Efficiency of drip irrigation technology of cotton in the saline soils of Bukhara oasis

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Abstract. This article presents the results of scientific research on the use of cotton drip irrigation technology in conditions of water scarcity, saving water resources, assessing the growth and yield of cotton. At the same time, the technology of drip irrigation in the cultivation of “Bukhara-102” variety of cotton was compared with the options grown in the traditional way. During the experiments, in the control field for the cultivation of Bukhara-102 variety of cotton, ie in the 1st variant, which was irrigated by land invasion, irrigation was carried out 5 times during the growing season according to the scheme 1-3-1. 1240 cbm·ha^{-1}, the seasonal irrigation norm was 4780 cbm·ha^{-1}, drip irrigation In variant 2, the irrigation regime was 8 times the cotton was irrigated according to the scheme 2-5-1. During the period of cotton growing and irrigation, irrigation works were carried out at the rate of 462-488 cbm·ha^{-1} and seasonal irrigation at the rate of 3339 cbm·ha^{-1}. less water was used than in 1916 cbm·ha^{-1}. When the effect of drip irrigation technology on the yield of cotton was studied, the yield of cotton in the first variant was 3.58 t·ha^{-1}, while in the second variant of drip irrigation it was 4.49 t/ha^{-1}. This is 0.91 t·ha^{-1} higher than the control variant.

1 Introduction

In recent years, in Uzbekistan has been working to raise the living standards of the country's population by increasing the quantity and improving the quality of irrigated crops based on the efficient use of water resources. Water-saving technologies on 642.4 thousand hectares in the country for 2017–2021, including 308.6 thousand hectares – drip irrigation, 14.7 thousand hectares – sprinkler irrigation, 10.6 thousand hectares – discrete irrigation system, 78.8 thousand per hectare – flexible pipes and 20.9 thousand hectares – film irrigation, and 208.9 thousand hectares of arable land were leveled using laser equipment, which is 15% of the total irrigated area. As a result, a total of 10 billion cub metr of water was saved in 2021, including 3.0 billion cub metr due to the introduction of water-saving technologies, which provide water for secondary crops.

Levels of evidence in research: Reducing water scarcity and proper use of water resources in the meadow-alluvial, saline soils of Bukhara region, the method of drip irrigation without adversely affecting the ecological situation of the system of agro-technological measures at the level of today's requirements and the order of irrigation of crops the fact that it has not been studied is the basis for the choice of this topic [1, 2].

A new system of water and irrigation use was established in the country, and the Law “on Water and Water Use” adopted in May 6, 1993, has been implemented. Water Consumer Associations was established on farms and dehkan farms. However, outdated techniques and technologies are still used to irrigate crops. In particular, irrigation of all agricultural crops, saline leaching, irrigation to create a reserve of moisture in the soil is carried out by furrow or flood irrigation. Also, the technology of growing all crops is inextricably linked with these irrigation methods [3].

For example, in the technology of caring for cotton, take the furrow for irrigation, place the canals and open them before watering, bury after watering, repeat the row spacing, mineral agro-technical measures, such as laying weeds at the bottom of the furrow, manual control of weeds, are carried out in connection with irrigation. Many measures are taken by hand to irrigate crops on the land, and most importantly, the water required for agricultural crops is much higher (25–30%) than required by this method. As a result of improper distribution of water to the furrows, mineral fertilizers applied to the bottom of the furrows are washed away with water or absorbed into the lower layers, their effectiveness is reduced [4–7].

In the developed world, the most economical, computerized drip irrigation method has been widely used for many years to irrigate crops.

The advantages of drip irrigation over other techniques and technologies have been studied to some extent by foreign and Uzbek scientists and experts in this field [8].

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According to the results of scientific research so far, drip irrigation saves up to 40–55% of water per 1 hectare of land by type of crop, 1.5–2 times reduction of labor costs, 35–40% It was found that the saving of mineral fertilizers will increase the yield of cotton by 0.8–1.0 $t \cdot ha^{-1}$.

