Çukurova Tarım Gıda Bil. Der. Çukurova J. Agric. Food Sci.
40(1):107-118
doi: 10.36846/CJAFS.2025.182

Research Article

The Effect of Deficit Water Applications on Yield Components and Fiber Quality Characteristics of Cotton (*Gossypium hirsutum* L.)

Selim YAŞA[1], Korhan ÖZCEYLAN[*2], Özgül GÖRMÜŞ[2]

ABSTRACT

The aim of this study was to investigate the effects of different irrigation levels on yield and fiber quality characteristics of cotton cultivars. The research was conducted at Cukurova University, Faculty of Agriculture, Field Crops Research and Experiment Station located in Sarıcam district of Adana during the 2021 growing season. The experiment included three different water applications (I_{25}, I_{50}, and I_{100}) determined based on measurements of yield components. Four cultivars (Fiona, May 344, May 455, and May 505) were widely grown in the region used in the study. The results showed that plant height, number of sympodial branches and bolls, 100 seed weight, ginning yield, seed cotton yield, fiber length, and fiber strength were significantly reduced with increasing water stress in irrigation water. May 455 variety showed more suitable fiber fineness in I_{25} irrigation treatment. The May455 cultivar can be recommended as a promising alternative for the coarse fiber problem, which is one of the biggest challenges in the textile industry. Finally, in the semi-arid climate zone of the Çukurova region, full irrigation practices remain advantageous for cotton production when water resources are abundant. However, this study shows that a 50% reduction in irrigation treatment can still provide acceptable fiber quality parameters for the textile industry. Therefore, in water scarcity scenarios, a 50% curtailment irrigation practice (I_{50}) is recommended for cotton cultivation in the region.

Keywords: Water stress, Yield components, Fiber quality, Irrigation practices

Kısıntılı Su Uygulamalarının Pamuğun (*Gossypium hirsutum* L.) Verim Bileşenleri ve Lif Kalite Özellikleri Üzerine Etkisi

ÖZ

Bu çalışmanın amacı, farklı sulama düzeylerinin pamuk çeşitlerinde verim ve lif kalite özellikleri üzerine etkilerini araştırmaktır. Araştırma, 2021 yetiştirme sezonunda Adana'nın Sarıçam ilçesinde bulunan Çukurova Üniversitesi Ziraat Fakültesi Tarla Bitkileri Araştırma ve Deneme İstasyonunda yürütülmüştür. Deneme, verim bileşenlerinin ölçümlerine dayalı olarak belirlenen üç farklı su stresi seviyesini (I_{25}, I_{50} ve I_{100}) içermektedir. Çalışmada bölgede yaygın olarak yetiştirilen dört çeşit (Fiona, May 344, May 455 ve May 505) kullanılmıştır. Sonuçlar, sulama suyunda su stresi arttıkça bitki boyu, meyve dalı ve koza sayısı, 100 tohum ağırlığı, çırçır randımanı, kütlü pamuk verimi, lif uzunluğu ve lif mukavemetinde önemli ölçüde azalma olduğunu göstermiştir. May 455 çeşidi I_{25} sulama konusunda arzu edilir seviyede lif inceliği göstermiştir. Tekstil endüstrisindeki en büyük zorluklardan biri olan kaba lif sorunu için May455 çeşidi umut verici bir alternatif olarak önerilebilir. Son olarak, Çukurova bölgesinin yarı kurak iklim kuşağında, su kaynakları bol olduğunda tam sulama uygulamaları pamuk üretimi için avantajlı olmaya devam etmektedir. Bununla birlikte, bu çalışma, sulama suyu miktarında %50'lik bir azalmanın yine de tekstil endüstrisi için kabul edilebilir lif kalitesi parametreleri sağlayabileceğini göstermektedir. Bu nedenle, su kıtlığı senaryolarında, bölgede pamuk yetiştiriciliği için %50 kısıntılı sulama uygulaması (I_{50}) önerilmektedir.

