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PHYSICAL AND HYDROLOGICAL CHARACTERISTICS AND MODELLING OF THE SOIL WATER RETENTION CURVE IN THE BRAZILIAN SEMI-ARID REGION

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Abstract

Semiarid regions are characterised by water scarcity, a limiting factor on plant growth and development. The Sertão Canal was built in the semiarid region of Brazil, more specifically in the state of Alagoas, with the aim of making year-round irrigation possible. However, for the best water management, a physical and hydrological knowledge of the soils is necessary. As such, the aim of this study was to determine the physical and hydrological characteristics of three different types of soil (Argisol, Quartzarenic Neossol and Regolithic Neossol) under native vegetation (Caatinga) and agricultural systems in the semiarid region of Alagoas, as well as to adjust the soil water retention characteristic curves. Soil samples were collected at depths of 0-10, 10-20 and 20-30 cm in the municipalities of Inhapi, Delmiro Gouveia and Pariconha, in the state of Alagoas. The points of the moisture characteristic curve were determined by the Richards method, at pressures of 33, 100, 500, 1000 and 1500 kPa. Retention curves were modelled using the exponential decay equation and compared using the van Genuchten equation, modelled with the help of the RETC computer software. Particle size varied according to the textural classification of the different soils, from Sand to a Sandy Clay Loam. The retention curve fluctuated due to the particle size of the soil, with the Red-Yellow Argisol (Inhapi) having a greater capacity for water retention. Extremely sandy soils, such as those in the Delmiro Gouveia region, had a low capacity for retaining water. For each soil sample, the exponential decay equation gave the best fit, with values for R^2_{adjust} of greater than 0.93. When the measured soil moisture levels were compared with the levels estimated by the RETC model, some of the treatments were unable to estimate accurately the moisture levels obtained with the soil water retention curves.

Keywords: Richards. Van Genuchten. Water management. Water deficit.

1. Introduction

The Brazilian semiarid region is characterised by high temperatures and irregularities in the spatial and temporal distribution of the rainfall, which is usually concentrated over three or four months of the year. In addition, there are periods of severe drought that compromise crop planning and management, with a negative effect on crop growth and production (Santos et al. 2020; Araujo-Neto et al. 2021).

In Brazil, the semiarid region occupies an area of approximately 970,000 km^2, with most of its territory inserted in the Northeast, and concentrates around 11.8% of the population (Medeiros et al. 2012). The Brazilian semiarid region is characterised by an annual average rainfall of less than 800 mm, aridity index of up to 0.5 and drought risk greater than 60% (Brasil 2007). Thus, the soil water deficit in this region results in low biological activity, affecting nutrient absorption by the plants, which reduces crop productivity (Ceballos et al. 2002; Kumar et al. 2018). Irrigation is therefore an essential factor for good crop performance in the field, especially when crops are grown during a period with hardly any rainfall (Magalhães et al. 2019). In addition, the rational use of water during irrigation reduces losses due to evaporation, runoff and percolation, among others (Souza et al. 2016).

However, to determine the optimal water depth to be applied, knowledge of the processes of soil water distribution is necessary, including the Soil Water Retention Curve (SWRC), which provides parameters for estimating water availability in different types of soil (Bienes et al. 2016; Müller et al. 2016).

Research has been developed to better understand soil water dynamics in semiarid environments using mathematical models (Geroy et al. 2011; Silva et al. 2020; Bai et al. 2020). These models are used to study the effects and interactions of environmental conditions and can simulate scenarios under different soil and atmospheric conditions (Schaap et al. 2001; Byrne et al. 2017). The HIDRUS 1D model is more sophisticated than the RETC and can easily estimate the retention curve of any soil type considering the physical properties of the soil (Van Genuchten et al. 2009). Use of the HIDRUS 1D model is therefore essential for quantifying the soil water content in semiarid environments.

Given the above, the aim of this study was to characterise physical and hydrological relationships through the elaboration of soil water retention curves for different soil types and managements, to estimate the soil water content using the Van Genuchten equation adjusted by the RETC model, and then compare the values observed in the field with those estimated by the RETC model for the semiarid region of Brazil.

2. Material and Methods

Location and general description of the study areas

The study was carried out in three locations distributed along the irrigated perimeter of the Sertão Canal in Alagoas, with samples collected in the municipalities of Delmiro Gouveia (09º23'19'' S, 37º59'57' 'W; mean altitude 256 m), Inhapi (09º13'17'' S, 37º44'55'' W; mean altitude 410 m) and Pariconha (09º15'10'' S, 38º00'17''W; mean altitude 0 m). According to the Köppen classification, the climate in the region is BSs'h' and BSsh', characterised by a dry, steppe-type climate, (rainfall between 380 and 760 mm) with rainfall during the winter and air temperatures above 18°C (Gois et al. 2005). In each municipality, areas of native vegetation (Caatinga) and agricultural systems were selected according to the use and management of the soil (Table 1).

Table 1. Description of the soil and management in the different study areas of the semiarid region of Alagoas.

Municipality	Type of Soil	System	Description
Inhapi	Red-Yellow Argisol	IN	Native vegetation;
		I30	Thirty years of rainfed agriculture (bean and maize crops);
Pariconha	Regolithic Neosol	PN	Native vegetation;
		P4	Four years of crop-livestock integration
		PP	Ten years of pasture;
Delmiro Gouveia	Quartzarenic Neosol	DN	Native vegetation;
		D15	Fifteen years of rainfed agriculture (bean, maize and cassava crops);
		D4	Four years of rainfed agriculture (bean, maize and cassava crops).

Physical analysis of the soil: texture

Soil samples were collected from May to June of 2014, at three points (replications) for each selected site, at depths of 0-10, 10-20 and 20-30 cm, for a total of 72 samples. The samples were air dried (ADFE) for 48 hours prior to analysis. Soil texture was carried out using the pipette method (EMBRAPA 1997). Texture data are shown in Table 2.

