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Water Use Efficiency of Long Staple Cotton Varieties in Southern Zone of Uzbekistan

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Abstract. Previous research established field capacity (Fc) based irrigation scheduling for upland cotton (Gossypium hirsutum L.) varieties in Uzbekistan. In this paper, the irrigation scheduling Fc for two long staple cotton (Gossypium barbadense L.) varieties and its effect on seed-lint yield and irrigation water use efficiency and water consumption of plants were reported. The field experiments were conducted in the condition of takyr soils with mechanical composition of silt loam in southern zone of Uzbekistan, at the Kashkadarya Experimental Station of Uzbekistan's Cotton Breeding, Seed Production and Agrotechnologies Research Institute in 2018, 2019 and 2020. In research, cotton growth stages such as germination to flowering, flowering to boll formation, and maturation were considered for the development of irrigation scheduling with respect to field capacity water content (Fc). Irrigation scheduling based on percentages of Fc and mineral fertilizer application rate of N250P175K125 should be considered applicable practices for long staple cotton varieties on silt loam soils of the southern zone of Uzbekistan and for similar soil-climatic conditions of Central Asian countries.
Key words: Water use efficiency, water consumption, irrigation scheduling, long staple cotton variety, seed-lint yield.

1 Introduction

Global climate change is having an adverse effect on the water availability in arid regions worldwide [1]. From this point of view, one of the main tasks of scientists is to study in depth the uncontrollable phenomena of this nature, to take measures to alleviate water shortages and improve the soil's ability to retain more moisture and increase the resistance of agricultural crops to external factors [2].

Several reforms were successfully implemented in agricultural sphere of Uzbekistan. The New Uzbekistan Development Strategy for 2022-2026 envisages saving at least 7 billion cubic meters of water resources and reducing electricity consumption at water facilities through the efficient use of water resources as part of a radical state reform of the water management system and the implementation of a special state program on water economy [3,

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4]. Current years, the area of long staple cotton varieties is expanding due to the demand for long fine-stapled cotton raw materials in Uzbekistan. The above mentioned issues show the relevance of studying water use efficiency of long staple cotton varieties which was studied in the current research.

Numerous researches on the irrigation scheduling of cotton and the water consumption have been studied by foreign and domestic scientists [5]. Under growing water shortage conditions, improved water use efficiency represents a key factor in increasing crop productivity, which is highly correlated with water use efficiency (WUE) [6]. WUE, defined as a ratio of yield to irrigation water requirements is studied for long staple cotton varieties.

Considerable research has been done on water-use efficiency, and many papers and reviews have been written [7, 8]. In irrigation, efficiency was first defined by Israelsen (1932) [9]. Efficiency is generally defined as the ratio of output over input and is expressed as a percentage [10].

The way to express water use efficiency is through crop production per cubic meter of water available for crops. This expression is used in the current paper.

Several papers suggested that in many irrigation schemes only about 45% of water diverted for irrigation actually reaches the crops [11]. De Pascale Maggio (2005) found that the loss percentages for different irrigation methods is as follows: drip irrigation 10-20%, sprinkler irrigation 30-50% and furrow irrigation 50-60%. The amount of water transpired by a crop may be increased either by reducing soil evaporation or by supplemental irrigation. Estimates of soil evaporation range from 20% to 70% of total water used [12-14]. Soil evaporation can be reduced by crop structure [15] and agronomic practices that stimulate early ground cover, such as application of fertilizers [13, 15, 16], early sowing [16] and increased plant density [17].

Irrigation systems have been under pressure to produce more with lower supplies of water. Various innovative practices can gain an economic advantage while also reducing environmental burdens such as water abstraction, energy use, pollutants, etc. [18].

US and German scientists Kate A Brauman, Stefan Siebert and Jonathan A Foley (2013) confirm that 40% of the water given to plants in areas where rainfall is low is sufficient to produce 20% of food calories [19].

Scientists of the Cotton Research Institute of the Chinese Academy of Agricultural Sciences [20] found out that removing diseased, yellowed, old leaves and non-fruit stalks of cotton plants during the growing season improved air circulation and penetrating the sunlight in the lower part of plant as well as preventing pest damage by reducing excessed soil moisture. Removal of old leaves and non-fruit stalks is recommended to be carried out after full flowering phase, depending on the growth and development of the plant.

