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"THE EFFECT OF LAYERED FERTILIZATION OF WINTER WHEAT ON WATER PERMEABILITY IN EXPERIMENTAL FIELDS AFFECTED BY IRRIGATION EROSION"

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Annotation

As a result of irrigation erosion caused by improper irrigation, varying soil fertility appears within the same crop field. The upper parts of the slope experience soil washing, while the eroded material accumulates in the lower flat areas. This situation necessitates layered fertilization of crops: in the eroded upper areas, plant growth is poor, whereas in the lower, accumulated parts, nutrients concentrate excessively, leading to overgrowth of crops — in particular, wheat tends to lodge (fall over).

At present, in our republic, along with cotton cultivation, more than 1.1 million hectares of land are sown with cereal crops. However, studying the layered fertilization of winter wheat depending on the slope of fields affected by irrigation erosion plays a significant role in solving existing problems. Therefore, under the conditions of typical irrigated gray soils that have long been subjected to irrigation erosion, researching the layered fertilization of winter wheat is considered one of the most pressing issues of today.

Keywords

land, soil, irrigation erosion, cotton, layered fertilization, winter wheat, mineral fertilizers, slope, water permeability.

Introduction. Currently, in our republic, a classification system for land erosion has been developed, and an erosion map has also been created. As a result of erosion processes, several soil types are formed — non-eroded, slightly eroded, moderately eroded, severely eroded, and eroded-down areas. These soils differ in fertility, the thickness of the fertile layer, the reserve and composition of humus, the amount of nutrient elements (macro- and microelements), the quantity and quality of microorganisms, as well as their chemical, physical, and biogenetic properties.

In Uzbekistan, the main requirement of the agrarian policy regarding land use is to account for every inch of irrigated farmland and to increase its productivity. Today, the lands most intensively used in agriculture are mainly irrigated areas, covering about 4.28 million hectares. More than 90 percent of the country's total agricultural output is produced on these lands. Currently, several negative processes that reduce soil fertility are occurring on irrigated lands. One of the most significant factors negatively affecting soil productivity is water and irrigation erosion.

In our republic, eroded lands cover 1,772.3 thousand hectares, accounting for 40 percent of the total arable land area. The most negative aspect is that, under the influence of irrigation erosion, the humus layer of the soil and the most essential nutrients required for crops are washed away, resulting in decreased agricultural productivity on irrigated lands.

As a result of irrigation erosion, the genetic layer of the typically irrigated gray soils has changed: in the eroded "A" horizon, its thickness has decreased, while in areas where eroded material has accumulated, the depth of the upper layer has increased.

It was found that when fields on sloping land were plowed along the contour and irrigation was carried out in alternate rows, and winter wheat was applied with layered mineral fertilization, soil fertility was maintained, and irrigation erosion was reduced.

The effectiveness of applying nitrogen fertilizers on soils affected by irrigation erosion was determined by Sh.N. Nurmatov [1]. The optimal timing, rates, and methods of applying mineral fertilizers were studied. Research on the effectiveness of different forms of nitrogen fertilizers showed that on eroded soils, when 150 kg/ha of ammonium sulfate and urea nitrogen were applied before sowing, the additional cotton yield was 1.6 and 1.8 c/ha higher, respectively, compared to ordinary ammonium nitrate.

According to Z. Muminova [2], the grain yield of winter wheat grown on lands affected by irrigation erosion, particularly on eroded soils, was 38–43% lower compared to areas not affected by erosion.

According to X.X. Xamdamov and Q.M. Mo'minov [3], to achieve high yields across the entire slope on eroded typical gray soils in Samarkand region, mineral fertilizers should be applied in a layered manner as follows: on severely eroded soils, 300 kg/ha of nitrogen (N), 300 kg/ha of phosphorus (P), and 90 kg/ha of potassium (K) should be applied, while in the eroded-down areas, these rates should be reduced by 60–70%.

Initial studies on the application of mineral fertilizers on eroded soils began in the 1930s and were conducted by H.W. Gardner [4]. In his experiments, the potato yield in the control variant was 78 c/ha, whereas with the application of nitrogen, this indicator increased to 342 c/ha.

According to S. Zokirova [5] and others, the phenomenon of erosion — the removal or washing away of the soil's upper layer — is related to both exogenous and endogenous processes. Endogenous (internal) processes include tectonic movements such as volcanic eruptions, earthquakes, landslides, extraction of mineral resources, and shifts around water reservoirs. Exogenous (external) processes occur as a result of sunlight, mechanical, physical, and chemical impacts.

