BIMODAL PORE DISTRIBUTION ON SOILS UNDER CONSERVATION MANAGEMENT SYSTEM FOR COFFEE CROP

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ABSTRACT: This study aims at detailing bimodal pore distribution by means of water retention curve in an oxidic-gibbsitic Latosol and in a kaolinitic cambisol Latossol under conservation management system of coffee crop. Samples were collected at depths of 20; 40; 80; 120 and 160 cm on coffee trees rows and between rows under oxidic-gibbsitic Latosol (LVd) and kaolinitic cambisol Latossol (LVAd). Water retention curve was determined at matrix potentials (Ψ_m) -1; -2; -4; -6; -10 kPa obtained from the suction unit; the Ψ_m of -33; -100; -500; -1,500 kPa were obtained by the Richards extractor, and WP4-T psychrometer was used to determine Ψ_m -1,500 to -300,000 kPa. The water retention data were adjusted to the double van Genuchten model by nonlinear model procedures of the R 2.12.1 software. Was estimated the model parameter and inflection point slope. The system promoted changes in soil structure and water retention for the conditions evaluated, and both showed bimodal pores distribution, which were stronger in LVd. There was a strong influence of mineralogy gibbsitic in the water retention more negative than Ψm -1500 kPa, reflected in the values of the residual water content.

KEYWORDS: psychrometer, mathematical modeling, *Cerrado* soils.

DISTRIBUIÇÃO BIMODAL DE POROS EM SOLOS SOB SISTEMA CONSERVACIONISTA DE MANEJO DO SOLO NO CULTIVO CAFEEIRO

RESUMO: Este trabalho teve por objetivo detalhar a distribuição bimodal de poros por meio da curva de retenção de água em um Latossolo de mineralogia oxídica-gibbsítica e um Latossolo cambissólico de mineralogia caulinítica sob sistema conservacionista de manejo do solo, no cultivo de cafeeiros. Foram coletadas amostras nas profundidades de 20; 40; 80; 120 e 160 cm, na linha e na entrelinha dos cafeeiros, sob Latossolo oxídico-gibbsítico (LVd) e Latossolo cambissólico (LVAd). A retenção de água foi determinada nos potenciais matriciais (Ψ_m) de -1; -2; -4; -6; -10 kPa obtidas na unidade de sucção; os Ψ_m de -33; -100; -500; -1.500 kPa obtidos no extrator de Richards e o psicrômetro WP4-T foram utilizados para determinar Ψ_m de -1.500 a -300.000 kPa. Os dados de retenção de água foram ajustados ao modelo duplo van Genuchten por meio de procedimentos de ajuste de modelos não lineares do software R 2.12.1. Estimaram-se os parâmetros do modelo e a inclinação dos pontos de inflexão. O sistema promoveu alterações na estrutura dos solos assim como na retenção de água para as condições avaliadas, e ambos apresentaram distribuição bimodal dos poros, fato este mais expressivo no LVd. Houve forte influência da mineralogia gibbsítica na retenção de água em Ψ_m mais negativa que -1.500 kPa, refletido nos valores do conteúdo de água residual.

PALAVRAS-CHAVE: psicrômetro, modelagem matemática, solos do Cerrado.

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INTRODUCTION

Latosols represent the class of soils with wider coverage in the brazilian region of *Cerrado*. Its mineralogy consists primarily of 1:1 type clay minerals and iron and aluminum oxides (which includes oxides, hydroxides and oxyhydroxides) (OLIVEIRA et al., 2004). They tend to disrupt the mineral particles promoting the formation of very small aggregates (VIDAL-TORRADO et al., 1999; ALBUQUERQUE FILHO et al., 2008). Thus, these soils have high porosity, especially inter-aggregate pores (COOPER & VIDAL-TORRADO, 2005) hence they present high permeability and better deep water retention capacity.

There is also a significant proportion of Latossol with their mineralogy predominantly composed of the 1:1 type clay minerals (kaolinite), which allows the development of structure in blocks. Because their mineralogy, and generally your position in the landscape, these soils present low permeability consistent with their higher density and lower porosity, which favor a lower vertical water flow, thus reducing their infiltration capacity and water retention capacities (RESENDE et al., 2007; MENEZES et al., 2009).

Even in contrasting soil classes may occur predominant structural pores, those of larger diameter (inter-aggregates), which are likely by management change (DEXTER, 2004) and textural pores that occur in a very small diameter range, between intra-mineral particles or aggregates (OLIVEIRA et al., 2004), especially in highly weathered soils. Thus, a large amount of water may remain trapped in these soils when subjected to high matric potential, especially in clayey soils (SEVERIANO et al., 2011a). Therefore, this pore segregation into two broad classes characterizes the bimodal pore distribution (DEXTER et al., 2008), by the the first derivative water retention curve.

