Substantiation of technology of using collector-drainage water for cotton irrigation

Sadriddin Urunboev[*]

"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan

Abstract. The article has developed the optimal options for the use of collector-drainage water as an additional source in the active layer of soil during irrigation of collector-drainage water of cotton variety "An-Bayaut-2" in Saykhunabad district of Syrdarya region, which is 567 m^3/ha. Innovative technologies for irrigating cotton with collector-drainage waters using the nuclear-physical method for determining the dynamics of water absorption in the active layer of soils with low salinity allow achieving water saving and a high yield of cotton 4.68 c/ha, saving 13-14% of river water and additionally net income in the amount of 1,150,000 UZS per hectare.

1 Introduction

The use of groundwater for irrigation of crops is one of the most important problems in the modern world. In this regard, using rivers and reservoirs with different mineralization levels for irrigation is particularly important. In this regard, including in the USA, Italy, China, India, Saudi Arabia, Russia, and other developed countries, when crops are irrigated with groundwater, the amount of salt in arable land increases, and special attention is paid to reducing the amount of salt after heavy rains or rinsing with saline [1-3].

About 300 km^3 of collector-drainage waters (CDW) are formed annually, which causes great damage to the economy and nature of all countries. Therefore, special attention is paid to conducting targeted scientific research aimed at protecting water resources and eliminating the negative impact of CDN on the environment. In this regard, one of the important tasks is the development of measures for the reuse of collector-drainage water for irrigation by demineralization and disinfection or their use in combination with river water.

To prevent water shortages in the country, a comprehensive study is being carried out to use water-saving irrigation technologies, improving the reclamation of irrigated lands, and a high yield. The Strategy of Actions for the Further Development of the Republic of Uzbekistan for 2017–2021 sets the tasks "to reduce energy consumption resources, to use intensive methods of agricultural production, first of all, modern water management and resource-saving methods of farming." It is important to conduct research on the use of

*Corresponding author: s.urinbaev@tiiame.uz

innovative technologies, including the use of collector-drainage water as an additional source for irrigation [4-7].

A number of scientists, including A.N.Kostyakov, B.A.Shumakov, I.A.Sharov, A.V.Frantsev, P.G.Krotkevich, G.Yu.Sheinkin, N.A.Maksimov, H.L.Penman, A.N.Lyapin, L.F.Lukina, N.T.Laktaev, N.V.Morozov, V.V.Kolpakov, B.F.Kambarov, A.A.Rachinsky, N.A.Yanishevsky, M.F.Natalchuk, H.A.Aksmedov, B.S.Serikbaev, F.A.Baraev, M.H.Khamidov, S.Kh.Isaev is engaged in developing water-saving technologies for irrigation agricultural crops, developing water use plans, and problems of effective water use [8-13]. Research on underground and collector-drainage waters and their influence on productivity is carried out by S.F.Averyanov, V.A.Kovda, B.A.Shumakov, I.A.Engulatov, D.M.Kats, A.V. Lebedev, N.I.Parfenova, P.S. Panin, Kelly, Libukhu, Gapon, Bauer, Messlenda, Villakh, G.Sabolcha, K.Daraba, K.Mirzhaionov, N.N.Chodzhiboev, V.G.Samoilenko, I.S.Rabochev, L.V.Kireicheva, V.S.Megeladze, E.V.Ovchinnikova, A.A.Rachinsky, F.A.Raksimbaev, N.F.Bespalov, V.A.Duksovny, R.K.Ikramov, V.Nasonov, E.I.Chembarisov, O.R.Razazanov, E. Kurbanbaev, H.E.Yakubov, T.P.Gluksova, G.A.Ibragimov, M.A.Yakubov, Sh.Kh.Yakubov, A.Kh.Karimov, Positive results were achieved in the work of S.Kh.Isaev, [14-21].

Despite the large-scale research in this area today, the relationship between the level and volume of the use of collector-drainage water in the context of using various irrigation technologies has not been sufficiently studied. No research has been conducted on innovative technologies for the effective use of collector-drainage waters in various ameliorative conditions for irrigating crops in water scarcity conditions.