The research results of T.Rajabov and N.Omonov (2001) under the conditions of takyr soils with a groundwater level of 3 m in Kashkadarya province show that irrigating 5 times with scheme of 1-3-1 and applying 4,500 m^3 ha^{-1} seasonal amount of water in irrigation scheduling of 70-75-65% Fc enabled obtaining 3.7 t ha^{-1} seed-lint yield of cotton from the long staple variety Karshi-9 [19].

Professor A.E.Avliyakulov and M.A.Avliyakulov (2015) has developed hydro-modular zoning of irrigated lands for upland and long staple cotton varieties [21]. Many years of research have shown that high seed-lint yield can be achieved by applying the irrigation scheduling of 75-75-60 % Fc for sandy soils, irrigation scheduling of 70-75-60%, 70-70-60% Fc for silt loam soils, irrigation scheduling of 65-65-60% and 70-70-60% Fc (60-60-60% for some unique varieties) for heavy loamy soils.

According to research results of V.T.Lev, D.Khasanov (1978) in the takyr soils of Surkhandarya province, the irrigation scheduling of 70-75-70% Fc with seasonal irrigation amount of 10.5 thousand m^3 ha^{-1} and plant density of 150-170 thousand plants ha^{-1} were recommended for obtaining 4.0-4.2 t ha^{-1} seed-lint yield of cotton from the long staple variety of 5904-I [22].

Howell (2003) [23] and Irmak et al. (2011) [24] reported the attainable application efficiencies for different irrigation methods, assuming irrigations are applied to meet the crops' water needs.

In research of S.Yuldashev et al (1976) it was identified that seasonal irrigation amount totaled 7,500 m^3 ha^{-1} in takyr soils of Surkhandarya and Kashkadarya provinces, 7,000 m^3 ha^{-1} in meadow alluvial soils of Bukhara province for obtaining high quality seed-lint yield from long staple cotton varieties C-6029 and C-6030 [25].

In the observations of S.DJumaev (2017), it was identified that unique characteristic feature of the Karshi steppe is the lack of water resources relative to available irrigated lands [26]. The average annual precipitation totals 244.2 mm while the average annual evaporation of moisture from the soil equals to 1500 mm. Global warming escalated water resource scarcity issue in the arid regions of Uzbekistan.

Y.Buriev and R.Choriev (2016) recommended the irrigation intervals of 18-19 days and water amount of 901-930 m^3 ha^{-1} per irrigation event for upland cotton variety UzPITI-2601 which enabled obtaining the highest seed-lint yield of cotton [27].

M.Khasanov, N.Kh.Durdiev and F.Gopporov (2017) have studied the irrigation and nutrition application scheduling for upland cotton varieties of Sultan and An-Boyovut-2 [28]. According to the field experiment results, the irrigation scheduling of 70-75-65% Fc for Sultan variety, the irrigation scheduling of 70-70-60% Fc for An-Boyovut-2 variety were optimal where the mineral fertilizer rates of $N_{220}P_{140}K_{110}$ kg ha^{-1} was identical for both aforementioned cotton varieties.

The objectives of the research were two-fold: (1) to determine water consumption for long staple cotton varieties under furrow irrigation, and; (2) to determine proper irrigation scheduling of cotton for increased water use efficiency.

2 Materials and methods

Obtaining high quality yields from agricultural crops require the use of agricultural measures which is optimal for biological characteristics of crops. Current years, in the southern regions, the decrease in the seed-lint yield of cotton observed because of the adverse effect of global climate change [29]. The loss of fruit elements occurs in the middle part of cotton plant due to high temperatures, heat and other factors which especially identical for upland cotton varieties. At the same time, long staple cotton varieties are more resistant to abovementioned factors. That is why the area under long staple cotton varieties in the southern regions is sharply increasing.

Saving water resources during the growing of agricultural crops depends in all respects on soil and climatic conditions. The soils of Uzbekistan differs sharply from each other geographically. For example, the Karshi steppe has its own soil-climatic conditions, which require more labor in production of crops in comparison with other soil-climatic conditions of the regions. Due to global warming, it is planned to increase the area under long staple cotton varieties in Karshi, Kasbi, Mirishkor, Mubarak, Nishan and Kasan districts which are part of the desert lowlands of the Kashkadarya province. That is why it is necessary to develop production agrotechnology for long staple cotton varieties. Cultivation of long staple cotton varieties in Kashkadarya province began in 1969. According to the results of scientific research and production tests, 4.0-4.5 to 4.8 t ha^{-1} seed-lint yield have been harvested from long staple cotton varieties before.

