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Cluster Analysis of the Soil Physical Attributes under Soil Preparation Systems

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Abstract: The adoption of conservation management systems in sugarcane is still incipient in comparison to the conventional tillage system, due to a lack of scientific knowledge on its effects in soil quality, technological quality. This work aims to study the behavior of soil physical attributes of a Dystroferric Red Latosol under no-tillage and reduced soil preparation systems in sugarcane cultivation. In each soil preparation system, the systematic sampling grid was used, composed by 32 soil sampling points, in the 0.00-0.10 and 0.00-0.20 m layers. The attributes evaluated were: soil bulk density (SD), total porosity (TP), macroporosity (MA), microporosity (MI) and soil penetration resistance (PR). The data was submitted to Shapiro-Wilk normality test (value – $p \leq 0.05$) and was also verified the presence of discrepant points (outliers) considering the boxplot. Then, was performed the hierarchical grouping analysis, using Ward's method. The physical attributes are more similar in within the preparation system, suggesting differentiated effect of the soil preparation on the attributes in the layers 0.00-0.10 and 0.10-0.20 m. In general, the relationships between soil porosity attributes in both soil preparation systems are influenced by the clayey soil texture and consequently the high soil microporosity.

Key words: soil compaction; soil physical quality, no-tillage, reduced preparation

1. Introduction

Sugarcane is one of the most important crops in Brazilian agribusiness, since it has high potential for several purposes in agroindustry and cogeneration of electricity power. The increase in the demand for sugarcane products due to the growth of the Brazilian sugar and ethanol sector, which results in the expansion of sugarcane farming areas and investments in the construction of new plants, especially in the Center-South region. The adequate planning of the activities involved throughout sugarcane crop cycle, from the soil preparation to the harvest, is fundamental to meet the demand of the industry raw material both in quantity and quality. When soils are susceptible to compaction, such as clayey Latosols, are inserted in these productive systems, the development of degradation processes such as compaction and erosion occur. Thus, changes in soil structure and physical attributes has shown an increase in soil bulk density, soil resistance to penetration, and decrease of soil macroporosity, affecting the quality, limiting its properties such as aeration, availability and retention of water and nutrients, as well as restricting crops root development. Thus, it is necessary to carry out studies for better understanding of the changes caused by soil use aiming to maximize production and avoiding the degradation of agricultural soils, since they generate important information for soil management and conservation incorporated under intensive production processes. In the sugarcane production units it is necessary to understand the relationship between the

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soil management practices and the ability of the soil classes to increase the longevity of the cane plants and minimization processes of soil physical degradation. Including conservation management systems such as no-tillage and reduced tillage can be a sustainable alternative [1]. Hence, the multivariate analysis techniques enable to explain the maximum correlation between the soil characteristics and indicate the ones that most contribute to the characterization and/or alteration of the soil [2, 3]. Research has been applied to the multivariate techniques for soil quality analysis [1, 3-5]. Therefore, this work aims to study the behavior of physical attributes of a Dystroferric Red Latosol under no-tillage and reduced tillage in sugarcane cultivation.

