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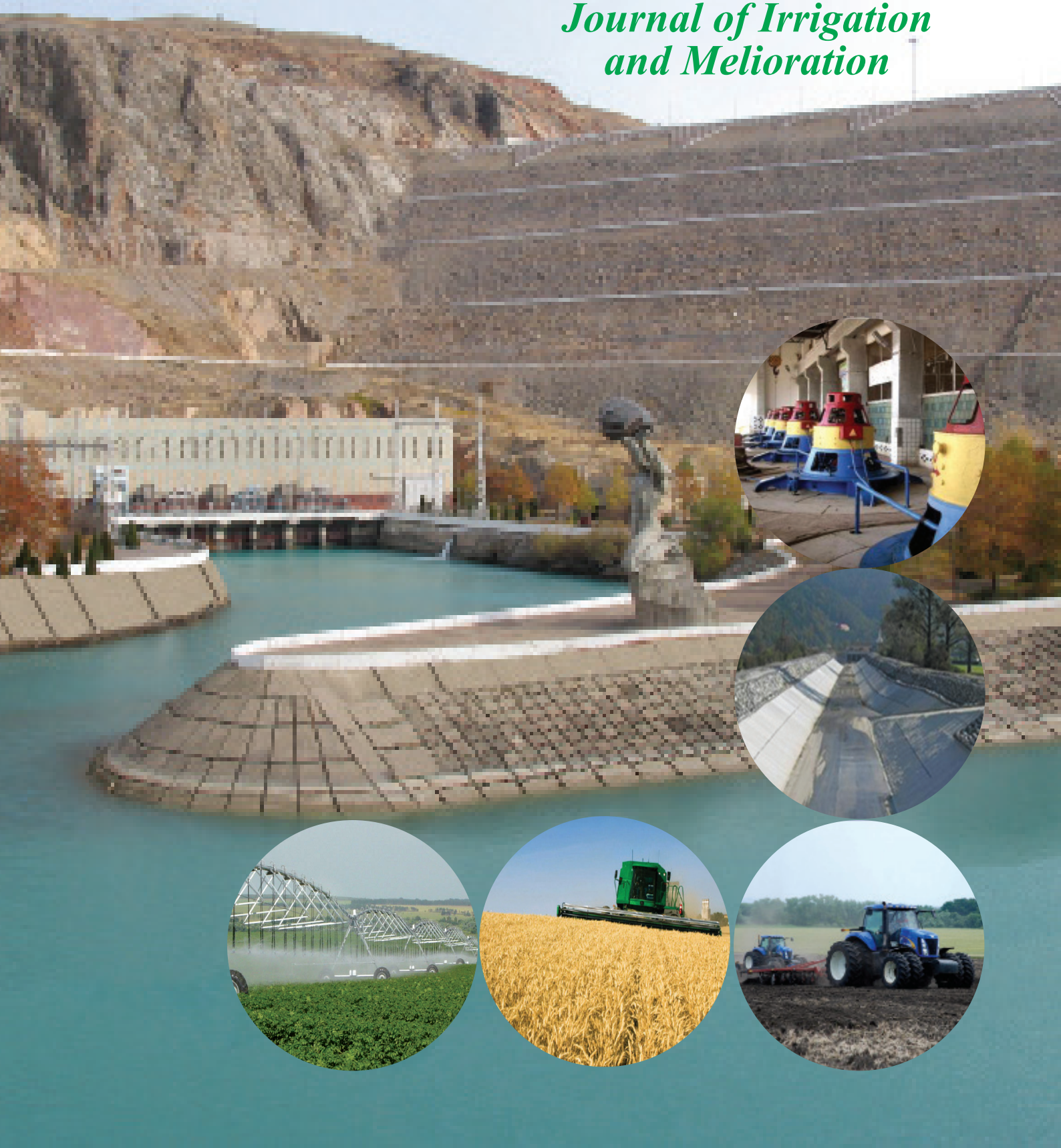

