Moisture Retention Caracteristics in the Soil Formed upon Limestones and Dolomites in the Republic of Macedonia

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Summary

The paper presents results from the research of the influence of soil texture on the water retention curves of calcomelanosols, calcocambisols and terra rossa in Republic of Macedonia. The content of the fine soil separates in the calcomelanosols varies depending on the subtype. The physical sand fraction (coarse sand + fine sand) in the Amo horizon amounts to: 44.81% in the organomineral calcomelanosols, 40.13% in the organogenic and 36.52% in brownised calcomelanosols. In the (B)rz horizon in the brownised calcomelanosols it amounts to 32.64%. The contents (clay + silt) or physical clay in the Amo horizon amounts to: 55.19% in the organomineral calcomelanosols, 59.87% in the organogenic, and the highest content was in the brownised calcomelanosols, 63.48%. The average value of this fraction in the horizon (B)rz in the brownised calcomelanosols amounts to 67.36%. In the calcocambisols the average content of the physical sand fraction in the Amo horizon amounts to 33.43%, and in the cambic horizon (B)rz 22.50%. In the terra rossa the fraction physical clay is represented with a greater percentage related to the physical sand fraction. In the Amo horizon in the physical clay fraction the clay fraction is predominant, average 43.08% and 52.13% in the cambic horizon, 24.90% in Amo and 19.37% in the silt fraction. There is the highest retention capacity, average 41.48% in the humus-accumulative horizon Amo in the calcomelanosols, subtype organogenic. The remaining subtypes of calcomelanosols have lower retention capacity in this horizon. As with retention capacity of 0.33 required in other points of tension (6.25 and 15 bar) it shows the same condition; mean value of organogenic was 29.39 and 17.22%, respectively, then organomineral 23.98 and 18.34%, respectively, and brownised calcomelanosols 21.70% and 16.60%, respectively. The average retention values in the Amo horizon and the cambic horizon (B)rz regarding calcocambisols amounts to 33.49% and 33.24%. The average retention values (pressure of 6.25 = 625 kPa and 15 bar = 1500 kPa) in the Amo horizon and the cambic horizon (B)rz regarding calcocambisols amounts to 25.27% and 17.06% respectively, and 27.89% and 16.68%, respectively. The average retention capacity in terra rossa, amounts to 39.05% in the Amo horizon, and 40.25% in (B)rz. The average retention values (pressure of 6.25 and 15 bar) in the Amo horizon and the cambic horizon (B)rz regarding terra rossa amounts to 29.92% and 20.93%, respectively, and 33.23% and 23.38%, respectively. The results from our research show that in Amo and (B)rz horizons there is a positive correlation between the water retention curves at 0.33; 6.25 and 15 bars and contents of physical clay (clay and silt) and clay. Also there is high negative correlation between the retention curves at 0.33 bars contents of physical sand fractions (coarse sand+fine sand; r = -0.47).

Key words

soil texture, retention curves, calcomelanosols, calcocambisols, terra rossa

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Introduction

The soils formed on limestones and dolomites can be found in all mountain regions and regions that are fully or partially composed of limestones and dolomites. It can be said that these soils are present on almost all continents due to their connection with the parent material. On the basis of the soil map of Macedonia with a 1:50 000 scale, the areas under soils formed on limestones and dolomites amount to 314.385 ha. These soils cover 12.23% of the total surface area of the Republic of Macedonia (2.571.300 ha) (Filipovski, 2003), where the calcomelanosols cover 8.61% or 221.441 ha, calcocambisols 3.61% or 92.944 ha, and terra rossa cover 0.005% or 117.7 ha. The hydrous and physical relations, in addition to the mineralogical composition of the soil, are also influenced by soil granulometry, by the content of organic matter, etc. (Hillel 1980). Maclean and Yager (1972), Jamison and Kroth (1958), Shaykewich and Zwarich (1968) as well as Heinonen (1971) studied the influence of organic matter and the soil texture over the retention of moisture in several different soils in the USA, Europe and Asia. In the research of Hollist et al. (1977), it is confirmed that the soil moisture retention in Western Midland (Great Britain) depends mainly on the organic matter and mineralogical composition of soil. According to Filipovski (1996), the retention of moisture at different tensions is strongly correlated with the content of humus, clay, silt and the mineralogical composition of the clay.

