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GENETIC PECULIARITIES OF THE NATURAL AND AGRICULTURAL GREY SOILS FROM THE REPUBLIC OF MOLDOVA FOREST-STEPPE

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Abstract

Some genetic peculiarities of natural and arable Grey Forest Soils (Greyzem) are presented in order to improve their classification. The textural differentiation of the typical (natural) grey forest soil profile from the northwest of the Northern Moldavian Plateau occurred under the action of three pedogenesis processes: in situ alteration of the soil material; leaching of the alteration colloidal material; migration on the profile of water-soluble organic-mineral compounds of Fe and Al in the podzolic process. The weakly textural differentiation of the arable grey soils profile is due to the partial inclusion of the illuvial horizon in the arable layer with a thickness of about 35 cm, the intensification of the in situ alteration process in the arable layer of these soils due to the change of reaction and hydrothermal regime as result of agriculture use. The textural differentiation of the grey forest soils profile in complex with other indicators is an important diagnostic index for improve the classification status of grey forest soils from forest-steppe of the Republic of Moldova.

Key words*: Grey Forest Soils, classification, texture differentiation, colloidal material, in situ alteration.*

INTRODUCTION

The development of soil science (pedology) at international and national level, the progress of soil knowledge in recent times, determines the need to re-examine and clarify the principles and criteria of soil classification (both higher and lower level), focusing on their concrete properties and appreciation of the factors and processes of pedogenesis that led to the formation or modification of some features.

At present, national soil classifications bear considerable influence from the soil classification system in the Legend of the World Soil Map (FAO-UNESCO, 1990) and the World Reference Base for Soil Resources (WRB, 2006, 2014). The radical change of the concept of classification, of the nomenclature and the scientific notions regarding the soils, sometimes makes impossible the use of the materials of the previous pedological researches. For these reasons, the transition to a completely new classification of Moldovan soils is not rational. Therefore, in order to improve the soil classification system, the collection, systematization, analysis and evaluation of archive and current materials were used. At the same time, field research was carried out by placing soil profiles and collecting soil samples in order to materialize some genetic features.

In the elaborating the improved grey soils classification, it is necessary that for some soil taxonomic units of the national classification, to find adequate names for the soil nomenclature of Moldova from the Romanian soil taxonomy system (Vlad et al., 2014), as well as the use of standards and diagnostic elements of these classification systems. Although elements and standards from other soil taxonomy systems will be introduced in the improved soil classification system, the main traditional elements of the pedology of the Republic of Moldova, based on the Russian naturalistic soil classification system (Иванов, 1956; Крупеников, 1973; Егоров, 1977; Ursu, 2001, 2006; Cerbari, 2001).

The partial agreement of the soil classification system in the Republic of Moldova with the classification system in the Legend of the “Soil Map of the World” (1990) and the “World Reference Base for Soil Resources” (2006, 2014) will contribute to the dissemination of information on soil variety of the Republic of Moldova internationally; partial unification of the soil taxonomic units system and diagnostic characters used; correlation of the soil map of the Republic of Moldova with the soil map of Romania and Russia, other countries, as well as with the Soil map of the World

The particularities of the genesis, classification and geographical spread of the Grey soils, formed under the forest vegetation are reflected in a series of researches (Крупеников & Скрябина, 1976; Урсу & Крупеников, 1984, Ursu, 2011; Cerbari et al., 2011, 2017; Cerbari, 2010; Leah, 2020). According to the mentioned authors, the genesis of forest soils of Moldova has common characteristics with forest soils in the Eurasian Steppe, Central and Eastern Europe, Romania and Bulgaria.

Thus, it was established that in Central Moldova the most widespread are the typical Grey soils. The illuvial horizons of these soils are formed as a result of the combination of the podzolic process and the alteration material of this *"in situ"* horizon (Reabinina, 1968; Хотинский, 1986). Then, the classification of the soils from "Codri" was improved at the level of genus, species and variety of soil, the agronomic grouping of the soils was performed, the suitability of Grey soils for different use was assessed. Of particular interest is the description of the stagno-gleic phenomena located in the lower part of the profiles of some grey forest soils (Balteanschi, 1979).

