






Development of Scientificly Based Cotton Irrigation Regulations for Hydromodule Regions

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Abstract: At the time of year-to-year global climate change, and taking into account the water demand of cotton grown in the Kashkadarya region in order to prevent the decrease in productivity and quality of agricultural crops due to the lack of irrigation water compared to the crop demand, the method of seasonal irrigation using the data of the weather station using “CropWat 8.0”. Based on the program, the coefficient values for the development stages of cotton were adopted based on the mechanical composition of the soil, the depth and mineralization of seepage waters. The results of scientific research carried out by scientists in cotton fields were analyzed. In addition, scientifically based irrigation methods of water-saving irrigation technology of cotton were developed according to generally accepted hydromodule regions for the conditions of Kashkadarya. According to the developed software, the seasonal irrigation standards of cotton in the hydromodule regions were 3500 m³/ha of the ninth hydromodule region, and 6900 m³/ha for the first hydromodule region.

1 INTRODUCTION

At the same time that the water shortage is increasing year by year in the whole world, including in the Republic of Uzbekistan, effective and rational use of irrigated land, economical use of existing water resources is one of the most important priorities in agricultural reform and will remain so.


Because the efficiency of agricultural production, ensuring the economic and food security of our


country, increasing the material well-being of not only rural workers, but also the entire population of Uzbekistan, the productivity of irrigated land, which is our priceless wealth, is inextricably linked with regular improvement of its quality.


As a result, the identification of limited water resources is a sign that every drop of water should be used sparingly in the agricultural sector.


In the effective and rational use of water resources, it is of great importance to use the

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economical irrigation method and to alleviate the water shortage by using it in the cotton field, according to the analytical result, 52.6 percent is saved, and the productivity is increased by 66 percent. When the number of irrigations during the season for irrigation increases, the productivity of water is 0.95 t/m³ and 0.54 t/m³ of water is saved compared to the surface irrigation method, and cotton productivity is increased (Matyakubov, Nurov, Teshayev, Kobulov, 2023).

The role of hydromodule zoning is incomparable in alleviating water scarcity, effective use of water resources in cultivated areas, and ensuring high and quality harvest of agricultural crops. In particular, it is important to determine the seasonal irrigation rate using a computer program, taking into account the mechanical composition of the soil, climate and other natural conditions, and crop demand (Khamidov, Matyakubov, Gadaev, Isabaev, Urazbaev, 2022; Khamidov, Inamov, Islomov, Mamatkulov, 2023; Khamidov, Juraev, Buriev, Sharifov, Isabaev, 2023).

Decree No. PD-6079 of the President of the Republic of Uzbekistan dated October 5, 2020 “Digital Uzbekistan - 2030” on the use of programs in the development of scientifically based cotton irrigation procedures for hydromodule zoning, Decree of the President of the Republic of Uzbekistan dated April 28, 2020 “Measures for the widespread introduction of digital economy and electronic government” - based on the implementation of work according to the decision PD-4699 “on activities”.

By saving available water resources and reducing water loss in the field, using water-saving irrigation methods, it was possible to get a higher and better-quality cotton crop, and it was possible to increase the productivity of irrigation water.

The necessary data for the software were obtained and analyzed from the Hydrometrological Center of the Republic of Uzbekistan, as well as from meteorological stations in the region. As a result of global climate change, the air temperature increases and the flow of rivers decreases significantly. In the global climate conditions, the warming of the air will have a great impact on the change of the water level and volume in the Amudarya river and the Amudarya basin. Based on the recommendations made by scientists, no increase in available water resources is predicted in any of the climate scenarios, depending on the increase in air temperature to the animal hot level. On the contrary, there are opinions about the increase of total evaporation from the irrigated area as a result of a sharp warming of the climate (Khamidov, Khamraev, 2020; Khamidov,

Ishchanov, Khamidova, Isabaev, Altmishev, 2023; Khamidov, Muratov, 2021).

