Improving operation of inter-farm channels

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Abstract. The country's water supply depends mainly on the water resources of the Amudarya and Syrdarya. 80,7 % of the country's water resources are formed in the Kyrgyz Republic and Tajikistan territory. The population of Central Asia is expected to increase by 40 % in the next 20 years. This, in turn, requires more economical use of water and land resources. At present, it is important to modernize irrigation systems, increase their efficiency, automate water distribution processes, and improve the distribution of water to consumers by accurate measurement of internal channels.

1 Introduction

The task of saving water and obtaining high crop yields can be achieved through developing innovative techniques and technologies and their implementation in practice [1-4]. Research on improving irrigation systems' performance in water saving and increasing efficiency (UWC) was carried out in the channels RK-7 in the Middle-Chirchik district of the Tashkent region. The following are the results of research conducted on the RK-7 inter-farm channel.

Table 1. Irrigated land areas

№	Name of districts	PK-7 channel length, km	Total irrigated area, ha	Including, ha		
				Cotton	Wheat	Other crops
1	Middle-Chirchik	6	1247	623	512	112
2	Lower-Chirchik	5	3190.4	1069.2	777.8	1342.5
3	Total	11	4437.4	1692.2	1290.7	1454.5

The RK-7 inter-farm irrigation systems distribute water to 42 farms. The water meter is only available at the main GTI of the RK-7 channel. The allotted plot is located in the middle of the channel. The channel test site has 3 side ditches, which were closed when the water flow was determined [5-9].

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Fig. 1. The main hydraulic structure of the rk-7 channel

2 Methods

In the scientific research process, systematic analysis, mathematical modeling, statistical methods, and measurements under production conditions per the methodological guidelines of existing scientific research were used. Water consumption was determined by Bakhirev feathers. When each water flow was determined, the pressure in the discharge was measured 3-4 times with a difference of one minute, and their average was considered. Then, considering the water flow time, information was obtained according to the method described in the lower hydropost [1, 2, 6, 14, 15].

The absolute water consumption index (S) is determined by the following formula:

$$S=\frac{\Delta Q}{l}\text{, l/s 1 km ha.} \quad (1)$$

Here in, ΔQ is the difference in water consumption in the upper and lower shears, l/s; l is the length of the experimental channel plot, km.

The relative loss (σ) of water consumption was calculated according to the following S.A.Grishkan formula [4, 8]:

$$\sigma=\frac{100S}{Q_T}\text{, \% one km} \quad (2)$$

then, Q_T is water consumption in the upper dam.

The average water consumption loss depends on the percentage of the channel barrier consumption above 1 km ha.

In the soil-climatic conditions of the Middle-Chirchik district, we determined the parameters "A" and "m" in the formula A.N.Kostyakov.

$$\sigma=\frac{A}{Q^m}\text{, \% one km} \quad (3)$$

We used the least squares method to determine the parameters "A" and "m", in which the final result led to the detection of two uncertainties from the Gaussian normal system:

$$na + b\,\Sigma I = \Sigma Z$$

$$a\,\Sigma I + b\,\Sigma I^2 = \Sigma IZ$$

The parameters "A" and "m" in the system are expressed as follows

$$a = lgA \text{ and } v = m.$$

In addition, the following characters are included:

$$lgQ = I \text{ and } lg\sigma = Z \tag{4}$$

An additional table was created using water consumption *(Q)* and relative loss consumption (σ) indicators to identify the characters. To further define the symbols "A" and "m" in the formula, it is necessary to observe in the calculation the numerical equality of each consumption symbol or consumption interval indicator with the experimental indicator. If the interval at one expenditure is greater than the experimental values but less for other intervals, they are taken into account in the calculation as an exception, and they are equalized at the expense of the auxiliary table [7-13].

The numbers in the table are arranged in ascending order for ease of calculation and control.

Based on the identified indicators, the system creates such a situation:

$$184a - 13.31799v = 91.96512$$
$$13.31799a + 4.344928v = 4.96612$$

We can solve this system based on the exception method:

$$a = A = 3.436;\ v = m = 0.5$$

The determination of the relative water consumption loss of the RK-7 channel is as follows

$$\sigma = \frac{3.436}{Q^{0.5}},\ \%\ 1km$$

Thus, the formula for determining the average water loss for channels with water flow from 0.2 m^3/s to 2.0 m^3/s, adapted to the soil-climatic conditions of the Middle-Chirchik district, was obtained:

$$\sigma = \frac{3.43}{Q^{0.5}},\ \%\ 1\ km$$

According to various authors, the relative water consumption for light soils is given in Table 2 for comparison.

Table 2. For light soils, compare the relative water consumption at Q= 1,5 m^3/s**.**

№	Authors	Coefficients		Relative loss	
		A	m	σ, %1 km.	Deviation %
1	A.N.Kastyakov	3.4	0.5	2.61	100
2	RIITWP	-	-	-	-
	a) min	2.85	0.5	2.55	96
	b) max	3.5	0.5	2.88	102
3	V.V.Kolpakov	3.4	0.45	2.94	103
4	Author	3.43	0.5	2.7	98

The table shows that the calculated relative consumption in the data is limited. This situation shows that due to the annual cleaning of the channels, their colmatage and technical condition deteriorate. The size of the water gap is also affected by the amount of water loss.

