Effects of different salinity levels in topsoil on the growth, development and yield of winter wheat

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Abstract. In this article, winter wheat varieties "Andijan-2" and "Andijan-4" were fed with mineral fertilizers under the conditions of irrigated, salinized, light gray soils of different degrees of salinity in the Syrdarya region of Uzbekistan. Compared to the control option, the volume mass of the soil increased by 0.02-0.03 g/cm^3, the porosity of the soil decreased to 0.4-1.2%, and the water permeability of the soil increased to 3.8-23.6 m^3/ha. Depending on the level of salinity, it was found that 2.2-2.5 centners of additional grain yield was obtained between the open and cotton rows of "Andijon-2" and "Andijon-4" varieties of winter wheat on soils with different levels of salinity with mineral fertilizers at different rates. The standard of seasonal irrigation of winter wheat planted between open and cotton rows was 2850-3050 m^3/ha, water consumption was 98.9 m^3/ha in the open field without salinity, and 87.4 m^3/ha in the field planted between cotton rows. In accordance with the above, it was 118.3 and 106.1 m^3/ha in the field with low salinity, and 194.3 and 173.9 m^3/ha in the medium salinity field. In the maintenance of winter wheat varieties "Andijon-2" and "Andijon-4" on soils with different degrees of salinity, compared to the non-saline field, the net profit was 105,992 UZS and the rate of profitability increased to 16.1%.

1 Introduction

Today, wheat is planted on an area of 220.4 million hectares around the world, and the average grain yield is 34.0 quintals per hectare [1]. According to the Food and Agriculture Organization, 777.0 million tons of wheat grain will be grown in 2031 in the countries of the world. In the next 10 years, this indicator will require 9.6% or 74.6 million tons more crops to meet the demand for grain and flour products along with population growth [2]. For 2022, more than 1.03 million hectares of Uzbekistan, of which 273,600 hectares were planted in open fields and 756,800 hectares between cotton rows [3]. One of the urgent issues is the development and implementation of modern technologies that save land, water,

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fertilizers and resources, taking into account the change of natural climate, especially winter wheat from lands with different levels of salinity [4].

In the world, efforts are being made to manage land, water, fertilizers and resources in an integrated manner in the processes of ensuring high and quality harvests, with optimal nutrition of agricultural crops in saline lands [5]. According to the Food and Agriculture Organization of the United Nations (FAO), more than 833 million hectares of agricultural land in the world are saline, which is 8.7% of the global area [6]. In particular, in the conditions of global climate change, research on the development of irrigation and feeding efficiency in winter wheat planting and maintenance on soils with different degrees of salinity (non-saline, weak and moderate) is important [7]. That is why scientific research on saving the amount of mineral fertilizers and improving the reclamation of irrigated lands by further improving the care of winter wheat in Uzbekistan is an urgent topic [8].

In Uzbekistan's irrigated agriculture, scientific results have been implemented and based on the study of the effects of methods, procedures, techniques and technologies of irrigation of agricultural crops on the water-physical properties of the soil, nutrient regimes, plant growth, productivity and its quality [9]. However, in the conditions of irrigated light-colored gray soils of Uzbekistan's Syrdarya region, which are being grazed, the techniques of developing the effect of feeding winter wheat varieties "Andijan-2" and "Andijan-4" with mineral fertilizers on different levels of salinity have not been studied [10-12]. Scientific research on determining the effect of this technology on the water-physical properties of winter wheat and its growth and grain yield has not been sufficiently studied [13-16].

The purpose of the study is to develop the effectiveness of irrigation and mineral fertilizer feeding on soils with different degrees of salinity (non-saline, weak and moderate) in the maintenance of winter wheat in the open field and between cotton rows under the conditions of global climate change.

2 Materials and methods

This research was carried out on the farm "Nurli zamin tuhfasi" in Hamid Olimjon WCA, Gulistan district, Syrdarya region of Uzbekistan, in the conditions of soils with varying degrees of salinity of winter wheat varieties "Andijon-2" and "Andijon-4". In total, 3 iterations were carried out on planting care between open and cotton rows.

As the object of the study, irrigated light-colored gray soils under grazing, varieties of winter wheat "Andijan-2" and "Andijan-4", soils with different levels of salinity (non-saline, weak and moderate), and different rates of mineral fertilizers were taken. The subject of the research is to achieve high-quality grain yield when feeding winter wheat varieties "Andijon-2" and "Andijon-4" with mineral fertilizers on different saline soils, irrigation and water consumption of winter wheat, agrophysical and agrochemical properties of the soil, its growth, development, grain yield and its effect on grain quality indicators.