Soil moisture retention curves

Soil moisture curves were determined in the Soil Physics laboratory of the Federal University of Alagoas, following the methodology proposed by Richards (1965) and EMBRAPA (2005). Moisture retention curves were characterised for each soil at a depth of 0-10, 10-20 and 20-30 cm. To characterise the retention curve, the soil samples were subjected to pressures (matric potentials) of 33,100, 500, 1000 and 1500 kPa, using equation (1).

$$Moisture(kPa) = 100\frac{(a-b)}{b} \quad (1)$$

where *a* is the weight of the sample after being subjected to the pressure used, and *b* is the weight of the dry sample at 105ºC. The values obtained for field capacity and wilting point for the different soil types are shown in Table 2.

The retention curves were obtained using two methods: the first was carried out following adjustment of the exponential decay equation, using three parameters, adjusting the points of the matric potential as a function of the water content by means of the Sigmaplot® computer software, using equation (2).

$$y = y_0 + a \ \ e^{(-b \ \ x)} \quad (2)$$

where *y* is the soil water content (%), y_0 is the initial water content (%), *x* is the matric potential (kPa), and *a* and *b* are the empirical parameters of the equation.

The second method followed adjustment of the points by the function proposed by Van Genuchten (1980), carried out with the aid of the RETC model, which considers the sand, silt and clay content, the bulk density, and the values for field capacity and wilting point as input data for the model. For this method, the retention curve was obtained with equation (3).

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{[(1+\alpha\Psi)^n]^m} \quad (3)$$

where, ϑ is the soil water content (%); ϑr is the residual water content (%); ϑs is the saturated water content (%); Ψ is the matric potential (kPa); and α, *n* and *m* are the empirical parameters of the model.

Statistical analysis

The statistical analysis for the retention curves obtained with the exponential equation was determined by the adjusted coefficient of determination (R^2adj). Student's t-test ($p<0.01$) was used to compare the observed mean values with those simulated. The Willmott index of agreement (d) (1981) was also used, which expresses the accuracy of the estimated values in relation to the observed values, and ranges from zero, which indicates no agreement, to one, which indicates perfect agreement.

3. Results and Discussion

Soil texture

Classification of the soils under study presented mostly sandy characteristics, ranging from Sand to Sandy Loam (Table 2). Ceballos et al. (2002) evaluated soil-water behaviour in sandy soils in the semiarid region of Spain and found a sand content ranging from 82 to 90%, similar to those found in this study (greater than 60%). Only in the region of Inhapi did the soils present a more clayey texture and were classified as a Red Yellow Argisol. The results seen in Inhapi corroborate those described by Byrne et al. (2017), who evaluated the water balance in soils used for mining in the southwest of the United States and found textures ranging from 17 to 25%. These results show that variability in the physical properties of the soil is also important for soil water retention, infiltration and water absorption in the surface layers in agricultural or urban areas (Paschke et al. 2003; Halecki and Stachura 2021; Çakir and Cangir 2021).

Table 2. Field capacity, wilting point, texture and class for different types of soil in the semiarid region of the state of Alagoas.

	IN	I30	DN	D4	D15	PN	P4	PP
				0-10 cm				
Field capacity (%)	20.80	21.85	10.68	6.96	20.23	15.63	17.74	18.35
Wilting point (%)	9.50	11.17	4.13	3.72	3.36	3.84	3.13	2.75
Clay (%)	15.70	20.70	7.80	5.10	11.70	5.20	7.00	2.60
Silt (%)	17.54	16.56	4.61	74.41	0.14	5.45	12.57	10.40
Sand (%)	66.76	62.74	87.60	91.42	88.16	89.35	80.44	87.00
				10-20 cm				
Field capacity (%)	30.57	23.30	13.81	11.44	18.55	12.80	12.53	14.27
Wilting point (%)	11.75	13.58	3.94	4.07	4.32	2.79	2.66	2.71
Clay (%)	23.95	20.70	7.80	8.53	5.15	3.40	8.05	3.50
Silt (%)	14.21	16.56	4.61	5.67	9.90	8.89	16.77	12.84
Sand (%)	61.84	62.74	87.60	85.80	84.95	87.72	75.18	83.66
				20-30 cm				
Field capacity (%)	22.80	26.42	17.21	18.73	24.80	17.06	19.02	17.97
Wilting point (%)	11.68	13.60	4.41	4.71	5.17	2.87	2.79	2.99
Clay (%)	23.23	32.17	8.30	11.80	4.00	5.70	7.70	4.60
Silt (%)	16.82	14.98	4.23	13.79	12.10	6.91	19.43	13.53
Sand (%)	59.95	52.86	87.47	74.41	83.90	87.40	72.87	81.87
Layer				Textural classification				
0-10 cm	Sandy loam	Sandy clay loam	Loamy sand	Sand	Loamy sand	Sand	Loamy sand	Loamy sand
10-20 cm	Sandy clay loam	Sandy clay loam	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Sandy loam	Loamy sand
20-30 cm	Sandy clay loam	Sandy clay loam	Loamy sand	Sandy loam	Loamy sand	Loamy sand	Sandy loam	Loamy sand

IN - Native vegetation (Inhapi); I30 – 30 years of rainfed agriculture (Inhapi); DN - Native vegetation (Delmiro Gouveia); D4 - 4 years of rainfed agriculture (Delmiro Gouveia); D15 – 15 years of rainfed agriculture (Delmiro Gouveia); PN - Native vegetation (Pariconha); P4 - 4 years of crop-livestock integration; PP – 10 years of pasture.

