistical difference between the values in all land use systems. According to Ferreira et al. (2003), the particle density refers to the source material of some soils and suffers small variations in values, being little influenced by soil management (Reichardt, 1985). Macroporosity is directly influenced by the degradation or improvement of the soil structure (Bonini et al., 2015). As there was no difference between the land uses, it is believed that there is a balance in the different uses because there is no traffic of heavy machines in the areas for management being carried out manually, mitigating the anthropic disturbances in the soil.

As for microporosity, the following statistical differences were observed: fruitful (1), coffee growing (2), native forest (2) and pasture (3). According to Bonini et al. (2015), soil microporosity is an attribute little influenced by soil management and its changes are more related to texture. Its reduction is harmful to the storage of water in the soil (Fonseca et al., 2007).

3.2 Dissimilarity Analysis

As shown in (Figure 1), the hierarchical grouping analysis of the physical attributes of the soil and the construction of the dendrogram allowed the evaluation of the similarity between the different land uses. This method of analysis makes it possible to group areas based on similarity, classifying them into homogeneous groups (Freitas et al., 2015). The *y* axis of the graph indicates the distances between the groups, while the *x* axis represents the union of the groups in descending order (Queiroz et al., 2019). The variation of the Euclidean distance in relation to the similarity of the physical attributes allowed the classification of land uses in 3 groups (GI, GII and GIII).

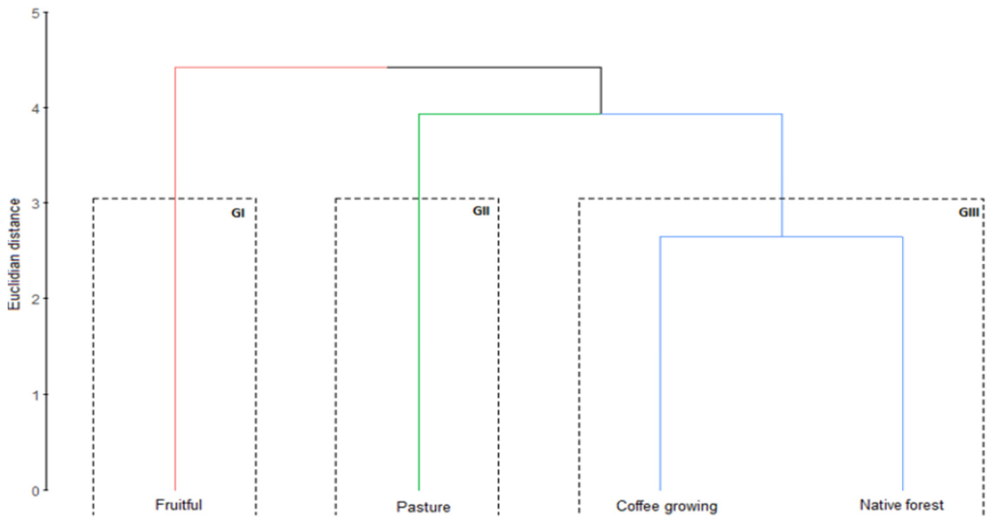

Figure 1. Clustering dendrogram constructed based on the Euclidean distance matrix, obtained from 7 variables analyzed at a depth of 0-20 cm

The distancing of GI from the other groups indicates that the soil attributes verified in fruitful are not similar to the results found for coffee, pasture and native forest. Soil preparation, scarce plant cover and irrigation in fruitful are responsible for changes in soil structure in relation to the original use (Cerda et al., 2021).

The bifurcation between GII and GIII shows that pasture differs from coffee, fruit and native forest. The cultivation of forage species contributes to the reduction of edaphic quality, making the soil a poorly sustained system due to the lower accumulation of organic matter and water (Jakelaitis et al., 2008). However, GII is more similar to native forest and coffee plantations, when compared to GI.

Coffee growing and native forest are in the same group (GIII), indicating that the two forms of land use have similar attributes. The proximity between the forest and the coffee plantation can be explained by the maintenance of organic matter and irrigation in place, allowing the environment to maintain similarities with the original cover. Perennial crops require less soil disturbance, preventing the disruption of aggregates and allowing greater accumulation of organic matter, thus ensuring greater soil stability when compared to annual crops (Means et al., 2022).

4. Conclusions

The native forest showed the best physical attributes of the soil, followed by coffee, fruit and pasture. Not differing in depth.

The replacement of native vegetation causes changes in the physical attributes of the soil. The Atlantic Forest was similar to coffee growing and fruitful showed the greatest dissimilarity between land uses, especially in relation to the Atlantic Forest.

Acknowledgements

To FAPES (Espírito Santo Research Support Foundation) for the confidence in approving this work related to the evaluation of soil attributes.

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