2 Research results

Study of the dynamics of water distribution in the area of active soil at the experimental site of the Institute of Nuclear Physics of the Academy of Sciences of the Republic of Uzbekistan and in the field of the "Shorozak Nurli Kelajak" farm in the Pakhtakor State Institution of the Saykhunabad district of the Syrdarya region. In the experimental study of scientific work, the patterns of water absorption in the first irrigated method were studied in 3 options: in high-quality cultivated soil, poorly cultivated soil, and uncultivated soil. Fig. 1 shows a diagram describing the laws of distribution of an aqueous solution in depth in the active soil layer. Curve 1 describes the distribution of water in uncultivated soil. In the case of poor-quality mechanically cultivated soil, large lumps at a depth of 40 cm make up about 20% of the total soil volume. In this case, the regularity of water distribution is characterized by a 2-curve. Curve 3 describes the regularity of water distribution in soil with fine cultivation along the entire depth of the curve and in fine-grained soils.
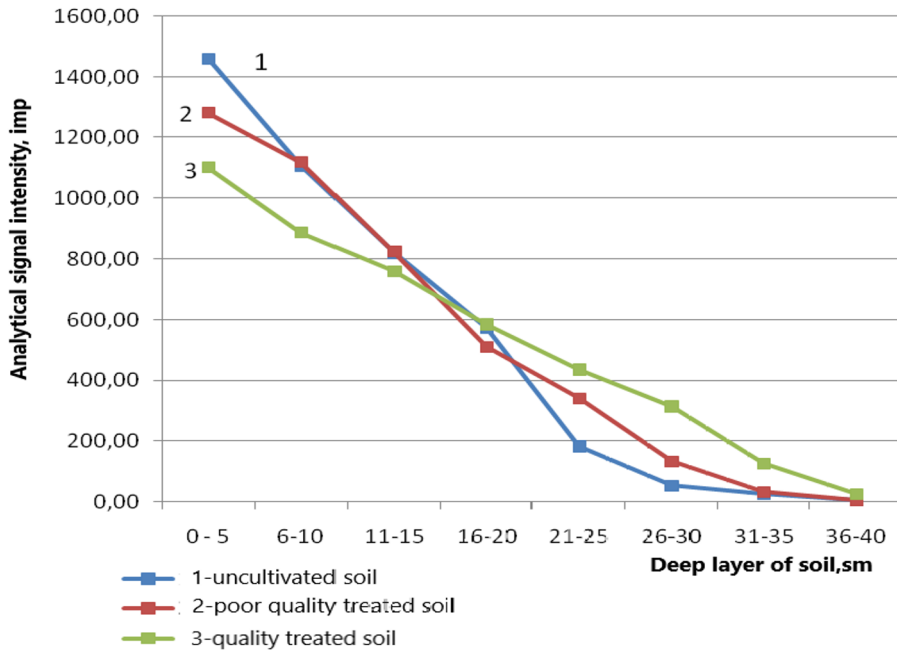
Fig. 1. Regularities of distribution of an aqueous solution in active layer of soil when using irrigation method

As can be seen from Figure 1 above, the dynamics of water distribution in the active soil layer differed from each other when the traditional irrigation method was applied with varying degrees of mechanical treatment. In untreated and poorly cultivated mechanically cultivated soils, water cannot be absorbed deeper when an average amount of water is given. Water absorption and uneven distribution along the soil depth were observed in poorly cultivated soils. Therefore, it was noted that the aqueous solution reached a depth of 30 cm at some points and did not reach it at some points. In well-cultivated soils, the amount of water absorbed to a depth of 5 cm and 10 cm differed from each other. For example, the analytical signal recorded at a depth of 5 cm in untreated soil was 1216 impulses, and in well-treated soil - 1206 impulses. At a depth of 10 cm, the recorded analytical signal was 934 pulses and 903 pulses. From a depth of 15–20 cm, water absorption began to differ depending on the soil type. For example, the recorded analytical signal of the radioactive isotope 63Cu is 347 and 157 pulses for 10 minutes at 25 cm and 35 cm with good soil cultivation and 103 and 40 pulses at the same depth in untreated soils, respectively. This means that the water uptake at a depth of 25 cm in uncultivated soil was 30% of the value of the treated soil quality. The ratio of the analytical signals of the 63 Cu radioactive isotope is 35 cm at a given soil depth (40 imp./157 imp.) = 0.25. This means that the water uptake at a depth of 25 cm from the uncultivated soil was 25% of the value of the treated soil quality. Thus, experiments show that the dynamics of water distribution in the active soil layer depend on the quality of soil cultivation.