It is known that climate change affects the formation of water resources and their efficient and rational use. Year-to-year changes in climate lead to 10-15% more water evaporation from land surfaces, and 10-20% more water use due to plant transpiration and increased irrigation rates. This causes an average 18% increase in non-renewable water consumption. Analytical conclusions made by scientists indicate that there will be no significant changes in water resources in the Amudarya and Syrdarya basins by 2030. However, by 2050, it is predicted that water resources will decrease by 10-15% in the Amudarya basin and 2-5% in the Syrdarya basin (Agaltseva, 2019). Assessment of the possible increase in water consumption in irrigated lands due to changes in climate conditions (water consumption of various crops, water losses, changes in land reclamation) is an urgent problem today.

Effective use of water in agriculture is becoming a priority due to observation of serious shortage of irrigation water in the management of water supply of agricultural crops in the Republic of Uzbekistan and climate change increasing the water demand of agricultural crops. It is in the Kashkadarya region that raising irrigation water to a height of N=140 m using the 6-stage pumping stations in the Karshi main channel indicates the high value of the water given to agricultural crops (Mamazhonov, Shakirov, Matyakubov, Makhmudov, 2022).

Compared to the data obtained from weather stations, the seasonal data on the analysis of rural irrigation precipitation show that the annual precipitation is 100-111 mm. Incorrect distribution and low amount of precipitation, low water holding capacity of soils are the main causes of crop stress. Therefore, it is important to determine the water needs of agricultural crops in different climatic, soil-hydrogeological conditions of our country using the “CropWat 8.0” program based on the FAO methodology.

2 MATERIALS AND METHODS

The “CropWat 8.0” program developed by FAO was used to determine the water demand of crops. The Penman-Monteith method was used to determine evapotranspiration (ET₀) from the theoretical side. Methods of systematic analysis and mathematical statistics, as well as agrotechnology of cotton breeding, breeding and cultivation “Methods of

conducting field experiments” were used in irrigation procedure of agricultural crops for each hydromodule region based on the conducting research.

3 RESULTS AND DISCUSSION

Hydromodule zoning of irrigated lands and the development of a scientifically based “CropWat 8.0” program is the easiest and most express method that does not require a lot of time. This is one of the important issues in the conditions of increasing water scarcity. FAO methodology, i.e. “CropWat 8.0”, using “Karshi” weather station data to estimate the water demand of cotton in Kashkadarya region.

Based on the program, cotton irrigation procedures and seasonal irrigation standards were determined.

The coordinates of the weather station “Karshi” located in the Kashkadarya region of the Republic of Uzbekistan have been determined (Country: Uzbekistan 2021 Station: Altitude: 384 m.; Latitude: 38.86 °S; Longitude: 65.79 °W). Data on air temperature (maximum and minimum, °C), relative humidity (percentage), precipitation amount (mm), wind speed (m/s) and duration of sunshine (hours) required for the program based on the results of observation at the weather station. was obtained (Table 1), on this basis indicators were developed (Fig. 1).

Table 1: “Karshi” weather station data (2022).

Months	Temperature, °S		Relative air humidity, %	Amount of precipitation, mm	Wind speed, m/s	Duration of sunlight	Radiation mj/m ² /day	ET _o mm/ day
	Max	Min						
January	8,8	-2,3	71	11,0	1,6	6,4	9,3	1,18
February	16,9	3,9	56	1,2	3,1	6,9	12,0	2,64
March	18,8	7,1	61	51,3	3,7	5,4	13,5	3,31
April	28,5	11,6	41	8,6	2,7	11,3	24,0	5,92
May	34,6	19,1	36	13,5	2,7	11,5	26,1	7,47
June	38,7	22,2	23	0,0	3,1	13,1	29,1	9,63
July	39,3	24,6	27	0,0	3,8	12,6	27,9	10,25
August	38,0	21,3	27	0,0	2,7	12,2	25,8	8,14
September	34,5	15,9	33	0,0	2,8	10,7	20,8	6,48
October	22,2	7,6	43	0,5	2,7	8,6	14,7	3,39
November	15,1	2,7	59	15,0	2,1	5,0	8,6	1,76
December	13,8	2,9	65	10,3	2,6	5,5	7,8	1,73
Average	25,8	11,4	45	111,4	2,8	9,1	18,3	5,16

As a result of entering the above indicators into the program, the dynamics of changes in radiation (mdj/ml/day) data by month were determined.

