Improving cotton irrigation methods in erodible soils of Tashkent province, Uzbekistan

Sabirjan Isaev[1*], *Sunnat* Tadjiev[1], *Odiljon* Ibragimov[2], *Sanoatkhon* Zokirova[3] and *Allamurat* Khojasov[4]

[1]"TIIAME" National Research University, 100000 Tashkent, Uzbekistan
[2]Fergana Polytechnic Institute, 150107 Fergana, Uzbekistan
[3]Fergana State University, 150100 Fergana, Uzbekistan
[4]Karakalpakstan Institute of Agriculture and Agrotechnologies, 230109 Nukus, Uzbekistan

Abstract. Agricultural degradation areas are increasing worldwide. From them, 56% due to water erosion, 28% due to wind erosion, 12% due to soil nutrient depletion, salinization, pollution processes, and 4% due to densification, swamping, and subsidence processes. As a result of such negative processes and the existence of the water shortage problem in 80 countries of the world, 7 million hectares of arable land are withdrawn from agricultural use every year, and the problem of food security is arising in the world. In this article, the results of scientific research and cost-effectiveness calculations on 3 different slopes of cultivated fields on soils prone to irrigation erosion are written. In Uzbekistan, great attention is paid to solving the problems of improving land reclamation and increasing the productivity of irrigated lands. In the Action Strategy for the further development of the Republic of Uzbekistan in 2017-2021, it is stated that "... further improvement of the reclamation condition of irrigated lands, development of the network of reclamation and irrigation facilities, wide introduction of intensive methods of agricultural production, first of all, modern water and resource-saving agro-technologies, highly productive tasks on the use of agricultural machinery" are defined. It is necessary to develop new technologies for effective methods of increasing the productivity of lands prone to irrigation erosion in order to implement part of the specified tasks.

1 Introduction

In today's contemporary society, agricultural degradation areas are increasing worldwide. From them, 56% due to water erosion, 28% due to wind erosion, 12% due to soil nutrient depletion, salinization, pollution processes, and 4% due to densification, swamping, and subsidence processes. As a result of such negative processes and the existence of the water shortage problem in 80 countries of the world, 7 million hectares of arable land are withdrawn from agricultural use every year, and the problem of food security is arising in the world.

* Corresponding author: s.isaev@tiiame.uz

In our republic, great attention is paid to solving the problems of improving land reclamation and increasing the productivity of irrigated lands. In the Action Strategy for the further development of the Republic of Uzbekistan in 2017-2021, it is stated that "... further improvement of the reclamation condition of irrigated lands, development of the network of reclamation and irrigation facilities, wide introduction of intensive methods of agricultural production, first of all, modern water and resource-saving agro-technologies, highly productive tasks on the use of agricultural machinery" are defined. It is necessary to develop new technologies for effective methods of increasing the productivity of lands prone to irrigation erosion in order to implement part of the specified tasks.

Modeling elements of irrigation technology in irrigated farming of cotton and winter wheat in the conditions of soils prone to irrigation erosion and studying the effect on land reclamation have been undertaken by following authors: from Uzbek scientists, they are K. Mirzajonov, N. Bespalov, G. Ibragimov, Sh. Nurmatov, M. Khamidov, B. Kambarov, K. Beysenboev, D. Umarova, S. Buriev, N. Malaboev, T. Rajabov, M. Mahmudov, A. Abdukarimov, S. Isaev, and I. Khoshimov; and from international scientists, they are D. Balla, S. Maasen, J. Andersson, B. Wedding, K. Tonderski, K. Keinzler, A. Qureshi, M. Qadir. Many significant results have been achieved through the research conducted. However, in Uzbekistan, scientific investigations on saving irrigation water, reducing erosion processes, keeping the environment clean, and preserving the fertile layer of the soil by providing water at an optimal rate in irrigation erosion have not been fully carried out. One such region of Uzbekistan is Tashkent province.

The purpose of the research is to determine the water consumption for irrigation of cotton in the conditions of soil subject to irrigation erosion, to determine the effectiveness of the fight against erosion, to reduce water consumption and erosion processes, to maintain the soil fertility, and to develop the efficiency of growing an abundant and high-quality cotton crop.

