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Morphological structure, agrophysical and agrochemical properties of irrigated typical gray and grass soils

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Abstract. The article presents information on morphological structures, general physical and agrochemical properties of typical irrigated gray and grassland soils. The general physical properties of the soil are that in typical gray soils the bulk density decreases and the porosity increases, while in grassland soils the bulk density decreases and the total porosity increases compared to typical gray soils. A typical irrigated gray soil is composed of large dust particles according to its mechanical composition and belongs to the category of medium sandy loam. According to the level of availability of humus and nutrients of the studied soils, typical gray and meadow soils irrigated are low in humus (0.36-0.87%), very low in mobile phosphorus (5.33-15.60 mg/kg), exchangeable potassium It is highlighted that it is provided with low (100-200 mg/kg).

1 Introduction

Soils, like other bodies, have a set of external signs, that is, certain morphological indicators. Morphological features of the soil are formed as a result of the processes of its formation and naturally reflect its chemical and physical properties. Based on the study of soil morphology, it is possible to have an insight about its composition, chemistry of the processes taking place in the soil [1-3]. Clearly, the cross-section of the soil characterizes the change of all its properties along the vertical. Also, the morphological features of the soil have an important diagnostic value in determining the type of soil, describing the soil, and determining the level of erosion [4, 5].

Typical gray soils occupy the middle part of the gray soil region and are found between 300 and 600 meters 800 m above sea level, depending on the soil climate 400 m. The total area of typical gray soils in the republic is 3 million 51 thousand hectares [6]. Typical gray soils are distributed in the middle and upper parts of the plains below the mountain, in the upper and middle terraces of the river valleys, partly in the hills and low mountain foothills. Typical gray soils occupy the largest area in Tashkent region on the upper terraces of Keles, Chirchik and Ohangaron rivers in the surrounding foothills [7]. Also, in the foothills and hills around the Fergana valley, in the foothills and upper terraces of Zarafshan, between Kitab-Shahrisabz mountain, the typical gray soil land consists of loess and loess-like

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deposits. In the foothills and hills, typical gray soils consist of proluvial, deluvial, and alluvial soils with skeletal-fine soil, calcareous and gravelly parent rocks [8, 9]. Furthermore, meadow soils form a large area in the middle and lower parts of the floodplains formed by the river. It can be found in the form of a single region in the sub-mountain slopes of Fergana, Zarafshan valleys, the Chu River valley. Grassland soils are characterized by the dark gray color of the upper layers and the presence of turf and good structure [10-13].

Knowledge of agrophysical properties under irrigated farming conditions plays an important role in improving the production properties of the land. In particular, mobile nutrient elements in the soil are often determined by agrophysical properties. L. T. Tursunov, I. Turapov and others have conducted studies on the physical properties of desert and semi-desert zone soils [6]. In the researches, specific characteristics of the agrophysical properties of typical irrigated gray soils have been identified.

The mechanical composition of the soil and its structural condition are related to the agrophysical properties of the soil, and water, air, and heat affect the physical and mechanical properties of the soil. Many scientists have conducted scientific research on the impact of physical and mechanical properties on soil fertility [6-7, 11-12]. According to them, the mechanical composition of the soil is one of the main indicators in the description of the soil, which is related to water-physical and physical-mechanical properties [1-3]. The surface layers of newly developed irrigated soils on the farm have gravelly layers, which cause some difficulty in their agrotechnical processing. In ancient irrigated soils, a gravel layer is found 2-3 meters below, in some cases at 1-2 m depth. The mechanical composition is largely expressed depending on the agrophysical properties of the soil (comparative and volume weight, porosity, moisture capacity and water permeability). Besides, it is known from the research on the mechanical composition of the soil that with the increase in the dispersion of soil particles and volume weight, hygroscopic moisture, maximum hygroscopic moisture capacity and capillarity also increase, water permeability decreases.