Data on irrigation erosion and some measures to combat it in such areas are presented, including the application of mineral fertilizers and fertilization of winter wheat on irrigated lands.

Experimental Field Methods. The Central Experimental Farm of the Uzbekistan Cotton Research Institute is located in Qibray district of Tashkent region, 7–8 km from the Chirchiq River, on the right bank of the Boʻz irrigation canal, about 20 km northeast of Tashkent city. The institute's site is situated on a plain, along the wind direction blowing from the Korjon hill slope, which is part of the Chotqol mountain range, from south to west. Its altitude is approximately 576 meters above sea level.

According to P.N. Besedin and P.N. Suchkov (1939), the soils of the Oq-Qovoq (Central Experimental Farm of the Uzbekistan Cotton Research Institute) have long been irrigated, are non-saline, and have deep groundwater (about 20 m), representing typical gray soils. The humus layer has a thickness of 0–70/80 cm, with total phosphorus at 0.170% and potassium at 2.0%. In the 20–40 cm layer, humus content is 1.29%, total nitrogen 0.09%, and total phosphorus 0.14%. These soils are poorly supplied with humus and total nitrogen. The humus content decreases with soil depth. According to their mechanical composition, the gray soils are medium to heavy sandy loams.

To classify the experimental field, a soil pit up to 2.0 meters deep was excavated, and morphological observations were conducted (based on data from A. Dehqonov). The morphological descriptions of the soil profile are presented according to the horizon elements.

Before conducting the research, data on the mechanical composition of the soil taken from the experimental field are presented in Table 1. The types of soil from the plowed layer, eroded, and eroded-accumulated areas did not differ significantly in sand content. Similarly, there was little difference in the content of coarse silt (0.05–0.01 mm); however, differences were observed in the amounts of medium and fine silt and clay. Specifically, in the eroded-accumulated areas, their amounts were higher compared to the eroded areas, which in turn affected changes in the soil's physical clay. The physical clay content was higher in the eroded-accumulated part of the plowed layer, with the eroded soil belonging to light sandy loam, while the eroded-accumulated soil corresponded to medium sandy loam.

Prior to the experiment, the agrochemical characteristics of the field were determined. These data are presented in Table-1.

Table -1.

Mechanical composition of the experimental field soil, %

Soil Layers, sm	**Fractions, mm**							**Physical clay**
	1-0,25	0,25-0,1	0,1-0,05	0,05-0,01	0,01-0,005	0,005-0,001	0,001	
Eroded part of the slope								
0-30	3,56	3,73	28,89	39,70	1,66	16,56	10,90	29,12
30-50	1,20	1,41	13,23	53,40	0,30	17,26	13,20	30,76
50-74	0,34	0,30	30,98	43,66	1,04	9,98	14,20	24,72
74,132	0,20	0,31	31,43	46,12	2,84	8,52	10,38	21,74
132-155	0,24	0,34	17,44	39,68	3,94	29,44	13,42	42,30
Eroded-accumulated part								
0-30	2,05	3,71	21,60	37,28	5,00	13,86	14,30	33,36
30-50	1,59	2,77	26,90	37,06	0,20	6,12	25,36	31,68
50-74	1,88	2,93	16,75	49,94	3,70	8,26	16,56	28,50
74-132	1,48	2,26	21,50	50,32	0,84	8,14	15,76	24,44
132-155	0,92	0,97	24,97	48,16	2,12	5,98	16,88	24,98

According to the data in Table 2, in the plowed layer of the field soil, depending on the degree of erosion, the humus content ranges from 0.906 to 1.137%, total nitrogen from 0.090 to 0.110%, and phosphorus from 0.100 to 0.141%. The soil is also poorly supplied with nutrients in their mobile forms. In the lower, eroded-accumulated part, an increase in humus and both total and mobile forms of nutrients was observed.

Although the soils are typical gray soils that have long been irrigated, the poor provision of mobile nutrients in the experimental field is due to soil washing caused by irrigation erosion. In the eroded parts of the field, soils are low in nitrogen, medium in phosphorus, and insufficient in potassium. In contrast, in the lower, flat areas where soil has accumulated, the aforementioned elements are present in sufficient to medium amounts.

This situation indicates the need to apply fertilizers in a layered manner when fertilizing wheat.