The results showed that when using the traditional irrigation method, the use of water resources in uncultivated and poorly cultivated soils is less effective since water remains mainly in the surface layers of the soil, for example, for large amounts of water reaching a depth of 30-40 cm will be necessary. Our experiments noted that the volume of aqueous solutions was 0.05 m3 per 1 m2 of surface; at this flow rate (50 l/m^2), the water did not reach a depth of 30-40 cm.

To further study the regularities of water distribution in the active soil layer, the second irrigation method was used - the sprinkler irrigation method. This method used the same volume of aqueous solution per unit area, and experiments were performed. As in previous experiments, the experiments were carried out on 3 types of soils, non-mechanically cultivated, poorly cultivated, and well-cultivated soils.

The regularity of water distribution when using the irrigation method of irrigation is shown in Fig. 2 in the form of a diagram. Curve 1 describes the distribution of water in uncultivated soil. Curve 2 describes the distribution of water in poorly cultivated soils. Curve 3 describes the laws of water distribution in well-drained and fine-grained soils.
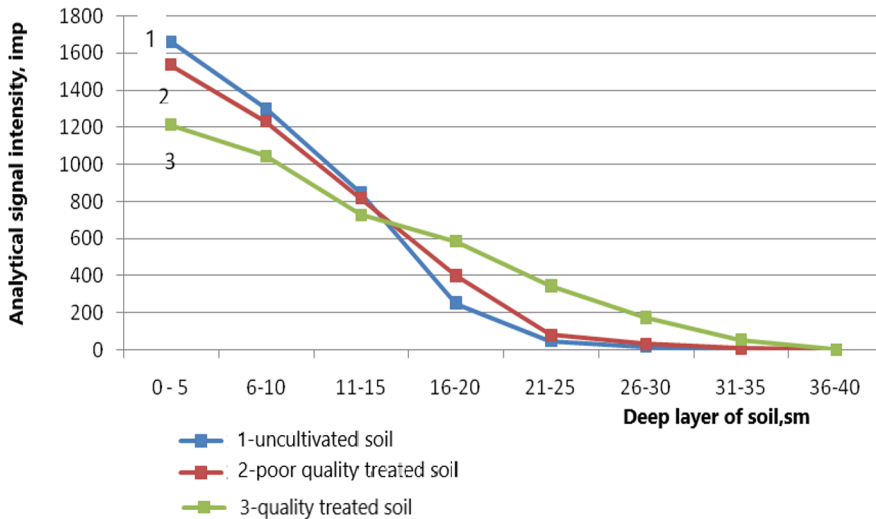

Fig. 2. Regularities of distribution of an aqueous solution over depth of the soil when using sprinkler irrigation method

As seen in Figure 2 above, when the sprinkler irrigation method was used, watering was done through the leaves of the plants, and most of the water was absorbed in the upper layers. In our experiments, an aqueous solution of radioactive elements was absorbed into the surface layers of the soil, and an aqueous solution below 20 cm was hardly detectable. Most aqueous solutions are absorbed at 0–10 cm from the soil. For example, at a depth of 5 cm in well-treated soil, the analytical signal recorded by a radioactive isotope in the same time interval was 450 pulses, while in poorly treated soil at the same depth, 550 pulses, that is, more water was absorbed. The water absorption coefficient at this depth was (550 imp./450 imp.) = 1.22. This means the water uptake at a depth of 5 cm in coarse cultivated soil was 122% of the value for good soil cultivation. The analytical signal at a depth of 15 cm with high-quality soil cultivation was 185 pulses and coarse cultivation at the same depth - 15 pulses, which is several times less than with high-quality soil cultivation. At a depth of 15 cm, the water absorption coefficient (15 imp /185 imp.) = 0.08. This means that water absorption during irrigation at a depth of 15 cm in poorly cultivated soil was 8% of the value of the quality of cultivated soil. Based on the results of the experiments, it can be concluded that this irrigation method was effective only for agricultural crops, the root system of which is located in the surface soil layer (5-10 cm) [16-21].

The results of experiments on sprinkler irrigation in the presence of large lumps up to 20% with poor mechanical soil cultivation are reflected in the 2nd curve. From this curve, it can be seen that with this irrigation method, the absorption depth in some places of soils with different mechanical properties was 15-25 cm, and in other places - 5-10 cm. The third

modern irrigation method - drip irrigation - was also tested for a more detailed study of rules for water distribution in the soil. As in previous experiments, an aqueous solution of the same volume was applied per unit of soil surface.

