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Research Article/Araştırma Makalesi

The effects of different irrigation levels and irrigation intervals on cotton cultivation: A study on yield, yield components, and fiber quality parameters

Farklı sulama seviyelerinin ve sulama aralıklarının pamuk yetiştiriciliği üzerindeki etkileri: Verim, verim bileşenleri ve lif kalitesi parametreleri üzerine bir çalışma

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ABSTRACT

This study was conducted for investigating the impact of irrigation interval and deficit irrigation on seed cotton yield, fiber quality, and water productivity of cotton (*Gossypium hirsutum* L.) in the Şanlıurfa province of Türkiye during the years 2020 and 2021. The experiment was conducted using a randomized complete block design with split plots. The main plots included three irrigation intervals (D_1: 4 day, D_2: 8 day, and D_3: 12 day), while the sub-plots consisted of three irrigation levels (I_1: %150, I_2: %120, and I_3: %90) considered by Class A pan evaporation using the drip irrigation method. The study resulted in that the crop evapotranspiration varied from 693 to 1153 mm in 2020 and from 716 to 1126 mm in 2021, respectively. Irrigation interval and deficit irrigation had a statistically significant effect on seed cotton yield, seed cotton weight, and ginning outturn in both years of the study. The highest seed cotton yield, seed cotton weight, and lint yield were obtained from the treatment with a 4-day irrigation interval and irrigation water level at 150% (D_1-I_1), while the lowest values were obtained from the treatment with a 12-day irrigation interval and irrigation water level at 90% (D_3-I_3). However, irrigation interval and deficit irrigation did not have a statistically significant effect on 100-seed weight, fiber fineness, fiber length, and fiber strength in both years of the study. In the study, water use productivity (WP) ranged from 0.32 to 0.55 kg m^{-3}, while irrigation water use productivity (IWP) ranged from 0.33 to 0.59 kg m^{-3}, and similar results were obtained in both years of the research. According to the research findings, to achieve the highest cotton yield and quality, an irrigation interval of 4 days and a total seasonal irrigation water of 1062 mm are recommended.

Key Words: Drip irrigation, Yield, cotton, Irrigation water level, Irrigation interval, Harran Plain

ÖZ

Bu çalışma sulama suyu aralığı ve kısıntılı sulamanın pamuk (*Gossypium hirsutum* L.) kütlü verimi, lif kalitesi ve su etkinliği üzerine etkisini incelemek amacıyla Türkiye'nin Şanlıurfa ilinde 2020 ve 2021 yıllarında yürütülmüştür. Araştırma tesadüf bloklarında bölünmüş parseller deneme desenine göre 3 tekerrürlü olarak yürütülmüştür. Çalışmada, ana konu olarak üç sulama aralığı (D_1: 4 gün, D_2: 8 ve D_3: 12 gün), alt konu olarak ise damla sulama yöntemi kullanılarak Class A pan'a bağlı olarak üç sulama suyu seviyesi (I_1: %150, I_2: %120 ve I_3: %90) ele alınmıştır. Araştırmada bitki su tüketimi (evapotranspirasyon) ilk yıl 693-1153 mm arasında değişirken ikinci yıl ise 716 ile 1126 mm arasında değişmiştir. Sulama aralığı ve kısıntılı sulama, pamuk kütlü verimi, pamuk koza ağırlığı ve çırçır randımanı üzerinde istatiksel olarak önemli etkisi olmuştur. En yüksek pamuk kütlü verimi, pamuk koza ağırlığı ve çırçır randımanı 4 gün sulama aralığı ve sulama suyu seviyesi %150 olan konudan (D_1-I_1) elde edilirken, en düşük değerler ise 12 gün sulama aralığı ve sulama suyu seviyesi %90 olan konudan (D_3-I_3) elde edilmiştir. Ancak, sulama aralığı ve kısıntılı sulamanın 100 tohum ağırlığı, lif inceliği, lif uzunluğu ve lif mukavemeti üzerinde istatiksel olarak önemli etkisi olmamıştır. Araştırmanın her iki yılında, su kullanım etkinliği (WP) 0.32-0.55 kg m^{-3}, sulama suyu kullanım etkinliği (IWP) ise 0.33-0.59 kg m^{-3} arasında değiştiği ve çalışmanın her iki yılında da benzer sonuçların alındığı saptanmıştır. Araştırma sonuçlarına göre, en yüksek pamuk verimini ve kalitesini elde etmek için damla sulama ile 4 günlük sulama aralığında toplam sezonluk 1062 mm sulama suyunun uygulanması önerilmektedir.

