GEOMORPHOLOGICAL AND LITHOLOGICAL FEATURES OF PEDOGENESIS AND SPACE DISPERSAL OF CHERNOZEMS STAGIC IN REPUBLIC OF MOLDOVA

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Abstract

As a result of large-scale soil research in Central part of Republic Moldova was established that chernozems stagnic are spread on the uniform horizontal surfaces of the river Răut basin or on the inconsistent interfluvial hills, lithological substrate of which is represented by clays. Landscape elements that formed these soils are the primary denudation areas that outcome of raising Alpine territory nowadays occupies absolute altitudes of 200-250 m. Pedogenesis of stagnic chernozems determined by non salinization clay texture of parental rocks. Chernozems stagnic differ from the zonal chernozems by presence of a gleyic horizon in the lower bioaccumulative layer, clay texture, higher cation exchange capacity and humus content. They have a high fertility potential, but not always give the corresponding results due to air – humidity regime in the years with abundance rainfall or due to hard tillage during the dry autumns.
Chernozems stagnic are a difficulties object for use in arable. In view of risk the stagnic chernozems are capability, primary for perennial grasses, apple and plum plantation, if the gleyic horizon is located deeper than 70-80 cm; secondary – for winter grain crops: in the third – for weeding crops. Chernozems stagnic tillage is recommended only to corresponding humidity of soil physical maturity. Average soil rating of chernozems stagnic consists 85 points.

Key words: chernozem stagnic, clay texture, gleyic horizon, pedogenesis

Soil water stagnation is a phenomenon of keeping in the soil or the soil surface an excess of water from precipitation, present above an impermeable layer, which usually is a soil horizon. In Republic of Moldova specific researches to assess genesis, nomenclature and classification of stagnic chernozem gleyic in depth were not performed. These soils occupy horizontal surfaces draining on local interfluvial heights (Чербарь В.В., 2007b). Stagnic chernozems are not highlighted in the existing system of classification and evaluation, and their genetic and production features are not studied. On the previous maps, the surfaces of stagnic chernozems were incorrectly entered into the zonal land areas. Concomitant incorrectly was calculated the rating note and their suitability for different agricultural use. No highlight the chernozems stagnic on the map can be explained by the fact that in the Russian naturalist classification used in the country, stagnic soils are not present (Cerbari V., Leah T., 2010, Leah T., 2010b, Чербарь В.В., 2007a).

Stagnogleic aquatic properties of soils formed as a result of wetting stagnic character are used as a diagnostic properties system of soil classification FAO UNESCO (Почвенная карта мира, 1990) and in the last Romanian system of soil taxonomy (2003). These properties relate to soil material that continuously or periodically are saturated with water from precipitation and which present manifestations of the reduction and segregation of iron and have a specific color.

The Romanian system of soil taxonomy emphasizes the need to distinguish between pedogenesis and geological gleyzation. The first is a biochemical process that in addition to water saturation is conditioned by the presence of organic matter, temperature higher than 0° and favorable reaction conditions to development reducing microorganisms. Pedogenesis gleyzation - is standing on the bases of the bioaccumulative horizon. Gleyzation in the deeper layers of soil and subsoil is relict and determined by geological processes as soon as soil. Stagnic soil properties into the Romanian system of taxonomy are separated at the stagnosoils type as the class "hydrosoils".

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MATERIALS AND METHODS

Research objects are chernozems stagnate spread on the wide interfluvial peaks within Raut river basin, the absolute altitude 200-250 m (profile 5 and 6) and parallel ordinary chernozems (profiles 7 and 8) on the same sole and altitudes:

Profile 5. Chernozem stagnic, humifere, weakly carbonate, gleyic in depth, clay, arable (village Chişteln̦a);

Profile 6. Chernozem stagnic, humifere, semicarbonatic, gleyic in depth, clay, arable (village Ordasei);

Profile 7. Chernozem ordinary, humifere, semicarbonatic, clay-loamy, arable (village Ordasei);

Profile 8. Chernozem ordinary, moderate humifere, semicarbonatic, loamy-clay, arable (village Chişteln̦a).

Stagnogleic pedogenesis processes are widespread in soils of Moldova. Anagogic soils are also found in other parts of the country, but most commonly spread of stagnic chernozems is characteristic for that territory.

Collection of samples was performed on the quasi horizontal areas of watershed located adjacent to the river valley. For all profiles was performed morphological description, soil sampling of on genetic horizons, determination of apparent density for Ahp1, Ahp2, Ah horizons (up to 50 cm of depth). The soil samples were performed using the analysis required by existing conventional classic methods.

