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THE MAIN PHYSICAL, HYDROPHYSICAL AND CHEMICAL ATTRIBUTES OF SOME VERTISOLS FROM OLT COUNTY, ROMANIA

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Abstract: The the main physical, hydrophysical and chemical attributes of some Vertisols from Olt county were investigated. The field study was carried out on agricultural area in four soils, from each pedogenetic horizon were collected soil in disturbed samples and undisturbed samples for laboratory analysis. The soil classification was made according WRB 2014 and SRTS 2012, and the investigated soils were classified as Vertisols. In the studied soils, the granulometry data showed a clay texture in all the pedogenetic horizons. According to the values of Saturated hydraulic conductivity (Ksat), most of the studied horizons had low and very low permeability. Useful water capacity (UWC) was obtained by calculation, as the difference between wilting coefficient and field water capacity, and in most of the horizons of the investigated soils, recorded very low values. Moreover, low values of draining capacity (DC) pointed out the studied soils have aeration, permeability drainage deficiencies. The studied Vertisols, in top soil, show moderat acid to low acid pH, low humus content (2.72–3.34%), low content of Pm and high content of Km.
Keywords: Vertisols, Olt County, physical, hydrophysical, chemical attributes

INTRODUCTION

Vertisols are defined as soils with distinct characteristics due to clayey texture and swelling mineralogy (*Somasundaram et al., 2018*). According to Soil Survey Staff (2014), Vertisols are soils with "a layer 25 cm or more thick, within 100 cm of the mineral soils surface, that has either slickensides or wedge-shaped peds that have their long axex tilted 10 to 60 degree from the horizontal" and 30 % or more clay in the first 50 cm of soil profile and cracks that open and close periodically.

However, WRB, 2014 described Vertisols as soils with high content of clays and high proportion of swelling clays, with deep craks from surface when dry out.

In Romanian System of soils classification (*SRTS, 2012*), Vertisols are soils with contractile-swelling properties (z) at the surface or at most 25 cm and a vertic horizon (Bzy) extending to at least 100 cm or up to the horizon R or C, if these appear above 100 cm). The color of the humic horizon, relatively uniform and deep, has values ≤ 3.5 and chrome ≤ 2. Vertisols have sliding faces oblique (10-60°) to the horizontal, glossy, sometimes striated, appearing on a minimum thickness of 25 cm in the subsurface horizon, large structural elements with sharp angles and edges, in one of the sub-horizons (*SRTS, 2012*).

In the conditions of our country, Vertisols is a relict intrazonal soil, whose spread is related to certain forms of relief (Piedmont plains, platforms, high terraces, depressions) at altitudes between 100 and 600 m. The evolution of these soils was made on clayey materials, of alluvial-proluvial nature, predominantly swelling.

The materials are, on the whole, poorly carbonated and hardly permeable (*Paltineanu et al.,2003; Blaga et al., 2005*). The climate is characterized by an average multi-annual temperature of 10-11^{0}C and an average multi-annual precipitation between 530 and 630 mm, with a moisture deficit during July-October and a surplus in the winter-spring months, which determines a water regime in the soil with large variations between seasons. (*Florea and Buza, 2004*).

In Romania, Vertisols are spread on 430,000 ha, respectively, 1.8% of the total area of Romania (*Florea and Buza, 2004*) and most of Vertisols and soils with vertic characters located in the south and west of the country (*Paltineanu et al., 2003*).

Generally, the Vertisols properties are known world-wide, but due to different environmental conditions, these characteristics are different from one region to another (*Jean Pierre et al., 2019; Lepre C. J. 2019; Kovda et al., 2017; Pal et al., 2012; Dudek et al., 2019; Azinwi Tamfuh et al., 2018*). So is important to do detailed investigation in a specific area

In this paper are studied the main physical (particle size distribution, bulk density, total porosity, saturated hydraulic conductivity, degree of compaction, resistance to penetration), hydrophysical (hygroscopicity coefficient, wilting coefficient, field water capacity, useful water capacity, total water capacity, draining capacity) and chemical (soil reaction, humus content, total nitrogen, mobile phosphorus and mobile potassium contents) features of some Vertisols from Olt County.