Table 2

Initial agrochemical characteristics of the experimental field soil

Soil Layers, cm	**Total forms, %**			**Mobile forms, mg/kg**		
	Humus	Nitrogen	Phosphorus	$N\text{-}NO_3$	R_2O_5	K_2O
Eroded part						
0-30	0,906	0,090	0,100	10,8	33,0	120
30-50	0,453	0,059	0,096	6,5	16,8	80
50-70	-	-	-	8,7	11,1	60
70-100	-	-	-	7,6	10,8	50
Eroded-accumulated part						
0-30	1,137	0,110	0,141	17,9	53,0	220
30-50	0,839	0,080	0,108	11,1	33,1	140
50-70	-		-	8,1	11,2	70
70-100	-		-	7,6	10,8	60

Methodological conditions. In conducting experiments on fields affected by irrigation erosion, several important aspects of mineral fertilizer application were taken into account. On sloping lands, irrigation often causes irrigation erosion, and many factors influence the effectiveness of applied mineral fertilizers, affecting both yield and the accuracy of the experiment.

Therefore, in our studies, the experiments were conducted based on the methodological guidelines developed by Q.M. Mirzajanov and S.S. Mayliboev [6]. These guidelines provide clear instructions on applying mineral fertilizers on lands affected by irrigation erosion.

To maintain and improve soil fertility in such areas, mineral fertilizers were applied to winter wheat in a layered manner. The experimental design is presented in the table. The field was divided according to the degree of erosion into two types: moderately eroded and moderately eroded-accumulated. Each variant was repeated three times across eight variants, with plot sizes of 324 m^2 (90 × 3.6 m). Winter wheat of the "Polovchanka" variety was sown.

The following mineral fertilizers were used in the experiment: ammonium nitrate (N-34%), ammophos (N-11%, P_2O_5-45%), and potassium chloride (K_2O-56%).

Phenological observations and calculations were carried out according to the "State Methods for Testing Agricultural Crops." To monitor the growth and development of winter wheat, for each variant and repetition, measurements were taken from five 1 m^2 sampling points.

Grain and straw yield data were analyzed using the dispersion analysis method according to Dospekhov (1965).

3.- Table

Experimental design

Treatment arrangement	**Experimental treatments**	**annual rates of mineral fertilizers, kg/ha**		
		N	R_2O_5	K_2O
Eroded part of the slope				
1	*Across the entire slope*	150	105	75
2	**Across the entire slope**	200	140	100
3	**Middle part of the slope (moderately eroded part)**	270	185	135
Eroded-accumulated part of the slope				
1	**Across the entire slope**	150	105	75
2	**Across the entire slope**	200	140	100
3	**Middle part of the slope (moderately eroded part)**	100	70	50
4	**Across the entire slope**	130	91	65
5	**Across the entire slope**	270	185	135

Note: The annual rates of phosphorus and potassium fertilizers were applied each year before plowing. For nitrogen fertilizers, 40% of the annual rate was applied during the winter wheat tillering stage, and 60% during the stem elongation stage.

Soil water permeability. Soil water permeability is an important physical property, largely determined by its mechanical composition, humus content, slope of the field, and other factors.

In our study, soil water permeability was assessed on a sloping experimental field (slope 2.5°), consisting of eroded and eroded-accumulated parts. The initial water permeability characteristics of the field soil, depending on the degree of erosion, are presented in Table 3.2.1. In the eroded part of the slope, the soil transmitted 1,761 m^3/ha of water over 6 hours, whereas in the eroded-accumulated part, it transmitted 1,872 m^3/ha during the same period.

4.- Table

Soil Water Permeability (Initial)

Hours	**Eroded Part of the Slope**	**Eroded-Accumulated Part of the Slope**

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	mm/min	m³/ha	mm/min	m³/ha
1- **hour**	16,0	1600	16,7	1670
2- **hour**	0,7	70	0,8	80
3- **hour**	0,5	50	0,5	50
4- **hour**	0,3	30	0,4	40
5- **hour**	0,1	10	0,3	30
6- **hour**	0,01	1	0,02	2
over 6 hours	17,61	1761	18,72	1872

Furthermore, hourly observations showed that water permeability was higher in the eroded-accumulated part of the field. We know that soil water permeability depends on its mechanical composition, bulk density, and porosity. In the eroded part of the slope, despite the lighter mechanical composition, the reduction in permeability is due to the decrease in humus content.

