THE CHEMICAL QUALITY EVALUATION OF SOME SOILS (CHERNOZEMS and LUVISOLS) FROM DOLJ COUNTY

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Abstract

Agricultural lands represent 79% of the surface of Dolj county and about 84% are used as arable crops. Depending on the culture system chosen, the physical and chemical quality of the soil can be affected in different ways. The chemical quality of some soils from Dolj county (Chernozems, Luvisols) was evaluated using several indicators (soil reaction, organic matter content, total nitrogen, mobile phosphorus and mobile potassium). On the depth of 0-50 cm, in both soils, 75% of the mobile phosphorus values were very low-low, respectively extremely low-low. Most of the studied Luvisols were characterized by low values of the mobile potassium content (50% in the topsoil and 63% on the 0-50cm depth, respectively). High correlation between P_{AL} and K_{AL} content was found in case of Luvisols (R^2=0.908) and low in case of Chernozems (R^2=0.300). High correlation in case of Luvisols may be due to the applied fertilizers.

The values of the content of organic matter, total nitrogen, mobile phosphorus and mobile potassium were lower in the case of Luvisols compared to Chernozems and in most cases the values of the studied chemical indicators decrease with an increasing depth. According to the analyzed data, these soils have high potential for mineral ang organic fertiliser application.

***Key words**:* chemical quality evaluation, chernozems, luvisols

INTRODUCTION.

Agricultural lands represent 79% of the surface of Dolj county and about 84% are used as arable crops.

The largest areas, in 2022, were cultivated with cereals (wheat, corn, barley), oil plants (sunflower, rapeseed), annual green crops, legumes for grains (peas, beans), vegetables, melons (INSS, 2023).

According to Oliver et al., 2013, CEC, 2006, Slavich 2001, some agricultural practices contribute to increasing soil degradation (acidification, fertility loss, soil carbon decline, salinisation, erosion, compaction, soil structure decline).

''Food insecurity due to limited and degraded soil resources is a threat of the 21st century'' (Mueller et al., 2010).

Depending on the crop management chosen, the physical and chemical quality of the soil can be affected in different ways.

The soil quality was defined by Doran and Parking, 1994, as: ''the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health'' and by Gregorich and Action, 1995, as ''soil capacity to support crop growth without resulting in soil degradation or otherwise harming the environment''.

''Soil parameters which reflect soil quality and soil-based ecosystem services'' are described as ''Soil quality indicators" (Hoek et al, 2019).

The physical quality evaluation of the main soils (chernozems, luvisols*)* from Dolj county was made by Manea et al., 2022.

The soil chemical quality in relation with crop production is to provide nutrients (Heil and Sposito 1997).

The soil chemical properties are ''mostly used to measure soil fertility and health'' (Sainju and Lipzin, 2022).

For the evaluation of soil quality, the most studied chemical properties are: soil reaction, calcium-carbonate, cation exchange capacity, soil salinity, exchangeable sodium percentage, soil organic matter, total nitrogen, extractable form of phosphorus and potassium content (Janků et al., 2022, Sainju and Lipzin, 2022, Hoek et al, 2019, Takoutsing et al., 2016, Toth et al., 2016, Oliver et al, 2013, Toth et al., 2013, Arshad and Coen., 1992).

The objective of this paper is to assess the impact of agricultural practices on chemical quality of some Chernozems and Luvisols from Dolj county.

MATERIALS AND METHODS

Description of Study area

From the point of view of geographical location, within Romania, Dolj County has a south-southwest position, focused on the lower course of the Jiu River.

The relief of Dolj County is in the form of an amphitheatre, with altitudes that decrease from north to south, from 350 m to 30 m, towards the Danube meadow.

The geographical units in Dolj county are the Getic Piedmont (Platforma Strehaia and Platforma Olteţului) in the north, with aspect of large platform fragmented by the hydrografical network of Jiu river and its afluents, and the Romanian Plain (Câmpia Olteniei) in the south. The terraces and the Danube meadow are the lowest relief units, and are covered in patches by sand dunes. In the south of the county, there are the largest sandy areas in the country, and there are also puddles and lakes formed either by the overflows of the Danube or by the accumulation of precipitation.