To date, many scientists have conducted scientific research on the agrochemical properties of soils distributed in Uzbekistan, and in their scientific researches, they have collected enough information about the agrochemical properties of different types of soils. [8-13].

The remains of many organic substances, consisting of plant residues, accumulate in the soil. Usually, the number of organic residues is higher in the upper layers of the soil than in the lower layers. The amount of plant residues in the territory of Uzbekistan is 0.8-1.5 tons per hectare in the dry desert regions, and 4-6 tons in the gray soil region, depending on the natural climatic conditions. The main source of humus formation in the soil is the organic remains of green plants that accumulate on the surface of the earth and between the soil layers [1-3, 11]. A large number of microorganisms and the remains of vertebrates living in the soil are also a source of humus accumulation to a certain extent. Hydromorphic soils are rich in mineral and readily hydrolysable forms of nitrogen, which are essential for the vegetation layer. It is known that the total amount of nitrogen is directly related to the amount of humus. Nitrogen in mineral form occurs mainly in the form of nitrate in gray soils, and in the form of ammonia in hydromorphic soils [8].

However, the agrophysical properties of hydromorphic soils have not been studied to this extent. Therefore, it is aimed at investigating the thickness of the humus layer, the color of the upper “A_h “arable layer, and the upper limit of the beginning of new wounds and the agrophysical properties of meadow soils, such as bulk density, porosity, moisture and fertility of the soil depend on the mechanical composition of the soil.

2 Materials and Methods

In this research, Yangiyul and Urtachirchik districts of Tashkent region were selected as a study site, where all research experiments were conducted towards analyzing morphological structure of typical gray and grassland soils [6]. The total land area of Tashkent region is 1,525,540 hectares, of which irrigated typical gray soils are 363,000/hectare, meadow soils are 190,800/hectare. Clearly, two different experiments were undertaken: in the first experiment, improvement of soil fertility of typical and grassland soils was investigated through mulching plants residues, and the second one was done using different type of fertilizers [3-4]. Noteworthy, the experiments on typic gray soils were made in three variants with three iterations, however, in the case of grassland soils, it was 7 variants with three iterations. After field experiments, all data were analyzed in the laboratory using generally accepted methods. Clearly, all experiments were conducted based on following manuals, such as "Methods of Conducting Field Experiments" developed by UzPITI scientists. Furthermore, soil analysis was done using E.V. Arinushkina`s manual namely Soil Chemical Analysis Guide [9].

Cross section 1. Irrigated typical gray soil, located in contour 8, average seed germination, planted with cotton variety S-6524 in arable land of the Experimental farm of the Scientific Research Institute of Agricultural Mechanization and Electrification of Uzbekistan, Yangiyol district, Tashkent region. Accordingly, followings were described:

A_{kh}. 0- 31 cm. Dark gray, moderately wet, medium-sandy according to mechanical composition, moderately compacted, half-decayed plant remains, transition to the next layer is sharp, with moisture and plant roots;

V_1. 31- 53 cm. Light gray, weakly moistened, medium sandy, dense compared to the upper layer, earthworm (animal) traces, half-decayed plant remains are found, there are carbonates in the form of dots, the transition to the next layer is sharp, with color and density; V_2. 54- 80 cm. Light gray, poorly moistened, medium sandy, small plant roots are found, there are carbonate stains, transition to the next layer is not noticeable, with carbonate stain;

S. 80- 120 cm. Light gray, moderately wet, medium sand, very small plant roots are found, a few animal nests, transition to the next layer is gradual, with moisture;

S_1. 120- 150 cm. Light gray, moderately wet, soft, medium sandy, moderately dense, some plant roots, carbonate stains are found, transition to the next layer with gradual moisture;

S_2.150-200 cm. Light gray, more wet than the upper layer, medium sand, denser than the upper layer, some thin root veins and carbonate stains are found.

