Effective and rational use of irrigation water in the conditions of the republic of Karakalpakstan

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Abstract. The lack of water that has been repeated in recent years dictates the requirements of a strict regime of water conservation and economical use of water. Understanding the need for strict water conservation and the fight against unproductive water losses must be started with the producers of agricultural products, i.e., from farms, as rational water use and water conservation at the field level could save a significant amount of irrigation water. The article reflects the current state of water use in irrigated agriculture in the Republic of Karakalpakstan. The main, inter-farm, and intra-farm canals have been studied in detail, and the mode and efficiency of their work have been assessed. The obtained results of the conducted field research works on irrigation technologies are presented. Suggestions on the choice of water-saving irrigation technologies are given, as well as recommendations on the effective use of irrigation water in the non-growing season.

1 Introduction

The low water level, which has been repeated in recent years, dictates the requirements of a strict regime of water conservation and economical use of water. Understanding the need for strict water conservation and the fight against unproductive water losses should be started with the producers of agricultural products, i.e., from farms, as rational water use and water conservation at the field level could save a significant amount of irrigation water [1-7]. Most of the irrigated lands of the Republic of Karakalpakstan are main areas of primitive agriculture, especially on-farm irrigation and reclamation system and irrigated fields. Irrigated areas are scattered over a large area; the value of the land-use factor does not exceed 0.65 - 0.70. In the contour of the irrigated land, there are large tracts of undeveloped land that are not suitable for irrigation. Irrigation systems, especially on-farm ones, have excessive length, tortuosity in the plan, and the value of efficiency does not exceed 0.65 - 0.66. Suppose the perfection of the irrigation network leads to large losses of water. In that case, the low efficiency of the collector-drainage system, in turn, leads to a rise in the level of highly mineralized groundwater and, accordingly, to soil salinity, which ultimately leads to a decrease in crop yields [8-15].

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According to the long-term research data (Bekimbetov N. Baymanov K. 1986-1988), almost half of the supplied water in the head of the main canal is lost to channel filtration. In this case, the efficiency of the system channels is main channel 0.95-0.96, interfarm canals 0.88-0.89, on-farm canals 0.65-0.66. As can be seen from this, on-farm channels have the lowest efficiency, the value of which is 0.65 - 0.66 [5, 16, 18]

All main and inter-farm canals run mainly in earthen channels. Engineering structures were built mainly on main and inter-farm canals and water outlets to rice farms. On-farm canals are not fully equipped with engineering structures, and no work has been done to streamline the number of water intake points to individual farms. The on-farm network is excessively long, and hence the large losses of water [17], [19-25].

2 Methods

One of the methods for determining water losses from canals of the on-farm network "area - speed", where a hydrometric spinner determines the flow rate, and the amount of losses for filtration from on-farm canals is determined by the balance method:

$\sum S = Q_B - Q_H - \sum Q_{B3} + \sum Q_{sbr}$, where: $\sum$ is total water losses in the investigated section of the canal.
 Q_B , Q_H is water flow in the upper and lower sections.
 Q_{B3} is water flow through all outlets in the canal section.
 Q_{sbr} is water discharge discharged in the investigated area.

The value of the absolute specific losses is determined by the dependence, $S = \frac{\sum S}{L} \text{ m}^3/\text{s}$ per 1 km of the channel length, where L is the length of the investigated channel.

When determining water losses from canals, you can use the formula: $b = \frac{A}{Q^n}$ where b is

the percentage of losses per 1 km of the canal length from the water discharge. A and n are parameters characterizing the filtration capacity of the soil.

An important issue is the rational use of irrigation water during the period of flush irrigation, where, due to technically incorrect irrigation, a large overrun of irrigation water occurs. Before the start of non-vegetation irrigation, it is necessary to select and approve the territories where it is necessary to carry out leaching of lands. The main criterion for selecting leaching areas is to determine the degree of soil salinity; the rate of water supply depends on this criterion. Basically, it is necessary to use the gradation according to the degree of soil salinity given in table1[2,4].

Table 1. Rates and terms of water supply for washing saline lands

Soil salinity	Washing rates, thousand m ³ /ha	Number of waterings	Terms of irrigation,%			
			XI	XII	II	III
Not salted	2.0 – 2.5	1	-	10	30	60
Slightly salted	2.7 – 3.2	2	-	15	35	50
Medium salted	3.5 – 4.0	2	-	50	-	50
Strongly salted	4.5 – 5.0	3	40	20	10	30

3 Results and discussion

The ancient and modern delta of the Amu Darya River is considered the final area of accumulation of salt reserves. From the total volume of inflow of liquid runoff in 1975 - 80. in the delta 60 - 65 km3 per year (according to the Samanbay hydroelectric station) and the annual amount of mineral salts brought into the territory of about 23.7 million tons, of which 9.5 million tons are poisonous to plants.