According to the prevailing morphological features of the relief, Dolj can be considered a plain county, except for its northern part.

Surface lithology. The surface lithological cover of Dolj county does not present a great diversity, being predominantly composed of mobile and weakly consolidated rocks. Thus, gravels and poorly cemented sands, corresponding to the platform area, are present in the northern part. In the central part there are clays and loesslike deposits. In the meadow areas, corresponding to the Danube and the Jiu rivers, there are wind-reworked deposits (sands, loamy sands), fluvial and fluvial-lacustrine alluvium**.**

Climate. Dolj County is placed in the temperate climate zone, with Mediterranean influences due to its south-western position in the country; these influences determine an average annual temperature between 10-11.7°C and annual precipitation of 523-574 mm; the average annual evapotranspiration is between 667 and 707 mm, and the annual water deficit is 107-184 mm.

Soil samples

The land use was arable, except for one site with orchard use. The field descriptions of soil profiles were made according to Munteanu and Florea, 2009 and Raducu, 2019. The soil classification was made according WRB 2014 and SRTS 2012.

The main identified soils were Cernozems, with different subtypes: calcic, hyposodic calcaro-calcic and haplic, and Luvisols haplic, mollic, chromic, arenic, vertic, stagnic (Manea et al., 2022).

From each pedogenetic horizon were collected soil in disturbed samples for particle size distribution, soil reaction, calcium-carbonate, cation exchange total capacity, soil organic matter, total nitrogen, mobile form of phosphorus and potassium contents.

Laboratory analysis

The pH was determined by potentiometry in aqueous suspension, soil: water ratio 1:2.5 using a combined glass-calomel electrode (pH units).

Calcium carbonate ($CaCO_3$) was determined by the Scheibler method; and it is expressed in %.

The degree of saturation in bases ($V_{pH8.3, \%}$) was obtained by calculation, in acidic soils, as a percentage ratio between the content of basic cations sum (BS, me/·100g soil) and the total cation exchange capacity ($T_{pH8.3}$ = BS+ $SH_{pH8.3}$).

Basic cations sum (BS) was obtained by extraction with 0.05 n HCl, Kappen method (me/100 g soil).

Total exchange acidity (SH) based on the percolation until exhaustion with a solution of Potassium acetate solution 1 N.

Organic carbon content (Corg, %) was measured by wet combustion procedure (Walkley-Black method modified by Gogoaşă).

The humus content was calculated by multiplying the organic carbon content by 1.724; is expressed in %.

Total nitrogen (N) was determined by the Kjeldahl method, disaggregation with H_2S0_4 at 350°C, potassium sulphate and copper sulfate catalyst; is expressed in %.

Accessible (mobile) phosphorus was determined by the Egner-Riehm-Domingo method and colorimetrically dosed with molybdenum blue, according to the Murphy-Riley method (reduction with ascorbic acid).

The content of soil phosphorus (P_{AL}) has been corrected according to soil reaction (Florea et al., 1987- Partea I).

Accessible (mobile) potassium was determined by extraction according to the Egner-Riehm-Domingo method and dosage by flame photometry.

The interpretation classes of studied properties are presented in MESP, 1987 Partea a III-a (Florea et al., 1987).

The statistical analysis (minimum values, maximum values, arithmetic mean, median, standard deviation, coefficient of variation) was performed using Microsoft Excel 2010 for topsoil and the average content on 0-50 cm.

RESULTS AND DISCUSSIONS

The main soil chemical properties (soil reaction, calcium-carbonate, cation exchange total capacity, soil organic matter, total nitrogen, mobile form of phosphorus and potassium contents) were studied on soil pedogenetic horizons.

Soil reaction (pH in water), is generally determined by natural conditions (vegetation, parent material, climate conditions, drainage) and fertilizers (Toth et al., 2016, Arshad and Coen., 1992).

