Change of water-physical properties of mountainous meadow-chernozem soils of the republic of Armenia under the influence of anthropogenic factor

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Abstract. The aim of the article is to study the direction of negative changes in water-physical properties occurring in meadow-chernozem soils under the influence of anthropogenic factor. The "soil keys" method was used to determine the location of transects. Field researches were conducted on the same-type relief areas, when comparing virgin and arable variants of soils. Soil samples were taken from the main sections by genetic horizons. In the article results of research on the influence of anthropogenic factors on the change of the water-physical properties of the mountain meadow-chernozem soils of the Republic of Armenia are presented. At the present stage the issues of storing and improving fertility of mountainous meadow-chernozem soils are very acute. These soils, under long-term use under agricultural crops, undergo considerable changes in the direction of deterioration, leading to activation of degradation processes of soils. Long-term and unsystematic agricultural use of mountainous meadow-chernozem soils leads to increase of their density. Soil porosity, its moisture capacity, mechanism of moisture movement, etc. depend on soil density. The studies conducted have shown that the density of the tilled layer of virgin soils is generally favourable for the growth and development of plants, but the upper part of the soil profile is somewhat compacted in the tilled variants. The data on porosity of mountain meadow-chernozem soils show that the soils studied are characterised by satisfactory general porosity. High porosity is especially in the whole-loam soil variants. In the arable soils some deterioration of water properties is observed. The results of maximum hygroscopicity, maximum field moisture capacity, and range of active moisture and moisture content of stable wilting slightly decrease.

1 Introduction

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Agricultural crops, undergo considerable changes towards deterioration, leading to activation and degradation of soil erosion processes. Now the most important factors contributing to deterioration of mountainous meadow-chernozem soils of the republic are changes in their water-physical properties. This naturally has a negative influence on soil fertility and yields of agricultural crops. Questions on water-physical and physical properties of soils of the republic in different time were studied by many authors who give data on moisture of steady wilting, limiting field moisture capacity, range of active moisture, volume and specific mass, water permeability, and also physical properties of these soils. Ways of rational use and measures are proposed for improving the basic properties of these soils. However, questions of change of water-physical properties under influence of the anthropogenic factor of mountain meadow-chernozem soils are insufficiently studied.

The aim of this work is a complex study and assessment of the negative consequences of the influence of anthropogenic factors on the physical and water properties of mountain meadow-chernozem soils.

2 Methods

The research material is mountainous meadow-chernozem soils of the Republic of Armenia, which have undergone changes due to long-term and unsystematic human economic activities. The field studies were carried out in the same-type relief areas, comparing virgin and arable variants of soils. To study soils in nature, establish boundaries between different soils, take soil samples for analyses, soil sections were laid. To determine the location of the transects, the "soil keys" method was used. Soil transects were made in the same type of terrain, up to the depth of the parent rock, which were described and classified. In loose bedrock, the depth of soil transects reaches up to 1-1.5m, while in dense bedrock they are comparatively shallower. In such areas, the depth of the incision usually reaches the bedrock. If there is a horizontal overland (drainage) network in the study area, half of the transects are placed in the centre and the other half in the inter-drainage zone.

Soil samples were taken from the main transects by genetic horizons and, if necessary, from half-sections. The selected soil samples were transported from the field to the laboratory, where they were dried (brought to air-dry condition), after which the samples were crushed and passed through a 1.0 mm sieve. The resulting melkozem is used for various analyses. In field conditions were also studied:
- volumetric weight by drilling in each 10 cm up to the depth of 50-60 cm in triple repetition;
- ultimate field water absorption capacity (FWC) by pouring over squares (2x2 m) with further sampling for moisture determination.

Laboratory works were carried out in the laboratory of the Soil Genesis and Geography Department of the G.P. Petrosyan Scientific Centre of Soil Science and Agrochemistry. The soil samples were taken by the laboratory of Genesis and Geography Department of Soil Science and Agrochemistry Center under the National Agrarian University of Armenia using generally accepted methods in soil science.

In laboratory conditions specific gravity was determined by pycnometric method; maximum hygroscopicity by Nikolayev; moisture content of stable wilting by Dolgov; range of active moisture was determined by calculation based on data of PWC and FWC by comparison of virgin and arable soils basic water-physical properties of soils were revealed.
3 Results

Meadow-chernozem soils are distributed in the chernozem belt in Ashotsk Plateau, Lori Steppe, Shirak Plain and Sevan Basin. Total area of these soils equals around 13 thousand hectares, i.e. 0.4 percent of total area of the country.