The field experiments on developing the irrigation and nutrition application scheduling of long staple cotton varieties were conducted in the Kashkadarya experimental station of Uzbekistan's Cotton Breeding, Seed Production and Agrotechnologies Research Institute within the framework of the project in 2018, 2019 and 2020 years. According to the Russian soil classification, which is still in use in Uzbekistan, the soil type is old irrigated takyr soil of meadow type with mechanical composition of silt loam [30]. The soil is similar to an Ustic Torriorthent in the USDA classification.

The research was conducted following the "Methods of field experimentation" [31] by Uzbekistan Cotton Research Institute. The field trials were conducted in three replicates. The experimental layout was a split-split plot with complete randomized block design. Each replicated plot size was 720 m^2 with 8 cotton rows and furrow length of 100 m (7.2 m x 100 m).

The field experiment included two irrigation scheduling treatments of 65-65-60% and 70-75-65% Fc and three mineral fertilizer rate treatments of $N_{200}P_{140}K_{100}$, $N_{250}P_{175}K_{125}$, $N_{300}P_{210}K_{150}$ kg ha^{-1} and two long staple cotton varieties Termez-202 and Surkhan-16. For the irrigation scheduling treatments, specific percentages of Fc were used according to the three chosen cotton growth stages. The stages of development were according to Elsner et al. (1979) [30], e.g., the irrigation scheduling of 70-75-65% involved irrigating when soil water content declined to 70% of Fc from germination till flowering (Stage 0–5), to 75% of Fc from flowering to boll formation (Stage 5–7), and to 65% of Fc during cotton boll maturation (Stage 7–9) [32].

Climate is arid continental. The average temperature in the season varies from 25-28 °C and the maximum temperature exceeds 47 °C in summer whereas the minimum temperature declines as low as -10 °C in winter. Long-term annual precipitation ranges from 90 to 200 mm, with 90% occurring from November through April. Composite soil samples were collected from the field at the 0-100 cm depths. Sampling was undertaken prior to each irrigation event. The collected samples were air dried and processed. The soil physical attributes consisted of particle-size analysis, field capacity, infiltration rate, and bulk density [33]. Particle-size analysis was determined on randomly selected samples by the sedimentation method using sodium hexametaphosphate as a dispersing agent. Field capacity was determined from one randomly selected location (2 m × 2 m) in each field by flooding, covering the flooded area with polyethylene sheet, and determining soil moisture in the following days over a period of 3-5 days until stabilization was achieved at all the soil depths. Infiltration rate was determined using standard double ring metallic infiltrometers with an outer ring diameter of 0.4 m and inner ring diameter of 0.2 m. Both rings were buried in the soil to a depth of 0.5-0.10 m. Soil bulk density was determined on undistributed soil samples collected from each soil depth using the core method [34]. Soil bulk density equaled to 1.35±0.02 Mg m^{-3} in the top, increasing to 1.47±0.03 Mg m^{-3} at the soil layer of 0-50 and 50-100 cm. The groundwater table was shallow from 2-2.5 m below the ground.

In the experiment year, the plant density was measured two times after germination and before harvesting period in each treatment. Irrigation water applications from the canal for cotton were monitored using trapezoidal weirs of 'Chippoletti' at the field and the trial level and by triangle weirs of 'Thomson' for each treatment. Phonological observations started from germination rates and dates of different growth stages. Crop parameters included: crop height (cm); fruiting branches (pieces); yield elements (buds, flowers, bolls) (pieces); the weight of 1000 seeds.

3 Results and discussion

Current years, in Uzbekistan, long staple cotton varieties were grown only in the southern zones. This is because of the growing degree days (GDD) as well as biological characteristics of long staple cotton varieties. The sum of positive temperatures for cotton plant equals to 2,330-2,991 °C. Climate of the Karshi steppe is very convenient to grow long staple cotton varieties where the GDD is sufficient.

