Dry mass accumulation of cotton under drip and furrow irrigation in Uzbekistan

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Abstract. Past investigate set up application of wrinkle water system to create growth-stage-specific water system planning for upland cotton (Gossypium hirsutum L.) in Uzbekistan. The paper presents encourage examination of water system planning for two cotton assortments and its impact on seed-lint abdicate and water system trim water efficiency beneath wrinkle and trickle water system innovation. Field experiments were conducted in silt loam soils of Samarkand province, Uzbekistan, in 2019, 2020, and 2021. The development stages of germination to blooming, blossoming to boll arrangement, and development were considered for the improvement of water system planning Fc with regard to field capacity (Fc). The best growth, development and seed-lint yield for the C-8286 cotton variety were achieved in drip irrigation with irrigation scheduling of 75-75-70% of Fc, wetting front layer of 50-70-50 cm where the seed-lint yield totaled 4.99 t ha^{-1}. The highest seed-lint yield (4.74 t ha^{-1}) obtained in irrigation scheduling of 70-70-60% Fc regarding Bukhara-102 variety. Irrigation scheduling of 75-75-70% Fc for cotton variety C-8286 and 70-70-60% Fc for Bukhara-102 variety and drip irrigation should be considered applicable practices for both aforementioned cotton varieties on silt loam soils of Samarkand province and for similar soil-climatic conditions of Central Asia.

1 Introduction

Cotton seed production worldwide in the 2020/2021 season reached 41.8 million tons, which is 16% higher in comparison with the 2015/2016 season. Seed production worldwide accounts for countries India (28.2%), China (24.0%), USA (12.7%), Brazil (9.6%), Pakistan (6.5%), Turkey (2.5%), EU (1.4%), Mexican states (1.2%). In terms of oil production in the world food industry, cottonseeds are only taken place after soybeans, rapeseed and palm oil, and in the 2020/2021 season cottonseed oil amounted to 4.86 million tons.

There are 53 species of cotton belonging to the Gossypium where the 4 species are mainly cultivated worldwide. It should be noted that the most widely grown cotton species in the

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world is Gossypium hirsutum L. According to data provided by the U.S. International Agricultural Service in 2020, the Indian state has 13.4 million hectares which is 1/3 part of world cotton cropping area where the total cropping area is 32.94 million hectares worldwide. In India, the fiber yield equals to 487 kg per ha in comparison with worldwide where the average fiber yield is 775 kg per ha (Abdurakhmanov, 2021) [1, 2].

According to materials of the World Resources Institute, Uzbekistan is ranked in 25th place out of 164 countries in the concept of water scarcity. According to the observation results, Uzbekistan is included in the group of 27 countries with high water shortages. These include Afghanistan (27th place), Turkey (32nd place), Kyrgyzstan (38th place), Portugal (41st place) and Italy (44th place). Other Central Asian states, Tajikistan and Kazakhstan, rank 51st and 60th, respectively, in the group with moderately high water shortages [3, 4]. Turkmenistan is ranked in 15th place (http://darakchi.uz/oz/112845).

According to the International Committee on Irrigation and Drainage, the area under drip irrigation in some countries has increased from 436,000 hectares to 3.2 million hectares between 1981 and 2000. Particularly, drip irrigation area reached more than 1 million hectares in the United States and 200 thousand ha in every country such as India, Australia, Spain, Israel and China. In recent years, drip irrigation is implemented on an area of 4.5 million ha worldwide (Jurayev et al, 2020).

According to research results of U.S. scientists, studies have shown that growth and development of cotton during squaring and flowering phases is 3 times faster at 30 ^{o}C air temperature in comparison with 18 ^{o}C (Mauney, 1986).

Almost 90 years ago, in 1932, the term “water use efficiency” was introduced into science by scientist Israelsen, and it should be noted that the problem of water scarcity has not lost its global significance for almost a century (Israelsen, 1932).

The effectiveness of irrigation scheduling studied in drip irrigated cotton in Turkey. According to research results, it was identified that water use efficiency, cotton yield and its quality were high in drip irrigation. It was found that the use of drip irrigation technology can save water resources by at least 25%, but the net profit will be reduced to 34%. However, when drip irrigation is used in arid areas, the cost increases in 1st year, but in next years this technology has been found to be highly effective (Dagdelen et al, 2009).

