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EVOLUTION OF DARK CHESTNUT STEPPE SOIL UNDER CONDITIONS OF DIFFERENT USE AND CLIMATE CHANGE

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Abstract

The results of studies on the evolution of dark chestnut steppe solonetzic soil under conditions of different uses (virgin lands - from „Askania-Nova" reservation, irrigated and non-irrigated) and climate aridization are presented. It is shown that under the influence of agricultural use, in the arable and long-term irrigated soils with fresh water, the direction of soil formation processes changes. This process affects the properties of soils and the ecosystem services that it provides. The upper part of the soil profile is transformed into a qualitatively new cultivated horizon with altered properties due to soil cultivation and irrigation water action. Irrigation with fresh water promoted the desalinization of the naturally solonetzic virgin soil. The content of Na + K from the sum of the absorbed cations is reduced, from 4.3% to 3.3% (0-25 cm) and from 3.6% to 2.4% (25-50 cm). Due to agriculture use, as well as irrigation by sprinkling, there have been changes in agrophysical indicators of virgin soil. They consist of compaction, structural state deterioration, decrease in the strength of the microstructure and the water resistance of aggregates of dark chestnut steppe soil.

Key words*: agriculture use, dark chestnut soil, evolution, irrigation, soil indicators.*

INTRODUCTION

In recent decades, as a result of increasing the anthropogenic pressures on soils, unbalanced land use, increasing areas of degraded land and climate change, the most urgent and priority area of action, both internationally and nationally, is the sustainable management of soil resources for the purpose protection and balanced use of them, achieving a neutral level of degradation, adapting agriculture to arid conditions for ensuring the country's food security and sustainable development goals.

In recent years, global warming has been observed, the water availability of crops in arid zones has decreased, which necessitates the use of irrigation. Climate, as an environmental factor, affects the development of biological, chemical, physical processes, soil properties.

The introduction of methods and principles for sustainable soil management is also one of the key among the five activities of the Global Soil Partnership of the FAO. To maintain and multiply productive, ecological, biological functions of soils, to ensure the fulfillment of ecosystem services, it is necessary to comply with the scientific and methodological principles of sustainable management (Revised World Soil Charter, 2015).

MATERIALS AND METHODS

To assess the impact of agricultural use, irrigation, climate conditions on the soil formation properties of dark chestnut solonetzic soil, the systematic approach, synthesis methods, comparative analysis were used. Observations were carried out on the stationary sites with various uses - absolutely virgin soil (from Natural biosphere reservation „Askania-Nova"), irrigated (the term irrigation is about 60 years old) and non-irrigated soils. The objects of research are located in the zone of the Steppe Dry Ukraine (Kherson region). For irrigation is used the water from the Kakhovka main canal through a network of inter-farm and on-farm canals. The is represented by a dark chestnut weakly solonetzous, light loamy soil on the loess loam. The content of physical clay is 60-66% in the 0-50 cm soil layer. According to the level of ground water, the soils are characterized by automorphic conditions - more than 10 m from the surface. Irrigated and non-irrigated plots are used in the field crop

rotation. The soil indicators were determined be State Standards of Ukraine.

RESULTS AND DISCUSSIONS

As a result of agricultural development of soils and their use in plowed fields, the natural phytocenoses are transformed, and the direction of soil formation processes is changing. The scale of the transformation depends on the degree of human impact on the soil. With extensive use of land, soil processes tend to have the same orientation as under natural conditions, and with the increase in the ameliorative load (under irrigation), the landscape-ecological situation, the direction and speed of elementary soil processes change, the agrogenic transformation of the composition and properties occurs in soils.

The objects of research are located in a zone with a temperate continental climate with hot dry summer (Балюк, 2016). Kherson region is characterized by the lowest values of the Selyaninov hydrothermal coefficient, which varies between 0.71 ... 0.46, thus, the climatic conditions affect the soil productive capacity. In order to increase the productivity of agricultural crops in this zone, it is necessary to develop irrigation.

The results of the studies indicate that in cultivated soils the water, air, nutrient, biological regime changes (Пухова, 2011). It should be noted that the parameters of virgin soil differ from agrozems - anthropogenically transformed soils. Irrigation enhances the spatial heterogeneity of the properties of arable soils. Morphological analysis of soil profiles of the investigated objects indicates that the upper part of the soil profile is transformed into a qualitatively new cultivated horizon with altered parameters and properties due to soil treatment and the operation of good quality irrigation water (Воротынцева, 2017).

For soils of the Dry Steppe, an important index is the composition of the soil-absorbing complex, which determines the physico-chemical, physical properties of the soil, since the dark chestnut soils are solonetzous in nature. It should be noted that as a result of the long-term influence of the factors studied, changes in the content of sodium and potassium solonetizing soils have occurred. As a result of plowing of virgin soil, its introduction into agricultural use, application of ameliorative methods, there have been changes in the orientation of soil processes and regimes, which contributed to decrease in the concentration of sodium and potassium in the 0-25 and 25-50 cm layers of dark chestnut irrigated soil in comparison with the virgin soil: from 4.7% to 4.2% (0-25 cm) and from 2.9% to 2.5% (25-50 cm) (Figure 1).

