

Physical-mechanical and technological properties of eroded soils

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Abstract. The research aims to study and analyze the physical-mechanical and technological properties of eroded soils in Uzbekistan. The data on the susceptibility of water erosion to sloping lands is presented. The average monthly indicators of precipitation over the last ten years in Uzbekistan are analyzed. The results of determining the moisture, density, and hardness of the soil of slopes are presented. It has been established that with the traditional technology of tillage on moisture, density, and other technical properties of soil of slopes, water erosion and slope of fields have a significant effect. The physical-mechanical and technological properties of soil of the arable and subsurface layers of the soil of the top, the middle and lower part of the slope in spring and after grain harvesting differs significantly: in the spring period, the moisture of soil layers 0-10; 10-20; 30-40; 40-50 and 50-60 cm of the lower part of the slope is more moisture content of these layers of the top respectively, 1.16; 1.24; 1.1; 1.4; 1.54 and 2.15 times. Approximately such a picture of moisture is preserved after grain harvesting as well.

1 Introduction

It is known that the development of new technologies and technical means, providing a high quality of soil cultivation with minimal energy consumption is impossible without determination of the physical-mechanical properties of soil [1–32], especially soils, subjected to wind and water erosion.

To a greater extent of wind erosion, mainly the soils of rain-fed lands are subjected. Rain-fed lands are mainly located on foothill plains and foothills. The slope of the terrain characterizes them. In Uzbekistan, practically the whole territory of rain-fed land is included in the arid zone [33–42]. The drought in the rain-fed land is a major factor, limiting crop yields. Therefore, on sloping rain-fed lands, the crop, first of all, depends on accumulation, conservation, and rational use of soil moisture.

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properties of eroded soils in Uzbekistan.

2 Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study.

According to Kh.M. Makhsudov [38], rain-fed lands in Uzbekistan, suitable for agriculture, is 2 mln. 130 thousand hectares. 710 thousand hectares are light grey-land, 814 thousand hectares are typical, 306 thousand hectares are dark-desert, and 300 thousand hectares are carbonate-brown mountain soils. 29% of rain-fed land is insufficiently supplied with rainfall. According to Kh.M. Maksudov's calculations, 700.4 thousand hectares of rain-fed lands are subjected to water erosion, from which 416,5 thousand hectares are of the greater and average extent [38].

Kh.M. Makhsudov [38] believes that for the effective use of rain-fed lands, it is necessary to solve the following actual tasks: increase and preservation of moisture in the soil, as well as effective usage of it; avoiding the development of erosion processes and increase of soil fertility, susceptible to erosion.

The erosion processes, especially water erosion to a high extent, are affected by agrometeorological conditions, in particular, atmospheric precipitation and their intensity [33, 34]. There have been studied the materials of Uzbek hydro-meteorological Center over the last eight years on the quantity of precipitation, wind speed, the temperature of air and soil in all regions of the Republic of Uzbekistan [42]. The analysis has shown that the average values of wind speed, precipitation, the temperature of air and soil across the territory of Uzbekistan, in the context of regions, are different from each other. A very important factor affecting water erosion is the quantity of precipitation and their intensity in a short period. The largest precipitation occurs in the districts with piedmont plains and foothills.

