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Review Article

THE CHANGES OF COTTON SEED-LINT YIELD IN PARTS OF FURROW LENGTH UNDER DIFFERENT IRRIGATION SCHEDULING

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Abstract
The paper indicates the results of furrow irrigation technology along parts of furrow and its impact on seed-lint yield and boll weight of upland cotton varieties (Gossypium hirsutum L.) Sultan, UzPITI-103, C-8295 and Kelajak. The research was conducted in the condition of old irrigated typical sierozem soils with mechanical composition of silt loam in Tashkent province, at the Central Experimental Station of Uzbekistan's Cotton Breeding, Seed Production and Agrotechnologies Research Institute in 2015 to 2019. In research, cutoff flow furrow irrigation was applied where irrigating with inflow rate of 0.40 to 0.42 l s^{-1} in the beginning of irrigation in three in four part of furrow, then decreasing it till 0.20 to 0.22 l s^{-1}, the inflow rate decreased twice 0.12 to 0.15 l s^{-1} by reaching water the end of furrow which ensured wetting the root zone layer of soil smoothly along the furrow length. Irrigation scheduling 70-75-65% Fc was optimal for cotton varieties of Sultan and C-8295, where the irrigation scheduling 70-70-60% Fc for UzPITI-103 variety and irrigation scheduling 65-65-60% Fc for Kelajak variety was optimal. In all abovementioned varieties the highest seed-lint yield and boll weight were obtained in the furrow length of 30 to 70 m. The highest seed-lint yield of cotton (4.71 t ha^{-1} Sultan variety, 4.48 t ha^{-1} UzPITI-103 variety, 4.27 t ha^{-1} C-8295 variety, 3.93 t ha^{-1} Kelajak variety) was obtained in the part of furrow length 30 to 70 m in comparison with the furrow length 0 to 30 m and 70 to 100 m the seed-lint yield was decreased by 0.17 t ha^{-1} and 0.39 t ha^{-1} in Sultan, 0.13 t ha^{-1} and 0.16 t ha^{-1} in UzPITI-103, 0.10 t ha^{-1} and 0.16 t ha^{-1} in C-8295, 0.14 t ha^{-1} and 0.21 t ha^{-1} in Kelajak varieties. According to research results, the furrow length must not exceed 70 m.

Key words: seed-lint yield of cotton, boll weight, furrow irrigation, irrigation scheduling, furrow length.

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INTRODUCTION

In Uzbekistan, cotton is dominant crop with cropping area of 1,033,629 ha, where in 2020 total area of upland cotton varieties (Gossypium hirsutum L.) equals to 981,129 ha and area of long staple cotton varieties (Gossypium hirsutum L.) totals 52,500 ha with total expected cotton raw material of 3,101,000 metric tons. In the Republic of Uzbekistan, cotton grown area under 60 cm row spacing equaled to 468,313 ha, 76 cm row spacing 69,565 ha, 90 cm row spacing 206,189 ha, double line spacing (60x30) 289,562 ha [https://lex.uz/docs/4642205].

Uzbekistan is located within Aral Sea basin. In the Republic of Uzbekistan, the Syrdarya and Amudarya river basins are considered as a main water resources. Only 9.6% of total runoff of transboundary rivers in the Aral Sea basin is formed within Uzbekistan. In case, Uzbekistan is quite dependent from other riparian countries from the point of view of available water resources. Water resources use by economic sector in Uzbekistan is as follows: agriculture 90.6 %, municipal water supply 4.4%, hydropower 2.6%, industry 1.3% and fishery 1.1%. The estimated regional reserves of groundwater available for beneficial uses in Uzbekistan amount to about 18.45 km^3 (Khamraev Sh.R. et. al. 2018.).

Water resources of the Republic of Uzbekistan also consists of 55 reservoirs, 500 natural lakes as well as 1448 springs for irrigation of agricultural crops (Avliyakulov A.E. 2015).