Despite being considered as unavailable to plants (KLEIN et al., 2010) for optimal cultivation conditions, residual water (Ψm > -1,500kPa, in absolute value) can be crucial in the regulation of microbial processes (MOREIRA & SIQUEIRA, 2007), in soil load bearing capacity (DIAS JÚNIOR, 2000), when it is subjected to external pressure during mechanized operations. For instance, oxidic Latosols have low load bearing capacity, even in dry seasons when water is retained in more negative than -1,500kPa soil matric potential, due to its granular structure (SEVERIANO et al., 2011a; SEVERIANO et al., 2011b). Furthermore, in the subsoil layers, residual water plays an important role in the maintenance of physical and thermal conditions, which minimizes root deaths in the dry seasons. Therefore, the understanding of water retention in the soil is critical in the evaluation of soil quality and adequacy of management practices for sustainable agricultural production systems.

Studies about soil water retention, regarding more negative than -1,500 kPa matric potential, are not common in literature. At the current stage of development of agricultural systems, which seeks to improve its quality aiming at increasing productivity coupled with environmental sustainability, it becomes necessary to know the water retention curve as detailed as possible in view of the range of functions exerted by soils, ranging from groundwater recharge through food production to maintenance of different types of life.

This study aims at detailing the bimodal pore distribution by means of water retention curve in an oxidic-gibbsitic Latosol and in a kaolinitic cambisolic Latosol under a conservation management system of coffee crop in Alto São Francisco River in Minas Gerais State, Brazil.

MATERIAL AND METHODS

The study was conducted in crops planted in November, 2005 and managed according to the assumptions of an conservation management system of coffee crop, located in the municipality of São Roque de Minas, physiographic region of Alto São Francisco, in the Minas Gerais State, Brazil, and it belongs to Empresa Agropecuária Piumhí. The farm coffee production area is of 52 ha and it coordinates are UTM 23 K 356,960 m and 7,766,680 m, and 891 m of elevation. The climate is classified as humid subtropical with dry winter and hot summer (Cwa) according to Köeppen classification. The monthly average rainfall in the region ranges from 30 mm in July to 300 mm (maximum precipitation) in December.

Crops composed of coffee trees (*Coffea arabica* L.) cv. Yellow Catucaí. They were planted about 3.5 years ago at the time of sampling (March, 2009), and were arranged in a dense spacing of 2.50 x 0.70 m (between rows and between plants, respectively). This system consists of: preparation of planting row at 60 cm depth, where it is incorporated into the fertilizer; and plantation of coffee seedlings is anticipated to be held in the first fortnight of November. After the plantation, 7 kg m^{-1} of phosphogypsum was distributed in the planting row, then the earthing-up procedure (20 cm of soil between rows) to the coffee tree trunk had taken place. A cover crop (*Brachiaria sp.*), which is kept mowed, were planted together with plantation. All plant residue produced is distributed both on furrows and between rows. The cultural practies is mainly made with animal traction equipment, and only the harvest is mechanized (SERAFIM et al., 2011).

For soil characterization and visualization of root development, three trenches were dug longitudinally to trees row, with dimensions of 150 x 200 x 200 cm. After a profile morphological description, samples were collected for hydro-physical and chemical analyzes. Nine samples of undisturbed soil were obtained in volumetric cylinder of 6.4cm of diameter x 2.5 cm of height using an Uhland sampler at depths of 20; 40; 80; 120; 160 cm in row and between row positions of the crop on oxidic-gibbsitic Latosol and kaolinitic cambisolic Latosol, totaling 90 samples per soil. the samples were wrapped in plastic and paraffin wax, for perform hydro-physical analysis.

Samples with preserved structure were prepared in laboratory, and the exceeding soil of upper and lower portions of the volume of their respective rings were air dried and passed through sieves of 2mm, thus obtaining deformed samples.

The pipette method was used for particle size analysis (EMBRAPA, 1997). Contents of SiO_2, Al_2O_3 and Fe_2O_3 were determined in sulfuric extract and used in the calculations of molecular relationships of Ki (SiO_2/Al_2O_3) and Kr [$SiO_2/(Al_2O_3 + Fe_2O_3)$] (EMBRAPA, 2006).

