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ALLUVIAL SOILS OF THE LOWER DNIESTER MEADOW - GENETIC FEATURES AND CLASSIFICATION PRINCIPLES

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Abstract

In the Lower Dniester meadow from the Republic of Moldova are spread the following subtypes of alluvial soils: ochric (poorly evolved), typical, humic, slitizated, hydric, salinized, solonetzed, gleyic. The most widespread are the clayey-loamy humic alluvisols in the central meadow, the post-marshy clayey deep-humic alluvisols in the meadow under the terrace and the weak humiferous alluvisols with semi-deep humiferous profile and humiferous soil layers buried deeper than 70 cm, formed on the loamy-sandy grind near the bed of the Blind Dniester. Most of the alluvisols in the Lower Dniester meadow are irrigated or have been irrigated. The texture is one of the most spatially variable on the profile of the alluvial soils in the Lower Dniester meadow.

Key words*: alluvial soil, Lower Dniester, texture, classification, genetic peculiarities.*

INTRODUCTION

In each soil-climatic zone, the territories of river valleys are peculiar natural landscapes. Alluvial (floodplain) soils are widespread here, distinguished by their natural fertility and being the most valuable agricultural land (Leah, 2019; Leah & Cerbari, 2019).

Floodplain - part of the river valley, periodically flooded with hollow waters of the rivers. A feature of soil formation in the territory of floodplains, which determines many features of the genesis, composition and properties of alluvial soils, is the development of floodplain and alluvial processes. Floodplain processes - periodic flooding of the territory of the floodplain with hollow waters.

River floods are seasonal and are associated with spring snowmelt, spring-summer melting of glaciers, and heavy monsoon rains. Hollow waters can flood the floodplain from several hours to several weeks (1.5-2 months). This is a kind of natural irrigation of the floodplain. It has a great versatile effect on soil formation: it creates a different water regime than on non-floodplain soils, affects the level and composition of groundwater, softens the soil climate, and promotes the activation of microbiological and geochemical processes (Leah et al., 2019; Leah et al., 2019). All this affects the composition and productivity of natural vegetation, salt, biochemical and soil and groundwater regimes (Лях, 2020; Канаш, 2004; Наконечний & Позняк, 2011).

Alluvial deposits are the mineral base from which floodplain soils are created. Therefore, the composition, properties of alluvium, its thickness, and the frequency of deposition are of decisive importance for the genesis of soils. The nature of the alluvial process is influenced primarily by the position of individual parts of the floodplain in relation to the riverbed. The territory of the floodplain, depending on the distance from the river, is divided into three parts (Вильямс, 1955): near-river, central and near-terrace. They differ in the composition of alluvial deposits, relief, depth of groundwater and, as a result, in vegetation and soil cover.

MATERIALS AND METHODS

In the process of researching the soil cover of the Lower Dniester meadow, the methods approved in Moldova were used for carrying out pedological research in the field, laboratory and office. Soil profiles with a depth up to the groundwater were placed in the field. The groundwater level in the recently drained meadow varies from a depth of 2.5 m in the middle part of the meadow to 1.5 m - in the meadow near the river bed. For laboratory analyses, samples were taken from each genetic horizon of the soil profiles (Florea et al., 1987). The analyses were performed according to the standardized methods in force.

RESULTS AND DISCUSSIONS

The surface of the Lower Dniester meadow is raised above sea level by only 4-5 m, which ensures a slow division of alluvial deposits during overflows and, in the past, until the construction of dikes and the drainage system, the contribution to the swamping of large areas of land in the meadow. At the moment, the groundwater on the dry lands is lowered deeper than 2 m from the land surface and the meadow is characterized by a satisfactory water regime.

Most of the alluvial soils in the Lower Dniester meadow are irrigated or were irrigated in the past. Until 1990 these soils were used in vegetable cultivation. Unfortunately, this vegetable production complex has been mostly damaged, but it can be restored (Didenco, 2022; Leah & Cerbari, 2019; Leah, 2018).

