PHYSICAL QUALITY EVALUATION OF SOME SOILS FROM DOLJCOUNTY

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Abstract

The quantity and quality of yield is determined by the soil quality. The agriculture is one of the main human activities that affect soil quality. In Dolj, the agriculture occupies an important place in the economy of the County. The main soils found in DoljCounty were Chernozems and Luvisols. Several indicators are used to quantify the physical quality of the soil.

To assess soil physical quality, disturbed samples from each pedogenetic horizon were collected to analyse: particle size distribution, soil organic content, dispersion and macrohydrostability. Undisturbed samples were also collected (by using a core sampler), for: bulk density, total porosity, saturated hydraulic conductivity, resistance to penetration determination. The degree of compaction, the packing density, the structural stability index as well as the structural instability index were obtained by calculation.

*The results showed that according to the degree of compaction values, both studied Luvisols (except ArenicLuvisols), and HyposodicCalcaro-calcic Chernozems and Haplic Chernozems with fine texture were severely compacted and required loosening works. Most of the studied horizons of Luvisols had low – extremely low permeability. With a few exceptions, the values of the resistance to penetration were medium***.** *The HyposodicCalcaro-calcic Chernozems shows the highest values of structural instability index.*

Key words: *Chernozems, Luvisols, physical quality evaluation*

INTRODUCTION

The quantity and quality of yield is determined by the soil quality. The agriculture is one of the *main* causes of soil degradation, especially soil physical degradation (Virto et al., 2015).

”From an agricultural point of view, soil physical quality decreases mainly in cases of soil cultivation due to decreases in soil porosity, increased soil bulk density, aeration and water balance, as well as increases in soil penetration resistance, structural degradation and erosion risk’’ (Borak, 2019).

”Soil physical quality is a central concept for quantifying land degradation and developing “best management” land use practices’’ (Reynolds et al.,2008).

The physical quality of the soil is difficult to quantify through a single indicator, and until now a combination of several properties has been used (Vizitiu et al., 2010).

Agriculture has an important role in DoljCounty, which owns about 4% of the country's total agricultural area (INS, 2014).

At the level of DoljCounty, 6 soil classes and 15 soil types were identified. About 37% of the County's soils are represented by Cernisols (typical, cambic, argic Chernozems and Phaeozems), 26% by Luvisols, 20% by Protisols (which group Regosols, Arenosols and FLuvisols), followed by Pelisols (7%), Hidrisols (4%), Anthrisols (4%) (Pavel and Meilă, 2012).

The objective of this paper is to assess the physical quality of Chernozems and Luvisols from DoljCounty.

MATERIALS AND METHODS

Description of Study area

The development of the relief in steps from south to north (river meadow, alluvial plain, high piedmont plain and piedmont) as well as the great variety of solification rocks, and as climate changes in the same direction, explain the diverse range of soils and their geographical distribution in Dolj County (Pavel and Meilă, 2012).

The Cernisols class covers an area of 215820 ha and includes Typical, Cambic and Argic Chernozems and, in some places,Phaeozems. The soils of this class dominate the southern central part of the County (Desnațuiului Plain and part of the Leu-Rotunda Plain) (Pavel and Meilă, 2012).

TheLuvisols class occupies an area of 151393 ha (26%) and is represented by Luvisols and Preluvosols. They appear dominantly in the northern central part of the County and are spread over most of the Piedmont plateaus, as well as part of the slopes that boundary these Piedmont plateaus(DesnațuiuluiPlain and a part of the Leo-Rotunda Plain) (Pavel and Meilă, 2012).

For the investigation of the main physical properties of some soils from DoljCounty, 8 profiles of Chernozems and 8 profiles of Luvisols were chosen.

Soil samples

The land use was arable, except for one site with orchard. The field descriptions of soil profiles were made according to Munteanu and Florea, 2009 and Raducu, 2019.

From each pedogenetic horizon both disturbed and undisturbed soil had been sampled.

The disturbed samples were collected to analyse: the particle size distribution, the soil organic content, the dispersion and the macrohydrostability.