Growing degree days equaled to 2,730 °C in 2018, 2,742 °C in 2019 and 2,272 °C in 2020 years where the base temperature was taken 10 °C for cotton plant (Figure 1.). These results show that the sum of positive temperature and growing degree days is sufficient to grow long staple cotton varieties in southern zone of Uzbekistan especially in Kashkadarya province.

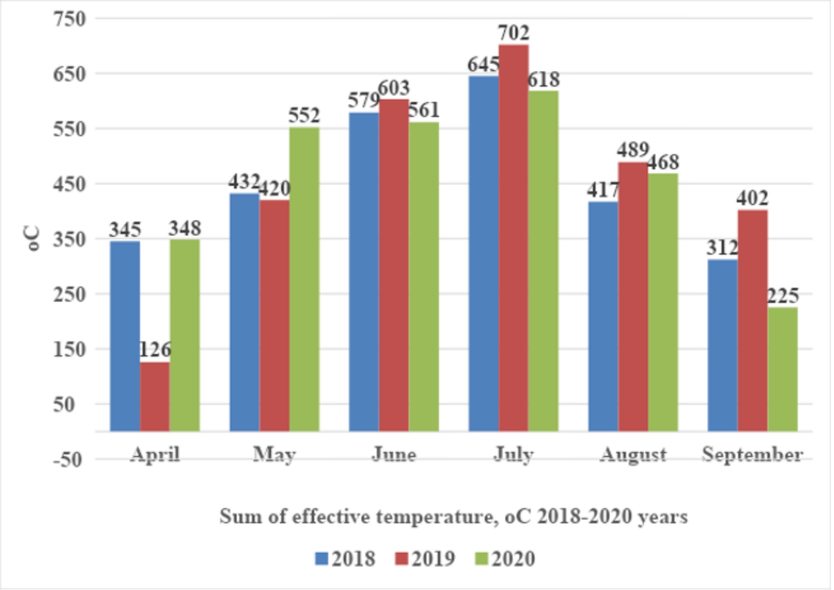

Fig. 1. Sum of effective temperatures by months, 2016-2019 years

The water balance consists of the revenue and consumption parts of the amount of water applied during the season. Revenues include water used to irrigate crops, groundwater, precipitation. The consumption part consists of water that is used for transpiration, absorption into the soil, mixing with groundwater and flowing to other areas [35-36].

In 2018, for irrigation scheduling of 65-65-60% Fc, the total seasonal irrigation amount was 4,150 m^3 ha^{-1} where the 1st irrigation event was in the phase of squaring, 2 irrigation events were held in flowering and boll maturation phase and the last irrigation event was in maturation phase of long staple cotton varieties. In irrigation scheduling of 70-75-65% Fc, the total seasonal irrigation amount equaled to 4,380 m^3 ha^{-1}, where the one additional irrigation event was held in comparison with irrigation scheduling of 65-65-60% Fc (Table 1).

Chinese scientists ZHANG Jin-zhu, Hudan Tumarebi, WANG Zhen-hua (2012) experimented the drip irrigation by covering the surface with polyethylene film of cotton variety Huiyuan-710 in Northern Xinjiang China [17]. Water consumption of cotton was studied along with the four seasonal irrigation amounts (3,300, 3,900, 4,500, 5,100 m^3 ha^{-1}) and three different irrigation events number (10 times, 13 times, 16 times). According to research results, water consumption of cotton plant equaled to 1.39-2.15 mm day^{-1} from germination till squaring phase, 2.58-5.29 mm day^{-1} for squaring phase, 4.35-6.38 mm day^{-1} from flowering to boll formation, 1.03-2.78 mm day^{-1} for maturation phase. Experiments have shown that cotton plant had the highest water requirement from July to the end of August. These results of foreign scientists show that the water requirement of cotton plant was identical in the present study as well.

In 2019, for irrigation scheduling of 65-65-60% Fc, the total seasonal irrigation amount was lower by 56 m^3 ha^{-1} and in irrigation scheduling of 70-75-65% Fc irrigation amount was lower by 108 m^3 ha^{-1} in comparison with 2020 year results where the irrigation amount was lower by 75 m^3 ha^{-1} in irrigation scheduling of 65-65-60% Fc and irrigation amount was greater by 33 m^3 ha^{-1} in irrigation scheduling of 70-75-65% Fc (Table 2.).