The chemical and physical characterization of the soil is found in Table 1 and the characterization of organic matter obtained according to EMBRAPA (1997) is found in Table 2. Given these characterizations and morphology, soils were described according to SANTOS et al. (2005) and classified according to EMBRAPA (2006) as cambisolic dystrophic Red-Yellow Latosol (LVAd) and typic dystrophic Red Latosol (LVd), both very clayey. A Ki value below 2.2 characterizes soils as well weathered and Kr values greater than 0.75 for cambisoli Latosol indicates its kaolinitic mineralogy; however, the value of Kr below than 0.75 for typic Latosol evidences its sesquioxide gibbisitc mineralogy.

TABLE 1. Physical and Chemical characterization of Bw horizon on typic Latosol (LVd) and cambisolic Latosol (LVAd).

	Granulometry			Sulfuric acid attack					
Soilss	Sand	Silt	Clayy	SiO_2	Al_2O_3	Fe_2O_3	Ki⁽¹⁾	Kr⁽²⁾	D_s⁽³⁾
	....			g kg^{-1}					kg dm^{-3}
LVAd	140	130	730	233.5	260.5	114.4	1.52	1.19	1.09
LVd	170	90	740	124.4	336.8	153.4	0.63	0.49	0.84

(1)Ki - molecular relationship SiO_2:Al_2O_3; (2) Kr - molecular relationship SiO_2: (Al_2O_3 + Fe_2O_3); (3)D_s - soil overall density.

Through morphological description of the study area, it was identified in LVAd horizons (Hz) A (A + AB) 0-50 cm and Bw 50-100 cm of depth, with effective depth of 210 cm, the structure developed in weak small angular blocks at 4-8% of inclination. For LVd Hz. A (A + AB) presented 0-65 cm and Hz. Bw $65\text{-}125^+$ cm of depth, with effective depth of 220 m, very small grain structure and strong degree of land slope of 9-14%.

TABLE 2. Organic matter characterization (1) along depth and position on typic Latosol (LVd) cambisoli Latosolic (LVAd).

Depth (cm)	LVAd		LVd	
	Between Rows	Row	Between Rows	Row
	....dag kg^{-1}......................................			
20	3.40	3.80	5.30	3.33
40	3.10	3.70	3.80	3.40
80	2.61	2.60	2.62	2.60
120	2.50	2.39	2.50	2.40

(1)Results by the soil analysis routine Laboratory of the Federal University of Lavras, Lavras - MG, Brazil.

In order to determine the water retention curve (WRC), the samples with preserved structure initially were gradually saturated and subjected to matrix potentials (Ψ_m) -1; -2; -4; -6; -10 kPa. Using the suction units, -33; -100; -500; -1,500kPa were obtained in the Richards extractor (EMBRAPA, 1997). Then the samples were dried in oven at 105-110 °C for 48 hours in order to determine the water content corresponding to the soil water potential.

For the purpose of obtaining values for retained water content in soil with higher Ψ_m than those determined by porous plate extractors (Ψ_m> -1,500 kPa) a WP4-T Dewpoint Potential Meter thermocouple psychrometer (DECAGON DEVICE, 2000) was used. Initially, deformed samples were equilibrated to the water content corresponding to Ψ_m of -1,500 kPa, and successively subjected to natural and/or artificial drying, using nature condition of temperature and/or force ventilation (laboratory oven) with temperature controlled between 55 and 60 °C. Subsamples of these materials with 2 g of soil were placed in specific WP4-T containers and inserted into the reading chamber until water content in its interior and soil water content are balanced, generating WRC points.

To obtain a better characterization of this segment of WRC, referring to high Ψ_m, successive readings were taken (≅ 15 points) between the potentials of -1,500 to -300,000 kPa (reading range allowed by the tool according to DECAGON DEVICE, 2000). Three replicates per Ψ_m were performed to build WRC.

Later it was set to the double van Genuchten equation proposed by CARDUCCI et al. (2011):

$$U = U_{res} + \frac{(U_{pmp} - U_{res})}{(1 + (\alpha_{tex}\psi_m)^{ntex})^{mtex}} + \frac{(U_{sat} - U_{pmp})}{(1 + (\alpha_{est}\psi_m)^{nest})^{mest}}$$

with restriction of m=1-1/n, taken for both curve segments. The gravimetric water content and matric potential are represented by U and ψ_m, respectively. U_{res} (residual water content), U_{pmp} (water content in the permanent wilting point) and U_{sat} (water content at saturation) parameters represent the lower asymptotic plateau ($\psi_m \rightarrow \infty$), the intermediate asymptotic plateau and upper asymptotic plateau ($\psi_m \rightarrow 0$), respectively. The parameters α_{est} and n_{est} (structural) and α_{tex} and n_{tex} (texture) are associated with the scale and shape of the curve, for both segments.