The hydrophysical properties of soils, the water retention and the water permeability in the saturated and unsaturated zone, not only affect the water balance but also have a dominant influence on the conditions of growth and development of plants. They determine the availability of water to plants and leaching of nutrients dissolved to the deeper layers of the soil (Coquet et al., 2005; Hillel, 1998; Kutilek and Nielsen, 1994).

The intensity of the impact of the soil texture on the retention of soil moisture depends on the share of certain fractions of soil separates (soil texture fraction). Clay particles, due to the large inner and outer active surface, high cation exchange capacity (CEC) and mineralogical composition, represent the most active soil texture fraction (Škorić, 1991). In our research, the main emphasis was on the dependence and impact of soil texture on the retention of water in the surveyed calcomelanosols, calcocambisols and terra rossa in Republic of Macedonia. Due to the mentioned importance of the particle size distribution and organic matter, this paper investigates the impact on mechanical composition retention of soil moisture at different points of tension, ranging from 0.33 field capacity up to 15 bars, which corresponds to the water constant, which is called permanent wilting point (PWP). The remaining moisture above 15 bars is unavailable to plants (Markoski, 2013).

Material and methods

During 2010, 2011 and 2012, field researches have been carried out on the soils formed on limestones and dolomites, on various locations on the territory of the Republic of Macedonia. Following the field recognition, locations were selected for digging out the basic pedological profiles. A total of 52 basic pedological profiels were dug out, from which 34 are calcomelanosols WRB-Molic Leptosol (WRB Classification, 2014), 13 calcocambisols (WRB-Calcic Cambisol) (WRB Classification, 2014), and 5 profiles of terra rossa WRB-Rhodic Leptic Cambisol (WRB Classification, 2014). Seventy eight soil samples were taken for laboratory analyses. The field researches were carried out in accordance with the accepted methodology in our country (Mitrikeski and Mitkova, 2006). During the laboratory phase, the following methodology was used: the soil particle size distribution was determined by dispersing the soil using a 1 M solution of $Na_4P_2O_7$ x 10 H_2O (Thurn et al., 1955). The particle size classes were determined following the International Classification, while classification of soils in textured classes was made by the American Triangle, described by Mitrikeski and Mitkova (2006).

The determination of moisture retention at a pressure of 0.33 bar (pF-2.54) and 1 bar (pF-3), was performed by a method of applying pressure with a Bar extractor. To determine the retention of soil moisture at higher pressures, the method of Richards (1982), Porous plate extractor at pressures:, 2.0 bar (pF-3.3); 6.25 bar (pF-3.8); 11 bar (pF-4.04) and 15 bar (pF-4.2) was applied, described by Resulović et. al. (1971). Descriptive statistics of the soil texture and constants of soil moisture were done in Microsoft Excel. The correlation between retention of moisture, soil texture is determined using the computer program Microsoft Excel.

Results and discussion

The texture of the soils formed on limestones and dolomites varies extensively and depends on the granulometry of the residuum from which the mineral part of the soil is composed, on the character of the limestone and the dolomite (the degree of weathering), on the deposition of nearby materials (from the higher fields) and on the degree of erosion (Markoski, 2013). It also depends on the processes that take place wihin these soils during their pedogenesis and evolution, and which cause the texture differentiation. In order to have better understanding, the mean values for earch fraction of the fine earth of the analyzed soils, by type, subtype and horizon are given in Tables 1 and 2.

The content of particular fraction of the fine earth in calcomelanosols varies depending on the subtype. The physical sand fraction (coarse sand + fine sand) in the Amo horizon amounts 44.81% in organomineral calcomelanosols, 40.13% in organogenic and 36.52% in brownised calcomelanosols. In the (B)rz horizon in the brownised calcomelanosols it amounts 32.64%.

The content (clay + silt) in the Amo horizon amounts: 55.19% in the organomineral calcomelanosols, 59.87% in the organogenic, and the highest content is found in the brownised calcomelanosols 63.48%. The mean value of this fraction in the horizon (B)rz in the brownised calcomelanosols amounts 67.36%. In all profiles of calcocambisols, the fine earth predominates over coarse. In the fine earth, the physical clay fraction in both horizons, Amo and (B)rz is present twice as much as the physical sand fraction. The average content of the physical sand fraction in the Amo horizon amounts 33.43%, and in the cambic horizon (B)rz 22.50%. In the terra rossa, the physical clay fraction is present in a greater percentage in relation to the physical sand fraction. At the same time, the physical clay fraction in the Amo horizon is predominated by the clay fraction, 43.08% in average and 52.13% in the cambic horizon, and 24.90% in Amo and 19.37% for the silt fraction. The differences in the texture composition are confirmed with the descriptive statistics and the analysis of variance was made for each type, subtype and horizon. The