In the Lower Dniester meadow, humic loamy-clay alluvial soils are spread from the central meadow (Profile A5); the deep humic loamy post-marshy alluviums from the meadow below the terrace (Profile A1 and 275) and the slightly humic alluviums with a semi-deep humic profile and layers of humic soil buried deeper than 70 cm, formed on the loamy-sandy gravel near the bed of the Blind Dniester (Profile A9).

Profile A9. Alluvisol low humiferous, semi-deep humic profile and humic soil layers buried deeper than 70 cm, loamy-sandy, moderately carbonate, arable, irrigated (Figure 1).

Profile A5. Alluvisol humiferous, very strongly deep stratified humic profile, loamy-clayey, moderately carbonatшc, arable, irrigated (Figure 2).

Profile A1. Alluvisol deep humiferous, very strongly humiferous profile, loamy, weak carbonatшc, arable, irrigated, post-marshy (Figure 3).

Profile 275. Alluvisol deep humiferous with a very strongly deep humic profile, weakly carbonatic, loamy, gleyed 62-130 cm, gleyic deeper than 130 cm, well-drained, post-marshy (Figure 4).

Granulometric composition of alluvium depends on the speed of hollow water movement along the floodplain: the greater the speed, the more stable fine (silty-dusty) particles in the flow, the larger the size of the settling particles.

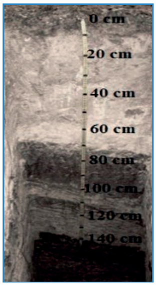

Figure 1. Profile A9

Figure 2. Profile A5

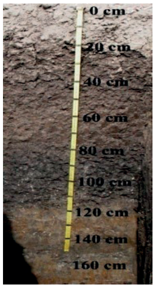

Figure 3. Profile A1

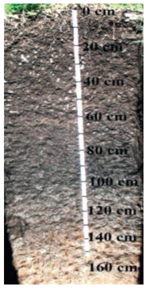

Figure 4. Profile 275

Since the velocity of hollow waters decreases with distance from the channel deep into the floodplain territory, the composition of alluvium gradually changes: predominantly loamy-sandy alluvium is deposited in the near-river part, and loamy-argillaceous sediments are deposited in the central and terraced parts.

Therefore, with distance from the river, the granulometric composition of alluvial soils also changes: the proportion of sandy particles in it decreases and the content of silty and silty particles increases. The latter always contain more organic matter and plant nutrients. Consequently, in the central and terraced floodplains, the soil-forming process develops on sediments richer in chemical composition and diverse in mineralogical than in the near-river part (Leah, 2018).

The texture or granulometric composition of the soil means the proportion in which soil particles of different sizes (from colloidal clay to coarse sand) participate in the composition of the soil.

The categories of particles of different sizes, which make up the solid phase of the soil, are called particle size fractions, which have been grouped into size classes, sand, dust and clay.

The proportion of these fractions in the soil determines the textural class of the soil.

Texture is one of the most important characteristics of alluvial soils and also one of the most variable spatially and on the soil profile in the Lower Dniester meadow.

Depending on the relief of the meadow, formed by the old beds of the Dniester, on the territory of the meadow there are both alluvial soils with a coarse loamy-sandy or loamy-sandy texture on the gravels near the riverbeds, as well as soils with a medium and fine texture on the territory of the central meadow and below the terraces - loamy-clay, clayey-loamy, clayey and fine clayey (Table 1).