Anahtar Kelimeler: Damla sulama, Verim, Pamuk, Sulama suyu seviyesi, Sulama aralığı, Harran Ovası

Introduction

The demand for water resources grows along with the global population (Boretti et al., 2019). The Earth's surface is covered by water to a percentage of around 71%, however only about 2.5% of that water is recognized as freshwater (Domingo, 2012). The other 70% of this freshwater is made up of groundwater and water from glaciers. Only about 0.3% of this freshwater is fresh water (Bhat, 2014). Rivers, lakes, aquifers, and atmospheric water vapor are a few examples of water sources. Geographically speaking, the distribution of Earth's water resources causes water scarcity and poor water quality in various regions (Oki et al., 2006). The climate, global warming, and human activity are just a few of the factors putting the world's water resources in danger (Pimentel et al., 2007). Although industry, agriculture, and urban use are the main causes of increased water use (Lv et al., 2020), additionally, all those sectors degrade and impair water quality (Fayiga et al., 2018).

On the other hand, the availability of water might be significantly impacted by global warming (Lu et al., 2019). Increasing temperatures may cause evaporation, which could reduce the amount of water that is readily available (Arnell, 2018). Water supplies could also be impacted by a change in precipitation or a lack (García-Ruiz et al., 2011).

Global warming significantly affects agricultural production, especially in arid regions. Adequate water availability is crucial for successful agricultural production as it facilitates the development, growth, and productivity of plants (Fageria et al., 2006). However, a lack of water resources and a drought may cause agriculture less productive (Pereira et al., 2002). There are a number of steps that may be done to prevent the decline in agricultural production caused by depleting water supplies, including the adoption of effective irrigation methods and rainwater collection (Mahmoud et al., 2016), using water resources efficiently (Pedro-Monzonís et al., 2015), choosing the crop varieties (Ashraf, 2010) improving soil cultivation methods, making plants drought-resistant, and using less water overall. Water-saving technologies are utilized to reduce the amount of water used in agricultural output (Blanke et al., 2007), modified irrigation schedules (Uniyal et al., 2019), as well as the choice of appropriate plant species (Nagase et al., 2012) may be used as efficient measures that use less water. Sustainable agricultural practices, water resource management, and irrigation methods have been used to increase agricultural production in desert cotton agriculture, particularly in recent years (Khor et al., 2017). By putting these techniques into practice, it will be easier to increase the cotton plant's tolerance to drought and boost agricultural productivity (Enebe et al., 2018).

Cotton is known as one of the most significant and extensively cultivated crops on a worldwide basis (Wegier et al., 2016). Because of its fibrous texture, which makes it a significant resource for the textile industry, cotton is a crop that is widely cultivated and highly valued in agricultural production (Campbell et al., 2010). The cotton plant is grown in many different countries all over the world (Ali et al., 2019).

Water is a significant resource for cotton plants, especially during the growth and production phases. The amount of water a cotton plant needs depends on numerous factors, such as the temperature of the place where it is grown, the type of soil, the age of the plant, and many other things (Ritchie et al., 2007). Cotton plants are put under water stress by the method of limited watering, which hurts their growth and defense systems (Khan et al., 2018). Deficit irrigation may be a way to save water and help protect water supplies, when used appropriate (Chartzoulakis et al., 2015). Through the restricted irrigation method, the cotton plant may also be able to handle water stress successfully (Kirda, 2002), suggesting that it might be possible to get work done even though there is no enough water.

Various irrigation methods have been used to save water resources, lower irrigation costs, and use water more efficiently in agriculture (Tuong and Bouman, 2000; Levidow et al., 2014; Muzammil et al., 2020).

The main goal of this study was to determine the effects of different irrigation interval and different amount of irrigation water applied on cotton yield, water productivity and some fiber qualities under the drip irrigation.

Material and Method

The study was conducted during the 2020 and 2021 growing seasons at the experimental fields of Harran University in Sanliurfa, Türkiye, located at 37°07'N and 38°48'E and 498 meters above sea level.

The experimental area is categorized as having an arid climate (Bölük, 2016). The summers in this region have high temperatures and low relative humidity, typically ranging from 25% to 40%. Conversely, the winters in this area are characterized by relatively cold temperatures and increased precipitation. The study region has an average annual precipitation of 360 mm, while the evaporation rate from open-water surfaces amounts to 1850 mm. Precipitation during the winter months continues until early spring, but there are significant differences in distribution from year to year. The hottest and driest months are June, July, August, and September, with daily maximum temperatures often exceeding 40°C, while January and February are the coldest months, with minimum temperatures rarely falling below 0°C. Some climate data for long period (1929-2021), 2020, and 2021 year in Şanlıurfa province are given in Table 1.

