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PHYSICAL PROPERTIES FEATURES OF ALLUVIAL IRRIGATED SOILS OF DNIESTER AND DNIEPER RIVER BASINS

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Abstract

The features of the physical properties of alluvial-meadow irrigated soils of the Dniester and Dnieper rivers basins have been studied. The irrigated soil of the floodplain of rivers is characterized by the apparent stratification of the profile and the presence of the buried humus horizon. Irrigated soil is more remote from the river bed, their profiles are less stratification, lack of buried horizons; with depth, alleviation of the granulometric composition from sandy loam to cohesive sand. Upper and buried humus horizons of irrigated soils of the Dnieper, after granulometric composition - sandy loam, transition horizon and parent rock - coherent sand. Irrigated alluvial soils in the Dniester meadow are characterized by comparatively homogeneous texture on the profile and fall into the fine clay texture class. The main processes that cause the degradation of fluvial soils in the river meadows are high gleizing and compacting of the 20-35 cm layer.

Key words: *humus horizon, irrigated soil, granulometric composition, physical properties.*

INTRODUCTION

The alluvial process is the accumulation of river alluvium as a result of sedimentation in the floodplain soil surface of solid particles from flood waters on the surface. In the result of the alluvial process on the surface of the floodplain, there is an annual deposition of alluvium immediately involved in soil formation. Therefore, alluvial soils constantly grow upward, obtaining systematically new portions of the soil-forming rock (Варка, 2018). It is important to emphasize that groundwater is an essential factor of alluvial soil formation. In any developed floodplain it is possible to distinguish three essential parts: a pristine elevated part or a crescent tree, the central most levelled part of the floodplain and a terrace lowering.

The soil cover of river floodplains is very variegated, complex, mosaic due to the constant meandering of the river bed and the migration of various parts of the floodplain. Hence the wide distribution of polycyclic, buried soils (Аллювиальные почвы..., 2018).

Ratio in soils of elementary particles of different sizes forms the basic properties of soils - productive and ecological. And the very formation and functioning of the soil as a natural component and object of human economic activity largely depends on the granulometric composition (Medvedev, Laktionova, 2011).

The nature and direction of soil use, agrarian specialization, farming systems, fertilizer and land reclamation techniques are often differentiated depending on the granulometric composition (Baliuk et al., 2015).

Irrigation further complicates the structure of the soil cover, which requires a differentiated approach to both irrigation development and agro-ameliorative measures, which should be based on studying the physical properties of soils. That is why when studying alluvial irrigated soils, they turned their attention primarily to their physical properties.

MATERIALS AND METHODS

The study objects were as follows:

1) Alluvial virgin soils clayey on the marshy deposits, non-irrigated (virgin) and alluvial arable soil, irrigated for 30 years, vegetable crop rotation, from the Lower Dniester meadow (Kopanca commune, Kausheni district, southern area of Moldova).

2) Alluvial soddy soil, used for a long time in organic farming, drip irrigation (20 years), vegetable crop rotation, and non-irrigated alluvial meadow soil used in agricultural production as pasture, Lower Dnieper meadow (Kopani village, Kherson region, southern area of Ukraine).

Field survey of irrigated lands was carried out using the method of analog keys on landfills. In the studied territories, key sites have been laid on irrigated and on non-irrigated soil. Within the sites, the soil profile was laid down to 1-2 m (depth of groundwater) and soil samples were taken from each genetic horizon. Selection, preparation for analysis and preliminary processing of soil samples of the lower reaches of the Dnieper and Dniester, subject to analysis, were carried out according to the normative documents existing in Moldova and Ukraine (Soils quality: 2004; 2007a, 2007b).

RESULTS AND DISCUSSIONS

Alluvial soils in the meadows of large rivers formed by the sedimentation of alluvial deposits, which led to the layered layout of their profile in space and depth, which is very variable regarding physical properties.