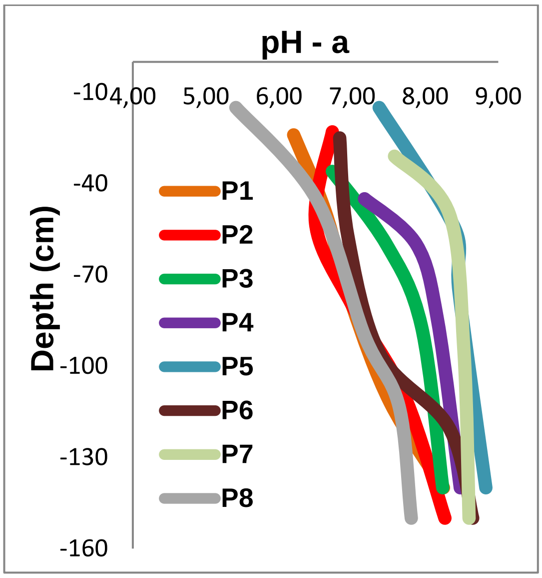
Soil reaction of studied Chernozems, in topsoil, was in the range of moderate acid-moderate alkaline and neutral-moderate alkaline at depths greater than 50 cm (fig. 1a).

Luvisols in topsoil present soil reaction in the range of moderate acid to neutral and moderate-low acid on the soil profile, with one exception (fig. 1b). Generally, the soil reaction increased with depth.

Moderate and low soil acidity reaction of the topsoil is most likely due to the application of nitrogen fertilizers.

The calcium carbonate ($CaCO_3$,%) content

In the cropland from European countries, the calcium carbonate ($CaCO_3$) content shows a strong climate dependence, (Toth et al. 2013). ''The higher temperatures and drier conditions that appear with lower latitudes show a slight increase of areas with more carbonaceous soils'' (Toth et al. 2016).



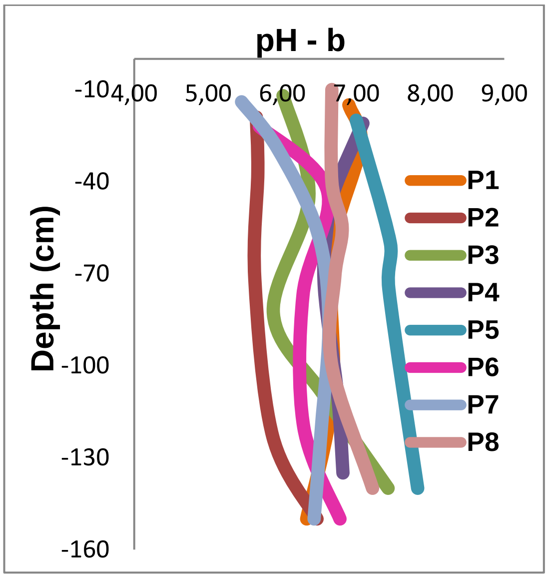


Fig.1. The variation on soil profiles of pH (a - Chernozems, b - Luvisols)

In case of Chernozems, the total $CaCO_3$ content values vary on the soil profile between 2.10% and 17.5% and the depth of occurrence of carbonates varied between 31 cm and 112 cm.

The soil percentage base saturation is related with soil reaction and the saturation type of soil in cations (Ca, Mg, Na, K). In the topsoil, the Chernozems, with an exception, have values ranked in the eubasic - saturated with bases and the same variation was recorded on the subsoil (-50 cm depth).

The soil percentage base saturation values of Luvisols were in the field of mesobasic – eubasic in top soils, on the 0-50 depth, most of the values of this indicator were eubasic.

Humus content (H,%).

In agricultural soils, specially, organic matter content performs a range of functions in soils that is why is considered key indicator of soil quality (Nortcliff, 2002, Oliver et al., 2013).

Soil organic matter content can vary widely within and between soil types due to many factors: soil mineral composition, vegetation cover, climate, topography, soil management (Baldock and Skjemstad 2001, Arshad and Coen., 1992).