Adjustment of the retention curves

Figure 1 shows the soil water retention curves adjusted for the decay equation in the region of Inhapi. It can be seen that the model was significant ($p<0.01$) for both study regions, adjusting to the values for moisture determined in the laboratory. For IN, the highest water retention capacity was seen in the 10-20 cm layer, with a percentage of 30.57 at a pressure of 33 kPa. The greater absorption capacity of this soil may be associated with the higher amount of clay (Table 2). A similar result was seen by Silva Neto et al. (2012) in an Argisol of the Brazilian semiarid region in Mossoró, which had a moisture content of approximately 30% at a pressure of 33 kPa; at the same depth the wilting point was 11.75%. In addition, the authors found that curves at a depth of 0-10 cm maintained their lower soil water retention capacity. This behaviour can be attributed to the particle size of the 0-10 cm layer, since the layers between 10 and 30 cm presented a higher clay content, ranging from 2.23 to 11.47% in relation to the surface layer of soil. Silva Neto et al. (2012) also attributes the variation in water retention to the soil structure in addition to the distribution and size of the particles. Another attribution of water retention was described for Oliveira et al. (2021), with greater contribution of the organic total carbon contents, hydrogenionic potential in water and macroprosity.

The coefficients of the exponential decay equation for the Inhapi region are described in Table 3. The parameters *a* for I30 at a depth of 0-10 cm and *b* for IN at a depth of 20-30 cm were not statistically significant ($p<0.05$) when fitted to the model. The adjusted coefficients of determination (R^2_{adjust}) indicated that the adjusted models represent almost all the total variability in soil moisture as a function of water potential, with $R_{2adjust}$ ranging from 0.94 to 0.98.

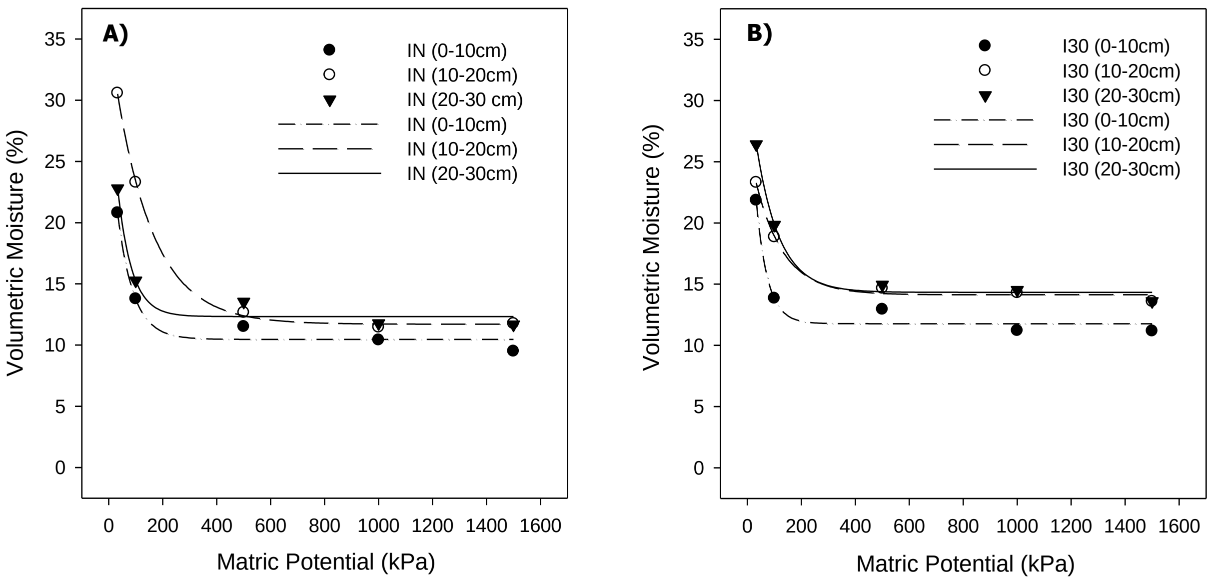

Figure 1. Soil water retention curves estimated with the exponential decay equation for A – IN and B – I30.

The characteristic soil water retention curves for the region of Delmiro Gouveia are shown in Figure 2. The area of native forest showed similar curves when a pressure of greater than 33 kPa was applied. Field capacity for this region (Figure 2A) ranged from 10.68% (0-10 cm) to 17.21% (20-30 cm). Comparing these results with those found in the region of Inhapi (Figure 1A), the Delmiro region had less capacity for retaining water in the soil. This is explained by the difference in particle size of the soil at these sites, where for a pressure of more than 100 kPa, there is greater dependence on the curve pattern relative to soil texture (Nascimento et al. 2010).

Table 3. Parameters of the exponential decay equation and adjusted coefficients of determination (R^2_{adjust}), for the region of Inhapi in the semiarid region of Alagoas.

	y_0 (±error)	a (±error)	b (±error)	R^2_{adjust}
		0-10 cm		
IN	10.4658 (±0.5781)	18.0938 (±3.7503)	0.0170 (±0.0051)	0.95
I30	11.7698 (±0.5851)	21.9782 (±6.3454)^{ns}	0.0236 (±0.0082)^{ns}	0.94
		10-20 cm		
IN	11.7061 (±0.1788)	23.7756 (±0.5689)	0.0071 (±0.0004)	0.99
I30	14.1309 (±0.3026)	12.5627 (±1.2284)	0.0096 (±0.0019)	0.98
		20-30 cm		
IN	12.3318 (±0.6041)	19.588 (±4.5222)	0.0190 (±0.0060)^{ns}	0.94
I30	14.3311 (±0.3911)	17.7103 (±1.8055)	0.0116 (±0.0021)	0.98

^{ns} – not significant.

The agricultural areas displayed a greater capacity for water retention, particularly in the 20-30 cm layer. For region D15, the soil maintained its capacity for retaining water, with rates ranging from 18.55% (10-20 cm) to 24.80% (20-30 cm). For the remaining agricultural areas of Delmiro Gouveia, the greatest values for field capacity were found in the 20-30 cm layer (18.73% for D4 and 24.8% for D15) (Figure 2B and 3C). These values agree with those obtained by Silva Neto et al. (2012) for the same soil type, where the authors adjusted a retention curve for moisture ranging from 30 to 45% at a pressure of 33 to 1500 kPa, at similar textures. Nascimento et al. (2010) observed a trend towards greater water retention using the Richards method at the deepest layers in a Quartzarenic Neossol in the semiarid region of Pernambuco. Silva et al. (2006) confirm that with an increase in clay content, there is an increase in water retention capacity when subjected to a pressure of 1500 kPa.