The law of water distribution in soils with different mechanical properties under drip irrigation is shown in Fig. 3, where curve 1 describes water absorption in uncultivated soils, curve 2 describes water absorption in poorly treated soils, and curve 3 describes water absorption in soils with good quality soil. As can be seen from Fig. 3, it was found that the nature of water distribution in non-mechanically treated soils when using drip irrigation corresponds to an exponential law. As a result of the slow and even dripping of water, the water use efficiency was high. In the experiments, moisture was absorbed to a depth of 30 cm or more in the soil, and most importantly, aqueous solutions of radioactive sodium and copper isotopes were distributed in the soil relatively evenly. Although the soil was not mechanically cultivated, water was absorbed deeply and evenly throughout the soil.
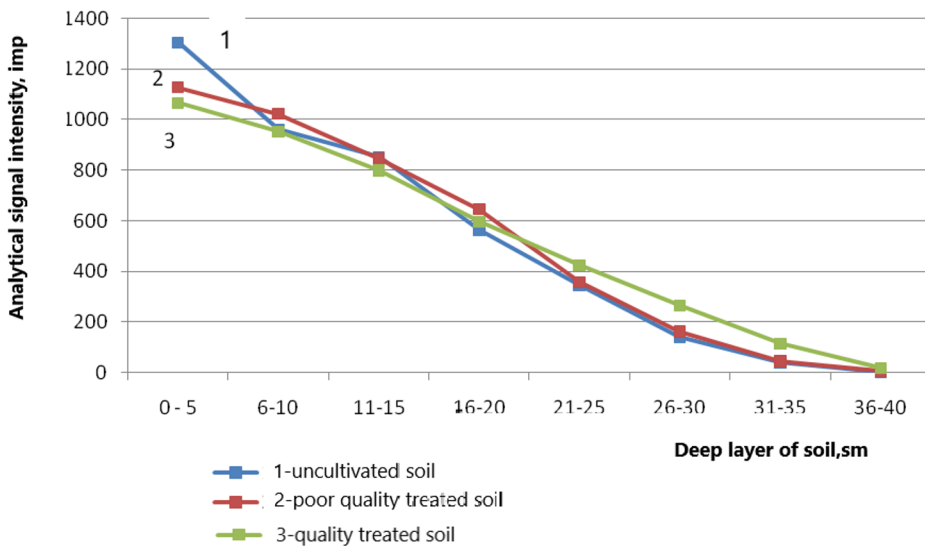

Fig. 3. The law of distribution of water along depth of soil when using drip irrigation technology

Experiments have shown that drip irrigation is the most effective with the rational use of water resources since it absorbs water as evenly and deeply as possible, especially on high-quality cultivated soils. For example, the recorded analytical signals at a depth of 20 cm in all types of soils were practically the same: 200 imp./min. With drip irrigation, the water absorption coefficient in all types of soils is 1; that is, water is absorbed evenly. This even water distribution creates favorable conditions for crops during the growing season.

Results of experiments on cotton irrigation with collector-drainage waters in the conditions of the "Shorozak Nurli Kelajak" farm of the Pakhtakor water consumers association of the Saykhunabad District. The irrigated land of "Shorozak Nurli Kelajak" farm is 122 ha, of which 54 ha is grain and 65 ha is cotton. The CDW Sh-4 network with a mineralization of 1.2 g/l and a groundwater level of 1.5-3 m is used as a water source. Considering the geographical location of the farm territory and the lack of irrigation water in the canals, the water from the Sh-4 collector is used for irrigation. The average water salinity ranges from 1 to 1.6 g/l depending on the season. The soils of the main areas of the farm are slightly saline, and the texture of the topsoil and subsoil consists of loose soils. The size of the experimental field is 50 x 200 m, that is, 1 ha. Experimental studies were carried out to study the patterns of absorption of GLC in the active soil layer to assess the

effect of collector-drainage waters (salinity 3 g/l) on irrigation in weak and moderately saline soils and their consequences.

A water flow at a variable flow was supplied to ensure complete uniform wetting along the length. In the experimental variants carried out, variant 1 was the most effective, with a variable flow rate for irrigated irrigation. On it: on a slope of 0.003 with a length of 150 m and a distance of 0.9 m, the depth of the ridge was 18-20 cm, uniform wetting at a flow rate of 1.0/0, 6 l/s, the variable water consumption was 0.89, and as a result, compared to the control in the vegetation, 567 m^3/ha of water was saved, and the cotton yield increased by 4.68 c/ha, Table 1.