Long-term observations have established that with irrigated waters, about 4.5 tons of mineral salts are annually applied to each hectare of sown area, 1.8 tons of which are harmful to plants. The analysis of long-term observations shows that, provided that the land is leached with load rates, very slow desalination of groundwater occurs, which leads to some improvement in the land reclamation state. But this is not enough for a radical solution to the issue of land reclamation and increasing the productivity of agricultural crops; this means that this method leads to overconsumption of irrigation water and gives only a short-term effect. Therefore, an important issue is the rational use of irrigation water during the period of flushing irrigation, where, due to technical improper irrigation, there is a large overrun of irrigation water. Before the start of non-vegetation irrigation, it is necessary to select and approve the territories where it is necessary to carry out leaching of lands. The main criterion for selecting leaching areas is to determine the degree of soil salinity; the rate of water supply depends on this criterion. Basically, it is necessary to use the gradation according to the degree of soil salinity given in table 1.

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The research results carried out for many years make it possible to recommend limiting to spring moisture recharge on non-saline and slightly saline lands.

The efficient use of irrigation water cannot be considered without rationalizing water use during the growing season. In irrigation practice, there are three methods of irrigation: surface, sprinkling, and drip (subsurface), but until now, the dominant method of irrigation in the Republic of Karakalpakstan is the surface method of irrigation along furrows and strips, and, despite the centuries-old history of irrigation along furrows, it is still weak resource-saving technologies for this irrigation method have been developed. The imperfection of the surface irrigation method ultimately leads to large water losses during irrigation and a large amount of time during their implementation.

Providing plants with water following their needs is a prerequisite for obtaining a high yield. A decrease in the flow of water into the root system leads to the emergence of water deficiency in plants and, consequently, to the attenuation of physiological processes. Watering is the only way to deal with moisture deficiency. Correct and economical use of irrigation water during irrigation and high labor productivity during irrigation depends on the correct choice of irrigation method. An important role in the effective use of irrigation water is played by choice of irrigation technology that meets the requirements of ensuring a sufficiently uniform soil moisture field in the required time frame. With minimal labor costs, the imperfection of the surface irrigation method ultimately leads to large water losses during irrigation and a large amount of time when watering. Experience shows that

the traditional irrigation method, which is practiced in a production environment, does not meet the requirements of today. This situation requires research, study, and selection of optimal options for irrigation technique and technology for the conditions of the lower reaches of the Amu Darya, and taking into account all of the above; the main attention should be focused on the problems of introducing perfect resource-saving technologies for surface irrigation in furrows, taking into account the terrain features.

In the practice of surface irrigation, several methods are known, such as flood, runoff, and furrow irrigation. One of the most common surface irrigation methods is furrow irrigation, which is widely used in production environments.

Ordinary irrigation - furrow irrigation is used everywhere in the production conditions of the Republic of Karakalpakstan. At the same time, depending on the slope of the terrain, irrigation is carried out on the one hand, and the main disadvantages are high labor costs, long duration of irrigation time, a large volume of vertical filtration, at low values of water flow in the furrow (up to 0.4 - 0.5 l / s), which ultimately leads to excessive consumption of irrigation water and an increase in the level of groundwater.

It is known that the most important factor in choosing the method of irrigation is the relief, and given the peculiarities of the local conditions of the Republic of Karakalpakstan, the following water-saving irrigation technologies can be recommended (Fig. 1):

- counter watering, i.e., water supply from both sides of the furrow by cutting single-sided temporary sprinklers from both sides;
- watering through the furrow;
- watering using an anti-filtration irrigation film.

Counter irrigation combined with concentrated water supply. At the same time, watering is carried out from both sides through one side temporary sprinklers (temporary sprinklers are cut using a canal digger, and one side of the roller is developed manually to supply water along the furrows). Water supply is carried out simultaneously from both sides. At the same time, the furrow length and irrigation time are reduced by 1.5 - 2.0 times. A prerequisite for this is a good grade for zero slope.

Fig. 1. Technologies of furrow irrigation of cotton: (a is traditional irrigation, b is counter forced irrigation, c is irrigation through the furrow, d is irrigation with flooring of an anti-seepage irrigation film)

Over-furrow irrigation - can be successfully applied both individually and in combination with counter irrigation. This option gives the expected results on soils with medium to light texture. When irrigating through the furrow, a slight slope is allowed close to the ground's

surface (0.0003 - 0.0005), and the water is supplied through the furrow. When using furrow irrigation, soil aeration is improved throughout the growing season, and thereby the amount of inter-row soil cultivation is reduced, and a high yield can be obtained with the lowest water consumption.

