Influence of irrigation technology with use of technical means on development and yield of cotton

A. U. Atajanov[1*], *F. A.* Bekchanov[1], *N. K.* Usmanov[1], *M. K.* Asrarova[1], and *N.* Akhilbekov[2]

[1]"Tashkent Institute of Irrigation and Agricultural Mechanization Engineers" National Research University, Tashkent, Uzbekistan
[2]South Kazakhstan University after names M.Auezova, Kazakhstan

Abstract. Currently, the intensification of agricultural production and the development of irrigated agriculture requires the search for solutions for the rational and economical use of irrigation water, the widespread introduction of new, improved water-saving technologies, and technical means into production, which directly positively affects the growth, development, and yield of cotton. This article is devoted to the influence of irrigation technology with technical means on the irrigation rate, growth, development, and yield of cotton.

1 Introduction

The most important issues in the world are the effective use of water resources in conditions of acute water scarcity, as well as the improvement of the reclamation condition of the irrigated area. The main purpose of irrigated agriculture is to increase soil fertility and agricultural crop yields. Under irrigation conditions, the soil fertility level depends on the terrain and the condition of the surface of the irrigated area. The research of scientists gives reason to believe that the condition of the surface of irrigated lands does not fully meet the requirements of intensification, mechanization, and automation of agricultural production [1-5].

The intensification of agricultural production and the development of irrigated agriculture requires the search for solutions for the rational and economical use of irrigation water, the widespread introduction of new, improved water-saving technologies, and technical means into production, which positively affect the growth, development, and yield of cotton.

The Action Strategy for the five priority areas of development of the Republic of Uzbekistan for 2017-2021 noted, "... improvement of the reclamation condition of irrigated lands, further development of reclamation and irrigation facilities to increase the competitiveness of the national economy, widespread introduction of intensive methods in the field of agricultural production, primarily modern technologies that save water and energy resources".

*Corresponding author: a.atajanov@tiiame.uz

https://doi.org/10.1051/e3sconf/202340104011

This research work is a certain extent, aimed at fulfilling the tasks provided for in the Decree of the President of the Republic of Uzbekistan PP-4486 of October 9, 2019 "On measures to further improve the water resources management system", Decree of the President of the Republic of Uzbekistan UP-6024 of July 10, 2020 "On approval of the concept of water management development of the Republic of Uzbekistan for 2020 - 2030", Resolution of the President of the Republic of Uzbekistan PP-5005 dated February 24, 2021 "STRATEGY for water resources management and development of the irrigation sector in the Republic of Uzbekistan for 2021-2023"[2], as well as other regulatory documents related to this activity. In this regard, developing and implementing new innovative technologies and technical means are of great importance.

2 Research methodology

When watering crops through furrows, the share of manual labor is still very large. In this regard, issues related to increasing labor productivity during irrigation are relevant, which can only be solved by mechanization and automation of all irrigation processes. Currently, operators have at their disposal a fairly diverse set of technologies and technical means for surface irrigation along furrows. Still, all these technologies and technical means do not meet the requirements of current agricultural technology [6-10].

A significant advantage of the proposed technology for supplying water to the furrows is that it ensures uniform moistening of the soil along the length and depth of the furrow. The proposed technology meets the requirements of mechanization and automation of surface irrigation. The experiments carried out show [11-16] that by introducing improved technology and technical means for supplying water through furrows, it is possible to achieve rational and economical use of irrigation water, increase labor productivity, and a more uniform distribution of moisture over the area of the irrigated field.

Experiments on carrying out scientific research were carried out on irrigated lands of farms in the Khorezm region and the Republic of Karakalpakstan.

1-experimental field: farms "Ergash Ruzimov" and "Ishchanov Odilbek" in the Shavatsky district of the Khorezm region, where the soil is of heavy mechanical composition.

2-experimental field: farm "Reyimbai bashlik" Beruniysky district of the Republic of Karakalpakstan, where the soil is of medium mechanical composition.