Undisturbed samples were also collected (by using a core sampler), for: the bulk density, the total porosity, the saturated hydraulic conductivity, the resistance to penetration determination. While, the degree of compaction, the packing density, the structural stability index as well as the structural instability index were obtained by calculation.

Laboratory analysis

The soils texture was determined by gravimetric method.

The methodology used to determine the bulk density, total porosity, saturated hydraulic conductivity, and resistance to penetration is detailed in the papers *(*ICPA-Methodology–1987*; Canarache, 1990; Dumitru et al., 2009)* and corresponds to the standard methods.

The interpretation of the studied properties data has been made according to the ICPA-Methodology–1987, whilst the soil classification was made according to SRTS–2012 and WRB–2014.

RESULTS AND DISCUSSIONS

In the studied area the soil cover is composed mainly by Cernozems and Luvisols. The Cernozems subtypes are

Calcic, Hyposodic Calcaro-calcic and Haplic, while the Luvisols subtypes were as following: Haplic, Mollic, Chromic, Arenic, Vertic, and Stagnic.

The Chernozems from the studied areahada clayey loam texture (38%) and Chernozems with loam – sandy loam texture (62%). In the A horizons, the clay (≤ 0,002 mm) content laid between 20.8% and 40.8%, with an average of 30.7%. The silt (0.02-0.002 mm) content ranged between 14.7 and 24.7%, with an average of 18.5%. Fine sand (0.2 - 0.02 mm contents) ranged from 33.9 to 59.1 % with an average of 42.2% and coarse sand (2-0.2 mm) content was between 0.6 to 24.5%, with an average of 8.5%.

The Luvisolsgranulometry, in the A horizons, showed loam – clayey loam texture, while in the Bt horizons the texture is clayey or loam – clayey, Except ArenicLuvisols.

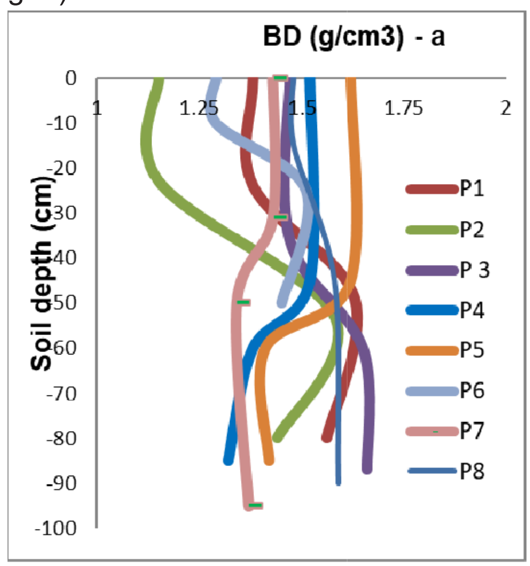
Theclay content,into the A horizons, falls within the limits24.0%–41.3%, with an average of 31.3%. Thesilt content belongs to the range of 16.5–27.7%, with an average of 20.8%. Fine sand ranged from 28.8 to 43.1 % with an average of 36.2%, while the coarse sand content was between 4.2%–22.9%, with an average of 11.8%.

In the Bt horizons, the clay content layed between 35.9% and 51.5%, with an average of 43.6%. The content of silt belongs to the value limits of 17.8–25.7%, with an average of 20.9%. Fine sand ranged from 23.9 to 38.2 % with an average of 28.7% and coarse sand content was between 2.0% to 16.4%, with an average of 6.9%.

The textural differentiationindexof Luvisolswas between 1.25 and 1.75, with a mean of 1.41 and a median of 1.34. The values of this index for ArenicLuvisols ranged from 1.9 to 2.1.

Thebulk density (BD,g/cm^3)influenced many soil properties as: ’’aeration, infiltration, strength, and ability to store and transmit water’’ (Reynolds et al., 2008) ’’rooting depth / restrictions, soil micro-organism activity, root proliferation, and nutrient availability’’ (Indoria et al., 2020).

