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Effect of Innovative Salinity Leaching Technology and Scientific Based Irrigation Regime to Cotton Yield (A Case Study from Bukhara Region of Uzbekistan)

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ABSTRACT: This article discusses the impact of the development of water-saving salinity leaching technology on the conditions of meadow-alluvial, moderately saline and medium sandy soils of Bukhara oasis according to its mechanical composition using Biosolvent compounds and the impact of the scientifically based irrigation regime on the reclamation regime of irrigated lands. In a saline-washed field with a Biosolvent combination, the Bukhara-102 variety of Gossypium received irrigation soil moisture at the beginning of vegetation when watered at 70-80-65 percent compared to LFMC, its yield is 40.5 cwt•ha-1, with an additional 3.9 cwt•ha-1 of cotton yield compared to the control, which allows to save 53.7 cbm of river water used for growing 1 cwt cotton yield.

KEYWORD: Uzbekistan, Technology, Region, Cotton.

1. Introduction

Today in the world there are about 1 billion hectares of arid and saline areas, which account for 25-30 percent of the land use. Of the 275 million hectares of irrigated land, 45 million hectares are occupied by saline and saline-prone soils, while saline areas account for 62 million hectares worldwide. In 75 countries of the world, mainly located in arid (arid) regions, the problem of salinity has taken a serious toll (Australia, China, India, Mexico, Pakistan, the United States, etc.). The yield of exactly 32 million hectares of land is directly affected by the salts contained in the soil. This leads to a decrease in the yield of agricultural crops.

According to scientists around the world, salts in the soil, especially readily soluble salts, can cause serious damage to the development of agricultural crops and send a sharp drop in their yields [1-8]. According to L.P. Rozov's doctrine, the degree of harmful effects of water-soluble salts on the soil composition on the development of agricultural crops varies.

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$NaCl$	Na_2SO_4	Na_2CO_3	$NaHCO_3$
$MgCl_2$	$MgSO_4$	$MgCO_3$	$Mg(HCO_3)_2$
$CaCl_2$	$CaSO_4$	$CaCO_3$	$Ca(HCO_3)_2$

Note: the salts located above the marked line are harmful to plants, while the salts below are harmless.

There are a number of measures to improve the reclamation of irrigated lands, including phytomelioration (improving land reclamation by planting saline-resistant (halophyte) crops), biomelioration (fertilizing, growing alfalfa), chemical reclamation, electricity (permanent electric tillage of the soil) and hydraulic reclamation (removal of salts from the soil by ditches and salt washing).

A number of scientists from the USA, England and Australia [9] have conducted extensive research on the formation of soil salinization, as well as on combating this problem, i.e. on improving land reclamation based on a number of agro-reclamation measures. Mohammad Zaman et al. [10] argue that in order to combat salinization, it is necessary to develop a salinization control strategy that will prevent the spread of salinization and reduce the impact of salinization in the future. To achieve this goal, a number of measures were recommended, in particular, the cultivation of deep-rooted plants in areas with water scarcity, the correction of LGW through drainage and the washing of saline soils.

I. Khudaynazarov et al. [11] as a result of scientific research carried out in laboratory conditions on highly saline soils to simulate desalination using a Biosolvent compound at a concentration of 0.5-10% (normally 500-1000 m^3/ha during desalination), it was found that the higher the concentration of the Biosolvent compound, the greater the desalination of salt can be achieved, as well as the leaching of divalent cations of calcium, magnesium increases the alkalinity of the soil, It was observed that sodium salt was washed in 0.05% solution (61%), 1% solution (57.1%) in 2% solution (51.4%), and potassium salt in 0.05% solution (19%). As a result of laboratory analysis, they recognized the biosolvent compound as the optimal concentration of 2% solution.

The aim of the research was to improve a water-saving technology for leaching of saline soils and work out a science-based irrigation scheduling for cotton using Biosolvent compound in the conditions of meadow-alluvial, moderately saline and medium sandy soils of Bukhara oasis according to its mechanical composition.

The object of the research was meadow-alluvial, moderately saline and medium sandy soils of Bukhara oasis according to its mechanical composition, Biosolvent compound, Bukhara-102 variety of medium-staple cotton.