The research on the genetic peculiarities continued with the observations made in stationary with lysimeters on the Grey soils of the forest and on the arable lands (Ivancea commune, Orhei district). These researches coincided with a comparatively humid climatic period 1960-1964 that was established on the territory of Moldova, which led to the intensification of the processes of argillisation, leaching and lessivage (Адаменко, 1996; Grati, 1975, 1977).

Thus, the Grey forest soils of Central Moldova differ from most forest soils in the forest-steppe area of Northern Moldova, Ukraine and Russia by the lack or very weak development of the podzolic process and its replacement with the process of comparatively low intensity lessivage and the process of *"in situ"* alteration of the underlying horizons (Ахтырцев & Щетинина, 1969; Полупан, 1986; Лунгу, 2008; Лях, 2017; Cerbari et al., 2017).

Currently, for practical purposes is used "Soil Classification of the Republic of Moldova", developed by Ursu (2001). In this classification the Grey soils are divided into four subtypes: albic, typical, molic and vertic.

The research aim was to evaluate the changes in the properties of Grey soils as a result of arable use and changes in the pedogenesis phases; improving the classification of Grey soils and highlighting soil taxonomic units.

MATERIALS AND METHODS

Classical research methods (Аринушкина, 1970; Агрохимические..., 1975) to perform the studies and criteria for evaluating soil properties (Florea et al., 1987; Jigău et al., 2007) were used. The Grey soils (virgin and arable) from the north-western part of the Northern Moldavian Plateau served as research objects. In order to fulfil the proposed aims, the soil profiles were placed in the virgin forest and on the arable land.

Grey soil typical (natural or virgin), located in the oak forest in the western part of Briceni city, on a horizontal surface of the plateau. Absolute altitude - 258 m. Latitude - 48.35466. Longitude - 26.99946. The parental rocks are presented by strongly altered loess deposits. The surface coverage with grasses and shrubs is 20-30%. The Grey forest soil is characterized by the type of profile: AEhț 0-8 cm →AEh 8-29 cm →EBhtw 29-47 cm →Btw 47-68 cm →BCtw1 68-96 cm →BCtw2 96-110 cm →Ck 110-130 cm (Figure 1).

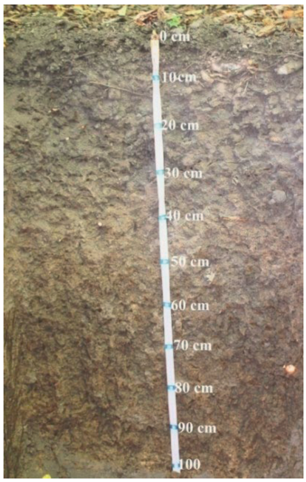

Figure 1. Profile of Grey soil (Greyzem) typical, clayey-loamy, forest

Grey soil cernic, arable, located on the horizontal surface of the “Movila Mare” height, opposite of Larga village, Briceni district. Absolute altitude - 248 m. Latitude - 48.38200. Longitude - 26.85202. Arable Grey soil is characterized by a profile of the type: Ahp1 0-12 cm →Ahp2 12-30 cm →Bh1 30-45 cm →Bh2 45-65 cm →BC1 65-90 cm →BC2 90-110 cm →Ck > 110 cm (Figure 2).

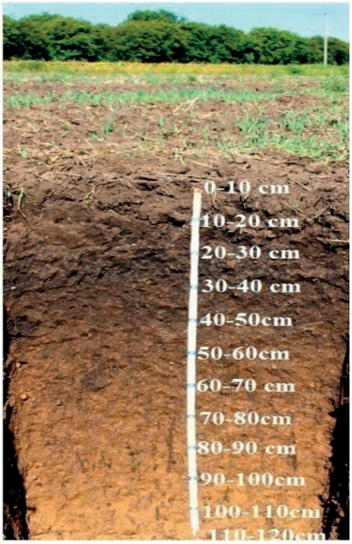

Figure 2. Profile of Grey soil (Greyzem) cernic, clayey-loamy, arable

The profile of arable Grey soil, compared to the profile of natural grey soil, is not differentiated textural (Figures 1 and 2). This is the result of the periodic restoration on this soils of the secondary steppe vegetation and its use in arable land during the Cucuteni-Tripole culture, 2000-4000 years until our era (Florea, 2005; Xenopol, 2006). This soil has a polygenetic origin, that is, it was formed as a result of deforestation of the virgin forest long ago and use of land for agriculture. According to historical sources (Докучаев, 1950; Гроссет, 1961; Александровский, 2006) during the migration of peoples from East to West, the land used for agricultural purposes was abandoned. Thus, on these soils, the natural vegetation was restored and the pedogenesis process was modified, towards the chernozems formation. As result of local climate Greyzems were formed.