In research, the share of precipitation in total water consumption was 11.1-11.4% in 2018, 15.8-16.5% in 2019, 13.2-13.4% in 2020 where the highest share was due to irrigation, and it ranged from 64.8 to 68.1% in 2018, 69.8 to 73.8% in 2019 and 78.3 to 83.2 % in 2020. The share of soil moisture use in total water consumption of the plant was higher in comparison with precipitation values where it formed 19.6-24.7 % in 2018. There was a decrease in the share of soil moisture use with results of 9.0-13.1 % in 2019, 3.7-8.3 % in 2020 (Table 1, 2, 3).

Previous research established the water consumption of long staple cotton variety Termez-49 in takyr soils by M.Avliyakulov (2016) [37] where 1,101-1,027 m^3 irrigation water was amounted for obtaining per ton seed-lint yield which is identical to present study. In comparison, cotton seasonal irrigation water amount ranged from 4,320 to 7,390 m^3 ha^{-1} for limited and full irrigation in California (Howell et. Al 1987) [38]. In Uzbekistan, cotton irrigation ranged from 4,210 to 4,700 m^3 ha^{-1} while ET ranged from 438 to 487 mm in furrow irrigated cotton under conditions similar to those in the present study (N.Ibragimov et. al 2011) [39].

Crop water productivity results were almost identical to the range of 0.55-0.62 kg m^{-3} and seed-lint yields ranging from 3.18 to 4.03 Mg ha^{-1} reported by N.Ibragimov et al. (2007) even if cotton varieties and types were different [40].

In 2018, the enhanced water consumption and water use efficiency was in irrigation scheduling of 70-75-65% Fc and mineral fertilizer application rate of $N_{250}P_{175}K_{125}$ kg ha^{-1} treatment in both long staple cotton varieties. But water consumption per ton seed-lint yield was much higher (3.9 m^3 t^{-1}) in Termez-202 variety in comparison with Surkhan-16. This can be explained by obtaining higher seed-lint yield from cotton variety Surkhan-16 (Table 1). The irrigation scheduling of 70-70-60% Fc was found to be optimal for upland cotton variety Akdarya-6 by Nazirbay Ibragimov, Steve Evett, Yusupbek Esanbekov, Bakhtiyor Kamilov, Lutfullo Mirzaev and John Lamers (2007) in the condition of typical sierozem soils of Uzbekistan where the increasing Fc values for irrigation did not increase productivity [40]. This irrigation scheduling Fc values is less in comparison with the Fc values in the present study. It can be concluded as that water requirement of long staple cotton varieties is higher in comparison with upland cotton varieties.

In 2019, the precipitation was higher 42.9 mm in April, 13.6 mm in May and 14.3 mm in June month which enabled decreasing the irrigation amount and enhancing irrigation water use efficiency. The lowest water consumption was observed in irrigation scheduling of 70-75-65% Fc and mineral fertilizer application rate of $N_{250}P_{175}K_{125}$ kg ha^{-1} in both long staple cotton varieties. The lowest water consumption for obtaining per ton seed-lint yield of cotton equaled to 935 m^3 in Termez-202 variety and 978 m^3 in Surkhan-16 variety. The water consumption was lower by 14.5 to 23.3 m^3 in irrigation scheduling of 70-75-65% Fc in comparison with irrigation scheduling of 65-65-60% Fc. This can be explained by obtaining the highest yield in treatments with higher Fc values (Table 2).

The results of 2020 were also analyzed. The same circumstances was also occurred in the third year of the research. The highest results were obtained in abovementioned treatments where the water consumption equaled to 1,041 m^3 t^{-1} in Termez-202 variety and 1,084 m^3 t^{-1} in Surkhan-16 long staple cotton variety. The water saving per ton yield totaled 145 m^3 in Termez-202 variety and 102 m^3 in Surkhan-16 variety in comparison with control treatment (Table 3).