The specificity of a drip irrigation system is determined by the fact that it consists of a permanent network of pressurized water distribution. This network delivers the same amount of water to the root layer of the crop as the plant needs [9–11].

Drip irrigation maintains a constant level of moisture in the root system of the plant, which allows the plant to grow evenly. In this case, soil moisture is mainly due to capillaries, as a result of which there are no sharp changes in the water-physical properties of the soil.

Research purpose: To obtain high-quality cotton from cotton using water-saving irrigation technology in the conditions of saline soils of Bukhara region and to scientifically substantiate their hydraulic parameters.

Research object: Research work on this topic was carried out on the irrigated lands of the Training Scientific Center of the Bukhara Institute of Natural Resources Management of the National Research University of Tashkent Institute of Irrigation and Agricultural Mechanization Engineers in Kagan district of Bukhara region.

Research subject: To assess the impact on the meadow drip irrigation in the conditions of alluvial, light and heavy mechanical soils of meadows of Bukhara region on the reclamation regime of irrigated lands and the growth and development of cotton, productivity and quality of cotton fiber.

2 Method and experimental system

Field and laboratory studies, as well as phenological observations "Methodology of field experiments" of the Research Institute of Agrotechnologies of Cotton Growing and Seed Growing (UzNIISKh, 2007) [1], the amount of salts in the laboratory was carried out using METROHM-858 and SPECORD-200 instruments developed in Switzerland.The accuracy and reliability of the data obtained were analyzed mathematically and statistically using the generally accepted multivariate method of B A Dospekhov's [2] and the computer program SPSS (Statistical Package for Social Science).

In order to achieve the above goals and objectives, the research conducted field experiments on the cultivation of cotton on the basis of drip irrigation technology in water-scarce areas of Bukhara region. The “Bukhara-102” cotton variety, which is regionalized for Bukhara region, was planted on the basis of special Chinese technology under a double film and for comparison with the traditional 90/90 cm control scheme [12–16].

Table 1. Field experiments were performed in the following system

Variant	Irrigation method and crop cultivation technology	Annual fertilizer norm, kg/ha		
		N	P	K
	Furrow irrigation (control)	250	180	100
	Drip irrigation technology	170	180	60

Experimental variants were carried out in three repetitions, and irrigation was carried out in the order of 70-80-65 % relative to the pre-irrigation soil moisture LFMC, recommended by the scientists of UzSRIC for the regions. In the control variant, the agro-technologies used for cotton growing in the region (plowing, saline washing, irrigation to collect moisture, pre-sowing tillage, planting, seedling thickness, row spacing, fertilization, irrigation, weed control, etc.).

In the experimental options, some elements of the adopted agro-technologies for growing crops (planting system – row spacing, seedling thickness, reduction in the number of cultivars, water and mineral fertilizers by drip irrigation equipment at the request of plants) giving) is improved [17–20].

In experiments, all scientific research (various analyzes, measurements, phenological observations) was carried out on the basis of tried and tested methods.

Research results: In the meadow-alluvial, saline soils of Bukhara region, as a result of research, due to the introduction of drip irrigation, up to 30–40% of water per 1 hectare of land by type of crop savings, 1.5–2 times reduction of labor costs, savings of 25–30% of mineral fertilizers and an increase in cotton productivity by 0.4–0.5 $t \cdot ha^{-1}$.

3 Result and discussion

The single rate of irrigation of the control field was measured with a Cipoletti water meter. When calculating the irrigation rate, the single irrigation rate of the control field was determined according to the following formula by S. N. Ryzhov according to the soil moisture value, determined taking into account the water-physical properties of the soil and the depth of moisture [21].

The norms of irrigation of control fields are determined by the following formula (1)

$$m = 100 \cdot h \cdot J \cdot (W_{LFMC} - W_{AH}) + K \text{ cbm} \cdot \text{ha}^{-1} \quad (1)$$

W_{LFMC} is the limited moisture capacity of the field compared with the mass of soil, %;

W_{AH} is the actual humidity before irrigation compared with the mass of soil, %;

J is the volume soil weight, $g \cdot cbcm^{-1}$;

h is the value of the computation layer, m;

K is the water consumption for evaporation in irrigation, $cbm \cdot ha^{-1}$ (10% of moisture insufficient in the calculation layer) [3].