3 Practical and scientific results

Measures to increase the efficiency of the inter-farm channel RK-7. The observations showed that the minimum water consumption of the RK-7 channel during the growing season was 0.8 m^3/s. It follows that water consumption is Q_{min}= 800 l/s and Q_{max}= 2000 l/s ha. Relative consumption loss [9]:

$$\sigma_1 = 3.85\% \text{ and } \sigma_2 = 1.7\% \text{ one km.}$$

The calculation of the channel length is l=11 km. The minimum and maximum values for UWC:

$$\eta_{min}=1-0.01 \text{ x } \sigma_1 \text{x} l = 1-0.32 = 0.82$$

$$\eta_{max}=1-0.01 \text{ x } \sigma_2 \text{x} l = 1-0.14 = 0.90$$

We determine the average UWC of the channel according to the following formula:

$$\eta_{p-1} = \frac{\eta_{\min} \times Q_{\min} + \eta_{\max} \, x \, Q_{\max}}{Q_{\min} + Q_{\max}} = \frac{0.82x800 + 0.90x2000}{800 + 2000} = 0.87$$

Second-order domestic channels receive water from the first-order channel, except for the service area, which differs in length of consumption and movement. During Irrigation, their water consumption varies from 50 l/s to 350 l/s. The length of the disconnectors is relatively short, from 0.5 km to 4.1 km.

Although the channels are cleaned every winter, the grass has been overgrown since May. The depth of the channels is 5 m deep during the irrigation period and 3-4 m in the last sections formed. To determine the UWC, a one-second order channel was selected from the RK-7 irrigation system, and a water consumption study was conducted.

The total length of the channel under study is 2.2 km, the experimental section is 0.95 km, and it is located at the head of the separator. This channel irrigates 167 hectares; in this area, only one plot of the channel is 400 hundred meters long, and the irrigated area is 22 hectares. Here, as mentioned above, there are no temporary gaps. According to our observations, its consumption ranged from 50 l/s to 200 l/s. The channel selected for the experiment shows the average condition of the second-order channel according to all instructions (service area, water consumption, and length in motion) [9].

To measure the flow of the upper dam, an Ivanov drain was installed on the lower dam. Measurements were carried out without side ditches in the experimental part of the channel.

To determine the $\sigma = f(Q)$ relationship, data from 50 observations, of which 22 measurements, were used. Data processing was carried out according to the above method. Calculations for determining water loss are provided. Certificate of №DGU 01802 EXM program of the State Patent Office of the Republic of Uzbekistan.

To determine the relative water consumption loss of the parameters "A" va "m" the calculation of the study in the formula was developed together and presented in the auxiliary table.

According to the results: A=3.01; m=0.487

Thus, the determination of the relative water consumption in channels with water consumption from 50 l/s to 350 l/s is as follows:

$$\sigma = \frac{3.01}{Q^{0.48}} \quad \text{\%, 1 km}$$

Water supply occurs when the minimum time t=30 days.
$W_{\min}$ = 86.4 x $Q_{\min}$ x t = 86.4x50x30=129600 m^3.
The amount of absolute water consumption loss for filtration is at the minimum consumption of the channel length:

$W_{ф\text{-}1}$ =0.01 x σ x 86.4x$Q_{\min}$ x tx l = 0.01x 12.97x 129600 x 2.2 = 36980 m^3.

Percentage of loss in the minimum amount:

$$S_{\phi-1}^{\min} = \frac{W_{\phi-1}}{W_{\min}} \times 100 = \frac{36980}{129600} \times 100 = 28\,\%$$

When the maximum water consumption time is 90 days, the volume of water supply in terms of channel length, the volume of absolute flow loss, the percentage was found as above and was as follows:

2721600 m^3; 300574 m^3; 11%

To determine the UWC of the second-tier channel, as shown above, the final discharge water consumption and leakage water flow from the structures were determined on three second-tier domestic channels, which are located in a 320 ha alternating planting area, the vegetation period is April-October.

Determining the minimum, maximum, and average UWC, taking into account the loss of filtration consumption of the second-order domestic channels:

$\eta_{\min}$=1-$S_{ф\text{-}1}$=1-0.285=0.715; $\eta_{\max}$=1-$S_{ф\text{-}2}$=1-0.110=0.89

$$\eta_{av} = \frac{\eta_{\min} \times Q_{\min} + \eta_{\max} \times Q_{\max}}{Q_{\min} + Q_{\max}} = \frac{0.715 \times 50 + 0.89 \times 350}{50 + 350} = 0.868$$

The average amount of UWC of the second-order channel, taking into account the filtration consumption and the final discharge, was as follows:

$\eta_{p\text{-}1\text{-}1}$=0.868-0.028=0.84

Thus, the second-order domestic channels receive water from the first-order channels and deliver 84 % of the water to the boundaries of the irrigated areas (temporary channels). The remaining 16 % of water consumption goes to waste, of which 2.8 % falls to the final discharge and 13.2 % to filtration and evaporation spent along the length of the second-order channel.

