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PLASTICITY OF VERTISOLS FROM PČINJA DISTRICT

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This paper presents the study of soil plasticity of vertisols from Pcinja District. Liquid (Wl) and plastic limit (Wp) were determined by the method of Atterbeg, and plasticity index (Ip) by calculation.

The results showed that plastic limits of the studied calcareous vertisols are higher compared to non calcareous vertisols. Values of plastic limit (Wp) of calcareous vertisols are fairly uniform along the soil profile and vary from 23.37 to 25.85%. Values of plastic limits of non calcareous vertisols are much lower and range between 15.66 and 17.30%. Values of the liquid limits (Wl) also differ. Plastic limits of calcareous vertisols vary between 46.39 and 47.31%, while at non calcareous it range from 29.98 to 32.50%. Plasticity index is lower in non calcareous vertisols which indicates the dominant influence of montmorillonite clay.

Keywords: vertisol, liquid limit, plastic limit, plasticity index, montmorillonite

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INTRODUCTION

According to Serbian soil classification system Smonice (Vertisols) belong to the order of automorphous soils, class of humus-accumulative soils with profile A-AC-C. Vertisols occur on every continent in the world and cover an area of 335,000,000 ha. In Serbia Vertisols cover 780,000 ha and are most common in the central part – Šumadija (BOGDANOVIĆ, 1958), east - Negotinska Krajina, in the south - Vranjska kotlina, in Kosovo and Metohija (FILIPOVIĆ *et. al*, 1965) and in the north of Vojvodina, around Vršac and Bela Crkva (ŠKORIC, 1986; NEJGEBAUER *et. al*, 1973). Smectite clay minerals i.e. montmorillonite have important role in genesis of vertisols.

Based on detailed research of GOLUBOVIC (2009), two subtypes of vertisols were differentiated: calcareous and non calcareous. These subtypes differ in clay (<0.002 mm) content. Minerals from smectite group are the most abundant in the clay size mechanical fraction.

Smectite clay influences plastic and liquid limit and increases the value of plasticity index. Plasticity is a property of the fine-grained portion of a soil which permits it, under certain moisture conditions, to be remoulded without crumbling or rupturing.

Plasticity of the soil is very dynamic physical property, which depends on the content and mineralogy of clay size mechanical fraction. Studies of OHOTINA and TKAČUKA, cit. BOGUNOVIĆ (1988), showed that plasticity is manifested to some extent already in the medium silt fraction, with a diameter of 0.01 to 0.005 mm. RALČEV (1972) has explained high plasticity of vertic soils and vertisols by the high clay and organic matter content, primarily hydrophobic and hydrophilic humus colloids. According to DJORDJEVIĆ (2002) there is a high correlation (r=0.959) between organic matter content and plastic limit in calcareous black soils of Rajac.

By ATTERBEG (1911), soil plasticity can be characterized by the following constants: plastic limit (determined by rolling out a thread of the fine portion of a soil on a flat, non-porous surface), liquid limit (the water content at which a soil changes from plastic to liquid behavior), and the plasticity index. Atterbeg's plastic limit is very important in assessing proper time for tillage because it also represents the upper limit of soil physical maturity for cultivation. The aim of this study was to determine the plastic limit and plasticity index of calcareous and non calcareous vertisols from Pčinja District.

MATERIALS AND METHODS

In Pčinja district, in southeastern Serbia, ten soil profiles were spatially positioned in vertisol soil type. These vertisols are formed between 400 and 500 m above sea level. We have identified two subtypes of vertisols according to Serbian national classification: calcareous and non-calcareous. Two soil profiles (one of each subtype that differ in particle size distribution) were chosen to determine plastic and liquid limits and index of plasticity. Particle size analysis was determined by pipette method, content of organic matter by the method of Tjurin, carbonates using Scheiblers calcimeter, plastic and liquid limit by the method of Atterbeg, and plasticity index (Ip) by calculation.

RESULTS AND DISCUSSION

Results show that plastic limit of surface soil samples (0-20 cm) from calcareous vertisols are higher than of the non calcareous vertisosl (table 1). Plastic limit (Wp) is fairly homogeneous throughout the profile of the studied calcareous vertisols and range from 23.37 to 25.85%.