3-experimental field: farm "Madaminov Uktam" in the Gurlensky district of the Khorezm region, where the soil is of light mechanical composition.

In the fields of these farms, there are collector–drainage networks, and irrigation networks have engineering structures. Irrigation water is delivered for the irrigation of crops by large channels and a temporary sprinkler; irrigation is carried out along furrows. The soils in the fields of farms are weak and strongly saline. The recommended technology and the created technical means were applied under conditions of three different mechanical compositions of the soil [17].

The following observations, measurements, and analytical observations were carried out on the selected experimental fields:

- to study the soil conditions of experimental plots before sowing cotton seeds to the depth of groundwater, the soil was studied in layers; soil samples were obtained in the genetic layers of the section, and the mechanical composition of the soil, humus, nitrogen, phosphorus, and potassium, as well as salts in the soil composition were determined in laboratory conditions;
- the volumetric weight of the soil of the experimental site was determined at the beginning of the growing season and the end in layers of 0-100 cm at the height of 10 cm using steel cylinders;

- the water permeability of the soil of the experimental site was determined at the beginning of the growing season and the end using a cylindrical circle based on the Nesterov method;
- the maximum field moisture capacity was determined by the Rozov method (a 2x2 m area is filled with water with a volume of 2000-3000 m^3 in layers of 0-100 cm at the height of 10 cm);
- observation wells have been installed to study the groundwater level of the experimental site and the degree of mineralization. Water samples were taken, and their level was monitored every 10 days. With the help of a conductometer, the composition and amount of salts were studied;
- the change in moisture in the experimental area at the beginning of the growing season and the end was determined using a digital moisture meter;
- humidity was determined at the experimental site using a digital moisture measuring device at a depth of 0-100 cm (after 3 days) at the beginning of the growing season and at the end;
- the moisture change in the experimental area was determined using a digital moisture measuring device;
- the water flow rate at the experimental site is determined by the Thomson (90) and Chippoletti (0.50 m) water measuring device and is determined according to the table by calculating;
- to determine the degree of salinity of the soil of the experimental site at the beginning of the growing season and the end using a digital moisture measuring device in layers of 0-100 cm at the height of 10 cm;

The growth and development of cotton at the experimental site were carried out by the methodology developed by the Research Institute of cotton breeding, agrotechnology of seed production [18-20].

Table 1. Mechanical composition of soil of experimental plots

Layer, cm	> 0.25	0.25-0.1	0.1-0.05	0.05-0.01	0.01-0.005
Experience - 1					
0-39	0.70	3.74	14.65	34.35	12.72
39-75	0.56	3.60	17.65	35.25	11.05
75-92	0.22	2.19	14.72	33.25	15.50
92-118	0.25	3.06	21.25	36.65	10.37
118-168	0.28	3.15	20.07	36.04	14.39
Experience - 2					
0 – 20	0.93	9.31	15.66	36.74	9.38
20 – 43	0.09	8.96	16.56	41.95	8.18
43 – 52	0.11	9.84	14.23	42.02	8.60
52 – 65	0.11	13.38	14.25	40.18	7.48
65 – 85	0.15	22.59	14.46	36.57	5.14
85 - 100	0.40	18.51	15.01	37.27	5.14
100-150	0.58	12.25	14.88	43.52	5.68
Experience - 3					
0 - 30	3.80	31.76	0.32	37.90	6.40
30 - 47	2.91	31.85	1.40	35.58	8.04
47 – 100	2.93	20.81	3.62	42.80	7.40
100-150	0.72	13.24	8.88	58.08	5.12

Continuation of table № 1.

