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Physical attributes of the soil in an area under Forage Palm management in the Agreste of Alagoas

Atributos físicos do solo em área sob manejo de Palma Forrageira no Agreste Alagoano

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ABSTRACT - The objective was to evaluate soil density (Ds) and penetration resistance (RP) in an experimental area with forage palm management. The study was conducted in an experimental area belonging to the Federal University of Alagoas - Arapiraca Campus. To determine the Ds, undeformed samples were collected at three points within the plot, each point with three different depths (0-10; 10-20 and 20-30 cm). To determine the PR, the impact penetrometer was used at depths of 0-60 cm. For comparison purposes, samples were collected in a native forest area. The data were submitted to analysis through the statistical program R and Tukey test at 1 and 5% probability. Ds ranged from 1.59 to 1.63 g cm-3, not differing significantly. The lowest densities were obtained in the surface layer, influenced by the contribution of organic matter and greater presence of roots. In all depths evaluated, the Ds values were lower for the native forest area. In relation to PR, the values gradually increased up to the first 20 cm of depth for most treatments, reflecting the influence that the non-soil revolution causes in the most superficial layers. Therefore, Ds did not differ significantly. The 0-10 cm layer showed the lowest Ds values. The native forest showed the lowest Ds values at all depths when compared to the managed area. PR gradually increased to the first 20 cm of depth for most of the treatments analyzed.

Keywords: Compression. Soil Properties. *Nopalea cochenilifera*. Native Forest. Surface Layer.

RESUMO - Objetivou-se avaliar a densidade do solo (Ds) e a resistência à penetração (RP) em uma área experimental com manejo de palma forrageira. O estudo foi conduzido em uma área experimental pertencente à Universidade Federal de Alagoas – Campus Arapiraca. Para determinar a Ds foram coletadas amostras não deformadas, em três pontos dentro da parcela, cada ponto com três profundidades diferentes (0-10; 10-20 e 20-30 cm). Para determinar a RP, utilizou-se o penetrômetro de impacto em profundidades de 0-60 cm. Para efeito de comparação, foram coletadas amostras em uma área de mata nativa. Os dados foram submetidos à análise através do programa estatístico R e teste de Tukey à 1 e 5% de probabilidade. A Ds variou de 1,59 a 1,63 g cm-3, não diferindo significativamente. As menores densidades foram obtidas na camada superficial, influenciada pelo aporte de matéria orgânica e maior presença de raízes. Em todas as profundidades avaliadas, os valores de Ds foram menores para a área de mata nativa. Em relação a RP, os valores aumentaram de forma gradativa até os primeiros 20 cm de profundidade para a maioria dos tratamentos, refletindo a influência que o não revolvimento do solo ocasiona nas camadas mais superficiais. Portanto, a Ds não diferiu significativamente. A camada de 0-10 cm apresentou os menores valores de Ds. A mata nativa apresentou os menores valores de Ds em todas as profundidades quando comparada à área com manejo. A RP aumentou gradativamente até os primeiros 20 cm de profundidade para a maioria dos tratamentos analisados.

Palavras-chave: Compactação. Propriedades do Solo. *Nopalea cochenilifera*. Mata Nativa. Camada Superficial.

INTRODUCTION

The physical attributes of the soil have direct effects on the root development of crops and, consequently, on their productivity (SIQUEIRA et al., 2008). Among these attributes are soil density (KIEHL, 1979) and penetration resistance (LLANILLO, 2006). Soil density is determined by the ratio of the mass of solids to the total soil volume and is affected by different crops, which change the structure and interferes with the arrangement and volume of pores (KLEIN, 2006). There is, in agricultural soils, a great amplitude of this attribute, which occurs due to its mineralogical characteristics, texture and content of organic matter (MARCOLIN; KLEIN, 2011).