Settlement of field experiments and all measurements, observations and calculations "Methods of conducting field experiments", analyzes on determining the amount of nutrients in soil and plants based on methodological manuals "Methods of agrochemical and agrophysical research in irrigated cotton areas", data on wheat yield obtained by Dospekhov Mathematical-statistical analysis was performed using the method of dispersion analysis in the "Field experiment methodology" manual and the Microsoft Excel program [9-12].

The rate of irrigation of winter wheat was determined by the formula proposed by Ryzhov [10]:

$$m = (W_{LFMC} - W_{SMBI}) \; x \; 100 \; x \; J \; x \; h + k, \; m^3/ha$$

where: W_{LFMC} - limited field moisture capacity of the soil, in % by weight of the soil; W_{SMBI} - before irrigation soil moisture in % of soil weight; J - volumetric weight of soil, g/cm^3; h – soil depth, m; and, k - evaporative water consumption during irrigation, m^3/ha (10% of moisture deficiency in the soil depth).

3 Results and discussions

The amount of humus in the arable layer of the experimental field is 0.959%, total nitrogen is 0.098%, and total phosphorus is 0.263%, as well as nitrate nitrogen in reactive form is 20.6 mg/kg, reactive phosphorus is 34.5 mg/kg, and the exchangeable potassium content is 150.0 mg/kg, it was determined that humus supply is average, nitrogen supply is low according to the classification, phosphorus supply is average, and potassium supply is low.

In 2019, the volume mass in the 0-30 cm layer of the soil in the non-saline part of the field was 1.30 g/cm^3, 1.34 g/cm^3 at 0-50 cm, and 1.41 g/cm^3 at 0-100 cm, correspondingly in the weakly saline field without 1.30; 1.34 and 1.42 g/cm^3, and 1.32 in the field with average salinity; It was equal to 1.36 and 1.43 g/cm^3. By the end of the growing season, the volume mass in the 0-30 cm layer of the soil in the non-saline field was 1.31 g/cm^3, 1.35 g/cm^3 in the 0-50 cm layer, and 1.42 g/cm^3 in the 0-100 cm layer. Compared to the beginning of the growing season, 0.01-0.01 g/cm^3 is concentrated, and accordingly 1.32 in weakly saline field; 1.35 and 1.43 g/cm^3, and 1.34 in the field with average salinity; was 1.37 and 1.44 g/cm^3. Compared to the beginning of the growing season, it was observed that it thickened to 0.01-0.02 g/cm^3 in the field with low salinity and 0.02-0.03 g/cm^3 in the medium salinity field. Similar data were observed in 2020 and 2021. According to the results of agrophysical observation of the soil at the beginning of planting winter wheat between the rows of cotton, in 2019, in the non-saline part of the field, the volume mass in the 0-30 cm layer of the soil was 1.31 g/cm^3, in 0-50 cm 1.35 g/cm^3, in 0-100 cm to 1.42 g/cm^3, corresponding to 1.32 in weak saline field; 1.36 and 1.45 g/cm^3, and 1.33 in the field with average salinity; It was found to be 1.38 and 1.46 g/cm^3.

At the beginning of the 2019 growing season, the water permeability of the soil was 0.85 mm/min in the first hour, and 0.54 in the following hours; 0.38; 0.26; 0.16 and 0.10 mm/min and 0.38 mm/min at 6 hours. By the end of the growing season of 2020, this indicator had significantly decreased and was 1110 m^3/ha or 0.31 mm/min in the non-saline field. In 2021, it was 0.89 mm/min in the first hour, and 0.53 in the following hours; 0.39; 0.26; It was 0.17 and 0.10 mm/min, 0.39 mm/min in 6 hours. By the end of the 2020 growing season, it was 1086 m^3/ha or 0.30 mm/min. 1037 m^3/ha or 0.29 mm/min in low salinity field, 968 m^3/ha or 0.27 mm/min in medium salinity field, 1024 m^3/ha or 0.28 mm/min in 2020, 994 m^3/min in medium salinity field ha or 0.28 mm/min. According to Kachinsky, it was noted that the water permeability of the soil in the observed areas enters the system of the best water-permeable soils (Figure 1).