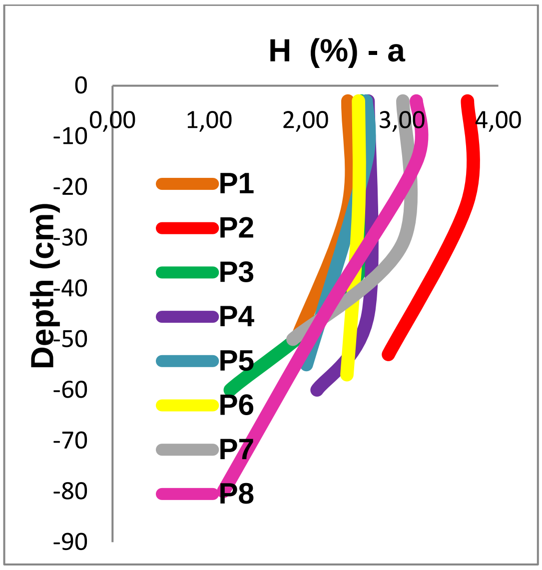
The interpretation of the data regarding the content of soil organic matter (humus) has been made in correlation with the textural classes of the soil.

In investigates Chernozems (fig. 2a, humus contents are low both in topsoil (2,41%-3,37%) and at the depth of 0-50 cm (2,10%-3,30 %) (tab.1).

The humus content values of Luvisols (fig. 2b), in topsoil, varies from very low to moderate values (0.52%-3.4%) and, in the 0-50 cm layer, from extremely low to low values (0.41%-2.91%) (tab. 2).

Table 1. The basic statistics of the chemical attributes of Chernozems

	H %		Nt %		Pm mg/g		Km, mg/kg	
	top soil	0-50 cm	top soil	0-50 cm	top soil	0-50 cm	top soil	0-50 cm
Minimum	2.41	2.10	0.144	0.119	7.9	7.8	114	112
Maximum	3.37	3.30	0.205	0.177	32.7	40.7	390	258
Median	3.06	2.44	0.169	0.149	18.8	17.1	189	162
Mean	2.98	2.48	0.174	0.152	19.2	18.7	199	169.6
Standard deviation	0.33	0.38	0.020	0.020	7.6	9.5	88.4	54.6
Coef. Variation, %	11	15.4	11.7	12.9	40	51	44.3	32.2



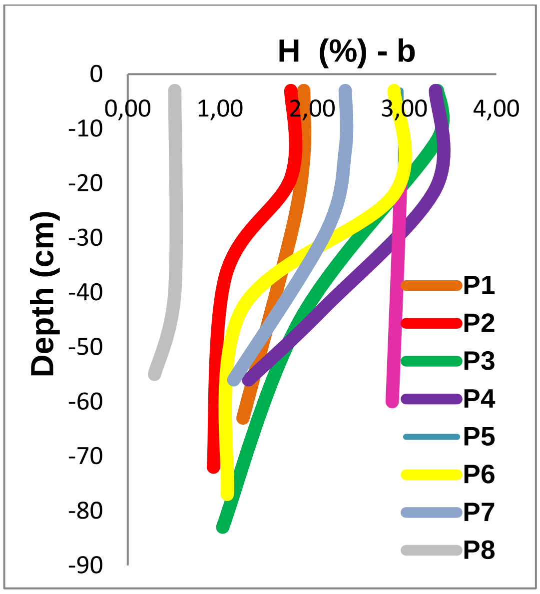


Fig. 2. The variation on soil profiles of Humus (a - Chernozems, b - Luvisols)

At the country level, in topsoil, were determined humus average contents of 3% for Chernozems and 2,57% for Luvisols (Dumitru și colab., 2011).

In the studied soils, the average values of humus content, in topsoil, were similar (2,98%) to those obtained, at the country level, by the Dumitru et al., 2011, for Chernozems and slightly lower (2,31%) for Luvisols.

The humus content values in the 0-50 cm layer are lower than those determined in topsoil for both type of soils. The values of humus content were smaller in case of Luvisols compare with Chernozems.

Total nitrogen content (Nt, %).

In plant nutrition, nitrogen is considerate the most important element. The soil total nitrogen content is an''important measure for agricultural and environmental applications'' (Toth et al. 2013).

In Romania, according to Lixandru et al., 1990, the frequent values of Nitrogen vary between 0.1 and 0.3%. In the agricultural soils of the monitoring sites, the highest proportions of total nitrogen content are in the low and medium classes (Dumitru et al., 2011).