2. Material and Methods

The trial was carried out in the municipality of Dourados, in the southern region of Mato Grosso do Sul, with the geographical coordinates 22°13'58"south latitude and 54°59'57" west latitude and 418 m altitude. The climate of the region is type Am, monsoon, with dry winter, and an annual average rainfall of 1500 mm, and annual average temperature of 22°C. The soil of the area is classified as Red Latosol Dystroferric, clay texture. The experimental area has been conducted in the last 14 years under cultivation of soybean and corn, in a system of succession and rotation of crops without soil mobilization. The area was divided into two subareas, composed by no-tillage and reduced tillage. In each preparation farming unit, the sugarcane cultivars were planted manually on 21 July 2016, in the density of 15 buds per meter. Eight sugarcane cultivars (RB965902, RB985476, RB966928, RB855156, RB975201, RB975242, RB036066 and RB855536) were planted in a completely randomized design with four replicates. The reduced preparation (RP) management system consisted of heavy harrowing. The operation was performed with an off-set disc harrower of 16 discs of 0.76 m in diameter (30") in each section, in the depth of 0.15 m. In the other hand, the no-tillage system consisted of mechanized control (weeding) of the weeds, and later, opening of grooves for planting. For this operation, it was used a straw crusher equipped with rotor of steel curved knives, working in high rotation and furrower to open the grooves for planting. For the preparation and opening of furrows for planting, a 4×2 power tractor was used in the 89.79 kW (122 hp) engine, 2200 rpm rotation, 3rd gear reduced, front tires 14.9-58 and rear 23.1-30, and mass of 4.51 Mg. In order to cover the furrows and crop management, a 4×2 TDA tractor with a power of 68.74 kW (92 hp), a rotation of 2200 rpm, a low gear, 7.50-18 and rear 18.4-34, and mass of 3.40 Mg; and a KO Cross-s 2000 sprayer, tires 9.5-24, 14 m bar and 1.40 Mg mass. Each experimental unit contained 55-meter long cane lines spaced 1.50 m (37.5 m^2), in a total of 32 experimental units per preparation. In each experimental unit, a soil sample with preserved structure was collected to determine the following soil physical attributes: soil bulk density, total porosity, soil macroporosity, soil microporosity and soil resistance to penetration (PR). The volumetric rings used to collect the soil were 0.0557 m in diameter and 0.0441 m high (107.45 cm^3), were wrapped in film paper and kept in a refrigerator after collection, aiming minimize the structural alteration and loss of sample water. The total porosity of the soil was obtained by the difference between the mass of the saturated soil and the mass of the dry soil in an oven at 110°C for 24 h; the microporosity of the soil determined by the tension table method with a water column of 60 cm in height. By the difference between total porosity and microporosity, macroporosity was obtained. Soil bulk density was determined by the mass of greenhouse dried soil at 105-110°C, values expressed as Mg dm^{-3} [6]. After reaching the equilibrium in the tension table, corresponding to the water column at 6 kPa, the PR was determined by means of an electronic penetrograph model MA-933, with a constant penetration velocity of 10 mm min^{-1}, a base diameter of the rod of 4 mm and conic angular tip at 30°, as standardized by ASABE [7].

For each attribute studied, the mean was calculated using the classical statistics. A multivariate technique was used by means of the hierarchical grouping analysis, calculating the Euclidean distance between the access among the ten attributes, using Ward's algorithm to obtain similar accessions groups. This analysis, aimed to verify the similarities between the attributes analyzed and the areas studied from homogeneous groupings represented in a dendrogram of similarity.

3. Results and Discussion

The Fig. 1 shows that, in the 0.00-0.10 m layer of soil with reduced tillage, attributes related to soil porosity, such as macroporosity (MA) and soil microporosity (MI) presented at least an unilateral outliers to the right side, also being observed a left sided for the total porosity (TP). In the 0.10-0.20 m layer, the same behavior was observed, however, with unilateral outliers to the right for TP, which also occurred for macroporosity under no-tillage. In both (0.00-0.10 and 0.10-0.20 m) layers, were observed outliers at the right either under no-tillage or reduced tillage (RT)for resistance to penetration (PR), while for the soil bulk density (SD) only left outliers under no-tillage in the 0.00-0.10 m layer was observed, and for the other layer there were no outliers in the data series for soil bulk density (Fig. 2).

After the removal of the outliers, all the soil physical attributes data presented normal distribution by the Shapiro-Wilk test (value – $p \leq 0.05$) under the soil with no-tillage and reduced tillage. In Fig. 3a, when defining the cutting Euclidean distance point at11, the formation of two groups for the attributes in the two areas was verified: no-tillage and reduced tillage in the 0.00-0.10 m layer. Group 1 (G1) was composed by PR, SD and MI and in group 2 (G2) were TP and MA. In the 0.10-0.20 m layer (Fig. 3b), when defining the cutting Euclidean distance point(for G1 was composed by PR, SD, TP, MA and MI, while group 2 (G2) were PR, SD, MI, TP and MA.