In 2019, limited field moisture capacity was 21.6% of dry soil weight in the 0-50 cm layer, 22.2% in the 0-70 cm layer, and 22.3% in the 0-100 cm layer; In 2020, 21.3% at 0-50 cm, 21.9% at 0-70 cm, and 22% at 0-100 cm; and in 2021, it was 19.3% at 0-50 cm, 20% at 0-70 cm, and 20.7% at 0-100 cm.

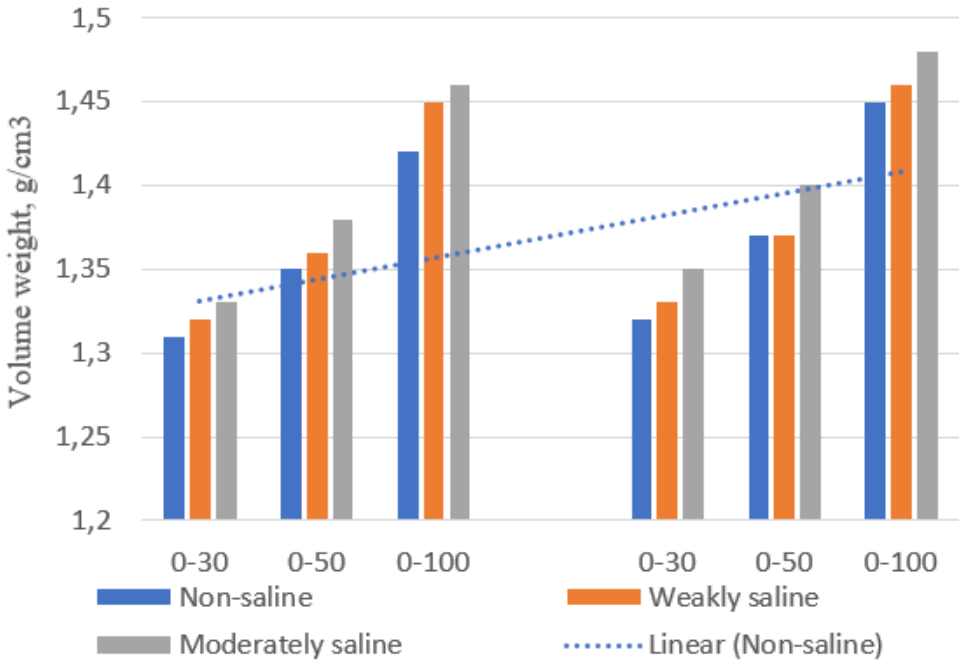

Figure 1. Effect of soil volumetric weight on open and intercropped winter wheat maintenance.

In the experimental years, after planting winter wheat seeds, due to the lack of moisture in the soil, 650-750 m^3/ha of seed water was applied annually. When irrigating winter wheat, the organization of irrigation by providing moisture to the 0.7 m layer of the soil made it possible to achieve good results in all respects (Table 1).

Table 1. Seasonal water consumption of growing winter wheat under different salinity soil conditions, three-year average.

Indicators		Non-saline		Weakly saline		Moderately saline	
		Bare field	**Between cotton rows**	**Bare field**	**Between cotton rows**	**Bare field**	**Between cotton rows**
Spring water reservoir, m^3/ha		4793	3768	4793	3768	4793	3768
Fall water reservoir, m^3/ha		2163.8	2163.8	2163.8	2163.8	2163.8	2163.8
Consumed water reserve	m^3/ha	2629.2	1604.2	2629.2	1604.2	2629.2	1604,2
	%	33.9	24.2	33.9	24.2	33.7	24,5
Irrigation water	m^3/ha	2958	2875	2992	2950	3050	3008
	%	38.4	43.5	38.5	43.9	38.9	44,9
Precipitation	m^3/ha	2064	2064	2064	2064	2064	2064
	%	26.7	31.3	26.6	30.9	26.4	30,6
Total, m^3/ha		7751	6643	7785	6718	7843	6776

Productivity, quintal/ha	29.9	32.9	25.3	27.8	15.7	17.3
Irrigation water used for 1 quintal crop, m^3/quintal	98.9	87.4	118.3	106.1	194.3	173.9
Yield based on 1 m^3 of irrigation water, quintal/m^3	9.9	8.7	11.8	10.6	19.4	17.4
Yield for 1 m^3 total water, quintal/m^3	2.6	2.0	3.1	6.5	5.0	3.9

During the irrigation of winter wheat, the rate of 1, 2 and 3 irrigations was irrigated at the rate of 900-1100 m^3/ha in three years in the field planted in the open field at 70-70-60% compared to the limited field moisture capacity (LFMC). Seasonal irrigation rate was 2900-3100 m^3/ha, while winter wheat was planted between cotton rows at 850-1050 m^3/ha and 2850-3050 m^3/ha, respectively.