Watering using an anti-seepage film - the main conditions for applying this technology is the use of the technology on sandy soil, and preferably on lands with deep groundwater levels. The use of this technology contributes to the retention of soil moisture for a long period, and the film coating also prevents the growth of weeds in the furrows. The results of the experiments showed a significant saving of irrigation water when irrigating cotton with various irrigation technologies without harming the cotton crop (table 2)

Table 2. Water-saving with different irrigation options

Variants	Volume of supplied water, m ³ /ha (irrigation norms)	Savings compared to the control option, m ³ /ha
I (traditional)	2682	
II (across the furrow)	1670	1012
III (counter irrigation)	2290	392

The efficiency of irrigation and irrigation water use depends on the land leveling, the state of irrigation systems. Therefore, by reconstructing the irrigation systems and carrying out the necessary land leveling, it is possible to achieve high yields with the lowest water consumption.

Further development of agricultural production in the lower reaches of the Amu Darya River entirely depends on the volume of Amudarya water flowing into this region. Given the current state of water use, a significant reduction in the provision of the Amu Darya with water is possible, especially in its lower reaches, i.e., within the Republic of Karakalpakstan. In this case, certain problems will arise with the water supply of irrigated lands, which in turn requires large water-saving measures for the economical use of water resources. One of the most effective measures for the rational use of water is the use of drip irrigation, which is widely used in the world experience where there is an acute shortage of water.

The high efficiency of drip irrigation contributes to its spread in many countries globally and is used for growing most types of agricultural products on all types of soils. Drip irrigation is based on the supply of water with mineral fertilizers dissolved in it to the root zone of the plant. In contrast, the amount and frequency of water supply is regulated following the needs of the plant, and the root system develops better than with any other type of irrigation. It provides the best opportunity to provide efficient nutrition throughout the plant's life cycle.

4 Conclusions

Analysis of the available long-term data from the study of the Republic of Karakalpakstan on the use of the drip irrigation system made it possible to draw the following conclusions:

According to the research results, it can be noted that they can be safely used for the drip irrigation system:

- on lands where there is an extreme shortage of water resources (remote areas of lands in the northern regions of the Republic of Karakalpakstan);
- on lands located at elevated levels, that is, subject to pumping irrigation;

- on saline soils with a salt content of up to 10 - 16 ms/cm.
- 1. Advantages of using a drip irrigation system:
 - 1.1. With increased water supply in all areas throughout the growing season, it is possible to maintain optimal humidity throughout the entire territory. The entire volume of the supplied water is concentrated on the upper root layer of the soil, which gives great water savings, and it is useful for plants.
 - 1.2. Vertical filtration during irrigation is practically excluded.
 - 1.3. There is practically no mechanized soil cultivation (in exceptional cases during the preparatory stage), and, accordingly, no fuel and lubricants are consumed.
- 2. Disadvantages of drip irrigation.
 - 2.1. It is extremely ineffective to use drip irrigation on a small area since two people will be employed to operate the system during the entire growing season.
 - 2.2. Experiments show the inexpediency of using drip irrigation on saline lands. Even with increased watering between the droppers, the saline soils are restored, so the yield will be low.

In conclusion, the following can be noted:

3 At present, all large canals and collectors that have the status of off-farm are being reconstructed (cleaning, fixing slopes, etc.) at the expense of state capital investments. Most of the on-farm irrigation and reclamation system is on the balance sheet of farms, and not all farmers can reconstruct these systems due to lack of funds. Therefore, many on-farm canals have not been cleaned for a long period, and the main losses of irrigation water currently occur in on-farm systems.

Considering the above, all measures aimed at increasing the efficiency of canals should be directed to the reconstruction of on-farm irrigation systems (on the territory of farms) because the greatest water savings will occur precisely due to the reconstruction of on-farm canals. The current state and the prospect of increasing the efficiency of canals in the lower reaches of the Amu Darya River are given in Table. 2.

Table 2. Current state and prospects of increasing the efficiency of canals in the lower reaches of the Amu Darya River

Channel links	Modern channel efficiency	The prospect of increasing efficiency
Trunk channels	0.92	0.93 – 0.94
Interfarm canals	0.88	0.88 – 0.89
On-farm canals	0.65	0.70 – 0.75

- 1 The results of studies carried out over a long-term period, and analysis of the factual material showed that one of the main reasons for the decrease in the efficiency of furrow irrigation in production conditions is the unevenness of irrigation furrows, i.e., the presence of forward and reverse slopes of the furrow, which lead to the overflow of water through the furrow, which ultimately leads to uneven moisture along their length. Taking this into account, it can be argued that a significant amount of irrigation water can be saved during field planning.
- 2 The drip irrigation system can be used if the following conditions are met:
- 1.1. a drip irrigation system is necessary where there is clearly a lack of water resources;
 - 1.2. it is necessary to take into account the interests of farmers;
 - 1.3. the system should be implemented, where irrigation of farmers' lands is carried out by machine irrigation, i.e., at elevated levels;
 - 1.4. the area where drip irrigation will be introduced must be at least 20 hectares (at the beginning 10 hectares);
 - 1.5. application of this system must be carried out on desalinated soils with low-mineralized groundwater.

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