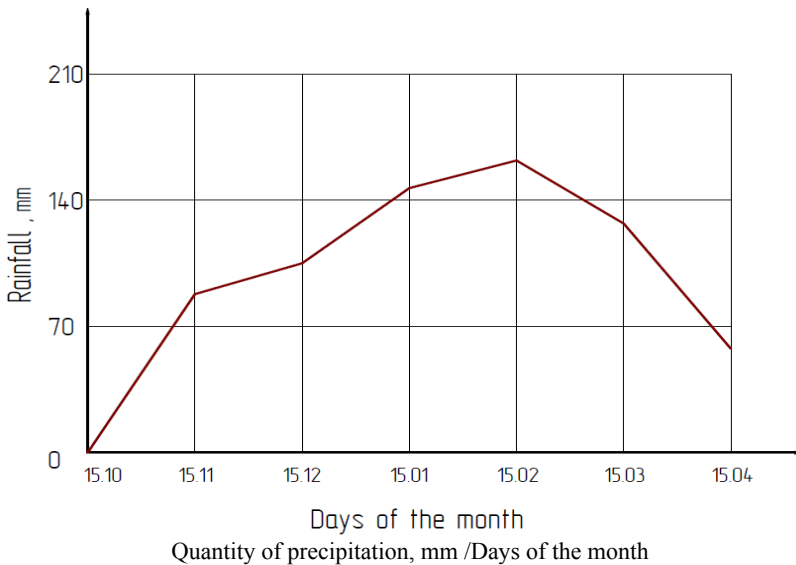


Fig. 1. Average monthly indicators of precipitation from October 15 to April 15 over the last 10 years

It can be seen from Fig. 1 that the greatest fallout of precipitation occurs in January, February, and March. During this period, average daily precipitation ranges from 129.1 to 153.7 mm. The largest average of daily rainfall is in February - 153.7 mm. With the

existing technology of tillage, such intensity and quantity of precipitation lead to water erosion of the soil (Figure 2 a and b).



Fig. 2. Characteristic description of manifestation of water erosion in the sloping fields

3 Results and Discussion

In Uzbekistan, numerous investigations have been carried out to study the physical-mechanical and technological properties of soil [33–36], [40]. Mainly, these investigations were conducted on irrigated soils. The analysis has shown that the physical-mechanical and technological properties of soils of rain-fed lands, especially slopes, have not been studied enough.

It is known that the physical-mechanical and technological properties of soil depend on its type, moisture, and mechanical composition, before the technology of tillage, relief of fields, and others. One of the investigation's main objectives is to study the existing technology of tillage for the formation of physical-mechanical and technological properties of soil slope, which is the basis for the development of new anti-erosion technologies and technical means for the treatment of tillage.

The study of the physical and mechanical properties of soils was carried out in the fields of farming in the Kamashi district of the Kashkadarya region of Uzbekistan. The climate is sharply continental, extremely arid, with high summer temperatures. The type of soil is medium loamy light gray-land. The pitch of the field is 7°. The density and moisture of soil were determined by the testing method with Litvinov instrument, and hardness measurer of Revyakin determined the hardness of soil with a conical tip, the base area of which is 1 cm².

One of the factors affecting the significant extent of quality and energy intensity of tillage is the soil's moisture. On the other hand, on the moisture of soil slope, there can be estimated erosion processes.

Studies have shown that for the formation of moisture, density, and other technical properties of soil, water erosion affects significantly. The moisture of soil slopes was determined at different periods: in spring and summer (after grain harvesting) at the top, in the middle and lower part of the slope.

The graphs show (Fig.3, *a* and *b*) that the moisture of the arable and subsurface layers of soil at the top, the middle and lower part of the slope, and spring and after grain harvesting differs significantly.