Layer, cm	0.005-0.001	< 0.001	< 0.01	According to the method of N. Kochinsky
Experience - 1				
0-39	21.57	12.27	47.56	Heavy loam
39-75	18.22	13.67	49.94	Heavy loam
75-92	19.65	14.47	39.62	Medium loam
92-118	15.62	12.80	38.79	Medium loam
118-168	13.77	12.30	29.45	Light loam
Experience - 2				
0 – 20	9.39	18.59	37.36	Medium loam
20 – 43	8.18	16.08	32.44	Medium loam
43 – 52	8.60	16.6	33.80	Medium loam
52 – 65	10.28	14.32	32.08	Medium loam
65 – 85	10.02	11.07	25.23	Light loam
85 - 100	12.52	11.15	28.81	Light loam
100-150	10.74	11.35	27.77	Light loam
Experience - 3				
0 - 30	9.74	10.08	26.22	Light loam
30 - 47	8.58	11.64	28.26	Light loam
47 – 100	10.66	11.78	29.84	Light loam
100-150	6.54	7.42	19.08	Sandy loam

Table 2. Marginal field moisture capacity of soil of experimental plots, %

Soil layers, cm	2020		
	Experience - 1	Experience - 2	Experience - 3
0-10	21.5	19.4	18.6
10-20	22.6	21.1	19.8
20-30	22.2	22.1	19.4
30-40	21.7	21.5	20.5
40-50	22.2	20.8	19.3
50-60	21.9	22.1	18.4
60-70	22.3	21.4	18.5
70-80	22.8	21.5	20.1
80-90	23.4	20.9	19.1
90-100	22.1	22.1	18.4
0-50	22.0	21.0	19.5
0-70	22.1	21.2	19.2
0-100	22.3	21.3	19.2

Growth and development of cotton. Phenological observations of the growth and development of cotton show that the maintenance of salinity or salinity in the root layers of the plant depends on the composition and amount of water-soluble salts in the soil, which determine the direction of physiological processes in plant organs. The main stage of cotton cultivation in the same fields is the stage of flowering and harvesting of cotton (Table 3).
According to Table 3, in experiment 1, the density of cotton seedlings at the beginning of the growing season was 97.6 thousand pieces per 1 ha. The yield branch was 6.7 pieces. In experiment 2, the density of cotton seedlings at the beginning of the growing season was 98.4 thousand pieces per 1 ha. The yield branch was 6.4 pieces. In experiment 3, the density of cotton seedlings at the beginning of the growing season was 96.5 thousand pieces per 1 ha. The yield branch was 5.7 pieces [11, 20].

Table 3. Growth and development of cotton (2018-2020)

Variants	Density of seedlings, thousand pieces	Leaves, cm	Height of cotton, cm		The number of harvested branches, pieces
	1.06	1.06	1.06	1.07	1.07
Experience - 1					
PK	96.8	3.7	9.5	47.1	6.27
ES	97.0	3.8	9.8	47.1	7.02
Experience - 2					
PK	99.9	3.4	9.6	35.8	6.0
ES	100.0	3.7	10.1	35.0	6.5
Experience - 3					
PK	96.7	3.5	8.3	35.7	6.43
ES	98.2	3.8	8.6	36.4	7.14

Note: PK-production control; ES-experienced square.

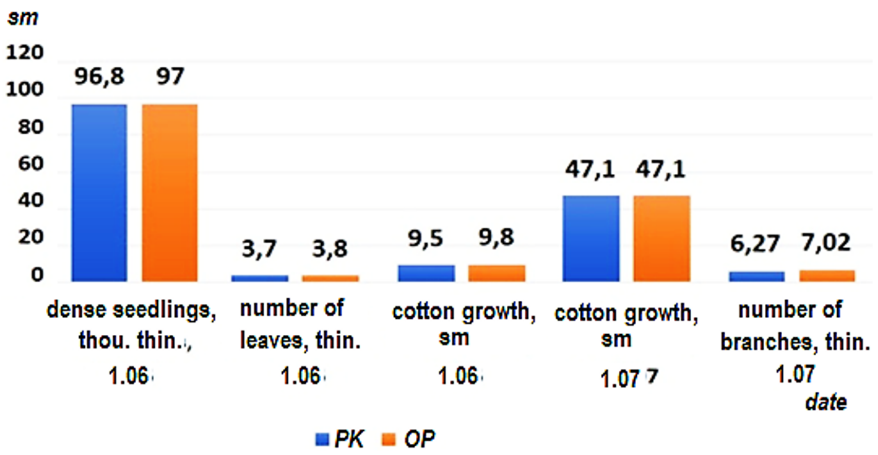

Fig. 1. Average growth and development of cotton in experimental field 1 (2018-2022)

