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THE IMPORTANCE OF MODERN SOFTWARE FOR DETERMINING COTTON IRRIGATION REGIME

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Abstract: *This article presents practical results of application of drip irrigation on cotton, as well as comparison of furrow and drip irrigation. While maintaining the pre-irrigation soil moisture in the mode of 70-80-65% of UFMC (marginal soil moisture capacity), the average seasonal drip irrigation rate was 3,354 m^3/ha on soils with light mechanical content and 3,583 m^3/ha on medium loamy soil during the years of research. This means that up to 1,926 m^3/ha of irrigation water (or 36%) used on light soil and up to 1,444 m^3/ha (or 28%) of irrigation water on medium loamy soil were saved respectively compared to traditional furrow irrigation. The average raw cotton yield during the three years of research irrigated with drip irrigation was in the range of 4,16 ton/ha on light soil and 4,10 ton/ha on medium loamy soil and were respectively higher than yields with furrow irrigation by 1,07 ton/ha (or 34%) and 0,88 ton/ha (or 27%). Cotton irrigation regime was determined using the computer program "CropWat-8.0". Based on field experiments and software data, comparative indicators of cotton irrigation regime were identified. The difference between field experimentation and "CropWat-8.0" software indicators occurred in the number of irrigation events (differed by 3), and in the irrigation rate (27-30% higher). This made it possible to determine the moisture content in the soil under drip irrigation and to plan the irrigation schedule using drip irrigation. Using the "Hydrus 1-D" software model, the characteristics of moisture distribution in the soil under drip irrigation of cotton were determined. This makes it possible to determine the moisture content in the soil during drip irrigation and plan the time, rate and number of irrigations.*

Key words: *Cotton, irrigation, seasonal irrigation rate, drip irrigation,*

"CropWat-8.0" program, "Hydrus 1-D" software model, UFMC (ultimate field moisture capacity), light mechanical content and medium loamy soils.

Introduction

Statistics shows that 1.1 billion out of 7.5 billion people in the world today suffer from water shortages. By 2025, the number of people living in water deficit areas is expected to exceed 3 billion and makeup 40% of the world population. This is the underlying reason for the growing attention to dissemination of drip irrigation systems around the world. In particular, great achievements have been made in the use of water-saving irrigation technologies in Israel, Cyprus, the United States, Italy, Australia, and Germany. Uzbekistan is sixth-largest producer of cotton in the world and fifth-largest exporter of cotton fiber, which in turn calls for the shift from traditional water consuming irrigation technologies to water-saving irrigation technologies, including drip irrigation. The most important and urgent task in the country is to maintain and even increase the yields of the main crops, increase the quality of produced crops with the use of water-saving technologies. On July 10. 2020, the Concept of Water Resources Development of the Republic of Uzbekistan for 2020-2030 was brought into force. According to this document water-saving technologies in Uzbekistan will be gradually implemented on the area of 2 million ha by 2030, including 600 thousand ha with drip irrigation technology. It is expected that during this period about 35-40% (3.5 - 4 billion m^3) of irrigation water will be saved, which will allow to additionally cultivate around 298 thousand ha, previously abandoned [1].

Drip irrigation of agricultural crops in the conditions of Uzbekistan was investigated and analyzed by such scientists as V.A.Dukhovniy, A.V.Novikova, R.K.Ikramov, K.M.Mirzazhanov, A.T.Salokhiddinov, M.Kh.Khamidov, G.A.Bezborodov, I.E.Makhmudov, B.F.Kambarov, A.Usmanov, B.Kamilov, Isaev S., E.D.Cholpankulov, R.G.Lyubar, U.Norkulov, A.G.Sherov, B.Sh.Matyakubov, S.A.Mamatov, Yu.M.Esanbekov, G.V.Stulina, A.A.Artikov, M.M.Sarimsokov and others [2-10].