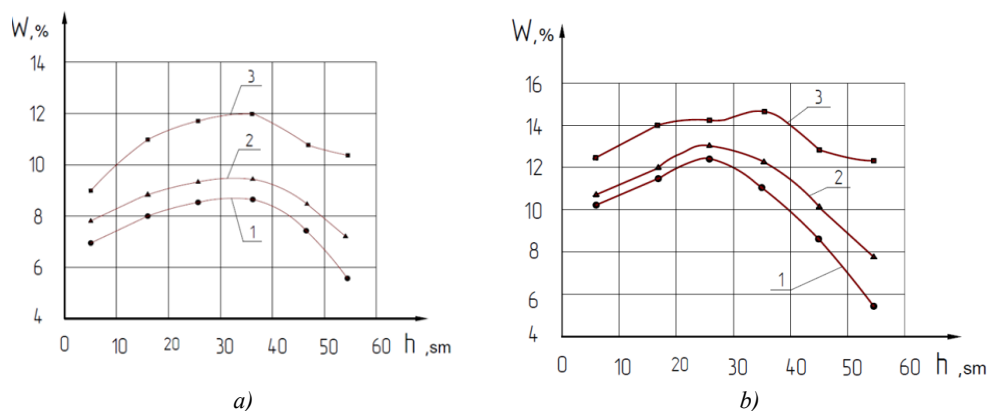


Fig. 3. Dependence moisture of grey-land soil on the depth of horizons: *a* is in spring; *b* is after grain harvesting; 1 is at the top of the slope; 2 is in the middle of the slope; 3 is in the lower part of the slope

For instance, in spring period the moisture of soil layers 0-10; 10-20; 30-40; 40-50 and 50-60 cm of the lower part of the slope is greater moisture of these layers of the top, respectively, 1,16; 1,24; 1,28; 1,4; 1,54 and 2,15 times. Approximately such a picture of moisture is preserved after grain harvesting. It proves that the precipitation is flown down to the lower part of the slope due to water erosion.

In the spring period at the top, the maximal humidity has a layer of 20-30 cm. With the increase of the depth of the layer initially, the humidity is increased and then intensively is decreased. The moisture of the layers 0-10 cm and 20-30 cm, respectively, is 1,82 and 2,54 times higher than the humidity of the lower layer 50-60 cm.

In the lower part of the slope, the humidity of the layers 0-10 cm and 50-60 cm is nearly the same, and the humidity of the layer 20-30 cm is insignificant, i.e., 1,08 times higher the humidity of the lower layer 50-60 cm. By this, the humidity of the layers 0-10 cm and 50-60 cm of the lower part of the slope is, respectively, 1,16 and 2,14 times higher than the moisture of layers 0-10 cm and 50-60 cm at the top.

In the summer period, after grain harvesting at the top and lower of the slope, the minimal humidity is at the top and lower layers of the soil. By this, moisture of soil with the increase the depth of the layers initially is increased (up to layers 30-40 cm), and then it is decreased.

The analysis of the studies has shown (Tables 1 and 2) that in the spring period at the top, the maximum density has layers of 10-20 cm and 20-30 cm. Their density is nearly the same. With the increase in the layer of soil, the density initially increases and then decreases. The density of the layer is 20-30 cm, respectively, to 1,1 and 1,13 times higher than the density of the layer 0-10 cm and 5-60 cm.

In the lower part of the slope, the layer of 10-20 cm is more condensed. With the increase in the depth of horizon, the density is initially increased, and then it is decreased to the layer of 50-60 cm, and in the lower layer of 50-60 cm, it is increased again. The density of the layer is 10-20 cm, respectively, to 1,14 and 1,09 times more than the layers 30-40 and 50-60 cm.

Table 1. The density of grey-land soil in spring (g/cm³)

The depth of horizon, cm	The density, g/cm ³		
	In the top of the slope	In the middle of the slope	In the lower part of the slope
0-10	1.17	1.18	1.23
10-20	1.29	1.33	1.38
20-30	1.28	1.27	1.24
30-40	1.24	1.22	1.21
40-50	1.22	1.19	1.16
50-60	1.14	1.21	1.27

Table 2. The density of grey-land soil after grain harvesting (g/cm³)

The depth of horizon, cm	The density, g/cm ³		
	In the top of the slope	In the middle of the slope	In the lower part of the slope
0-10	1,21	1,21	1,25
10-20	1,29	1,35	1,4 1
20-30	1,31	1,34	1,34
30-40	1,26	1,25	1,31
40-50	1,20	1,20	1,27
50-60	1,14	1,19	1,28

The density of soil layers 0-10 cm, 10-20 cm, and 50-60 cm of the lower part of the slope is higher than the density of these layers at the top of the slope. The density of the layer is 50-60 cm of the lower part of the slope, 1.17 times higher than the density of this layer at the top of the slope.

The hardness of the soil was determined in spring and after grain harvesting. The results of determining the hardness of the soil are shown in tables 3 and 4.