Table 1. Water consumption of long staple cotton varieties m3 t-1 (2018 year)

No	Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Cotton varieties	Kashka-darya-5 (control)	Termez-202						Surkhan-16					
2	Irrigation scheduling Fc, %	70-75-65	65-65-60			70-75-65			65-65-60			70-75-65		
3	Mineral fertilizer rates (NPK), kg ha^{-1}	200:140:100	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150
4	Soil moisture reserves in the beginning, m^3 ha^{-1}	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223	4,223
5	Soil moisture reserves at the end, m^3 ha^{-1}	2,980	2,630	2,630	2,630	2,980	2,980	2,980	2,630	2,630	2,630	2,980	2,980	2,980
6	Use of soil moisture, m^3 ha^{-1}	1,243	1,593	1,593	1,593	1,243	1,243	1,243	1,593	1,593	1,593	1,243	1,243	1,243
7	Portion of soil moisture reserves in total water consumption, %	19.6	24.7	24.7	24.7	19.6	19.6	19.6	24.7	24.7	24.7	19.6	19.6	19.6
8	Precipitation, m^3 ha^{-1}	705	705	705	705	705	705	705	705	705	705	705	705	705
9	Portion of precipitation in total water consumption, %	11.1	10.9	10.9	10.9	11.1	11.1	11.1	10.9	10.9	10.9	11.1	11.1	11.1
10	Seasonal irrigation amount, m^3 ha^{-1}	4,380	4,150	4,150	4,150	4,380	4,380	4,380	4,150	4,150	4,150	4,380	4,380	4,380
11	Portion of irrigation amount in total water consumption, %	69.2	64.4	64.4	64.4	69.2	69.2	69.2	64.4	64.4	64.4	69.2	69.2	69.2
12	Total water consumption, m^3 ha^{-1}	6,328	6,448	6,448	6,448	6,328	6,328	6,328	6,448	6,448	6,448	6,328	6,328	6,328
13	Seed-lint yield, t ha^{-1}	3.21	3.10	3.40	3.12	3.42	3.75	3.51	3.07	3.37	3.10	3.56	3.88	3.60
14	Total water consumption for per ton yield, m^3 t^{-1}	1,971	2,080	1,896	2,067	1,850	1,687	1,803	2,100	1,913	2,080	1,778	1,631	1,758
15	Seasonal water consumption for per ton yield, m^3 t^{-1}	1,364	1,339	1,221	1,330	1,281	1,168	1,248	1,352	1,231	1,339	1,230	1,129	1,217

Table 2. Water consumption of long staple cotton varieties $m^3 t^{-1}$ (2019 year)

No	Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Cotton varieties	Kashka-darya-5 (control)	Termez-202						Surkhan-16					
2	Irrigation scheduling Fc, %	70-75-65	65-65-60			70-75-65			65-65-60			70-75-65		
3	Mineral fertilizer rates (NPK), kg ha^{-1}	200:140:100	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150
4	Soil moisture reserves in the beginning, $m^3 ha^{-1}$	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962	3,962
5	Soil moisture reserves at the end, $m^3 ha^{-1}$	3,445	3,204	3,204	3,204	3,445	3,445	3,445	3,204	3,204	3,204	3,445	3,445	3,445
6	Use of soil moisture, $m^3 ha^{-1}$	517	757	757	757	517	517	517	757	757	757	517	517	517
7	Portion of soil moisture reserves in total water consumption, %	9.0	13.1	13.1	13.1	9.0	9.0	9.0	13.1	13.1	13.1	9.0	9.0	9.0
8	Precipitation, $m^3 ha^{-1}$	950	950	950	950	950	950	950	950	950	950	950	950	950
9	Portion of precipitation in total water consumption, %	16.6	16.4	16.4	16.4	16.6	16.6	16.6	16.4	16.4	16.4	16.6	16.6	16.6
10	Seasonal irrigation amount, $m^3 ha^{-1}$	4,272	4,094	4,094	4,094	4,272	4,272	4,272	4,094	4,094	4,094	4,272	4,272	4,272
11	Portion of irrigation amount in total water consumption, %	74.4	70.6	70.6	70.6	74.4	74.4	74.4	70.6	70.6	70.6	74.4	74.4	74.4
12	Total water consumption, $m^3 ha^{-1}$	5,739	5,801	5,801	5,801	5,739	5,739	5,739	5,801	5,801	5,801	5,739	5,739	5,739
13	Seed-lint yield, t ha^{-1}	3.78	3.32	3.79	3.65	4.06	4.57	4.15	3.23	3.66	3.50	3.80	4.37	4.18
14	Total water consumption for per ton yield, $m^3 t^{-1}$	1,518	1,747	1,531	1,589	1,413	1,256	1,383	1,796	1,585	1,658	1,510	1,313	1,373
15	Seasonal water consumption for per ton yield, $m^3 t^{-1}$	1,130	1,233	1,080	1,122	1,052	935	1,029	1,267	1,119	1,170	1,124	978	1,022