Cross section-5. Irrigated meadow soils formed on light sandy and alluvial deposits. The followings were identified from the experiments conducted at "Makhmudov Bakhtiyor Agro" farm, Okhunboboev territory, Ortachirchik district, Tashkent region.

0- 28 cm. bluish gray, wet, the mechanical composition is medium sand, plant roots are dense, scaly, soft, stone occurs, the transition to the next layer is clear, with the mechanical composition;

28-45 cm. Bluishness is gray, wet, slightly sandy according to the mechanical composition, the roots of plants are sparse, sparse, bluish spots are found, it is clear to move to the next layer, with moisture and bluish spots;

45- 47 cm. Sandy layer;

47- 90 cm. Bluish gray, loose, light sand according to mechanical composition, plant roots are sparse, scaly, closely spaced, bluish spots are found;

90- 120 cm. The color is gray, loose, the mechanical composition is light sand, the roots of the plant are sparse, flaky, densely arranged, blue spots are found, no new wounds and inclusions are found.

3 Results and Discussion

The results of the research experiments showed that erosion processes affected the thickness of the humic layer in typical gray soils. In these soils, the humus layer ($A+V_1+V_2$) was 40- 80 cm. It was reported that carbonates were found in the form of white pores and their distribution limit was observed at the depth of 45-80-100 cm. According to the mechanical composition, it was formed on medium and heavy sand, loess bed. Moreover, the research was undertaken on irrigated grassland soils. Accordingly, the color of the lower part of the soil gradually was bluish-gray due to increasing moisture, and rust spots appear. As a result of strong marlization of the soil at a depth of 50-150 cm, the flow became dark. In this marly layer, carbonate concentrations were formed in large quantities, and in some places, cemented (solid rock-like) layers of calcium carbonate were formed. Furthermore, water-soluble salts (mainly sodium, sulfate and gypsum) appear in the soil in the lower parts of the plains in the form of white spots and veins, and at a depth of 70-120 cm, a dense layer called formed by the accumulation of calcium carbonate, appears.

According to the morphological records of meadow soils, these soils were different from typical gray soils in terms of mechanical composition, distribution of carbonate and gypsum crystals. In these soils, blue spots and gypsum crystals were found and the surface layer consisted of stone and some layers of sand and gravel layers. It was found that the level of seepage water was 120-200 cm. As a result of long-term irrigation of hydromorphic soils, its morphological, genetic, chemical composition, physical properties and soil fertility were formed by agroirrigated layers, and its thickness and composition were changed.

It was observed that these soils differ from each other according to the morphological records of typical gray, grassy soils of the studied area, which are humus layer thickness, mechanical composition, carbonate and gypsum crystals differ according to the distribution limit and the level of seepage water. It was reported that in typical gray soils, the thickness of the humus layer was 40-80 cm, and the mechanical composition was medium and sometimes heavy sand. Moreover, Meadow soils have light and medium sandy mechanical composition, the presence of separate sandy layers, meadow soils have light mechanical composition, blue spots and gypsum crystals are found, the surface layer is stone and some layers consist of sandy and gravelly layers.

The results of the experiment on general physical properties of soils showed that the mechanical composition became heavier, the intermediate active moisture content was 50%, the amount of physical clay and silt did not exceed 25%. It can be concluded that the mechanical composition of the soil depends on the formation of the soil and the mother rock.

The results depicted that depending on the mechanical composition, the bulk density of typical irrigated gray soils was 1.31 g/cm^3 in the top soil, and it was 1.33-1.38 g/cm^3 in the subsoil. It was found that the relative weight was 2.69 g/cm^3 to 2.72 g/cm ^{3} along the layer. However, in the irrigated meadow soils, the bulk density was 1.29 g/cm ^{3}, and in the lower layer, it was 1.39 g/cm^3. Total porosity ranged from 49.3% to 51.3% across layers in irrigated typical gray soils, whereas it was ranged from 50.3% to 48.1% across layers in irrigated grassland soils (Table 1).