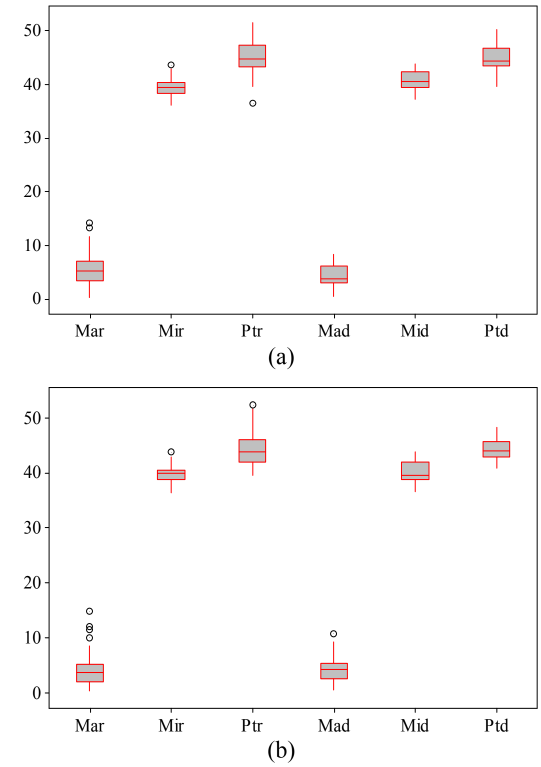


Fig. 1 ***Box-plots*** **of MAr, MIr, TPr, MAd, MId and TPd in the depth 0.00-0.10 m (a) and 0.10-0.20 m (b) under no-tillage and reduced systems.**

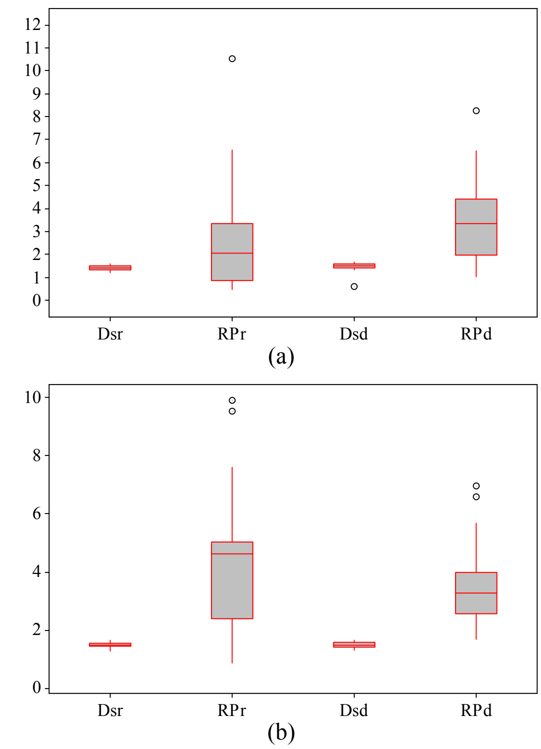
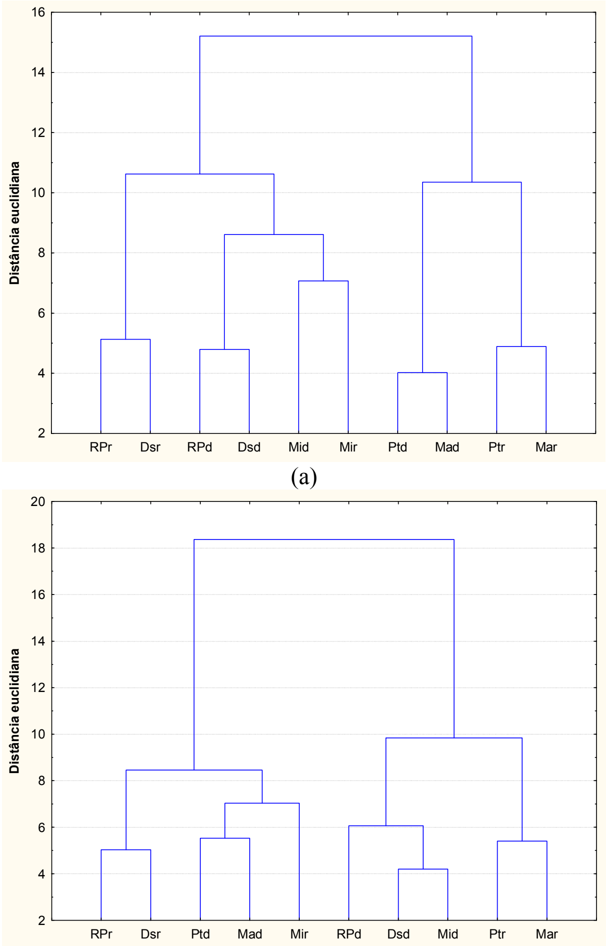