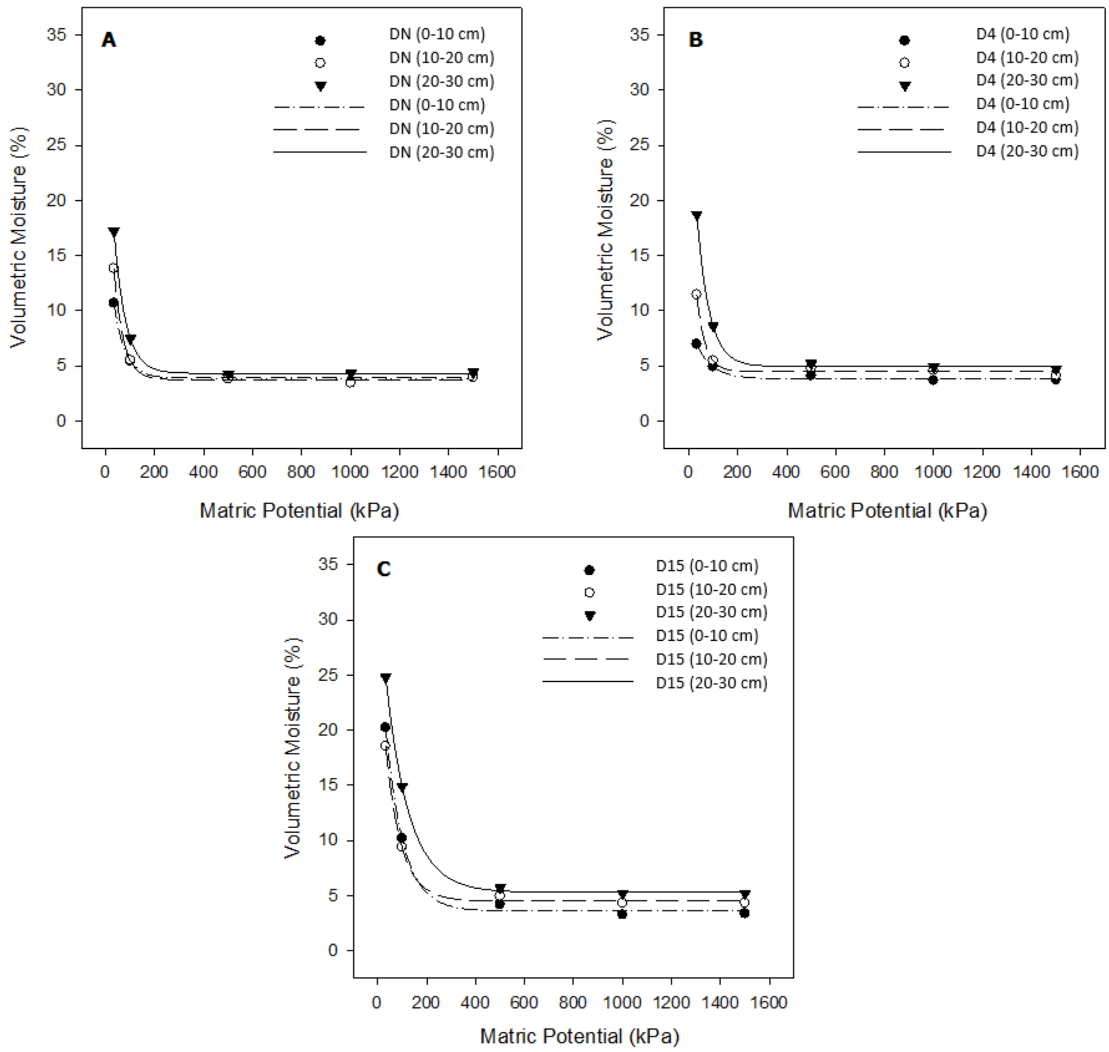

Figure 2. Soil water retention curves estimated with the exponential decay equation, for A – DN, B – D4 and C – D15 in Delmiro Gouveia, in the state of Alagoas.

Table 4 shows the coefficients of the exponential decay equation for the regions of Delmiro Gouveia. The coefficients were statistically significant ($p<0.05$), with R^2_{adjust} ranging from 0.97 to 0.99. The results for the y_0 parameter remained close to the experimentally observed values, confirming the fit of the model.

Table 4. Parameters of the exponential decay equation and adjusted coefficients of determination ($R_{2adjust}$), for the region of Delmiro Gouveia, Alagoas.

	y_0 (±error)	a (±error)	b (±error)	R^2_{adjust}
		0-10 cm		
DN	3.8832 (±0.2174)	14.0901 (±2.0737)	0.0221 (±0.0041)	0.98
D4	3.8251 (±0.1375)	5.2517 (±0.8157)	0.0156 (±0.8157)	0.97
D15	3.5905 (±0.2876)	26.1552 (±1.5098)	0.0137 (±0.0013)	0.99
		10-20 cm		
DN	3.7300 (±0.1498)	23.7445 (±1.9961)	0.0260 (±0.0025)	0.99
D4	4.4633 (±0.2067)	18.1029 (±3.6104)	0.0289 (±0.0060)	0.98
D15	4.5291 (±0.2060)	23.5607 (±1.2287)	0.0157 (±0.0012)	0.99
		20-30 cm		
DN	4.3098 (±0.0553)	25.7923 (±0.4827)	0.0210 (±0.0005)	0.99
D4	4.9361 (±0.1389)	26.5340 (±1.1070)	0.0198 (±0.0011)	0.99
D15	5.2969 (±0.1309)	27.5855 (±0.5645)	0.0105 (±0.0004)	0.99

Figure 3 shows the retention curves adjusted for the exponential decay equation in the region of Pariconha. It was found that in the regions of native forest and those used for crop-livestock integration

(CLI), the curves followed the same trend at depths of 0-10 cm and 20-30 cm, especially at pressures greater than 100 kPa. This can be explained for the depth of 20-30 cm by the silt content being greater compared to the other depths.