Table 1. General physical properties of studied soils.

#	The name of the soil	Cutting depth	Volume is heavy, g/cm^3	S is the weight of the sample , g/cm^3	Total porosity %
1	K-1 A typical gray soil that is irrigated	0-31 31-53 53-80 80-120 120-150 150-200	1.31 1.33 1.34 1.36 1.36 1.38	2.69 2.71 2.72 2.70 2.72 2.72	51.3 50.9 50.7 49.6 50.0 49.3
2	K-5 irrigated meadow soil	0-28 28-45 47-90 90-120	1.29 1.35 1.39 1.39	2.60 2.61 2.67 2.68	50.3 48.2 47.9 48.1

In short, the general physical properties of the soil are reflected in all the currents passing through it and in the soil types. In particular, the general physical properties of the soil in typical gray soils have decreased bulk density and increased porosity. In grassland soils, the bulk density decreases and the total porosity increases compared to typical gray soils. This porosity participates in all processes in the soil and is considered one of the main factors determining soil fertility.

Regardless of the morphological structure, the soils studied are medium and heavy loam according to their mechanical composition. According to the mechanical composition, one or another fractions (coarse sand (1.0-0.05 mm), medium sand (0.05-0.01 mm), fine dust (0.01-0.001 mm) and silt (from 0.001 mm small)) is determined to prevail.

It was found that the typical irrigated gray soil was composed of large dust particles according to its mechanical composition and belongs to the category of medium sandy loam. The results showed that the amount of physical clay in the depth of 31-53 cm layer in the experimental field of UzMEI was 32.4-33.7%, and the amount of physical clay in the lower layer increased to 33.8-37.5%, respectively. According to its mechanical composition, meadow soils (section 5) are light loamy in the upper 0-28 cm layer, the amount of physical clay was 29.79%, in the 28-45 cm layer it is medium loam, and in the lower 90-120 cm layer, the amount of physical clay was 20.64%. In fact, it was slightly gray according to its mechanical composition (Table 2).

Table 2. Mechanical composition of studied soils.

Section # soil type,	Depth, cm	Fraction, mm							Physical clay
		> 0.25	0.25 - 0.1	0, 1 - 0.05	0.05-0.01	0.01-0.005	0.005-0.001	< 0.001	
K-1 A typical gray soil that is irrigated	0-31	0.8	0.2	13.1	53.2	10.7	12.0	9.7	32.4
	31-53	0.4	0.1	17.0	50.1	10.7	9.4	12.6	32.7
	53-80	0.8	0.2	16.5	48.8	14.0	10.6	9.1	33.7
	80-120	0.4	0.1	10.9	54.8	13.3	14.6	5.9	33.8
	120-150	0.5	0.1	12.6	50.0	15.2	14.6	7.0	36.8
	150-200	0.4	0.1	14.3	47.7	14.2	14.5	8.8	37.5
K-5 Irrigated meadow soil	0-28	0.8	0.5	17.8	51.0	3.9	12.5	13.2	29.7
	28-45	0.9	0.8	10.0	52.3	14.0	10.6	11.2	35.8
	47-90	0.8	0.8	10.0	48.0	10.0	12.5	17.4	40.0
	90-120	0.9	0.7	16.1	62.5	6.01	0.68	12.9	19.6

It can be said that the typical irrigated gray soil was composed of large dust particles according to its mechanical composition and belongs to the category of medium sandy loam. In the upper layers, the amount of physical clay increased to 32.4-33.7%, whereas in the lower layers it increased to 33.8-37.5%. According to the mechanical composition of meadow soils, it is light loam and medium loam, and the amount of physical clay in the upper layers was 29.79% and in the lower layer, it was 19.64%. This situation can be due to the processes of soil formation and the structure of the lithological profile.