With the increase in density and resistance to penetration, there is a decrease in the ability of roots to penetrate the soil profile (HAMZA; ANDERSON, 2005) since the empty spaces are occupied by them and ultimately decrease with the gradual increase in these attributes (OHLAND et al., 2014). According to Richard et al. (2005), in most intensely cultivated soils, the presence of a massive and dense structure in the superficial and subsurface layers is common, which increases the soil density and ultimately affects aeration, penetration and root growth. This occurs as a function of anthropogenic actions, the use of machinery, and other factors.

Changes in the physical properties of the soil can cause the loss of quality, interfering with the ability to sustain biological productivity and maintain environmental quality (COSTA et al., 2009). This finding demonstrates the importance of the management of resistant crops adapted to different conditions, in addition to crops that help improve soil properties. In this way, it is common to use forage palm, which is one of the cacti with the greatest potential for exploitation, especially in Northeast Brazil, due to the high potential for the production of phytomass (SANTOS et al., 2006; RAMOS et al., 2011) and cover plants, which allow improvements in physical, chemical and biological soil characteristics (PERIN et al., 2003; LIBARDI, 2005).

As reported by Reinert et al. (2008), certain species, even in compacted environments, can develop their root systems due to their specificities and, subsequently, end up being used in soil recovery. The contribution of this waste culture, which encompasses the root system, represents an effective and low-cost alternative for adding organic compounds to the soil, improving its structure (GONÇALVES et al., 2006).

In this way, the objective was to evaluate the soil density and resistance to penetration in an experimental area with forage palm management in the Agreste region of Alagoas.

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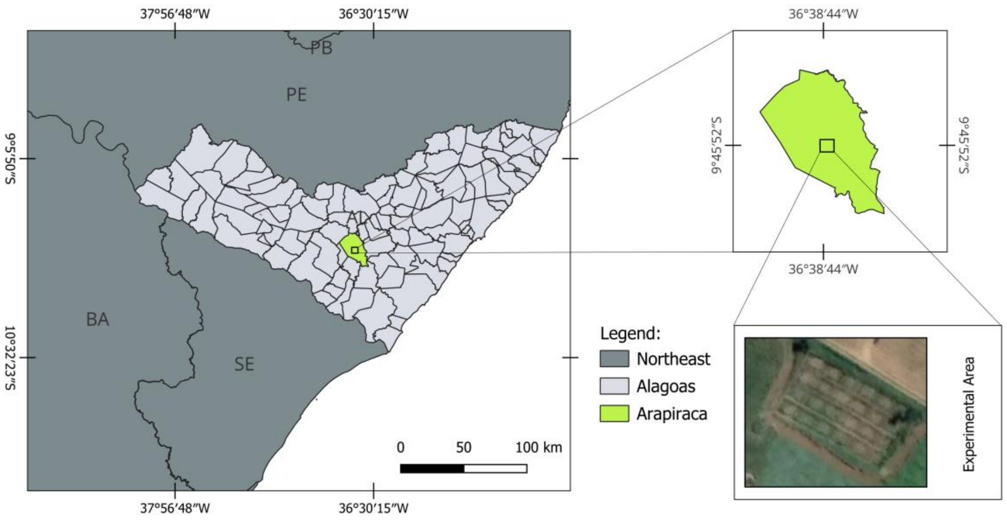
METHODOLOGICAL MATERIALS

The study was conducted in an experimental area belonging to the Federal University of Alagoas - Arapiraca Campus, located in the municipality of Arapiraca (Figure 1) and in the Agreste Alagoano region, with the following geographical coordinates: 9°45'09” S, 36°39'40” W.

Figure 1. Location of the experimental area on the map of the state of Alagoas.



Source: Authors, 2024.

The samples were collected in an experiment that had a randomized block design, with the treatments arranged in a 3x2 factorial scheme, with four replications, totaling 24 plots. The first factor of the experiment corresponded to fertilization: a) green fertilization (Stylosanthes) (AV); b) organic fertilization (bovine manure) (AO); and c) control without green or organic fertilization (CS). The second factor was the spacing, which consisted of a) 1.20 m between the lines and 0.20 m between plants (E1) and b) 1.20 m between the lines and 0.25 m between plants (E2).