Anahtar Kelimeler: Su stresi, Verim bileşenleri, Lif kalitesi, Sulama uygulamaları

ORCID ID (Yazar sırasına göre)
0009-0007-1925-4464, 0000-0003-0226-6198, 0000-0003-2214-6708

Yayın Kuruluna Geliş Tarihi: 27.11.2024
Kabul Tarihi: 18.04.2025

[1] Çukurova Üniversitesi, Fen Bilimleri Enstitüsü
[2] Çukurova Üniversitei, Ziraat Fakültesi, Tarla Bitkileri Bölümü
*E-posta: kozceylan@cu.edu.tr

The Effect of Deficit Water Applications on Yield Components and Fiber Quality Characteristics of Cotton (*Gossypium hirsutum* L.)

Introduction

Cotton is one of the world's most important industrial crops, producing natural fiber and vegetable oil, and it is highly adaptable to many climates. However, current cotton varieties grown as annuals experience serious problems in plant morphology, physiology, metabolism, and production caused by water stress at all stages of growth, especially during flowering (Pettigrew, 2004). Intensive selection for high fiber yields has resulted in modern cotton varieties. However, the genetic variability in drought tolerance and in the efficiency of water use tends to be reduced by this selection. Cotton species *G. hirsutum* and *G. barbadense* exhibit significant differences in physiological traits such as water use efficiency and photosynthetic rate. Adequate water availability for optimum plant growth and development is critical in cotton production (Radin et al., 1992).

As the impact of global climate change intensifies, water resources for crop production are progressively declining (Barnabás et al., 2008). Therefore, it is crucial to understand how drought stress induces alterations in the ecological and morphological characteristics of the cotton plant (dos Santos et al., 2022). The response of a plant species to water stress can vary significantly depending on the specific plant and the stage of its growth cycle (Saini, 1999). Drought affects photosynthesis by reducing CO2 assimilation, leaf water potential, and stomatal conductance. As a result, the proportion of assimilates available for photosynthesis is reduced, which in turn affects growth and development, leading to decreased yields (Dias et al., 2018; Asif et al., 2023).

The interval between squaring and flowering is critical to the growth and development of cotton plants (Oosterhuis, 1990). Pettigrew (2004) notes that drought stress, which can occur during this period, negatively affects cotton yield. In conclusion, the morphological and physiological processes of the plant under drought are correlated with a decline in cotton yield. Drought stress affects both fiber quality and yield (Tunalı et al., 2019). The primary objective for cotton growers is the quality of the fiber, given the increased demand for quality fiber resulting from developments in the textile industry (Wendel & Cronn, 2003). Many researchers have reported that drought during the cotton fiber elongation period negatively affects fiber fineness, fiber length, and fiber strength (Mert, 2005; Basal et al., 2009;). However, it has also been reported that fiber properties are not sensitive unless water stress is very severe (Roth et al., 2013).

One of the most important strategies in areas where water is limited, and irrigation opportunities are restricted is implementing efficient irrigation practices. Since cotton is a water-intensive crop, much research has been conducted on the effects of water deficit on cotton in our country (Tunalı et al., 2019; Goren & Basal, 2020; Odabasıoglu & Copur, 2023; Tuylu & Akın, 2023). Research shows that when water is limited, low yields are observed in plants that use a lot of water. Consequently, the principal objective of research in diverse climates is to ascertain the quantity of irrigation water required to minimize yield loss.

This study was conducted to investigate the yield and fiber quality characteristics of cotton cultivars under water stress conditions induced by different irrigation levels using a drip irrigation system in the Cukurova region.