Irrigation of cotton in the experimental fields was carried out according to the system adopted in the scientific work program. In this case, the duration of irrigation and irrigation standards for the options were determined based on the moisture content of the soil. In variant 2, germination – in determining the rate of irrigation in the pre-flowering phase, soil moisture is 0–50 cm, irrigation – in the flowering phase, irrigation in the 0–70 cm layer, irrigation in the ripening and opening phase Determined by soil moisture in a layer of 70–100 cm.

Table 2. Irrigation order of cotton

Variants	Indicators	Irrigation, cbm·ha^{-1}								Irrigation scheme	Seasonal irrigation norm, cbm·ha^{-1}
		1	2	3	4	5	6	7	8		
1	Irrigation norm, cbm·ha^{-1}	1064	1170	1176	1194	980				1-3-1	5584
2	Irrigation norm, cbm·ha^{-1}	386	392	432	448	480	471	385	345	2-5-1	3339

Based on the results of experimental and control field studies, Table 2 shows that under experimental production control, cotton was irrigated five times under the 1-3-1 irrigation scheme during the growing season. Due to large irrigation standards (980–1194 cbm·ha^{-1}) during the period from sowing to flowering to the beginning of flowering and the beginning of flowering, the moisture content of the soil in the intended layer of the soil was kept constant. during the ripening period, cotton was irrigated sparingly, with a seasonal irrigation rate of 5584 cbm·ha^{-1}. The interval between irrigations was 19–21 days [22].

In option 2, drip irrigation, cotton was irrigated 8 times according to the scheme 2-5-1, irrigation criteria from sowing to germination after flowering and at the beginning of flowering and harvest. 462-488 cbm·ha^{-1} were irrigated, the seasonal irrigation norms totaled 3339 cbm·ha^{-1}, or 1916 cbm·ha^{-1} less than the control option. The interval between irrigations was 12–14 days, and the duration of irrigation was 6^{20}–6^{50} hours.

Experimental field changes in groundwater levels and mineralization: Groundwater level and mineralization regime is one of the important indicators for assessing the reclamation status of irrigated lands. The formation of the groundwater regime is determined by various factors, including surface relief, lithology, climate, hydrogeological, hydrological conditions, and human irrigation activities.

According to the results of changes in the mineralization of ground water in the experimental and control fields, the mineralization of groundwater in the experimental production areas was 2.3–3.0 g·l^{-1}.

Observations on the effect of drip irrigation on the mineralization of groundwater in the experimental field during the growing season show that in 2–3 variants irrigated with irrigation standards designed to cover the moisture deficit of the active layer of soil. at the end of the growing season, the mineralization of groundwater changed relatively little after irrigation. Due to the fact that the field of control option 1 was irrigated with large irrigation standards, the mineralization of groundwater increased to 2.315–3.250 g·l^{-1} after irrigation, ie, along with irrigation water to groundwater, the addition of water-soluble salts was also observed [23].

Influence of irrigation methods and procedures on the growth and development of cotton: Phenological observations on the growth and development of cotton show that in saline or saline-prone areas, maintaining an optimal water regime in the root layers of the plant, the direction of physiological processes in plant bodies depends on the composition and amount of water-soluble salts in the soil.

Table 3. The effect of irrigation on the growth and development of cotton

Variants	Cotton height, cm				Number of harvested branches, pcs		Number of bolls, pcs		
	1.06	1.07	1.08	1.09	1.07	1.08	1.08	1.09	1.09 openeds
1	12.8	32.8	71.8	90.0	8.5	12.6	7.8	10.6	4.1
2	12.2	32.4	73.4	89.7	9.1	13.7	8.7	13.5	5.6

The results of experimental and observational field observations showed that there was no difference in the thickness of the cotton seedlings between the experimental options. Phenological observations show that in the drip-irrigated variant 2 of the experiment, the yield of cotton stalks was 13.7, the number of bolls was 13.5, and the number of bolls opened on September 1 was 5.6. and the number of branches increased by 1.1, the number of buds by 0.9, and the number of bolls opened on September 1 by 1.5 compared to the control variant. In the 1st control variant, the number of cotton stalks in the years of the study was 12.6, the number of bolls was 10.6, and the number of cottons opened on September 1 was 4.1.