Objectives of the research are:

-To reveal changes in the properties of the soil depending on the method of irrigation of cotton in lands subject to irrigation erosion;

-To assess the meteorological and agromelioration conditions of the research object and the representativeness of the lands of the experimental site and Piskent district;

-To distinguish the relationship between agrophysical and agrochemical properties of the soil;

-To plotthe optimum irrigation period, number, norms of cotton in the lands affected by irrigation erosion;

-To evaluate the influence of the irrigation method on the growth, development, productivity and technological quality indicators of the cotton fiber, depending on the soil and climate conditions;

-To identify the water consumption used to produce one quintal of the studied cotton;

-To increase economic efficiency of cotton irrigation method in lands subject to irrigation erosion.

2 Materials and methods

As the study area, the irrigated land of Tashkent province prone to irrigation erosion and the complex zig-zag irrigation method of cotton variety "Sultan" were taken.

The subject of the research is the water consumption parameters of the elements of the irrigation technology of the "Sultan" variety of cotton in the irrigated lands prone to irrigation erosion in a zig-zag irrigation method

In this article, laboratory and field experiments are conducted based on SRICR's "Methods of studying agrophysical, agrochemical and microbiological properties of soil in

cotton fields", "Methods of conducting field experiments", soil analysis, cotton monitoring, soil-soil moisture measurement and analysis. "Agrochemical and Agrophysical Research Methods in Irrigated Cotton Fields, Field and Vegetative Experiments with Cotton", also compared to the FAO method. Reliability and accuracy of the obtained data are verified by B. Dospekhov's well-known multifactorial, as well as theoretical results, with experiments carried out in the field.

3 Results and discussion

To irrigate cotton in farms operating in the conditions of typical gray soils subject to irrigation erosion of the Tashkent province:

- when irrigating cotton with a slope of 1.5^0, 2.5^0 and 3.5^0, when calculating the amount of water supplied to the soil in the zig zag method, when 0.15 L/s of water is given, the leaching of nutrients from the soil during the growing season is reduced by 35-40%, 693 m^3/ha , water economy has been achieved, in which the KPI has been developed to increase from 0.88% to 0.92%.

By applying the above-mentioned irrigation techniques and elements, the average productivity of "Tojiboeva Zavra", "Oybek Sotiboldiev" and "Ashirmetov Jumaboy" farms in the Piskent district of Tashkent region was increased by 3.2 tons/ha, and as a result of the application of these technologies, the river water was reduced by 10-20%, Economic efficiency has been achieved due to 10-15% reduction in soil leaching and an additional 3.2 tons/ha of cotton.

Based on the results of the conducted research, the purpose and tasks of this dissertation were formed based on the study and analysis of methods of effective use of water resources to obtain abundant harvests from agricultural crops in the conditions of complex climate, hydrogeology and water shortage in Tashkent region.

In the methods of conducting experiments: in the conditions of typical gray soils of "Tojiboeva Zavra", "Oybek Sotvoldiev" and "Ashirmetov Jumaboy" farms in Piskent district, Tashkent province, which have been irrigated for a long time, affected by irrigation erosion; It was conducted at slope levels of 1.5^0, 2.5^0, and 3.5^0. The experimental system consists of 4 options in each farm field, in all three farms, mineral fertilizers were used in the rates of N-200, P-140, K-100 kg/ha for feeding cotton, the "Sultan" variety of cotton was planted, and the researched areas were typical It is located in the region of gray soils, the elevation of the relief, the deep (15-20 m) location of the soil, uneven slopes and other factors caused the soil layer to be different. Typical gray soils, which have been irrigated since ancient times and have been newly cultivated, are scattered. In terms of erosion, they are divided into groups of unwashed, washed and accumulated soil particles. Therefore, the soils of the field experiments were subjected to irrigation erosion at different levels.

The soils of the experimental area are typical gray soils that have been irrigated for a long time, affected by irrigation erosion, medium and heavy sand according to the mechanical composition, and the groundwater level is deep (15-20 m). During the agrochemical analysis of the soil of the experimental area before the experiment, the amount of humus in the 0-30 cm layer in the field with a slope of 1.5^0 was 0.840%, and 0.695% in the 30-50 cm layer. The amount of gross nitrogen in the upper layers is 0.070; 0.062%, total phosphorus was 0.96; 0.83%. The amount of mobile nitrogen in the upper layers is 9.35; 9.0 mg/kg, phosphorus 30.20; 26.52 mg/kg, and potassium 140; 160 mg/kg.