Materials and Method

The study was conducted at the experimental area of the Department of Field Crops at Cukurova University, in the cotton growing season of 2021, with 3 replications according to the split plot experiment design within a Randomized Complete Block Design (RCBD), with irrigation levels as the main plots (I_{25}, I_{50} and I_{100}) and cultivars as the subplots. Plots consisted of four rows spaced 70x10 cm apart and 7 m in length. Cotton (*G. hirsutum* L.) cultivars, Fiona, May344, May455 and May505, which are widely cultivated in the region, were used as plant material (Table 1). The area is known for its Mediterranean climate, which is defined by hot, dry summers and mild, rainy winters. The experimental site's soil had a low salt content of 0.27 mmhos/cm and was primarily clay-loam in composition. The weed management strategy involved the use of pre-sowing herbicides. Other cultural practices were performed in accordance with local practices.

Table 1. Some information about cotton cultivars.

Cultivars	LP (%)	FL (mm)	FS (g/tex)	Earliness	Drought	Source
Fiona	44-46	30-32	33-35	Mid-Lately	Tolerant	BASF®
May344	41-43	29-31	29-31	Early	Tolerant	MAY Seed®
May455	44-46	31-32	32-35	Early	Tolerant	MAY Seed®
May505	43-45	31-32	32-36	Mid-Early	Tolerant	MAY Seed®

LP: Lint Percentage, FL: Fiber Length, FS: Fiber Strength

Irrigation treatments

Replacement of soil water consumption is the basis for irrigation practices. The term "consumption" is defined as the difference between the depth of water retained in the root zone at the time of irrigation and the depth of water retained in the root zone at field capacity. The irrigation treatments were the full irrigation treatment (I_{100}) and the deficit irrigation treatment (I_{50} and I_{25}). Under full irrigation (I_{100}), soil moisture was monitored and when 40% of the available moisture in the 120 cm soil profile was consumed, enough irrigation water was applied to restore the losing moisture to the field capacity. The first irrigation was performed when 40% of the available capacity had been reached, and subsequent irrigations were performed considering the total evapotranspiration over an 8-day irrigation interval. 50% and 25% of the amount given to the full irrigation treatment was applied to the deficit irrigation treatment. Soil moisture in the treated plots was monitored at one-week intervals, using the gravimetric method. The wet weights of the soils taken from 0-30, 30-60 and 60-90 cm depths at 5-day intervals were weighed, dried in an oven at 105 ºC to constant weight, and the soil moisture was determined as a percentage by weight. While determining the amount of irrigation water given to the plots in each irrigation, the available water holding capacity of the soil was determined in terms of depth (Keten et al., 2019). The amount of irrigation water to be applied was calculated using Class A pan, plant pan coefficients and wetting percentage values. For this purpose, cumulative open water surface evaporation values measured at Class A pan irrigation intervals were used (Tuylu & Akın, 2023). The amount of irrigation water was calculated the following equation 1:

$$I = A \times Ep \times Kcp \times P \quad (1)$$

I : Amount of irrigation water (L),

A: Parcel area (m2),

Ep : Cumulative evaporation at irrigation intervals (mm, Class A Pan),

Kcp : Plant-pan coefficient,

P : Percent Cover (%)

In the study, the percentage of wetted area value (P) was taken as 100% for hoe crops planted in the row. The first irrigation was applied 71 days after sowing, when 40% of the available water holding capacity had been used, the next irrigations were applied according to the 8-day irrigation interval and the last irrigation was applied 128 days after sowing. The total amount of irrigation water applied to each subject was 690 mm for I_{100}, 350 mm for I_{50} and 175 mm for I_{25} (Table 2). Irrigation water was provided by a drip irrigation system. In the study, the gaps left to prevent infiltration were determined as 3 m among the blocks and 2 m among the plots.

