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Article

Results of Using Spersal Chemical Meliorant to Improve the Reclamation State of Saline Soils in The Kashkadarya Region

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ABSTRACT

The article presents the results of experiments conducted in the Karshi district of the Kashkadarya region to improve the reclamation condition of moderately saline soils, enhance the efficiency of irrigated land use, and achieve higher crop yields. Considering the region's water scarcity, a water-saving "Chemical" method was employed to improve the reclamation state of saline soils. To ensure the leaching of salts to lower soil layers, irrigation rates exceeding the standard by 25% and 50% under water scarcity conditions were applied, and these methods were compared with traditional approaches to study the soil's water-salt regime. The chemical ameliorant SPERSAL, recommended by the Swiss company "Sibo-Novartis," was used as a soil amendment at a rate of 5 kg/ha. When applied to the soil before irrigation or mixed with irrigation water, SPERSAL induces an ion exchange reaction in the soil adsorption complex, displacing sodium cations with calcium and magnesium cations. Salts such as sodium chloride, sodium sulfate, and sodium bicarbonate formed in the plant root zone dissolve in irrigation water and leach into lower soil layers. Key parameters studied include soil water absorption, field capacity, capillary rise height of soil moisture, the amount of water-soluble salts in irrigation, drainage, and groundwater, as well as soil moisture dynamics. Calculations for the water required for leaching and irrigation of saline soils, along with the economic efficiency of the applied variants based on cotton yields, were determined according to the "Methods of Conducting Field Experiments" (Tashkent, 2007) guidelines.

INTRODUCTION

The annual volume of water resources in Central Asia is approximately 116 km³, with 90% originating from two major river systems: the Amudarya and the Sirdarya. The volume of groundwater in the region is estimated at around 43,49 km³. About 80% of the water resources are used in agriculture, nearly 7-8% in industry, and the remaining portion is utilized for domestic, service, and other purposes [1].

Significant efforts are being undertaken across our countries to ensure the rational use of water resources in Central Asia. On November 6, 2024, the 87th meeting of the Interstate Commission for Water Coordination (ICWC) of Central Asia was held in Ashgabat, Turkmenistan. The meeting addressed issues related to the utilization of water accumulated in reservoirs of the Amudarya and Sirdarya basins at the end of the 2024 season. Operational schedules for reservoir cascades and water distribution limits for the 2024-2025 off-season were analyzed and approved. Additionally, the implementation of decisions

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adopted by the heads of the founding countries of the International Fund for Saving the Aral Sea was reviewed [2].

It is important to note that, on a global scale, the growing population and the increasing demand for food products are paralleled by a rise in the demand for irrigation water. As a result, water scarcity is being observed worldwide. This issue of water shortage has not bypassed our country and the Central Asian region. According to experts in the water management sector, by 2050, water resources in the Amudarya basin are predicted to decrease by up to 15%, and in the Sirdarya basin by up to 5%. In Uzbekistan, the demand for water is expected to reach 7 billion cubic meters by 2030 and increase to 14 billion cubic meters by 2050.

In line with the directives of the President of our country, the implementation of water-saving technologies in irrigated agriculture by 2030 has been prioritized. Measures have been established to further enhance incentive mechanisms for farmers and agricultural workers adopting such technologies. For instance, since 2019, a new state-supported system of subsidies for introducing water-saving technologies has been implemented. Starting in 2022, this system has been digitized.

It should be emphasized that, as in other fields, significant attention is being given to the integration of digital technologies in the water management sector. To this end, 1 446 online monitoring devices have been installed at 5 479 “Aqlli suv” pumping stations, along with 5 055 “Dayver” devices for monitoring mineralization levels in reclamation monitoring wells. Furthermore, management processes at 45 major water management facilities have been automated [4].

As a result of these measures, 3 billion cubic meters of water have been saved, and water supply has been improved on an additional 400 000 hectares of land. Automation of water management processes has reduced water losses by up to 10% [4].