The value of plastic limit, which also represents the upper limit of the moisture content for soil cultivation is much lower in non calcareous. The value of plastic limit is increasing with depth in both profiles (of calcareous and non-calcareous vertisols) which corresponds to increasing clay content.

Higher plastic limit with the same clay content enables wider interval for soil cultivation, period in which tillage could be carried out with less resistance and less energy consumption (SCHEFFER *et al.,* 1970). BOGUNOVIĆ (1988) pointed out that soil tillage when the soil moisture is above plastic limit will lead to more energy consumption, soil structure deterioration, compaction and forming of plough pan.

BABOVIC (1971) has showed that in surface horizon of vertisols from Kosovo, plastic limits vary in quite a narrow interval, from 24.0 to 27.2% as a result of uniform particle size distribution and mineral composition along the soil profile.

RALČEV (1976) showed similar values of the plastic limits for vertisols from Bulgaria, 24 to 27%, with a slight increase in part of the humus horizon that has not being ploughed.

Liquid limit (table 1), the water content at which a soil changes from plastic to liquid behavior is much higher in the calcareous than in non calcareous vertisols. Liquid limit of the calcareous vertisol varies from 46.39 to 47.31%, while at the non calcareous vertisol it ranges from 29.98 to 32.50%. Liquid limit (Wl) of the studied profiles increased with depth, which is correlated to clay content.

The values of Wl in surface horizon of vertisols from Kosovo, vary in a rather wide range, from 52.0 to 67.5% , while in the subsurface horizon it is gradually increasing (BABOVIC, 1977).

The plasticity index is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. It is the difference between the liquid limit and the plastic limit.

Table 1 Soil characteristics of calcareous and non-calcareous vertisol from Pcinja District

Profile location	depth (cm)	SOM (%)	$CaCO_3$ (%)	<0,002 mm	<0,01 mm	Wl (%)	Wp (%)	Ip (-)	Class of plasticity Lieberoth
Calcareous vertisols									
Profile 1 (Coordinates N 42° 31.259', E 021° 53.207', 409 m a.s.l.)									
Vranje Neradovac	0-20	2,68	4,2	73,67	84,11	46,64	23,37	23,27	Very plastic
	20-40	1,89	5,1	77,34	87,06	46,39	25,85	20,54	Very plastic
	40-65	1,24	8,2	78,49	89,25	47,31	24,86	22,45	Very plastic
Non calcareous vertisols									
Profile 7 (Coordinates N 42° 26.934', E 021° 53.058', 445 m a.s.l.)									
Vranje Milanovo	0-20	3,04	-	43,07	52,87	29,98	15,66	14,32	Medium plastic
	20-40	2,15	-	45,11	55,19	32,13	16,03	16,10	Medium plastic
	40-60	1,52	-	46,98	57,34	32,50	17,30	15,20	Medium plastic

According to Bakhtin's (1969) the plasticity of soil is most affected by mineral composition, particle size distribution, chemical composition, adsorbed cations, the concentration and composition of the soil solution. Results (table 1) show that the plasticity index (Ip) in the investigated calcareous vertisols is higher than of the non calcareous vertisol. Ip value decreased with depth of soil profile of calcareous vertisol and ranged from 20.54 to 23.27, and according to Lieberoth's (1969) it is classified as very plastic soil.

Surface horizon of calcareous vertisol with highest clay content had the highest value of plasticity index (23.27). Surface horizon of non calcareous vertisol had the lowest value of plasticity index (14.32).

The value of plasticity index of non calcareous vertisols ranged from 14.32 to 16.10, and according to Lieberoth makes it medium plastic soil. Based on the correlation analysis we found that there is strong correlation between Ip and the clay content, where r = 0.95 (chart no. 1). The results of plasticity index indicate the dominant influence of smectite clay, being twice as high at calcareous vertisols.

There are various opinions on humus impact on the soil plasticity. Stojanovic et al. (1998), emphasize that the increase of humus content in soil decreases its plasticity. Sokolovski (quoted Zivkovic, 1983) considered plasticity to be affected by hydrophilic (active), and not by hydrophobic (passive) humus colloids in the soil.