In native forest, a lower water retention capacity may be associated with the lower clay content in the 10-20 cm layer, with a decrease of approximately 35% compared to the other layers. A lower soil water retention capacity was described by the PP curve (Figure 3), with values for the wilting point of 2.75 and 2.71 for the 0-10 cm and 10-20 cm layers respectively. Pedron et al. (2011), evaluating water retention capacity in profiles of a Neossol, found results for field capacity of between 42 and 51% and a wilting point ranging from 10 to 24%. These results are superior to those found in this work for each Neossol under study (6.96 to 24.80% for field capacity, and from 2.66 to 5.17% for the wilting point).

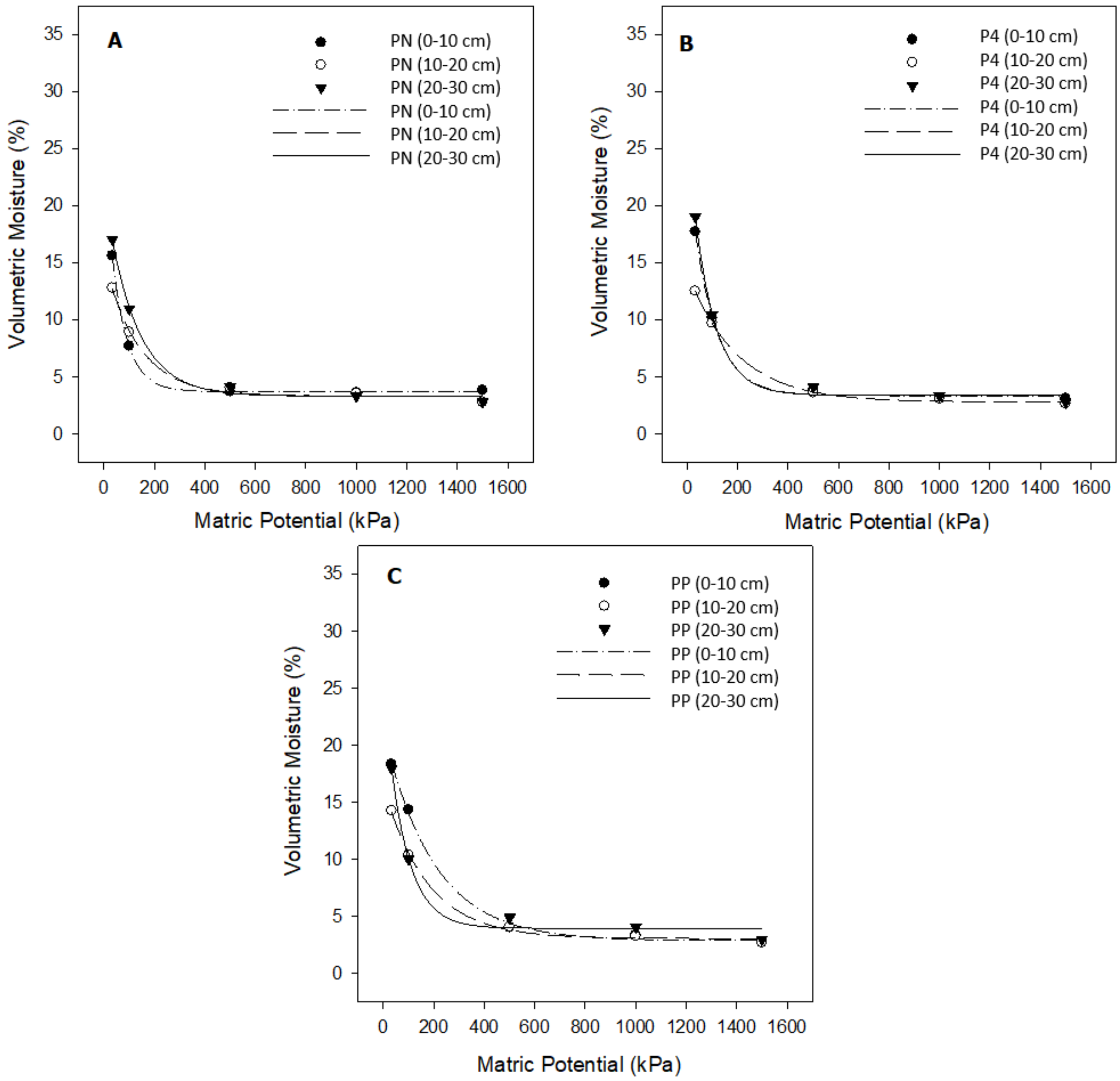

Figure 3. Soil water retention curves estimated with the exponential decay equation, for A – PN, B – P4 and C – PP in Pariconha, in the state of Alagoas.

For the coefficients of the exponential decay equation in the regions of Pariconha, all the parameters were statistically significant (Table 5) and can be used to determine the retention curve for these regions. For the region of PP, in the 0-10 cm layer, each value of y_0 was similar to those observed experimentally. The values for R^2_{adjust} ranged from 0.97 to 0.99, showing that the model almost completely explained the total variability in moisture as a function of the matric potential.