Table 1. Particle size distribution mean values for horizon Amo

Soil type	N	Coarse > 2 mm		Coarse sand 0.2 – 2 mm		Fine sand 0.02 – 0.2 mm		Total sand 0.02 - 2 mm		Silt 0.002 – 0.02 mm		Clay < 0.002 mm		Silt + Clay < 0.02 mm	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	7	12.20b*	3.05	2.83	1.80	37.30	8.07	40.13ab	8.18	37.60b	4.95	22.27a	7.23	59.87ab	8.18
2	22	11.08b	6.43	10.81	14.70	34.00	15.21	44.81b	13.41	22.52a	9.56	32.68ab	9.50	55.19a	13.41
3	5	6.70a	3.42	10.28	8.33	26.24	4.88	36.52ab	6.33	26.88a	3.39	36.60ab	3.89	63.48ab	6.33
4	13	4.82a	3.56	6.18	5.20	27.25	9.27	33.43ab	9.96	28.38a	10.05	38.19b	6.77	66.57ab	9.96
5	5	3.18a	1.02	8.27	5.91	23.75	8.22	32.02a	14.00	24.90a	8.06	43.08b	10.40	67.98b	14.00

* Values in each column marked with the same letter don't differ significantly between themselves; 1. calcomelanosols organogenic; 2. calcomelanosols organomineral; 3. calcomelanosols brownised; 4. calcocambisols; 5. terra rossa;

Table 2. Particle size distribution mean values for horizon (B)rz

Soil type	N	Coarse > 2 mm		Coarse sand 0.2 – 2 mm		Fine sand 0.02 – 0.2 mm		Total sand 0.02 - 2 mm		Silt 0.002 – 0.02 mm		Clay < 0.002 mm		Silt + Clay < 0.02 mm	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
3	5	4.39b*	5.24	10.47	5.57	22.17	4.92	32.64	8.29	26.33ab	6.79	41.03a	3.11	67.36	8.29
4	14	1.65b	2.06	5.31	4.27	16.89	5.02	22.20	7.72	31.80b	5.63	46.00ab	8.10	77.80	7.72
5	7	1.42a	0.9	9.05	5.29	19.45	4.44	28.50	9.06	19.37a	5.49	52.13b	8.71	71.50	9.06

* Values in each column marked with the same letter don't differ significantly between themselves; 3. calcomelanosols brownised; 4. calcocambisols; 5. terra rossa

analysis of variance demonstrated that in both horizons, the soil type has an important influence over the variability of the content of coarse, silt and the total content of clay. In the Amo horizon, the soil type has influence both over the physical sand fraction and the physical clay fraction. The data on the soil texture of the analized soils formed on limestones and dolomites are similar to the data for these soil types presented by other authors: Andreevski (1996), Mukaetov (1996), Pavićević (1953); Vilarov (1960, 1972), Popovski et al. (1969), Spirovski (1964, 1971), Djordjević (1993), Filipovski (1997), Martinović (1997), Vrbek et al. (2001), Ćorić (2009), Marić (1964), Škorić (1987), Durn (2003) and Delgado et al. (2003).

On the basis of the obtained values for the mechanical composition of the examined soils formed on limestones and dolomites, a classification in texture classes was made according to the American Triangle (Moeys, 2012) (Table 3). It can be seen from the Table 3 that there is a great diversification among soil types and subtypes, where the diversity is the greatest at the calcomelanosols (five texture classes), which is understandable due to the subtypes. The calcocambisols belong in four texture classes, and terra rossa in two texture classes. Ćorić (2009) has an interesting consideration regarding the homogeneity of the textural classes in the formation of terra rossa. He points out that the content of certain categories of particles in the homogenous soils, as terra rossa should be, indicates the autochthony of the texture categories and simultaneously, it is a confirmation that the same has been formed at that place. In contrary, if these categories are not homogenous, it means that the soils have polygenetic characters, and that the solum has a depositing character.

Water is one of the five environmental factors for normal growth and development of the plant, and it has strong influence on the quality and stability of the crop yield. The retention of water in the soil is the result of two forces: adhesion (attraction of water molecules by soil particles) and cohesion (water molecules attract each other). Adhesion is much stronger than cohesion. The force with which water is retained in the soil is called capillary potential and is closely related to water content. Free water in the soil has capillary potential equal to zero, a condition when all the soil pores, capillary and non-capillary, are filled with water.