To determine the soil density, undeformed samples were collected in a volumetric cylinder using a modified Uhland sampler. The material was collected at three points within the plot, each with three different depths, 0-10, 10-20 and 20-30 cm, as shown in Figure 2. For comparison, samples were collected in an area of native forest, which also belongs to the university in question.

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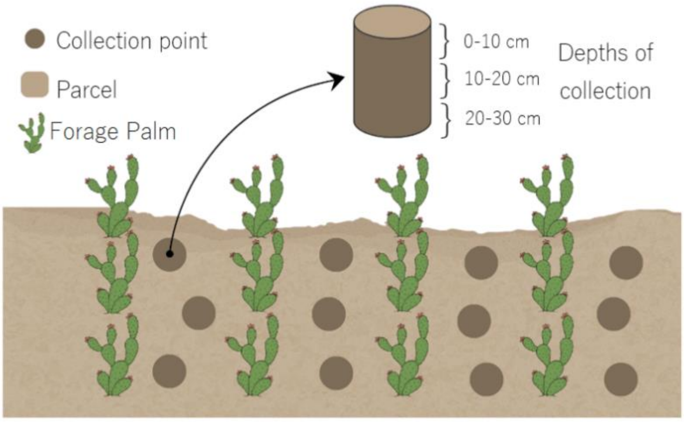
Figure 2. Example of sample collection in the experimental area.



Source: Authors, 2024.

The collected material was transferred to an aluminum container and stored in a greenhouse at 105°C until it reached a constant weight. To determine the soil density, Equation 1 was used.

Equation 1:

$$Ds = \frac{\mathrm{M}solids}{\mathrm{V}soil}$$

In it:
Ds - soil density, in g cm^{-3}.
Msolids - mass of dry soil in a greenhouse, in g.
Vsoil - volume of the soil, equivalent to the volume of the cylinder, in cm^3.

To determine the resistance to penetration, an impact penetrometer was used (STOLF et al., 2014) at depths of 0-60 cm. The data were recorded as the number of impacts (n), later processed in equation 2 (SENE et al., 1985) and multiplied by 0.098 to reach the MPa unit (ARSHAD et al., 1996).

Equation 2:

$$R\ (kgf\ cm^{-2}) = 5{,}6 + 6{,}98\ \times n$$

In it:
n - Number of impacts.

The physical attribute data were subjected to analysis through the R statistical program and Tukey's test at 1 and 5% probability.

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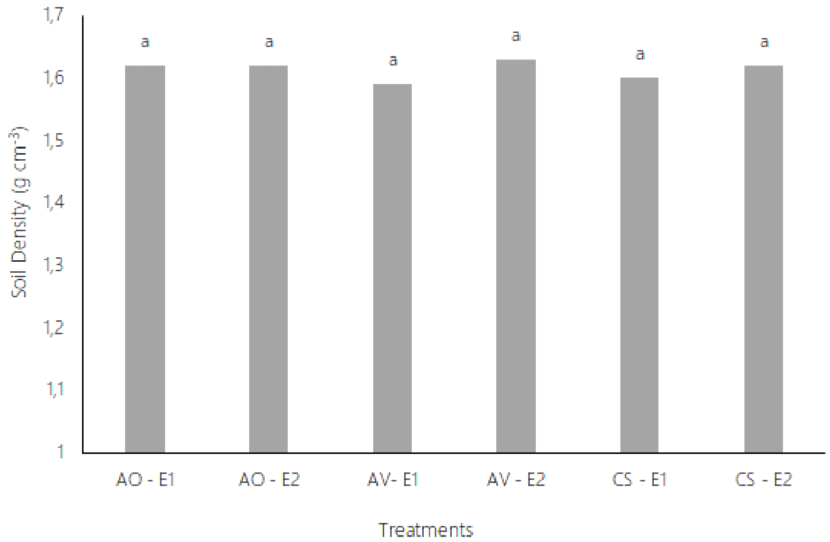
RESULTS AND DISCUSSION