Table 2. ET_0 (mm), Total Irrigation Water (mm) and Total Rainfall (mm)

Irrigation Application	ET_0(mm)	Total Irrigation Water (mm)	Total Rainfall (mm)
I_{100}	748	690	
I_{50}	408	350	58
I_{25}	233	175	

Measurement of seedcotton yield (kg ha^{-1}) and morphological characteristics

The yield was determined by harvesting the central two rows of each plot by hand and subsequently weighing the seedcotton. The plant height, number of sympodial branches, number of bolls per plant were measured on 10 randomly selected plants from each plot, and the results were averaged. The lint percentage and 100 seed weight characteristics were determined from a random sample of 30 bolls from each replication. The 100 seed weight value was determined by weighing the seeds obtained from ginned cotton samples in groups of four on a balance with a sensitivity of 0.01 g. Lint percentage was measured using the following equation 2:

$$\text{Lint Percentage (\%)} = [LW / SCW] \times 100 \qquad (2)$$

LW: Lint Weight (g)

SCW: Seedcotton Weight (g)

Measurements of fiber quality characteristics

The fiber technological properties, including fiber length (mm), fiber fineness (mic) and fiber strength (g/tex), were determined by the HVI 1000 device using 30 bolls randomly selected from each replication.

Statistical analysis

Statistical analysis of the data was performed using MSTAT-C software. The LSD test was used to compare the difference between means.

Results and discussion

Plant height (cm)

Mean plant height varied significantly between irrigation levels, with the tallest plants being 126.7 cm at I_{100}, followed by a significant difference at I_{50} (113.1 cm) and the shortest plants (88.4 cm) at I_{25} (Table 3). Plant height is sensitive to water availability during the plant's growth and development. Therefore, cotton plant growth slows under deficit irrigation conditions, and plant height remains short (Saleem et al., 2016).

Plant height varied between 104.2 cm and 115.4 cm between cultivars, the highest plant height being 115.4 cm for variety May 505, followed by variety May 344 with a significant difference, and the shortest plant height being 104.2 cm for variety Fiona (Table 3). Differences in height between cultivars may be due to differences in the genetic structure of the cultivars and their different responses to cultural practices. The effect of irrigation level on plant height was more pronounced for the mid-late variety (Fiona). This may be because it has a longer growing season than the early cultivars and therefore requires more water. Similar findings were reported by Ödemis et al., 2018; Ekinci & Basbag, 2019; Uzen et al., 2019.

Seedcotton yield (kg ha^{-1})

The highest seedcotton yield (4549.2 kg ha^{-1}) was obtained from full irrigation (I_{100}), followed by I_{50} (3372.5 kg ha^{-1}), and the lowest seedcotton yield (2349.2 kg ha^{-1}) was obtained from I_{25} (Table 3). There was a significant reduction in seedcotton yield in the I_{50} plots exposed to water deficit compared to the full irrigation plots. Our findings confirm with Basal et al., 2009; Hu et al., 2018; Karademir et al., 2011; Papastylianou

& Argyrokastritis, 2014. Water stress caused significant reductions in boll number, boll weight (not given) and lint percentage, which are important yield components, compared to the full irrigation treatment, resulting in low seedcotton yield. The appropriate level of irrigation contributed to the accumulation of photosynthetic products, which had a positive effect on the number of sympodial branches and the growth of bolls. According to a previous study, assimilate accumulation promoted the activity of plant roots and physiological development, resulting in an increase in seedcotton yield (Kumar et al., 2022).

Seedcotton yield ranged from 3164.4 kg ha^{-1} to 3640 kg ha^{-1} among the cultivars, with cultivar May 505 having the highest yield of 3640 kg ha^{-1}. The seedcotton yields of Fiona and May 455 were similar and significantly lower than those of variety May 505, and the lowest seedcotton yield of 3164.4 kg ha^{-1} was observed for variety May 344 (Table 3). Differences in seedcotton yield between cultivars may be due to differences in the genetic structure of the cultivars and different irrigation water levels.

Table 3. Mean plant height (cm), seedcotton yield (kg ha^{-1}), number of sympodial branch, number of bolls, lint percentage (%) and 100 seed weight (g) values obtained from different cultivars and level of irrigation water applied in 2021.