Table 1. The texture of the Alluvisols in the Lower Dniester meadow

The horizon and depth, cm	The fractions size (mm); content (% g/g)							
	1.0-0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Profile A9. Alluvisol low humiferous with semi-deep humic profile and humic soil layers buried deeper than 70 cm, loamy-sandy, moderately carbonate, arable, irrigated								
0-20	0	0	30.2	36.4	5.6	10.6	17.2	33.4
20-40	0	0	29.0	36.4	8.8	10.1	15.7	34.6
40-58	0	0	26.8	42.1	5.7	11.4	14.0	31.1
58-71	0	0	25.7	45.2	6.6	11.9	10.6	29.1
71-98	0	0	18.1	40.9	8.0	12.5	20.5	42.0
98-120	0	0	41.3	34.0	6.5	7.0	11.2	24.7
120-140	0	0	37.2	37.8	5.4	6.6	13.0	25.0
140-160	0	0	24.7	39.8	6.3	11.2	18.0	35.5
160-200	0	0	45.9	30.1	5.2	9.5	9.3	24.0
Profile A5. Alluvisol humic with very strong deep stratified humic profile, loamy-clayey, moderately carbonate, arable, irrigated								
0-23	0	0	5.9	34.0	12.6	17.6	29.9	60.1
23-38	0	0	7.2	32.3	14.9	14.2	31.4	60.5
38-63	0	0	2.8	36.1	12.1	15.4	32.6	61.1
63-81	0	0	3.6	34.4	13.3	16.0	32.7	62.0
81-110	0	0	8.4	33.3	9.8	13.4	35.1	58.3
110-140	0	0	8.2	28.0	6.2	16.1	41.5	63.8
140-160	0	0	2.4	24.0	9.6	13.7	50.3	73.6
160-180	0	0	13.4	25.0	6.1	14.3	40.2	61.6
180-200	0	0	11.2	30.2	8.0	12.3	38.3	58.6
Profile A1. Alluvisol deep humiferous with a very strong humiferous profile, loamy, weak carbonate, arable, irrigated, post-marshy								
0-20	0	0	5.6	13.8	9.0	21.7	49.9	80.6
20-38	0	0	4.6	13.0	8.5	20.1	53.8	82.4
38-58	0	0	3.9	12.8	8.1	21.3	53.9	83.3
58-79	0	0	4.7	13.7	6.8	25.2	49.6	81.6
79-95	0	0	2.5	9.8	5.4	23.3	59.0	87.7
95-115	0	0	2.8	6.9	6.3	20.3	63.7	90.3
115-135	0	0	3.1	7.2	6.8	22.3	60.6	89.7
135-160	0	0	2.2	7.2	8.7	22.0	59.9	90.6
180-200	0	0	2.5	7.5	8.3	22.7	59.0	90.0
Profile 275. Alluvisol deep humiferous with a very strong deep humic profile, weakly carbonate, loamy, gleyed 62-130 cm, gleyic deeper than 130 cm, well-drained, post-marshy								
0-18	0	0.2	8.2	23.3	6.9	6.9	15.5	68.3
18-40	0	0.2	9.3	23.8	5.8	5.8	15.7	65.7
40-62	0	0.2	5.2	26.8	5.0	5.0	16.4	67.8
62-80	0	0.2	7.7	14.7	6.1	6.1	15.5	77.4
80-100	0	0.4	9.6	12.6	6.8	6.8	16.9	77.4
100-112	0	0.5	9.1	13.9	5.2	5.2	18.2	76.5
112-130	0	0.3	7.4	20.9	7.7	7.7	14.4	71.4
130-150	0	0.2	4.4	32.2	5.9	5.9	10.1	53.2
150-175	0	0	8.1	40.5	7.4	7.4	10.9	51.4
175-200	0	0	6.4	45.1	4.9	4.9	10.4	48.5

Genetic particularities and classification of the alluvisols in the Republic of Moldova.

According to the World Reference Base of Soil Resources (WRB 2014) the alluvial soil group *de facto* includes all soils formed on alluvial deposits, lacustrine deposits, alluvial deposits on dejection cones in river valleys. All these deposits and the soils spread over them are predominantly young stratified formations, formed during the overflowing of rivers. The stratified alluvial profiles are characterized by weak differentiation of pedogenetic horizons deeper than the horizon on the soil surface. The main qualifiers used to classify these soils are diagnostic characters (Soil map..., 1990; Cerbari, 2001; Егоров & Фридланд, 1977).