The influence of irrigation technology on the growth and development of cotton. Phenological observations of the growth and development of cotton show that maintaining an optimal water regime in the layers in which the plant root spreads on saline or saline-prone soils is associated with the content and amount of water-soluble salts in the soil, which determines the direction of physiological processes in plant bodies. This is the main period of cotton growing in such sites, since the flowering and harvesting of goose are the final phase of the harvest (Table 4).

Table 4. The influence of irrigation regime on growth and development of cotton

Variants	Density of seedlings, thousand pieces	Leaves, cm	Height of cotton, cm			
	1.06	1.06	1.06	1.07	1.08	1.09
2018						
Experience - 1						
PK	95.3	3.4	9.6	49.6	97.3	99.3
ES	95.6	3.8	9.9	48.8	90.9	92.9
Experience - 2						
PK	100.6	3.5	10.1	34.6	80.9	95.3
ES	100.8	3.7	11.0	32.7	78.8	87.8
Experience - 3						
PK	97.0	3.9	8.0	38.6	78.9	95.1
ES	98.7	4.2	8.4	39.3	76.5	86.6
2019						
Experience - 1						
PK	96.6	3.6	9.4	44.4	96.6	99.8
ES	97.6	3.7	9.6	44.8	91.4	91.6
Experience - 2						
PK	97.4	3.2	9.1	36.5	82.6	98.7
ES	98.4	3.5	9.1	36.4	76.4	88.9
Experience - 3						
PK	95.1	3.1	8.6	32.6	76.4	94.3
ES	96.5	3.2	8.7	33.3	75.2	85.3
2020						
Experience - 1						
PK	98.4	3.7	9.6	47.4	97.3	99.8
ES	97.8	3.8	9.9	47.8	96.2	92.6
Experience - 2						
PK	101.6	3.5	9.7	36.2	86.8	97.9
ES	100.7	3.8	10.2	35.9	83.4	88.8
Experience - 3						
PK	97.9	3.6	8.4	35.8	77.9	97.2
ES	99.4	3.9	8.7	36.7	76.8	88.6

Continuation of table № 4.

Variants	The number of harvested branches, pieces		Number of boxes, pieces			Density of seedlings, thousand pieces
	1.07	1.08	1.08	1.09	1.09 disclosures	1.09
2018						
Experience – 1						
PK	7.6	10.2	5.9	10.3	4.1	92.8
ES	7.9	11.9	6.4	11.1	4.5	94.6
Experience - 2						
PK	6.6	10.4	6.1	10.2	2.1	98.5
ES	7.2	11.3	6.8	11.2	2.8	99.7
Experience – 2						
PK	5.8	10.2	4.4	10.1	2.4	94.9
ES	6.2	10.7	5.2	10.6	3.3	97.6
2019						
Experience - 1						
PK	6.2	10.6	5.5	9.8	3.8	93.2
ES	6.7	11.8	6.2	10.4	4.4	94.9
	Experience - 2					
PK	6.3	10.1	5.7	9.7	2.0	95.2
ES	6.4	10.9	6.3	10.5	2.6	96.9
	Experience - 3					
PK	5.6	9.9	4.2	9.6	2.2	93.2
ES	5.7	10.5	5.0	10.4	3.1	95.0
2020						
Experience - 1						
PK	6.9	10.6	5.8	10.5	4.2	94.4
ES	7.5	11.9	6.6	10.9	4.9	96.9
	Experience - 2					
PK	6.9	10.7	6.3	10.2	3.6	96.4
ES	7.4	11.6	6.9	11.5	3.7	97.9
Experience - 3						
PK	5.9	10.7	5.5	9.9	3.3	95.6
ES	6.6	11.6	6.1	10.8	4.2	98.2

According to Table 4, at the beginning of the growing season of the 1st experimental field, if the density of seedlings was 95.6-97.6 thousand bushes per hectare, by the end, the thickness of seedlings was 94.6-96.9 thousand bushes per hectare and a decrease was observed.