Variations	Plant height (cm)	Seedcotton yield (kg ha^{-1})	No. of sympodial branches	No. of bolls	Lint percentage (%)	100 Seed weight (g)
Cultivars (C)						
Fiona	104.2 ^{d}	3455.6 ^{b}	13.72 ^{a}	12.63 ^{b}	42.09	10.44
May344	110.6 ^{b}	3164.4 ^{c}	12.61 ^{b}	10.97 ^{d}	41.28	10.77
May455	107.3 ^{c}	3455.6 ^{b}	12.84 ^{b}	11.98 ^{c}	41.91	10.29
May505	115.4 ^{a}	3640 a	14.08 ^{a}	13.51 ^{a}	41.84	10.6
LSD(0.05)	**2.99**	**14.31**	**0.55**	**0.54**	**NS**	**NS**
Irrigation (I)						
I_{25}	88.4 ^{c}	2349.2 ^{c}	10.12 ^{c}	6.84 ^{c}	38.94 ^{c}	8.75 ^{c}
I_{50}	113.1 ^{b}	3372.5 ^{b}	13.72 ^{b}	11.61 ^{b}	42.27 ^{b}	10.73 ^{b}
I_{100}	126.7 ^{a}	4549.2 ^{a}	16.09 ^{a}	18.37 ^{a}	44.13 ^{a}	12.10 ^{a}
LSD(0.05)	**12.62**	**269.2**	**0.37**	**1.56**	**1.07**	**0.28**
İnteraction (IxC)						
I_{25}xFiona	87.3 ^{f}	2366.7 ^{f}	10.5 ^{e}	7.13	38.57	8.53
I_{25}xMay344	84.7 ^{f}	2236.7 ^{f}	8.47 ^{f}	5.83	38.83	8.37
I_{25}xMay455	82.7 ^{f}	2336.7 ^{f}	9.8 ^{e}	6.43	39.33	9
I_{25}xMay505	99.0 ^{e}	2456.7 ^{f}	11.77 ^{d}	7.97	39.03	9.1
I_{50}xFiona	106.7 ^{d}	3376.7 ^{de}	14.63 ^{b}	11.93	43.1	10.63
I_{50}xMay344	115.0 ^{bc}	3243.3 ^{e}	13.67 ^{c}	9.57	41.7	10.73
I_{50}xMay455	111.7 ^{cd}	3346.7 ^{de}	12.33 ^{d}	11.5	42.47	10.8
I_{50}xMay505	119.0 ^{b}	3523.3 ^{d}	14.23 ^{bc}	13.43	41.8	10.73
I_{100}xFiona	118.7 ^{b}	4623.3 ^{b}	16.03 ^{a}	18.33	44.6	12.17
I_{100}xMay344	132.0 ^{a}	4013.3 ^{c}	15.7 ^{a}	17.5	43.3	11.77
I_{100}xMay455	127.7 ^{a}	4620 ^{b}	16.4 ^{a}	18	43.93	12.5
I_{100}xMay505	128.3 ^{a}	4940 ^{a}	16.23 ^{a}	19.13	44.7	11.97
LSD(0.05)	**5.18**	**24.78**	**0.95**	**NS**	**NS**	**NS**
Grand mean	**109.39**	**3423.6**	**13.31**	**12.27**	**41.78**	**10.53**

NS: Not significant, LSD: Least significant differences

Number of sympodial branches

The highest number of sympodial branches per plant was in the I_{100} trial with 16.09 number plant^{-1}, followed by the I_{50} trial with a significant difference (13.72), and the lowest number of sympodial branches was in the I_{25} trial with 10.13 (Table 3). This result shows that cotton is a plant with indeterminate growth characteristics and that it forms a greater number of sympodial branches more quickly and a greater number of sympodial branches under full irrigation conditions.