Table 3. Distribution of soils formed on limestones and dolomites in Macedonia on texture classes

Soil type		%	Texture classes
Calcomelanosols		32	Clayey loam
		26	Sandy clay loam
		18	Loam
		18	Clayey
Sub type	Organogenic	72	Loam
		14	Clayey loam
		14	Sandy loam
	Organomineral	24	Clayey
		35	Clayey loam
		38	Sandy clay loam
		5	Sandy loam
	Brownised	20	Sandy clay loam
		60	Clayey loam
		20	Clayey
	Brownised in (B)rz hor.	80	Clayey loam
		20	Clayey
Calcocambisols		48	Clayey
		41	Clayey loam
		7	Sandy clay
		4	Sandy clay loam
Calcocambisols in Amo hor.		62	Clayey loam
		15	Clayey
		15	Sandy clay
		8	Sandy clay loam
Calcocambisols in (B)rz hor.		79	Clayey
		21	Clayey loam
Terra rossa		92	Clayey
		8	Sandy clay loam
Terra rossa in Amo hor.		80	Clayey
		20	Sandy clay loam
Terra rossa in (B)rz hor.		100	Clayey

Table 4. Mean values for retention on the horizon Amo

Soil type	N	0.33 bars		1 bars		2 bars		6.25 bars		11 bars		15 bars	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Calcomelanosols organogenic	7	41.48b*	10.04	36.93b	9.80	32.25b	4.94	29.39b	9.16	22.41a	7.09	17.22b	9.02
Calcomelanosols organomineral	22	32.16a	7.27	28.89a	6.97	26.73a	6.54	23.98a	5.11	20.16a	5.22	18.34a	5.00
Calcomelanosols brownised	5	31.23a	6.81	27.74a	6.96	25.47a	6.26	21.70a	5.27	18.25a	4.35	16.60a	4.37
Calcocambisols	13	33.49a	3.57	30.17a	3.49	29.01ab	3.58	25.27ab	3.07	21.05a	2.07	17.06a	3.13
Terra rossa	5	39.05ab	0.82	35.95b	1.30	32.81b	1.66	29.92b	2.66	25.17b	2.21	20.93ab	1.09

* Values in each column marked with the same letter don't differ significantly between themselves

Table 5. Mean values for retention on the horizon (B)rz

Soil type	N	0.33 bars		1 bars		2 bars		6.25 bars		11 bars		15 bars	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Calcomelanosols brownised	5	35.86ab*	7.86	32.64a	6.61	31.19a	6.41	27.61a	4.92	23.12a	4.03	19.38ab	2.23
Calcocambisols	14	33.24a	4.41	29.44a	3.83	27.89a	4.07	23.91a	4.08	20.58a	3.60	16.68a	4.69
Terra rossa	7	40.25b	1.00	38.29b	1.24	36.28b	1.30	33.23b	1.95	28.30b	1.37	23.38b	1.02

* Values in each column marked with the same letter don't differ significantly between themselves

Soil water potential can be determined indirectly by recourse to measurements of soil water content and soil water release or soil moisture characteristic curves that relate volumetric or gravimetric content to soil water potential. The measurement of water potential is widely accepted as fundamental for quantifying both the water status in various media and the energetics of water movement in the soil-plant-atmospheric continuum (Livingston, 1993). Markoski (2013) points out that by reducing the moisture content in the soil, the value of the capillary potential is increasing.

For assessment of soil moisture by means of capillary potential Schofield (quoted by Vucić, 1987) suggested pF values, where the force of water in the soil was expressed by the height of the water column in cm (1 bar = 1063 cm water/ cm^2). The pF values are affected by the change of the soil texture and, according to the same author, the greater the share of the smaller fractions, the greater the pF values, especially at a pressure of 0.33 bars.

The degree the mineralogical composition affects the soil moisture retention depends on the percentage amount and fraction of the clay minerals present in a soil type. The clay particles represent the most active part of the fine earth because of their large external and internal active surface, cation-exchange capacity (CEC) and mineralogical composition (Skoric, 1991). Many authors state that the increase in the slightly smaller particles in their quantity increases the surface of tangency between the solid phase and soil moisture (cit. Markoski, 2012). In addition to the soil texture explanation presented before, the paper researches the influence of the moisture retention given the different levels of tension in soil starting with 0.1 (pF-2) and going to 15 bar or (pF-4.2), which corresponds to the wilting point). The remaining soil moisture above 15 bars is not available to the plant (Bogdanovic, 1973).