Hydric - it is used to classify alluvial soils from the point of view of the depth from the surface of the layer of soil saturated with water from the ground water account (Крупеников & Подымов, 1987). From the limit of the depth of the water-saturated soil layer, the following alluvium taxonomic units are divided:

- *hydric*, saturated in water starting from the land surface;
- *semihydric,* saturated in water in the depth range 35-70 (100) cm;
- *typical,* saturated in water deeper than 70 (100) cm.

Humic - it is used to classify alluvial soils from the point of view of humus content and the thickness of the humic profile. It is divided into the following subdivisions:

- *ochric* or poorly developed, the humus content in the surface layer of the alluvium in the Ao horizon is less than 1%;
- *poorly humiferous*, humus content 1-2% in the 0-30 cm layer or the arable layer;
- *humic,* alluvial soils with a weighted average content of humus in the 0-50 cm layer greater than 2%.

Deeply humic - is used to name alluvial soils with a weighted average content of humus greater than 2.5% in the 100 cm layer.

Gleyed - it is used to divide alluvial units according to the degree and depth of glazing;

Gleyic - is used to divide alluvial units according to the depth of the gleyic horizon (horizon with a heavily gleyic surface (gleyic) greater than 90%).

Salic (salinized) - is used to divide soil taxonomic units according to the degree and depth of the appearance of salinization or solonetization on the soil profile etc. (Table 2).

Table 2. Systematic list of alluvial soils of the Republic of Moldova at subtype level

Upper level of soil taxon: ALLUVISOLS	
Lower level of soil taxon:	
- ochric (poorly developed)	- the humus content in the 0-20 cm layer is less than 1%.
- typical	- weakly humiferous, humus content in the 0-30 cm layer is 1-2%.
- humic	- weighted average humus content greater than 2% in the 0-50 cm layer.
- deeply humic	- weighted average humus content greater than 2% in the 0-100 cm layer.
- slitizated	- the apparent density of the unworked subarable layer is >1.6 g/cm^3.
- hydric	- marshy, the 0-30 cm soil layer is saturated in water.
- semihydric	- semi-marshy, the 30-70 cm soil layer is saturated in water.
- salinized	- it is divided according to the depth and degree of salinization of the salinized soil layer.
- solonetizated	- it is divided according to the depth and degree of solonetization of the solonetized soil layer.
- gleyed	- it is divided according to the depth and degree of gleizated of the glazed soil layer.
- gleyic	- it is divided according to the depth of the location of the gleyic layer.

Ochric alluvial soils are defined by a weakly evolved Ao horizon no more than 20 cm thick with a humus content of less than 1%, followed by parent material consisting of alluvial (fluvial), alluvial-lacustrine or recent lacustrine deposits of any texture. These soils are formed in conditions of more or less regular overflows of running water. In the intervals between overflows, it is possible to manifest solification, the intensity of which is all the greater, the longer the time since the last overflow (Ursu, 2011; Парникова, 2020).

In the meadows or parts of the meadows, out of the influence of overflows or flooded only at long time intervals, solification advances leading to the transformation of poorly evolved alluvial soils (ochric) into typical alluvial soils. So, the alluvial soils, as a result of the extremely different conditions regarding the duration of the manifestation of solification, the climate of the area, the origin of the alluvial deposits, their texture and composition, the depth and mineralization of the groundwater, are characterized by a very large variation in the properties and composition of their profile.

Poorly developed alluvisols have a profile of the type: AC - 1C - 2C - 3Cg. They are spread in the meadows of the Prut and Dniester on young relief units (minor beds), which carry out intense actions of transporting and depositing alluvial material.