When considering the number of sympodial branches among the cultivars, it was observed that it varied between 12.61 and 14.08. The highest number of sympodial branches was recorded in May 505 (14.08) and Fiona (13.72), while the lowest number of sympodial branches was recorded in May 455 (12.84) and May 344 (12.61) (Table 3). Differences are attributed to responses to different irrigation practices. Similar to this study, previous studies reported that the highest number of sympodial branches occurred in full irrigation subjects (Tunalı et al., 2019), while different irrigation water amounts were reported to have no effect on sympodial branch number (Uzen et al., 2019).

Lint Percentage (%)

The lint percentage value decreased significantly due to the irrigation water deficit, and the highest value was obtained from the I_{100} trial with 44.13% and the lowest value was obtained from the I_{25} trial with 38.94% (Table 3). It is thought that the enhancement in ginning yield observed in conjunction with full irrigation application is attributable to the augmentation in dry matter production and cellulose accumulation. However, these results contradict the results of the study, which reported a 3% increase in lint percentage under water stress conditions compared to the irrigated treatment (Mert, 2005).

Differences among cultivars in lint percentage are not significant, with average lint percentage ranging from 41.28% (May 344) to 42.09% (Fiona) (Table 3). The results of this study do not agree with those of Pettigrew (2004), who reported that lint percentage increased in some varieties and decreased in others under different irrigation conditions.

Number of bolls

When the boll number per plant values were considered in relation to irrigation levels, it was found that the number of bolls decreased significantly as the applied water levels decreased.

The highest number of bolls occurred in I_{100} with 18.37, and the lowest number of bolls occurred in I_{25} with 6.84 (Table 3). This result is due to the indeterminate growth characteristic of the cotton plant, which results in a rapid and higher number of bolls under full irrigation conditions. Under drought stress, photosynthetic activity and plant dry matter content are adversely affected because of stomatal closure in cotton plants, leaf area development is slowed, shrinkage increases due to low assimilate accumulation in the bolls, and thus boll number decreases (Lokhande & Reddy, 2014; Wang et al., 2016; Shareef et al., 2018).

The differences in the number of bolls among the cultivars were not significant, ranging from 10.97 to 13.51. The highest number of bolls was observed in variety May 505, with 13.51, and the lowest number of bolls was observed in variety May 344, with 10.97 (Table 3). This result might have been due to the different responses of the cultivars to irrigation levels. As irrigation water levels increase, dry matter accumulation in the bolls increases in the outer and upper parts of the plant, away from the main stem. In contrast, the relative rate of accumulation in the upper bolls depends primarily on the variety (Pettigrew, 2004; Snowden et al., 2013).

100 Seed Weight (g)

The 100 seed weight decreased significantly due to the irrigation water deficit and the highest 100 seed weight value obtained from I_{100} with 12.10 g and the lowest 100 seed weight was obtained from I_{25} with 8.75 g. The differences in 100 seed weight among cultivars were not significant, with mean 100 seed weights of 10.29 g (May 344) and 10.77 g (May 455). (Table 3). In moisture in in the effective root depth of the plant was met increased (Ozkara & Sahin, 1993). 100 seed weight increased in full irrigation condition (Tunalı et al., 2019); 100 seed weight did not show any change in reduced irrigation. Different studies, 100 seed weight was found to be affected by water stress and varieties (Mert, 2005), 100 seed weight values were found between 9.31 and 11.20 in different irrigation methods and programs (Dagdelen et al., 2009), (Peynircioglu, 2014), 100 seed weight values were found to vary depending on the number and amount of irrigation water in irrigation subjects where 100%, 66%, 33% of the missing moisture in the effective root depth of the plant was met increased (Ozkara & Sahin, 1993).

