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THE WATER RETENTION CURVE IN THE SOIL AS A FUNCTION OF THE TYPE OF MECHANIZED SOIL MANAGEMENT AND PREPARATION TIMES

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1 SUMMARY

A prática agrícola onde são efetuadas o plantio direto continuamente podem acarretar mudanças na estrutura do solo, como o aumento da densidade, principalmente em solos argilosos. Essas alterações, relacionadas ao manejo do solo, podem ser avaliadas por meio de atributos físicos e hídricos. Com a curva de retenção de água no solo (CRA) é possível ter informações sobre a capacidade de água disponível (AD), água que não está disponível (AND) e da capacidade máxima de água (CMA), além da distribuição dos poros ao longo do perfil de solo. Este trabalho teve como objetivo avaliar a curva de retenção de água no solo de um solo submetido a diferentes sistemas de preparo mecanizado em função do tempo de preparo. O experimento foi composto de três sistemas de preparo do solo, preparo convencional (PC), cultivo mínimo (CM) e plantio direto (PD). As curvas de retenção de água no solo foram ajustadas por meio da equação de Van Genuchten. É possível observar na CRA que o PD, um mês após o preparo do solo, apresentou melhor curvatura da CRA e consequentemente melhor qualidade do solo.

Palavras-chave: plantio direto; argissolo; água disponível

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SOIL-WATER RETENTION CURVE AS A FUNCTION OF THE TYPE OF MECHANIZED SOIL MANAGEMENT

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2 ABSTRACT

The agricultural practice where no-tillage is carried out continuously can lead to changes in soil structure, such as increased density, especially in clayey soils. These changes, related to soil management, can be evaluated through physical and water attributes. With the soil–water retention curve, it is possible to obtain information about the available water capacity, the water that is not available and the maximum water capacity, in addition to the distribution of pores along the soil profile. This information is essential for water management, allowing the provision of the ideal amount of water for the development of crops and the rates of water infiltration into the soil. The experiment consisted of three soil tillage systems: conventional tillage, minimum tillage and no tillage. The soil–water retention curves were fitted using the van Genuchten equation. It is possible to observe in the soil–water retention curve that no-tillage had a better curvature of the soil–water retention curve and, consequently, better soil quality.

Keywords: No-tillage; ultisol; available water.

3 INTRODUÇÃO

Soil preparation provides crops with a suitable environment for development. This process can affect physical and water parameters such as water density and availability. Unlike conservation tillage, conventional tillage intensely mobilizes the soil by incorporating surface beds and leaving the soil exposed. In conservation systems, such as minimum tillage and direct planting, soil mobilization is reduced, as is machine traffic. These systems are useful preparation options for maintaining cultural remains in the soil, enabling greater incorporation of organic matter and increasing water retention in the soil, as they are options for the formation of more stable aggregates (Aguiar *et al*., 2021). According to Demuner *et al*. (2017), the relationship between the water content and the energy in which it is retained is represented by the water retention curve (CRA), which is a mathematical function that describes the relationship between the matrix potential and the soil moisture content. It is relatively simple to determine, and a relationship between the curve and the distribution of pore sizes is obtained (Parahyba *et al*., 2019). Campos *et al.* (2018a), evaluating the physical properties of a Red Oxisol after twenty years with different types of soil preparation, observed an increase in soil density and a decrease in organic matter and available water capacity. Santos *et al.* (2011), when studying pastures with two, three and four years of use and plantings of annual crops subjected to conventional tillage and direct planting, observed an increase in density and a reduction in humidity, porosity, hydraulic conductivity and effective saturation only with conventional tillage. Through CRA, it is possible to obtain information about the available water capacity (AD), water availability (AND) and maximum water capacity (CMA), in addition to the distribution of pores throughout the soil profile. This information is essential for water management, allowing for the supply of the ideal amount of water for crop development and water infiltration rates into the soil. The objective of this work was to evaluate the water retention curve of the soil of an Argisol from the Zona da Mata Mineira subjected to different mechanized preparation systems according to the preparation time.