The BD of Chernozems, was in the range of 1.15 g/cm^3–1.66 g/cm^3, although for the Luvisols varied from 1.44 g/cm^3 to 1.81 g/cm^3 and generally increased with dept (fig. 1).



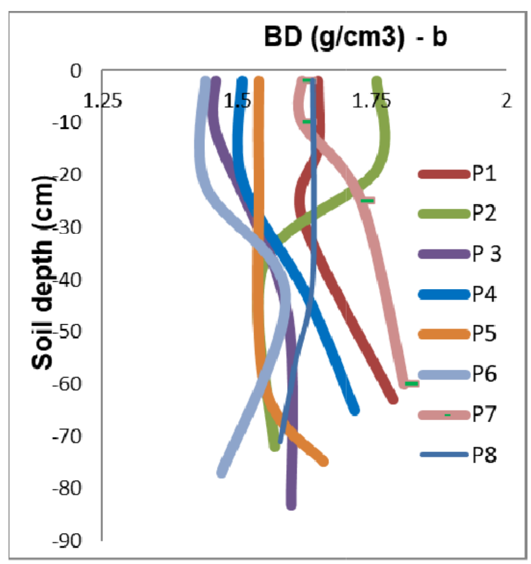


Fig. 1. The variation of Bulk Density with depth, in Chernozems(a) and Luvisols (b).

In the investigated soils due to the clayey – loamyclayeytexture and the high values of the BD, the root growth could be restricted and consequently the plant growth could be affected.

A BD''between 1.3 and 1.55 g cm^{-3} is fair, and greater than 1.8 g cm^{-3} is considered extremely bad'' (Mukhopadhyay et al., 2019). The BD values greater than 1.25-1.30 g·cm^{-3} could cause yield loss due to poor soil aeration (Borek, 2019).

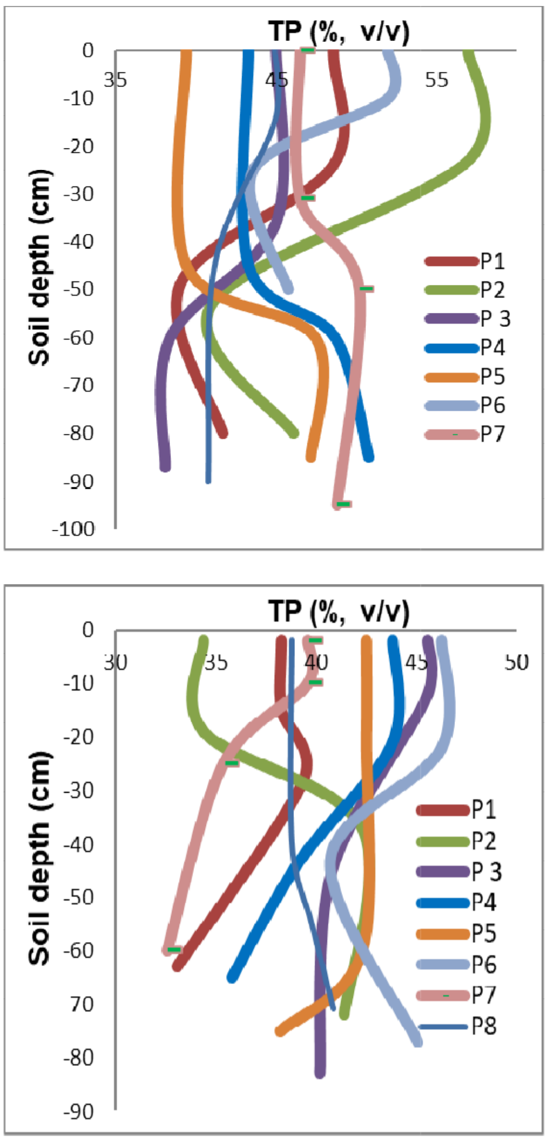


Fig. 2. The variation of Total Porosity with depth, in Chernozems(a) and Luvisols (b).