Nazirbay Ibragimov, Steve Evett, Yusupbek Esanbekov, Bakhtiyor Kamilov and Lee Heng have studied the optimal duration of irrigation, irrigation scheduling and evapotranspiration rates during 2000-2002 on drip irrigated cotton variety Oqdaryo-6 and furrow irrigated winter wheat variety in the condition of irrigated typical sierozem soils. In research, the moisture profile of the soil layers was determined using the Neutron Probe (Soil moisture Neutron Probes) equipment, as well as the soil moisture measurement by gravimetric method for the water balance, which is determined weekly. In the case of drip-irrigated cotton, it was found that the optimal irrigation scheduling Fc was 70-70-60% with improved water use efficiency. This drip irrigation technology saved 35% of water compared to conventional furrow irrigation under the same conditions. In the case of furrow irrigated winter wheat, optimal irrigation scheduling Fc was 75-75-60%, increasing the irrigation rates did not increase productivity (Ibragimov et al 2010) [5. 6, 7].

Research studies of foreign scientists on the influence of different irrigation methods on yield and loss of fruit elements of cotton have shown that the highest yields were in drip irrigation technology with seed-lint yield of 4.38 t ha^{-1} in comparison with furrow and sprinkler irrigation where the seed-lint yield totaled 3.63 and 3.38 t ha^{-1} respectively.

Recent years, global warming causes a shortage of water not only in Uzbekistan, but in all arid regions worldwide. There is a large demand for the implementation of modern water-saving irrigation technologies, especially drip irrigation. That is why the main goal of the research were as follows:

Determining the optimal irrigation scheduling Fc and wetting front layer for upland cotton varieties under furrow and drip irrigation technology.

2 Materials and methods

Field trials were conducted in 2019 to 2021 a long time within the condition of ancient flooded knoll sierozem soils with mechanical composition of residue soil with profound >2 m water table in Samarkand territory, Uzbekistan. Amid the 2019 to 2021 a long time upland cotton assortments S-8286 and Bukhara-102 were examined within the taking after water system planning 70-70-60%, 75-75-70. Three wetting front layers (30-50-50 cm, 50-70-50 cm, 70-100-70 cm) were compared beneath distinctive water system technology.

In Central Asia, climate is parched conjointly mainland (Giese, Ernst & Jenniver Sehring 2010). In test location, the normal temperature shifted from 15.8 to 16.2 oC. Yearly precipitation aggregates from 300 to 400 mm. Nearly 90 % precipitation happens from harvest time till spring. Inquire about strategy were taken after by “Methods of field experiments” distributed by Uzbekistan Cotton Inquire about Organized (UzCRI 2007 and Dospekhov B.A. 1985). The exploratory format was a total randomized piece plan with three replications. Each duplicated plot estimate equaled to 336 m2 with 8 cotton columns and wrinkle length of 100 m (4.8 m x 70 m). Cotton push dividing equaled to 60 cm.

The soil physical properties comprised of particle-size examination, field capacity, invasion, BD, porosity and dampness substance were distinguished by standard strategy. Particle-size examination was decided on randomly selected tests by the sedimentation strategy utilizing sodium hexametaphosphate as a scattering operator. Soil dampness substance was decided by the gravimetric strategy.

Within the field, water system water run on and run off was measured with water measuring weir “Chippoletti”, where the width of water passing portion equaled to 0.25 and 0.50 m. In each wrinkle, the water system water was measured by utilizing weir Tompson. In trickle water system, water measuring controller were utilized for water estimation. Wetting root zone layer of the soil from germination till blossoming was 0-70 cm, blooming to boll arrangement 0-100 cm and development 0-70 cm in wrinkle water system. Diverse root zone layers were chosen in trickle water system innovation. The water system planning Fc rates were moreover considered abovementioned development stages. For case, water system planning 75-75-70, 75% for germination till blooming, 75% blooming to boll arrangement, 70% for development [8, 9, 10].

Field capacity was decided from one haphazardly chosen area (2 m × 2 m) within the field by flooding, covering the overflowed area with polyethylene sheet, and deciding soil dampness within the taking after days over a period of 2-5 days until stabilization was accomplished at all the soil profundities. Field capacity (Fc) was decided in 10-cm increases to profundity of 100 cm for receiving an record in arrange to create Fc based water system planning. Field capacity (Fc) of soil within the 0-100 cm profundity layer was 0.30 m3 m-3 (VWC). Invasion capacity was decided some time recently sowing and at the conclusion of season utilizing standard twofold ring metallic infiltrometers with an external ring diameter of 0.4 m and internal ring breadth of 0.2 m. Both rings were buried within the soil to a profundity of 0.15 m and nonstop six hours' perceptions were conducted. Each season, soil bulk thickness (BD, Mg m-3) was measured in each 10 cm from the surface to 100 cm soil profundity some time recently sowing and at the conclusion of season utilizing the center method [11, 12, 13].