Meadow-chernozem soils are half-hydromorphic analogues of chernozems and are formed in conditions of close groundwater occurrence with seasonal wetting of upper part of profile. Groundwater is at the depth of 1.5-2.0 m. Soil-forming rocks of meadow-chernozem soils are alluvial and dealluvial deposits of quaternary basalts and andesite basalts. Natural vegetation of meadow-chernozem soils differs much from that of chernozems and is of meadow origin. The morphological structure of meadow-chernozem soils is similar to that of automorphic leached chernozems. However, peculiar hydrological conditions give intensive colouring of upper humus horizons and contribute to their increased humus content.

Their association with groundwater or long-term stagnation of surface water is accompanied by specific features—formation of brown spots of iron oxide and blue stains of gleying.

The nature of changes in the main water-physical properties of mountain meadow-chernozem soils under the influence of anthropogenic factor can be seen in Figures (1-8).

The uncultivated surface layer of meadow-chernozem soils is friable due to the content of quite a lot of organic matter and high texture. Its density is 0.90 g/cm³ (Fig. 1).

Density of the soil increases in arable horizons and reaches 1.12 g/cm³, and in subsoil horizon it increases even more to 1.30 g/cm³ (Fig. 2).

In soils without gleying and in soils with weak signs of gleying density increases slowly, but in soils with highly gleyed horizons density increases. Let's note that according to a number of researchers at oybemogo weight (OW) more than 1.60 g/cm³ plants cannot develop root system [1-3]. The specific weight (SW) on a profile of these soils varies considerably in the top rather rich humus horizons its size more often varies within the limits 2.43-2.53, and in the bottom layers in connection with gradual reduction of the organic matter content and increase in quantity of ferrous compounds considerably increases 2.70-2.71 g/cm³ (Fig. 1, 2).

Fig. 1. Physical properties of meadow-chernozem soils (virgin land)

Fig. 2. Physical properties of meadow-chernozem soils (arable)
Porosity of soils with weak signs of fire along the whole profile is high, but even on these soils with moisture content equal to field moisture capacity, free from moisture space only in the surface horizon is satisfactory for normal aeration. In the subsoil layer aeration pores are below the critical level. If in 0-20 cm layer of virgin soil total porosity is 63%, in 0-50 cm layer it is 56.3%, in cultivated layers it is equal to 55.7 and 49.4%. The given data indicate that in arable variants of mountain meadow-chernozem soils there is a marked decrease of total porosity [4-6], (Fig. 3, 4).

Mountain meadow-chernozem soils are characterised by high maximum hygroscopic capacity (MH). The highest values of MH are observed not in top soil layers, but in middle and lower parts of profile, where soil is to some extent gleyed. Moisture content in one meter layer of virgin soil reaches 163.5 mm.

The value of permanent wilting coefficient (WLC) along the whole profile is high and varies little. Moisture reserves at POD in one-meter layer of these lands are 247.1 mm [7-10] (Fig. 5).
Fig. 5. Water properties of mountain meadow-chernozem soils, mm (virgin land)

- Maximum field water holding capacity (IFC) of upper horizons of virgin meadow-chernozem soils is high, 57.7%, which determines a wide range of active moisture rate (AMR) (Fig. 6).
- Arable soils' field water holding capacity is greatly influenced by soil density, which in turn leads to reduction of productive moisture stocks. Reserves of productive moisture in one meter layer of these soils are 291.2 mm.

Fig. 6. Water properties of mountain meadow-chernozem soils, % (virgin land)

Fig. 7. Water properties of mountain meadow-chernozem soils, % (arable)
It is necessary to regulate the water regime by lowering the groundwater table, loosening compacted layers by sowing perennial grasses, especially legumes, whose root systems use large amounts of moisture from the lower layers and act as biological drainage [11, 12]. Thus, in case of no crop rotations and low level of agrotechnics, there is a significant deterioration of overall physical properties. The density of such soils, both in the arable and in the subsoil horizons, increases considerably, and this, in turn, leads to a decrease in total porosity, field moisture capacity and active moisture range. At the same time there is a sharp decrease in water permeability [13–15].

4 Conclusion

The long-term and unsystematic agricultural use of mountain meadow-chernozem soils leads to an increase in their density. Research conducted has shown that the density of the arable layer of virgin soils is as a whole favourable for growth and development of plants, however, in arable variants the upper part of a soil profile is a little compacted.

The data given on the porosity of mountain meadow and chernozem soils show that the soils studied are characterised by satisfactory general porosity. Especially whole types of soils have high porosity.

In the arable soils some deterioration of water properties is observed. The results of maximum hygroscopicity, maximum field moisture capacity, and range of active moisture, and moisture content of stable wilting slightly decrease.

References


Fig. 8. Water properties of mountainous meadow-chernozem soils, mm (arable)