Table 1. Some climate data of Şanlıurfa province

Mounts	Years	Av. Temp. (°C)	Max. Temp. (°C)	Min. Temp. (°C)	Av. Rel. Hum. (%)	Av. Wind Speed (m s^{-1})	Total Rainfall (mm)
May	**Long Year**	22.6	40.3	2.5	44.6	2.20	26.8
	2020	23.2	38.0	11.1	41.0	1.70	39.1
	2021	26.6	40.4	13.6	25.7	1.90	2.7
June	**Long Year**	28.1	44.1	8.3	32.6	2.80	4.3
	2020	28.9	41.6	15.3	29.9	1.90	0.4
	2021	28.9	41.4	18.7	29.6	2.10	0.0
July	**Long Year**	32.0	46.8	15.0	29.3	2.80	2.0
	2020	34.2	45.3	23.8	24.9	1.60	0.0
	2021	33.8	44.4	22.6	25.9	1.40	0.0
August	**Long Year**	31.5	46.2	16.0	32.0	2.50	3.4
	2020	32.4	43.9	21.9	25.3	1.80	0.0
	2021	32.7	43.4	20.6	30.2	0.70	7.7
September	**Long Year**	27.2	43.9	10.0	35.0	2.20	4.6
	2020	30.9	43.9	19.9	29.2	1.40	0.0
	2021	27.3	38.2	16.2	33.8	1.70	0.0
October	**Long Year**	20.6	37.8	1.90	44.1	1.60	26.5
	2020	24.0	34.2	16.1	27.5	1.10	0.0
	2021	22.0	34.5	13.7	32.0	1.30	2.3

The soil in the experimental area is clay (USS 1954) with an infiltration rate of 9 mm h^{-1}. It is slightly alkaline and there is no considerably salt. The lime content of approximately 8.80% in the soil profile is presented in Table 1, demonstrating the results of the analysis. Furthermore, the soil profile's available water holding capacity within the depth range of 0 to 90 cm is measured to be 182 mm. Some parameters of the research area soil (0-90 cm) are given table 2 (Akın et al., 2020).

Table 2. Some physical and chemical properties of soil of the research area

Depth	FC (%)	WP (%)	BD (g cm^{-3})	Texture	pH	EC (dS m^{-1})	Lime (%)
0-30	28.04	16.74	1.37	C	7.85	0.67	7.90
30-60	28.82	17.35	1.39	C	7.94	0.59	9.50
60-90	29.96	18.20	1.40	C	7.62	0.86	9.80

FC: Field capacity; WP: Wilting point; BD: Bulk density; EC: Electrical conductivity

On May 21, 2020 and May 08, 2021 cotton seeds were planted with a row spacing of 75 cm and an interrow spacing of 10 cm, resulting in a plant density of 133,333 plants per hectare using the May-455 variety. The size of the plot was 27 m^2 (6.00×4.50 m). During the harvest period, a distance of 0.5 meters from the edges and two border rows were intentionally left to mitigate the edge effect. As a result, the plants that remained within a 15 m^2 area were collected manually. The cotton was harvested by manual in twice year. The initial harvest was done when the cotton bolls reached a state of 90% openness, while the subsequent harvest was conducted once the remaining 10% of bolls had fully opened. The experimental design was randomized blocks in split-plots with three replications. The main plots were three different irrigation intervals (4, 8, and 12 days) and the subplots were three different amount of irrigation water (I_1, I_2, and I_3) using various coefficients of Class A pan evaporation. The experimental design is shown in Table 3.

Table 3. Treatments of trial

Main Plots (Irrigation intervals)	Subplots (Irrigation levels)
D_1: 4 day	I_1: %150 (Kp_1= 1.50)
D_2: 8 day	I_2: %120 (Kp_2= 1.20)
D_3: 12 day	I_3: %90 (Kp_3= 0.90)