3 Results and discussion

There are several factors affecting the seed-lint yield of cotton. Obtaining highest yield depends on enhancing dry mass accumulation as well. According to research conducted in Samarkand province in 2019, the highest dry mass accumulation of cotton variety C-8286 was in the 1st treatment under furrow irrigation. In the 1st treatment dry mass were as follows: leaf 58.7 g, stem 53.8 g, calyx 23.5 g and cotton seed-lint yield raw material 53.0 g, total plant dry mass was 189.1 g. Achieving the highest dry mass in the 1st treatment did not result of obtaining the highest yield. Because conducting furrow irrigation led to an increase the soil moisture above optimal, in fact plant nutrient uptake directed to vegetative mass where dry mass of stems and leaves were higher than other treatments. According to research on the influence of furrow and drip irrigation on dry mass accumulation of cotton, it was identified that total dry mass accumulation was much higher under furrow irrigation in comparison with drip irrigation technology. But while analyzing dry mass accumulation in cotton parts, it was investigated that accumulation of cotton seed-lint yield raw material were higher in drip irrigation technology in comparison with furrow irrigation. This resulted obtaining highest seed-lint yield of cotton in drip irrigation technology. In research, the lowest dry mass accumulation was in drip irrigation technology with irrigation scheduling of 70-70-60% Fc and wetting front layer of 30-50-50 cm. Having lower wetting layer caused reduction of dry mass accumulation of plant. Dry mass accumulation were as follows: leaf 32,2 g, stem 30,3 g, calyx 22,3 g, cotton seed-lint yield raw material 52,9 g and total dry mass 137,6 g (Table 1) [14, 15, 16].

The highest dry mass accumulation of cotton variety C-8286 was in furrow irrigation, but the highest seed-lint yield material accumulation was higher in drip irrigation technology with irrigation scheduling of 75-75-70% Fc where the raw material was higher to 13.6 g in comparison with control treatment. The highest seed-lint yield material of Bukhara-102 variety was also in drip irrigation technology. But Bukhara-102 cotton variety has shown the highest dry mass in irrigation scheduling of 70-70-60% Fc where the raw material was higher to 12.7 g in comparison with control treatment. In research, the most dry mass accumulated treatments enabled obtaining the highest yield. In 2019-2021 research years, while growing cotton variety C-8286 in drip irrigation, the highest seed-lint yield (4.99 t ha^{-1}) obtained in irrigation scheduling of 75-75-70% Fc with wetting front layer of 50-70-50 cm where the additional yield formed 0.73 t ha^{-1} in comparison with conventional irrigation. However, increasing the wetting front layer of soil to 70-100-70 cm and in contrast decreasing the wetting front layer to 30-50-50 cm, both of them did not increase the yield. In particular, it was observed that the cotton yield totaled 4.4 t ha^{-1} in wetting front layer of 70-100-70 cm which is 0.59 t ha^{-1} lower yield in comparison with optimal treatment [17,18,19].

The decrease of seed-lint yield of cotton in wetting front layers of 70-100-70 cm and 30-50-50 cm can be explained that, choosing lower layers resulted the weak development of root system of cotton plant and the lack of moisture could not cover all the water requirement of plant. As a result, the yield loss and short plants did not allow obtaining highest yield. According to wetting layer of 70-100-70 cm, where the excess of soil moisture resulted getting higher plant heights with less fruit elements (Table 4). In research, it was investigated the varietal difference on water requirement. According to research results, it was identified that cotton variety Bukhara-102 differed from the cotton variety C-8286 by its biology and low demand for water. That is why the best results were in lower Fc values, in irrigation scheduling of 70-70-60% Fc for Bukhara-102 cotton variety with wetting layer of soil 50-70-50 cm, where the yield formed 4.74 t ha^{-1} with additional yield of 0.44 t ha^{-1} in comparison with control. Cotton variety Bukhara-102 has more vegetative mass and less accumulation of generative mass in irrigation scheduling of 75-75-70% Fc, especially when the root zone layer was 70-100-70 cm, which led to a decrease in yield (Table 4).