Current research was conducted via field, laboratory research and phenological observations based on the methodology described in such manuals as "Methods of studying the agrophysical, agrochemical and microbiological properties of soil in cotton fields", "Methods of field experiments", "Methodology of field and vegetative experiments with cotton under irrigation conditions". The accuracy and reliability of the obtained data were confirmed with mathematical-statistical analysis using the generally accepted B.A.Dospekhov's multifactorial method [11-14] .

The study was undertaken with the aim to contribute to the improvement of the elements of drip irrigation technology, development of cotton irrigation regime and scientific substantiation of the effectiveness of this technology in Bukhara region of Uzbekistan [15].

Field trials were carried out in conditions of slightly saline soils with light and medium loamy texture in the Bukhara region with a groundwater level of 2.0-2.5 m and groundwater salinity of 2.0-3.0 g/l. Field experiments determined the irrigation regime, the mechanical components of the soil, and moisture levels in the process of irrigating cotton in two different ways (furrow irrigation and drip irrigation). The experiments were performed based on the system described in Table 1. In experiments medium-fiber cotton variety “Bukhara-6” was grown on soil with mechanical composition of middle sand at the distance between rows of 60 sm [16].

Table 1. Description of field experiments

№	Soil moisture before irrigation, % of MSMC (marginal soil moisture capacity)	Irrigation method	Irrigation rate, m^3 / ha
1.	control	Surface (furrow) irrigation method	Actual measurements
2.	70-80-65	Drip irrigation	0-50 sm. and 0-70 sm. with moisture deficiency
3.	80-80-65	Drip irrigation	0-50 sm. and 0-70 sm. with moisture deficiency

Note: Field experiments were performed in 4 replicates. 70-80-65 % (before flowering of cotton: from flowering to ripening: percentage of moisture retention after ripening, relative to the limit humidity) [17].

In experiments, soil moisture and water-physical properties of the calculated layer of soil were determined on the basis of methods in the laboratory and in the field. Soil moisture in the experimental field using drip irrigation method was 60 sm, and 100 sm in the field using the traditional irrigation method. Soil moisture from depth was constantly monitored. A soil moisture tensiometer (irrimeter) was used to determine the timing of cotton irrigation. During the development stages of cotton, its demand for water was

studied and the optimal options for irrigating the crop with conventional and drip irrigation methods were tested [18].

Findings

The norms and periods of drip irrigation on cotton were calculated on the basis of a computer program, taking into account the natural, climatic and soil conditions according to the international methodology of FAO "CropWat-8.0" [19, 20], adopted for irrigated areas in the world. (Figure 1). The mode of drip irrigation of cotton, determined by the FAO method, was compared with the data obtained in the field in the experimental years (Table 2).