4 MATERIALS AND METHODS

The work was carried out in an experimental area belonging to the Federal University of Viçosa (MG), geographic coordinates corresponding to latitude 20° 45' 14” S, longitude 42° 52' 53” W and average altitude of 650 m. According to Köppen (1948), the region's climate is classified as humid mesothermal, and the soil is classified as dystrophic Red Yellow Argisol (Embrapa, 2013). The experimental area was fallow with low vegetation cover, which was removed mechanically before soil preparation. The experiment included three treatments, conventional tillage (PC) and conservation tillage, with minimum tillage (CM) and direct tillage (PD). In conventional preparation, the soil was mobilized with one pass of the reversible disc plow with three 26' discs, followed by two passes with a tandem declogging-levelling harrow with 24 discs. For minimum cultivation, soil preparation was carried out using a five-rod scarifier, and for direct planting, a direct planting fertilizer with three planting lines was used. The implements were pulled by a tire tractor with an auxiliary front-wheel drive (TDA) and 59 kW of nominal power. Soil samples were collected using volumetric stainless steel rings at depths ranging from 0 to 0.10 m. At two time points, the first collection was carried out one month after soil preparation, and the second was collected six months after preparation. from soil. The experiment was arranged in accordance with a split-plot scheme, with the types of soil preparation in the plots and the sampling times in the subplots, in accordance with a randomized block design with four replications. The data were tested for normality using the Shapiro–Wilk test and subjected to analysis of variance. When significant, the means were compared using the Tukey test at 5%. All analyses were carried out in the SAS University program Edition. In the laboratory, the saturated samples were subjected to matric potentials of -0.004, -0.006, -0.008, and -0.01 MPa on the stress table and to matric potentials of -0.03, -0.05, -0.07, -0.1, -0.5 and -1.5 MPa in the Richards chamber. The soil water retention curves were adjusted using the van Genuchten equation, 1980 (equation 1).

$$\theta_{ij=\theta_r} + \frac{\theta_s - \theta_r}{\left[1+(\alpha\, \psi_{ij})^n\right]^m};\ \psi_{ij} \geq 0 \qquad (1)$$

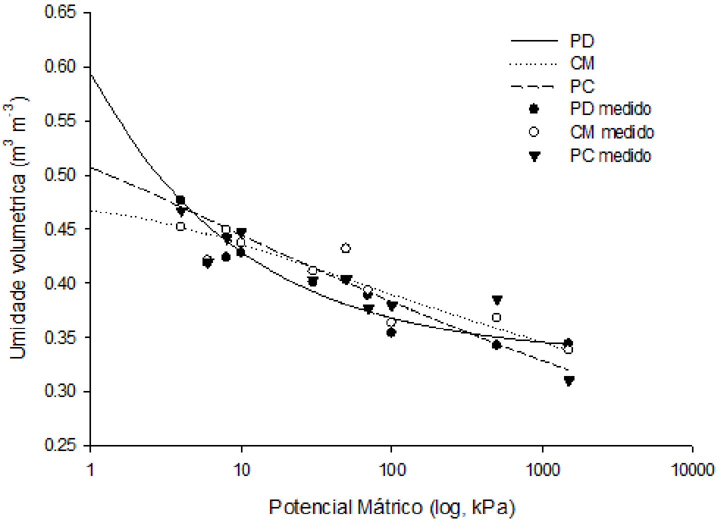
On what:
θij – Sample humidity (m³ m $^{-3}$);
θr – Residual humidity (m³ m $^{-3}$);
θs – Saturated humidity (m³ m $^{-3}$);
ψij – Soil matric potential (kPa);
α - Parameter related to the soil matric potential; (1/cm)
nor are the parameters related to the slope of the line.

The model parameters were determined by the Soil Software Water Retention Curve (SWRC) version 3.0 beta (Dourado Neto; Nielsen, 2001). To calculate the parameter m, the Maulem restriction was used. To calculate θr and θs, the extrapolation method suggested by Lier and Dourado Neto (1993) was used.

5 RESULTS AND DISCUSSION

Figure 1 shows the soil water retention curves (CRAs) one month after preparation. It appears that the water retention capacities were close, but direct planting presented greater value. The greater retention of water in the surface layer of the soil in PD was due to the lack of disturbance of the soil in this type of preparation, allowing the maintenance of the micropores that are responsible for retaining water in the soil. Similar results were found by Fagundes *et al.* (2019), who evaluated a dystrophic Red Yellow Oxisol cultivated with corn via direct and conventional planting methods. The authors attributed the higher value of available water found in direct planting to the maintenance of surface vegetation, which led to a greater input of organic matter in this type of preparation.

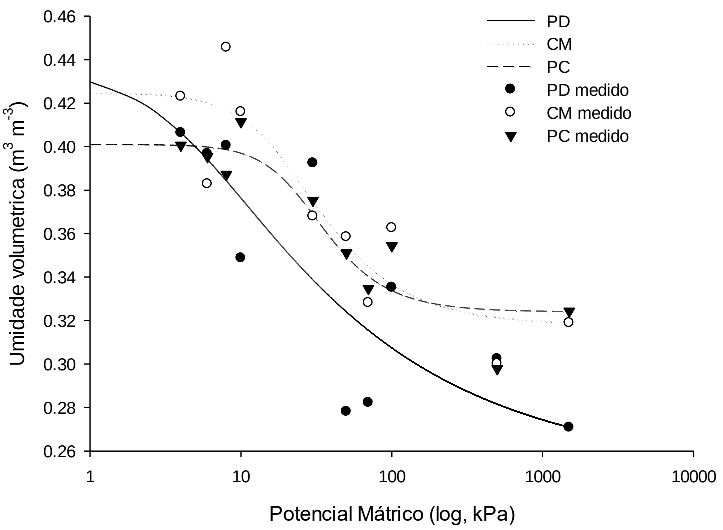
Figure 1. Water retention curve 1 month after soil preparation.