The double van Genuchten model was adjusted to experimental data of water retention for each level combination (2 soils x 2 positions x 5 depths) totaling 20 WRC, by least squares method. This procedure was obtained by the adjustment of nonlinear models, where the Gauss-Newton algorithm was used with terminal tolerance of 10^{-6} and maximum number of iterations equal to 700. Estimates of the inclination in the two inflection points of the WRC were obtained. The first value of the slope in the first inflection point (Ψ_m less negative) is treated here as structural slope (I_{est}) referring to the S index proposed by DEXTER (2004), while that for the second inflection (Ψ_m more negative), as textural gradient (I_{tex}), adjusted according to the formulas proposed by DEXTER & BIRD (2001) and DEXTER & RICHARDS (2009). All statistical inferences were considered with nominal significance level of 5%. For model adjustments and construction of graphs was used the R 2.12.1 computational application (R DEVELOPMENT CORE TEAM, 2009).

RESULTS AND DISCUSSION

Convergence was obtained for the double van Genuchten model adjustment to data in all level combinations (2 soils x 2 positions x 5 depths) (Figure 1 and 2). The model was highly explanatory, and complied with the assumptions of least squares method (normality and homoscedasticity). As noted, the model characterizes well the relationship between the soil water content within the range of Ψ_m evaluated. The nonlinear relationship between the variables expressed in the model, as well as the presence of two inflection points in this study conditions (soils under agricultural cultivation), were evident. CARDUCCI et al. (2011) found this characteristic by investigating the Bw horizons of different Latosols of the *Cerrado* region.

As seen in other models (DEXTER et al., 2008; ALFARO SOTO et al., 2008), the derivative of the double van Genuchten model presented the bimodal characteristic for soil pore size distribution, which characterizes the porosity in structural and textural pores obtained by the two inflection points, which considered, however, different intervals of Ψ_m the WRC establishment. However, due to the larger number of parameters, the double van Genuchten model becomes more flexible.

As the first derivative of WRC represents pore size distribution, it is possible to verify that on LVd the pore size has a strong segregation into two classes (DEXTER et al., 2008), whose class size corresponds to Ψ_m related to inflection points of WRC. On LVAd, segregation into classes is less abrupt, with greater continuity, which indicates the presence of various pore sizes associated with the studied WRC interval (Figures 1 and 2). Therefore, this format confirms the presence of structural pores, and mainly textural pores (DEXTER et al., 2008; ALFARO SOTO et al., 2008).

There were differences in WRC, caused both by handling and by the clayey mineralogy (kaolinitic and oxidic), thus the double sigmoid curve may be divided into regions of less negative Ψ_m (below the first inflection point), medium Ψ_m (between the first and second inflection points) and more negative Ψ_m (above the second inflection point). Furthermore, it was observed on LVAd the influence of little weatherable materials in increasing proportions from 80cm depth that attributed to heterogeneity and consequent soil complexity.

In less negative Ψ_m there was high influence of handling on water retention on both soils (Figures 1 and 2). The structural pores differed both in rows and between rows. A beneficial influence of the coffee root system due to the larger volume of roots (visual observation) associated with the revolving occurred with the opening of row to a depth of 60 cm were observed in furrows. Between rows showed the beneficial effects of *Brachiaria sp.* root system in the improvement of aggregation provided in part by the rapid rate of growth and renewal of the roots, and besides of performing the function of protection as a cover crop (CONTE et al., 2007; CUNHA et al., 2007; LIMA et al., 2012), which favored expressive values of organic matter along the soil profiles. However, in similar amounts in both positions (Table 2), after the mowing the plant residue is spread in rows and between rows; along with the absence of soil disturbed and more pressure applied by the traffic of agricultural machinery with respect to the different treatment of the coffee cultures, these were seen as the main factors that contributed to the structural changes, and, consequently, reflected in the greater water retention.

In the region of WRC medium Ψ_m, major differences in water retention for the soils evaluated were observed. The characteristic of WRC on LVd for medium Ψ_m showed parallelism to the abscissa axis indicating absence of pores with a diameter corresponding to the area (OLIVEIRA et al., 2004), suggesting that weathering homogenized the soil leaving pores divided into two distinct classes. On LVAd, the presence of primary minerals and minor weathering conferred to this soil greater complexity to the porous system during this Ψ_m evaluated.