MATERIALS AND METHODS

For the investigation of the main physical, hydrophysical and chemical properties of some Vertisols, were chosen 4 sites from Olt County, located in the south of the country. The relief of Olt County is characterized by two major types of structural units in its territory: orogen and platform. The orogen units are highlighted by hilly with an altitude of 200-400 m, being part of the Getic Piedmont, which occupies a third of its extent in the northern part of county. The platform units correspond to the plain relief, having altitudes of 70–200 m, which fall into the Romanian Plain, which accounts for 2/3 of the county surface. Due to its position in the southwest of the country, the climate of Olt County belongs to the temperate-continental type. The average monthly air temperature values according to the meteorological stations in the territory are 11.3 ºC in Caracal and 10.9 ºC in Slatina, values closely related to the general conditions of this area where the continental climate predominates.

Soil samples. Four soils profiles were dug until 100 cm depth, three of them were located in piedmond plain and 1 profile in terraces. The land use were arable for three sites and grass land for one sites. The field descriptions of soil profiles were made according to Munteanu and Florea, 2009 and Raducu, 2019. From each pedogenetic horizon soil were collected soil in disturbed samples for particle size distribution, hygroscopicity coefficient and chemical characteristics. Also, soil samples were collected from undisturbed samples *by using a core sampler (cylinder method), in three* repetitions, in order to determine the bulk density, total porosity, saturated hydraulic conductivity, resistance to penetration.

Laboratory analysis. The soils texture was determined by gravimetric method. Coefficient of hygroscopicity was obtained by using Mitscherlich method. The methodology used for determining the bulk density, total porosity, saturated hydraulic conductivity, resistance to penetration is given in detail in the papers *(Florea et al., 1987; Canarache, 1990; Dumitru et al., 2009)* and corresponds to the standard method. The hydrophysicals parameters (wilting coefficient, field water capacity, useful water capacity, total water capacity, draining capacity) were obtained by calculation (*Dumitru et al., 2009*).

Soil reaction (pH) was determined potentiometric method, in water suspension (1:2.5). Organic carbon content (Corg, %) was meaured by wet combustion procedure (Walkley-Black method modified by Gogoaşă). The available phosphorus and potassium contents were determined by the Egner-Riehm-Domingo procedure, by extraction with the ammonium lactate acetate. The interpretation classes of studied properties are presented in MESP, 1987 (*Florea et al., 1987*). The soil classification was made according WRB 2014 and SRTS 2012, and the investigated soils were classified as Vertisols.

The statistical analysis (minimum values, maximum values, arithmetic mean, median, standard deviation, coefficient of variation) was performed using Microsoft Excel 2010.

RESULTS

PHYSICAL ATTRIBUTES. In table 1 are listed the basic statistics of the physical properties of examinated soils. In the studied soils, the granulometry data showed a clay texture in all the pedogenetic horizons (fig. 1). In the soil profile, clay (≤ 0,002 mm) content layed between 44.1% and 69.1%, with an average of 60.2% and median of 60.3%. Content of silt (0.02-0.002 mm) belong to the field of 17.7-32%, with an average of 22.87% and median of 23.8%.

Fine sand (0.2 - 0.02 mm contents) ranged from 6.9 to 20.1 % with an average of 13.4% and coarse sand (2 -0.2 mm) content was between 1.6 to 7.6%, with an average of 3.5%. The highest CV was in coarse sand (52.7%). Vertisols or horizons of vertical soils in our country generally contain over 45-50% clay (*Paltineanu, et al., 2003*), however in soils from West of country were found a clay content average of 61.76% (*Bertici et al., 2005*).

In the fig. 2 are presented the variation of bulk density, total porosity, degree of compaction, saturated hydraulic conductivity, and resistance to penetration on soil profiles.