Fiber Length (mm)

The values of the fiber length varied between 28.85 - 32.65 mm in relation to the water levels (Table 4). A significant increase in fiber length values was observed. This was due to the increase in water levels. The highest fiber length value was obtained in $I_{100,}$ and the lowest fiber length value was obtained in I_{25}. Gao et al. (2020) reported that sucrose content and sucrose synthase activity decreased under moderate and severe drought conditions, resulting in low turgor pressure and a reduction in fiber length. During the early stages of fiber development, moisture deficiency affects fiber length and uniformity by altering various mechanical and physiological processes of cell elongation (Bradow & Davidonis, 2000). Similar to our study, water stress was reported to affect fiber length (Pettigrew, 2004, Hussein et al., 2011), while some studies reported no significant effect of stress (Karademir et al., 2011).

The highest fiber length value among the cultivars was found in Fiona with 31.88 mm, followed by cultivar May-455 with an insignificant difference, while the fiber length values of cultivars May-505 and May-344 were similar and lower (Table 4). When the values were examined, all the cultivars were classified into the long fiber group (Anonymous, 1997), and all the fiber values obtained can be utilized in the textile industry. The fiber length values obtained under both I_{100} and I_{50} irrigation conditions also fall within the long fiber group. In other words, reducing the irrigation amount by 50% did not have a negative effect on fiber length. According to previous studies, some researchers reported that the responses of cotton genotypes to irrigation levels were quite significant (Karademir et al., 2011; Snowden et al., 2013; Avsar, 2019), while some researchers reported that fiber length did not vary significantly among cultivars (Ullah et al., 2017).

Fiber Fineness

Fiber fineness values varied between 4.03 and 5.47 in relation to water levels (Table 4). A significant increase in fiber fineness was observed with full irrigation compared to limited irrigation. Compared to I_{100}, the fiber fineness values for I_{50} and I_{25} were 0.67 and 1.44, respectively. Water deficit leads to the production of finer fibers, which are ideal for use in the textile industry, as evidenced by these values. According to previous studies, water stress was reported to increase the micronaire value (Pettigrew, 2004; Balkcom et al., 2006; Snowden et al., 2013; Zhang et al., 2016), while others studies reported a decrease, similar to this study (Ramey, 1982; Mert, 2005; Wang et al., 2016). The existing literature about fiber fineness responses to water stress is inconclusive. Water stress has been shown to either decrease fineness (Pettigrew, 2004) or increase it (Bradow & Davidonis, 2000), with no impact being observed in other cases (Booker et al., 2006). However, a substantial body of research has identified a negative correlation between micronaire and irrigation level (Elms et al. 2001; Balkcom et al. 2006). Economically, fiber is an important component of the cotton plant. Managing fiber quality during production is a very important issue. Micronaire, a highly required property in the textile industry, is a direct measurement of cotton maturity and fineness. Fiber fineness values are classified as 3-3.9 fine, 4-4.9 medium, and 5–5.9 rough (Anonymous, 1997). According to this classification, the fiber fineness values obtained from applying water deficit in the study were in the 'medium' fiber group.

Table 4. Mean fiber length (mm), fiber fineness (mic.) and fiber strength (g/tex) values obtained from different cultivars and level of irrigation water applied in 2021.