For more negative Ψ_m there was also a strong influence of mineralogy on water retention (Figures 1 and 2). The greater the gibbsite content, the more strongly the water is retained in the pores texture (SEVERIANO et al., 2011a; SEVERIANO et al., 2011b) and on the contrary, the higher the content of kaolinite, the more easily the water is removed in the textural pores. This was proven by the Ψ_m average value and the content of water in the second inflection point (Ψi_{tex}) whose Ψi_{tex} was approximately -5,666kPa for water content of 0.20g g^{-1} on LVd, while on LVAd, with 0.20 g g^{-1} of water content Ψi_{tex} was -3,590 kPa.

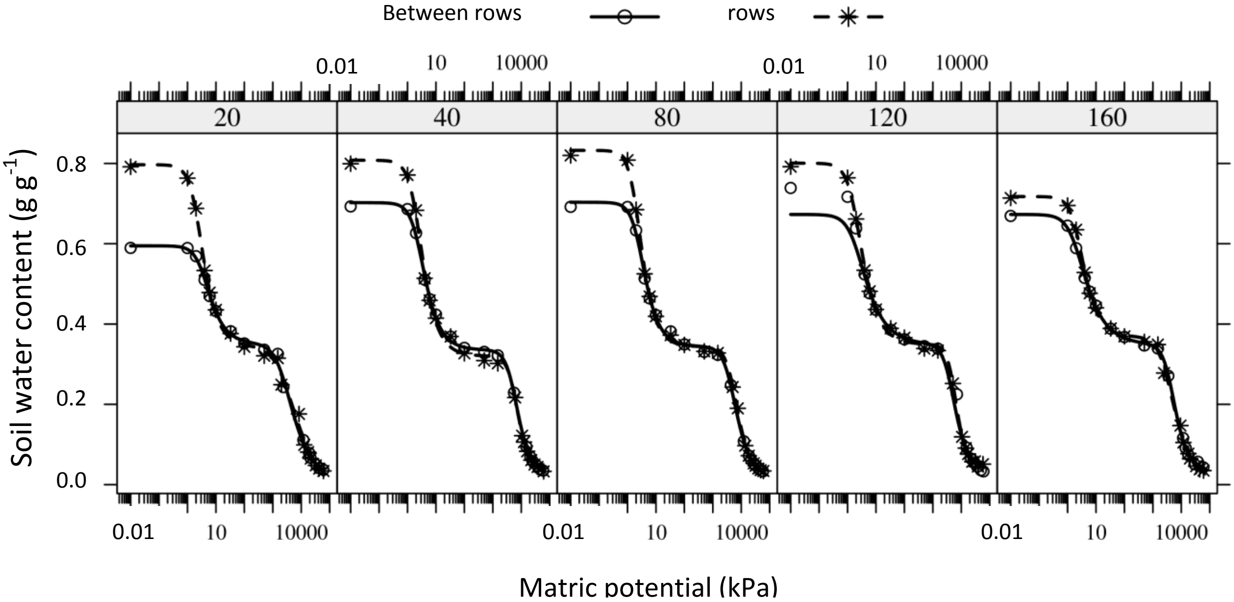

FIGURE 1. Water retention curves [soil water content (U, g g^{-1}) as a function of matric potential (kPa)] of typic dystrophic Red Latosol (LVd), according to double van Genuchten model on five depths of the soil profile (cm).

When comparing the sampling positions (row and between rows) on LVd a higher water retention in furrow less negative Ψ_m was evident, particularly in the first 20cm and still more outstanding until 120 cm (Figure 1). Until the depth of 60 cm this result could be explained by the effect of furrow opening associated with the incorporation of fertilizers and crop residues that conditioned the reduction of soil density. At greater depths it is likely due to the presence of large amounts of coffee roots, which is subsidized by the observation made at the morphological description of the profile, which certainly produced positive changes on soil structure (LIMA et al., 2012).

The greatest difference observed in the first 20 cm was probably due to the cumulative effect of pressure applied by the combine harvester since the culture had three yields, as well as, even if to a lesser intensity, the load applied by equipment moved by animal-traction in the row, promoted negative changes in soil structure (ARAUJO JUNIOR et al., 2008; IMHOFF et al., 2001).

Under the Ψ_m -1,500 kPa, and even at potentials more negative than this value, there was still a large amount of water retained, beyond the similarities of the LVd WRC at various depths, regardless of the sampling position (Figure 1); this is one reason for the high susceptibility to compaction of very clayey gibbsitic Latosols (SEVERIANO et al., 2011b). This large water retention in these Ψ_m is due to greater surface area available for water adsorption (SEVERIANO et al., 2011; MACHADO et al., 2008), due to the clayey soil and sesquioxidic gibbsitic mineralogy which favors the presence of intra-aggregate pores (textural pore) responsible for the process of very strong water retention (DEXTER et al., 2008; DEXTER & RICHARD, 2009; KLEIN et al., 2010).