Table 1. The basic statistics of the physical attributes of examinated soils

	Clay	Silt	Coarse Sand	Fine sand
	%			
Minimum	45.60	17.70	0.60	6.90
Maximum	69.10	28.30	7.60	23.50
Median	56.00	24.20	2.40	16.70
Mean	56.44	24.06	2.71	16.77
Standard deviation	6.33	3.18	1.63	4.48
Coef. Variation,%	11.21	13.23	60.13	26.70

	DA	PT	Ksat	Gt	RP
	g/cm³	% v/v	mm/h	% v/v	kgf/cm²
Minimum	1.30	44.80	0.30	4.86	33.00
Maximum	1.48	51.50	4.23	18.29	54.00
Median	1.40	47.70	0.40	12.08	44.00
Mean	1.39	47.99	1.24	11.64	43.33
Standard deviation	0.05	1.84	1.29	3.34	6.00
Coef. Variation,%	3.60	3.83	103.46	28.66	13.84

Bulk density (BD, g/cm³) is considered one of the most important physical soil properties, which determines many physical properties of the soil, such as compaction and hydrophysical properties of soils. Bulk density (BD) was between 1.30 g/cm³ and 1.48 g/cm³, the values in the same variation field were found by Rogobete and Bertici (2006). The BD values greater than 1.25-1.30 g·cm^{-3} could cause yield loss due to poor soil aeration (*Borek Ł., 2019*). In case of clay texture, high and very high values of BD characterize moderately and strongly compacted soils (*Canarache , 1990*).

Total porosity (TP, % v/v) varied from 44.8 (% v/v) to 51.7 (% v/v), with an average of 47.9 (% v/v). According to Canarache (1990), for Vertisols, total porosity is generally between 48-52%, but there are frequent cases in which total porosity falls below 45%, the very compacted soils could reach even values of 42% (*Paltineanu, et al., 2003*). The Vertisols are known as poor porosity and aeration soils (*Kadu et al., 2003; Pal et al., 2012)*.

The degree of compaction (DG, % v/v), Soil compaction due to agricultural activities could be a serious threat to yield and soil ecological functions (*Guimarães et al., 2017*). DG is one of the indicators that characterize the soil settlement, is obtain by calculation according to the total porosity and the soil texture. DG was in the range of low compacted (4.86 % v/v) to strongly compacted (18.29 % v/v) and the average value belongs to medium compacted (11.64 % v/v).

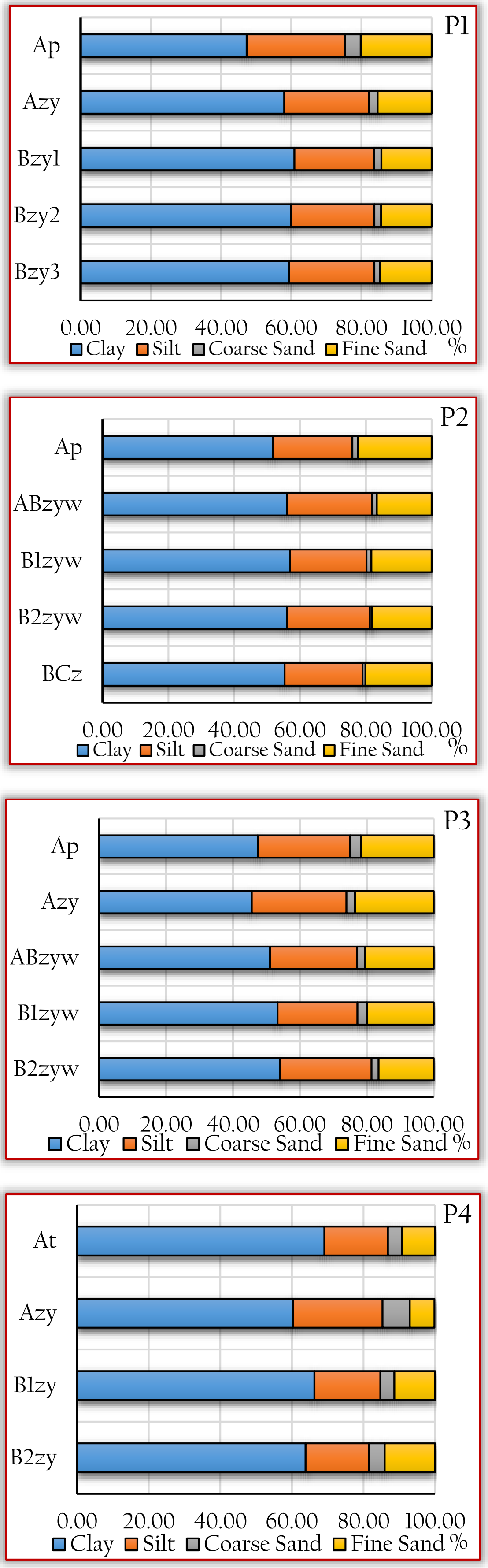

Figure 1. The variation on soil horizons of particule size distribution

Saturated hydraulic conductivity (Ksat, mm/h) characterizes the soil permeability to water for the control section and could be affected by ”biological activity, swelling, aggregate failure and dispersion of clays” *(Ranade and Gupta, 1987)*.