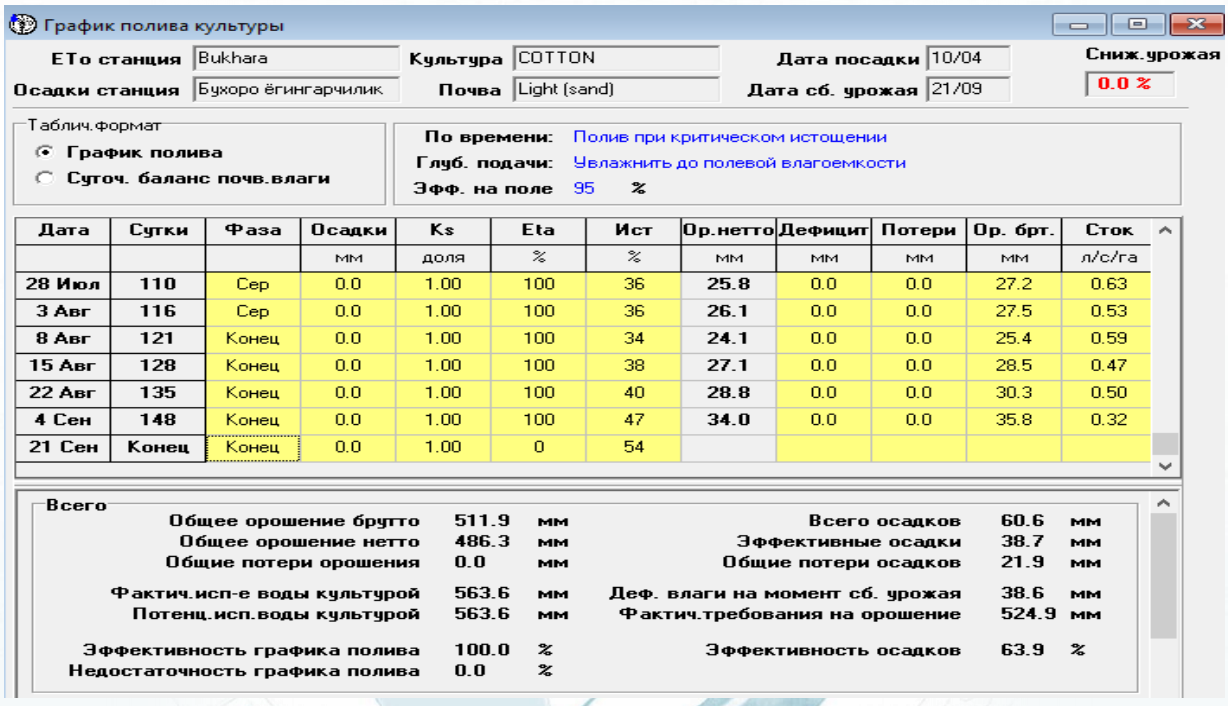

Figure 1. Determining the mode of drip irrigation of cotton using the "CropWat-8.0" program

Table 2. Comparative watering regime values

№	Options	Conditional values	Field experience	FAO methodology
1.	Number of irrigation events	quantity	15-18	18-21
2.	Irrigation rate	m^3/ha	180-290	230-340
3.	Seasonal irrigation volume	m^3/ha	3,283-3,686	4,863-5,015

It has been shown that while maintaining the pre-irrigation soil moisture in the regime of 70-80-65%, optimal moisture rate can be provided for the growth and development of cotton. During the growing season of cotton, on average:

on light loamy soils, 18 irrigations events were carried out according to

the 4-12-2 scheme, irrigation rates were 194-177-224 m^3/ha and seasonal irrigation volume totaled 3,354 m^3/ha;

on soils of medium loamy mechanical composition, 15 irrigations events were carried out according to the 4-9-2 scheme, irrigation rates were 245-227-279 m^3/ha and seasonal irrigation rates were 3,583 m^3/ha;

while ensuring optimal moisture for the growth and development of cotton in the experimental fields in the mode of 70-80-65% of UFMC, drip irrigation allowed to save 1,926 m^3/ha and 1,444 m^3/ha of irrigation water on soils with light mechanical content and on soils with medium mechanical content respectively.

It is known that the study of the patterns of formation of the soil moisture contour during drip irrigation is the most important issue. With this regards software model "Hydrus 1-D" was used to determine the properties of moisture distribution in the soil during drip irrigation of cotton [21]. (Figure 2), which made it possible to determine the moisture content in the soil during drip irrigation and plan the irrigation regime.