The total porosity (TP, % v/v) of Luvisols varied from 32.6 (% v/v) to 46.3 (% v/v), with an average of 47.9 (% v/v) and between 38.1 and 57 (% v/v), with an average of 39.9 (% v/v) in the case of Chernozems (fig. 2).

The compactiondegree (DG, % v/v). The yield and soil ecological functions could be seriously affected by soil compaction (Guimaraes et al., 2017).''To characterize the state of compactness of a soil layer, dry bulk density and total porosity are the most frequently used parameters'' (Hakanssona and Lipiec, 2007).

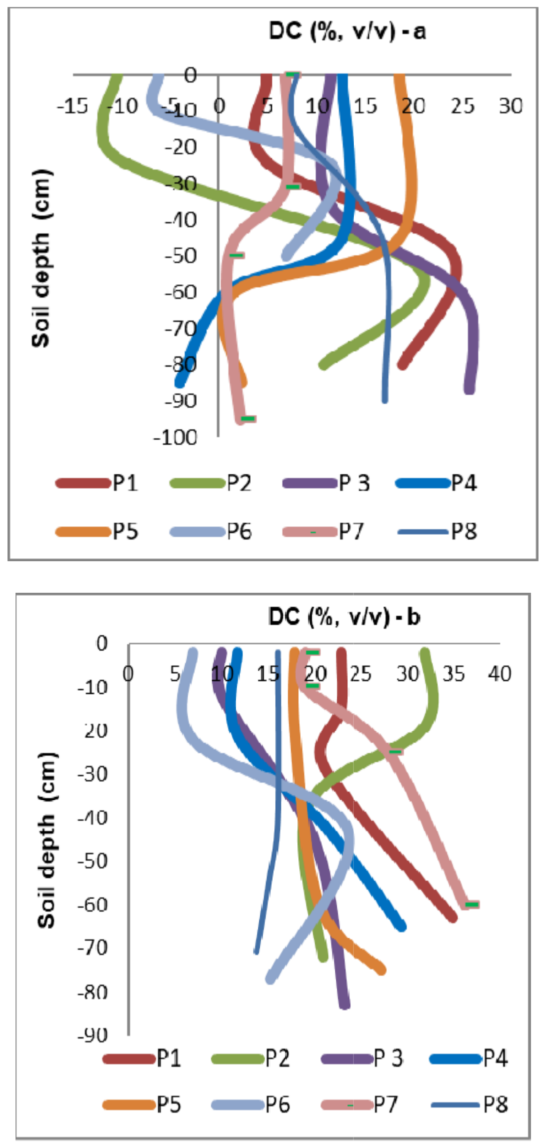


Fig. 3. The variation of the Compaction Degree on soil profiles (a - Chernozems, b - Luvisols).

DG was calculated according to the soil clay content (%), bulk density (BD, g/cm^3) and density (D, g/cm^3) (ICPA-Methodology–1987; Dumitru et al., 2011).

DG of Luvosols, was in the range of low compacted (7 % v/v) to strongly compacted (36 % v/v) and the average value belongs to medium compacted (21 % v/v) and between 10.4% v/v to 25.6% v/v with an average of 8.9% v/v in the case of Chernozems (fig.3).

Moderately and strongly compacted soils have a clayey texture and a high to very high BD values (*Canarache ,1990*).

CD is used to determine the need for loosening works (Stanga, 1978, quoted by Canarache,1990). The studied Luvisols, according to DG values, are severely compacted and require the loosening works, except ArenicLuvisols (with loam sandy – sandy loam texture), that is moderately compacted.

The Calcaro-calcic Cernozems and Haplic Cernozems with fine texture are, also, severely compacted and require the loosening works.