According to investigations, almost 71% of the Earth planet is covered with water resources, only 2% of it contributes to fresh water. Currently, 1.2 billion people worldwide are living in fresh water scarcity condition. Over the last 40 years, the amount of fresh water per capita in the world has decreased by 60% (Ulugmurodov D. 2015).

In Uzbekistan, main cotton grown area are irrigated by applying furrow irrigation. In this case, one of the crucial issue in furrow irrigation is wetting the root zone layer smoothly along the full length of furrow. It is difficult to achieve moistening root zone in all parts of furrow. Especially the initial part of furrow is over moistened in comparison with the end of furrow where at the end of furrow wetting layer is mostly shallow. Differences of wetting soil layer in parts of the furrow length effects on harvested seed-lint yield and boll weight. That is why the seed-lint yield of cotton is mostly dependent on furrow length and entire wetting zone. Problems related to developing the irrigation rates to ensure feasible wetting of entire soil layer along the length of furrows were investigated by many researchers.

According to research materials on investigating the effect of different furrow length (60, 90, 170 m) on seed-lint yield of cotton shows that the furrow length 60 m assuming the optimal with wetting coefficient of 0.88 % in the condition of meadow sierozem soils of Samarkand province Uzbekistan (Abdurakhmanov 2016).

Rhyzov suggested that there is no urgency for wetting more than 100 cm soil layer because the root system of cotton plant is located in 100 cm soil layer and cotton plant are utilizing moisture from 30 to 90 cm soil layer for transpiration (Rhyzov S.N. 1948).
Several agrotechnologies are in a wide impelementation in Uzbekistan for rational use and saving available water resources, ensuring a uniform wetting of the soil root zone layer throughout the field and reducing run off (Shamsiev A. 2015).

Based on the research results conducted by Japan International Research Center for Agricultural Sciences (JIRCAS) in Syrdarya province of Uzbekistan with the furrow length of 100 m, 50 m and 25 m, the optimal furrow length was 50 m which enabled to reduce the evaporation losses and filtration water as well as it ensured location of the groundwater level in optimal depth [https://www.jircas.go.jp/sites/default/files/publication].

According to the results of the research of A.Isashev and M.Dalieva, the use of non-traditional irrigation technique ensures a uniform distribution of moisture along the length of furrow, prevents soil erosion and decreases runoff water [http://library.ziyonet.uz/ru/book/download/15053].

Several papers suggested that in many irrigation schemes only about 45% of water diverted for irrigation actually reaches the crops (Levidow, Les, et al. 2014).

Population growth and increased levels of income, however, have caused an increased water demand (Tsur 2005), making it a more and more scarce resource in many locations throughout the world. In this domain, water is one of the limiting factors and it is not renewable resource (Steduto, P. 1996).

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. (Faurès, J., Svendsen, M., Turral, H., 2007.).

Howell and Irmak et al. reported the attainable application efficiencies for different irrigation methods, assuming irrigations are applied to meet the crops' water needs. While evaluating WUE, this study looks for both, introducing low water demanding crop and improving irrigation practices of farmers.

Farmers manage labour and other inputs to get better economic gains (Molden et al., 2010). Yet even water productivity remains distant from farmers' perspectives. They generally perceive 'irrigation efficiency' as maximizing net revenue rather than saving water (Knox et al., 2012).

From all abovementioned, improving irrigation water use efficiency and developing optimal irrigation scheduling of cotton are very prominent.

The field experiment objectives included two steps:

- developing the optimal irrigation scheduling Fc of upland cotton varieties.
- to investigate the changes of seed-lint yield and boll weight with respect to wetting root zone layer of soil along the parts of furrow.

MATERIALS AND METHODS

Field trials were conducted in 2015 to 2019 years in the condition of old irrigated typical sierozem soils with mechanical compostion of silt loam with deep >18 m water table, at the Central Experimental Station of Uzbekistan's Cotton Breeding, Seed Production and Agrotechnologies Research Institute (CBSPARI).