The scientific novelty of the research include – for the first time in the conditions of meadow-alluvial, moderately saline and medium sandy soils of Bukhara oasis according to its mechanical composition:

the Biosolvent compound has been found to increase salt solubility in water and water permeability by 14 %;

in water-saving technology of soil leaching on the basis of Biosolvent compound was found that saline washing standards are reduced by 38 % and duration is reduced to 15 days;

a scientifically based irrigation regime has been developed to ensure high yields of cotton in the washed field on the basis of soil saline Biosolvent compound, saving 32 % of river water and increasing cotton yield by 3.9 $c \cdot ha^{-1}$;

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during the water-salt balance of the experimental field, 4.2 $t{\cdot}ha^{-1}$ of salt was released and its reclamation condition was improved.

2 *Methods*

“Methods of field experiments, determination of water-physical, agrochemical properties of soil and the amount of salts” and “Methods of studying the agrochemical, agro-physical and microbiological properties of irrigated areas of cotton” of the Research Institute of Cotton Breeding, Seed Production and Agro-technology, and the accuracy and reliability of the data obtained were analyzed mathematically in the method of dispersion analysis in the source of B.A.Dospexov's “Methods of Field Experiments”.

3 Results and Discussion

Scientific research works were conducted in 2017-2019, the groundwater of the State Unitary Enterprise “Training and Scientific Center” of the Bukhara branch of TIIAME, located in the territory of Khoja Yakshaba rural citizens' counsel, Kagan district, Bukhara region, 1.5-2.0 meters, alluvial meadow, moderately saline, mechanical composition performed on medium sandy soils.

In the option 1 of the experiment to determine the effectiveness of saline washing, saline washing was carried out at a rate determined on the basis of V.R. Volobuev's formula. In the variant 2 of the study, using a biosolvent compound, the saline wash was performed at a rate 30% lower than the saline wash standard determined using V.R. Volobuev’s formula. In the variant 3 of the experiment, the traditional method, i.e., the saline wash rate was performed on the basis of actual measurements.

Experimental results on soil saline leaching based on Biosolvent compound. Periodic experiments conducted in 2017–2019 took into account the amount of salts in the soil (chlorine ion, sulfate ion and dry residue), the type of salinity, its mechanical composition and the specific natural and climatic indicators of the region. In determining the rate of saline leaching, the water-physical properties of the soil were calculated by the following formula of V.R. Volobuev on one meter of soil layer (formula 1):

$$N_{s.s.l.n.} = 10000 \cdot lg\left(\frac{S_i}{S_{adm}}\right)^{\alpha}, \qquad cbm{\cdot}ha^{-1}, \qquad (1)$$

Note: Here: a - free salt transfer coefficient, S_i, S_{adm} - salts in the soil before saline leaching and the specified amount, in% of weight.

Comparing the three-year average results, it was found that the saline leaching rate was the highest in control option 3, using Biosolvent compound, and consumed an average of 1514 $cbm{\cdot}ha^{-1}$ more water than in saline wash option 2. During the experiments, the lowest water consumption for saline washing was observed in option 2, the average seasonal saline leaching rate was 2499 $cbm{\cdot}ha^{-1}$, or water resources were saved by 30% compared to option 1, 38% compared to option 3 (1- picture).

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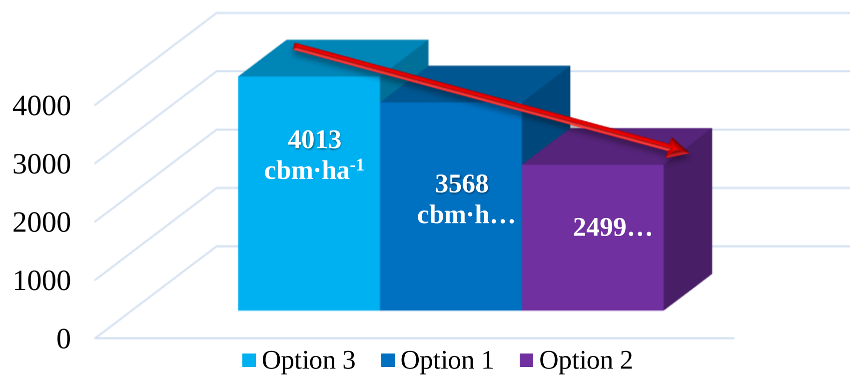

Fig. 1. Soil salinity leaching norms in the experimental field (average 3 years).