The packing density(PD, g/cm^3) is another index that describes the soil compaction (Canarache, 1991) and was determined according to the Eq.1.

$$PD = BD + 0.009\ C$$

where:

PD– packing density (g/cm^3);

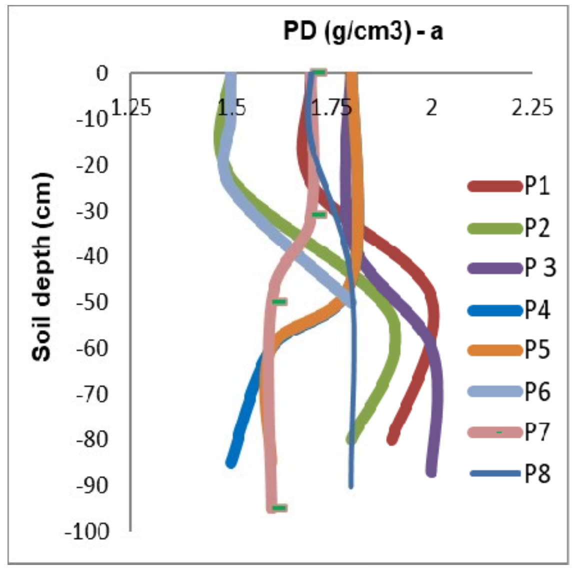
BD – bulk density (g/cm^3);

C – the clay content(%, v/v).

Since there are different indices, which evaluate the state of compaction, and each of them ''expresses some kind of specific inforrmation'' is necessary to use ''several of these indices at the same time'' (Canarache, 1991).

''PD is strongly influenced not only by the type of packing (loose or densely), but also by the shape and the size of the aggregates, as well as by the roughness of their surfaces'' (Eftene et al., 2020).

The high values of PD (> 1.75 g/cm^3**)** were recorded in Luvisols, except for theArenicLuvisolswhere the PD reached medium values(fig. 4).



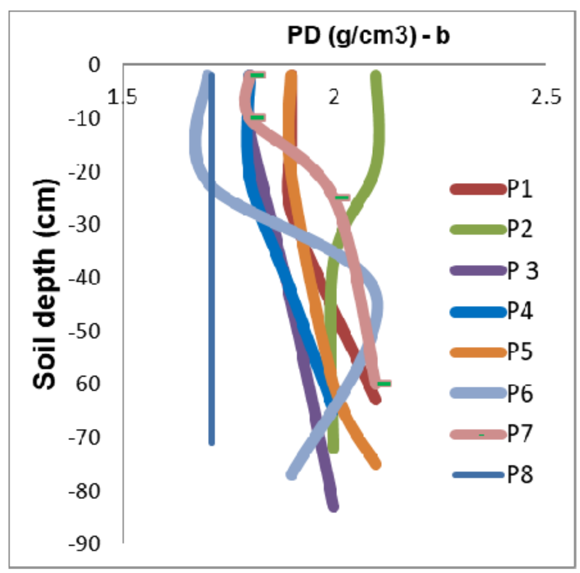


Fig. 4. The variation of Packing Density on soil profiles (a - Chernozems, b - Luvisols).

Chernozems are medium–high compacted according to PD values. The PD average and median was 1.92 g/cm^3 and, respectively, 1.93 g/cm^{3}in the case of Luvisols and 1.72 g/cm^3 and, respectively, 1.73 g/cm^{3}in the case of Chernozems.

Generally, PD values higher than 1.9 g/cm^3 correspond to strong compaction assessment by Stanga (1978, quoted by Canarache,1990). The similar results were obtained by Paltineanu et al. (2015).

The high correlation between GT and PD was found both in Luvisols (R^2=0.825) and in Chernozems (R^2=0.955) (fig. 5).