RESULTS AND DISCUSSIONS

The characteristic of Grey soil properties was made based on the results obtained for the Grey soil profiles (forest and arable) in the north-western part of the Northern Moldavian Plateau. This territory is characterized by absolute heights within the limits of 242-284 m and a wetter climate than in the other administrative districts located on this plateau.

Texture is the main physical property of the soil with a particularly important role in determining most of the other physical properties, as well as many chemical properties (Canarache, 1990). In wetter areas (e.g. forests), where during the soil genesis there are intensification processes of argillisation and clay migration, soil profiles are formed with deep textural differentiations (Лунгу, 2007, 2008). In general, profiles with textural differentiation are presented by the soils with horizons of clay formation and accumulation (Btw, BCtw etc.).

Grey soil typical in the north-west is characterized by clearly differentiated texture, by the eluvial-illuvial process and pedogenesis on the depth of the profile (Figure 1, Table 1).

For quantitative expression of the textural differentiation between horizons, the *textural differentiation index* (*Idt*) is used which represents the value of the ratio between the percentage of clay in horizon B and the percentage of clay in horizon A. The index of textural differentiation, compared to the eluvial horizon, reaches values 1.7-1.9. Soils with such *Idt* values are appreciated as moderately differentiated texture of soils (Figure 3).

The textural differentiation of the typical grey soil profile occurred under the common action of the following processes (as mentioned above in the text): “*in situ*” alteration of the soil material of the eluvial horizon; leaching the alteration colloidal material; podzolic process - migration of soluble organo-mineral Fe and Al compounds in the profile (Зонн, 1976).

However, in the opinion of the authors, in this concrete case the main role in the textural differentiation of the researched typical Grey soil profile belongs to the podzolic process. Indirectly, this is confirmed by the value of pH_{KCl} = 4.1-4.3 of the eluvial - illuvial horizons in the depth of 27-96 cm (strong and moderate

acidity). At the same time, the values of hydrolytic acidity at 27-96 cm are medium and vary within the limits of 4.1-5.9 me (Table 2). In the researched profile, the soil color of the eluvial horizons is grey, and of the illuvial horizons - dark brown (Figure 2).
According to the data the thickness of the humiferous profile is 47 cm. According to the humus content, the genetic horizons of the researched soil can be assessed as follows: AEhț (0-8 cm) - high content; EAh (8-27 cm) - submoderate content; EBhtw (27-47 cm) - small content. The other underlying horizons are characterized by a humus content of less than 1.00% (Figure 4).

Table 1. Texture of Greyzems from the north-western part of the Northern Moldavian Plateau

Horizon and depth, cm	Dimensions of fractions (mm); content (%)						
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Grey soil (Greyzem) typical, submoderate humiferous with semi-deep humiferous profile, clayey-loamy 0-47 cm, loamy-clayey >47 cm							
AEhț 0-8	0.4	14.1	39.1	8.9	16.9	20.6	46.4
EAh 8-27	0.2	11.2	40.5	9.8	16.8	21.5	48.1
EBhtw 27-47	0.2	8.4	40.7	6.3	15.7	28.7	50.7
Btw 47-68	0.1	6.4	30.5	8.2	18.5	36.3	63.0
BCtw 68-96	0.1	8.4	29.9	9.7	14.2	37.7	61.6
BCtw 96-110	0.1	9.7	28.6	9.5	12.4	39.7	61.6
Cwk 110-130	0.3	9.1	28.2	9.7	15.1	37.6	6..4
Grey soil (Greyzem) cernic, submoderate humiferous with semi-deep humiferous profile, clayey-loamy							
Ahp 1 0-12	0	19.2	26.0	5.2	15.7	33.9	54.8
Ahp2 12-30	0	20.8	24.7	5.3	15.6	33.6	54.5
Bh1 30-45	0	14.4	30.8	9.1	14.9	35.4	54.8
Bh2 45-65	0	11.4	31.0	8.1	13.3	36.2	57.6
BC1 65-90	0	10.8	31.6	7.8	13.2	36.6	57.6
BC2 90-110	0	10.5	32.4	7.6	12.1	37.4	57.1
Ck 110-130	0	11.3	30.9	7.6	12.9	37.3	57.8