During the 2015 to 2017 years upland cotton varieties Sultan and UzPITI-103 were investigated in the following irrigation scheduling 70-70-60%, 70-75-65% Fc. During the 2018 to 2019 upland cotton varieties C-8295 and Kelajak was studied in irrigation scheduling 65-65-60% and 70-75-65% Fc. In all research years, upland cotton variety C-6524 was selected as a control. In Uzbekistan, according to methodology the released cotton variety with highest cropping area are selected as a control variety and the results of studied varieties are compared with control.

In Central Asia, climate is arid and also continental (Giese, Ernst & Jenniver Sehring 2010). In research area, average temperature ranges from 16.2 to 16.8 ^{o}C. Annual precipitation totals from 350 to 400 mm. Almost 90 % of precipitation covers months from October to May.

Research methodology were followed by "Methods of field experiments" published by Uzbekistan Cotton Research Institute (UzCRI 2007 and Dospekhov B.A. 1985). The experimental layout was a complete randomized block design with three replications. Each replicated plot size equaled to 480 m^2 with 8 cotton rows and furrow length of 100 m (4.8 m x 100 m). Cotton row spacing equaled to 60 cm.

The soil physical attributes consisted of particle-size analysis, field capacity, infiltration, BD, porosity and moisture content were identified by standard method. Particle-size analysis was determined on randomly selected samples by the sedimentation method using sodium hexametaphosphate as a dispersing agent. Soil moisture content was determined by the gravimetric method. Soil agrophysical properties of the experimental field is given in table 1.

Table-1. Agrophysical properties of soil in experimental field, 2015-2019

Soil layer	Average soil bulk density with standard deviation	Average soil porosity with standard deviation	Average soil field capacity with standard deviation
cm	g cm^{-3}	%	VWC m^3 m^{-3}
2015 to 2017 years			
0-30	1.28±0.02	52.72±0.7	26.7±0.3
0-50	1.33±0.02	50.86±0.7	27.9±0.3
0-70	1.34±0.01	50.25±0.4	28.3±0.1
0-100	1.35±0.01	49.88±0.4	28.7±0.3
2018 to 2019 years			
0-30	1.29±0.04	52.22±1.5	27.4±1.6
0-50	1.34±0.03	50.56±1.1	28.4±0.8
0-70	1.36±0.03	49.81±1.1	29.0±0.6
0-100	1.36±0.02	49.63±0.7	29.2±0.0

In the field, irrigation water run on and run off was measured with water measuring weir "Chippoletti", where the width of water passing part equaled to 0.25 and 0.50 m. In each furrow, the irrigation water was measured by using weir Tompson. Wetting root zone layer of the soil from germination till flowering was 0-70 cm, flowering to boll formation 0-100 cm and maturation 0-70 cm. The irrigation scheduling Fc percentages were also considered abovementioned growth stages. For example, irrigation scheduling 70-75-65% Fc, 70% for germination till flowering, 75% flowering to boll formation, 65% for maturation.

In field trials, the furrow length equaled to 100 m in each treatment. Seed-lint yield and boll weight of cotton was harvested in the following furrow lengths' 0 to 30 m, 30 to 70 m and 70 to 100 m separately. The effect of irrigation scheduling on seed-lint yield of cotton and boll weight along parts of furrow length were investigated.

RESULTS AND DISCUSSION

Achieving the highest yield is dependent on the number of bolls and its weight. According to 2015 to 2017 years results, the highest cotton boll weight was achieved in the middle part of furrow with the length of 30 to 70 m in all cotton varieties where the lowest yield results were in the furrow length of 70 to 100 m. In furrow irrigation, the initial part of furrow has much more irrigation duration in comparison with the end of furrow. It also effects on wetting root zone layer as well. In most cases, the initial part of furrow are over moistened because of the more duration of irrigation in comparison with the end of furrow where at the end of furrow the situation is vice versa. This effects on yield and boll weight results.