According to Filipovski (1996), soil water retention in different tension is in tight correlation with humus, clay, and silt content and mineralogical composition of the clay. Maclean and Yager (1972), Jamison and Kroth (1958), Shaykewich and Zwarich (1968) and Heinonen (1971) studied the effect of the organic matter and the mechanical content over the water retention in several soils throughout U.S., Europe and Asia. Data for the water capacities of calcocambisols (pF 1; pF 2; pF 2.5; pF 3.5 and pF 4.2) can be found in the researche of González - Pelayo et al. (2006). They are dealing with the issue for hydrological constants and the influence of the fires on the retention of calcocambisols around Mediterranean.

All profiles of the examined soils were placed on six difference pressure regimes (0.33; 1; 2; 6.25; 11; 15 bars). The mean values of moisture, expressed in mass percentages, in Amo and (B)rz horizons are given in Tables 4 and 5 in order to have better understanging of the intensity of the moisutre retention in the soil types and subtypes.

Due to the large content of humus, as well as due to the large content of clay and the high hydrophilicity and the capillary porosity, the soils formed on limestones and dolomites are characterized with high values of water capacities. It can be seen from the data in Table 4 and 5 that largest retention capacity, 41.48% in average under pressure of 0.33 bars, is found in the humus accumulative horizon (Amo), in the subtype organogenic calcomelanosols. The other subtypes have lower retention in this horizon, i.e. the organomineral, 32.16% in average, and the brownised calcomelanosols, 31.23% in average, and in the cambic horizon (B)rz at the brownised calcomelanosols, the retention amounts 35.86% in average. As for the retention capacity of 0.33 bars, the same condition can also be noticed in the other points of tension (6.25 and 15 bars) (the organogenic have the highest average value (29.39 and 17.22%, respectively),

Table 6. Correlation coefficients between the tension points of 0.33; 1; 2; 6.25; 11; 15 bars and humus, physical sand and physical clay content in the Amo and (B)rz horizons

Hor. Amo / Hor. (B)rz	Organic matter	Total sand	Silt+ clay	0,33 bars	1 bars	2 bars	6,25 bars	11 bars	15 bars
Organic matter		0.21	-0.21	0.12	0.12	0.18	0.01	0.03	0.16
Total sand	0.01		-1	-0.47	-0.46	-0.32	-0.42	-0.41	-0.35
Silt+clay	-0.01	-1		0.47	0.46	0.32	0.42	0.41	0.35
0.33 bars	-0.38	-0.28	0.27		1	0.90	0.95	0.93	0.89
1 bars	-0.49	0.01	0.15	0.98		0.91	0.95	0.93	0.89
2 bars	-0.39	-0.14	0.14	0.97	0.99		0.88	0.88	0.84
6.25 bars	-0.44	0.06	0.06	0.90	0.97	0.96		0.99	0.93
11 bars	-0.44	-0.04	0.04	0.89	0.96	0.96	0.99		0.95
15 bars	-0.39	0.19	0.19	0.73	0.84	0.87	0.88	0.87	

* The correlations in the upper part of the table refer to the Amo horizon, and in the lower part refer to the (B)rz horizon.

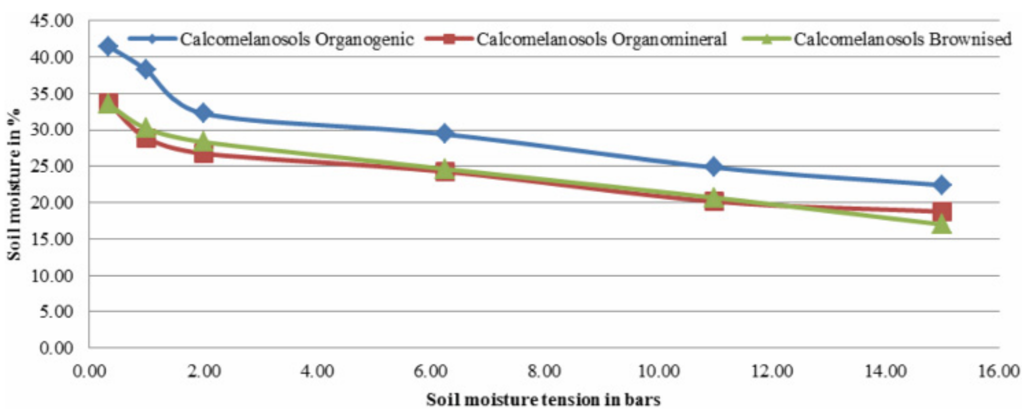

Figure 1.
Retention curves of soil moisture in subtypes of calcomelanosols in the Amo horizon