The projected water scarcity issues demand fundamental reforms in the water management sector. Addressing these challenges necessitates the adoption of water-saving technologies to ensure the efficient use of irrigation water. This is particularly essential in improving the reclamation conditions of saline soils, as it is crucial to reduce the significant amount of water used for soil leaching. This calls for the development of modern methods for improving soil reclamation conditions, requiring scientific research. The present scientific research belongs to the category of such studies.

METHODS

River flows are formed by the seasonal melting of snow cover, glaciers, and snowfields in the mountains, as well as by precipitation. Mountain groundwater is replenished by these water sources. In foothill and irrigated areas, groundwater is mainly recharged by surface water. The water resources of rivers and groundwater are interdependent. Excessive use of groundwater significantly reduces river flow. In the irrigated agricultural regions of Central Asia, the annual water resources of rivers amount to 114 km^3, including 74,7 km^3 in the Amudarya basin (including the Zarafshan and Kashkadarya), 39 km^3 in the Sirdarya basin, and 2,4 km^3 in the Tejen and Murgab rivers. Water resources are unevenly distributed geographically: although they originate in the mountains, they are primarily utilized on plains through an extensive network of irrigation canals [3].

Due to global climate change, a reduction in the area of glaciers in the mountains is expected to lead to water shortages in the Amudarya and Sirdarya rivers, which are the main sources of irrigation water for our country, as well as in the region as a whole. In various countries around the world, including Israel, irrigation areas have transitioned to water-saving technologies, achieving a 100% adoption rate. In the United States, this figure stands at 38,2%, in Egypt at 36%, in Kazakhstan at 14%, in Turkey at 12%, and in the People’s Republic of China at 11% [3].

According to calculations, in 2020, the use of drip irrigation technology in cotton cultivation in Uzbekistan

resulted in the following average savings per hectare: water consumption was reduced by 40-50%; fuel consumption decreased by 60%; the efficiency of mineral fertilizers increased by 30%; labor resources and wage costs were reduced; the biological ripening period of cotton was shortened by 12-15 days; and yield increased by 20-30 quintals [3].

The decree of the President of the Republic of Uzbekistan, PQ-4919, dated December 11, 2020, titled "Measures to Accelerate the Introduction of Water-Saving Technologies in Agriculture," outlines the tasks for significantly increasing the efficiency of water use in agriculture under conditions of growing water scarcity and increasing demand for water resources. The decree specifies the following areas for implementation in 2021: drip irrigation on 160000 hectares of cotton, 30000 hectares of fruit crops, 15000 hectares of vineyards, and 5000 hectares of other crops; sprinkler irrigation on more than 14000 hectares of grain crops, 2000 hectares of vegetables and melons, and 2000 hectares of forage crops; and the introduction of discrete irrigation technology on 623 hectares of cotton-growing land [3].

In our country, additional water consumption of 2500-6000 m^3 per hectare is required for leaching saline soils of varying degrees of salinity. Such challenges encourage the development of water-saving new technologies to improve the reclamation state of irrigated lands.

From 2008 to 2010, we conducted scientific research in the conditions of moderately saline, sulfate-chloride type soils with heavy mechanical composition and desertification-prone pasture lands in the Karshi district. The aim was to improve the irrigation technique for cotton of the "Bukhara-6" variety and scientifically substantiate the effect of the SPERSAL chemical meliorant on the soil's water-salt balance. The research was carried out based on the following variants [10]:

1. Sowing cotton using the traditional method, irrigating with furrow irrigation based on moisture deficiency (control).
2. Sowing cotton under plastic film, irrigating with furrow irrigation at 70-70-60% of the standard irrigation rates.
3. Applying chemical meliorant (5 kg/ha) to the soil, sowing cotton under plastic film, and irrigating with furrow irrigation at 70-70-60% of the standard irrigation rates.
4. Sowing cotton under plastic film, irrigating with furrow irrigation at 70-70-60% of the standard rates with 25% reduced water consumption.
5. Sowing cotton under plastic film, irrigating with furrow irrigation at 70-70-60% of the standard rates with 25% increased water consumption.
6. Applying chemical meliorant (5 kg/ha) to the soil, sowing cotton under plastic film, and irrigating with furrow irrigation at 70-70-60% of the standard rates with 25% increased water consumption.
7. Sowing cotton under plastic film, irrigating with furrow irrigation at 70-70-60% of the standard rates with 50% increased water consumption.
8. Applying chemical meliorant (5 kg/ha) to the soil, sowing cotton under plastic film, and irrigating with furrow irrigation at 70-70-60% of the standard rates with 50% increased water consumption [6].

For the research, a small experimental plot was selected, with an area of 1440 m^2, a slope of 0,002, and furrow lengths of 200 m with a 0,9 m spacing between them. The plot was adjacent to an open drainage ditch, and the groundwater level was located 2,2-2,5 m below the crop surface. The number of replications was four. The soil moisture before irrigation was taken as the baseline for this region, and the irrigation system at 70-70-60% of the standard irrigation rates was adopted for the "Bukhara-6" cotton variety, which showed positive results [5].

Taking into account that the TFWC (The threshold field wet capacity) is 21,6% and the soil's bulk density is 1,44 g/cm^3, and using S.N. Rijov's formula for calculating the moisture content for irrigation in a 70-

70-60% system relative to TFWC, we determined that for the period from flowering to boll opening, the required water for the 0-70 cm soil layer is 780 m³/ha. For the period from boll opening to maturation, the required irrigation for the 0-100 cm soil layer is 1083 m³/ha [5].

The agrotechnical measures applied in the experimental plot were carried out based on the scientifically grounded farming system developed at PSUEATI and its Karshi branch. The annual rates of mineral fertilizers were 200 kg/ha of nitrogen (N), 140 kg/ha of phosphorus (P), and 70 kg/ha of potassium (K). 50% of the phosphorus and potassium fertilizers were applied before irrigation, with the remaining phosphorus applied during flowering, potassium during boll opening, and nitrogen applied at the stages of 2-3 true leaves, boll opening, and flowering periods.

RESULTS AND DISCUSSIONS

The tillage for irrigation was carried out annually in the fall to a depth of 30-35 cm using the PYa-3-33 type plows. To preserve soil moisture, harrowing was done at the beginning of April each year, followed by rolling and pre-sowing operations to ensure the quality of seedbed preparation. Cotton was sown in rows at a 90x10x1 system on April 19, 2008, March 31, 2009, and March 20-22, 2010. During the growing season, 5-6 cultivations were carried out between the rows using the KRX-4 cultivator, and weed control was performed by hand 1-2 times [7-8].

During the growing season, chemical pesticides were used to control cotton diseases and pests. To prevent excessive vertical growth and promote the growth of lateral branches, which would help achieve a higher number of bolls, two hand thinning operations were conducted. The harvested cotton was collected in three stages [8-9].

The SPERSAL chemical meliorant consists mainly of a polymer, butene dioic polyallelic acid, with 30% homopolymer, 6% linear sulfonated alkyl benzol, and 64% inert substances [6,10].

The mechanism of SPERSAL's physicochemical action is as follows: when applied to the soil, the meliorant causes the displacement of sodium cations in the soil's adsorption complex, leading to an exchange reaction with calcium and magnesium cations [6-11].

Salts such as chloride, sodium sulfide, and sodium bicarbonate, formed in the plant root zone, dissolve with the irrigation water and leach down to the lower layers of the soil.

When SPERSAL is applied, an exchange reaction takes place in the soil. Before leaching, based on the degree and type of salinity, the required amount of SPERSAL is applied to the soil. During leaching, the volume of water and the amount of relative expenses for desalinization of the root zone and soil are reduced. In other words, conditions are created for reducing the leaching norm. Due to changes in the soil's physical and water properties, the rate of water infiltration into the soil increases, and the elements of irrigation technique also change [12-13].