Source: Authors

It is possible to observe that in the CRA one month after soil preparation, the PD had better curvature and, consequently, better soil quality. Figure 2 shows the improvement in the curvature of the CRA over time, indicating an improvement in physical-water quality for all types of preparations. According to Jardini and Amorim (2017), the curve shapes found six months after soil preparation indicate a well-structured soil, with a better distribution of pores throughout the soil profile.

Figure 2. Water retention curve six months after soil preparation.



Source: Authors

Six months after soil preparation, at low matrix potentials, conservation tillages presented a larger volumetric unit than did conventional tillage. At high matrix potentials, the values are close to those of CM and PC, and the values are lower for PD. The CRAs for p CMs and PCs were similar.

Table 1. The soil density (g cm^{-3}), available water (m3 m^{-3}), unavailable water (m3 m^{-3}), maximum water capacity (m3 m^{-3}) and S index were measured under conventional tillage (PC), minimum cultivation (CM) and direct planting (PD) for sampling carried out after and six months after soil preparation.

	After	**Six months later**	**Average**	**CV**
		Soil density		
PRAÇA	1.06	1.04	1.05	1.18
CM	1.12	1.09	1.10	1.34
P.D.	1.12	1.08	1.10	1.74
Average	1.10	1.07	1.09	
		Available water		
PRAÇA	0.082	0.047	0.064	26.62
CM	0.043	0.028	0.036	20.33
P.D.	0.052	0.071	0.061	16.08
Average	0.059	0.049	0.054	
		Water not available		
PRAÇA	0.284	0.276	0.280	1.40
CM	0.312	0.300	0.306	1.94
P.D.	0.314	0.275	0.295	6.69
Average	0.30A	0.284B	0.293	
		Maximum water capacity		
PRAÇA	0.548 aA	0.432 bB	0.490	11.78
CM	0.604 aA	0.419 aB	0.511	18.1
P.D.	0.478 aA	0.423 aB	0.451	6.07
Average	0.543	0.425	0.484	
		Indices		
PRAÇA	0.033	0.041	0.037	11.04
CM	0.064	0.070	0.067	4.49
P.D.	0.033	0.062	0.047	31.11
Average	0.043	0.058	0.050	

Means followed by the same lowercase letter in the column and capital letter in the row do not differ from each other according to the Tukey test at 5% significance.
Source: Authors

The available water content (AD) did not significantly differ in relation to soil preparation. According to Dalmago *et al.* (2009), the amount of water available on the soil surface is approximately 60% greater in the PD system than in the PC system in areas with a time interval of 7 years since the preparations were implemented. Campos *et al.* (2018b) evaluated a Dystrophic Red–Yellow Argisol in different types of soil preparation and reported higher available water values in preparations with low soil mobility than in those with native forest mobility in the layer from 0 to 0.20 m. The authors associated these values with the movement of clay due to the mobilization of soil preparation, which does not occur in native forest soil. The average unavailable water content (AND) for plants was greater immediately after soil preparation than after six months of preparation, with no significant interaction between the system and soil preparation time. This value indicates an improvement in soil quality over time as more water became available for crops. Among the soil preparation systems, no significant differences were observed. The highest maximum soil water storage capacity (CMA) was found immediately after soil preparation for all the tillage systems. For the soil preparation systems, no significant differences were observed in the CMA values at either preparation time. The S indices did not differ according to the system or soil preparation time. Jardini and Amorim (2017) evaluated the physical water quality of soils in the Mato Grosso cerrado under different management practices using the S index. The authors observed higher S-index values in areas without agricultural management and in natural pasture areas, associating these areas with better physical soil quality. The S index has a negative correlation with soil density; that is, the S index increases with decreasing density (Yang *et al.*, 2015). As in this work, the variation in density was low, and the S index followed this trend.

6 CONCLUSIONS

One month after soil preparation, it was possible to observe a better curvature of the WHC in the PD, indicating better physical-water quality for this type of preparation than for the other preparations studied. In general, it is possible to observe an improvement in the physical quality of all preparations over time.

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