As shown in Table 1, in 2022, according to data from the “Karshi” weather station, the maximum value of the average air temperature is 25.8 °S, the minimum value is 11.4 °S, the relative humidity of the air is 45%, 111.4 mm throughout the year. It is mentioned that there was precipitation, wind speed was 2.8 m/s, and the average duration of sunshine was

9.1 days. On this basis, the amount of sunlight radiation and evaporation was determined.

Changes in the indicators of the dynamics of the maximum and minimum air temperature, relative humidity, duration of sunlight, wind speed, amount of precipitation, solar radiation and ET_o change during 12 months of 2022 in the Kashkadarya region. It was observed that the relative air humidity was high in January-May (36-71%) and October-December (43-65%). Other indicators such as wind speed, radiation, evaporation, maximum and minimum air

temperature, and duration of solar radiation can be seen to change accordingly (Figure 1).

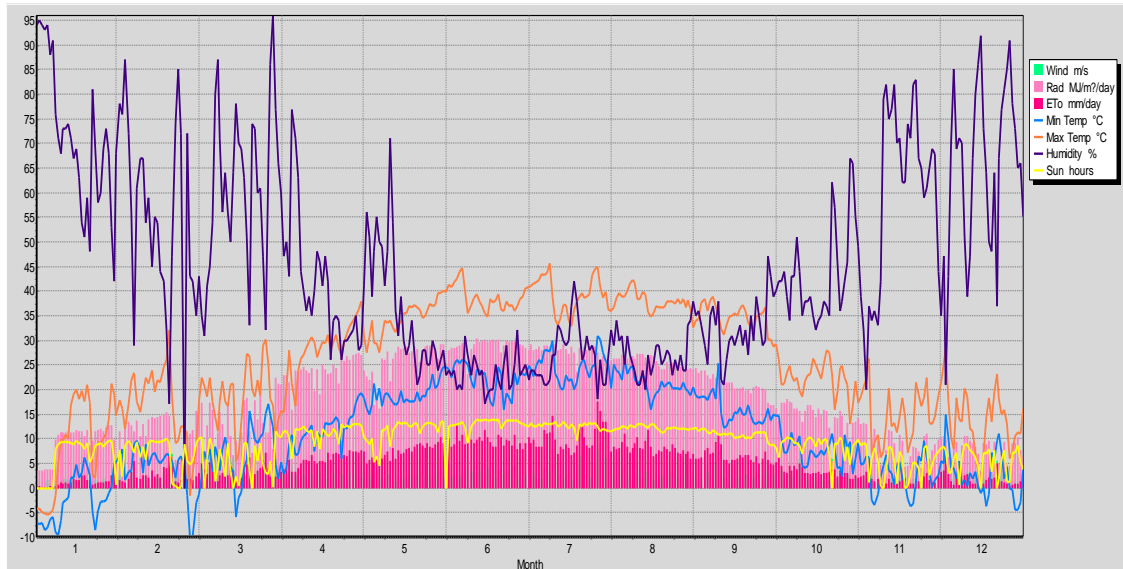


Figure 1. Changes in natural climate data in Kashkadarya region.

In order to compare the results of scientific research carried out in field conditions in Kashkadarya region, the “Porloq-4” variety of cotton, which is currently included in the State Register of the region and grown on a large area, was selected. Taking into account the water demand of the “Porloq-4” variety of cotton, which is grown in the conditions of heavy and medium sandy soils in Kashkadarya region, using the “CropWat 8.0” program of the FAO methodology, the seasonal irrigation rate and water consumption of cotton were calculated. The indicators determined by the program and the data obtained from the results of field experiments were compared.

In the program, standard evapotranspiration was calculated using the Penman Monteth formula (1) (table 1) (Sherov, Amanov, Gadayev, Tursunboev, Gafarova, 2021).

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma * \left(\frac{900}{T + 273}\right) u_2 * (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (1)$$

Here: ETo – benchmark evapotranspiration [mm day-1];

Rn- net radiation reaching the plant level [MDj m-2 day-1];

G - heat flow density in the soil, [MDj m-2 day-1];

T - average daily air temperature at a height of 2 m above ground level [°S];

u2 - wind speed at 2 m above ground level [m s-1];

es - saturated vapor pressure [kPa];

ea - actual vapor pressure [kPa];

(es-ea) - saturation vapor pressure deficit [kPa];

Δ - the gradient of the vapor pressure curve [kPa °S-1];

γ - psychrometric stability (constant) [kPa °S-1] (Khamidov, Ishchanov, Khamidova, Isabaev, Altmishev, 2023).