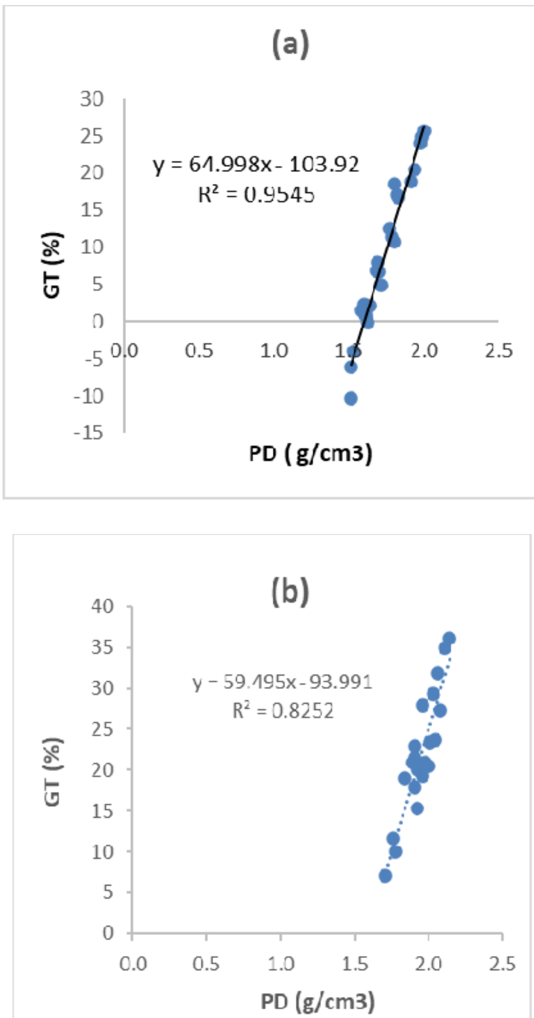


Fig. 5. The correlation between the Compaction Degree and Packing density (a - Chernozems, b – Luvisols).

The sturated hydraulic conductivity (Ksat, mm/h)represents the ''ability of soils totransmit water throughout the saturated zone, which is essential for relating water transport rates to hydraulic gradients'' (Gootman et al., 2020).

Ksatis influenced bythesoil texture, soil forming processes particle size, management practices, organic matter content (Reichert et al., 2009; Gootman et al., 2020.) and may vary over several orders of magnitude (Gootman et al., 2020).

The Ksat median value of Luvisols was very low (0.51 *mm/h*). So, most of the studied horizons of Luvisols had low - extremely low permeability (58%) and only 17 % of samples hade de high-very high permeability (fig.6).

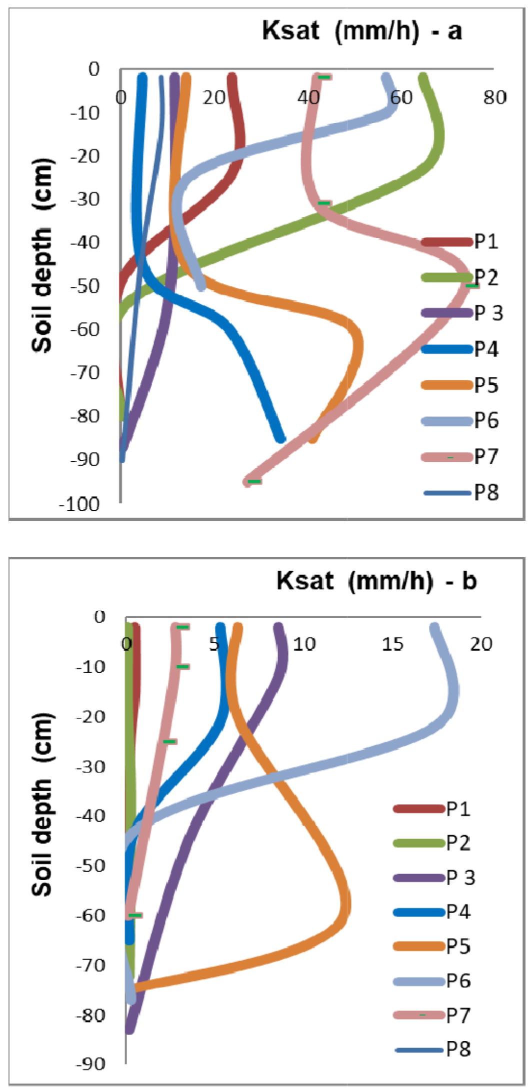


Fig. 6. The variation of Saturated Hydraulic Conductivity with depth (a - Chernozems, b - Luvisols).