The some young plants were removed after emergence, with an interrow spacing of 15-20 cm. Hoeing was carried out twice by hand, as well as by machine. At planting, a compound fertilizer (20-20-0) was used as a source of 80 kg N ha^{-1} and 80 kg P_2O_5 ha^{-1}. Subsequently, the remaining amount of nitrogen was applied for fertigation. According to Çetin and Akalp (2019), the fertilization process involved the use of 80 kg P_2O_5 ha^{-1} and 160 kg N ha^{-1}, which were applied in three equal amounts via drip irrigation. To prevent Empoasca sp., a chemical containing 20% Acetamiprid at a rate of 100 g ha^{-1} was applied, while a chemical with 100 g l^{-1} Cyantraniliprole was used to manage thrips. The irrigation water obtained from the open channel had a low sodium content and a medium level of salinity, with a pH and electrical conductivity of 7.80 and 0.71 dS m^{-1}, respectively. Based on the USDA salinity classification, the irrigation water falls under the C_2S_1 class. The drip irrigation system is equipped with a control unit. A 75-mm polyethylene pipe (PE) was used for water filtration and delivery to the experimental site. Afterwards, 50-mm PE pipes were used to distribute the water to the plots. The drip lines utilized in the experiment had a diameter measuring 16 mm. The drippers were placed at intervals of 33 cm, and each dripper had a flow rate of 4 L h^{-1} (Keller et al., 1990). The pressure that operated the drip irrigation device worked was 1 bar. All the experimental plots were irrigated twice with a sprinkler irrigation system and a small amount of water to make sure the seeds would grow. After the plots were planted for the second time, the drip irrigation system was set in the experimental plots.

Irrigation water applied

To determine the quantity of irrigation water used, the evaporation rate from the Class A Pan was multiplied by various K_p coefficients. To account for various coefficients and crop cover percentages, the total evaporation amount for each of the four days was multiplied accordingly. Before each irrigation, the width of the plant canopy was measured to determine the percentage of crop cover. The initial irrigation was performed after 50% of the available water in the 0 to 60 cm soil profile had been depleted in all treatments. During the initial stage of irrigation, all experimental plots were irrigated until it reached field capacity using a sprinkler irrigation system. For the remaining irrigations, drip irrigation was used in the all treatments. The quantity of irrigation water was estimated utilizing equation 1.

$$IW = A * E_{pan} * K_p * Pc \quad \text{(Eq.1)}$$

Where IW: the amount of irrigation water (L), A: parcel area (m^2), E_{pan}: the cumulative evaporation from the Class A pan for 4, 8, and 12 days, K_p: the coefficient used to calculate various irrigation levels, Pc refers to the percentage of plant canopy cover (To calculate PC during the irrigation season, five plants were randomly selected from each plot and their entire canopies were measured). Moreover, the assumed value of Pc was 0.35 until the cover percentage reached 35%, after which the actual value of Pc was used in the treatments. To calculate actual evapotranspiration, the water balance equation was used.

$$ET_c = IW + P - D_p - R_{off} \pm \Delta S \quad \text{(Eq.2)}$$

The following variables were used in the study: ET_c, which stands for crop evapotranspiration (mm); IW, which refers to the amount of irrigation water applied (mm); P, which represents the precipitation (mm); D_p, which indicates the deep percolation (mm); R_{off}, which denotes the runoff (mm); and ΔS, which shows the change in the moisture content at a root depth of 0-90 cm (mm).

The measurement effects of irrigation programs were used to compute productivity of the water productivity (WP) and irrigation water productivity (IWP) (Pereira et al., 2012). The following are the equations:

$$WP = Y/ET \quad \text{(Eq.3)}$$

$$IWP = Y/IW \quad \text{(Eq.4)}$$

Where Y represents the yield (kg ha^{-1}), ET is the seasonal evapotranspiration (m^3), and IW means the seasonal irrigation water amount (m^3).

Seed cotton yield and some yield parameters

The determination of yield was carried out by the collection and weighing of three meters of cotton from the central portion of two rows within each parcel. The quantification of cotton production was achieved through the conversion of the output into units of kilograms per hectare (kg ha^{-1}). The determination of cotton yield per boll and gin yield involved the selection of fifty bolls from each plot, as per the definition provided by Worley et al. (1976). The height of five plants that were chosen at random from each parcel was additionally documented.

Statistical analyses

The statistical program of SPSS was used for the statical analysis. The present study employed the statistical techniques of analysis of variance (ANOVA) and the Tukey test for mean comparison to investigate the impact of varied irrigation schedules on both the yield and quality of cotton.

Results and Discussion

The experimental treatments were applied with varying numbers based on the intervals between irrigation days. Table 4 shows the seasonal crop evapotranspiration (ET_c) of each treatment, as well as the amount of irrigation water applied for each.