Alluvisols formed on homogeneous deposits have a uniform texture, and those formed on inhomogeneous parent material have a contrasting texture. As a rule, poorly developed alluvial soils are unstructured. The accumulation of organic matter in these soils is poorly expressed. It is characterized by a low content of humus around 0.5-1.0%, coming from the respective deposits or formed due to the organic matter resulting from the weak vegetation spread on these soils (Didenco, 2022; Leah & Cerbari, 2019).

Typical alluvisols are formed on unflooded high meadows or on parts of meadows that are flooded at longer time intervals (Думих, 2016). In such situations, the development of vegetation, the manifestation of solification in the formation of a moderately evolved humiferous horizon was possible. They have a profile of the type: Ah - 1Ah - 2Ah - 1Cg - 2Cg. The thickness of the humiferous profile is 40-50 cm and more. The texture of the profile, depending on the homogeneity of the alluvial deposits, can be uniform or contrasting. Typical alluvisols have a glomerular, granular or polyhedral structure, poorly to moderately developed. In comparison with the poorly evolved alluvisols, they have a higher humus content than the typical ones - 1-2% (Leah et al., 2019).

The ***hydric*** and ***semi-hydric*** alluvisols are spread in the recently abandoned riverbeds and were formed due to silty alluvial deposits in the long-term presence of groundwater at a depth of 35-70 cm from the surface. They have the profile of the type: Ahp - 1Ahg - 2ACr - Gr or ACg - ACr - Gr. The humiferous profile is weakly or moderately developed, and the gleization process is strongly expressed. Humus content is 1-3% or even higher.

Humic and ***deeply humic*** alluvial soils are mainly spread in the lower meadow of the large Dniester and Prut rivers and in the lower meadow of small rivers, at their discharge into the Dniester and Prut rivers. The formation mechanism of these soils is further described for the meadow of Lower Botna and Lower Dniester (Leah, 2018; Didenco, 2022).

At the moment, the territory of the Lower Dniester meadow is used for arable land and is characterized by an unstable favorable water table regime. In case of irrational soil and water management, the unstable favorable hydrological regime can become unstable unfavorable (which happens as a result of incorrect irrigation).

The arable deep-humic post-swampy arable alluvisols of the Lower Dniester meadow are weakly carbonated and are characterized by favorable pH values in the range of 7.2-7.4. An extremely important index of these soils is the very high content of mobile phosphorus throughout the humiferous profile, up to a depth of about 2 m (>10 mg/100 g soil).

Such soils, with analogous historical conditions of solification - gradual synergetic accumulation over thousands of years of fine alluvial - proluvial deposits mixed with organic ones, rich in mobile phosphorus, formed in conditions of marsh pedogenesis, are very rare. Phosphorus is a strategic element that makes possible the use in ecological agriculture of the deep-humic post-marshy alluvial soils drained from the Lower Dniester meadow.

CONCLUSIONS

The process of pedogenesis in synergistic conditions of the marsh and the periodic overflow of the Lower Dniester over the course of millennia, then the desiccation and the use of arable land for about 60 years led to the formation today in the Lower Dniester meadow of post-marshy deep-humic alluvisols (the humus content in the upper layer is 4-5%) with extremely deep humiferous profile with a depth up to 1.7-2.0 m, very rich in mobile phosphorus. At the moment, the soil cover of the Lower Dniester meadow is used in non-irrigated agriculture. In the post-Soviet period, about 30 years ago, after the drying up of the 60s, the lands with these endemic soils were irrigated;

after the land reform, the irrigation system was completely damaged.

The investigated soils are characterized by a high level of natural fertility, they are rich in humus and mobile phosphorus, it is only necessary to restore the unfavorable physical condition of their arable layer by increasing the flow of qualitative organic matter in this layer.

Reducing the negative consequences of climate change that directly influences the degradation of the previously arable layer 0-30 or 0-35 cm is possible only by switching to green agriculture that provides for the systemic use of the green mass of leguminous ameliorating plants (peas or autumn and spring peas) as an organic fertilizer in couple with the gradual periodic implementation of the Mini-till tillage system.

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