Moreover, the experiments on chemical and agrochemical properties of soils were undertaken. Accordingly, the level of nutrient supply of the investigated irrigated soils in typical gray soils, especially, the amount of humus in the plow layer and sub-plot layers was low, accounted for 0.65-0.81%. Furthermore, the total nitrogen content was 0.046-0.080%, and phosphorus was 0.373%, and potassium was 1.37-1.50%. It was recorded that there was very low supply of mobile phosphorus, which was 10.0-5.33 mg/kg, and the supply of exchangeable potassium was also low, accounted for 120-200 mg/kg. Interestingly, CO_2 carbonates ranged from 8.30 to 8.55% across the soil cross section (Table 3).

Table 3. Agrochemical properties of studied soils

Sections	Soil layer, cm	Humus, %	Total, %			Active, mg/kg		CO^2	SO_4 gypsum, %
			N	P	K	P_2O_5	K_2O		
K- 1 Irrigated typical gray soil	0-31	0.81	0.080	0.373	1.50	10.0	200	8.30	-
	31-53	0.65	0.060	0.295	1.37	6.53	180	8.48	-
	53-80	0.48	0.046	0.203	1.37	5.33	150	8.50	-
	80-120	0.40	0.030	0.172	1.20	5.27	150	8.55	-
	120-150	-	0.028	0.155	1.12	4.67	120	-	-
	150-200	-	0.013	0.144	1.07	4.33	120	-	-
K-5 Irrigated grassland soil	0-28	0.87	0.082	0.463	1.62	15.60	145	6.33	0.230
	28-45	0.77	0.068	0.348	1.50	12.80	120	6.37	0.263
	45-90	0.60	0.045	0.313	0.80	5.33	115	6.47	0.271
	90-120	0.36	0.022	0.123	0.80	6.67	100	6.37	0.304

It was reported that in irrigated meadow soils, the humus content was 0.87% in the upper layer and it was 0.36% in the lower layer. However, the total nitrogen content fluctuated from 0.022% to 0.082% along the section, and the total phosphorus was 0.463% in the upper layer, followed by 0.123% in the lower layer, and 0.123% in the upper layer. The results represented that the potassium was 1.50% in the upper layer, and in the lower layer it was 1.07%. Noteworthy, the top layer was very low in mobile phosphorus, which was 10.0 mg/kg, whereas it was 4.33 mg/kg in the the bottom layer, and the exchangeable potassium was low, which was 200 mg/kg and 100 mg/kg in the top and bottom layers, respectively (Table 3).

According to the obtained data, the irrigated typical gray and meadow soils were low in humus (0.36-0.87%), followed by very low in mobile phosphorus (5.33-15.60 mg/kg). It was found that the exchangeable potassium was also low, accounted for 100-200 mg/kg, and this has a negative impact on the growth and development of agricultural crops. Therefore, in order to increase the productivity of these soils, it is necessary to use agrotechnologies aimed at enriching them with organic matter.

4 Conclusions

The results of the research experiments showed that erosion processes affected the thickness of the humic layer in typical gray soils. In these soils, the humus layer ($A+V_1+V_2$) was 40- 80 cm. It was reported that carbonates were found in the form of white pores and their distribution limit was observed at the depth of 45-80-100 cm.

The results depicted that depending on the mechanical composition, the bulk density of typical irrigated gray soils was 1.31 g/cm^3 in the top soil, and it was 1.33-1.38 g/cm^3 in the subsoil. The results of the experiment on general physical properties of soils showed that the mechanical composition became heavier, the intermediate active moisture content was 50%, the amount of physical clay and silt did not exceed 25%. It can be concluded that the mechanical composition of the soil depends on the formation of the soil and the mother rock.

It can be said that the typical irrigated gray soil was composed of large dust particles according to its mechanical composition and belongs to the category of medium sandy loam. In the upper layers, the amount of physical clay increased to 32.4-33.7%, whereas in the lower layers it increased to 33.8-37.5%.

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