In the examinated soils, the highest *Ksat*, value was 4.23 *mm/h*, the median values was very low (0.4 *mm/h*) and the high value of variation coefficient was noticed (103.5%). So, most of the studied horizons had low and very low permeability.

Saturated hydraulic conductivity sharp decreased from top soil to very low values (0.3 *mm/h*) in the lower part of Profiles 1 and 2 and gradually decreased to deeper horizons of profiles no 3 and 4 (figure 2).

A gradually decresead on soil profiles of Vertisols were noticed also by Oosterbaan and Nijland, 1994, which considere that the topsoil is made more permeable because of physical and biological processes.

The loss of Vertisols hydraulic activity seems to be determined by swelling (Ranade, Gupta, 1987).

Resistance to penetration (RP, kgf/cm^2) predominantly increasing with depth and layed between medium (33 kgf/cm^2) and high values (54 kgf/cm^2), with a medium value of 43 kgf/cm^2. *Dumitru et al. (2011)* found a mean value of 47.4 kgf/cm^2 in the 0-25 layer of Vertisols.

Resistance to penetration increases as clay content and bulk density increase *(Canarache, 1990)*.

HYDROPHYSICAL ATTRIBUTES

In table 2 are listed the basic statistics of the hydrophysical properties of examinated soils and in the fig. 3 are presented the variation of hygroscopicity coefficient, wilting coefficient, field water capacity, useful water capacity, total water capacity, draining capacity on soil horizons.

Table 2. The basic statistics of the hydrophysical attributes of examinated soils

	CH	CO	CC	CAU	CT	CD
	% g/g					
Minimum	11.00	16.50	24.09	3.46	30.27	1.70
Maximum	15.70	23.55	31.20	10.20	39.62	10.50
Median	13.95	20.93	26.52	5.00	34.07	8.70
Mean	13.74	20.61	26.83	5.90	34.53	7.71
Standard deviation	1.27	1.91	2.00	2.02	2.58	2.32
Coef. Variation, %	9.25	9.25	7.46	34.32	7.48	30.10

Hygroscopicity coefficient (HC, % g/g) recorded values in the field of 11-15.7 (% g/g), but in the most of the horizons values were over 13 (% g/g) (tab. 2). These results are in line with results obtained by the Paltineanu, et al. (2003), which noticed values between 12 and 15 % v/v 9 (tab. 2).

Wilting coefficient (WC, % g/g) range between 16.5% g/g to 23.35 % g/g, with a mean of 20.61% g/g, and are very high on the whole profile of the all investigated soils. In case of Vertosols, high values of WC were, also, reported by Tamfuh et al. (2018). Field water capacity (FWC, % g/g) expressed the water content that a soil retains in a sustainable manner and depends mainly on the clay and bulk density. The values of field water capacity were, generally, high in Profile 1 (26.5-28.5% g/g) and 4 (26.3-31.2 % g/g) and high to mediu in the Profile 2 (24.4-29.1 % g/g) and 3 (24.1-26.2% g/g). Except

Profile 4, the values of FWC recorded slighter decrease on the soil profile (figure 2).