REZULTATE ŞI DISCUŢII

Geomorphologic and lithological features of soil formation and dispersal space of Chernozems stagnic in r. Rãut basin

Chernozems stagnic of river Rãut basin in Central Moldova are spread over uniform surfaces (horizontal) or weak inconsistent interfluvial peaks, lithological substrate of which is represented by clays. Landscape elements that formed these soils are the primary areas of denudation that outcome of raising Alpine territory now occupies absolute altitudes 200-250 m

Pedogenesis of stagnic chernozems mostly is determined by clay texture of the parental rock. Clay on the plateaus differs from marine clay, that appearing on the slopes, the lack of salinization. It is possible limnisch or alluvial - limnic origin of this clays. Information on the geological structure of territory located in the basin of river Rãut, where soil samples were collected for research is very limited in volume.

According to geological research, at the end of the Pliocene on the territory of Central and Southern Moldova is established the continental climate regime, forming alluvial plain, sedimentary deposits which were now preserved only on the highest elevation areas of relief (Покатилов В., 1983). Leveled surface sediments are particularly altered psammyte-clay deposits of lakes and lagoons with low water level. In composition of clays mainly prevails the montmorillonite deposits. Most clay rocks are dense and the composition of chlorito-montmorillonito-hydromicaceous (Геоморфология Молдавии, 1978).

Contemporary relief formation was based on alluvial-limnic plain of Pliocene which served as the original initial surface. In Moldova the alluvial-delta plains of the middle Pliocene replaced marine deposits of Middle Sarmatian. Composition of deposits shows a weakly fragmented landscape. Fauna was found in the middle Pliocene (mastodons, rhinoceroses, etc.) proves in favor of a savanna landscape type and a warm climate interspersed with high humidity phase (Билинкис Г., 2004). Morphogenesis at the stage between middle Pliocene and Pleistocene is characterized by periodic changes of cold and warm climate cycles. The same time is initiated delta formation of a powerful flood flow and wide floodplain associated with lakes and moods.

In late Pliocene and Eopleistocen stands gradual lifting of the territory, dividing unique river into two large flows. In the Pleistocene tectonic movements are amplified, forming mountains with small altitudes of the woods, named “Codri”; is born contemporary river network. At the same time is formed Dniester Plateau, its ramifications constitutes is watershed on surfaces which have been studied soil profiles (Билинкис Г., 2004).

River Rãut during his middle and upper Sarmatian discovered lower sublevel deposits of (N1S1), which are represented by calcareous rocks, marl and clay, less commonly sandstone.

Currently sedimentary deposits on the surface of Rãut river basin is a complex of Pliocene-Quaternary eluvial formations non disrupted on the surface of watershed and early river terraces (eN_2-Q); upper Quaternary formations of contemporary eluvial-deluvial deposits, etc. (Атлас Молдавской ССР, 1978).

Geological research confirms origin of alluvial-limnic of clay that formed the chernozems stagnic on the local interfluvial peaks in Rãut river basin. Bottom part of soil profiles formed on clays is temporarily saturated in stagnant rainwater and presents events gleyzation processes. Properties stagnic correlate with provided aquatic condition of "episaturation" defined as soil water saturation in one or more layers (horizons) in the first 200 cm of mineral soil surface. Saturation zone is composed of water suspended from a relatively waterproof layer. Stagnogleic properties are note with the "g" when color reduction-oxidation up to 50% of the gleyied horizon and “G” when the

color reduction - oxidation occupies over 50% of the surface horizon (Leah T., 2010a).

In the field mostly areas of clay stagnic chernozems are adjacent to areas with zonal chernozems with texture - loamy and sandy loam, located at slightly higher altitudes. All these affirmations confirm the alluvial-limnic origin of deposits that have formed these soils.

Genetic characteristics and properties of Chernozems stagnic located in the zone of ordinary chernozem, altitude 200-250 m

Morphometric indices include data on thickness and morphology of the genetic horizons of investigated soil profiles *(tab. 1).*

Parental rocks are limnic deposits formed in Pliocene. Profile depth - 160 cm. Effervescence - from 30 cm. Carbonates as veined - from 60 cm and bieloglasca - from 75 cm to 142 cm. Profile have genetic horizons: Ap1 - Ap2 - Ah - AB - BG - BG - BCG-Cg – C. Gleyzation start at 75 cm, high gleyzation - from 125 cm *(fig.1, 2).*

Comparative analysis of morphometric indices and morphological characteristics of the studied profiles of chernozems stagnic gives opportunity to make the following conclusions:

- The thickness of the humus profile varies from 80 cm up to 100 cm.
- Horizon Ah and/or ABh is distinguished by black pronounced gloss aggregates faces
- In basis of humus profile outlined a clay horizon, marl, gleyic, well developed, which also is a horizon of carbonate accumulation as bieloglasca.
- Greenish-yellow clay under gleyic horizon is less gleyied and often located on eluvial compact limestone rocks.