The amount of humus in the 0-30 cm layer with a soil slope of 2.5^0 was 0.750%, and 0.670% in the 30-50 cm layer. The amount of total nitrogen in the upper layers is 0.052; 0.038%, total phosphorus was 0.75; 0.68%. The content of mobile nitrate nitrogen in the upper layers is 7.50; 6.75, phosphorus 25.50; 21.84 mg/kg, and potassium 120; 140 mg/kg. The amount of humus in the 0-30 cm layer with a soil slope of 3.5^0 was 0.885%, and

0.780% in the 30-50 cm layer. The amount of total nitrogen in the upper layers is 0.082; 0.075%, total phosphorus 0.98; 0.85%, the amount of mobile nitrate nitrogen is proportionally in the upper layers; 9.25, absorbable phosphorus, 30.50; 27.72 mg/kg, and exchangeable potassium was 160; 140 mg/kg. The given data indicate that the soil of the experimental field is low in humus and nitrogen, and sufficiently supplied with phosphorus. In order to grow abundant and high-quality crops on these types of soils subjected to irrigation erosion, it is necessary to apply high amounts of fertilizers.

S. Iskandarov [8], Q. Mirzajonov and others [9], and others determined the effectiveness of using nitrogenous fertilizers on soils subject to irrigation erosion. Optimal terms, proportions, and methods of using mineral fertilizers have been studied. According to research conducted on the effectiveness of forms of nitrogen fertilizers, it was stated that when 150 kg/ha of ammonium sulfate and carbamide were used before planting in washed soil, the yield of additional cotton was 1.6 and 1.8 ton/ha higher than that of ordinary ammonium nitrate.

Fig. 1. Irrigation erosion types.

In 2020, at the beginning of the operation period, when the soil slope is 1.5^0, its volume mass is 1.28 g/cm^3 in the upper (0-30 cm) layer; it was 1.30 g/cm^3 in the 30-50 cm layer. At least 1.29 g/cm^3 in the 0-30 cm layer when the soil slope is 2.5^0; It was 1.31 g/cm^3 in the 30-50 cm layer. Noting that 1.31g/cm^3 in the 0-30 cm layer when the soil slope is 3.5^0; it was 1.35 g/cm^3 in the 30-50 cm layer. By the end of the period of operation, these indicators were equal to 1.28-1.30 g/cm^3 in the above-mentioned layers when cotton was irrigated through egates when the soil slope was 1.5^0. 1.25 g/cm^3 in the 0-30 cm layer when irrigated with 0.10 L/s water in the zig-zag method; it was 1.27 g/cm^3 in the 30-50 cm layer. When the slope of the soil is 2.5^0, in the case of irrigation, the volume mass of the soil in the above-mentioned layers was equal to 1.29-1.31 g/cm^3. In the zig-zag method, it was 1.27-1.29 g/cm^3. When irrigated on a slope with a soil slope of 3.5^0, the volume mass of the soil in the above-mentioned layers was 1.31-1.35 g/cm^3. When irrigating in the zig-zag method, the volume mass of the soil was equal to 1.30 - 1.33 g/cm^3 (Table 1).

Table 1. Effect on soil volume mass depending on cotton irrigation method, g/cm^3 (2020).

Soil layer, cm	At the beginning of the period of action	At the end of the period of action			
		Conventional furrow irrigation, control	Irrigating in the zigzag method, experimental (0.10 L/s)	Irrigating in the zigzag method, experimental (0.15 L/s)	Irrigating in the zigzag method, experimental (0.20 L/s)
In the field of "Tojiboeva Zavra" farm with a slope of 1.5^0					
0-30	1.24	1.28	1.25	1.28	1.32
30-50	1.26	1.30	1.27	1.30	1.34

In the field of "Oybek Sotiboldiev" farm with a slope of 2.5^0					
0-30	1.25	1.29	1.27	1.31	1.34
30-50	1.29	1.31	1.29	1.34	1.37
In the field of "Ashirmetov Jumaboy" farm with a slope of 3.5^0					
0-30	1.28	1.31	1.30	1.34	1.36
30-50	1.31	1.35	1.33	1.36	1.38

Sh. Nurmatov and G. Abdalova [12] studied soils prone to irrigation erosion by connecting irrigation technologies to water permeability. According to Sh. Kholmatova [14], water permeability is well preserved when artificial cavities are created in the bottom of the egate against washing in soils prone to erosion. G. Abdalova [15] determined the impact of irrigation technologies on water permeability against the background of agrotechnical measures against soil erosion.