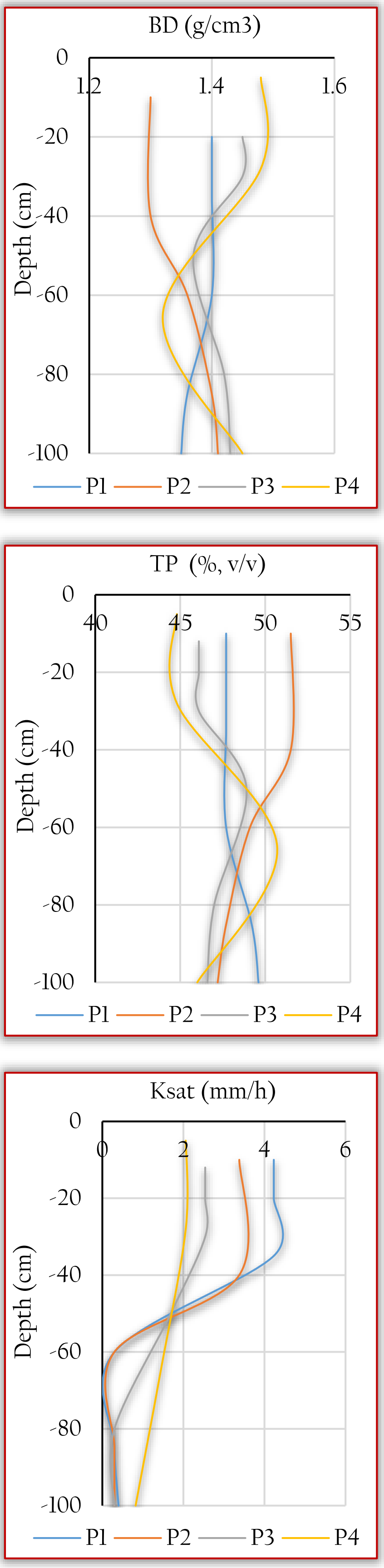

Figure 2. The variation on soil profiles of bulk density, total porosity, degree of compaction, saturated hydraulic conductivity, resistance to penetration

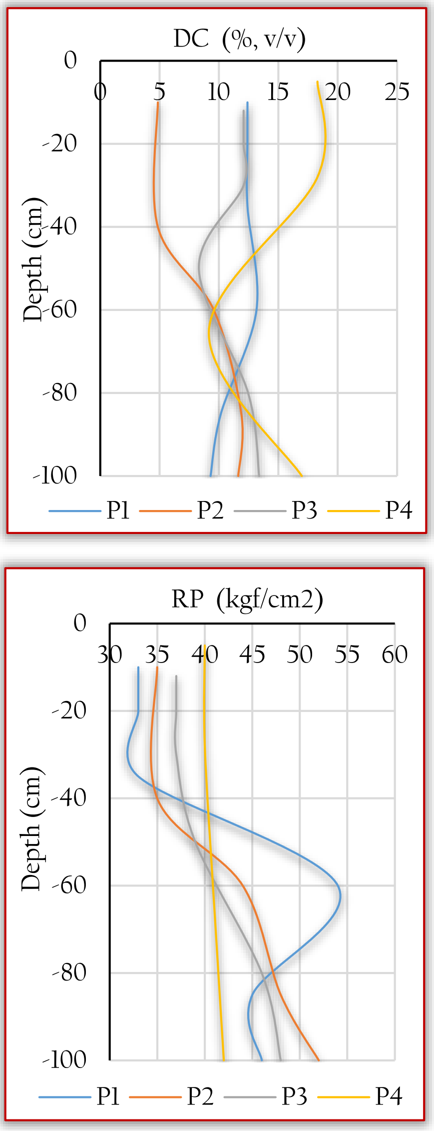

Figure 2. The variation on soil profiles of bulk density, total porosity, degree of compaction, saturated hydraulic conductivity, resistance to penetration (continuing)

Useful water capacity (UWC, % w/w) it is a key indicator of the potential water reserve and is obtained by calculation, as the difference between wilting coefficient and field water capacity. In the examinated profiles, UWC is low to very low (3.46-10.2 % g/g), but in most of the horizon, the recorded values were very low (< 8% g/g). The total capacity of the soil water (TC, % g/g) means the maximum water quantity that soil could retain when its entire porous space is filled with water. The values of TC were high (30.27-39.62% g/g) on the whole profile of investigates soils. Draining capacity (DC % g/g) of soil is the maximum water amount that soil could release. Vertisols are known as poorly drained soils (*Paltineanu et al., 2003; Lepre, 2019*). The DC values were extremly low to low (1.7-10.5 % g/g), with an average belong to low value (7.7 % g/g). According to the DC values, the studied soils have aeration and permeability deficiencies and excess water potential.