According to the 2019 data of the experiment, at the beginning of the growing season, the amount of humus in the 0-30 cm layer of the soil was 0.959%, the amount of nitrogen was 0.098%, and the amount of phosphorus was 0.263%. Before harvesting the winter wheat crop, soil samples were taken from the cultivation (0-30 cm) and sub-cultivation (30-50 cm) layers, and the general forms of humus, nitrogen and phosphorus were determined.

By the end of the 2019 growing season, when all options were studied, the amount of humus in the 0-30 cm layer of the soil in the non-salted field was 0.960%, the amount of nitrogen was 0.099%, the amount of phosphorus was 0.264%, nitrate nitrogen-20.7 mg/kg, reactive phosphorus-34, It was observed that 6 mg/kg and exchangeable potassium was 150.1 mg/kg. In accordance with the above, the general form in the weakly saline field is 0.961; 0.100; 0.265%; reactive form 20.8; 34.7 and 15.2 ni, and the total form of 0.962 in medium salinity field; 0.101; 0.266%; reactive form 20.9; 34.8 and 150.3 mg/kg, or compared to the growing season - it was found that the general form increased to 0.002% and the reactive form increased to 0.2 mg/kg. Similar data were observed in 30-50 cm layers. Compared to the beginning of the growing season, it was observed that the general form increased by 0.002% and the reactive form by 0.2 mg/kg in all variants.

In the cultivation of winter wheat in the open field, it was observed that the amount of chlorine ion in the non-salted field at the beginning of the growing season was 0.016% in the 0-10 cm layer. It was observed that total alkalinity was 0.033% in the growing season, but it increased by 0.063% by the end of the growing season, or by 0.029% compared to the beginning of the growing season. Sulfate was 0.063% in the growing season, but by the end of the growing season it increased by 0.069%, or by 0.006% compared to the beginning of the growing season. It was observed that the dry residue increased by 0.285%, compared to the beginning of the growing season, by 0.291%, or by 0.006%, by the end of the growing season. The above information was also confirmed in fields with weak and medium salinity, that is, it was observed that the amount of sulfate and dry residue increased slightly by the end of the growing season. As a result, authorship copyright for software numbered DGU-08352-"Evaluation of soil salinity in winter wheat" was developed to evaluate soil salinity during winter wheat planting in the open field and between cotton rows.

Biometric indicators of winter wheat in 2020 in the non-salted field nitrogen-160, phosphorus-100, potassium-70 kg/ha in the 1st option, the length of the spike is 6.6 cm, the number of spikes in the spike is 13.4, the number of grains in the spike is 38.1 grain and the weight of 1000 grains was 34.5 grams and 6.7 when applying nitrogen-190, phosphorus-130, potassium-90 kg/ha in accordance with the above; 13.4; 38.3 and 34.5 and 6.9 when applying nitrogen 220, phosphorus-160, potassium-110 kg/ha; 13.6; It was 38.5 and 34.5. In 2021, according to the above, nitrogen-160, phosphorus-100, potassium-70 kg/ha are

used in the option 6.5; 12.7; 36.6; 30.6, nitrogen-190, phosphorus-130, potassium-90 kg/ha 6.6; 12.9; 37.0; 30.7, nitrogen 220, phosphorus-160, potassium-110 kg/ha, 6.8; 13.2; 37.4; was 30.7, and there was almost no difference between the options. Similar data were observed in variants in weak and moderate salinity fields.

According to the results of the research of winter wheat variety "Andijan-2" at different salinities, the highest grain yield was applied in the unsalted field at the rate of nitrogen-220, phosphorus-160, potassium-110 kg/ha. That is, in the 3rd option, the average grain yield per hectare in three years was 30.7 tons/ha, in the 2nd option 29.9 tons/ha, and in the 1st option 29.1 tons/ha, compared to the 1st option, 0.8-1 An additional grain yield of 6 tons/ha was obtained (Figure 2).