Figure 3 shows the soil density in the different treatments analyzed. The average densities ranged from 1.59 to 1.63 g cm-3 and did not significantly differ. Therefore, these treatments did not influence this attribute. Higher values of soil density in cultivation with forage palm were observed by Lima et al. (2021) when studying the physical characterization of the soil under different management practices, differing from the results of this research.

Figure 3. Soil density in the different treatments in the experimental area.



Means followed by the same letter do not differ statistically from each other by the Tukey test at 5% probability.
Source: Authors, 2024.

Figure 4 shows the soil densities at the different depths analyzed. The lowest values of this attribute were obtained in the surface layer (0-10 cm), with a density equivalent to 1.51 g cm^{-3}. This fact may be related to the contribution of organic matter and the greater presence of roots in this surface area. With the absence of a mechanized system in the experimental area, there is a lower revolution of the soil, contributing to the maintenance of its physical properties, which explains why the highest values were obtained at the other depths.

Figure 4. Soil density at the different depths analyzed.

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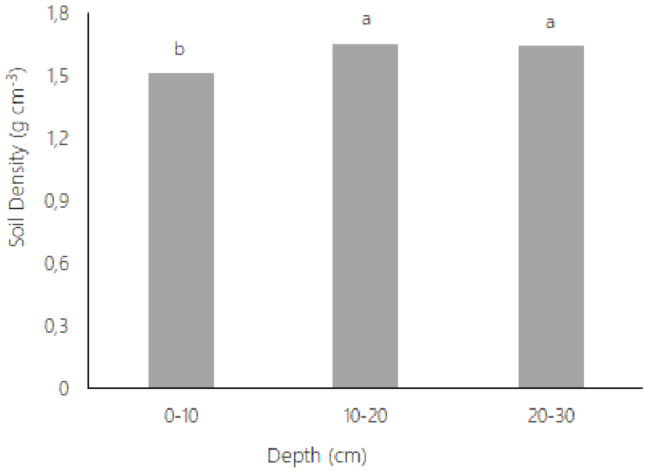

Means followed by the same letter do not differ statistically from each other by the Tukey test at 5% probability.
Source: Authors, 2024.

Similar results were obtained by Gomes et al. (2019) in studies with different use and management systems, where forage palm showed higher values of soil density in the subsurface layer. These findings corroborate the results obtained by Guimarães (2017), who analyzed the dynamics of the drainage of caatinga soils in use with forage palm and observed that the soil density was greater up to 30 cm deep, mainly due to the absence of machines for the revolving of the soil, making this layer more compressed.

According to Santos et al. (2020), the change in soil attributes under native forest vegetation is significantly lower than that under soils for agricultural use; in this way, this vegetation is a reference for the evaluation of soils integrated into systems.

Figure 5 shows a comparison of the areas with managed forage palm and native forest. It is remarkable that, at all the depths evaluated, the soil density values were lower for the area of native forest, reinforcing that the contribution of organic matter and the absence of anthropogenic actions influence the decrease in this attribute.