Table 4. Amount of IW and ET_c in both years

Treatments		2020				2021			
		Rainfall (mm)	ΔS (mm)	IW (mm)	ET_c (mm)	Rainfall (mm)	ΔS (mm)	IW (mm)	ET_c (mm)
D_1	I_1	35	24	1057	1068	11	20	1066	1057
	I_2	35	13	856	878	11	5	871	877
	I_3	35	-1	656	693	11	-30	675	716
D_2	I_1	35	12	1075	1098	11	16	1093	1088
	I_2	35	-9	871	915	11	-4	892	907
	I_3	35	-12	667	714	11	-33	692	736
D_3	I_1	35	8	1126	1153	11	9	1124	1126
	I_2	35	-13	912	960	11	-10	917	938
	I_3	35	-17	698	750	11	-37	710	758

D_1: 4-day irrigation interval, D_2: 8-day irrigation interval, D_3: 12-day irrigation interval, I_1: 150% irrigation level, I_2: 120% irrigation level, I_3: 90% irrigation level, ΔS: The variation in soil moisture content was monitored at a root depth of 0-90 cm, IW: Irrigation water, ETc: Seasonal crop evapotranspiration.

Due to a lack of rainfall in the study region, irrigation was the primary source of water for the crop in both years. During the cotton growing season (May to September), there is almost rainfall of 30 mm. However, it was 35 mm in the first year and only 11 mm in second year. As a result, irrigation was the only source of water for the crop to meet water requirement for cotton. During the first year, a fixed amount of 55 mm of water was applied for irrigation, while in the second year, 90 mm of water was applied for irrigation to obtain a good emergency of plants. In the first year of the experiment, irrigation treatments began on 4 July and ended on 10 September. In the second year, irrigation treatments began on 5 July and ended on 11 September. During the period of cotton production, the region observed high temperatures and low relative humidity, requiring the application of extensive irrigation practices in cotton growing, as noted by (Chapagain et al., 2006; Darouich et al., 2014). The value of IW ranged from 656 mm to 1126 mm during the first year of the study, and from 675 mm to 1124 mm during the second year. In similar studies, the amount of seasonal IW was determined as 408-773 mm (Hussein et al., 2011), 177-508 (Basal et al., 2009). The amount of IW applied is primarily determined by climatic factors and crop development (Simonne et al., 2004). As a result, differences in the amount of IW could be depending on mainly the climatic conditions.

The evapotranspiration of the experimental treatments was different depending on the amount of IW during both years. In the first year, the evapotranspiration ranged between 693-1153 mm, while in the second year, it also varied between 716-1126 mm. The treatments that received less irrigation water were able to use the soil's moisture available during the sowing period to their advantage. The highest ET_c value in both years occurred in treatment of D_3-I_1. In both years, the lowest ET_c value was determined in the treatment of D_1-I_3. Variations of ET_c on a yearly basis may manifest fluctuations in diverse meteorological reasons and during distinct seasons (Ertek et al., 2000). Similar results have been reported by several researchers for semi-arid area (Hunsaker et al., 2015; Tüzel et al., 2003). The ET_c value recorded in comparable studies carried out in different climate regions changed between 390-689 mm (Yang et al., 2015), 813-927 mm (Oweis et al., 2011), 313-701 mm (Çetin et al., 2021). As a result, differences in plant water consumption might be found between this research and previous studies. One of the most significant factors affecting plant water consumption seems the amount of IW applied (Yuan et al., 2003). Moreover, differences between present and previous studies occur due to variations in seasonal climate conditions (Harmsen et al., 2009) and chose cultivars not being the same (Munk et al., 2004; Witt et al., 2020).

Seed cotton yield and some yield parameters

Table 5 shows the cotton yield obtained from the experimental treatments, as well as the values of specific yield components and the results of statistical evaluation.

Table 5. The means and statistical groups for the seed cotton yield, boll seed cotton weight, and 100 seed weight values of cotton for the different treatments are shown in the table

Treatments	Seed cotton yield, kg ha^{-1}		Seed cotton weight, g boll^{-1}		100 seed weights, g	
	2020	2021	2020	2021	2020	2021
D_1	4132a	4276a	4.19a	4.21a	10.29	10.51
D_2	3751b	3861b	4.00b	4.08b	10.29	10.55
D_3	3442c	3611c	3.86c	3.96c	10.58	10.50
P (Factor A)	*	*	**	**	ns	ns
I_1	4096a	4221a	4.16a	4.21a	10.38	10.53
I_2	3806b	3950a	3.97b	4.08b	10.38	10.51
I_3	3424 c	3577b	3.92b	3.96c	10.41	10.52
P (Factor B)	**	**	**	**	ns	ns
D_1-I_1	4433	4567	4.29	4.28	10.29	10.53
D_1-I_2	4157	4310	4.17	4.22	10.39	10.54
D_1-I_3	3807	3950	4.09	4.11	10.21	10.45
D_2-I_1	4143	4237	4.15	4.21	10.30	10.60
D_2-I_2	3710	3843	3.94	4.02	10.28	10.48
D_2-I_3	3400	3503	3.92	4.00	10.30	10.56
D_3-I_1	3710	3860	4.04	4.09	10.54	10.44
D_3-I_2	3550	3697	3.79	3.92	10.56	10.51
D_3-I_3	3067	3277	3.75	3.88	10.63	10.55
P (A*B)	ns	ns	ns	ns	ns	ns

[a]The treatments which have the same letter are not significantly different at the 5% level by Tukey's test.