Table 1. Dry mass accumulation of cotton varieties of C-8286 and Bukhara-102 under different irrigation technologies (2019 year).

No.	Irrigation technologies	Irrigation scheduling Fc, %	Wetting front layer, cm	Dry mass of single cotton plant, g					Difference with control, g (+-)	
				Leaf	Stem	Calyx	Seed-lint yield material	Total dry mass	Seed-lint yield material	Total dry mass
Upland cotton variety C-8286										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	58.7	53.8	23.5	53.0	189.1	-	-
2	Drip irrigation		30-50-50	32.2	30.3	22.3	52.9	137.6	-0.1	-51.5
3			50-70-50	39.4	39.2	28.3	62.9	169.7	9.9	-19.4
4			70-100-70	45.0	42.8	26.9	60.5	175.2	7.5	-13.9
5		75-75-70	30-50-50	36.3	33.8	29.9	61.8	161.8	8.8	-27.3
6			50-70-50	41.6	40.1	33.4	66.6	181.7	13.6	-7.4
7			70-100-70	47.3	45.3	31.2	62.8	186.6	9.8	-2.5
Upland cotton variety Bukhara-102										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	66.3	64.5	24.0	54.8	209.5	-	-
2	Drip irrigation		30-50-50	39.7	36.9	24.6	52.0	153.2	-2.8	-56.3
3			50-70-50	43.8	40.7	30.3	67.5	182.3	12.7	-27.2
4			70-100-70	50.5	47.6	29.0	64.5	191.6	9.7	-17.9
5		75-75-70	30-50-50	44.1	42.0	25.3	58.0	169.3	3.2	-40.2
6			50-70-50	53.7	51.4	26.4	60.7	192.2	5.9	-17.3
7			70-100-70	61.0	59.0	24.0	55.2	199.1	0.4	-10.4

Table 2. Dry mass accumulation of cotton varieties of C-8286 and Bukhara-102 under different irrigation technologies (2020 year).

No.	Irrigation technologies	Irrigation scheduling Fc %	Wetting front layer, cm	Dry mass of single cotton plant, g					Difference with control, g (+-)	
				Leaf	Stem	Calyx	Seed-lint yield material	Total dry mass	Seed-lint yield material	Total dry mass
Upland cotton variety C-8286										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	49.8	44.6	23.6	54.6	172.6	-	-
2			30-50-50	22.7	19.4	21.5	51.2	114.8	-3.4	-57.8

3	Drip irrigation		50-70-50	30.2	25.3	25.6	56.4	137.5	1.8	-35.1
4			70-100-70	35.8	28.9	24.7	54.2	143.6	-0.4	-29
5		75-75-70	30-50-50	26.4	24.6	23.4	56.8	131.2	2.2	-41.4
6			50-70-50	33.2	28.2	28.3	62.3	152.0	7.7	-20.6
7			70-100-70	38.4	36.8	25.4	59.6	160.2	5	-12.4
Upland cotton variety Bukhara-102										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	52.6	46.5	23.7	57.1	179.9	-	-
2	Drip irrigation		30-50-50	35.2	29.7	21.6	54.7	141.2	-2.4	-38.7
3			50-70-50	38.9	32.6	26.9	61.2	159.6	4.1	-20.3
4			70-100-70	44.8	41.2	23.8	58.4	168.2	1.3	-11.7
5		75-75-70	30-50-50	42.6	36.8	20.2	53.5	153.1	-3.6	-26.8
6			50-70-50	48.2	45.2	22.4	57.2	173.0	0.1	-6.9
7			70-100-70	54.6	51.9	19.5	51.9	177.9	-5.2	-2

Table 3. Dry mass accumulation of cotton varieties of C-8286 and Bukhara-102 under different irrigation technologies (2021 year).