In table 3 are listed the basic statistics of the chemical properties of exanimated soils and in the figure 3 are presented the variation of soil reaction, humus content, total nitrogen, mobile phosphorus and mobile potassium contents on soil profile.

Table 3. The basic statistics of the chemical attributes of examinated soils.

	pH	H %	Nt %	Pm mg/g	Km, mg/kg
Minimum	5.13	0.96	0.09	0.50	200.00
Maximum	8.11	3.43	0.25	18.10	356.00
Median	6.27	2.14	0.15	6.50	236.00
Mean	6.30	2.21	0.15	7.03	247.00
Standard deviation	0.79	0.81	0.04	5.68	44.57
Coef. Variation, %	12.50	36.63	28.98	80.84	18.04

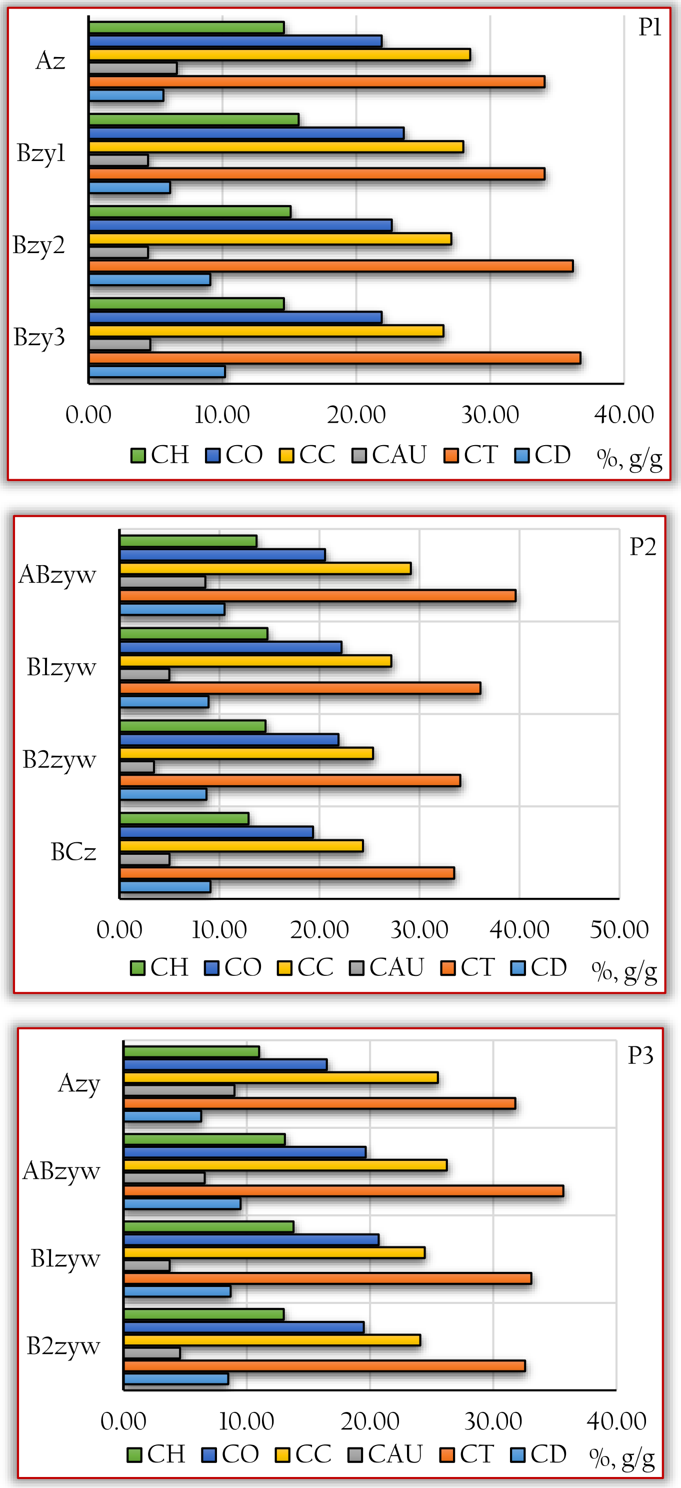

Figure 3. The variation of CH, CO, CC, CAU, CT and CD on soil horizons

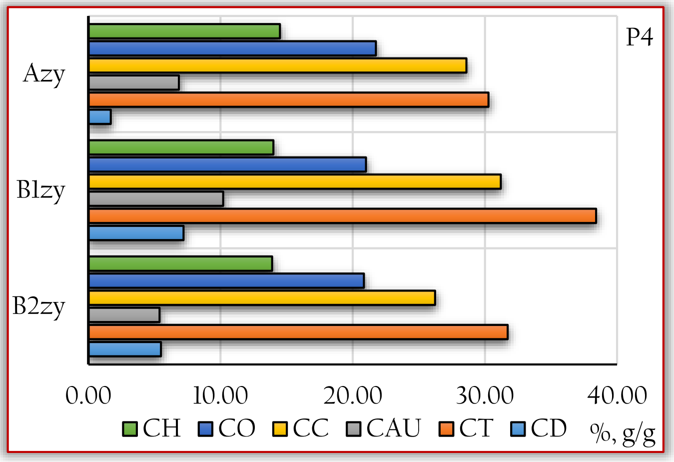

Figure 3. The variation of CH, CO, CC, CAU, CT and CD on soil horizons (continuing)

Soil reaction (pH in water) increased on the soil profile from moderate acid (pH=5.4) to low acid (pH=6.3) in case profiles no 1 and 3, from low acid (pH=6.6) to low alkalinity (pH=7.6) in case of profile no 2, and from moderate acid (pH=5.1) to low alcalinity (pH=8.11) in case profiles no 4 (figure 3).