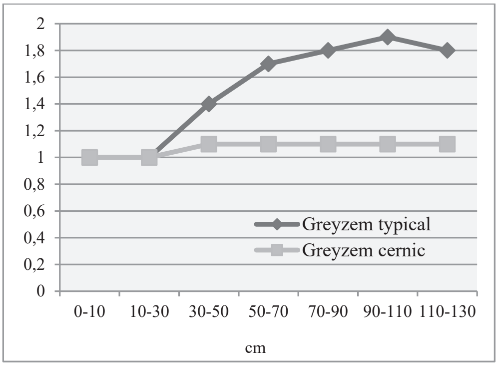

Figure 3. Index of textural differentiation (Idt) values of the Greyzems

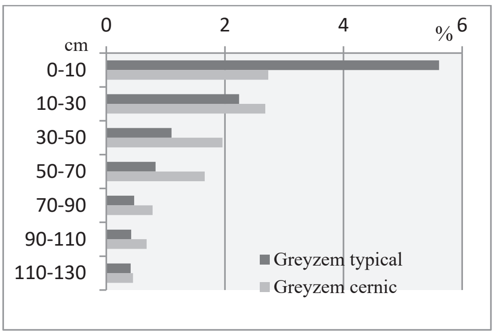

Figure 4. Humus content in the Greyzems

The carbonates content on the profile of the researched soil are leached deeper than 110 cm. The sum of exchangeable cations is medium in the depth 0-68 cm and large in depth > 68 cm. The value of the ratio Ca:Mg is equal to 3.4-3.7 for the eluvial horizons; 5.1 - for the Btw illuvial horizon; 2.5 - for the illuvial horizon. In the Ctw and Ck horizons the exchangeable Mg^{2+} content is higher than the exchangeable Ca^{2+} content. A possible magnesium slitization of this horizon is not excluded (Table 2).
The hygroscopicity coefficient and the plant wilting coefficient for the typical Grey soil are characterized by moderate values. According to its properties and natural conditions, the natural grey soil can be appreciated as typical.
Grey soil cernic on the arable is characterized by homogeneous clayey-loamy texture on the depth (Table 1). This texture is favorable for growing field crops. Soils with medium-fine texture have a high fertility, if their arable layer is structured and loose. The tillage of the clayey-loamy soils is necessary to be carried out at the humidity corresponding to its friable state - the state of humidity at which the soil crumbles easily (Cerbari et al., 2017). The arable clayey-loamy Grey soils are comparatively resistant to drought as a result of

the high capacity to accumulate water in the cold period of the year. However, the water regime of compacted arable clayey-loamy soils is partially unfavorable. Therefore, the preventive restoration of the physical quality state of destructured and compacted arable layer is absolutely necessary to be carried out until the implementation of conservative agriculture system (Cerbari & Leah, 2010).

Table 2. Physical and chemical properties of grey soils (greyzems) of the North Moldovan plateau