UWC of on-farm irrigation network. From the average number of second and first-order channels, we find the main UWC of the economic network of the Water Consumers

Association:

$$\eta_{xT}=0.81 \text{ x } 0.84 = 0.68$$

Based on the study's results, it can be said that the irrigation network of the Water Consumers Association consists mainly of internal channels of the second and first branches, which supply 68 % of water to irrigated areas. The remaining 32 % falls on water loss.

UWC of section channels. Observations show that not all irrigated areas also have permanent disconnectors, which are either replaced by secondary channels or temporary ditches. At the farm level, 80 % of irrigated areas have a temporary ditch because there is no plot channel, but 20 % of irrigated plots have a channel and do not have a temporary ditch.

Observations showed that the UWC of the temporary channel and the UWC of the section channel are close to each other [7, 8].

The length of the UWC was determined in a typical plot channel of 640 meters. Consumption was determined by Chipolleti water discharge (threshold width 0.75 m). The method for determining water loss and determining pressure measurement is described above. To determine the relationship, the losses were determined by $\sigma=f(Q)$ at different costs.

We determined the coefficients "A" and "m": A=2.388; m= 0.675.

Thus, for the section channels, "σ" is determined based on the formula A.N.Kostyakov, which has the following appearance with the coefficients "A" and "m":

$$\sigma = \frac{2.388}{Q^{0.675}} \text{ \% 1 km.}$$

The main UWC of the section channel was determined in the following indicators:

$$Q_{\min}= 45 \text{ l/s}; \; Q_{\max}= 170 \text{ l/s}; \; l= 0.73 \text{ km}.$$

According to the graph of minimum and maximum water consumption, the relative losses are as follows:

$$\sigma_1=19.41 \text{ \%} \quad \text{and } \sigma_2= 9.99 \text{ \%}$$

UWC at the minimum and maximum consumption:

$$\eta_{\min}=1\text{-}0.01\text{x } \sigma_1 \text{x} l= 1\text{-}0.01\text{x}19.41 \text{ x } 0.73=0.858$$

$$\eta_{\max}=1\text{-}0.01\text{x } \sigma_2 \text{x} l= 1\text{-}0.01\text{x}9.99 \text{ x } 0.73=0.927$$

Average UWC size for a plot channel

$$\overline{\eta}_{av} = \frac{\eta_{\min} \times Q_{\min} + \eta_{\max} x Q_{\max}}{Q_{\min} + Q_{\max}} = \frac{0.858x45 + 0.927x120}{45+120} = 0.91$$

The length of the channel on the farm plot was L=0.6-1.1 km. There is an inverse relationship between the length of the channel and its UWC; the larger the channel length, the greater the water loss and the smaller the UWC. We determine the UWC of the section channels by calculating their minimum and maximum lengths: [11,12].

a) the length of the plot channel of 0.6 km:

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η_{min}=1-0.01 x 19.41 x 0.6=0.884;

η_{max}=1-0.01 x 9.99 x 0.6=0.94;

$$\overline{\eta}_{y.a} = \frac{0.884 \times 45 + 0.94 \times 120}{45 + 120} = 0.92$$

b) the length of the plot channel of 1.1 one km:

η_{min}=1-0.01 x 19.41 x 1.1=0.786;

η_{max}=1-0.01 x 9.99 x 1.1=0.89

$$\overline{\eta}_{av} = \frac{0.786 \times 45 + 0.89 \times 120}{45 + 120} = 0.86$$

As a result of calculations to determine the UWC of the site channel, their UWC $\eta_{y.a}$= 0.86÷0.92.

Actual UWC of temporary channels. Through our experiments in 2008, the UWC calculation of 4 temporary channels was determined. The average filtration flow loss in the temporary ditches was up to 0.004 slope, and the working water consumption was found to be 50-100 l/s. In general, the length of the temporary ditches on the farm was between 75-150 meters. The lengths of the temporary ditches selected to determine water consumption are 75, 96, 128, and 140 m.

4 Conclusions

Chipoletti water discharge (threshold width 0.5 m) determined water consumption in the upper and lower dams. The calculation of water consumption in the same temporary irrigation ditches was carried out on all irrigation days on the first and subsequent working days. The pressure gauge was calculated to reach the water every 30 minutes from the main discharge to the lower discharge.

As can be seen from the table, the UWC of temporary channels, as well as sectional channels, varies between 0.86-0.92. Observations have shown that the UWCs of temporary ditches and section channels are mutually exclusive. The UWC calculations of the temporary channels are given in Table 3.

Table 3. UWC of temporary furrows

Irrigation channels №	Calculated length, m.	Period of observations, hour	Water consumption during observation, l/s		UWC
			min	max	
1	75	74	10.3	40.4	0.90
2	140	70	20.5	50.1	0.92
3	98	69	11	38.7	0.86
4	128	65	20.9	45	0.88

Calculations show that the average UWC of temporary channels was 0.86-0.92. The average UWC of the temporary channel was 0.89.

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