Influence of irrigation method on cotton yield per bowl of cotton mass: The results of the analysis of cotton yield from Bukhara-102 cotton variety in experimental and control fields showed that the 1st control study In the variant, a maximum of 13.35 cbm·t^{-1} of water was used to grow one tonna of cotton and 3.58 cbm·t^{-1} of cotton was harvested.

Table 4. The effect of drip irrigation on the weight of cotton in a boll of cotton

Variants	The weight of a boll of cotton in return, gr			Average gram	Extra weight, grams per control	Consumption of water per 1 tonna of cotton, cbm·t^{-1}
	I	II	III			
1	4.5	4.8	4.0	4.4	0.0	13.35
2	6.2	6.1	6.2	6.2	+1.8	7.36

In Drip Irrigation variant 2, a minimum of 8.76 cbm·t^{-1} of water was used to grow one tonna of cotton, and a maximum of 4.49 t·ha^{-1} of cotton was harvested. This is 1.61 t·ha^{-1} more than the control variant.

Table 5. The effect of irrigation method on cotton productivity

Variants	Cotton yield by return, t·ha[1]			Average yield, $t \cdot ha^{-1}$	Extra yield, relative to control ± $t \cdot ha^{-1}$
	I	II	III		
1	3.55	3.58	3.6	3.58	0.0
2	4.48	4.5	4.49	4.49	+ 0.91

The effect of drip irrigation on the weight of cotton in a bowl is shown in the table, which shows that in fact, drip irrigation increases the weight and improves the quality of cotton in a boll [24, 25].

4 Conclusion

Based on the analysis of the results of research conducted in Bukhara region to study the method of economical drip irrigation of cotton, the following conclusions can be drawn:

1. In the experimental field planted with cotton, at the beginning of the growing season, the soil water permeability was 960 $cbm \cdot ha^{-1}$ or 0.27 mm/min for 6 hours. permeability was 736 $cbm \cdot ha^{-1}$ or 0.21 mm/min for 6 hours, and soil water permeability was 88 $cbm \cdot ha^{-1}$ or 0.06 mm/min for 6 hours compared to the control option.
2. In the experimental field planted with cotton, the volumetric weight of the soil at the beginning of vegetation was 1.24 $g \cdot cbcm^{-1}$ in the 0–30 cm layer and 1.34 $g \cdot cbcm^{-1}$ in the 0–100 cm layer. By the end of the growing season, the volumetric weight of the soil is 1.26 $g \cdot cbcm^{-1}$ in the 0–30 cm layer and 1.35 $g \cdot cbcm^{-1}$ in the 0–100 cm layer, and increased by 0.02–0.03 $g \cdot cbcm^{-1}$.
3. In drip-irrigated variant 2, the cotton was irrigated 8 times according to the scheme 2-5-1, after sowing the cotton from seed germination to flowering and during the period of flowering and harvest. irrigation norms were irrigated with 345–480 $cbm \cdot ha^{-1}$, seasonal irrigation norms totaled 3339 $cbm \cdot ha^{-1}$, or 1916 $cbm \cdot ha^{-1}$ less than the control option.
4. In variant 2 with drip irrigation, cotton yield stalks were 13.7, the number of bolls was 13.5, and the number of bolls opened on September 1 was 5.6. 1.1, the number of bolls increased by 0.9, and the number of bolls opened on September 1 increased by 1.5.
5. In variant 2, drip irrigation used a minimum of 7.36 $cbm \cdot t^{-1}$ of water per tonna of cotton and a maximum of 4.49 $cbm \cdot t^{-1}$ of cotton. This is 0.91 $t \cdot ha^{-1}$ more than the control variant.

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