No.	Irrigation technologies	Irrigation scheduling Fc %	Wetting front layer, cm	Dry mass of single cotton plant, g					Difference with control, g (+-)	
				Leaf	Stem	Calyx	Seed-lint yield material	Total dry mass	Seed-lint yield material	Total dry mass
Upland cotton variety C-8286										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	48.5	43.3	21.8	52.8	166.4	-	-
2	Drip irrigation		30-50-50	21.9	18.6	23.6	50.4	114.5	-2.4	-51.9
3			50-70-50	29.1	24.8	23.7	55.1	132.7	2.3	-33.7
4			70-100-70	34.8	29.1	24.1	52.6	140.6	-0.2	-25.8
5		75-75-70	30-50-50	25.4	23.5	24.6	55.7	129.2	2.9	-37.2
6			50-70-50	31.9	26.1	25.8	60.9	144.7	8.1	-21.7
7			70-100-70	37.6	35.4	21.9	58.4	153.3	5.6	-13.1
Upland cotton variety Bukhara-102										
1	Furrow irrigation (conventional)	70-70-60	70-100-70	51.4	45.2	22.56	56.4	175.6	-	-
2	Drip irrigation		30-50-50	34.6	28.4	21.6	54.0	138.6	-2.4	-37
3			50-70-50	37.2	31.0	25.12	62.8	156.1	6.4	-19.5
4			70-100-70	43.5	38.6	22.84	57.1	162.0	0.7	-13.6
5		75-75-70	30-50-50	35.6	31.8	21.88	54.7	144.0	-1.7	-31.6
6			50-70-50	44.1	39.4	23.16	57.9	164.6	1.5	-11
7			70-100-70	51.1	43.7	21.16	52.9	168.9	-3.5	-6.7

Table 4. Seed-lint yield of cotton under different irrigation technologies (2019-2021 years average).

No	Irrigation technologies	Irrigation scheduling Fc %	Wetting front layer, cm	Seed-lint yield of cotton, t ha^{-1}			Additional yield, t ha^{-1}
				1-harvest	2-harvest	Total	
Upland cotton variety C-8286							
1	Furrow irrigation (conventional)	70-70-60	70-100-70	3.36	0.90	4.26	-
2	Drip irrigation	70-70-60	30-50-50	3.62	0.54	4.16	-0.1
3			50-70-50	3.90	0.68	4.58	0.32
4			70-100-70	3.77	0.63	4.40	0.14
5		75-75-70	30-50-50	3.85	0.72	4.57	0.31
6			50-70-50	4.16	0.83	4.99	0.73
7			70-100-70	3.95	0.78	4.73	0.47
Upland cotton variety Bukhara-102							
1	Furrow irrigation (conventional)	70-70-60	70-100-70	2.93	1.38	4.30	-
2	Drip irrigation	70-70-60	30-50-50	3.11	1.10	4.21	-0.09
3			50-70-50	3.52	1.22	4.74	0.44
4			70-100-70	3.27	1.19	4.46	0.16
5		75-75-70	30-50-50	3.13	1.14	4.27	-0.03
6			50-70-50	3.22	1.19	4.41	0.11
7			70-100-70	3.06	1.10	4.16	-0.14
LSD_{05} = 0.24 t ha^{-1} for irrigation technologies, LSD_{05} = 0.21 t ha^{-1} for wetting front layers							

According to research results, the optimal wetting layer was 50-70-50 cm for drip irrigation and 70-100-70 cm for furrow irrigation. Optimal wetting layer 50-70-50 cm in drip irrigation technology enabled obtaining highest dry mass, especially cotton raw material.

4 Conclusion

Based on the research results (2019-2021 years) on development of furrow and drip irrigation technology of C-8286 and Bukhara-102 cotton varieties in the condition meadow sierozem soils with mechanical composition of medium texture, groundwater level of 2-3 m in the fields of cluster “Maroqand sifat textile” in Ishtikhon district, Samarkand province the central zone of Uzbekistan, the following conclusions were given according to the research results.

It should be noted that the highest yield from cotton variety C-8286 were obtained in drip irrigation technology with irrigation scheduling of 75-75-70% Fc and wetting front layer of 50-70-50 cm where an additional yield equaled to 0.73 t ha^{-1}. While growing cotton variety Bukhara-102, the highest yield was obtained (4.74 t ha^{-1}) in drip irrigation technology as well with irrigation scheduling of 70-70-60% Fc and wetting layer of 50-70-50 cm where an additional yield was 0.44 t ha^{-1}. Achieving highest yield from Bukhara-102 variety in lower irrigation scheduling Fc in comparison with C-8286 variety can be explained by lower water requirement and strong root system development.

The wetting front layer 50-70-50 cm was considered as an optimal in drip irrigation technology, which is explained by the improved use of moisture by the plant, enhanced root development and optimal use of soil moisture and nutrients. This is explained by the fact that when wetting front layer was 70-100-70 cm, the duration of irrigation was longer and the moisture is higher than the optimal for the plant, consequently the plant accumulates more vegetative mass.

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