The effect of cotton on the growth, development and yield of Bukhara-102 variety was studied in a leaching soil salinity experimental field using a Biosolvent compound. Field experiments conducted on following system (Table 1):

Table 1. Field experiment system on cotton irrigation.

№	Soil moisture before irrigation,% of LFMC	Irrigation norm, $cbm \cdot ha^{-1}$
1.	production control	actual measurements
2.	70–80–65	On the moisture deficit in the layer of 70–100–70 cm
Note: here: a scientifically based irrigation regime for cotton was experimented in option in which a Biosolvent compound was used in soil salinity leaching experiments. In the traditional soil salinity leaching by delyans, the control option replaced the cotton irrigation period.		

The field experiments were conducted on 2 options 3 repetitions, in both options same fertilization norm and cotton variety. Options, the furrow consists of 8 rows with a spacing of 90 cm, all the calculations were done in the middle four, the two rows next to it are protective rows. All laboratory, field, production experiments, their observation, analysis and calculations were carried out on the basis of "Methods of conducting field experiments" (UzCSRI 2007) adopted by Research Institute of Cotton Breeding, Seed Production and Agro-technology.

Irrigation regime of cotton. The aim of the research is to determine the optimal irrigation regime for saline leaching process in soils with a mineralization of 1–3 $g \cdot l^{-1}$, groundwater at a depth of 1.5–2.0 m, moderately saline medium sandy soils using Biosolvent compound. In the study of the optimal irrigation regime, the norms, timing and number of each irrigation, as well as the norms of seasonal irrigation were determined, depending on the established soil moisture levels and specific climatic indicators. Every irrigation norm was measured and copied down using a “Chipoletti VCh-75” water measurement device.

In calculating the irrigation norm, taking into account the water-physical properties of the soil and the depth of wetting, calculated according to the S.N. Ryjov's (1948) formula (formula 2).

$$M = 100 \cdot h \cdot d \cdot (W_{LFMC} - W_{FM}) + k, \quad cbm \cdot ha^{-1}, \qquad (2)$$

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Note: here: W_{LFMC}– limited field moisture capacity relative to soil weight, %; W_{FM}– actual moisture before irrigation relative to soil weight, %; d– weight density of soil, g·cm^{-3}; h– calculated soil layer, m; k– water consumption for evaporation in irrigation, cbm·ha^{-1} (10 percent of the moisture missing in the calculated soil layer).

During the experiments, average for 3 years (Table 2) in the first production control option, irrigation during the growing season was 1–3–1 system, a total of 5 times, the irrigation norm was 877–1086 cbm·ha^{-1}, and the seasonal irrigation norm was 5049 cbm·ha^{-1}.

When the pre-irrigation soil moisture was 70–80–65% of the LFMC, the irrigation scheme was 1–3–1, the irrigation norm was 655–752 cbm·ha^{-1}, and the seasonal irrigation norm is 3414 cbm·ha^{-1}, which is less than the control, and 1635 cbm·ha^{-1} (32%) of river water was saved. In this option, the interval between irrigations was 16–22 days, which was 3–5 days shorter than in the control variant.

Table 2. Irrigation schedule for cotton (in average for 2017–2019 years)

Options	Indicators	Irrigations					Irrigation system	Seasonal irrigation norms, cbm·ha^{-1}
		1	2	3	4	5		
1	irrigation date	14.06	04.07	25.07	14.08	05.09	1-3-1	5049
	between irrigations, days		20	21	20	22		
	irrigation norm, cbm·ha^{-1}	877	982	1086	1085	1019		
2	irrigation date	14.06	30.06	17.07	03.08	25.08	1-3-1	3414
	between irrigations, days		16	17	17	22		
	irrigation norm, cbm·ha^{-1}	670	655	679	658	752		

Note: here Option 1 is production control; Option 2 - a variant in which a Biosolvent compound was used for leaching soil salinity, and a scientifically based irrigation regime for cotton was studied.