Chernozems ordinary differ from the Chernozem stagnic by lack gleyic horizon stagnic and gleyied horizons.

Figure 1 **Location of Chernozems stagnic, profile 5, Chişteliniţa**

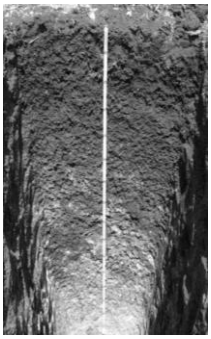

Figure 2 **Profile 5. Chernozem stagnic**

Table 1

Average statistical parameters of the morphometric indices of arable stagnic chernozems studied the 2006-2010 within Rãut river basin, district Teleneşti

Horizon and depth, cm		X	s	V, %	m	P, %	n
		Thickness of genetic horizons, cm					
Ahp	0-33	33	3	9,4	1	3,0	10
Ahk	33-50	17	6	34,7	2	11,2	10
ABhk	50-75	25	12	50,0	4	16,0	10
Bhkg	75-102	27	12	45,9	4	14,4	10
Gk	102-127	25	5	21,6	2	6,8	10
Ckg	127-175	38	20	40,6	6	12,8	10
2CRgk	>175	-	-	-	-	-	3

Texture Pedogenesis of chernozems stagnic is determined by clay texture of the parent rock. Physical clay content in investigated soils varies from 70% to 80% and clay - from 48% to 57%. The fine texture is characteristic for parental rock. Physical clay content in the underlying horizons of the profiles is 76-79% and clay - 53-57%. The high percentage of clay in the parent material can be formed only in alteration of underwater rocks in warm weather conditions. Size composition of parent material that is formed alluvial chernozem stagnic confirms origin alluvial-limnic of late Pliocene, established by geological research

During normal hydrothermal regime in early spring crumb structure with small aggregates and fluffy state of arable layer of chernozem stagnic ensures the possibility of soil material to destroy in the contrasts of temperature and wetting conditions. The references often indicate that soils with high clay content are vertic soils. Case studies show that not all vertic processes can be assessed by high clay content in soil (Крупеников, 1990).

Ordinary chernozem (profile 7, 8), located on the same plots with chernozems stagnic

(polygon 5, 6), is characterized by loamy-clay texture. Texture of these soils differs from chernozems formed on the loess by a high percentage of sand, as a result of joint aerial global accumulation process of loess deposits with local process of deflation of Pliocene alluvial deposits, sometimes spread over the highest peaks.

High content of sand, in the recent destruction of the arable layer of typical chernozems, provides for clayey, sandy-clay soils more favorable physical and mechanical properties, which gives way to more easily work the soil and create a favorable germinating bed crops in any year. Completely different situation is characteristics for clay chernozem stagnic.

Structural composition Chernozems stagnic clayed have high content of fine clay in years with wet autumn is tillage comparatively easy. As a result of frost and thaw arable layer is structured, which gives way to accumulate large reserves of water in the soil and create a favorable germinating bed of spring crops. Also these soils are resistant to spring drought.

In the end of summer and dry autumn, because the blocks structure, loamy stagnic chernozem working very hard, plowing on these soils is extremely rough, creating a favorable germinating bed is impossible both for winter crops and for the spring *(fig.3).*

a) *b)*

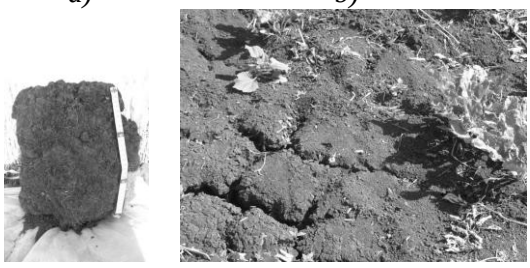

Figure 3 **Structural state chernozem stagnic in dry condition of the summer 2007. Territory of Chişteln**i**ța, Telenesti; a) - blocks structure, b) - cracks on the surface**

During heavy rainfall, due to high water field capacity, these soils dries hard and slowly reach physical maturity status. As a result the rhythm of agricultural work is disturbing with bad consequences for crop yields.