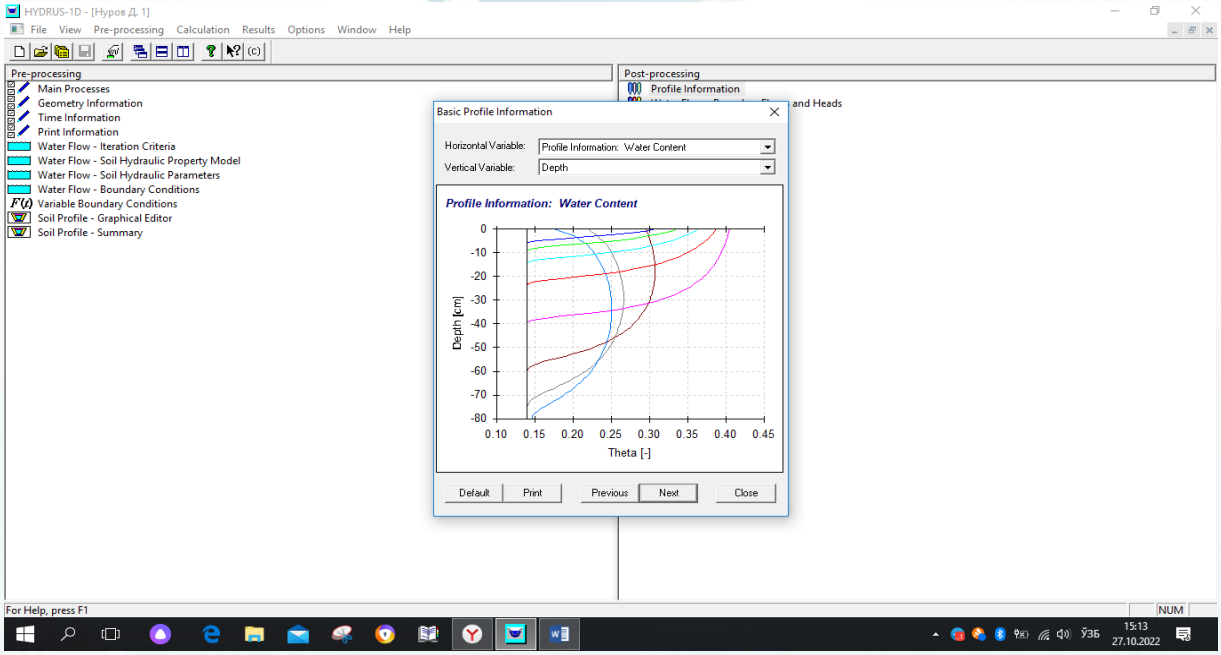

Figure 2. Formation of the soil moisture contour in the "Hydrus 1-D" program Conclusions

While ensuring optimal moisture for the growth and development of cotton in the experimental fields in the mode of 70-80-65% of UFMC, drip irrigation helped to increase cotton yields. Likewise, the average cotton yield during the three years of experimentation with drip irrigation was 4.16 ton/ha on soils of light mechanical composition and 4.10 ton/ha on medium loam. Average cotton yield compared with furrow irrigation increased by 1.07 ton/ha (or 34%) and 0.88 ton/ha (or 27%), on two experimented soils respectively.

During the years of research, the productivity of water, i.e., cotton yield harvested per 1,000 m^3 of irrigation water, in the mode of 70-80-65% of the UFMC with drip irrigation: was 1,234 tons on light soils, 1,145 tons on medium loamy soils respectively. Whereas furrow irrigation water productivity was -0.587 tons (light soil), 0.641 tons (medium loam). The effectiveness of drip irrigation technology was proved with a higher cotton yield per irrigation water used.

On the experimental fields, the best economic indicators were achieved with drip irrigation favorable for the growth, development and increase in cotton yields at pre-irrigation soil moisture in the mode of 70-80-65% of UFMC:
the level of profitability in the variants with furrow irrigation on soils of light mechanical composition on average for 3 years was 52.4%, in the experimental variants with drip irrigation - 69%, the level of profitability was 16.6% higher than in the control variants;

the level of profitability in the variants with furrow irrigation on soils of medium loamy mechanical composition on average for 3 years was 54.7%, in the experimental variants with drip irrigation - 67%, the level of profitability was 12.3% higher than in the control variants.

When irrigating cotton using drip irrigation technology, it is recommended to plan irrigation using the Food and Agriculture Program of the United Nations (FAO) “CropWat-8.0” and the “Hydrus 1-D” program.

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