For the experiment, the application rate of SPERSAL was set at 5 kg/ha based on the recommendations of the Swiss company "Sibo-Novartis".

To study the changes and trends in the soil's water regime in the root zone, the individual components of the water balance in the 0-100 cm soil layer were determined. Based on the average values from the research years, the total water consumption from the cotton field in the compared variants ranged from 6330 m³/ha (in variants 7 and 8) to 7100 m³/ha (in variant 1).

The experimental data show that as the irrigation rate increases by 25% and 50% compared to the TFWC 70-70-60% system, the water volume used per unit area decreases. In other words, in the control variant, the water consumption was 7100 m³/ha, whereas in variants 2 and 3, where polyethylene film and SPERSAL chemical meliorant were used, water consumption was reduced by 870 m³/ha. When the irrigation norm was reduced by 25% compared to TFWC, the difference was 390 m³/ha in favor of the

lower water consumption (variant 4).

When the cotton was planted under polyethylene film, and the SPERSAL chemical meliorant was applied at a rate of 5 kg/ha (variants 5 and 6), the difference in total water consumption between the variants was minimal, amounting to just 140 m³/ha [12-14].

Table 1. The water consumption for irrigation required to obtain 1 centner of raw cotton

Experimental variants	2008 year			2009 year			2010 year		
	Seasonal irrigation norm, m³/ha.	Yield, c/ha	Irrigation water consumption per 1 centner of yield, m³/c	Seasonal irrigation norm, m³/ha.	Yield, c/ha	Irrigation water consumption per 1 centner of yield, m³/c	Seasonal irrigation norm, m³/ha.	Yield, c/ha	Irrigation water consumption per 1 centner of yield, m³/c
1	7100	27,8	255,4	6370	29,6	215,2	7190	31,5	228,2
2	6230	39,5	157,7	5670	36,4	155,8	6510	39,3	165,6
3	6230	41,3	150,8	5670	37,1	152,8	6510	40,6	160,3
4	6710	34,2	173,4	5220	31,5	165,7	5830	32,4	179,9
5	6960	41,4	168,1	6220	40,2	154,7	6760	42,2	160,2
6	6960	43,6	159,6	6220	42,7	145,7	6760	44,3	152,6
7	6330	42,4	149,3	5780	41,6	138,9	6310	39,6	159,3
8	6330	45,5	139,4	5780	44,3	130,5	6310	45,4	139,0
Aver.	6509	39,5	169,2	5866	37,9	157,4	6522	39,4	168,1

In conditions similar to the experiment, when the irrigation norm was increased by 50% compared to the 70-70-60% system of TFWC (variants 7 and 8), 770 m³/ha less water was used per hectare of cotton land compared to the control variant. In the presented total water consumption volumes, the amount of atmospheric precipitation was almost the same in variants 1, 2, and 3, constituting 24,3-25,3%. Notably, in the variants where the moisture was increased by 25% (variants 5 and 6) and 50% (variants 7 and 8) compared to the 70-70-60% system of TFWC, the share of atmospheric precipitation in the total water consumption remained almost the same, i.e., 19,6% and 18,6%, respectively [8, 10].

The data from the experiment show that at the end of the vegetation period, compared to the spring period, the largest reduction in the amount of salts in the 0-100 cm soil layer was observed in variant 7, where the irrigation norm was increased by 50%, and in variant 8, where an additional 5 kg/ha of SPERSAL chemical meliorant was applied. In these variants, the total amount of salts decreased by 2,4-2,5 times, chloride ions by 2,3-2,6 times, and the amounts of sodium and potassium decreased by 0,83-1,81 times.