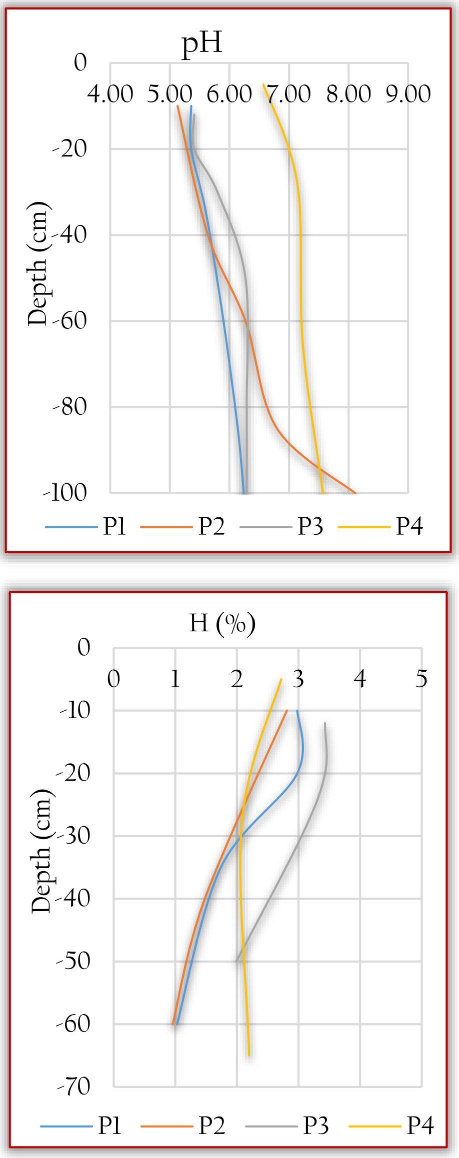

Figure 4. The variation of pH, H, N , Pm and Km on soil profiles

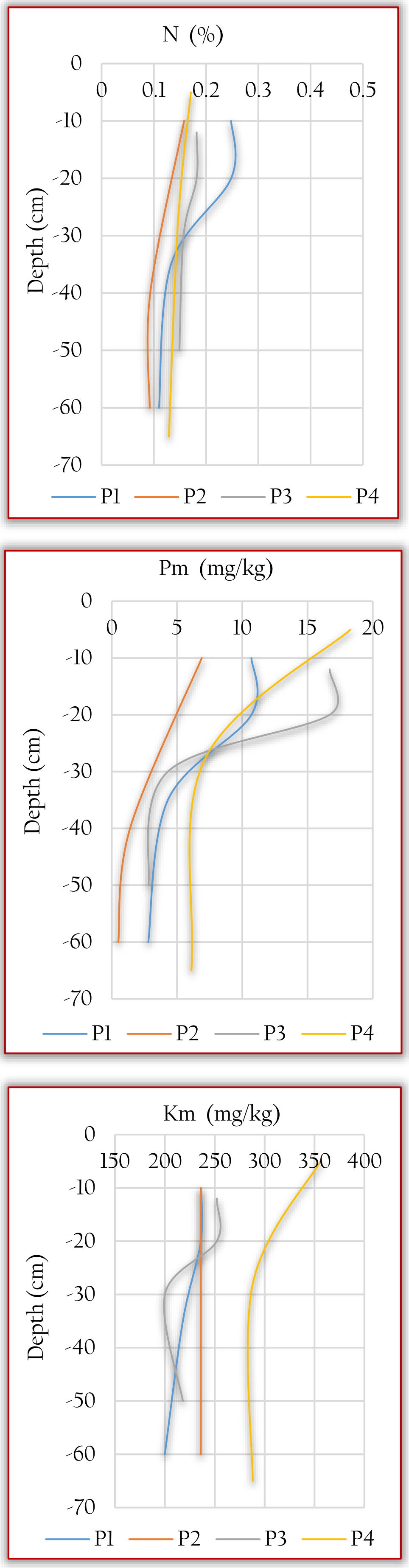

Figure 4. The variation of pH, H, N , Pm and Km on soil profiles (continuing)

Humus content (H,%). Vertisols are characterized by relatively high values of humus content, both in the upper horizon (2.0-3.3%), as well as on the profile with more than 1% up to 110-120 cm depth (*Paltineanu et al., 2003*). In investigates soil, humus ranges from 3.34% to 2.72% in the upper part of soil profile and decrease o up to 2.2% at the 65 cm depth in case of P4 and up to 0.96 % at the 60cm depth in case of P2 (figure 3). In upper horizons, the organic carbon content reported in other studies varies from 3.23% (*Kovda et al., 2017*) to 1.6-2.5 % (*Dudek et al., 2019*). *Total nitrogen content* (Nt, %) range from 0.17%-0.25% in the upper part of soil profile and decreased gradually up to 0.11%, except P2 were Nt decrease sharply from 0.16% in top soil to 0.09% under 20 cm depth.

Mean mobile phosphorus contents (Pm, mg/kg) lay between low (18 mg/kg) to very low values (6.9 mg/kg) in the upper part of soil and from very low (6.1 mg/kg) to extremely low values (0.5 mg/kg) at the 60 cm depth. *Mean mobile potassium contents* (Km, mg/kg) was very high – high (356-288 mg/kg) in the first 50 cm of the P4 and high (200-256 mg/kg) in the other studied soils

CONCLUSIONS