IRRIGATION AND MELIORATION

HYDRAULIC ENGINEERING STRUCTURES AND PUMPING STATIONS

ELECTRIFICATION AND AUTOMATION OF AGRICULTURE AND WATER RESOURCES MANAGEMENT

ECONOMICS OF WATER MANAGEMENT AND USE OF LAND RESOURCES

SOIL PROTECTION AND WATER-SAVING TECHNOLOGIES IN AGRICULTURAL CROPS IRRIGATION ON ERODED SOILS

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Abstract

Results of analysis of many years of research in soil-protection and water-saving technologies the cultivation of crops on eroded soils are presented in the paper. For the conditions of irrigated and erosion impacted typical loamy soils of the Chirchik-Angren valley, the law of a pliability of the typical loamy soils to erosion is revealed depending on the form of a furrow and the size of a jet. The optimal forms of furrows, the sizes of jets are determined for condition of typical loamy soils at growing potatoes. The influence of the form of furrow on the contents of organic matter, total nitrogen, and total phosphorus in a liquid and firm drain is established; the losses of nutritious substances with a liquid and firm drain are revealed depending on elements of irrigation technology. The growth, development and yield of potato crop is studied. The economic efficiency is determined at cultivation of potatoes on typical erosion damaged loamy soils.

Key words: Potatoes, irrigation regime, irrigation technics, irrigation technology, erosion, slope, leas moisture, irrigation rate, period of irrigation.

Introduction. The Action Strategy for 2017-2021, approved by the Decree of the President of the Republic of Uzbekistan, states that "... the use of intensive methods in agricultural production, primarily the introduction of modern water and resource-saving technologies" is one of the most important tasks [1]. In this regard, scientific research to improve the methods and application of anti-erosion measures, growth of agricultural crops in lands subject to erosion, is an effective way to dramatically increase and stabilize the crop yields, improve their quality, maintain and increase the soil fertility [2,3,5,6,7,9,10,11,12,16,17,18,19,20].

In the complex of means aimed at the rational use and improvement of the fertility in irrigated lands, an important place is occupied by the measures against soil erosion, as since the introduction of furrow irrigation in the foothill zones of the republic, irrigation erosion has been spreading. In Uzbekistan, 618 thousand ha of irrigated land are subject to erosion impact [17,18,19,20]. This environmentally dangerous phenomenon is common in Tashkent, Samarkand, Kashkadarya, Surkhandarya, Andijan, Namangan, Jizzakh, partly in Fergana regions, where the fertile soil layer and a significant part (15-35%) of the crop are lost annually as a result of soil wash-out, resulting in environment pollution [4.17,18,19,20].

In this regard, research on the development of scientifically based techniques and technology for irrigation of crops, in particular potatoes crops, on lands subject to erosion is of great relevance; it has important economic and environmental significance [10,14,17,18,19,20].

The aim of research is to develop an anti-erosion technology for irrigation and to obtain high crop yields on typical loamy soils of the Chirchik-Angren Valley. Based on the objectives of research, the problems to be studied are:

- determination of the degree of pliability to erosion of irrigated typical loamy soils, depending on the form of furrow and the size of water jet;
- determination of the optimal number of zigzags in furrows of zigzag form;
- identification of the optimal dimensions of the irrigation jet rate in the furrow;
- determination of the dependence of irrigation water discharge volume, wash-out intensity, chemical composition of liquid and firm drain on the form of furrow and the size of jet;
- identification of losses of nutritious substances with liquid and firm drain on eroded typical loamy soils depending on irrigation technology;
- study of the growth, development and yield of crops, depending on the form of furrow and the size of jet on typical loamy soils subject to irrigation erosion;
- determination of economic efficiency of anti-erosion irrigation technology on eroded soils.

Object of study. The studies were carried out in conditions of old irrigated typical loamy soils of the Chirchik-Angren Valley, in particular in the Kibray district of Tashkent region on the right bank of the Chirchik river, in the foothill slopes of the southwestern Karzhantau of the Chatkal ridge system. The geographic latitude is C420251, the longitude is B-690301, the highest point above sea level is 576.23 m.