It is known that water requires a certain amount of energy to change its state from a liquid state to a vapor state. In this process, energy is obtained from “Solar radiation” and “Air temperature”. During the process of evaporation, evaporation slows down until the air above the earth's surface becomes saturated with moisture until it diffuses into the vapor state. The exchange of waterlogged air with drier air is controlled by the wind. Therefore, not only “Solar energy” and “Air temperature”, but also relative humidity and wind speed are one of the climate indicators required to estimate evaporation.

Based on the hydrometeorological data of Kashkadarya region, the method of irrigation of cotton was developed using the “CropWat 8.0” program of the FAO methodology (Fig. 2). Analyzing the developed data, as a result of using water-saving improved irrigation technology during the growing season (160 days), cotton can be

irrigated 10 times, the duration of irrigation is between 12-25 days, and the irrigation rate can be managed taking into account soil moisture.

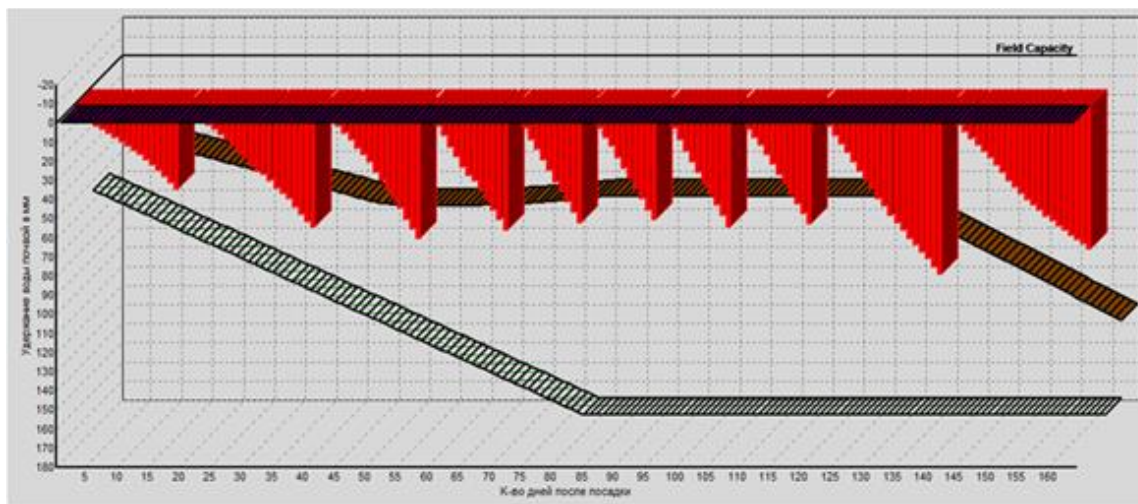


Figure 2. Indicators of cotton irrigation according to FAO methodology in Kashkadarya region.

Table 2 shows the information on cotton irrigation procedures based on the FAO methodology in the hydromodule regions of Kashkadarya region.

Based on the results of scientific research conducted by professor Bepalov, N.F. in

Kashkadarya region, cotton irrigation procedures were developed and recommendations were prepared on this basis [20]. Cotton irrigation is being carried out using the recommendations presented to date (Fig. 3).

Table 2: Irrigation procedure of cotton by hydromodule regions of Kashkadarya region.

Hydromodule region	Number of irrigations, times	Irrigation norm, m ³ /ha	Seasonal irrigation standards, m ³ /ha		Watering periods, day	
			“TIAME” NRU recommendation of scientists	Recommendation of Bepalov, N.F	the beginning	the end
I	8	700-1200	6900	7600	20 IV	3 X
II	8	600-1100	6600	6900	22 IV	27 VIII
III	8	650-900	6000	6600	26 IV	18 VIII
IV	7	700-900	6000	6500	24 IV	26 VIII
V	7	600-900	5500	4900	20 IV	24 VIII
VI	6	600-1000	5200	5900	25 IV	19 VIII
VII	5	700-1000	5200	5600	1 V	24 VIII
VIII	4	700-900	3400	3300	20 V	3 IX
IX	4	750-950	3500	4300	15 V	26 VIII