Chernozems (fig. 3a) are characterized by moderate values of total nitrogen content in topsoil (0,144-0,205%) and low-moderate values (0,119-0,177) on the 0-50 cm depth. The Luvisols (fig. 3b) present low-moderate values (0,113%-0,193) and, respectively, very low-moderate values (0,065%-0,260%).

''The nitrogen quantity in soil is generally low, mostly being fixing in soil organic matter (95%)'' (Dumitru et al.,2011). In the studied soil, high correlation between Humus content and nitrogen content was found both Chernozems (R^2=0.892) and Luvisols (R^2=0.723).

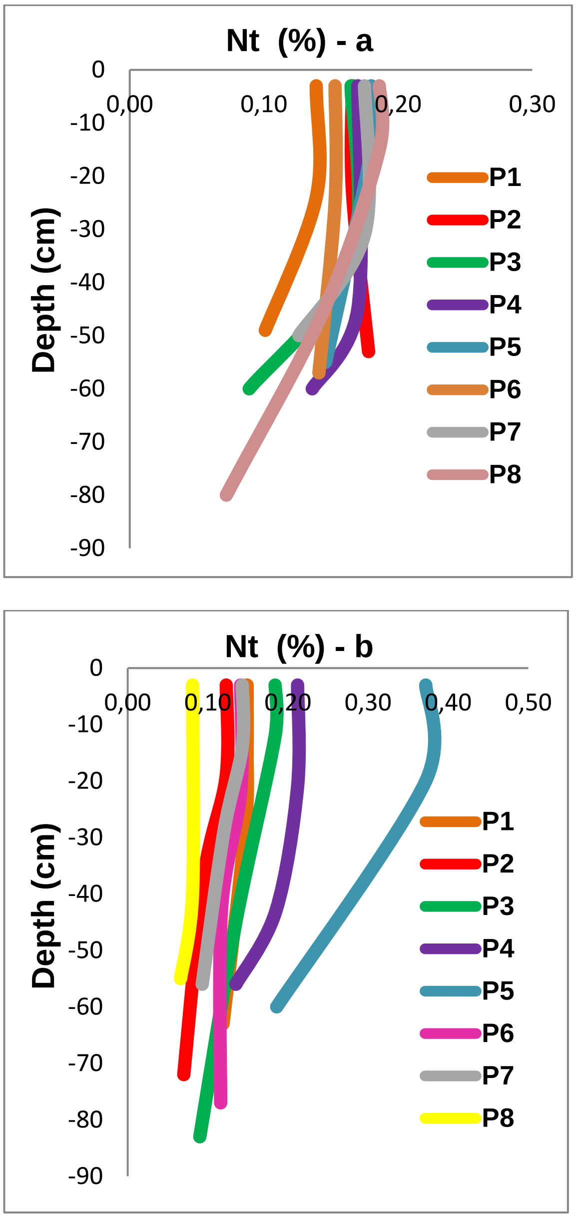


Fig. 3. The variation on soil profiles of N (a - Chernozems, b - Luvisols)

The mobile Phosphorus (P_{AL}, mg/kg)

A small fraction of soil P is available to plants (Bai et al., 2013) due to, in calcareous soil, Phosphorus (P) is firmly fixed? in soils, because of P precipitation with calcium ions, and in acid soil due to P adsorption of by Fe- and Al- oxides (Hinsinger 2001). Generally, in the humic horizon, the soil phosphorus is bound in organic compounds (it can exceed 50% of the soil total phosphorus) (Chiriţă, 1974).

The Chernozems Pm contents (Pm, mg/kg) lay between low (18 mg/kg) to moderate values (32.7 mg/kg) in topsoil and from very low (7.8 mg/kg) to high values (40.7 mg/kg) on the 0-50 cm depth (fig. 4a). The median values were 18.8 mg/kg and, respectively, 17.1 mg/kg.