Very high values of Ksat were found in ArenicLuvisols. The ChernozemsKsat median was high (14.1 *mm/h*).

Thus, most of the studied Chernozems horizons had high – very high permeability (58%), while 21% of samples had very low up to extremely high permeability.

With some exception, Ksat decreased from top soil to deeper horizons of the studied profiles.

The resistance to penetration (RP, kgf/cm^2) is influenced by a number of soil properties such as density, moisture content, water potential, texture, aggregation, cementation, organic matter content and mineralogy (Tavares et al., 2012).

RPof Luvisolsranging between 35 kgf/cm^2 and 45 kgf/cm^2 with an average of 42 kgf/cm^2, all the values being moderate. The only exception is for the ArenicLuvisolsto which values are extremely low (fig.7).

In the case of Chernozems, the RP valueswere moderate, with a few exceptions.

The structural instability index (SII)has been calculated as the ratio between dispersion and aggregates hydrostability(determined in laboratory) (Canarache, 1990). The SII is mainly influenced by the clay and calcium carbonate content, the quantity and quality of the organic matter, the soil acidity, soil alkalinity, ase well as the management technologies (Dumitru et al., 2011).

Half of the studied Chernozems had extremely high-very high values of IIS and the other half had moderate values (fig. 8).

The highest value (4.7) of IIS has been reached in the upper horizon of the HyposodicCalcaro-calcic Chernozems.

Moreover, high values of IIS were found in 60% of the investigated Luvisols. Low and very low values were recorded, only, in two sites.

Another index used to assess the soil risk to structural degradation is **Structural Stability Index (StI),** which is calculated according to the soil organic, silt and clay contents (Peri, 1992; Reynolds et al., 2009; Borek, 2019) (Eq. 1).

$$StI = \frac{1.724 * Corg}{(Silt + Clay)} * 100$$

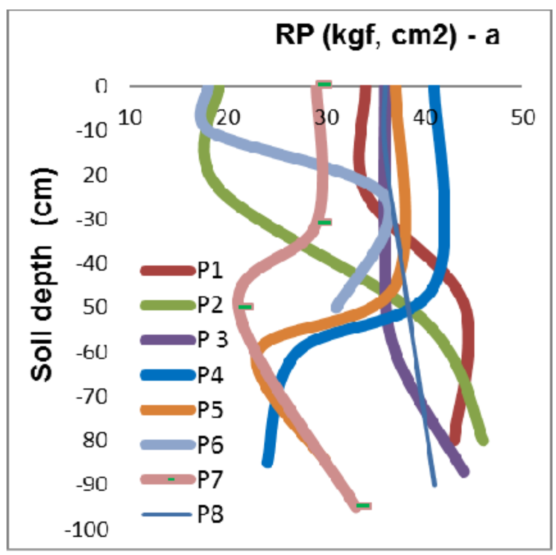
where:

StI – structural stability index;

Corg – the soil organic carbon content (%);

Silt – the soil silt content (%);

Clay – the soil clay content (%).



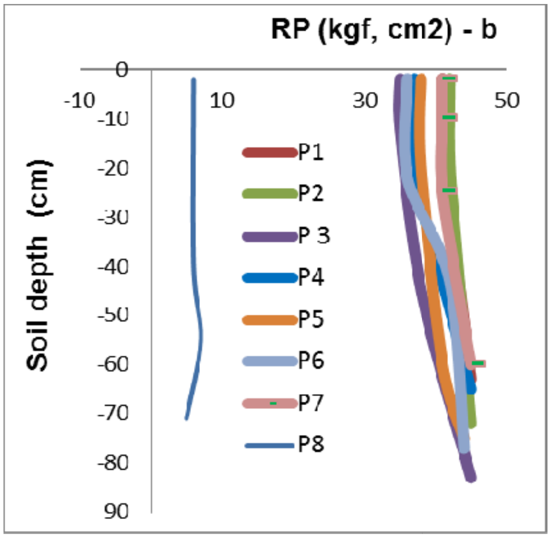


Fig. 7. The variation on soil profiles of Resistance to Penetration (a - Chernozems, b - Luvisols).