In geomorphological terms, the territory is located on the wavy foothills of Karzhantau slopes, characterized by a variety of soils of different age and composition: the oldest of them are Paleozoic, represented mainly by porphyries, tuffs and porphyrites. According to soil conditions, the object is located in the belt of typical loamy soils. Due to the wavy surface of relief, the soil cover is variegated, which is due to pedogenic rocks, different depths of groundwater occurrence, various inclinations of slopes and other factors.

The source of irrigation is the Chirchik River, the flow of which is regulated in the reservoir. Water for crop irrigation is distributed along the canals of farm irrigation network of various structures: canals with concrete lining and chute canals. Agricultural land development is characterized by high coefficient of land use.

Research methods. The studies were carried out according to the methods developed at NIISSAVKH, NIIIVP and LLC UzGIP [4,6,16,17,18,19,20]. The tests on small-scale plots of land were conducted with 3 times repetition. The area of each plot was 280 m^2, the registered one - 140 m^2. The distance between the

furrows was 70 cm, the furrow length – 80 -100 m.

Field experiments were carried out according to the following scheme (Table 1):

Pic -1. Cotton field watering along a zigzag furrow

Research results. The formation and development of irrigation erosion of soil is determined by a combination of numerous factors. Among them, a special role in determining the pliability to erosion belongs to local relief, soil properties, the form of furrow and the size of irrigation jet [7,17,18,19,20].

It is known that the irrigation jet rate in the furrows depends to a greater extent on soil properties and the size of jet. At a jet rate of 0.1 l/s, the velocity of water flow in an ordinary furrow at watering potato crop is 0.18-0.26 m/s, at 0.15 l/s - 0.21-0.32 m/s and at 0.30 l/s - 0.31-0.40 m/s, respectively, that is, at an increase in the size of the water jet, the irrigation jet rate increases. At a jet of 0.1 l/s, the irrigation water rate in a zigzag furrow (1 sinusoid of amplitude of 20 cm per 1 running meter) is 0.16-0.24 m/s, at 0.15 and 0.30 l/s they are 0.19-0.30 and 0.29-0.36 m/s, respectively. At a jet of 0.1 l/s the irrigation water rate along a zigzag furrow (2 sinusoids of amplitude of 20 cm per 1 running meter) is 0.11-0.17 m/s, and at a jet of 0.15 and 0.30 l/s they are 0.13-0.22 and 0.15-0.32 m/s, respectively.

At cotton crop watering, the highest rate of water flow in the furrow is observed in the control option (Table 2). In a zigzag furrow, the water flow rate is much lower. A decrease in water flow rate in the furrow leads, in turn, to a decrease in irrigation erosion.

An increase in water jet size contributes to an increase in its rate in ordinary furrows. A similar pattern was observed in zigzag furrows with one and two sinusoids (of an amplitude of 20 cm per running meter), but to a lesser extent, and the lowest water rate was observed (at appropriate consumption) in furrows with two sinusoids. The research results showed that irrigation in zigzag furrows significantly reduces the rate of irrigation jet. Ultimately this reduces the degree of soil compliance to wash-out and erosion.

It was stated that in crop irrigation on sloping lands the part of water goes to discharge and the irrigation water loss due to discharge, depending on the form of the furrow and the size of the jet, varies sharply. So when supplying water for irrigation at the rate of 800 m^3/ha and a jet size of 0.10; 0.15 and 0.30 l/s the water discharge in an ordinary furrow was 230, 400 and 650 m^3/ha, respectively (an average value over three years of research). It can be seen, that with an increase in jet rate in the furrow, the volume of discharge water increases.

The volume of discharge water in a zigzag furrow (1 and 2 sinusoids (of an amplitude of 20 cm per 1 running

Table 1.