The calculation of the hypothetical composition of salts and the change in their amounts during the study period showed the following results. In the examined soil layer, the water-soluble salts decreased in the following order: $CaSO_4$, NaCl, Na_2SO_4, $MgSO_4$, and $Ca(HCO_3)_2$, while $MgCl_2$ was not observed in the soil. During the vegetation period, a reduction in water-soluble salts was noted in almost all variants, except for variants 1 and 2, where the amount of Na_2SO_4 increased by 1.3 and 1.8 times, respectively. There were minimal changes in the amounts of $Ca(HCO_3)_2$and Na_2SO_4. In the soils of variants 5, 6, 7, and 8, the amount of $CaSO_4$ decreased by 2,3; 3,6; 7 and 3,9 times, respectively; MgSO4 decreased by 2,3; 4,4; and 4 times; and NaCl decreased by 2,2; 2,3; 2,3 and 2,6 times.

The data from the table show that the seasonal irrigation norms decreased in variants 5, which were irrigated with a 25% increased norm, in variant 6 where 5 kg/ha of SPERSAL chemical meliorant was applied, in variant 7 with a 50% increased irrigation norm, and in variant 8 where 5 kg/ha of meliorant was applied. This is because the soil of the experimental plots is heavy loamy. Such soils, due to their

ability to retain water for an extended period, resulted in an increase in the irrigation interval from 17-19 days to 27-28 days. As a result, in the control variant, irrigation was carried out 7 times according to the 2-4-1 scheme, while in variant 5, which was irrigated with a 25% increased norm, irrigation was carried out 5 times according to the 1-3-1 scheme. Similarly, in variant 6, which also received 5 kg/ha of SPERSAL chemical meliorant, irrigation was carried out 5 times according to the same scheme. In variant 7 with a 50% increased irrigation norm, irrigation was performed 4 times according to the 1-2-1 scheme, and the same irrigation regime was followed in variant 8, where 5 kg/ha of SPERSAL chemical meliorant was applied.

In the 6th variant of the conducted experiments, 6960 m^3/ha of water was used, and the average three-year cotton yield was 41,27 s/ha. In the same 6th variant, with the same water usage of 6960 m^3/ha, the yield reached 43,5 s/ha. In variants 7 and 8, these figures were 41,2 s/ha and 45,0 s/ha, respectively.

Based on the provided data, the highest water consumption for producing 1 quintal of cotton yield was 232,9 m^3/s in the control variant, while in variants 5 and 6, the water consumption was 161,0 and 152,6 m^3/s, respectively. In variants 7 and 8, the corresponding figures were 149,27 and 136,3 m^3/s [8-13].

Based on this information, it can be concluded that increasing the irrigation rate by 25% compared to the TFWC (field water demand) led to a reduction in soil salinity, which in turn resulted in an increase in yield. Similarly, when irrigated in the same manner and supplemented with an additional 5 kg/ha of SPERSAL chemical meliorant, the yield increased by 2,23 s/ha. However, no significant changes were observed in variant 6, where the irrigation rate was increased by 50%. Yet, when the same irrigation method was applied with the addition of the meliorant, a significant increase in yield was observed.

CONCLUSION

In soils with a heavy mechanical composition and medium salinity of sulfate-chloride type, increasing the irrigation water by 25-50% (variants 5, 6, 7 and 8) before irrigation and applying an additional 5 kg/ha of SPERSAL chemical meliorant improves the soil's meliorative condition and increases the yield by 3-5 s/ha per hectare.

According to the results of the experiment conducted in the water scarcity conditions of the Karshi district (variant 4), it was found that reducing the irrigation rate by 25% compared to TFWC (70-70-60% rule) in medium-saline soils was not advisable. This is because the soil moisture reserves in the 70-70-60% irrigation schedule were insufficient, which led to a reduction in the interval between irrigations and an increase in the number of irrigation events. Due to the low efficiency of irrigation techniques and irrigation networks, water wastage increased during each irrigation.

These results were applied in the "Mahmudov Alpomish" farm in the "Chillabulak" SIU in Kasbi district and in the "Umidullaev Shamshodbek" farm in Mirishkar district, where the Bukhara-6 cotton variety was cultivated on 6 hectares of medium-saline, heavy-textured soils in 2019. Positive results were achieved, as confirmed by a report from the Ministry of Water Management of the Republic of Uzbekistan.