In both years, the irrigation interval ($p \leq 0.05$) and different irrigation levels ($p \leq 0.01$) had a significant impact on cotton yield. However, in both years of the study, the interaction between irrigation interval and irrigation water level did not show a significant effect on seed cotton yield. As the irrigation interval increased, a decrease in seed cotton yield was observed in the study. The highest yield was obtained in the treatment of D_1 (4-day interval) in both years of the study, while the lowest yields were obtained in the treatment of D_3 (12-day interval). As a result, an 18-20% increase in cotton yield was obtained in the treatment of D_1 compared to the treatment of D_3 Similar results were found for irrigation water levels, and in both study years, increased irrigation water levels resulted in increasing seed cotton yields. The treatment of I_1 provided the maximum yield in both years of the study (IW: %150), whereas the treatment of I_3 produced the lowest yields (IW: %90). In comparison to I_3, the cotton yield obtained in I_1 was 10–20% higher. The seed cotton production in the I_1 treatment was 16% greater than the I_3 treatment in the study's first year, and it increased by 18% in the second. Although having shown that there was no statistically significant interaction between irrigation interval and irrigation water level and seed cotton yield, the D_1-I_1 treatment had the highest yield, and the D_3-I_3 treatment had the lowest yield. On seed cotton weight in both years, irrigation interval and irrigation amount showed a significant impact ($p \leq 0.01$). Nevertheless, the findings from both study years indicate that the interaction between irrigation interval and irrigation water level did not have a statistically significant effect on the yield of cotton. The seed cotton yield in previous similar studies was determined as 2070-4900 kg ha^{-1} (Cetin et al., 2002), 1140-3899 kg ha^{-1} (Ünlü et al., 2011), 1826-2664 kg ha^{-1} (Rao et al., 2016), 1113-5170 kg ha^{-1} (Basal et al., 2009). The application of IW has a significant impact on the yield of seed cotton (Onder et al., 2009). Moreover, the amount of fertilizer applied has an impact on the yield of cotton (Sawan et al., 2008). However, previous research studies, similar to the current investigation, have shown that the treatment group that utilized the greatest quantity of IW achieved the most beneficial seed cotton yield.

According to the study, the weight of the seed cotton decreased as the irrigation interval grew. In both years, the D_1 treatment achieved the highest yield, while the D_3 treatment resulted in the lowest yields. In both of the study's years, an increase in irrigation water levels caused an important improve in the weight of seed cotton. The treatments with the highest irrigation water levels produced the most substantial seed cotton, whereas the treatments with the lowest irrigation water levels produced the lowest-weight seed cotton. These findings show how critical effective irrigation management is to be providing beneficial cotton yields. The D_1-I_1 treatment combination provided the highest seed cotton weight, whereas the D_3-I_3 treatment produced the lowest seed cotton weight, even though there was no statistically significant interaction between irrigation interval and irrigation water level on seed cotton weight. The determination of seed cotton weight in previous similar studies was established as 6.32-6.36 g (D. Zhang et al., 2016), 2.60-3.35 g boll^{-1} (Singh et al., 2010). Differences in seed cotton weight were observed between this current research and previous studies. The differences may be due to the preferred variety (Amanov et al., 2022), the amount of irrigation water (Singh et al., 2010), and the fertilizer applied (Shahzad et al., 2019).

The 100 seed weight determined by the watering interval, irrigation levels, and their interaction failed to yield any statistically significant results in either of the study's two years. This indicates that there might not be a significant correlation between these variables and cotton yield in the study's area. It is important to keep in mind that more research may be required to confirm these results and investigate additional potential factors that might influence cotton production. Previous research indicates that the frequency and quantity of irrigation exert a statistically significant impact on the weight of 100 seeds (Basal et al., 2009; Sampathkumar et al., 2013). The observed differences in the 100 seed weights between the current investigation and the prior study could potentially be attributed to varietal distinctions (Mert, 2005).