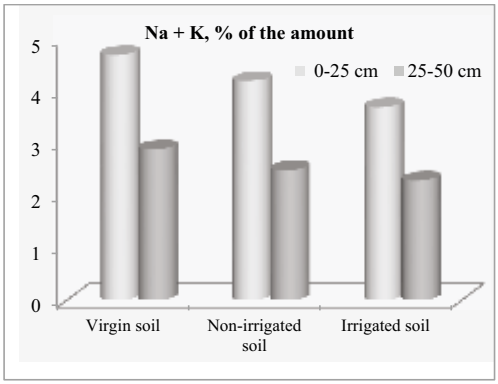

Figure 1. Changes in solonetizing of dark chestnut soil under the influence of agricultural use and irrigation

By the years of research, the dynamics of the absorbed cations content is noted. In irrigated soil under the action of fresh water and the improvement of the water regime, take place the desalinizes of the initial naturally solonetzic soil. According to the results of research conducted in 2016, the content of Na + K from the sum of absorbed cations decreased from 4.7% to 3.7% (0-25 cm soil layer) and from 2.9% to 2.3% (25-50 cm soil layer), which contributed to the improvement of physical and chemical properties of the soil.

In the absorbed cations of the studied soils, the calcium predominates, the content of which in the virgin soil in the 0-50 cm layer is 70-77% of the sum of all cations. As a result of changes in the water, air, and biological conditions of the dark chestnut soil (as a result of agricultural use), quantitative changes occurred in the cation composition of the absorbed cations: in non-irrigated soil, the content of absorbed calcium decreased to 60-70%, and under irrigation conditions - up to 60-66%. But at the same time, the concentration of absorbed magnesium increased from 23-30% in the virgin soil to 28-36% in arable soil.

Therefore, we can assume that the absorbed magnesium influences the solonetzization of the soil, determines the morphological features and agrophysical indices (clumpiness and compaction).

Long-term mechanical tillage of soil is the most significant factor that can cause negative, stable changes in agrophysical indicators and physical condition of soils, which leads to the development of degradation processes. The bulk density indicator of virgin soil differ from agrozemes (Figure 2).

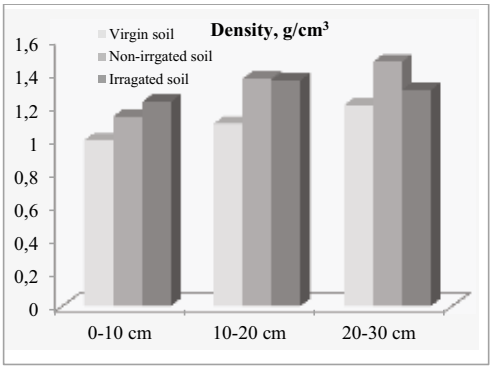

Figure 2. Density of dark chestnut soil for different uses

The results of investigations showed that in virgin dark chestnut soil the equilibrium density in the upper 0-10 cm layer was 1.00 g/cm^3, and with depth increased to 1.22 g/cm^3 (20-30 cm) and 1.37 g/cm^3 (30-40 cm). As a result of prolonged agricultural use of dark chestnut soil in the 0-10-cm layer, this index significantly increases to 1.14 g/cm^3 (non-irrigated soil) and 1.23 g/cm^3 (irrigated soil) - the smallest significant difference (SSD) - 0.08. In arable soils at a depth of 10-30 cm, the plow outsole is formed due to the different depths of tillage, and the density increases significantly to 1.30-1.47 (SSD for 10-20 cm soil layer - 0.08; for 20-30 cm - 0.14).

The bulk density of soils increases with a decrease in the amount of humus. In the upper elluvial layer of virgin soil, the humus content varied within 5.0-5.5% (0-25 cm) and in the upper layer of arable soil it decreased to 2.9-3.2% (0-25 cm), which is associated with a change in the functional structure of the microbial cenosis, type of vegetation, and physical and chemical properties of soil.

The introduction of soils into agricultural use contributed to the deterioration of the structural state of dark chestnut soil - a decrease in the strength of the microstructure and the water resistance of aggregates. Under the influence of irrigation and agricultural use, the structural coefficient decreases. So, in virgin soil, this index in 0-10 cm and 15-25 cm layers was 2.4-2.5, and in irrigated fell to 1.2-1.4, which indicates the deterioration of soil structure as a result of destruction and decreasing the number of agronomically valuable aggregates with a size of 0.25-10 mm and increasing the amount of lumpy fraction (larger than 10 mm) (Воротынцева, 2017).