Table 5. Parameters of the exponential decay equation and correlation coefficients (r), coefficients of determination (R^2) and adjusted coefficients of determination ($R_{2adjust}$), for the region of Pariconha, Alagoas.

	y_0 (±error)	a (±error)	b (±error)	R^2_{adjust}
		0-10 cm		
PN	3.7248 (±0.0639)	20.4099 (±0.3966)	0.0163 (±0.0005)	0.99
P4	3.3676 (±0.2255)	20.6394 (±1.0024)	0.0110 (±0.0010)	0.99
PP	2.8774 (±0.3262)	18.4409 (±0.6910)	0.0050 (±0.0006)	0.99
		10-20 cm		
PN	3.3390 (±0.3285)	11.9330 (±1.0730)	0.0073 (±0.0016)	0.98
P4	2.8105 (±0.1328)	11.5377 (±0.2929)	0.0052 (±0.0004)	0.99
PP	3.0762 (±0.2613)	13.4169 (±0.6679)	0.0058 (±0.0008)	0.99
		20-30 cm		
PN	3.3307 (±0.3082)	18.0420 (±1.1347)	0.0084 (±0.0012)	0.99
P4	3.3892 (±0.3747)	22.9801 (±1.7406)	0.0117 (±0.0015)	0.99
PP	3.9662 (±0.5501)	21.0349 (±2.6593)	0.0124 (±0.0026)	0.97

Observed values versus values estimated by the RETC model

A comparison of the observed and estimated values for moisture is shown in Figures 5, 6 and 7. Based on the t-test, it was found that most comparisons showed statistical differences at a level of 1% probability. In the region of Inhapi, significant values were only seen at a depth of 0-10 cm. In Pariconha, only at a depth 10-20 cm was there no statistically significant difference in the estimated and observed values, i.e. the model was not able to estimate the actual values accurately. For the region of Delmiro Gouveia, the depths of 0-10 cm in D4 and 20-30 cm in D15 were statistically insignificant.

From the simple linear regression analysis (Figure 4), it can be seen that parameter *a* in the equation was significant at 1% probability in the region of Inhapi with 30 years of cultivation (I30), confirming that the equation could be used in future studies of the region. No significance was seen for *a* at depths of 0-10 or 10-20 cm in the area of native forest of the municipality, with the equation only represented by the angular coefficient (b). The value for the angular coefficient of the regressions ranged from 0.7306 to 1.0016, showing that the equations continued to underestimate the measured values in most cases. For IN (0-10 cm), the overestimation was 0.0016%. For this same depth, an index of agreement *d* of 0.96 was found, higher than in the other regions under study.

The significance of the intercept of the line with the vertical axis (a) for each depth in Delmiro Gouveia proved to be insufficient (except for 0-10 cm in D4), indicating that the fit of the models compared to the van Genuchten equation was enough to explain the comparison between estimated and observed values for the angular coefficient (b) only (Figure 5).

Despite the high correlation coefficient (0.99), the index of agreement was low (d = 0.34). This differential can be explained by the low value for field capacity (6.96%) compared to particle size, since for the RETC model, determining the retention curves by the van Genuchten equation considers the physical and hydrological conditions of the region. This trend differs from Moraes and Libardi (1993), who found variable results, particularly at high pressures. However, Solone et al. (2012) point out that the occurrence of errors when using pressure plates depends on soil texture, with significant errors seen for sandy soils.

