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THE EFFECT OF SOIL TILLAGE METHODS ON THE AGROPHYSICAL PROPERTIES OF SOILS SUBJECTED TO IRRIGATION EROSION

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Abstract

This paper presents data on the influence of pre-sowing soil tillage methods, seeding rates, and fertilization norms on the agrophysical properties of soils under winter wheat cultivation on lands subjected to irrigation erosion.

Keywords

lands subjected to irrigation erosion, soil tillage methods, soil bulk density, aggregate (granular) structure, water permeability.

Introduction

Researchers have established that the structure of the arable layer can be regulated by altering the arrangement of soil aggregates. It is known that soil consists of three components - solid, liquid, and gaseous. The solid phase is composed of various mineral and organic substances of differing density. Soil bulk density (volume mass) refers to the ratio of the mass of an absolutely dry soil sample with undisturbed structure to its volume. Changes in soil bulk density are accompanied by corresponding changes in water permeability, moisture-holding capacity, aeration, and moisture retention, which in turn affect the nutrient and water regimes of the soil and, consequently, exert either a positive or negative influence on plant growth and development. For optimal plant development and high yields, a soil bulk density of 1.1–1.3 g/cm³ is considered favorable.

Soil bulk density varies depending on the degree of irrigation erosion and the extent of soil washout. As bulk density increases, soil aeration and moisture retention deteriorate (decrease), which in turn disrupts the plant's nutrient and water regimes and

reduces yield. On lands affected by irrigation erosion, the following are considered priority tasks: efficient use of irrigation water, reduction of soil particle washout, preservation and enhancement of soil fertility, development of agrotechnologies for producing high and quality yields of agricultural crops, rational and efficient use of land, water, fertilizer and other resources, and the development of resource-saving, innovative agrotechnologies to ensure food security, supply raw materials to industry, and provide nutritious feed for livestock.

Research Methods

Field studies were conducted on lands subjected to irrigation erosion to examine pre-sowing soil tillage methods, seeding rates, and fertilization norms for producing high and quality grain yields of winter wheat (Table 1). The methodology followed *Guidelines for Conducting Field Experiments* (Tashkent, 2007).

Research Results

Analysis of soil bulk density in the conducted experiments showed that soils subjected to irrigation erosion differ noticeably in bulk density from non-eroded soils; furthermore, weakly, moderately, and severely washed sections of the experimental field, as well as the zones where washed-off soil particles had accumulated along the slope, exhibited different bulk density values. Soil bulk density depends on mechanical composition, humus content, macro- and micro-structure, and salt content - parameters that are themselves closely linked to the degree of soil erosion at different points along the slope.

Table 1. Experimental design

№	Soil tillage method			Seeding rate, million seeds/ha	Mineral fertilizer rate, kg/ha
1	Sowing with inter-row cultivation between cotton rows at 12–14 cm depth	Sowing after chiseling at 16–18 cm depth	Sowing after autumn plowing at 28–30 cm depth	4,0	N_{150} P_{105} K_{75}
2				4,0	N_{200} P_{140} K_{100}
3				4,0	N_{250} P_{175} K_{125}
4				5,0	N_{150} P_{105} K_{75}
5				5,0	N_{200} P_{140} K_{100}
6				5,0	N_{250} P_{175} K_{125}

7				6,0	N_{150} P_{105} K_{75}
8				6,0	N_{200} P_{140} K_{100}
9				6,0	N_{250} P_{175} K_{125}

At the beginning of the growing season, the bulk density of eroded soils was found to be favorable for the germination, growth, and development of winter wheat. When inter-row cultivation between cotton rows was applied at a depth of 12–14 cm prior to sowing, the bulk density in the 0–30 cm layer was 1.30 g/cm³ (porosity 51.9%), and in the 30–50 cm layer 1.41 g/cm³ (porosity 47.8%). In the chiseled variants, bulk density decreased by 0.03 g/cm³ and porosity increased by 4.3 percentage points, while in the plots plowed to 28–30 cm depth, bulk density decreased by 0.05 g/cm³ and porosity increased by 5.9 percentage points.

As a result of the agrotechnical measures applied during winter wheat cultivation, bulk density increased in all variants by the end of the growing season. The highest value was recorded in the variant with inter-row cultivation between cotton rows, a low seeding rate (4 million seeds/ha), and a fertilizer rate of N150P105K75 kg/ha, where bulk density reached 1.48 g/cm³ (porosity 45.0%) in the 0–30 cm layer and 1.55 g/cm³ (porosity 42.8%) in the 30–50 cm layer. When the seeding rate under this tillage method was increased to 6 million seeds/ha, bulk density decreased by 0.07–0.05–0.06 g/cm³ in the 0–30 cm layer and by 0.08–0.04–0.02 g/cm³ in the 30–50 cm layer, with porosity reaching 47.7–48.7–49.6% in the 0–30 cm layer and 45.3–44.3–45.0% in the 30–50 cm layer (Table 2).