The studied of the main physical, hydrophysical and chemical attributes of some Vertisols from Olt County pointed out the following:

— the granulometry data showed a clay texture in all the pedogenetic horizons, the mean of clay, silt, fine sand and coarse sand were: 60.2%, 22.8%, 13.4% and 3.5%, respectively;
— the bulk density (BD) was between 1.30 g/cm^3 and 1.48 g/cm^3, and total porosity (TP) varied from 44.8 (% v/v) to 51.7 (% v/v), with an average of 47.9 (% v/v), these values are in the field of poor soil aeration with implications of yield;
— the values of Saturated hydraulic conductivity (Ksat), in the most of the studied horizons, had low and very low permeability;
— the degree of compaction was in the range of low compacted (4.86 % v/v) to strongly compacted (18.29 % v/v) and the average value belongs to medium compacted;
— resistance to penetration predominantly increasing with depth and layed between medium (33 kgf/cm^2) and high values (54 kgf/cm^2), with a medium value of 43 kgf/cm^2;
— the useful water capacity (UWC) in most of the horizons of the investigated soils, recorded very low values
— the draining capacity (DC) recorded low values of draining capacity (DC) highlighted that the studied soils have aeration, permeability drainage deficiencies;
— the examinated Vertisols, in top soil, show moderat acid to low acid pH, low humus content (2.72–3.34%), low content of Pm and high content of Km.

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