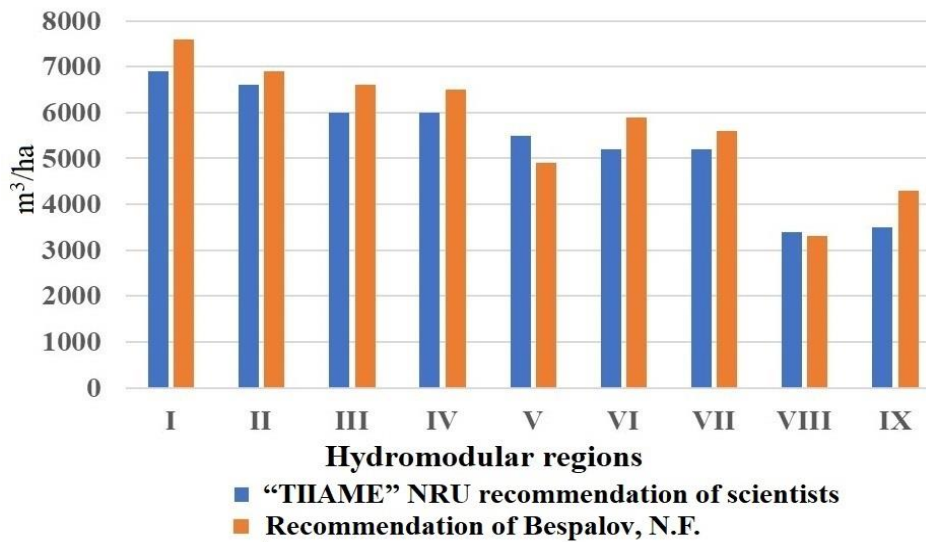


Figure 3: Variation of seasonal irrigation norms by hydromodule regions.

Using the “CropWat 8.0” program of the FAO methodology, the seasonal irrigation standards of cotton were developed for the research objects, the irrigation standards recommended by Professor Bepalov N.F. were compared with the standards developed by the scientists of the “TIAME” NRU, and a correlation coefficient coordinate system was developed. The correlation coefficient was equal to $R^2=0.8935$. Each pair of values is denoted by a certain symbol, and these pointers are represented by Figure 3. It was found that the change of “Y” and “X” coordinate axis has the following relationship (2).

$$y = 1,0424 X + 83,434 \quad (2)$$

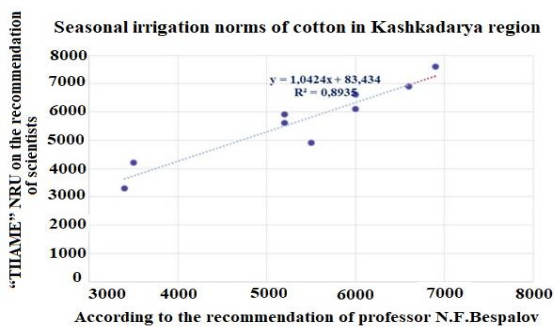


Figure 3: Correlation coefficient comparing cotton irrigation rates.

4 CONCLUSION

In Kashkadarya region, according to the recommendations of the scientists of the “TIQXMMI” MTU and professor Bepalov N.F., the seasonal irrigation norms of cotton were compared and the correlation coefficient was equal to $R^2=0.8935$.

Using FAO's “CropWat 8.0” program, standard evapotranspiration and radiation rates were determined for the research objects. These indicators were 18.3 mdj/ml/day and 5.16 mm/day in Kashkadarya region.

Using FAO's “CropWat 8.0” program, a scientifically based irrigation procedure for the main agricultural crops, including cotton, was developed in the irrigated lands of Kashkadarya region.

In Kashkadarya region, it was studied that the seasonal irrigation norms of cotton vary between 3500-6900 m³ per hectare according to hydromodule regions, and according to the recommendation of Professor Bepalov N.F., the seasonal irrigation norms of cotton are between 3300-7600 m³.

In the Kashkadarya region, the irrigation standards of cotton by hydromodule regions were 600-1200 m³ per hectare and the number of irrigations was 4-8. According to the recommendation of Bepalov N.F., it was studied that

the standards of cotton irrigation were 700-800 m³ per hectare and the number of irrigations was 3-10.

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