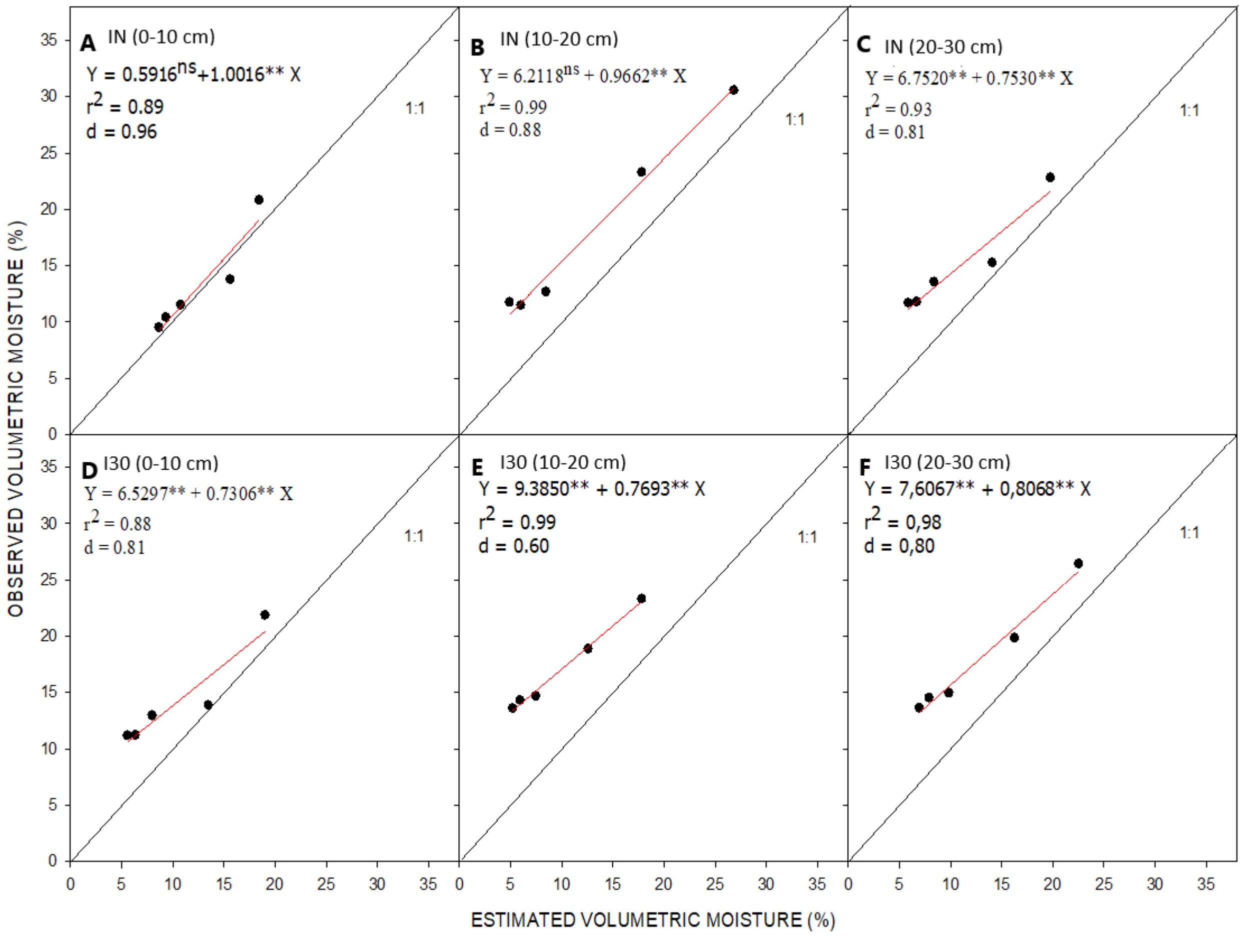

Figure 4. Linear correlations and index of agreement (d) between values observed experimentally and those estimated by the van Genuchten equation, for semiarid soils in Inhapi Native Vegetation 0-10cm (A), 10-20 cm (B), 20-30 cm (C) and Thirty years of rainfed agriculture 0-10 cm (D), 10-20 cm (E), 20-30 cm (F), Alagoas.

The overestimation pattern for the estimated values compared to those observed was also seen at depths of 0-10 cm and 20-30 cm in the region of Delmiro Gouveia with 15 years of cultivation (D15), showing 7.64 and 12.38% respectively (Figure 5). For the remaining soil layers, values were underestimated by the RETC model in relation to the observed values, with a value for the angular coefficient ranging from 0.68 to 0.98. According to the index of agreement, all the layers and regions in this study showed excellent agreement, except for the 0-10 cm layer of D4, with values ranging from 0.85 to 0.98.

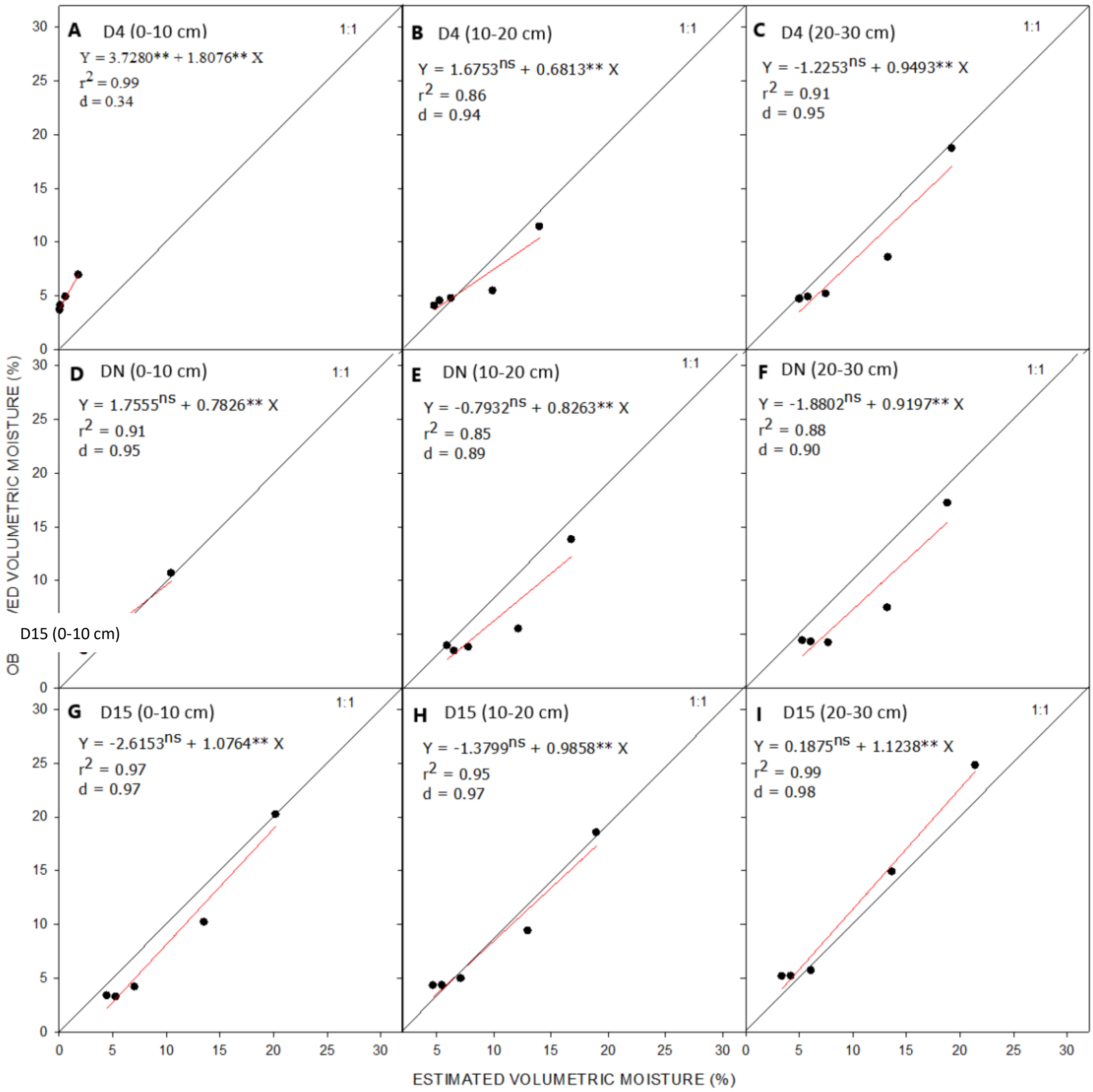

Figure 5. Linear correlations and concordance index (d) between values observed experimentally and those estimated by the van Genuchten equation, for semiarid soils in Delmiro Gouveia Four years of rainfed agriculture 0-10cm (A), 10-20 cm (B), 20-30 cm (C), Native Vegetation 0-10 cm (D), 10-20 cm (E), 20-30 cm (F) and Fifteen years of rainfed agriculture 0-10 cm (G), 10-20 cm (H), 20-30 cm (I), Alagoas.