Physical characteristics Average statistics data confirm that chernozems stagnic clay is characterized by high values of the hygroscopic coefficient within the limits of 7-12%. So in the soils the high water reserves are also inaccessible to large plants.

Density average statistical values of soil material are ranges: from 2.62 to 2.65 in stagnic humifere horizons, up to 2.70 to 2.75 in gleyied clayey underlying layers. The density of these horizons is comparatively low due to the high content of humus.

A full index of physical quality status of the soils is apparent density. The values of this indicator for investigated soil profiles range from 1.20 to 1.30 g/cm³ in the arable layer of chernozems stagnic to 1.50 to 1.60 g/cm³ in gleyied clay parent rock. Total porosity, while it is large in arable layer of these soils and very low in the underlying gleyied layers.

Apparent density values for arable layer within 1.1 to 1.3 g/cm³ to consider optimal. So, stagnic arable layer of chernozems are characterized by comparatively favorable physical properties and underlying gleyied layers - the physical unfavorable attributes.

Generally, in terms of texture and physical properties, chernozems stagnic are a difficult object for use in arable both in dry years and in years with heavy rainfall.

In the normal hydrothermal regime of chernozems stagnic the arable layer in early spring in some extent can be seen as too loose and then, after sowing requires easy rollers.

In years with dry autumn is hard to work these arable soils and crushing layer to create a favorable germinating bed.

In years with abundant rainfall during the vegetation period growing danger to forming in these soils an aerobic deficit regime.

Long term preservation of favorable state of physical quality of stagnic chernozems is possible through measures that would help ensure continuous flow of organic matter in arable layer of their soil for forming an agronomic valuable structure.

Chemical and physical-chemical characteristics The studied soils are characterized by a neutral reaction from the surface horizons (pH = 6.9-7.3) and underlying horizons slightly alkaline (pH = 7.8 to 8.3). For gleyic horizons there is a trend towards a slightly alkaline reaction than the surrounding horizons. Surface horizons of chernozems stagnic are decarbonatat or weak carbonate. Maximum carbonates content are characteristic for gleyic horizons and altered material of limestone rocks, shown in clays, profile 5, 6 (Leah T.,2010b, Leah T.,2011).

Investigated soils are low content of phosphorus. Total phosphorus content in the profile is range from 0.10 to 0.11% in arable layer to 0.05 to 0.06% in the parent rock.

Humus content (statistical average) in chernozem stagnic equals 4.5 to 4.6% in the Ahp, 3.0 to 3.9% in Ah non plowing, 2-3% in ABh and 1-2% in Bh2. Humus profile ends rather abruptly,

but the following horizon practically non humifer, meet black humifer languages, formed as a result of mechanical flow humus material above the crack of horizons *(tab. 2).*

Table 2

Average statistical indexes (X ± s) of chemical properties of standards genetic horizons of arable stagnic chernozems studied in 2006-2010, Rãut river basin, district Telenesti

Horizon and depth, cm	pH	$CaCO_3$	P_2O_5 total	Humus	N total	Mobile forms, g/100 g soil	
		% g/g				P_2O_5	K_2O
Ahp 0-33	7,1±0,2	0,3±0,9	0,127±0,054	4,35±0,21	0,226±0,021	1,8±0,5	38±9
Ahk 33-50	7,3±0,3	2,2±2,7	0,103±0,036	3,80±0,21	0,190±0,016	0,9±0,2	27±6
ABhk 50-75	7,6±0,3	5,5±3,5	0,073±0,009	3,04±0,46	0,138±0,027	-	-
Bhkg 75-102	7,9±0,1	11,9±5,8	-	1,52±0,25	-	-	-
Gk 102-127	8,1±0,1	18,1±5,0	-	0,65±0,20	-	-	-
Ckg 127-175	8,0±0,2	12,1±7,3	0,061±0,014	0,36±0,19	-	-	-
CRkg >175	7,9±0,2	28,1±3,6	-	0,09±0,05	-	-	-

Humifer profile is black; the surface of aggregates from humifer profile is characterized by a characteristic gloss anthracite coal.

The C: N in the arable layer and underlying humus is 10-13. Increases in value ratio C: N in the underlying horizon, indicating carbonatization of organic matter in underlying horizons of these soils. Soils are rich in potassium mobile (30-40 mg/100 g soil) and low in mobile phosphorus (2.0 - 2.5 mg/100 g soil).

Chernozems stagnic have high cation exchange capacity in the humifer horizons and middle in the gleyied horizons and parent rock. There is a gradual increase in depth of the Mg content. Stagnic chernozems are characterized by chemical characteristics favorable for plant growth.