For Sultan cotton variety the highest boll weight was obtained in irrigation scheduling 70-75-65% Fc with average value of 6.5 g. Comparison of boll weight results of Sultan variety with respect to furrow length show that the highest results 7.1 g were obtained in the middle part of furrow with the length of 30 to 70 m in comparison with initial and end of furrow length, the results were decreased by 0.7 g and 1.0 g respectively. The same circumstances were occurred in UzPITI-103 variety while having the highest yield in the middle part of furrow with the length of 30 to 70 m. But the irrigation scheduling 70-70-60% Fc was optimal for UzPITI-103 cotton variety. The differences of boll weight with respect to furrow length can be explained with the differences of wetting root zone layer. The initial part of furrow is over moistened where the high vegetative biomass was accumulated in comparison with the end of furrow where the soil root zone layer is not well moistened causing the less dry mass accumulation. That is why the well moistened furrow length was the middle part of furrow following with high boll weight and seed-lint yield of cotton (Fig 1.). Generally, the differences in boll weight can be explained by biological characteristics of cotton varieties. For example, the boll weight is much higher in Sultan variety in comparison with UzPITI-103. This is connected with biological characteristics of cotton varieties.

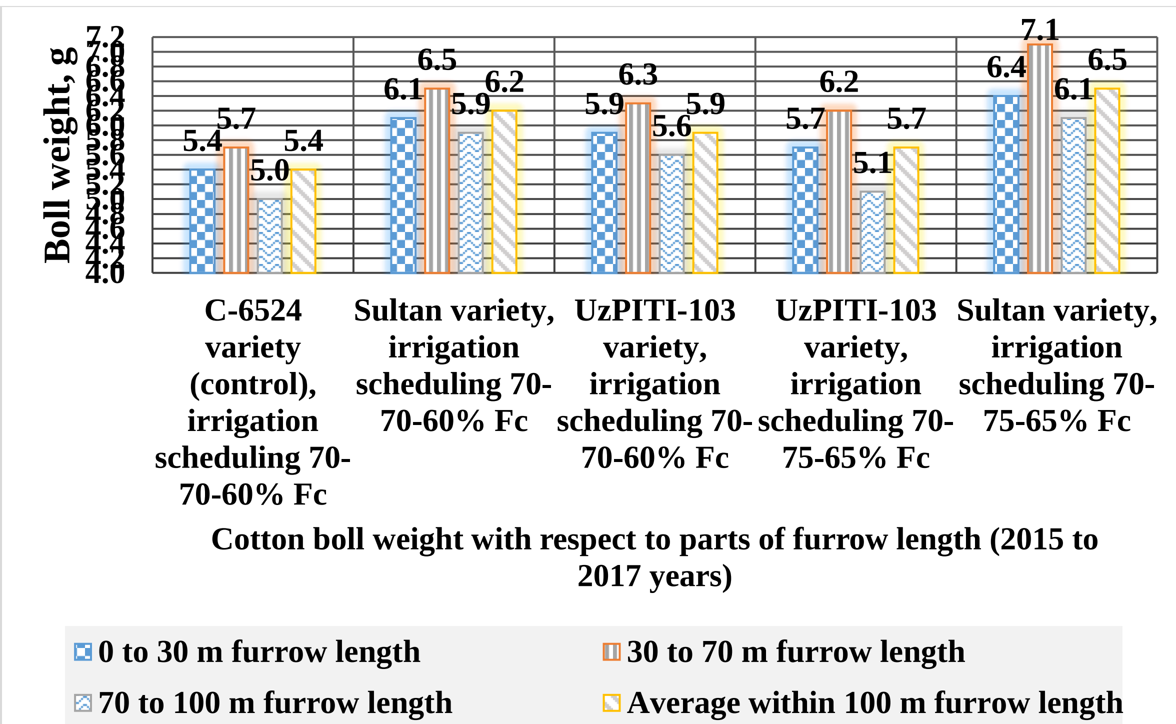

Figure-1. Boll weight of cotton varieties Sultan and UzPITI-103 with respect to parts of furrow length (2015 to 2017 years)