The scheme of field experiments with potato crop

Options	Types of furrows	The rate in the furrow, l/s	Soil moisture content before watering, % from field moisture capacity	Calculated layers
1	Ordinary	0.10	70-80	On moisture deficit in the layer of 0-50 cm before flowering, 0-70 cm during flowering and tuberization
2	Ordinary	0.15	70-80	same
3	Zigzag form (1 sinusoid per 1 running meter)	0.30	70-80	same
4	Zigzag form (1 sinusoid per 1 running meter)	0.10	70-80	same
5	Zigzag form (1 sinusoid per 1 running meter)	0.15	70-80	same
6	Zigzag form (1 sinusoid per 1 running meter)	0.30	70-80	same
7	Zigzag form (1 sinusoid per 1 running meter)	0.10	70-80	same
8	Zigzag form (1 sinusoid per 1 running meter)	0.15	70-80	same
9	Zigzag form (1 sinusoid per 1 running meter)	0.30	70-80	same

Table 2.

Water flow rate in the furrow at cotton crop watering

Repeatability	Watering				
	1	2	3	4	5
	Ordinary furrow				
I	0,13	0,12	0,10	0,09	0,85
II	0,14	0,12	0,11	0,09	0,08
III	0,14	0,14	0,12	0.10	0,09
	Zigzag furrow				
I	0,09	0,09	0,07	0,06	-
II	0,10	0,10	0,07	0,05	-
III	0,10	0,10	0,08	0,05	-

meter) at appropriate consumption was 150; 230, 380 and 80, 150; 240 m^3/ha. The least loss of irrigation water discharge was observed in the furrows with two sinusoids of an amplitude of 20 cm per 1 running meter. Observations showed that the turbidity of discharge water increases with increase in irrigation water jet in the furrow. When the rate of water jet is 0.10; 0.15; 0.3 l/s, the turbidity of discharge water in an ordinary furrow (an average value over vegetation season) was 20.2, 21.7 and 22.5 g/l, respectively. At watering in a zigzag furrows (1 and 2 sinusoids per 1 running meter) at appropriate consumption, the turbidity of discharge water was: 14.8; 15.5; 16.7 and 9.2; 10.0; 10.4 g/l. At watering potato crops, the least turbidity of the discharge water was observed in a zigzag furrow (2 sinusoids per 1 running meter). A comparison of the obtained data shows that soil erosion (wash-out) increases with increasing size of the irrigation water jet. At a water jet rate of 0.10 l/s, the soil wash-out from an ordinary furrow over vegetation season is from 35.2 to 37.5 t/ha, at a jet rate of 0.15 and 0.30 l/s, it amounts to from 36.6 to 39, 5 and from 38.3 to 45.4 t/ha, respectively. At a water jet rate of 0.10; 0.15 and 0.30 l/s in a zigzag furrow (1 sinusoid of an amplitude of 20 cm and 2 sinusoids of an amplitude of 20 cm per 1running meter) soil erosion was 28.0-36.6, 24.2-27.8; 21.9-25.4 and 22.4-27.8; 16.9-20.6; 15.7-19.3 t/ha, respectively. This shows that the firm drain during irrigation in zigzag furrows is less than when irrigating in ordinary furrows. The least soil erosion was observed at watering potato fields in zigzag furrows (2 sinusoids of an amplitude of 20 cm per 1 running meter).Thus, if an increase in water jet size contributes to a decrease in the lag time, an increase in irrigation jet rate and an increase in liquid and firm drain in an ordinary furrow, then a change in the form of furrow (zigzag furrow) makes it possible to extend the lag time, to reduce the water flow rate and the water loss due to the drain and wash-out of soil. So, at a water jet rate of 0.10 l/s, the loss of humus in an ordinary furrow over vegetation season was 489.3-542.3 kg/ha, at water jet rates of 0.15 and 0.30 l/s, the loss was 519.8-583.8 and 540.9-674.6 kg/ha, respectively. At water jet rates of 0.10; 0.15 and 0.30 l/s in a zigzag furrow (1 and 2 sinusoids of an amplitude of 20 cm per 1 running meter), the loss was 334,4-356,8; 366,9-407,5; 400,1-477,5 and 199,8-282,6; 234,3-313,8; 268,3-362 kg/ha, respectively.