A comparative study of the mineralogical state of genetic close, but different in age, alluvial clayey soil of the Dniester tributary floodplain and stagnant chernozem on the Late Pliocene age clayey rock of alluvial origin from one of the watersheds of northern Moldova has been performed. These researches showed the identity of the qualitative composition of primary and clay minerals and the presence in both soils heterogeneity (stratification) of the rock, which in the alluvial soil received a more pronounced manifestation. Alluvial soils are distinguished by a high content of micas, which should be considered as a specific feature in general of heavy rocks of alluvial origin (Алексеев et al., 2016 a; Воробьев, 1974).

A hypothesis has been advanced that the exceptionally high content of total potassium reserve in soils on alluvial deposits, irrespective of age, is their genetic particularity and is due to the plastic form of micaceous minerals that facilitates their migration in the sedimentary material of the catchment basins and accumulation in river floodplains (Алексеев et al., 2016 б).

The investigated soil profiles from the Dniester and Dnieper meadows are less differentiated in the upper horizons and are characterized by buried soils and gleyed horizons in the lower part (Figures 1 and 2).

Figure 1. Alluvial soils: a) non-irrigated and b) irrigated from the Dnieper meadow (Ukraine)

This is due to the fact that in the underground terrace of the meadows the river overflowing were rare, and after the construction of the dykes, they were stopped. The more or less regular genetic horizons are only observed up to a depth of 80 cm. In the depth range of 80-95 cm is situated a humid horizon Abhg, formed in another historical period (Алексеев, 1999, Stegărescu, 2016). This is a common feature for the Dniester and Dnieper soils. Under this horizon there is an extremely pronounced gleic horizon with dark, humid-colored layers. So, the profile of the studied soils consists of the buried, very humid, gleic soil, located more than 80 cm, and the contemporary soil with humeferous developed profile, poorly gleyed in the lower part, situated in the depth range of 0-80 cm.

Alluvial soils from the Dniester meadow.
From the profiling structure the irrigated alluvisoils is divided into three segments:
- contemporary soil (0-80 cm) with homogeny clayey texture;
- humifer horizon of buried marshy alluvisoil (80-115 cm) with fine clayey texture;
- fine-grained clayey horizon (115-200 and deeper) with gray-bluish colour and dark humic thin layers.

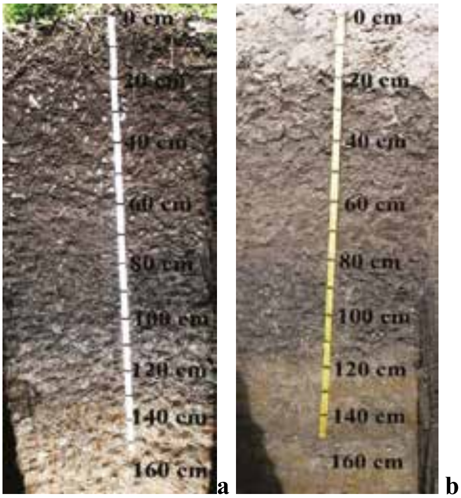

Figure 2. Alluvial soils: a) non-irrigated and b) irrigated from the Dniester meadow (Moldova)

The composition of the alluvial soil profile confirms the cyclicity of the pedogenesis process in the meadow beneath the terraces of the Lower Dniester as a result of the different co-ratio of the manifestation intensity of the following processes: alluvial - accumulation of deposits, subterranean alteration *in situ* and gleizing, pedogenesis (humus formation).
Irrigated alluvisoils are characterized by comparatively homogeneous texture on the profiles. The physical clay content ranges from 82.7% in the arable layer to 88.7% in the highly gleaned horizon, while the fine clay content is at 49.4% to 61.8% (Table 1), indicating a strong argillization in the gleic horizon. Soil falls into the medium and fine clayey texture class. Non-irrigated grounded soil falls into the clayey-loamy texture class.
The accuracy of the average statistical parameters of the physical clay and clay content of irrigated soils is within the limits of 0.8-1.9%.
From the point of view of clayey texture, the studied alluvisoils are a difficult object for irrigation. Being low humid, they are characterized by cloggy structure and low resistance to compaction.
In relation to the decrease of the arable layer thickness from 35 cm to 20 cm, the destruction and decrease of the humus content in the arable layer are the factors leading to the excessive compaction of the soil layer of 20-35 cm of irrigated soils (Table 1).