Table 1. Influence of cotton irrigation with a variable flow on cotton yield, centner/ha

Versions	Identification results				Σ	X_{av}	$A\pm$	The average c/ha on the farm
	1	2	3	4				
4 versions (constant flow)	25.61	26.43	27.14	25.64	105.82	26.45	-4.68	32.72
I version (alternating current)	31.84	30.76	30.81	31.12	124.53	31.13	+4.68	

To assess the possibility of using nuclear physics methods to study the regularities of water absorption in the active layer of the soil in the experimental fields, the content of macro- and microelements in the soil was monitored using the method of neuron activation analysis. For this, samples were taken from experimental fields at 0 cm to 90 cm, dried to constant weight, and a neuron activation analysis was performed, Table 2.

Table 2. The amount of macro- and microelements in soil samples of the experimental field, (μg/g)

Identified elements	Control plot of soil samples	Experimental 1 plot soil samples		Experimental 2 plot soil samples		Experimental 3 plot soil samples	
Sm	5.4	4.1	4.4	3.9	9.4	4.7	6.2
Mo	3.3	0.95	1.2	1.5	0.95	1.6	1.8
U	2.49	3.1	4.4	4.1	4.1	3.8	3.5
Yb	2.7	2.2	2.6	2.9	3.4	2.8	3.3
Nd	21	19	17	28	34	24	33
As	5.0	6.2	5.0	5.3	5.4	6.8	5.1
Br	2.9	3.9	3.8	4.7	3.6	4.0	3.8
Ca	81500	83400	43100	57400	85900	80400	83000
La	37	32	21	38	56	42	54
Ce	54	46	31	41	83	47	77
Th	11	8.9	7.3	9.9	10.5	9.1	11
Cr	63	55	55	66	81	54	69
Hf	9.85	4.6	3.3	8.1	10	4.4	6.4
Ba	400	390	450	460	345	430	320
Cu	490	480	265	250	490	490	450
Cs	2.5	3.4	3.5	4.5	2.3	3.5	2.3
Ni	170	150	150	140	94	210	168
Sc	13	10	11	12	13	10	13
Rb	68	76	89	89	58	78	56
Zn	52	156	130	89	55	54	52
Co	8.3	8.8	9.9	11	8.0	9.0	8.1
Fe	26000	24000	25000	29000	26000	24000	27000

As seen from the table, the amount of copper in the soil samples is small (490 μg/g or 0.49 mg/g), which made it possible to use copper as an analytical element to study the regularities of water distribution in the active soil layer.

The results of experimental work to study the dynamics of water absorption in the active layer of soil when using the method of irrigated irrigation are shown in Fig. 4 as a diagram. Curve 1 describes the soil's water distribution on June 2-4, 2018. Curve 2 describes the soil's water distribution on July 17-20, 2018. Curve 3 describes the soil's water distribution on August 1-3, 2018.
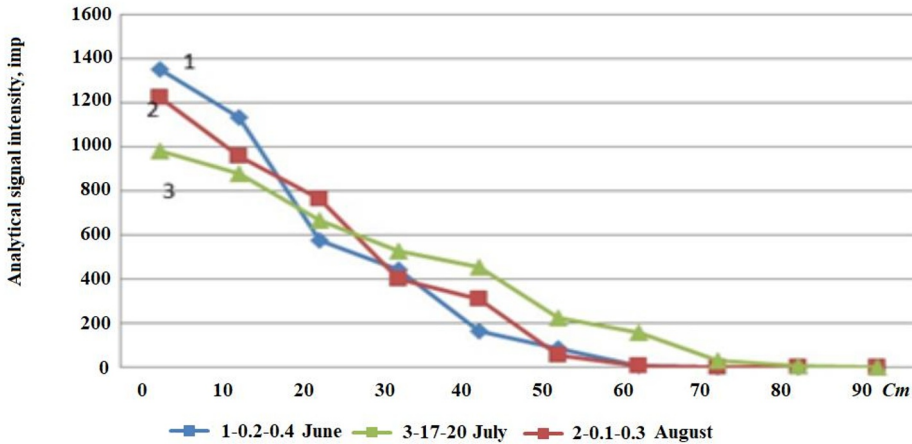

Fig. 4. Regular distribution of water along soil depth at different times when watering cotton.