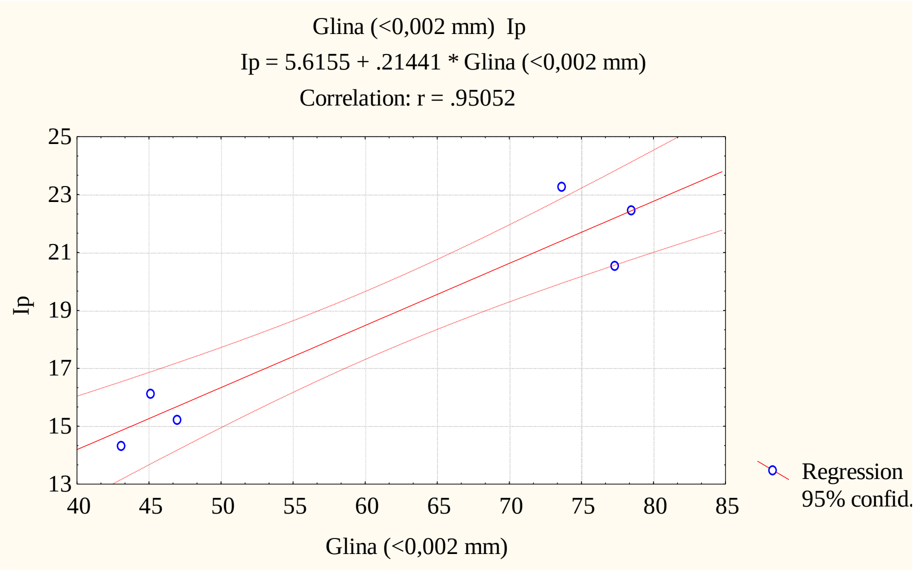

Figure 1 The regression model of plasticity index and clay content

Content of humus is higher and plasticity index is lower in non calcareous vertisols compared to calcareous, so humus in non calcareous vertisols could have an impact on soil plasticity.

CONCLUSIONS

Based on the plastic and liquid limits, and plasticity index of the studied vertisols, it can be concluded

- values of the plastic limits are higher in calcareous vertisols
- plasticity index values are also higher in calcareous vertisols due to significantly higher content of clay from the smectite group (very plastic soils)
- non calcareous vertisols have lower plastic limits (medium plastic soils).

Plasticity indexes of vertisols are significantly different from other soil types. The other soil types with less smectite minerals and no carbonates have lower plasticity indexes.

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PLASTIČNOST SMONICA PČINJSKOG OKRUGA

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I z v o d

Smonice pripadaju redu automorfnih zemljišta, klasi humusno-akumulativnih zemljišta sa A-AC-C građom profila. U Srbiji smonice zauzimaju površinu od 780.000 ha i najzastupljenije su u njenom centralnom delu - Šumadiji, istočnom - Negotinskoj Krajni, na jugu - Vranjska kotlina, na Kosovu i Metohiji kao i u severnim delovima Vojvodine oko Vršca i Bele Crkve (ŠKORIĆ, 1986). Značajnu ulogu pri obrazovanju smonica imaju minerali gline iz grupe smektita (ROZANOV, 1983).

Na osnovu detaljnih istraživanja (Golubović, 2009) smonica Pčinjskog Okruga izdvojena su dva podtipa smonice na ovom području i to karbonatni i beskarbonatni koji se prilično razlikuju u sadržaju gline (< 0,002mm), u čijem sastavu najveći procenat pripada mineralima gline iz grupe smektita. Minerali gline iz grupe smektita povećavaju vrednosti indeksa plastičnosti i utiču na veličinu donje i gornje granice plastičnosti.

Plastičnost zemljišta je veoma dinamična fizička osobina koja najviše zavisi od sadržaja i vrste minerala gline. Ispitivanja OHOTINA i TKAČUKA, cit. BOGUNOVIĆ (1988), pokazuju da se plastičnost u izvesnoj meri manifestuje već kod frakcije srednjeg praha, sa prečnikom od 0,01-0,005 mm.

Po ATERBERGU (1911), plastičnost zemljišta se može okarakterisati pomoću sledećih konstanti: donja granica plastičnosti gornja granica plastičnosti i indeks plastičnosti. Poznavanje veličine Aterbergove donje granice plastičnosti veoma je značajno radi pravovremene obrade zemljišta jer ona istovremeno predstavlja i gornju granicu fizičke zrelosti zemljišta za obradu.

Cilj ovog rada je određivanje granice plastičnosti karbonatnog i beskarbonatnog podtipa smonica sa područja Pčinjskog okruga i izračunavanje indeksa plastičnosti.

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