As of September 1, the height of cotton was 91.6-92.9 cm, the branches of the crop were 11.8-11.9 pieces, the number of boxes was 10.4-11.1 pieces, and the number of open boxes was 4.4-4.9 pieces. Growth and development compared to production control amounted to more than 1.2-1.7 units of crop branches, the number of boxes 0.4-0.8 units, and the number of open boxes more than 0.4-0.7 units.

As of September 1, on the 2nd experimental field, the height of cotton was 87.8-88.9 cm, the branches of the crop were 10.9-11.5 pieces, the number of boxes was 10.5-11.5 pieces, and the number of open boxes was 2.6-3.7 pieces. Growth and development compared to production control amounted to more than 0.8-0.9 units of crop branches, the number of boxes 0.8-1.3 units, and the number of open boxes more than 0.1-0.7 units.

At the beginning of the growing season on the 2nd experimental field, the seedling density was 96.5-98.7 thousand bushes per hectare, then by the end of the growing season, the seedling density was 95.0-98.2 thousand bushes per hectare, or a decrease of 0.5-1.5 thousand bushes was observed. In the case of September 1, the height of cotton was 85.3-88.6 cm, the yield branches were 10.5-11.6 pieces, the number of boxes was 10.4-10.8 pieces, and the number of opened boxes was 3.1-4.2 pieces, compared with the production control, the yield branches were 0.5-0.9 pieces, the number of boxes was 0.5-0.8 pieces and by September 1, the number of opened boxes was more than 0.9 pieces.

The effect of irrigation on the weight of a cotton box. According to the observation of the weight of cotton in one box (Table 5), it was found that in the production field, in the 1st experimental production control for collection, the average was 5.3-5.4 grams, in the experimental field, the weight of cotton in one box in terms of field conditions averaged 5.5-5.7 grams.

Table 5. Weight of cotton in one box

Variants	Weight of cotton in one box according to fees, gr			Average weight of cotton in one box, gr
	1	2	3	
2018 year				
Experience - 1				
PK	6.3	5.1	4.4	5.3
ES	6.4	5.3	4.7	5.5
Experience - 2				
PK	6.5	5.2	4.3	5.3
ES	7.2	5.6	4.4	5.7
Experience - 3				
PK	6.2	5.3	4.2	5.2
ES	6.5	5.5	4.4	5.5
2019 year				
Experience - 1				
PK	6.3	5.4	4.4	5.4
ES	6.7	5.6	4.7	5.7
Experience - 2				
PK	7.8	6.0	4.1	6.0
ES	8.3	6.4	4.3	6.3
Experience - 3				
PK	6.1	5.0	4.2	5.1
ES	6.4	5.2	4.6	5.4
2020 year				
Experience - 1				
PK	6.3	5.3	4.4	5.4
ES	6.6	5.5	4.7	5.6
Experience - 2				
PK	7.2	5.6	4.2	5.7
ES	7.8	6	4.4	6.1
Experience - 3				
PK	6.2	5.2	4.2	5.2
ES	6.5	5.4	4.5	5.5

In the 2nd experiment, the cotton weight in one production control box averaged 6.0-6.2 grams, while in the experimental field, it was 6.3-6.5 grams.

In experiment 3, the weight of cotton in one production control box averaged 5.1-5.2 grams, while in the experiment field, it was 5.4-5.5 grams.