Erosion processes depend on the mechanical composition of the soil, the amount of humus, the degree of slope and exposure of the sloping land, and the amount of water supplied to the soil. Q. Mirzajonov, M. Nazarov, S. Zokirova, and F. Yuldoshov [13] wrote recommendations on irrigation erosion control:

- when the slope of the land is 2.5-3.50 m, water is 0.07 L/s, slowly increasing it to 0.10 L/s;
- the slope is 1-20, the length of the slope is up to 50 meters; slowly increase the flow to 0.15-0.10 L/s; but reduce to 2-30 – 0.10-0.05 L/s.

But if the slope decreases slowly, the water should be left from the upper side as shown above, and the water from the lower part should be added to the second one, and they stated that the length of the part should not exceed 100 meters.

Based on many years of experience, K. Mirzajonov wrote that in the areas where erosion processes occur, the distance between the ridges should be 50 to 100 meters.

In our scientific research conducted in 2020, 6.32 tons/ha of soil was washed in the area with a slope of 1.5^0 in a total of 3 irrigations of cotton. 2.75 tons/ha in experimental irrigation of zig-zag irrigation (0.10 L/s), 3.29 tons/ha in experimental irrigation of zig-zag irrigation (0.15 L/s) and experimental irrigation of zig-zag irrigation (0.20 L/s) soil leaching of 3.77 tons/ha was observed. 9.63 tons/ha of soil was washed in the control option with a slope of 2.5^0. 3.70 tons/ha in experimental irrigation of zig-zag irrigation (0.10 L/s), 4.60 tons/ha in experimental irrigation of zig-zag irrigation (0.15 L/s) and experimental irrigation of zig-zag irrigation (0.20 L/s) soil leaching was observed at 4.93 tons/ha. 26.18 tons/ha of soil was washed in the control option with a slope of 3.5^0. 4.06 tons/ha in experimental (0.10 L/s) irrigation with zig-zag irrigation, 6.91 tons/ha in experimental irrigation with zig-zag irrigation (0.15 L/s) and 6.91 tons/ha in experimental irrigation with zig-zag irrigation (0.20 L/s) irrigation revealed 7.39 tons/ha of soil leaching (Table 2, Fig. 2).

Table 2. Effect of cotton irrigation method on leaching of soil particles, tons/ha (2020).

Irrigation method	Irrigations			In a season, tons/ha
	1	2	3	
In the field of "Tojiboeva Zavra" farm with a slope of 1.5^0				
Conventional furrow irrigation, control	2.06	2.11	2.15	6.32
Irrigating in the zigzag method, experimental (0.10 L/s)	0.89	0.92	0.94	2.75
Irrigating in the zigzag method, experimental (0.15 L/s)	1.12	1.10	1.07	3.29
Irrigating in the zigzag method, experimental (0.20 L/s)	1.21	1.25	1.31	3.77

In the field of "Oybek Sotiboldiev" farm with a slope of 2.5^0				
Conventional furrow irrigation, control	3.43	3.15	3.05	9.63
Irrigating in the zigzag method, experimental (0.10 L/s)	1.11	1.36	1.23	3.70
Irrigating in the zigzag method, experimental (0.15 L/s)	1.56	1.61	1.43	4.60
Irrigating in the zigzag method, experimental (0.20 L/s)	1.63	1.67	1.63	4.93
In the field of "Ashirmetov Jumaboy" farm with a slope of 3.5^0				
Conventional furrow irrigation, control	8.69	8.82	8.67	26.18
Irrigating in the zigzag method, experimental (0.10 L/s)	1.42	1.33	1.31	4.06
Irrigating in the zigzag method, experimental (0.15 L/s)	2.12	2.37	2.42	6.91
Irrigating in the zigzag method, experimental (0.20 L/s)	2.38	2.43	2.58	7.39