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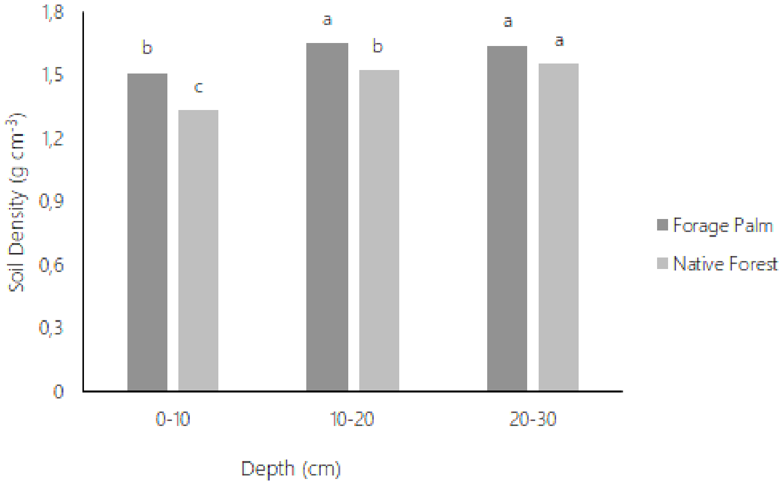
Figure 5. Soil density at the different areas analyzed.



Means followed by the same letter do not differ statistically from each other by the Tukey test at 1% probability.
Source: Authors, 2024.

Similar results were observed by Custódio et al. (2015) in studies that evaluated different management systems, where the native forest presented the lowest soil density values in the surface layer. Other authors have analyzed the physical attributes of soil in different management systems compared to those in native forests (Fernandes et al., 2014; Freitas et al., 2017).

Regarding the resistance to penetration, it can be observed (Figure 6) that the values increased gradually to the first 20 cm of depth for most of the treatments present in the area, reflecting the influence that the nonrevolving of the soil causes on most of its superficial layers. As mentioned earlier, agricultural implements were not used in the experimental area, which explains the greater compaction in the previously mentioned layer.

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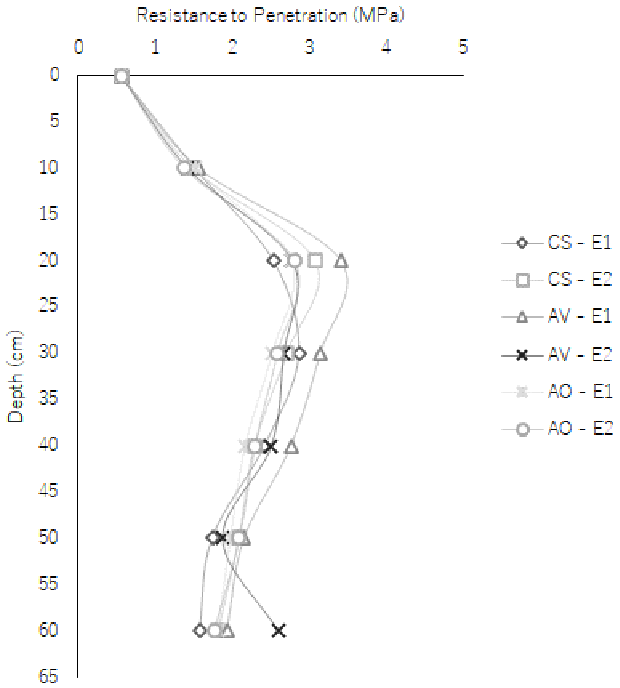
Figure 6. Resistance to penetration at the different depths analyzed.



Source: Authors, 2024.

Behavior similar to that of this research was observed by Ortigara et al. (2014), where the resistance to penetration gradually increased in the 0-15 cm layer in the system with soil management. In studies on the spatial variability of soil attributes and forage palm production, Silva et al. (2020) reported that the resistance to penetration was lower in the most superficial layers (0-10 cm), similar to the results obtained in this research.

CONCLUSIONS

The soil density did not significantly differ among the analyzed treatments.

The 0-10 cm layer had the lowest soil density, resulting from the contributions of organic matter and roots.

Compared with the area with forage palm, the native forest had the lowest soil density at all depths.

The resistance to penetration gradually increased until the first 20 cm of depth for most of the treatments analyzed due to the absence of agricultural implements.

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CONFLICT OF INTEREST

The authors declare that the work has no conflict of interest.

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