Thus, applying 5 kg/ha of SPERSAL chemical meliorant before the first irrigation and increasing the irrigation rate by 25% and 50% compared to TFWC improves the meliorative condition of sulfate-chloride, medium-saline soils and saves 3500-4500 m^3/ha of water for leaching during the non-irrigation period. Therefore, this method can be classified under "Water-saving technologies for improving soil meliorative conditions."

REFERENCES

[1] *Markaziy Osiyodagi suv munosabatlari: tarix va istiqbol – Davr24*. (n.d.). https://davr24.uz/archives/1282

[2] https://water.gov.uz/uz/page/5/40

[3] Contributors to Wikimedia projects, "Suv resurslari," *Vikipediya*, Sep. 04, 2023. https://uz.wikipedia.org/wiki/Suv_resurslari

[4] "O'zsuvta'minot aksiyadorlik jamiyati." https://uzsuv.uz/ru/posts/844

[5] Avlakulov M., Doniyorov T.O. G'o'zani egatlab sug'orishda egat gidravlik elementlari orasidagi bog'liqlikni o'rnatish. //Innovatsion texnologiyalar Ilmiy texnik jurnali 2021. Maxsus son. Qarshi 2021 y. 31-35 b.

[6] Doniyorov T.O. Egatlab sug'orishning tuproq suv-tuz tartiboti o'zgarishiga ta'siri. // Innovatsion texnologiyalar 3(35)-son. 2019 y. -56-59 b.

[7] Avlakulov M., Doniyorov T.O. Solution of the problem of the flow of filtration flow in a heterogeneous medium during furrow irrigation of cotton. "Actual Problems of Modern Science" Moscow. No. 2 (111), 2020, pp. 100-104.(original in Russian)

[8] Doniyarov T.O., Avlakulov M., Tursunov G'.J. Tuproq meliorativ holatini yaxshilashda suv tejamkor texnologiyalarning ahamiyati. "Innovatsion texnologiyalar" ilmiy texnik jurnali. Qarshi. 2022 yil. 1 (45) - son, 31-35 b.

[9] Doniyarov T.O. O'rtacha sho'rlangan og'ir qumoq tuproqlarning meliorativ holatini yaxshilash va paxtadan mo'l hosil olish texnologiyasi. Oriental Renaissance: Innovative, educational, natural and social sciences 3(12), Dec., 2023 y. 292-299 b.

[10] Doniyarov T.O. O'zbekistonda sug'orish nasos stansiyalari energiya iste'moli. Oriental Renaissance: Innovative, educational, natural and social sciences 4 (5), May, 2024 y. 387-393 b.

[11] Urishev B., Kuvvatov, D.; Doniyorov, T.; Kuvatov, U.; Umirov, A. Hydraulic storage of solar energy for supplying pumping units with drip irrigation of plants. Publication: AIP Conference Proceedings, Volume 2612, Issue 1, id.020016,7pp. DOI: 10.1063/5.0113641. 2023AIPC.2612b0016U.

[12] Urishev B.; Artikbekova F.; Kuvvatov D.; NosirovF.; Kuvatov U. Trajectory of sediment deposition at the bottom of water intake structures of pumping stations. Publication: IOP Conference Series: Materials Science and Engineering, Volume 1030, Issue 1, pp. 012137 (2021). Pub Date: January 2021. DOI: 1088/1757-899X/1030/1/012137.

[13] Urishev B.; Kuvatov U.; Umirov A. Determination of main energy parameters and efficiency of local energy system based on renewable energy sources. Publication: IOP Conference Series: Earth and Environmental Science, Volume 1070, Issue 1, id.012043,7pp. Pub Date: July 2022. DOI: 10.1088/1755-14.15/1070/1/012043.

[14] U.J.Quvatov, I.E. Saidov, S.X.Qulmatov, and S.I.Davronov, "Improving The Efficiency of Hydropower Devices ", JNCI, vol. 43, no. 3, pp. 69–72, Jan. 2024.