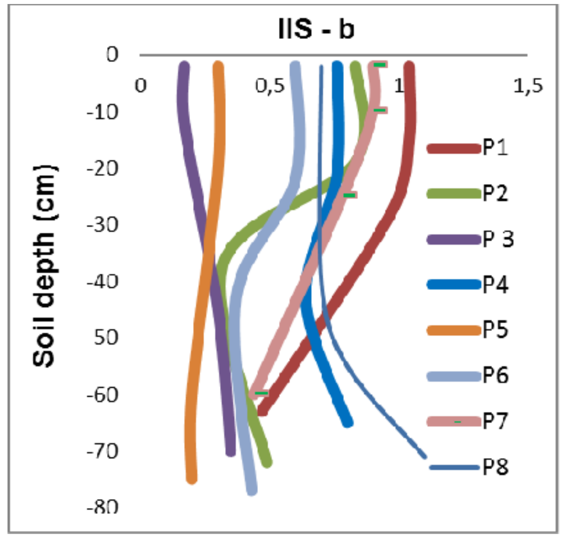
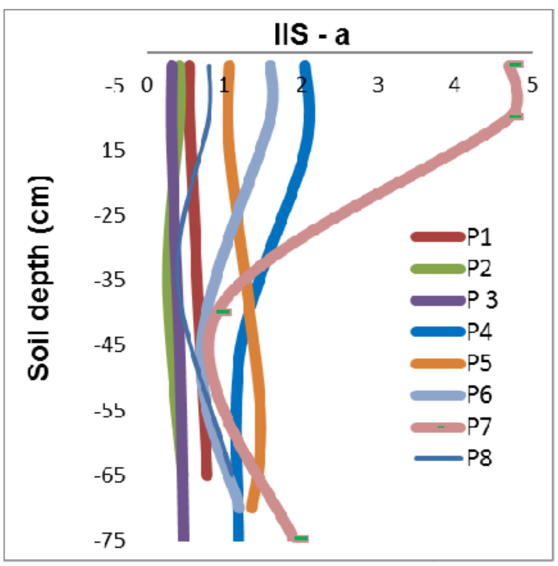


Fig. 8. The variation of Structural instability index on soil profiles (a - Chernozems, b - Luvisols).

This index is based on the humus and texture and is not relating to ''the porosity aspects of soil structure, but rather to the resilience of the structure'' (Reynolds et al., 2009).



According to the StI values, 67% of the analysed samples theLuvisols are structural degraded and 33% present a high risk to soil structural degradation.

Regarding the Chernozems, 36% were structural degraded, 36% presents a high risk to degradation, 24% a low risk and only one case showed no risk to degradation.

CONCLUSIONS

In the investigated soils due to the clayey-loam – clayey texture and high values of bulk density, the plant growth could be affected as a result of the root growth restrictions.

The studied Luvisols, according to DG values, are strongly compacted and require loosening works, with the exception of ArenicLuvisols (with loamy sandy -sandy loam texture), which are moderately compacted.

The Calcaro-calcic Cernozems and Haplic Cernozems with fine texture are, also, highly compacted and require loosening works.

The high values of PD (> 1.75 g/cm^3**)** were recorded in the case of Luvisols, except of

ArenicLuvisols with medium values. The Cernozems are medium-high compacted according to the PD values.

The high correlation between GT and PD was found both in Luvisols (R^2=0.825) and Chernozems (R^2=0.955).

Most of the studied horizons of Luvisolshad low-extremely low permeability (58%).

Half of the studied Chernozems had extremely high – very high values of IIS.High values of IIS were found in 60% of the investigated Luvisols.

The mean (5.6%) value of ChernozemsStI indicates a high risk of soil to degradation and the mean (3.8%) value of LuvisolsStI indicates a very high risk to soil degradation.

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