The results of investigations of the nutrient regime of dark chestnut soils of various uses have shown that there are differences in the content of mobile forms of nitrogen, phosphorus and potassium in virgin soil and arable soils. According to the content of mineral nitrogen, virgin soil is characterized by a high degree of availability, non-irrigated - low, irrigated - medium, according to State Standards of Ukraine DSTU 4362 (Figures 3, 4).

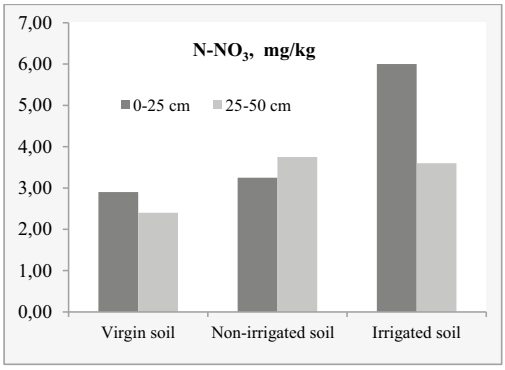

Figure 3. Content of nitrate nitrogen in dark chestnut soil of various uses

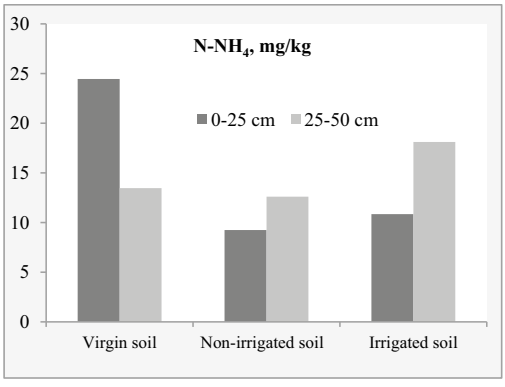

Figure 4. Content of ammonium nitrogen in dark chestnut soil of various uses

According to the availability of mobile phosphorus (Figure 5), dark chestnut soil was characterized by an average (virgin, non-irrigated soil) and its increased content (irrigated soil). An increase in the content of mobile forms of this element can be associated with an increase in the solubility of its compounds as a result of an improved water regime.

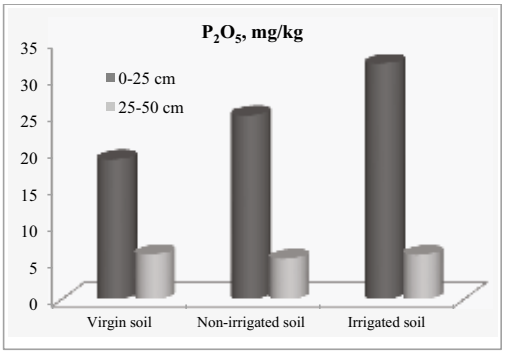

Figure 5. The content of mobile forms of phosphorus in dark chestnut soil of various uses

The content of mobile forms of potassium was characterized by an increased level of content, but somewhat higher in the variant with virgin soil (Figure 6).

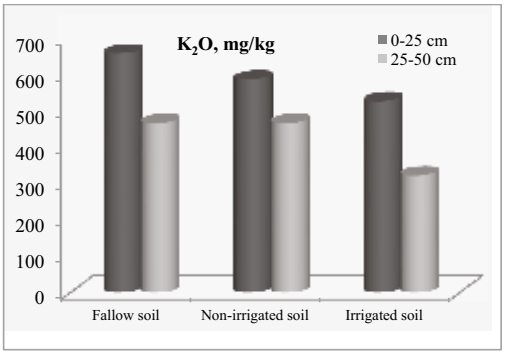

Figure 6. The content of mobile forms of potassium in dark chestnut soil of various uses

Thus, the soil availability of nutrients is influenced by the nature of soil use, the crop culture, the fertilizer application system, and the water regime.

CONCLUSIONS

The introduction of lands into agricultural use leads to a change in the factors and conditions of soil formation, the direction of the evolution of dark chestnut soil. For Dry Steppe conditions the factor that affects the properties and condition of the soil, the performance of its ecosystem services is a climate that is characterized by low values of the hydrothermal coefficient.

The introduction of virgin soil into agricultural use led to a change in the composition of the soil absorbing complex. There is a decrease in the content of absorbed sodium and potassium in non-irrigated soil in comparison with virgin soil from 4.7% to 4.2% (0-25 cm layer) and from 2.9% to 2.5% (25-50 cm layer).

In the irrigated soil under the influence of fresh irrigation water, the process of desalinization was more intense: the content of Na + K from the sum of the absorbed cations decreased from 4.7% to 3.7% (0-25 cm layer) and from 2.9% to 2.3% (25-50 cm), which contributed to the improvement of the physical and chemical properties of the soils.

Long machining and irrigation as anthropogenic factors led to a change in the physical state of the soils: soil compaction, a decrease in the strength of the microstructure and the water resistance of the aggregates. Due to active land use and transformation of the soil microbial coenzyme structure, dehumification processes are developing and changes in nutrient regime.

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