For the region of Pariconha, the intercept of the line with the vertical axis (a) was significant at depths of 20-30 cm in native forest (PN) and 0-10 cm in the region with 4 years of cultivation (P4), at 1 and 5% respectively. The correlation coefficients of the linear regression remained above 95% (0.99 <R^2 <0.93). Following the same relevance, Willmott's *d* presented values close to 1, i.e. close agreement between estimated and observed values, with significant accuracy. The angular coefficient of regression (b) for the region of pasture (PP) showed the values estimated by the RETC model to be overestimated compared to those determined by the Richards methodology, ranging from 8.59 to 24.30%. This trend was also seen at 20-30 cm in both PN and P4 (Figure 6). In relation to the other study sites, the values were underestimated, correlating with those observed.

This study shows a trend for model acceptability in relation to the degree of texture of the soils under evaluation, where those with a more-sandy texture presented more-accurate statistical values and with the linear equation nearer a 1:1 line, except for D4 (0-10 cm). The saturation pressure estimated by the RETC model remained below those studied in regions with a sand content (approximately 88%). In the regions of Delmiro Gouveia and Pariconha, saturation was 40%. These values are below those observed by Aguilera et al. (2016), of around 70%.

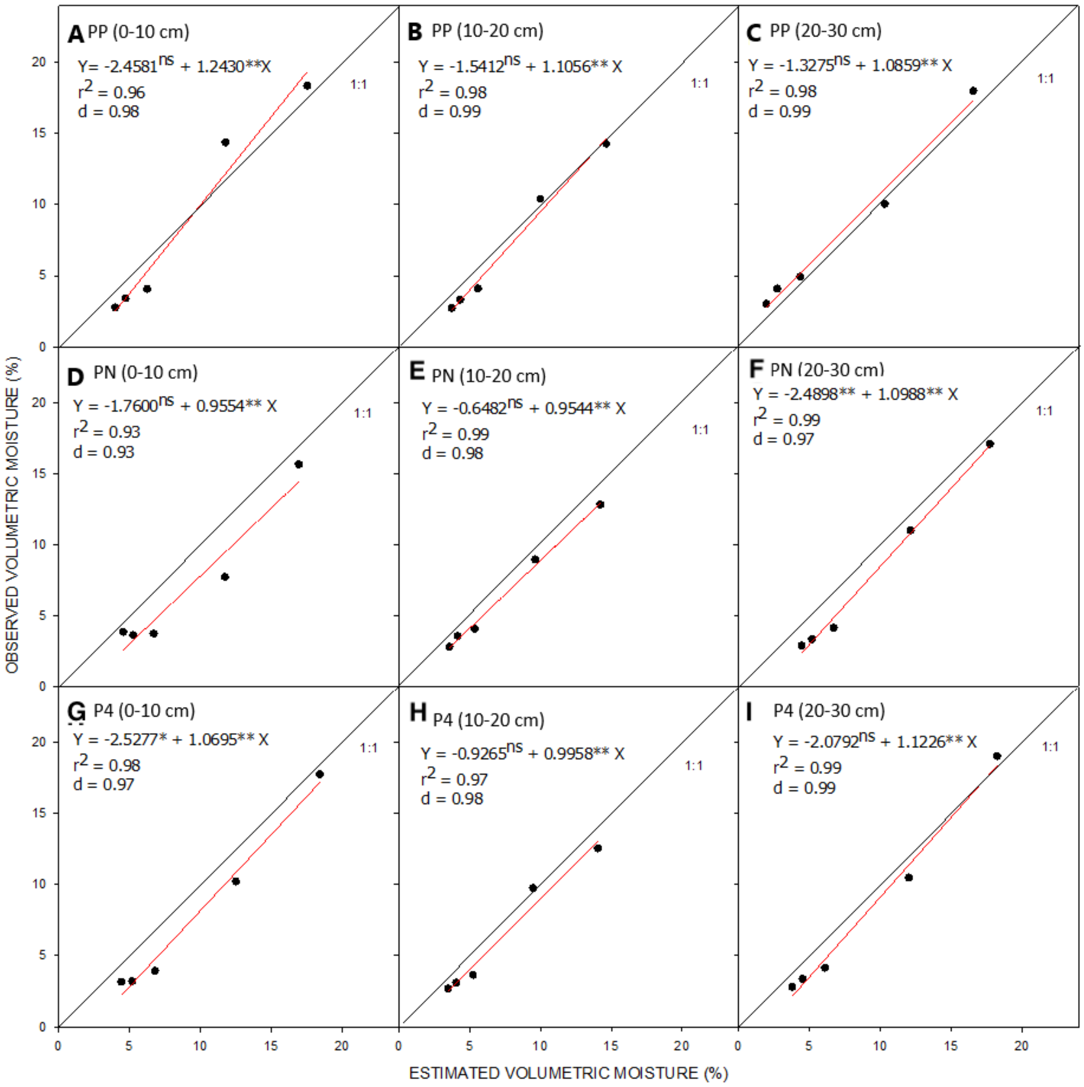

Figure 6. Linear correlations and index of agreement (d) between values observed experimentally and those estimated by the van Genuchten equation, for semiarid soils in Pariconha Ten years of pasture 0-10cm (A), 10-20 cm (B), 20-30 cm (C), Native Vegetation 0-10 cm (D), 10-20 cm (E), 20-30 cm (F) and Four years of crop-livestock integration 0-10 cm (G), 10-20 cm (H), 20-30 cm (I), Alagoas.

4. Conclusions

The region of Inhapi has soils with a greater capacity for water retention. Despite the different physical and hydrological characteristics of the soils under study, it is possible to adjust the exponential decay equation to the retention curves obtained in the laboratory, which can be used for soils in the semiarid region of the Northeast of Brazil. The RETC model can estimate precisely and accurately the retention curve of some soils in the semiarid region of Alagoas. More-clayey soils have a better statistical fit than do sandy soils. It is possible to simulate the variable water balance in regions with similar physical and hydrological characteristics to those of the study, determining which periods have the lowest water deficit with a view to better irrigation management.

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