Under conditions of typical grey (sierozem) soils subjected to irrigation erosion, water permeability at the beginning of the growing season - with inter-row cultivation between cotton rows - was 875 m³/ha. By the end of the growing season, in the variant with a 4-million-seed/ha rate and the lowest fertilizer rate, water permeability was 638 m³/ha. When mineral fertilizers were applied at N200P140K100 and N250P175K125 kg/ha, water permeability was 657 and 723 m³/ha, respectively. In the plowed field with a seeding rate of 6 million seeds/ha, water permeability corresponding to the respective fertilizer rates was 811, 827, and 856 m³/ha. Overall, when the field was plowed in

autumn prior to sowing winter wheat, soil water permeability was improved compared with the variants receiving inter-row cultivation or chiseling.

Table 2. Effect of soil tillage methods, seeding rates, and mineral fertilizer rates on soil bulk density and porosity in lands subjected to irrigation erosion

№	Soil layer, cm	Inter-row cultivation		Chiseling		Autumn plowing	
		g/cm³	%	g/cm³	%	g/cm³	%
0 (initial)	0–30	1.30	51.9	1.27	53.0	1.25	53.7
	30–50	1.41	47.8	1.33	50.7	1.32	51.1
1	0–30	1.48	45.2	1.43	47.0	1.37	49.3
	30–50	1.55	42.6	1.48	45.2	1.47	45.6
2	0–30	1.43	47.0	1.42	47.4	1.36	49.6
	30–50	1.54	43.0	1.47	45.6	1.46	45.9
3	0–30	1.42	47.4	1.37	49.3	1.35	50.0
	30–50	1.50	44.4	1.47	45.6	1.45	46.3
4	0–30	1.44	46.7	1.42	47.4	1.36	49.6
	30–50	1.56	42.2	1.56	42.2	1.45	46.3
5	0–30	1.44	46.7	1.41	47.8	1.34	50.4
	30–50	1.54	43.0	1.55	42.6	1.43	47.0
6	0–30	1.43	47.0	1.40	48.1	1.33	50.7
	30–50	1.52	43.7	1.56	42.2	1.42	47.4
7	0–30	1.41	47.8	1.40	48.1	1.33	50.7
	30–50	1.47	45.6	1.51	44.1	1.40	48.1
8	0–30	1.38	48.9	1.38	48.9	1.32	51.1
	30–50	1.50	44.4	1.49	44.8	1.38	48.9
9	0–30	1.36	49.6	1.37	49.3	1.31	51.5
	30–50	1.48	45.2	1.44	46.7	1.36	49.6

Note: Rows 1–9 correspond to the treatment combinations listed in Table 1.

Conclusions

In the experimental plots where the field was autumn-plowed prior to sowing winter wheat, soil bulk density by the end of the growing season was lower - and porosity correspondingly higher - than in the plots receiving inter-row cultivation between cotton

rows or chiseling. As seeding rates and mineral fertilizer rates increased, soil bulk density decreased accordingly, following the same pattern across all tillage methods.

Regarding the agronomically valuable soil fraction (aggregate structure), among the tillage methods studied, plowing to a depth of 28–30 cm combined with a seeding rate of 6 million seeds/ha and mineral fertilizer rates of N150P105K75, N200P140K100, and N250P175K125 kg/ha produced the highest aggregate structure content in the 0–30 cm layer - exceeding the inter-row cultivation variant by 1.5% and the chiseling variant by 0.7%.

In the plots where the field was autumn-plowed prior to sowing winter wheat, soil water permeability was improved compared with the variants where the field received inter-row cultivation or was chiseled before sowing.

For the production of high and quality winter wheat grain yields on lands subjected to irrigation erosion, it is recommended to: plow the field to a depth of 28–30 cm and sow at a rate of 4 million seeds/ha; apply chiseling at 16–18 cm depth and sow at 5 million seeds/ha; or apply inter-row cultivation between cotton rows at 12–14 cm depth and sow at 6 million seeds/ha - combined in all cases with mineral fertilizer application at a rate of 200 kg/ha nitrogen, 140 kg/ha phosphorus, and 100 kg/ha potassium.

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