As per discussion one theoretical mathematic calculation can be explained as an example. For example if the boll weight is higher by 1.0 g in optimal treatment by comparing with control or furrow lengths. If assuming 10 boll pcs per plant with plant density of 100 thousand plants ha^{-1}. It can be calculated as follows:

100000 plants per ha, 10 bolls per plant, 1 g extra boll weight. 1x10x100000=1000000 g= 1000 kg. it means that extra 1.0 t ha^{-1} seed-lint yield of cotton can be obtained. This calculation shows the importance of boll weight in achieving the highest yield.

The results obtained in 2018 to 2019 years with cotton varieties C-8295 and Kelajak has shown the same circumstances. The highest boll weight in both C-8295 and Kelajak varieties were obtained in the middle part of furrow with the length of 30 to 70 m.

The highest boll weight was mentioned in irrigation scheduling 70-75-65% Fc in C-8295 cotton variety with average boll weight of 6.2 g, and in irrigation scheduling 65-65-60% Fc in Kelajak cotton variety with value of 6.3 g (Fig. 2).

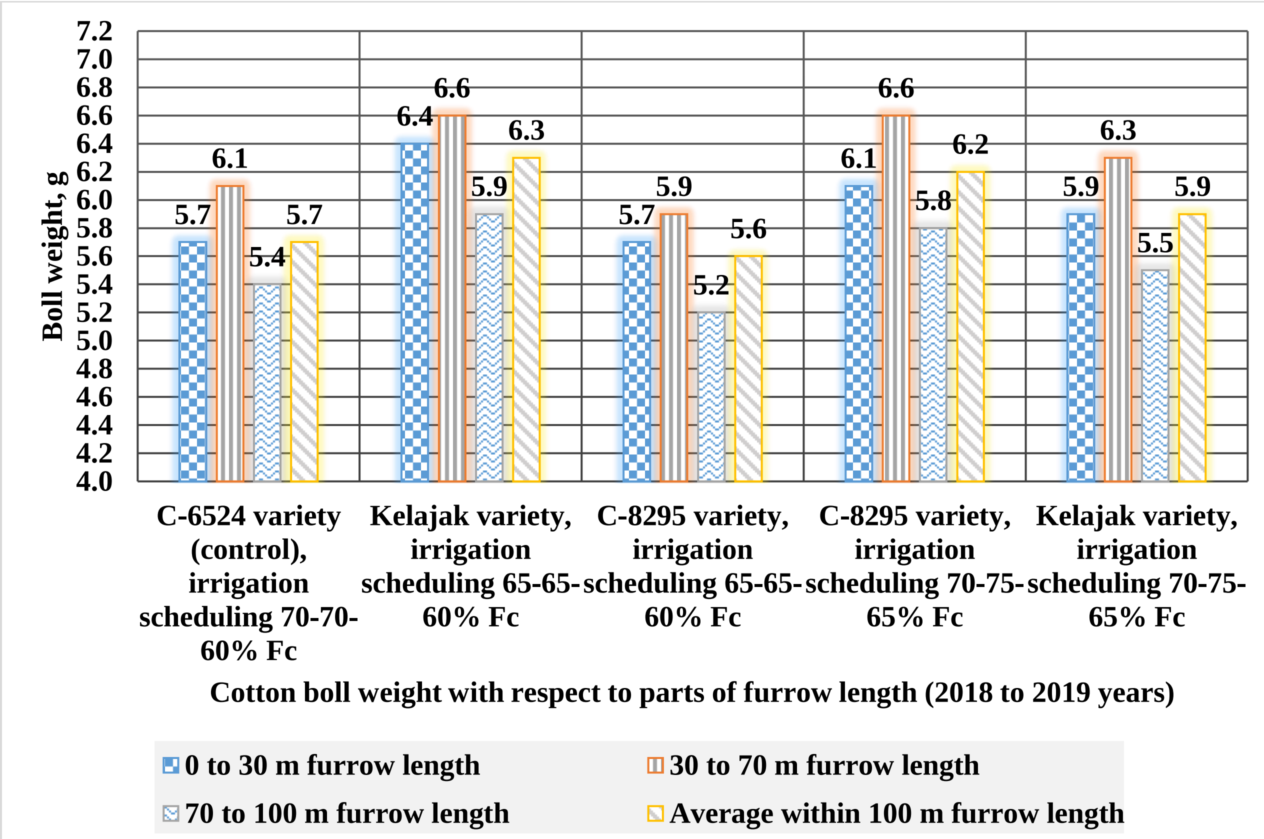

Figure-2. Boll weight of cotton varieties C-8295 and Kelajak with respect to parts of furrow length (2018 to 2019 years)

Water requirement of cotton is mostly dependent on biological characteristics of variety. Research results of 2015 to 2017 years demonstrates that the irrigation scheduling 70-75-65% Fc was optimal for cotton variety Sultan with highest seed-lint yield of 4.52 t ha^{-1} in comparison with irrigation scheduling 70-70-60 % Fc where the seed-lint yield were less by 0.27 t ha^{-1}. The comparison results of seed-lint yield in different furrow length parts show that the highest seed-lint yield were obtained in the middle part of furrow between 30 to 70 m with values of 4.71 t ha^{-1}. The seed-lint yield were higher in 30 to 70 m furrow length by comparing with 0 to 30 m and 70 to 100 m furrow length with values of 0.17 t ha^{-1} and 0.39 t ha^{-1}. The results show that water requirement of Sultan variety is much higher and because Sultan variety is early maturing. This is the reason of having high water requirement. In contrast, upland cotton variety UzPITI-103 did not show the highest water requirement. Irrigation scheduling with higher Fc values did not results increasing the yield in UzPITI-103 cotton variety. It can be cleared that UzPITI-103 cotton variety's water requirement was much more less in comparison with Sultan cotton variety (table 2).