Influence of irrigation regime on cotton yield. Data on the yield of the Bukhara-102 cotton variety in the experimental cotton cultivated in the research field in 2017-2019 are given in Table 3. Data shows that in control option 1, an average of 138.0 cbm of river water was used to grow 1 quintal of cotton and a yield of 36.6 cwt·ha^{-1}.

Table 3. The Effect of irrigation on cotton yield.

Options	Cotton yields on repetitions, cwt·ha^{-1}			Average yields, cwt·ha^{-1}	Extra yield, relative to control, ± cwt·ha^{-1}	Used river water for one c cotton yield, cbm
	I	II	III			
2017 year						
Option 1	38,6	36,6	37,3	37,5	0,0	134,9
Option 2	40,9	42,4	40,2	41,2	+3,7	82,1
2018 year						
Option 1	34,8	37,2	37,3	36,4	0,0	137,9
Option 2	40,4	40,6	40,3	40,4	+ 4,0	85,9
2019 year						
Option 1	36,7	34,8	36,5	36,0	0,0	140,8
Option 2	40,9	38,6	40,2	39,9	+ 3,9	85,0
average for 3 years						
Option 1	36,7	36,2	37,0	36,6	0,0	138,0
Option 2	40,7	40,5	40,2	40,5	+ 3,9	84,3
NSR_{05}=1,02 c·ha^{-1}						

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In the second option, when the soil moisture before irrigation was 70-80-65% relative to LFMC, 84.3 cbm of river water was used on cultivation 1 quintal of cotton, and the total yield of cotton was 40.5 $t \cdot ha^{-1}$.
According to the results of the study, scientifically based pre-irrigation soil moisture is maintained at 70–80–65% relative to the LFMC, with an additional not only 3.9 quintals of cotton per hectare of Bukhara-102 variety of cotton, but also 1 quantial of cotton allowed to save 53.7 cbm of river water.

Cost-effectiveness of soil salinity leaching and holding cotton irrigation process with using Biosolvent compound. In determining the economic efficiency of medium-fiber cotton Bukhara-102, the cost of all agro-technical measures was calculated according to the approved technological map for the region, including pumping water for irrigation, as well as the cost of Biosolvent and its application.

Irrigation of saline soils with Biosolvent and irrigation of cotton with pre-irrigation of soil moisture by 70-80-65% compared to LFMC, ie additional cost of 533.3 thousand soums compared to the control option, increased the yield of cotton by 3.9 $t \cdot ha^{-1}$, and an additional net profit of 453.6 thousand sums was achieved, amounting to 2525.7 thousand soums. The level of profitability was 32.0%, which is 3.6% higher than the control.

4 Conclusions

On the basis of research on the impact of water-saving technology of saline soil leaching on soil reclamation and cotton yields in the conditions of meadow-alluvial, moderately saline and medium sandy soils of Bukhara oasis groundwater level of 1.5–2.0 m and mineralization of 1–3 g / l, the following conclusions were done:

1. During the researches, the lowest water consumption for leaching soil salinity was observed on using Biosolvent compound, the average seasonal saline leaching norm was 2499 $cbm \cdot ha^{-1}$, or 38% of river water was saved compared to salt leaching in the control option.

2. When cotton soil was irrigated at 70–80–65% relative to the LFMC before irrigation, the irrigation scheme was 1–3–1, with an irrigation norm by 655–752 $cbm \cdot ha^{-1}$ and a seasonal irrigation norm was 3414 $cbm \cdot ha^{-1}$, and 1635 $cbm \cdot ha^{-1}$ (32%) river water was saved compared to the control option.

3. Irrigation of saline soils with Biosolvent and irrigation of cotton with pre-irrigation of soil moisture by 70-80-65% compared to LFMC, additional cost of 533.3 thousand soums compared to the control option, increased the yield of cotton by 3.9 $t \cdot ha^{-1}$, 1 quantial of cotton allowed to save 53.7 cbm of river water and an additional net profit of 453.6 thousand sums was achieved, amounting to 2525.7 thousand sums. The level of profitability was 32.0%, which is 3.6% higher than the control.

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