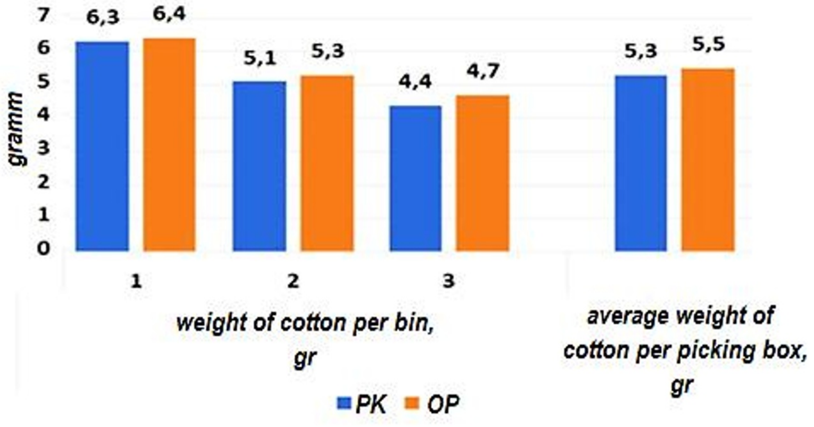

Fig. 2. Weight of cotton on one box

3 Results and Discussion

The effect of using technical means on cotton's irrigation rate and yield. In the 1st control variant, a cotton crop of 31.6-33.4 c/ha was obtained, and 115.4-116.6 m^3 of irrigation water was used to grow 1 hundredweight of cotton. A cotton harvest of 37.9-38.5 c/ha was obtained in the experimental field, and 57.7-58.2 m^3 of irrigation water was used to obtain 1 hundredweight of cotton.

In the 2-control variant, a cotton crop of 31.9-32.8 c/ha was obtained, and 143.8-146.3 m^3 of irrigation water was spent for growing 1 hundredweight of cotton. A cotton harvest of 35.8-36.3 c/ha was obtained in the experimental field, and 77.6-79.8 m^3 of irrigation water was used to grow 1 hundredweight of cotton.

In the 3-control variant, a cotton crop of 31.5-31.6 c/ha was obtained, and 165.4-171.1 m^3 of irrigation water was spent for growing 1 hundredweight of cotton. A cotton harvest of 35.5-37.5 c/ha was obtained in the experimental field, and 102.7-105.9 m^3 of irrigation water was used to obtain 1 hundredweight of cotton.

The methodology of conducting experiments in the proposed technical means. For crops that are irrigated by furrowing or by strips (rowed, grain, grass), an inclined surface of the same slope is needed. To determine the influence of the field surface on the irrigation water flow, the work is carried out in the following order: fields with deviations of the actual surface from the design to ± 3 cm, ± 5 cm, ± 10 cm are prepared. The leveling of the field surface is performed, then the planning of the plots is carried out. After the planning is completed, the quality control of the work is carried out. Agrotechnical measures are carried out (furrow cutting, sowing, etc.).

To determine the effect of the flatness of the field surface on the irrigation water flow, the same volume of water is supplied to all three prepared areas of the same size with different deviations of the actual surface from the design one. The volume of water supplied is measured by a flow meter.

To determine the uniformity and degree of soil moisture, 3 samples are sampled from one place along the furrows in 10-20 m increments. Soil samples are taken depending on the irrigation rate of the soil type and weather conditions after irrigation in 1-4 days. Soil moisture is determined in the laboratory using a generally accepted method (drying at a temperature of 1050C, weighing, and calculating humidity) [6, 16].

A comparison of the selected samples' moisture values and the conclusion is made about the linear uniformity of soil moisture. The comparison of the value for all linear shafts (furrows) is made by the conclusion about the uniformity of soil moisture over the area. Comparing the soil moisture at each point of the plane in-depth, a conclusion is made about the uniformity and degree of soil moisture. To clarify the dependence of irrigation water consumption on the surface layout, a table is compiled for different irrigation methods in which water use efficiency is an indicator [7, 18].

For clarity, this dependence can be graphically depicted, as shown in Figure 3.