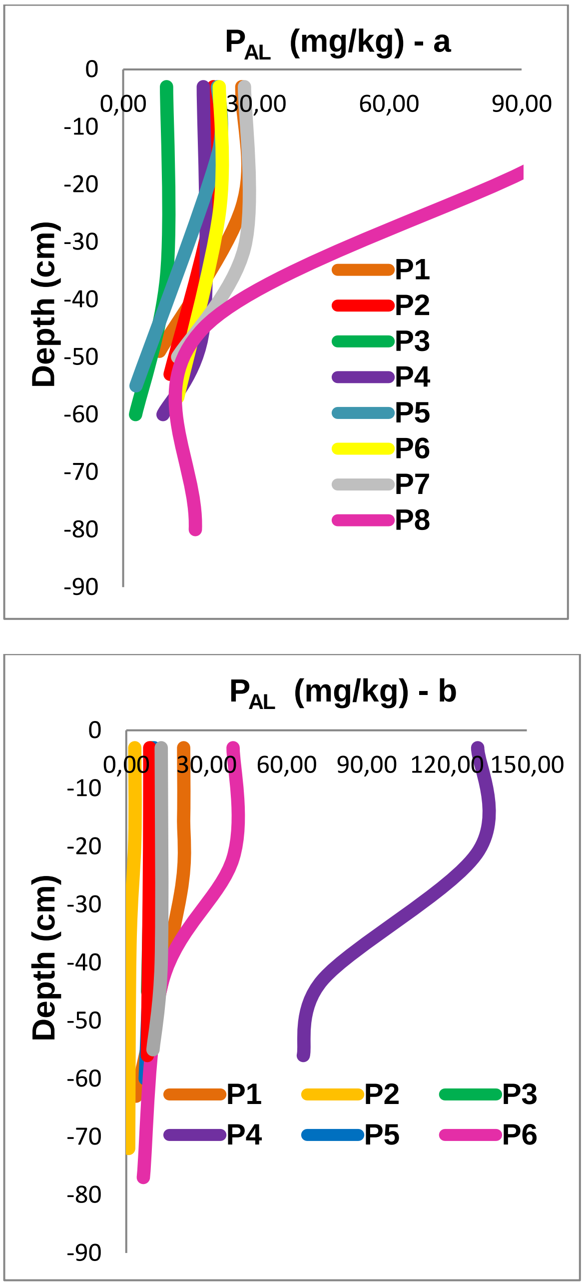


Fig. 4. The variation on soil profiles of P_{AL} (a - Chernozems, b - Luvisols)

Table 2. The basic statistics of the chemical attributes of Luvosols

	H %		Nt %		Pm mg/g		Km, mg/kg	
	top soil	0-50 cm	top soil	0-50 cm	top soil	0-50 cm	top soil	0-50 cm
Minimum	0.52	0.41	0.113	0.065	2.70	1.95	94	75
Maximum	3.40	2.91	0.193	0.260	91.7	97	496	438
Median	2.36	1.87	0.154	0.131	17.9	9.5	125	115
Mean	2.31	1.83	0.155	0.142	25.7	21.4	178.5	161.1
Standard deviation	1.01	0.77	0.030	0.060	28.3	31.2	137.9	119.1
Coef. Variation, %	43.7	41.97	19.3	42.2	110	145.5	77.1	73.9

The Pm content of Luvosols (P_{AL}, mg/kg), in the both studied depth (fig. 4b), ranged from extremely low (2.7 mg/kg and, respectively, 2.0 mg/kg) to very high (91.7 and, respectively, 97 mg/kg). The median values were 17.9 mg/kg and, respectively, 9.5 mg/kg. On the 0-50 cm depth, in the both studied soils, 75% of the mobile phosphorus values (Pm, %) were very low-low and, respectively, extremely low-low.

In the south part of the country, in arable soils, total phosphorus content decreases from Kastanozeoms and Chernozems to Luvisols (Davidescu et al., 1974). Manea et al., 2016, found P_{AL} average value of 17 mg/kg in soils from the South-West Oltenia region. At the country level, low values of the phosphorus P content were found by Dumitru et al., 2011 and Toth et al. 2016. Romanian croplands show the ''lowest P values among all EU Member'' (Toth et al. 2016).

The phosphorus content in topsoils is one of the most relevant indicators of the intensity of fertiliser application (Toth et al. 2013).

''Conversely, these results highlight the potentials of agricultural land for further intensification with respect to environmental capacities on these lands''. (Toth et al. 2016).

High correlation between P_{AL} and K_{AL} content was found in case of Luvisols (R^2=0.908) and low in case of Chernozems (R^2=0.300). High correlation in case of Luvisols may be due to the applied fertilizers.