Horizon and depth, cm	*HW, %	*HC, %	Density, g/cm^3	$CaCO_3$, %	*pH_{H2O}	*pH_{kcl}	*HA,	Ca^{2+}	Mg^{2+}	∑Ca+Mg
							me/100 g soil			
Grey soil (Greyzem) typical, submoderate humiferous with semi-deep humiferous profile, clayey-loamy 0-47 cm, loamy-clayey >47 cm										
AEhț 0-8	2.9	8.5	2.54	0	5.9	5.6	5.7	17.6	5.2	22.8
EAh 8-27	2.4	8.2	2.63	0	5.6	5.0	5.9	12.4	4.4	16.8
EBhtw 27-47	2.5	7.4	2.65	0	5.6	4.3	5.0	13.2	3.6	16.8
Btw 47-68	3.6	9.4	2.68	0	5.8	4.1	4.8	16.4	3.2	21.6
BCtw 68-96	4.0	9.7	2.68	0	5.9	4.3	4.1	18.0	7.2	25.6
BCtw 96-110	4.0	10.7	2.70	0	7.0	6.0	1.1	12.8	15.2	28.0
Cwk 110-130	3.8	10.5	2.69	5.9	7.0	-	-	12.8	17.2	28.0
Grey soil (Greyzem) cernic, submoderate humiferous with semi-deep humiferous profile, clayey-loamy										
Ahp 1 0-12	3.1	8.6	2.56	0	6.5	5.8	5.5	20.4	3.2	23.6
Ahp2 12-30	3.3	8.7	2.63	0	6.4	5.6	4.8	20.2	3.0	23.2
Bh1 30-45	3.3	9.4	2.62	0	6.4	5.6	3.2	18.8	3.6	21.6
Bh2 45-65	3.5	9.9	2.64	0	6.2	5.6	3.1	18.0	4.8	22.8
BC1 65-90	3.7	10.2	2.65	0	6.5	5.5	1.9	18.4	4.4	22.8
BC2 90-110	3.6	9.9	2.67	0	6.7	5.7	1.4	18.6	4.4	24.0
Ck 110-130	3.0	8.9	2.68	12.0	7.8	-	-	18.8	4.0	22.0

According to the data (Table 2), the arable Grey soil is submoderately humiferous with semi-deep humiferous profile and requires application of organic fertilizers. The pH value of the arable Grey soil is characterized by a weakly acid reaction, homogeneous on the profile. The pH values vary in the range of 6.5-6.7. The values of hydrolytic acidity vary on the arable soil profile in the limits of 5.5-5.8 me and can be appreciated as moderate. The sum of exchangeable cations varies in soil depth within 22-24 me. The Ca:Mg ratio is favorable.

The researched arable soil is an automorphic soil provided with moisture and under normal fertilization conditions will permanently ensure high yields of agricultural crops.

The anthropogenic transformation of the soils represents a major change as a consequence of the human intervention on the environmental conditions through the land improvement works and implicitly on the pedogenesis process, of some mechanical interventions that strongly change the soil profile, of the improper use of the soils leading to degradation processes.

CONCLUSIONS

Grey Forest soils (Greyzems) typical are predominantly widespread in the forests of the Northern Moldovan Plateau and were formed in conditions of moderately warm semi-humid to humid temperate climate and low-contrast soil hydrothermal regime. The pronounced textural differentiation of the typical Greyzem profile of the Northern Moldavian Plateau occurred under the action of pedogenesis processes: *"in situ"* alteration; leaching of the colloidal material of the alteration; podzolic process of soluble organo-mineral Fe and Al compounds migration. They are characterized by a semi-deep humiferous profile and are submoderate humiferous.

The weakly textural differentiation of the arable Grey soils profile is due to: the partial inclusion of the illuvial horizon in the arable layer with a thickness of about 35 cm; intensification of the alteration *"in situ"* process in the arable layer as a result of the changes of the pH reaction and the hydrothermal regime of the soil as consequence of its use in agriculture.

The tillage followed by the destructuring of the arable layer led to the loss of the compaction resistance capacity; decrease the humus content by 1.6-1.7 times; the apparent density at the depth of 10-30 cm (below the periodically cultivated layer) towards the middle of summer reaches values equal to 1.50-1.65 g/cm³ (very high), and the degree of compaction - exceeds 20% (very compacted soil); as a result, the physical quality of this layer became unfavorable for the plants growth as well as the underlying illuvial layer.

Textural differentiation of the Grey soils profile (greyzems) in complex with other indicators is an important diagnostic index of these soils for the purpose of their classification. Thus, in the perfected Soil Classification of the Republic of Moldova, the natural Grey soil (forest) were called Greyzem typical, the arable Grey soils - Greyzem cernic.

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