Fig. 2 ***Box-plots*** **of SDr, PRr, SDd and PRd in the depth 0.00-0.10 m (A) and 0.10-0.20 m (B) under no-tillage and reduced systems.**



(b)

Fig. 3 Dendrogram of hierarchy analysis cluster showing two groups, in the depth of 0.00-0.10 m (a) e 0.10-0.20 m (b).

When analyzing the Euclidean distances, it is verified that attributes of the G1, in the layer of 0.00-0.10 m, being the smaller distances were verified when different attributes were compared in the same environment. The MI attribute presented the greatest distances in relation to the PR, while the smaller ones were verified in relation to the SD. This was also observed for the PR and SD attributes in the same preparation system. It is possible to verify that attributes from the G2, in the layer of 0.00-0.10 m, for PR and SD attributeS, the Euclidean distances was larger when compared between the preparations systems. This shows a differentiated effect of the soil preparation on the attributes in the superficial layer. Such differences between the treatments studied on the soil physical attributes in the superficial soil layer can be attributed to the action of the preparation tools; as well as to the reorganization of soil particles under soil preparation systems, causing a higher densification in the superficial layers in the reduced preparation [8]. Additionally, in post-soil machine traffic, there is an increase in compaction with changes in soil structural quality [9, 10]. However, this can occur even in the absence of soil disturbance, where compaction processes associated with the natural accommodation of the particles can be diagnosed. According to Collares et al. (2006) [9], the structural alteration can imply the increase of the density and the soil penetration resistance, with a reduction of the macroporosity.

In addition, smaller distances between MA and PT were observed for both preparations systems. Similarly to the G1 of the layer of 0.00-0.10 m, the G1 attributes of the layer of 0.10-0.20 m presented the smaller Euclidean distances for the attributes SDr and PRr, and MAd and PTd; while greater distance between PRr and MIr was observed. When analyzing the attributes that constituted Group 2 in the 0.10-0.20 m layer, similar relationships was observed in group 1, with the lowest distances between SDd and PRd; SDd and MId; MId and TPr; and TPr and MAr. It is emphasized that PR is more influencied by the mass-volume relations expressed by SD and the water content in the soil at the moment of its determination. Thus, the relationships between soil porosity attributes suggests that, at these depths, there is a significant effect of the clayey texture and consequently, the high microporosity on the structure and total volume of pores is on detriment to the type of soil preparation. Bergamin et al. (2010) report that in dystroferric Red Latosol, the mineralogical composition of the clay fraction conditions, the behaviour of microporosity is a detriment of soil management, contrary to macroporosity. On the other hand, is observed a direct relationship between SD and PR in both soil preparations systems, as expected, as well as the greater sensitivity of these attributes to reflect the effects of management practices on the structure of soils cultivated with sugarcane [11]. In the present study, in this sense, Cabral et al. (2015) [12] observed a high correlation between SD and PR when studying the different systems of soil preparation in sugarcane reforestation area. Dalchiavon et al. (2013) [13] verified that, among the properties of the soil cultivated with sugarcane, SD was the one that most correlated with the yield of stalks, but with low correlation to PR. This due to PR is significantly influenced by soil moisture variability. Thus, the preparation of the soil should be carried out only once during the sugarcane cycle, its effect must be investigated in the most different edaphoclimatic environments, in order to maintain the adequate structural quality of the soil and its functions aiming to increase the longevity of sugarcane with high yield levels.

4. Conclusion

The soil physical attributes are more similar in the same environment, suggesting differentiated effect of the soil preparation on the attributes in the layers 0.00-0.10 and 0.10-0.20 m. In general, the relationships between soil porosity attributes in both treatments are influenced by the clayey soil texture and consequently by its high microporosity.

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