Table 6. Means and statistical groups for some fiber quality characteristics of treatments

Treatments	Fiber fineness micronaire		Fiber length, mm		Fiber strength, g tex^{-1}		Ginning outturn, %	
	2020	2021	2020	2021	2020	2021	2020	2021
D_1	5.13	5.12	28.43	28.35	30.92	30.56	42.89a	43.33a
D_2	5.21	5.22	28.24	28.10	30.08	30.70	42.22a	41.89b
D_3	5.19	5.28	28.67	28.54	32.48	31.88	40.78b	40.67b
P (Factor A)	ns	ns	ns	ns	ns	ns	**	*
I_1	5.14	5.14	28.46	28.26	30.91	31.20	42.56a	42.78a
I_2	5.21	5.21	28.65	28.28	31.03	31.27	42.11ab	42.00ab
I_3	5.18	5.26	28.24	28.45	31.53	30.67	41.22a	41.11b
P (Factor B)	ns	ns	ns	ns	ns	ns	*	*
D_1-I_1	5.15	5.13	28.44	28.42	30.73	30.7	43.67	44.33
D_1-I_2	5.08	5.06	28.54	28.10	31.10	30.50	42.67	43.00
D_1-I_3	5.16	5.15	28.33	28.53	30.93	30.47	42.33	42.67
D_2-I_1	5.09	5.08	28.14	28.13	30.87	31.33	42.67	43.00
D_2-I_2	5.22	5.24	28.59	27.86	30.73	31.03	42.67	41.67
D_2-I_3	5.31	5.36	28.00	28.29	28.63	29.73	41.33	41.00
D_3-I_1	5.17	5.22	28.80	28.22	31.13	31.57	41.33	41.00
D_3-I_2	5.34	5.33	28.81	28.87	32.77	32.27	41.00	41.33
D_3-I_3	5.07	5.28	28.38	28.54	33.53	31.80	40.00	39.67
P (A*B)	ns	ns	ns	ns	ns	ns	ns	ns

[a]The treatments which have the same letter are not significantly different at the 5% level by Tukey's test.

The main aim of the current study was to examine the effects of irrigation interval and irrigation water level, as well as their combined influence, on fiber fineness. However, the study determined that all applications weren't having a statistically significant effect on the fineness of fibers. Furthermore, it was determined that different amounts of irrigation water could not have any impact on the quality of cotton fiber. Consequently, the impact of certain applications on fiber fineness was found to be insignificant. Furthermore, the findings obtained from the study area showed that the irrigation intervals could not have any significant impact on the cotton fiber fineness. The fineness of fiber might be influenced directly by the variety employed and environmental conditions. To investigate the impact of water on the fineness of cotton fibers, further research is required that covers a greater number of irrigation factors. Papastylianou and Argyrokastritis, (2014) reported that the impact of irrigation water on fiber fineness was not statistically significant. (Basal et al., 2009) determined that the fiber fineness was changed between 4.0-5.0 micronaire.

There was no statistically significant impact of the irrigation interval, irrigation water level, and their interaction on fiber length in both years of the research. According to the results that were obtained from the research participants, it seems obvious that changing the irrigation interval, whether by reducing it or increasing it, wouldn't have a significant impact on the length of cotton fibers. Additional research should be conducted to investigate the correlation between irrigation water and fiber length in cotton crops. Dağdelen et al., (2009) determined that the deficit irrigation had no significant effect on the fiber length. However, water stress during the fiber elongation stage may lead to a reduction in fiber length as a result of the mechanical and physiological effects on cell expansion (Dağdelen et al., 2009; Pettigrew, 2004).

The two years of research results showed that neither the irrigation interval nor the irrigation water level, nor the combination of all three, had a significant impact on the fiber strength. Research results demonstrate that changes in irrigation methods might not have a major effect on the length of cotton fibers. The genetic of the used variety and environmental factors may both have an impact on cotton fiber strength.

The lint yield plays a crucial role in determining the quantity and quality of cotton fibers obtained after harvesting. Therefore, it has become an important component of cotton cultivation. The findings reveal a significant relationship between irrigation intervals ($p \leq 0.01$) in both years of the study. In the first year, there was a statistically significant correlation between irrigation levels ($p \leq 0.05$) and ginning yield, which was also observed in the second year. Additionally, it was determined that there was no statistically significant interaction between irrigation intervals and irrigation water levels on ginning yield. The findings of the study demonstrate a negative relationship between irrigation interval and cotton yield. Particularly, it was observed that ginning yield decreased as the irrigation interval increased. The study showed an increase in ginning yield with an increase in the amount of irrigation water in both years. The highest ginning yield was determined in the D_1-I_1 application, while the lowest yield was obtained in the D_3-I_3 application in both years. The application of the interaction between irrigation interval and irrigation water level did not have a significant effect on ginning yield in the relevant subjects. The results of this study indicate a beneficial relationship between irrigation water consumption and ginning yield.