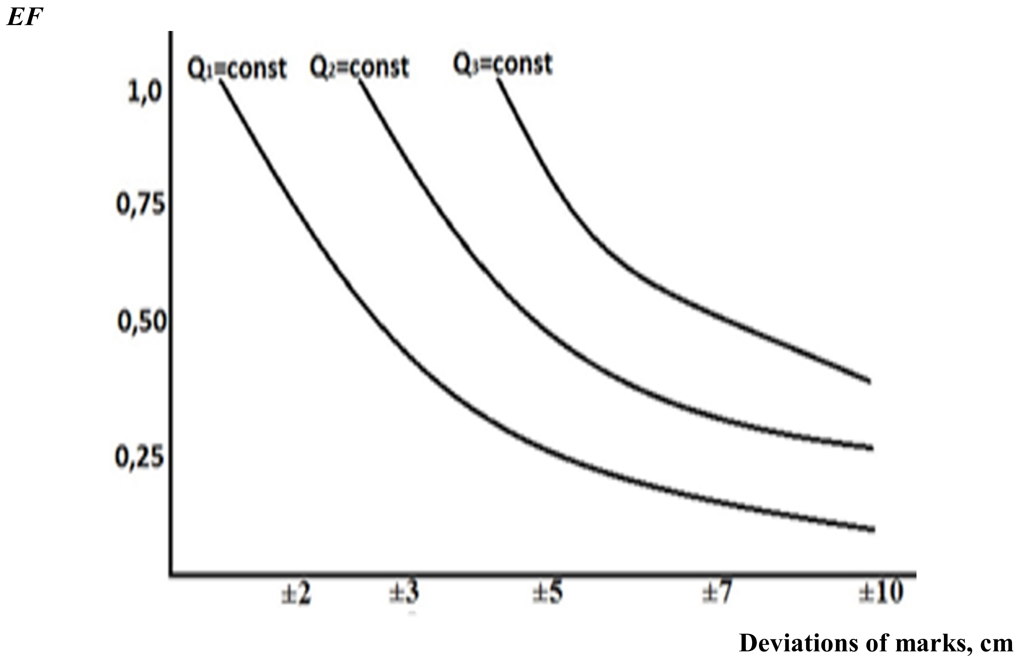

Fig. 3. Graph of dependence of water use efficiency on deviation of marks (surface layout).

Note: EF **-** efficiency factor

The research results showed that using this equipment in irrigation and using irrigation technology, a high yield from cotton was obtained, and the possibility of saving the amount of irrigation water supplied during the season was proved [19].

4 Conclusions

1. The influence of water-saving irrigation technology on the growth, development, and yield of cotton has been established:

- on soils with a light mechanical composition, the height of the stem as of September 1 was 92.2 cm, the number of boxes was 10.7, of which 4.6 pieces were opened, the yield was 38.5 c/ha;

- on soils with an average mechanical composition, the height of the stem as of September 1 was 88.4 cm, the number of boxes was 11.2, of which 3.1 pieces were opened, the yield was 36.0 c/ha;

- on soils with heavy mechanical composition, the height of the stem as of September 1 was 87.1 cm, the number of boxes was 10.6, of which 3.7 pieces were opened, and the yield was 36.5 c/ha. Cotton yields were higher by 6.3 c/ha, 3.2 c/ha, and 5.0 c/ha, respectively, compared with production control.

2. Economic indicators of the use of water-saving technology:

- 5444.6 thousand soums were received from the sale of cotton grown on an area of 1 ha of irrigated land with a light mechanical composition of the soil. Total production costs in the area of one hectare were 3854.4 thousand soums, conditional net profit was 1580.2 thousand soums/ha, and profitability 41%;
- 5518.4 thousand soums were received from the sale of cotton grown on an area of 1 ha of irrigated land with an average mechanical composition of the soil. Total production costs per hectare were 3338.6 thousand soums, conditional net profit was 2179.8 thousand soums/ha, and profitability 39 %;
- 5394.4 thousand soums were received from the sale of cotton grown on an area of 1 hectare of irrigated land with the heavy mechanical composition of soils. The total production costs per hectare were 3918.5 thousand soums, the conditional net profit was 1475.9 thousand soums/ha, and the profitability was 37%.

Acknowledgments

The study was funded by the National Research University - "Tashkent Institute of Irrigation and Agricultural Mechanization Engineers".

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