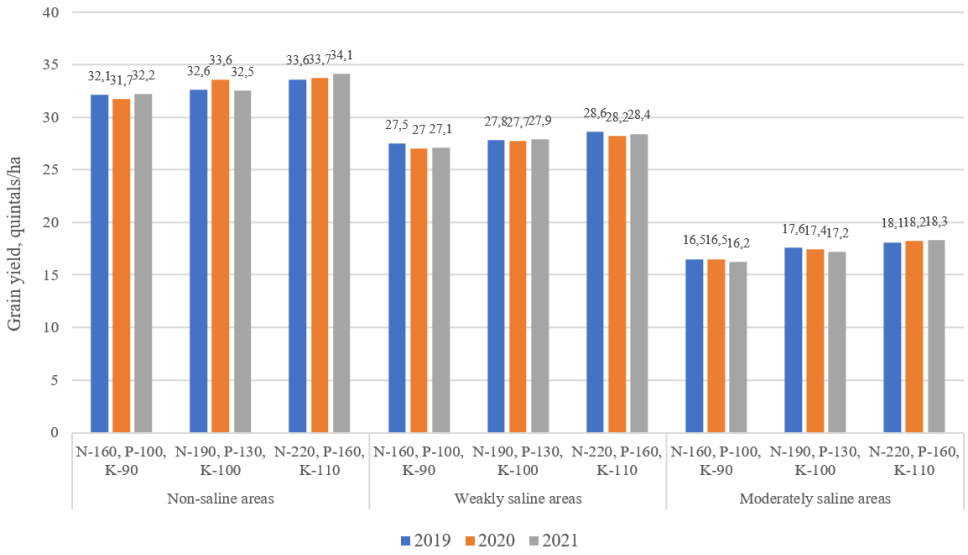

Figure 2. Effect of winter wheat on grain yield during maintenance of winter wheat between open and cotton rows, quinals/ha.

When the winter wheat variety "Andijan-4" is planted between rows of cotton and the grain yield is compared in the conditions of soils with different levels of salinity, when nitrogen-160, phosphorus-100, potassium-70 kg/ha are applied in the non-saline field, the average three-year yield is 32.0 quintals(q)/ha; nitrogen-190, phosphorus-130, potassium-90 kg/ha in the norm-32.9 q/ha; nitrogen - 220, phosphorus - 160, potassium - 110 kg/ha, the norm was 33.8 q/ha. Nitrogen-160, phosphorus-100, potassium-70 kg/ha in the field with weak salinity -27.2 q/ha; nitrogen-190, phosphorus-130, potassium-90 kg/ha and 27.8 q/ha; Nitrogen-220, Phosphorus-160, Potassium-110 kg/ha produced 28.4 q/ha, Nitrogen-160, Phosphorus-100, Potassium-70 kg/ha averaged 16.4 q/ha; 17.3 q/ha with nitrogen-190, phosphorus-130, potassium-90 kg/ha and 18.3 t/ha with nitrogen-220, phosphorus-160, potassium-110 kg/ha. According to the results of the research of winter wheat variety "Andijan-4" at different salinities, the highest grain yield was 33.8 tons per hectare in the average of three years in the non-salted field, which was applied at the rate of nitrogen-220, phosphorus-160, potassium-110 kg/ha formed. That is, in option 2, 32.9 q/ha and 32.0 q/ha grain yield was obtained in option 1, or 0.9-1.8 q/ha additional grain yield compared to option 1 was achieved. Similar data were observed in fields with weak and moderate salinity.

The amounts of winter wheat use of soil moisture, irrigation water, and atmospheric precipitation have been studied. In this experiment, 0.7 m of soil layer was supplied with

moisture in an open field in a non-saline field with irrigation water consumption for 1 quintal of grain yield. The soil moisture before irrigation of winter wheat was 98.9 m^3/h in the unsalted open field at 70-70-60% compared to LFMC, and 87.4 m^3/h in the field planted between cotton rows. In accordance with the above, it was 118.3-106.1 m^3/ha in weak salinity and 194.3-173.9 m^3/ha in medium salinity field.

The production experiments were carried out in 2020, in which the "Andijan-2" variety of winter wheat was planted in the open field at the "Nurli Zamin Tufasi" farm and produced 3350 m^3/ha in the control option and 3050 m^3/ha in the experimental option. On the farm "Shoruzak Nurli Nekavek" winter wheat variety "Andijan-2" in the field planted between rows of cotton is 3200-2850 m^3/ha in accordance with the above, and on the farm "Ahmad Khodzhiev" winter wheat variety "Andijon-4" in the field planted between rows of cotton is 3250-2900 m^3/ha. Andijan-2 and "Andijan-4" varieties of winter wheat were cultivated, and in the farm field "Nurli Zamin Tuhfasi" in Gulistan district of Syrdarya region, in the control version, 29.2 q/ha, in the experimental option 31.4 q/ha, or 2, It was more than 2 q/ha. This, in turn, is 29.7 q/ha in the control option in the "Shuruzak Nurli Nekak" farm field in the Saykhunabad district, 32.2 q/ha in the experimental option, or 2.5 q/ha in comparison to the control and the control in the "Ahmad Khodzhiev" farm field in the Khovos district. It was stated that the grain yield was 30.3 q/ha in the variant, 32.6 q/ha in the experimental option or 2.3 q/ha in comparison to the control.