In research investigating drought stress, the examination of water productivity and irrigation water production holds great importance. The water productivity (WP) and irrigation water productivity (IWP) measures in the current study are given in Figure 2.

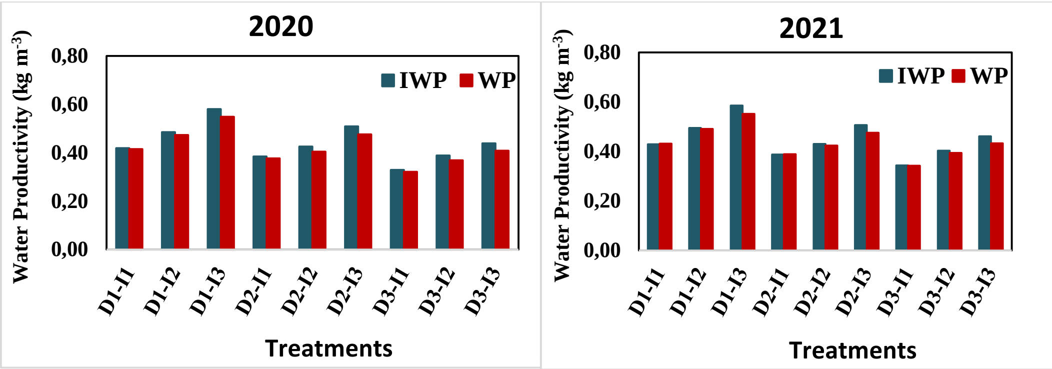

Figure 1. Water productivity and irrigation water production for the treatments

The study revealed that the IWP showed variations in the period of both years, dependent on the quantity of IW and the irrigation interval. The highest IWP value was determined from the D_1-I_3 treatment, and the lowest IWP value was gathered from the D_3-I_1 treatment. The IWP values obtained from the same treatments exhibited a notable similarity across the years. When comparing the IWP values to the WP values, it was observed that the latter exhibited lower values. In the first year, the IWP values ranged between 0.33-0.58 kg m^{-3}, while in the second year, it changed between 0.34 to 0.59 kg m^{-3}. Similar to IWP, the D_1-I_3 treatment provided the highest WP value, while the D_3-I_1 treatment provided the lowest WP value. The values of WP and IWP are rising in arid and semiarid regions. In those areas, there was a lack of sufficient precipitation during the period of cotton cultivation. Furthermore, the amount of ET rises to a degree that exceeds that of various other climatic conditions. Previous studies were determined the WUE as 0.55-0.67 kg m^{-3} (Yazar et al., 2002), 0.84-1.17 kg m^{-3} (Sarı et al., 2010), 0.76-1.06 kg m^{-3} (Yilmaz et al., 2021), and IWUE as 0.81-1.46 kg m^{-3} (Dağdelen et al., 2009), 0.48-1.27 kg m^{-3} (Van Rossum et al., 1997), 0.85-2.42 kg m^{-3} (Yilmaz et al., 2021). The water restriction results in an increase in both WP and IWP (Fan et al., 2018; Yang et al., 2015).

Conclusion

For both years of the study, it was determined that the seasonal irrigation water and plant water consumption amounts for cotton plants ranged between 656-1126 mm and 675-1153 mm, respectively. It was observed that the water consumption of cotton plants increased in proportion to the amount of irrigation water applied. The conducted study revealed that different irrigation water levels had a significant impact on seed cotton yield, seed cotton weight, 100 seed weight, and ginning outturn. On the other hand, it was determined that the amount of irrigation water had no significant effect on important parameters of cotton fiber quality, such as fiber fineness, fiber length, and fiber strength. At the end of the study, it was concluded that in order to avoid any negative impact on seed cotton yield and yield components, the irrigation interval for cotton plants should be make at four days. In cotton cultivation, it is recommended to use a K_p coefficient of 1.50 under conditions where irrigation water is abundant and unrestricted. However, under conditions of limited irrigation water, a minimum K_p of 1.20 is necessary for cotton plants. In places where high temperatures and low relative humidity prevail, the preference for modern irrigation methods such as surface or subsurface drip irrigation is of importance in terms of water conservation.

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