From table 3, it can be seen that in spring on all parts of the slope, the hardness of soil initially to the 30-40 horizon is increased, and then in the 40-50 cm horizon it is decreased, and in the 50-60 cm horizon is increased again. By this, a noticeable increase is observed in the horizon of 50-60 cm at the top and in the middle of the slope. The maximum hardness has a horizon of 20-30 cm.

Table 3. Hardness of grey-land in spring (in MPa)

The depth of horizon, cm	Hardness , MPa		
	In the top of the slope	In the middle of the slope	In the lower part of the slope
0-10	0.99	1.47	1.86
10-20	2.41	2.21	2.53
20-30	3.06	2.98	2.79
30-40	2.11	2.01	1.74
40-50	2.33	2.12	1.68
50-60	2.51	2.43	1.69

Table 4. Hardness of grey-land soil after grain harvesting (in MPa)

The depth of horizon, cm	Hardness, MPa		
	In the top of the slope	In the middle of the slope	In the lower part of the slope
0-10	2.88	2.67	2.31
10-20	3.90	3.71	3.21
20-30	4.01	4.12	3.82
30-40	3.74	3.75	4.29
40-50	3.70	3.72	3.81
50-60	3.26	3.63	3.80

The hardness of soil after grain harvesting on all parts of the slope initially is increased, and then it is decreased (Table 4).

The maximum hardness is observed at the top and in the middle of the slope in the layer of 20-30 cm and in the lower part of the slope- in the layer of 30-40 cm.

4 Conclusions

It has been established that with the traditional technology of tillage on moisture, density, and other technological properties on the soil of the slopes have slopes of fields and water erosion. The physical-mechanical and a technological property of soil of the arable and subsurface layers of soil at the top, middle, and the lower part of the slope in spring and after grain harvesting differs significantly:

1. In spring period, soil moisture of layers 0-10; 10-20; 30-40; 40-50 and 50-60 cm of the lower part of the slope are greater moisture of these layers at the top, respectively to 1,16; 1,24; 1,1; 1,4; 1,54 and 2,15 times. Approximately this picture of moisture is preserved after grain harvesting as well;
2. In the spring period at the top, the maximum moisture has a layer of 20-30 cm. With the increase in the depth of the layer, the moisture is initially increased, and then it is decreased intensively. The moisture of layers 0-10 and 20-30 cm, respectively, 1.82 and 2.54 times higher than the moisture of the lower layer of 50-60 cm. In the lower part of the slope, the moisture of the layers 0-10 and 50-60 cm is nearly the same, and the moisture of the layer 20-30 cm is 1.08 times higher than the humidity of the lower layer 50-60 cm. By this, the moisture of the layers 0-10 and 50-60 cm of the lower part of the slope is 1,16 and 2,14 times higher than the moisture of the layers 0-10 cm and 50-60 cm at the top;
3. After grain harvesting at the top and the lower of the slope, the minimum moisture has the upper and lower soil layers. In this case, the moisture of soil with the increase the depth of layers initially is increased (to layers 30-40 cm), and then it is decreased;
4. At the top, the maximum density has a layer of 10-20 cm and 20-30 cm in the spring period. In this case, with the increase of layer of soil, the density initially is increased, and then it is decreased. The density of the layer is 20-30 cm, respectively, to 1,1 and 1,13 times higher than the density of the layer 0-10 and 50-60 cm. In the lower part of the slope, the 10-20 cm layer is more condensed; its density is 1.08 times higher than the density of this layer at the top of the slope. With the increase in the depth of horizon, the density is initially increased, and then it is decreased to a layer of 50-60 cm, and in the lower layer of 50-60 cm is increased again. The density of the layer is 10-20 cm, respectively, 1,14 and 1,09 times higher than the layers of 30-40 and 50-60 cm. The density of the layer 50-60 cm in the lower part of the slope is 1,17 times higher than the density of this layer at the top of the slope.

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