In the conditions of light-colored gray soils, the highest index of winter wheat variety "Andijan-2" when planting winter wheat in an open field in a non-saline field and irrigating at 70-70-60% soil moisture before irrigation compared to LFMC, conditional net income in option 3 is 659695 UZS/ha, profitability level is found to be 13.6%. In the 1st option, the conditional net income was 568597 UZS/ha, the profitability level was 12.2%, that is, it was found that 91098 UZS less income was obtained compared to the third option (Table 2).

Table 2. Economic efficiency of intercropping winter wheat between open and cotton rows under conditions of varying salinity.

#	Options	Yield, q/ha	Additional yield, q/ha	Income, UZS	Total expenses, UZS	Conditional net profit, UZS	Profitability, %
“Andijan-2” variety of winter wheat planted in a bare field							
Non-saline							
1	N-160, P-100, K-70	29.1		5238000	4669403	568597	12.2
2	N-190, P-130, K-90	29.9	+0.8	5382000	4765410	616590	12.9
3	N-220, P-160, K-110	30.7	+1.6	5526000	4866305	659695	13.6
Weakly saline							
1	N-160, P-100, K-70	24.7		4446000	4354642	91358	2.1
2	N-190, P-130, K-90	25.3	+0.6	4554000	4465345	88655	2.0
3	N-220, P-160, K-110	25.8	+1.1	4644000	4576125	67875	1.5
Moderately saline							
1	N-160, P-100, K-70	14.9		2682000	4234560	-1552560	-36.7
2	N-190, P-130, K-90	15.7	+0.8	2826000	4345356	-1519356	-35.0
3	N-220, P-160, K-110	16.5	+1.6	2970000	4423454	-1453454	-32.9
“Andijan-4” variety of winter wheat planted between rows of cotton							
Non-saline							
1	N-160, P-100, K-70	32.0		5760000	4569615	1190385	26.1
2	N-190, P-130, K-90	32.9	+0.9	5922000	4669120	1252880	26.8

3	N-220, P-160, K-110	33.8	+1.8	6084000	4787623	1296377	27.1
Weakly saline							
1	N-160, P-100, K-70	27.2		4896000	4386545	509455	11.6
2	N-190, P-130, K-90	27.8	+0.6	5004000	4462420	541580	12.1
3	N-220, P-160, K-110	28.4	+1.2	5112000	4582410	529590	11.6
Moderately saline							
1	N-160, P-100, K-70	16.4		2952000	4365421	-1413421	-32.4
2	N-190, P-130, K-90	17.3	+0.9	3114000	4432540	-1318540	-29.7
3	N-220, P-160, K-110	18.2	+1.8	3276000	4312410	-1036410	-24.0

In winter wheat cultivation between cotton rows, planting "Andijon-4" variety, the highest indicator was obtained in the non-irrigated field with soil moisture of 70-70-60% compared to LFMC, in the 3rd option, conditional net income was 1296377 UZS/ha, profitability was 27.1%. In the 1st option, the conditional net income was 1190385 UZS/ha, the profitability level was 26.1%, that is, compared to the third option, a lower income of 105992 UZS was observed.

4 Conclusions

In order to ensure a high and high-quality grain yield from "Andijan-2" and "Andijan-4" varieties of winter wheat in the conditions of light-colored gray soils of the Syrdarya region with varying degrees of salinity and growing grazing:

Winter wheat variety "Andijan-4" is planted between rows of cotton on non-saline and weakly saline lands and irrigated 3 times during the season. Apply at the rate of 190, P-130, K-90 kg/ha;

Winter wheat variety "Andijan-2" is planted in the open field on non-saline and weakly saline lands and irrigated 3 times during the season, in which the rate of irrigation is 900-1100 m^3/ha, seasonal irrigation is 2900-3100 m^3/ha, and N-160 per hectare , P-100, K-70 kg/ha is recommended.

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