Table 1. Average statistical parameters (X ± s) on genetic horizons of the granulometric composition of irrigated and non-irrigated alluvisoils from the Dniester meadow

Horizon and Depth, cm	The size of the fractions, mm; content, % g/g					
	0.1-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01
Irrigated Alluvial Soil						
Ahp1 (0-20)	3.3±1.2	13.8±1.2	10.6±1.2	22.9±1.6	49.4±0.9	82.7±1.6
Ahp2 (20-38)	3.7±0.9	13.7±1.4	8.6±1.4	22.3±2.1	51.7±1.4	82.6±1.4
ABh (38-58)	3.9±1.0	12.4±1.2	10.1±1.6	21.7±1.6	52.0±1.2	83.7±0.8
Bhg (58-79)	3.9±0.9	12.8±1.2	8.4±1.5	24.1±1.5	50.8±1.2	83.2±1.1
Abhg (79-95)	2.2±0.8	11.5±1.5	7.2±1.5	22.5±1.9	56.4±1.5	86.1±1.4
Bbhgk (95-115)	2.0±1.0	9.3±1.3	7.6±1.6	19.3±1.9	61.8±1.9	88.7±1.1
Non-irrigated Alluvial Soil						
Ahpț (0-18)	8.2±1.0	23.3±1.1	6.9±1.2	15.5±1.5	45.9±1.0	68.3±1.5
Ah (18-40)	9.3±1.1	23.8±1.1	5.8±1.2	15.7±1.6	45.2±1.2	65.7±1.4
ABh (40-62)	5.2±0.9	26.8±1.2	5.0±1.1	16.4±1.5	46.4±1.3	67.8±1.4
Bhg (62-80)	7.7±0.8	14.7±1.2	6.1±1.2	15.5±1.6	55.8±1.3	77.4±1.4
Abhg (80-100)	9.6±0.8	12.6±1.3	6.8±1.2	16.9±1.7	53.7±1.3	77.4±1.4
Bbhg1 (100-112)	9.1±0.9	13.9±1.3	5.2±1.5	18.2±1.7	53.1±1.3	76.5±1.3
Bbhg2 (112-130)	6.4±0.9	20.9±1.3	7.7±1.5	14.4±1.8	49.3±1.2	71.4±1.2
G1 (130-150)	4.4±0.8	32.2±1.2	5.9±1.4	10.1±1.7	37.2±1.1	53.2±1.1

According to the average statistical parameters of the structural composition (dry sieving) the researched soils (irrigated and non-irrigated) are characterized by a good structure in the layer 0-20 cm (result of the plowing and permanent work between the rows, and grasses of virgin soil) and very unsatisfactory in the compact layer 20-38 cm. Wet sieving data demonstrate that the hydrostability of the aggregates in both the 0-20 cm arable layer and the 20-38 cm layer is very high - the result of the large clay content. The causes of the degradation of the structure of the irrigated soil are the dehumification of the arable layer and its intensive work with heavy machinery.

The hygroscopicity of irrigated soils varies (increases) in profile from 6.6% in the arable layer to 9.1% in the gleic horizon as a result of the increase in the depth of clay content. The coefficient of variation is equal to 5.7% in surface horizons and 19.6% in gleic horizons. The coefficient of hygroscopicity concurrently ranges from 9.6% to 12.0%.