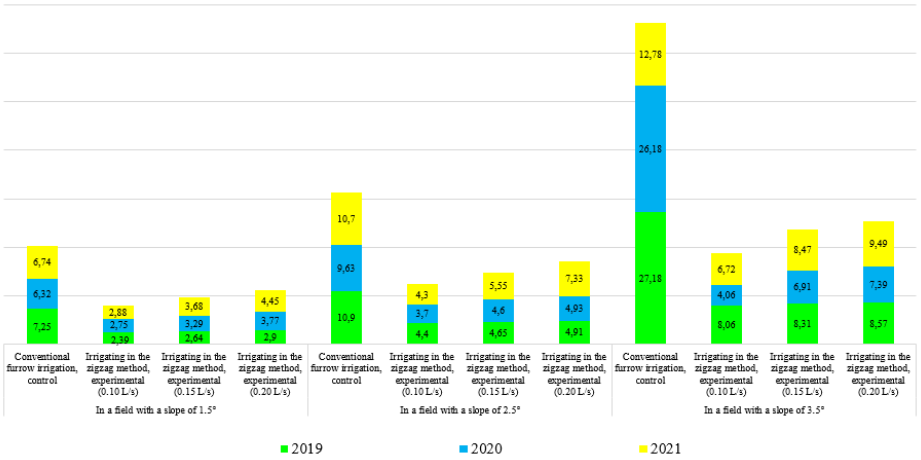

Fig. 2. Influence of cotton irrigation methods on leaching of soil particles (tons/ha).

The proceeds from the sale of cotton grown in a field with a different slope of 1.5^0, when irrigated, amounted to 12,226,210 UZS, total costs to 9,618,460 UZS, and conditional net profit to 2,607,750 UZS, profitability was 27.1%. When cotton was irrigated by zig-zag method, compared to the control, it was found that the yield was 1,847,975 UZS/ha and the yield was 19.2% higher. Similarly, when the slope is 2.5^0, in the control option, the proceeds from sales were 10,277,810 UZS, the total costs were 9,618,460 UZS, and the conditional net profit was 659,350 UZS, the profitability was 6.8%. When cotton was irrigated by the zig-zag method, compared to the control, it was found that the yield was 2,238,770 UZS/ha and the yield was 23.3% higher. When the slope of the cotton was 3.5^0, in the control option, the proceeds from the sale were 8,085,860 UZS, the total costs were 9,618,460 UZS, and the conditional net profit was 1,532,600 UZS, the profitability was -15.9%. When cotton was irrigated by zig-zag method, compared to the control, it was found that 510,430 UZS/ha and yield was 5.3% higher. Thus, in the conditions of the typical gray soils of the Tashkent province, when irrigating the "Sultan" variety of cotton, it was possible to achieve high profitability when irrigated by the zig-zag method.

4 Conclusions

It is known that water resources are limited in the Republic of Uzbekistan, therefore, the population is increasing sharply. More agricultural production is required than at present, and this can be achieved by increasing the yield per hectare of land and developing additional land. Therefore, the development of irrigation methods that save water resources is an important issue.

It was found that the water-physical, agro-physical and agro-chemical properties of the soil are more optimally maintained when cotton is irrigated by the zig-zag method compared to the traditional simple straight irrigation.

In the conditions of typical gray soils, which have been irrigated for a long time and suffered from irrigation erosion; Research was carried out on slopes of 1.5^0, 2.5^0 and 3.5^0. Compared to traditional irrigation of cotton with simple straight lines, 693.7 m^3/ha of unwashed soil and 785.9 m^3/ha of washed soil were saved by zig-zag irrigation. Besides, 740.5 m^3/ha of river water was saved in the lower part of the slope, where the washed soil particles are sitting (accumulated).

In the leached part of the soil, during the season, the leaching of soil particles was 40.58 tons/ha when cotton was irrigated through traditional simple straight egates. Soil leaching in zig-zag irrigation was 13.07 tons/ha or 3.1 times less. It was found that soil washing decreased by 2.4 times in the unwashed part of the slope, and by 3.2 times in the lower part where washed soil particles are sitting.

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