Regarding the sampling positions on LVAd (Figure 2), similar to LVd, the biggest difference was observed in the first 20 cm, and this was also explained by changes on soil structure caused by machinery traffic between the rows even in a small intensity, as well as the positive effect promoted by the opening of holes in the rows. In this case, the positive effect soil promoted by the opening of holes was restricted to 40 cm of depth (Figure 2), which need to be investigated as its opening reached 60 cm, as the LVd area.

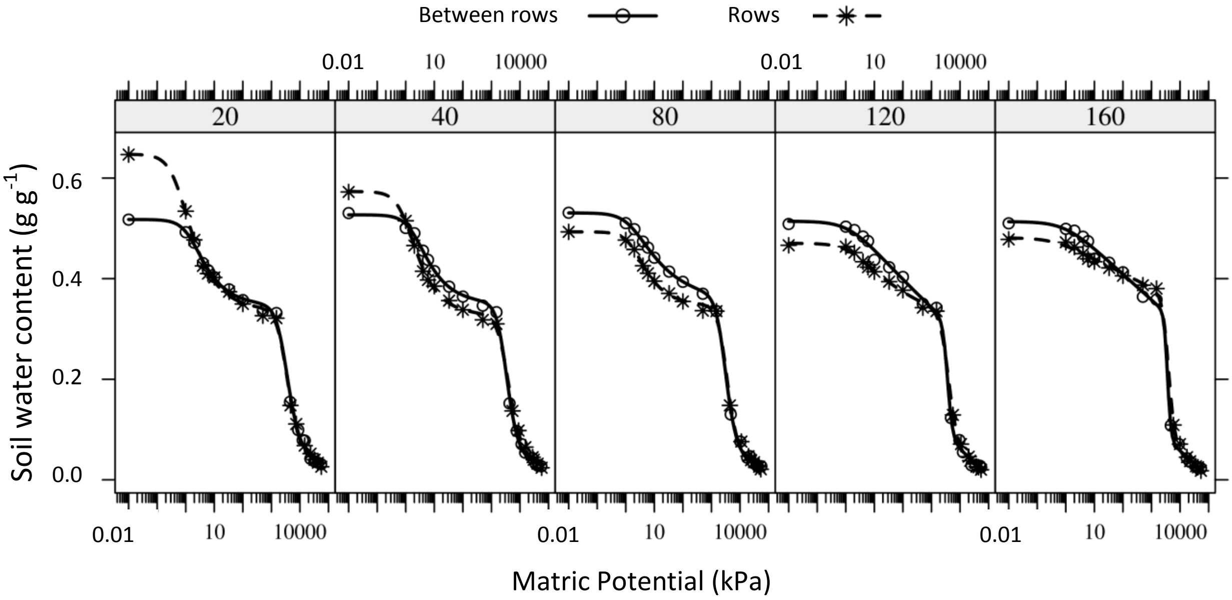

FIGURE 2. Water retention curves [soil water content (U, g g^{-1}) as a function of matric potential (kPa)] cambisolic dystrophic Red-Yellow Latosol (LVAd), according to double van Genuchten model on five depths of soil profile (cm).

The higher water retention was found on other depths, in less negative Ψm between rows. In open trench for morphological description of the soil along coffee row and laterally to between rows, there was a sharp natural intensification, starting at depths of 70 cm, coincident with the presence of the BC horizon. Although several coffee tree roots have been observed until a depth of 120 cm, it is suggested here that the beneficial effect on the structure of LVAd promoted by the roots only occurred in between rows and was due to the efficient action of *Brachiaria sp.* (CUNHA et al., 2007), which presents a more aggressive root system in relation to the coffee tree, which was found in profusion in the densest layers that promoted a little soil restructuring and biopore formation (LIMA et al., 2012).

The parameter estimate that composes the double van Genuchten model was significant except for the residual water content (U_{res}) for both positions during the first sampling depths (20; 40; 80) and at 160 cm on LVd row (Table 3); while for LVAd U_{res} at greater depths in between rows (120 and 160 cm) and estimates for water content at wilting point (U_{pmp}) in both positions and at the same depths showed no significant differences. This result indicates that all water of these soils was removed, considering the amplitude of the Ψ_m reading obtained in WP4-T.

Elevated U_{pmp} values were found for both soils (Table 3). Despite this potential for water retention in the soil to be considered borderline for the metabolism of most cultivated plants in terms of hidric stress (TORMENA et al., 2007), it is noteworthy that the existing water content in that Ψ_m can be sufficient to regulate soil microbial biochemical processes (e.g. extension of hyphae of symbiotic fungi) (MOREIRA & SIQUEIRA, 2007), and be critical to the trafficability of some agricultural soils, due to its soil particle lubricating potential (SEVERIANO et al., 2011b).