Table 3. Water consumption of long staple cotton varieties $m^3 t^{-1}$ (2020 year)

No	Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Cotton varieties	Kashka-darya-5 (control)	Termez-202						Surkhan-16					
2	Irrigation scheduling Fc, %	70-75-65	65-65-60			70-75-65			65-65-60			70-75-65		
3	Mineral fertilizer rates (NPK), kg ha^{-1}	200:140:100	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150	200:140:100	250:175:125	300:210:150
4	Soil moisture reserves in the beginning, $m^3 ha^{-1}$	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190	5,190
5	Soil moisture reserves at the end, $m^3 ha^{-1}$	4,996	4,757	4,757	4,757	4,996	4,996	4,996	4,757	4,757	4,757	4,996	4,996	4,996
6	Use of soil moisture, $m^3 ha^{-1}$	194	433	433	433	194	194	194	433	433	433	194	194	194
7	Portion of soil moisture reserves in total water consumption, %	3.7	8.3	8.3	8.3	3.7	3.7	3.7	8.3	8.3	8.3	3.7	3.7	3.7
8	Precipitation, $m^3 ha^{-1}$	698	698	698	698	698	698	698	698	698	698	698	698	698
9	Portion of precipitation in total water consumption, %	13.2	13.4	13.4	13.4	13.2	13.2	13.2	13.4	13.4	13.4	13.2	13.2	13.2
10	Seasonal irrigation amount, $m^3 ha^{-1}$	4,413	4,075	4,075	4,075	4,413	4,413	4,413	4,075	4,075	4,075	4,413	4,413	4,413
11	Portion of irrigation amount in total water consumption, %	83.2	78.3	78.3	78.3	83.2	83.2	83.2	78.3	78.3	78.3	83.2	83.2	83.2
12	Total water consumption, $m^3 ha^{-1}$	5,305	5,206	5,206	5,206	5,305	5,305	5,305	5,206	5,206	5,206	5,305	5,305	5,305
13	Seed-lint yield, t ha^{-1}	3.72	3.29	3.75	3.58	3.85	4.24	4.01	3.25	3.50	3.63	3.75	4.07	4.14
14	Total water consumption for per ton yield, $m^3 t^{-1}$	1,426	1,582	1,388	1,454	1,378	1,251	1,323	1,602	1,487	1,434	1,415	1,303	1,281
15	Seasonal water consumption for per ton yield, $m^3 t^{-1}$	1,186	1,239	1,087	1,138	1,146	1,041	1,100	1,254	1,164	1,123	1,177	1,084	1,066

4 Conclusions

Based on the research results on identifying of water consumption and water use efficiency of furrow irrigated long staple cotton varieties Termez-202 and Surkhan-16 in the condition takyr soils with mechanical composition of silt loam, groundwater level of >2 m in Kasbi district, Kashkadarya province the southern zone of Uzbekistan, the following conclusions were given:

The lowest water consumption for long staple cotton variety Termez-202 equaled to 1,168 m^3 for obtaining per ton seed-lint yield in irrigation scheduling of 70-75-65% Fc and mineral fertilizer application rate of $N_{250}P_{175}K_{125}$ kg ha^{-1} treatment where water saving was 196 m^3 t^{-1} in comparison with control treatment.

The lowest water consumption for long staple cotton variety Surkhan-16 was observed in the same abovementioned treatment with value of 1,129 m^3 for obtaining per ton seed-lint yield where water saving equaled to 235 m^3 t^{-1} in comparison with control treatment.

Precipitation was higher 42.9 mm in April, 13.6 mm in May and 14.3 mm in June months in comparison with many years results which enabled saving irrigation water resources for obtaining per ton seed-lint yield of cotton.

Comparison results of the three years research (2018 to 2020), the lowest water consumption of cotton varieties and high cotton yields were observed in the 2019 which is mainly due to high precipitation in spring time.

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