Chernozems ordinary investigated parallel, located on the same plots as stagnic, are moderately humifer (humus content in arable layer varies within 3.0 to 3.5%) and is characterized with lower cation exchange capacity. However, due to more favorable texture, these soils are more easily work, by tillage in them creates favorable regimes for plant growth and as a result, yields on these soils are higher than on the stagnic chernozems.

The stagnic chernozem productivity The productivity of chernozems stagnic was determined by the methods of plots with surface of 1m² of green mass. In parallel, the same method was determined harvest level on zonal ordinary chernozem, spread on the same area. This made it possible to compare the productivity of crops on ordinary chernozem and stagnic chernozems in analogical agrotechnical conditions *(tab.3).*

Peculiarities of agriculture 2008: dry autumn (2007), warm winter with precipitation deficit, dry spring, drought summer. Soils were plowed autumn, but autumn drought has not allowed the work to prepare the soil quality and favorable germinating bed for crops, particularly on the land with clay stagnic chernozem that early autumn arable layer structure turned into blocks. For zonal ordinary chernozem, soils with coarse texture, they managed to create a germinating bed.

Table 3

Harvest of green mass on soil plots, surface, 1m²

Soil	Average harvest, t/ha
Polygon 5. Chernozem stagnic	3,8 t/ha
Polygon 6. Chernozem stagnic	4,5 t/ha
Polygon 7. Chernozem ordinary	2,6 t/ha
Polygon 8. Chernozem ordinary	2,3 t/ha

Assessment of winter wheat harvest was estimated on the polygon were located the chernozem stagnic. Also, on the same field, was determined the yield of winter wheat for zonal ordinary chernozem (Cerbari V.,Leah T.,2010, Leah T.,2011, Чербарь В.В.,2007b).

The results of measurements in 5 repetitions on the surface of 1 m² plots was established that the winter wheat crop is 27.4 q/ha on the chernozems stagnic and for the same ordinary chernozems - 32 q/ha, with 14 -15% higher.

Corn harvest on these soils was only 15.8 q/ha, on the ordinary chernozems on the same lot – 35 q/ha, 55% higher.

Given the fact that agrotechnical factors less influenced crop yields on investigated soils was consider that the difference in harvest of winter wheat on zonal and stagnic chernozem can be used in calculating the rating note of chernozems stagnic, which can be assessed about 85 points.

CONCLUSIONS

Chernozems stagnic differ from the typical area of zonal soils by the presence of a gleyic horizon in the lower part of bioaccumulative layer, clay texture, higher cation exchange capacity, high humus content.

Gleyzation in profile is distinguished at the depth 50-100 cm from the surface, gleyzation processes occur due to excess moisture derived from rain water and lead to accumulation of free iron compounds in gleyic horizon.

Stagnation excess moisture in the lower profile of chernozem stagnic is subject to their clay texture. In the cold period the soil clay profile humidity are gradually and achieve total water capacity. During warm period water losses by evaporation in clay soils are not high. Evaporation leads to loss of water, but only in the top of soils (0-50 cm), due to low speed of water movement to surface in the fine textured soil profile.

Dry clay soils leads to their surface cracks of 3-7 cm. Cracks are important in the genesis and hydric regime of these soils. During summer heavy rains the surface water flows through cracks, leading to maintain excess water in the bottom of the soil profile. In drought years, when the cracks are wide and deep in the bottom of soil profile penetrates (flows) humus material from the upper, leading to the formation of a transitional nature glossic horizon with humifer "languages".

Stagnic chernozems have a high potential for fertility, but not always give the corresponding results due to aerohydric defective regime during heavy rainfall or due to issue their work in years with dry autumn.

Chernozems stagnic are a difficult object for use in arable, in years with dry autumns, because of the structure in blocks of arable layer is hard to create a germinating bed for autumn crop quality. In years with dry spring these soils, resulting in high field capacity water, are resistant to drought, but if drought is prolonged and summer, spring crop harvest may be lost.

In terms of risk stagnic chernozems are suitable: I – for perennial grasses, apple and plum plantation, if the gleyic horizon is located deeper than 70-80 cm, II – for winter grain crops, III – for weeding crops.

During normal hidrotermic regime the harvest crops on these soils differs little from that of the zonal soil and is only 10-15% less.

Tillage of chernozems stagnic is advisable to work only to appropriate humidity of soil physical maturity. Average rating note of chernozems stagnic is 85 points.

For chernozems stagnic gleyied in depth were developed a set of measures and recommendations, performing and implementation which will have both economically and environmentally effect, will lead to long-term preservation of their quality status and increase their production capacity at least 20%.

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