then the organomineral (23.98 and 18.34%, respectively) and the brownised calcomelanosols (21.70 and 16.60, respectively). The average retention values (pressure of 0.33 bars) in the Amo horizon and the cambic horizon (B)rz at calcocambisols amount 33.49%, and 33.24%. The greater presence of the small pores, the content of humus and clay, also affects the high moisture retention values under pressure of 6.25 bars. The average retention content under pressure of 15 bars in the Amo horizon amounts 17.06%, and 16.68% in average in (B)rz. According to Ćirić (1986 cit. Markoski, 2013) even despite the heavy soil texture, the good water permeability of the calcocambisols is due to the favorable structure and the moderate swelling of the soil aggregates. We can see in our researches that the water infiltration in the soil is slower and takes more time. The reason for this appearance stems from the higher presence of micro pores within the soil aggregates, and that is why a longer period was necessary to moisturize the soil samples during the analysis of water capacities. This makes the soils dry, especially at a particular constellation of factors (shallow solum, less rainfalls, greater slope field as well as south exposure). Compared with calcocambisols, terra rossa had a higher retention capacity in all three tension points (0.33; 6.25, and 15 bars) (Figure 3). The average retention in terra rossa under pressure of 0.33 bars in the Amo horizon amounts to 39.05%, and in the (B)rz horizon to 40.25%. Under pressure of 6.25 bars, the retention in the Amo horizon on average amounts to 29.92%, and in the (B)rz horizon to 33.23%, and under pressure of 15 bars in the Amo horizon it amounts to 20.93% and in the (B)rz horizon 23.38% on average.

The moisture retention clearly indicates the texture differentiation of the profile (the Amo horizon has the lowest retention, and the cambic horizon (B)rz has the highest). Terra rossa contains high percentage of clay, but unlike in calcomelanosols and calcocambisols, it is joined in stabile structure aggregates under the effect of humus and sesquioxides, due to which the soils show good water permeability, aeration and are warm soils.

Table 6 shows the correlation coefficients between the humus, physical sand and physical clay content and retention in different tension points in both horizons.

Based on the correlation analysis of the Amo horizon, it can be noted that the physical sand has a negative correlation with all retention constants. The physical sand has a small negative correlation with retention of 0.33 bars (FWC) (r= -0.28). In both horizons, significant positive correlations were observed between the retention constants.

Retention curves can be obtained if the tension of soil moisture is constantly measured and for each tension the moisture quantity is measured, expressed in percentage, and if the data obtained are entered in a coordinate system. They reflect the ratio between the attractive forces (tension) and the amount of soil moisture. Matula et al. (2007) emphasize that soil hydraulic characteristics, especially the soil water retention curve, are essential for many agricultural, environmental, and engineering applications. Their measurement is time-consuming and thus costly.

The Figures 1, 2 and 3 show retention curves in six different tensions (0.33; 1; 2; 6.25; 11, and 15 bars) for soil testing.