It was also found that the amount of mineral fertilizers applied in the eroded-accumulated part had a noticeable effect. Soil water permeability depends on mechanical composition, bulk density, and porosity. In the eroded part, the decrease in permeability is primarily caused by reduced humus.

According to the 2020 data, at the end of the winter wheat growing period, when mineral fertilizers were applied at the rate of N-150, P_2O_5-105, K_2O-100 kg/ha in the eroded part of the slope, the soil water permeability over successive observation hours was 4.1; 0.3; 0.2; 0.1; 0.1; and 0.07 mm/min, equivalent to 410, 30, 20, 10, and 7 m³/ha (see Table 3.2.1). When fertilizer rates were increased to N-200, P_2O_5-140, K_2O-100 kg/ha, the water permeability over 6 hours reached 4.93 mm/min or 493 m³/ha, which is 0.06 mm/min or 6 m³/ha higher than the previous variant.

Notably, even at lower fertilizer rates (N-100, P_2O_5-70, K_2O-50 kg/ha), water permeability in the eroded part was higher than in soils with N-270, P_2O_5-185, K_2O-130 kg/ha. The effect of mineral fertilizer rates on soil porosity significantly differs between the eroded and eroded-accumulated parts of the slope.

The highest values were obtained in the eroded-accumulated part with fertilizer rates of N-270, P_2O_5-185, K_2O-130 kg/ha, where 6-hour water permeability reached 5.49 mm/min or 549 m³/ha. According to S.V. Astapov's classification, eroded soils have low water permeability, while eroded-accumulated soils are classified as medium.

However, when fertilizers were applied at N-200, P_2O_5-140, K_2O-100 kg/ha in the eroded-accumulated part, water permeability was 5.44 mm/min or 544 m³/ha, only 0.05 mm/min or 5 m³/ha lower than the previous variant.

5.- Table

Soil Water Permeability (at the End of the Growing Period)

	Hours													
	1		2		3		4		5		6		6- **hour**	
	mm	m^3/ ha	mm min	m^3	mm min	m^3 ha	mm min	m^3 ha	mm min	m^3/ ha	mm min	m^3 ha	mm min	m^3/ ha
Eroded Part of the Slope														
1	4,1	410	0,3	30	0,2	20	0,1	10	0,1	10	0,07	7	4,87	487
2	3,3	330	0,6	60	0,5	50	0,3	30	0,2	20	0,03	3	4,93	493
3	3,1	310	0,6	60	0,5	50	0,4	40	0,3	30	0,08	8	4,98	498
Eroded-Accumulated Part of the Slope														
1	4,0	400	0,5	50	0,3	30	0,2	20	0,2	20	0,08	8	5,28	528
2	3,9	390	0,6	60	0,5	50	0,2	20	0,1	10	0,04	4	5,44	544
3	3,9	390	0,7	70	0,4	40	0,3	30	0,1	10	0,09	9	5,49	549
4	3,8	380	0,7	70	0,5	50	0,4	40	0,2	20	0,03	3	5,33	533
5	3,9	390	0,7	70	0,4	40	0,3	30	0,1	10	0,09	9	5,49	549

Conclusion

In conclusion, the best soil water permeability in the eroded part of the slope was observed when mineral fertilizers were applied at rates of N-270, P_2O_5-185, K_2O-130 kg/ha, while in the eroded-accumulated part, optimal results were obtained with N-200, P_2O_5-140, K_2O-100 kg/ha. Similar trends were observed in other years of research.

Under the influence of irrigation erosion, the water permeability of soils in the eroded part decreases year by year, whereas in the eroded-accumulated part, a slight improvement is noted. Typical gray soils affected by irrigation erosion differ in mechanical composition: the upper slope layer becomes lighter due to soil erosion, forming light sandy loam, while the lower, accumulated part consists of medium sandy loam.

In the eroded part, when fertilizers were applied at N-150, P_2O_5-105, K_2O-75 kg/ha, the soil bulk density increased by 0.02 g/cm³ compared to the lower accumulated part. Erosion processes and the amount of applied fertilizers had different effects on wheat growth and development. The maximum plant height in the eroded part was 105.7 cm, while in the accumulated part it reached 113.4 cm.

To achieve high and quality grain yield and economic efficiency under conditions of typical gray soils affected by irrigation erosion, it is recommended to apply mineral fertilizers in a layered manner: N-270, P_2O_5-185, K_2O-135 kg/ha in the eroded part, and N-200, P_2O_5-140, K_2O-100 kg/ha in the eroded-accumulated part.

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