The mobile Potassium (K_{AL}, mg/kg)

The first research on the total potassium content of Romanian soils was done by Popovici Lupa 1889, quoted by Davidescu and Davidescu, 1979, on some soils from Dolj county.

In soils, potassium is found in quantities of 0.2-3% and over 98% of the soil total potassium is in the unchangeable form (Chiriţă, 1974).

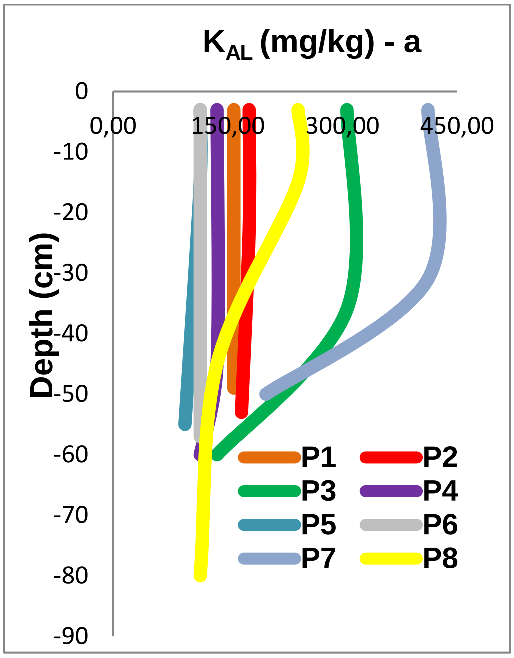
''The potassium part in soil which becomes available for plants is determined by different soil characteristics, such as content of clay and its mineralogical nature, soil reaction, organic matter content, soil moisture regime'' (Dumitru et al., 2011).

In the studied area, generally, the values of mobile Potassium contents are moderate-high in case of Chernozems (fig 5a).

Most of the studied Luvisols (fig 5b) were characterized by the low values of mobile Potassium content (50% in topsoil and, respectively, 63% on the 0-50 depth.).

CONCLUSIONS

High correlation between the Humus content and the nitrogen content was found both in Chernozems (R^2=0.892) and in Luvisols (R^2=0.723).



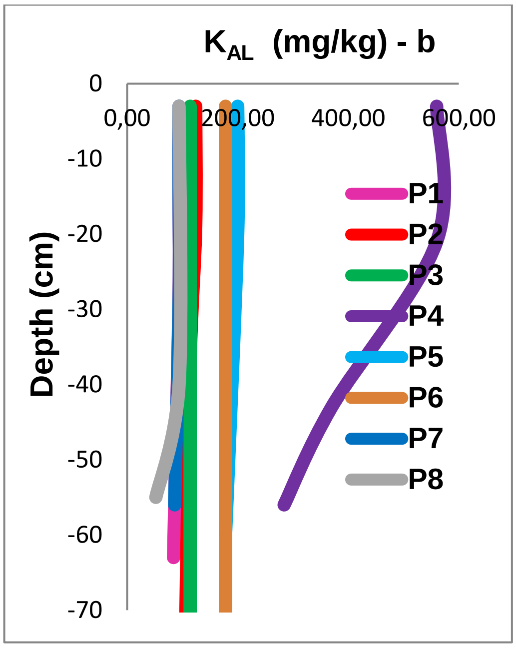


Fig. 5. The variation on soil profiles of K_{AL} (a - Chernozems, b - Luvisols)

On the depth of 0-50 cm, in both soils, 75% of the mobile phosphorus values were very low-low, respectively extremely low-low.

Most of the studied Luvisols were characterized by low values of the mobile potassium content (50% in the soil surface and 63% on the 0-50cm depth, respectively).

The values of the content of organic matter, total nitrogen, mobile phosphorus and mobile potassium were lower in the case of Luvisols compared to Chernozems.

In most cases, the values of the content of organic matter, total nitrogen, mobile phosphorus and mobile potassium decrease with an increasing depth.

According to the analyzed data, these soils have high potential for mineral ang organic fertiliser application so it is necessary to pay special attention to the applied fertilization plans.

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