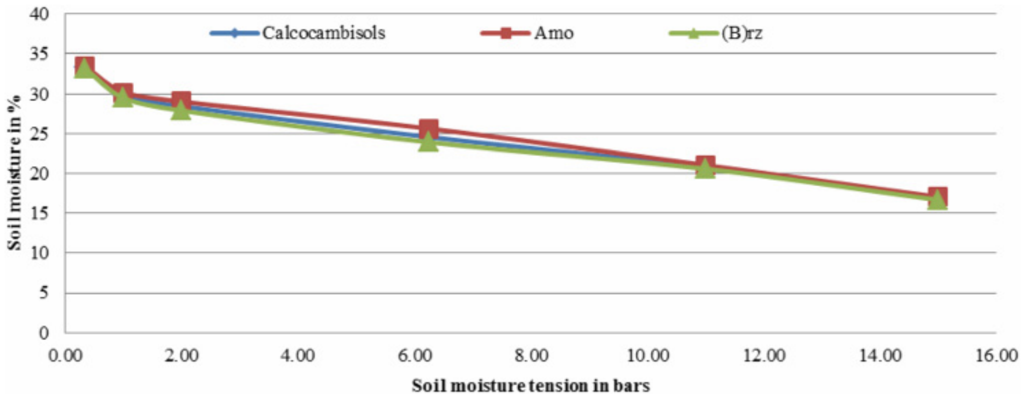

Figure 2.
Retention curves of soil moisture in calcocambisols

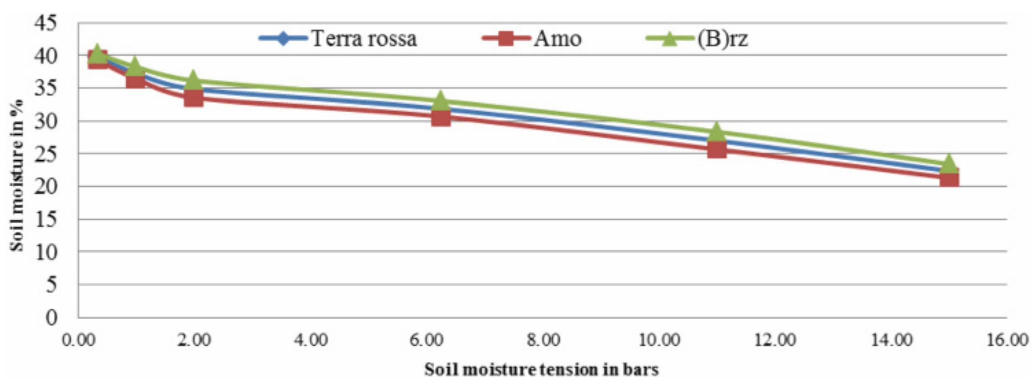

Figure 3.
Retention curves of the soil moisture in terra ross

From the Figure on retention curves of soils formed over limestones and dolomites it can be noted that the soil retention is very high in all three soil types, due to the high content of humus and clay.

Figure 1 shows the retention curves for three subtypes of calcomelanosols and it can be noted that the retention curve in the organogenic calcomelanosols subtype is the highest, which is due to the higher content of humus in this subtype as well as the content of physical clay. The retention curves in organomineral and brownised calcomelanosols is almost parallel in all points of tension. All three curves are almost horizontal with a small decrease in brownised calcomelanosols in tension of 15 bars.

Figure 2 shows the average values of retention curves in calcocambisols. It can be seen that calcocambisols have high retention in all points of tension and do not have a big slope of soil moisture. Also, it can be noted that retention curves with tension of 11 and 15 bars are almost identical. The small difference between retention curves is the result of combined effect from clay, humus and mineral composition of clay.

In the terra rossa (Figure 3) retention curves are high, which means that there is high moisture retention (high content of clay and humus).

The mineral composition of clay according to dept of profile is the same that means that the retention depends on the clay content: the differences in retention between different horizons follow the clay content. The fall of retention curves from lower to higher tensions is small, which means that a good portion of the water is not held by a great force by the soil particles and is more easily freed from them. The texture differentiation is clearly reflected in the moisture retention: the Amo horizon has the lowest retention, which contains less physical clay, and the cambic horizon (B)rz has higher retention since it contains more physical clay.

From the soil retention curves formed upon limestones and dolomites a gradual change in retention forces is noted with the change of moisture without jumps. This indicates that the division of soil moisture into various forms is not justified in the retention curve, since the reduction of the water quantity does not have great jumps in different tensions.

Conclusion

Based on the obtained results, the following conclusions can be drawn on the impact of soil texture of soil on the retention curves:

Texture of the tested soil is characterized by the predomination of the physical clay and clay separates in the fine earth that strongly influences the soil moisture retention curves.

The amount of moisture that is retained in the soil at the pressure of 0.33 bars is high in all horizons.

The data that were obtained for a wilting point (pressure of 15 bars) are high in all horizons for all tested soil samples. This is the result of a high content of clay in soil separates.

The results from our research show that in Amo and (B)rz horizons there is a positive correlation between the water retention curves at 0.33; 6.25 and 15 bars and contents of physical clay (clay and silt) and clay. Also there is high negative correlation between the retention curves at 0.33, 6.25 and 15 bars contents of physical sand fraction (coares+fine sand). In both horizons, significant positive correlations were observed between the retention constants.

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