At an increase in water jet in an ordinary furrow, humus losses increase; at watering in zigzag furrows, the humus losses depend on the number of zigzags per 1 running meter. The least loss of humus was observed at watering in zigzag furrows (2 sinusoids per 1 running meter). These patterns are revealed in terms of losses due to firm drain of total nitrogen and total phosphorus. Thus, it can be stated that with an increase in the irrigation water jet in an ordinary furrow, an intensive soil wash-out occurs, accompanied by the loss of humus, common nitrogen and total phosphorus. Irrigation in zigzag furrows dramatically reduces the volume of firm drain and the loss of nutrients.

The correct determination of the optimal sizes of water application and irrigation rates is of great importance for the rational use of irrigation water [5,8,17,18,19,20].

The irrigation norm value according to experimental tests options was determined by calculation, taking into account the water properties of soil, the depth of wetted layer, the permissible moisture threshold according to the S.N.Ryzhov formula. In options 1, 2 and 3 where the watering was done in an ordinary furrow, at flow rates of 0.10; 0.15 and 0.30 l/s, the number of irrigations was 8, at water application rates of 700-800 m^3/ha and irrigation rates of 6100, 6200 and 5970 m^3/ha. Accordingly, the period between the watering was 9-15 days. In options 4, 5 and 6, where irrigation was done in a zigzag furrow (1 sinusoid per running meter) with a flow rate of 0.10; 015; 0.30 l/s the number of irrigations was 8, at water application rates of 700-800 m^3/ha and irrigation rates of 5890, 6000 and 5730 m^3/ha. The period between the watering was 10-17 days. In options 7, 8 and 9, where irrigation was done in a zigzag furrow (2 sinusoids per running meter) at flow rates of 0.10; 0.15 and 0.30 l/s the number of irrigations was 7, with watering rates of 700-800 m^3/ha and irrigation rates of 5500, 5570 and 5550 m^3/ha, the period between the watering was 13-18 days.

The results of biometric and phenological observations showed that, at the same amount (norm) of mineral fertilizers and the size of water jet feeding into the furrow, the growth and development of potato crops on eroded soils depend on the form of the furrow. The height of the potato bush when irrigated in an ordinary and zigzag furrow (1 and 2 sinusoids of an amplitude of 20 cm per 1 running meter) at a jet rate of 0.10 l/s was 22; 27 and 33 cm, when irrigated at a jet rates of 0.15 and 0.30 l/s, were 27; 33; 39 and 32; 37; 44 cm, respectively. As for the bush growth, the best option was where the watering was done in zigzag furrows (2 sinusoids of an amplitude of 20 cm per 1 running meter).

Under the same conditions (the slope steepness, the size of water jet and the norms of applying mineral fertilizers) of eroded soils, the potato crop depends on the form of irrigation furrow. So, the potato yield when the crop was irrigated in ordinary furrows, with a jet rate of 0.1

l/s, amounted to 226 centner /ha, in zigzag furrows (1 and 2 sinusoids of an amplitude of 20 cm per 1 running meter) it amounted to 237 and 259 centner /ha, respectively. At jet rates of 0.15 and 0.30 l/s, the yield was 237; 248; 299 and 223; 235; 268 centner /ha, respectively. Thus, when watering potato bushes in a zigzag furrow at a flow rate of 0.15 l/s (2 sinusoids of an amplitude of 20 cm per 1 running meter), the water regime is improved and soil erosion is reduced; this contributes to better growth and development of bushes and an increase in potato yield.

Calculation of economic efficiency of potato growing at various forms of furrows and the size of irrigation jet in potato crop watering was carried out in accordance with the current standards and salary systems adopted in the Republic of Uzbekistan. When calculating the economic efficiency, the costs (in Uzbek soums) to carry out the agricultural practice procedures for irrigation and harvesting per 1 ha of crops were taken into account. The size of conditional net profit from 1 ha has been established with account for the cash-in value of potatoes yields. The most effective option was the 8th option, where irrigation was done in a zigzag furrow (2 sinusoids per 1 running meter). Conditional net profit of this option amounted to 1053360 soum/ha.

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