Density in the profile of irrigated aluvisoils ranges from 1.23 g/cm^3 in the arable layer to 1.44 g/cm^3 of the underlying layers. Apparent density on irrigated soils ranges from 2.65 in the arable horizon to 2.75 g/cm^3 in the Bbhgk horizon. The precision of the average indices varies within the range of 1.86-3.03%, the coefficient of density variation in space does not exceed 6.1%. The arable layer is characterized by optimal values of apparent density, but the underlying layer is compacted (Figure 3).

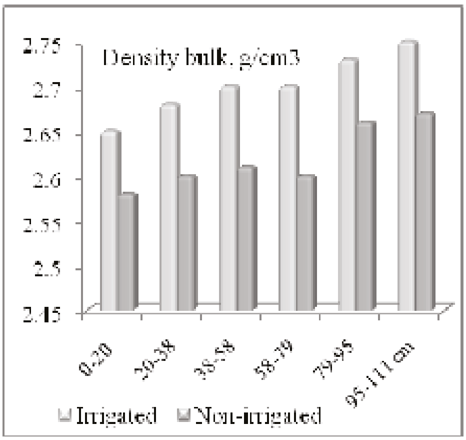

Figure 3. Density bulk in alluvial soils of Dniester floodplain

The total soil porosity values for the studied soil are medium in the recently arable layer (53.7 ± 0.9%) and small in the underlying layers (49.4 ± 0.5%).

According to the size of the compaction, the soil is poorly compressed (3.3 ± 1.3%) in the 0-20 cm layer and moderately compressed (16.0 ± 1.2) in the underlying layers. According to the values of the degree of compaction, the studied soil is characterized by a small degree (low settled soil) of compaction of the recent arable horizon (3.3 ± 1.3%) and a high degree of compaction (moderately settled soil) in the underlying horizons 11.5-16.0 with a deviation of ± 0.8-1.2%.

Generally, the physical properties of arable post swampy alluvisoils are satisfactory for the arable and unsatisfactory for the compacted, post-arable layer (Cerbari, Stegarescu, 2016).

Alluvial soils from the Dnieper meadow.

The profile of the non-irrigated soil in the lower reaches of the Dnieper is characterized by pronounced stratification and is horizontally located layers that are sufficiently contrasting in the granulometric composition.

This significantly worsens the water regime of these soils and contributes to waterlogging during rainy periods and drying out during droughts. There are five genetic horizons in the profile of the non-irrigated soil.

The granulometric composition of the upper horizons (sodden 0-9 cm and humus gleyed 9-25 cm layers) is characterized as sandy-loamy. In the first transition horizon (25-44 cm), the quantity of clay fractions decreases (Figure 4).

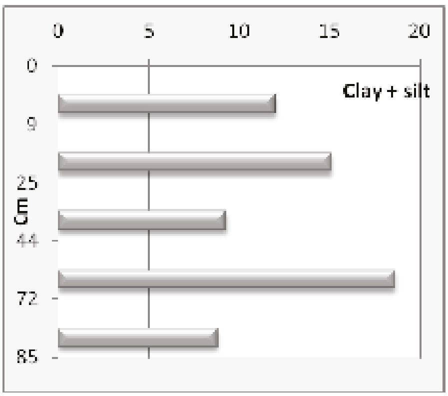

Figure 4. Content and profile distribution of physical clay in non-irrigated soil of the Dnieper floodplain, %

This horizon regarding granulometric composition is a cohesive sand.
In the second horizon (44-72 cm), the sum of fractions less than 0.01 mm decrease in two time, in comparison with the previous one, and it is characterized as sandy loam. It is buried under sandy alluvial deposits the humus horizon. Deeper in the profile, the content of clay fractions decreases - the rock is characterized as cohesive sand.
Alluvial (soddy non-irrigated) soil is characterized by a high degree of structurization and lumpy-granular structure. The humus gleyed horizon (9-25 cm) is poorly structured. The remaining horizons are practically structureless. The first transitional (25-44 cm) is due to a light granulometric composition, deeper due to the high degree of gleying (Figure 4).
When studying the profile of irrigated soil, the lower reaches of the river Dnieper three genetic horizons are distinguished. The irrigated alluvial soil in the 0-20 cm layer (arable horizon) has sandy loam granulometric composition (Figure 5) and is characterized by a high degree of cultivation - contains more than 4 percent of humus, which contributes to its structuring. The lower horizons of this soil, typical of soils formed on sands of alluvial origin, are cohesive sands.