The first inflexion point corresponding to the first WRC segment, the structural one (Ψi_{est}) for both soils occurred under less negative Ψ_m between -2 and -5 kPa throughout the profile, and LVd between -1 and -4 kPa for the surface layers of LVAd, corroborating values found by CARDUCCI et al. (2011) for oxidic Latosols under native vegetation of the *Cerrado* region. These Ψi_{est} values for LVd and LVAd showed the positive effects favored by conservation system on the structure of these soils.

Due to the density observed at greater depths of LVAd, more negative values (-40 to -150 kPa) to the depths of 120 to 160 cm between rows, respectively, and particularly to the depth of 160 cm in culture row (-237 kPa) were found (Table 3).

Since many researchers consider this inflection point of water retention curve in field capacity evaluation (KELLER et al., 2007; DEXTER & BIRD, 2001), it is emphasized that the Ψ_m that defines this parameter varies from soil to soil and even from horizon to horizon of the same soil, thus corroborates with the exposed by FREDDI et al. (2009). It is emphasized that the retained water content in this condition (Ui_{est}) showed considerable amplitude (from 0.49 to 0.61 and from 0.39 to 0.52 g g_{-1} for LVd and LVAd, respectively) (Table 3).

The value of the first slope inflection of WRC was determined by DEXTER (2004) as *S index*, and considers it as a structural quality indicator, since the soil physical degradation can be detected by its alteration. This ratio indicates a better pore size distribution, mainly the structural ones (inter-aggregate pores and biopores), which may reflect in many soil physical properties (FREDDI et al., 2009; LIMA et al., 2012).

TABLE 3. Parameter estimates of double van Genhuten model in Latossols.

Parameter	**Between rows**					**row**				
	20	40	80	120	160	20	40	80	120	160
typic dystrophic Red Latosol - LVd										
U_{sat}	0.5948	0.7024	0.7033	0.6730	0.6730	0.7969	0.8080	0.8326	0.8007	0.7176
U_{pmp}	0.3508	0.3353	0.3441	0.3486	0.3486	0.3444	0.3202	0.3436	0.3488	0.3682
U_{res}	0.0075^{ns}	0.0224^{ns}	0.0162^{ns}	0.0348	0.0348	-0.0518^{ns}	0.0279^{ns}	0.0205^{ns}	0.0432	0.0059^{ns}
α_{est}	0.2787	0.4015	0.3878	0.4993	0.4993	0.4418	0.4660	0.4698	0.5154	0.4203
n_{est}	2.0380	2.0795	2.1607	1.7589	1.7589	2.1590	2.1293	2.2825	2.0206	2.1542
α_{tex}	0.4000	0.2000	0.2000	0.2000	0.2000	0.4000	0.2000	0.2000	0.2000	0.3000
n_{tex}	1.7772	2.3646	2.1910	2.3763	2.3763	1.5075	2.6322	2.3983	2.9234	1.9107
Ψi_{est}	4.997	3.414	3.438	3.230	3.230	3.019	2.890	2.740	2.720	3.178
Ψi_{tex}	3822	6771	5861	5340	5340	4825	7087	6692	6310	4616
Ui_{est}	0.4911	0.5455	0.5483	0.5419	0.5419	0.6017	0.5983	0.6189	0.6092	0.5669
Ui_{tex}	0.2116	0.1975	0.2022	0.2103	0.2103	0.1972	0.1891	0.2010	0.2096	0.2173
I_{est}	0.0965	0.1494	0.1542	0.1025	0.1025	0.1941	0.2052	0.2261	0.1765	0.1494
I_{tex}	0.1103	0.1516	0.1435	0.1530	0.1530	0.0946	0.1623	0.1594	0.1930	0.1303
cambisolic dystrophic Red-Yellow Latosol - LVAd										
U_{sat}	0.5180	0.5270	0.5307	0.5141	0.5134	0.6473	0.5732	0.4930	0.4702	0.4811
U_{pmp}	0.3460	0.3490	0.3538	-0.3432^{ns}	-2.9590^{ns}	0.3367	0.3272	0.3462	0.2881^{ns}	-7.5701^{ns}
U_{res}	0.0300	0.0290	0.0249	-0.5739^{ns}	-3.2087^{ns}	0.0308	0.0255	0.0299	-0.0028	-7.8757
α_{est}	0.6530	0.5080	0.6046	0.6740^{ns}	0.9758^{ns}	1.8335	1.0239	0.5121	0.6411^{ns}	2.6520
n_{est}	1.6020	1.5860	1.3604	1.0342	1.0067	1.5774	1.6609	1.6744	1.1804	1.0016
α_{tex}	0.4000	0.4000	0.4000	0.3000^{ns}	0.3000^{ns}	0.4000	0.3000	0.3000	0.3000	0.3000
n_{tex}	2.3790	2.6264	2.7086	5.36695^{ns}	7.5825	2.4572	2.3575	2.7735	2.9955	4.1970
Ψi_{est}	2.823	3.689	4.391	40.059	149.818	1.031	1.701	3.361	7.658	236.773
Ψi_{tex}	3510	3352	3052	3608	3624	3540	3848	3458	3980	3930
Ui_{est}	0.4520	0.4587	0.4707	0.4219	0.3998	0.5285	0.4764	0.4350	0.4218	0.3996
Ui_{tex}	0.2070	0.2059	0.2055	-0.4538	-3.0803	0.2010	0.1945	0.2031	0.1551	-7.7144
I_{est}	0.0460	0.0468	0.0333	0.0253	0.0222	0.0811	0.0706	0.0427	0.0209	0.0126
I_{tex}	0.1540	0.1772	0.1893	0.2893	0.4523	0.1557	0.1455	0.1874	0.1891	0.2928