As can be seen from Fig. 4, the dynamics of water distribution in the active soil layer at different times when the usual irrigation method was used differed significantly from each other. When fresh water mixes with the collector ditch, the distribution of water in the active soil layer is as follows: 40% water at a depth of 0-20 cm, 30% water at a depth of 20-40 cm, 20% at a depth of 40-60 cm, 10% water absorption was found at a depth of 60-90 cm.

After irradiation of soil samples with a neutron flux, measurements of the gamma spectrum were carried out to determine the amount of water absorbed in the soil and the correlation between the concentration of copper and the aqueous solution of copper sulfate used for irrigation. As an analytical signal in the experiments, copper gamma lines with energies E=511 keV and E=1039 keV were used. Copper concentration in soil samples was determined from the intensity of gamma radiation using known formulas.

In experiments, the concentration of copper in soil samples is directly proportional to the amount of water absorbed in this soil. This made it possible to study the patterns of absorption of aqueous solutions in soils using the existing irrigation method.

3 Conclusions

On the collective farm of the Pakhtakor State Institution of the Saykhunabad district of the Syrdarya region, 72% (1294 ha) of irrigated land on 1798 ha are meadow gray soils and medium sandy soils in terms of texture. The groundwater level in the farm is 1.5-3 meters, and the area of their mineralization is 1-3 g/l, which is 95.7% (1722 ha). Of the total of 1,798 hectares of irrigated land on the farm, 86.5% (1555 ha) was slightly saline, 11.5% (207 ha) was moderately saline, and 2% (36 ha) was highly saline.

The composition of macro- and microelements in soil samples of the experimental fields of the "Shorozak Nurli Kelajak" collective farm in Saykhunabad region was studied based on neutron activation analysis, and the following elements were determined: Ca, Fe, Mo, Ni, Zn, Co, Cu, U, Th. A quantitative analysis of elements in soil samples from experimental fields revealed that the amount of copper varied from 0.25 mg/g to 0.49 mg/g. Considering that the sensitivity of copper detection using the neutron activation analysis method is 0.02 mg/g, using the ^{63}Su isotope for experimental studies was justified.

In the course of laboratory and field experiments, it was found that water use efficiency depends primarily on the irrigation method used in agriculture and the quality of soil cultivation. In irrigated soils, the absorption of 70% of water in the surface layer of the soil, that is, up to 15 cm, was determined by recording analytical signals of the radioactive isotope ^{63}Su. The absorption in the lower layers is very low; for example, 1-2% of the water has been found to reach a depth of 35 cm. In well-cultivated soils, the absorption of most of the water, i.e., 65%, in a layer at a depth of 10-30 cm was determined experimentally, and the absorption of 5-7% of water in the lower soil layers was from 35 cm.

The dynamics of water absorption in the active layer of slightly saline soils using collector-drainage waters with a mineralization index of 3 g/L was studied by the distribution of aqueous solutions of stable isotopes ^{63}Su. Based on experimental studies, a nuclear-physical methodology for determining water absorption dynamics in the active soil layer has been developed.

When using the traditional irrigation method, the dynamics of water distribution in the active soil layer at different times significantly differed from each other. When fresh water mixes with collector-drainage water, the distribution of water in the active soil layer is as follows: 40% of water at a depth of 0-20 cm, 30% of water at a depth of 20-40 cm, 20% at a depth of 40-60 cm, 60 At a depth of -90 cm, 10% water absorption was found.

When used with a CDW mixture with mineralization of 3 g/l in slightly saline soils, option 1 - a mixture of ChDNS 70% 1: 4 (1-channel water, 4-river water, mineralization-1: $4 = 3$ g/l + 4, 8 g/l = 7.8: 5 = 1.56 g/l) is the most effective option, and has been proven in field experiments to improve the efficiency of water use in agriculture without compromising the ecological state of the area. Studies have shown that the salinity of the experimental areas did not increase; remained weak when using mineralized CDP of the same value during the season.

When irrigating the cotton crop, a drainage collector was provided with a variable water flow rate to ensure complete uniform wetting along the ridge length. In the experimental options carried out, option 1 was the most effective for irrigated irrigation. On it: with a slope of 0.003 at a length of 150 yards and a variable water flow of 1.0/0.6 at a distance of 0.9 m, uniform wetting was 0.89, which led to water savings of 567 m3/ha and cotton yield compared to the control option. Developed up to 4.68 c/ha[24- 27].

Acknowledgments

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