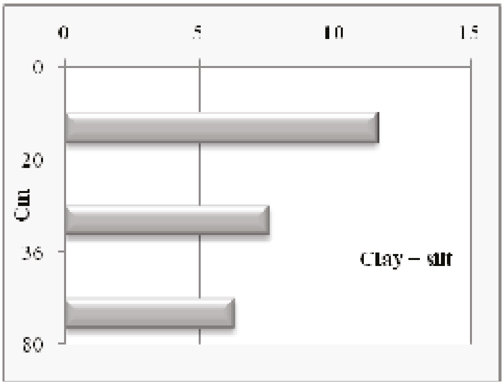

Figure 5. Content and profile distribution of physical clay in irrigated soil of the Dnieper floodplain, %

Sandy and sandy-loamy soils are easy to process without significant effort. However, on light soils there is no mechanism for maintaining the addition parameters created as a result of processing, so they require more frequent loosening (Medvedev, Laktionova, 2011). They are often characterized by lack of structure, caused by a low amount of physical clay, which we observe.
In addition, high water permeability and low water retention capacity create the danger of insufficient supply of plants with moisture and cause the spontaneity of the water regime. These features of the granulometric composition of the studied soils must be taken into account when determining the list of necessary ameliorative effects in irrigated agriculture.
The common characteristic of alluvial soils in the meadow beneath the Dniester and Dnieper terraces is the cyclicity of the pedogenesis processes in them. Alluvial soils are by nature cumulative soils: they grow upward under the influence of the alluvial process. The evolution of the cyclical process of alluvial soil pedogenesis comprises three phases.
The first phase of pedogenesis is the underwater gleic phase, that result in the intense accumulation and gleyzation of the accumulated material in short periods between the overflows of evil, which favors the formation of thin humic layers.
The second phase of aluvisoils pedogenesis was influenced by the radical changes in the course of the river's lateral arms, characterized by long periods without flooding or with very slow overflows, which did not lead to massive accumulations of alluviums and to the process of pedogenesis.
The third phase of pedogenesis is related to the accumulation of a layer (about 80 cm) of homogeneous texture alluviums by massive flooding, which led to the burial of the marshy soil, formed in the previous phase (Calaşnic, 2008).
Under conditions of anthropic degradation of soil cover and global warming, food security can only be ensured by extending the surfaces with irrigated soils. For the development of the irrigated agriculture the most suitable are the lands in the meadows of rivers with non-salinizated and non-solonetzizated soils.

CONCLUSIONS

Irrigated soil of the floodplain of river Dnieper is characterized by visible layering of the profile and the presence of a buried humus horizon. The upper and buried humus horizons in the granulometric composition are sandy-loamy, the transition horizon and the parent rock are cohesive sand. Irrigated soil is more remote from the river bed. Its profile is characterized by lower stratification, absence of buried horizons, gradual, with depth, facilitation of granulometric composition from sandy-loamy to cohesive sand.

Humus horizons of soils are characterized by structurization (varying degrees), deeper horizons of soils are structureless.

Alluvial soil of Dniester meadow have a clayey texture and low content of humus, unsatisfactory physical state of arable layer, it's are hard object to use in agriculture.

Alluvial clayey-loamy soils from Dniester basin and alluvial sandy-loamy soils from Dnieper are suitable for irrigation and use in agriculture for vegetables, potatoes, annual and perennial leguminous (Program, 2004).

The main measure of remediation of the irrigated post-marshy alluvisoils needs to be oriented towards increasing the flow of organic matter into the arable layer and restoring their natural structure.

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