U_{sat} - upper asymptotic plateau; U_{res} - lower asymptotic plateau; U_{pmp} - intermediate plateau; α_{est} and n_{est} empirical parameters in the first inflection point; α_{tex} and n_{tex} - inclination empirical parameters in the first inflection point; α_{tex} were multiplied for 1,000 to highlight differences between estimates from the fourth decimal. Water content (Ui, g g^{-1}) and inflection point potential (Ψi), first (I_{est}) and second (I_{tex}) inclination estimates in inflection points. All model parameter estimates, except U_{res},U_{pmp}, α, n in some depths, were significative at 1%.

Thus, in this study, the Ψi_{est} (structural less negative Ψ_m) was used for soil quality structural diagnosis in the study and treated here as structural slope (I_{est}), while the inclination for the second inflection (textural more negative Ψi_{tex}) will be treated as textural slope (I_{tex}), and their values are shown in Table 3.

It was observed that all I_{est} values for LVd, independent of the depth and position of sampling, reflected a very good structural condition in light of the value considered as limited by DEXTER & RICHARD (2009), ($S > 0.05$) (Table 2). These high values reflect a better configuration of the pores in the soil, which greatly favors crop development (STRECK et al., 2008), as well as highlights environmental importance, especially the Latosol, corroborates SILVA (2004) in their study with Red-Yellow Latosol under natural condition.

The cambisolic Latosol has been only observed at depths of 20 and 40 cm, reflecting the good structural conditions of the surface layer. Below 80 cm, and particularly in the larger depths examined, both row and between rows, low values of I_{est} are justified by the presence of BC and C horizons in these depths, which originally are denser. It is emphasized that this parameter is influenced by all the factors that affect soil structure, which reflects the handling (addition of organic matter, soil tillage, conservation practices, compaction) (STRECK et al., 2008), but is also due to natural conditions and soil intrinsic characteristics, but either way reflecting their physical fertility.

Moreover, with the drying of the soil, granulometric and mineralogical compositions assume greater importance, which is due to the larger specific surface area for the adsorption of water molecules (SEVERIANO et al., 2011a; SEVERIANO et al., 2011b; MACHADO et al., 2008). Since the soils of this study are very clayey and LVd presents gibbsitic-oxidic mineralogy and LVAd is more kaolinitic, Ψi_{tex} occurred under a very negative Ψ_m and were more contrasting, placed between -3,000 and -7,000 kPa for LVd and between -3,000 and -4000 kPa for LVAd. It was also found higher I_{tex} values (Figures 1 and 2; Table 2), a reflect of this bimodal pore distribution; however, it cannot be considered as an indicator of structural quality.

CONCLUSIONS

For water retention curves adjusted to different soils it was found that the pore distribution is bimodal in the range of the assessed matrix potential, and it is more significant on LVd;

This conservation manegement system promoted alterations in the structure of the soil and water retention, both in furrows and between furrows. On LVd, changes occurred at different depths, while on LVAd it occurred only at the first depths;

I_{EST} parameter values related to high quantity of pores in less negative matrix potentials indicate excellent structural quality for LVd for the two positions assessed, regardless of depth;

The greater influence of the oxidic mineralogy of LVd resulted in greater water retention force compared to LVAd of kaolinitic mineralogy.

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