Irrigation scheduling 70-70-60% Fc ensured achieving highest seed-lint yield (4.38 t ha^{-1}) in UzPITI-103 variety in comparison with higher Fc values by means of in irrigation scheduling 70-75-65% Fc the seed-lint yield was decreased by 0.14 t ha^{-1}. According to furrow length comparison, the same results were obtained for UzPITI-103 variety as well. The seed-lint yield were decreased by 0.13 t ha^{-1} and 0.16 t ha^{-1} in 0 to 30 m and 70 to 100 m furrow length respectively in comparison with 30 to 70 m furrow length (Table 2).

Table 2. Seed-lint yield of cotton varieties Sultan and UzPITI-103 with respect to parts of furrow length (average for 2015-2017 years)

Treatment No.	Upland cotton varieties	Irrigation scheduling Fc, %	The parts of furrow, m	Seed-lint yield of cotton with respect to parts of furrow, t ha^{-1}	Average seed-lint yield of cotton, t ha^{-1}	Differences with respect to average, ±	Differences with respect to control
1	C-6524 (control)	70-70-60	0-30	3.99	4.00	-0.01	-
			30-70	4.18		0.18	-
			70-100	3.83		-0.17	-
2	Sultan	70-70-	0-30	4.27	4.25	0.02	0.28

		60	30-70	4.42		0.17	0.24
			70-100	4.06		-0.19	0.23
3	UzPITI-103	70-70-60	0-30	4.35	4.38	-0.03	0.36
			30-70	4.48		0.10	0.30
			70-100	4.32		-0.06	0.49
4	UzPITI-103	70-75-65	0-30	4.19	4.24	-0.05	0.20
			30-70	4.37		0.13	0.19
			70-100	4.16		-0.08	0.33
5	Sultan	70-75-65	0-30	4.54	4.52	0.02	0.55
			30-70	4.71		0.19	0.53
			70-100	4.32		-0.20	0.49

The seed-lint yield variations with respect to parts of furrow length can be explained by differences of wetting root zone layer of soil. For example, in the flowering phase, in the initial part of the furrow (0 to 30 m) the wetting layer equaled to 1.2 m, in the 30 to 70 m and 70 to 100 m furrow length the wetting layer were the following 1.0 m and 0.8 m. This is the reason of having differences in seed-lint yield.

Based on the research results, it was found out that the water requirement of Kelajak variety was much more less in comparison with C-8295 variety. According to research results of 2018 to 2019 years, the same tendency was occurred with C-8295 and Kelajak varieties by comparing with Sultan and UzPITI-103 varieties. The highest seed-lint yield was obtained in the middle part of furrow with the length of 30 to 70 m with results of 4.27 t ha^{-1} in C-8295 variety, 3.93 t ha^{-1} in Kelajak variety. The lowest yield was obtained in 70 to 100 m furrow length in both abovementioned varieties with results of 4.11 t ha^{-1} and 3.72 t ha^{-1} (Table-3). As per discussion, one fact can be indicated that in all cotton varieties the highest seed-lint yield and boll weight were achieved in the middle part of furrow 30 to 70 m length despite the different irrigation scheduling. It can be explained that in all irrigation scheduling the same tendency were occurred and the highest yield were achieved in the middle part of furrow.

Table 3. Seed-lint yield of cotton varieties Kelajak and C-8295 with respect to parts of furrow length (average for 2018-2019 years)

Treatment No.	Upland cotton varieties	Irrigation scheduling Fc, %	The parts of furrow, m	Seed-lint yield of cotton with respect to parts of furrow, t ha^{-1}	Seed-lint yield of cotton, t ha^{-1}	Differences with respect to average t ha^{-1}, ±	Differences with respect to control, t ha^{-1} ±
1	C-6524 (control)	70-70-60	0-30	3.72	3.74	-0.02	-
			30-70	3.86		0.12	-
			70-100	3.64		-0.10	-
2	Kelajak	65-65-60	0-30	3.79	3.81	-0.02	0.07
			30-70	3.93		0.12	0.07
			70-100	3.72		-0.09	0.08
3	C-8295	65-65-60	0-30	3.73	3.75	-0.02	0.01
			30-70	3.88		0.13	0.02
			70-100	3.64		-0.11	0.00
4	C-8295	70-75-65	0-30	4.17	4.18	-0.01	0.45
			30-70	4.27		0.09	0.41
			70-100	4.11		-0.07	0.47
5	Kelajak	70-75-65	0-30	3.57	3.57	0.00	-0.15
			30-70	3.69		0.12	-0.17
			70-100	3.44		-0.13	-0.20

Having the lowest yield at the end of furrow with the length of 70 to 100 m can be explained by not enough wetting the entire root zone layer of soil.

CONCLUSION

Based on the research work on developing the irrigation scheduling for cotton varieties and determining cotton seed-lint yield changing dynamics with respect to parts of furrow length, the cutoff flow furrow irrigation approach appear to be promising alternatives for smoothly wetting entire root zoning layer in the old irrigated typical sierozem soils of Tashkent province. According to results, the highest cotton seed-lint yield and boll weight were obtained in the 30 to 70 m part of furrow length. The lowest results were in the part of furrow 70 to 100 m. It can be concluded that in the area with old irrigated typical sierozem soils, while growing cotton in row spacing of 0.6 m, the furrow length must not exceed 70 m. The cotton seed-lint yield can be decreased by 0.10 to 0.39 t ha^{-1} while prolonging the furrow length to 100 m.

In all abovementioned cotton varieties, the highest boll weight and seed-lint yield were obtained in the middle part of furrow with the length of 30 to 70 m. The decrease of yield and boll weight in the initial part of furrow with respect to middle part can be explained by over moistening which negatively effect on seed-lint yield and boll weight. The decrease of results at the end of furrow can be explained with not enough wetting entire root zone layer by comparing with the middle part of furrow.

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