Variations	Fiber lenght (mm)	Fiber fineness	Fiber strenght (g/tex)
Cultivars (C)			
Fiona	30.0 [b]	4.8	32.09 [a]
May344	30.64 [ab]	4.73	30.82 [c]
May455	31.18 [a]	4.73	31.36 [b]
May505	30.44 [b]	4.8	32.41 [a]
LSD(0.05)	0.72	NS	0.45
Irrigation (I)			
I_{25}	28.85 [c]	4.03 [c]	29.20 [c]
I_{50}	30.20 [b]	4.8 [b]	31.39 [b]
I_{100}	32.65 [a]	5.47 [a]	34.42 [a]
LSD(0.05)	1.32	0.14	0.51
Interaction (IxC)			
I_{25}xFiona	29.27	4.14 [d]	29.93
I_{25}xMay344	28.67	4.05 [de]	28.2
I_{25}xMay455	29.13	3.86 [e]	28.87
I_{25}xMay505	28.33	4.09 [d]	29.8
I_{50}xFiona	30.9	4.75 [c]	31.93
I_{50}xMay344	29.03	4.61 [c]	30.67
I_{50}xMay455	30.23	4.77 [c]	30.8
I_{50}xMay505	30.63	5.06 [b]	32.17
I_{100}xFiona	33.37	5.51 [a]	34.4
I_{100}xMay344	32.3	5.54 [a]	33.6
I_{100}xMay455	32.57	5.57 [a]	34.4
I_{100}xMay505	32.37	5.26 [b]	35.27
LSD(0.05)	**NS**	**0.22**	**NS**
Grand Mean	**30.57**	**4.77**	**31.67**

NS: Not significant, LSD: Least significant differences

Fiber Strength (g/tex)

Fiber strength is an expression in 'g' of the force required to break a 'tex' unit volume of fiber bundle and is determined by genotype (Basra & Malik, 1984). The secondary wall thickening stage, which is the stage after the fiber elongation stage, provides strength to cotton fibers (Ruan, 2007).

In this study, fiber strength values varied between 29.20 and 34.42 g/tex according to the water levels, and fiber breaking strength increased as the water level increased (Table 4). Water stress leads to a lower accumulation of photosynthates produced in cotton plants in the reproductive organs. This results in less assimilation accumulation, especially in developing bolls. Moreover, this unbalanced accumulation of assimilates leads to competition between seeds and fiber cells in the bolls. As a result of this competition, fiber strength may be affected (Shareef et al., 2018). Similarly, in our study, it was observed that water stress affected fiber strength.

The highest fiber strength value among the cultivars was found in variety May505 with 32.41 g/tex, followed by variety Fiona with an insignificant difference, while the fiber strength value of May-344 variety was the lowest. (Table 4). Strikingly, these values were in a very strong class (Anonymous, 1997) and were within acceptable limits for the textile industry.

Conclusion

Plant height, number of sympodial branches, number of bolls, seed cotton yield, fiber length and fiber strength showed significant differences between cultivars, while 100 seed weight, lint percentage and fiber fineness were not significantly affected. However, as the amount of water applied decreased, there was a significant decrease in all the traits studied. In the semi-arid climate zone of Çukurova region, full irrigation practices continue to be advantageous for cotton production when water resources are abundant. However, this study shows that a 50% reduction in water can still provide acceptable fiber quality parameters for the textile industry. The May455 variety can be suggested as a promising alternative for the coarse fiber problem, which is one of the major challenges in the textile industry.

Acknowledgments

This study is part of the first author's master thesis. The authors are grateful to BASF and May Seed for providing the materials.

References

Anonymous, (1997) High Volume Instruments (HVI) Catalog. Costumer information service, No: 40, Volume May, Sweden.

Asif, M., Khan, A. A., Cheema, H. M. N., Khan, S. H., & Iqbal, Z. (2023). Cotton Germplasm Characterization for Drought Tolerance Based on Morpho-Physiological and Fiber Quality Parameters. *Sabrao Journal of Breeding and Genetics*, *55*(4), 1079–1093. https://doi.org/10.54910/sabrao2023.55.4.6

Avşar, Ö. (2019). Pamukta Bazi Fizyolojik Parametreler İle Verim Ve Lif Kalite Özelliklerinin Su Stresi Koşullarinda Değerlendirilmesi. In *Siirt Üniversitesi Fen Bilimleri Enstitüsü* (Vol. 1, Issue 1). Siirt Üniversitesi.

Balkcom, K. S., Reeves, D. W., Shaw, J. N., Burmester, C. H., & Curtis, L. M. (2006). Cotton yield and fiber quality from irrigated tillage systems in the Tennessee Valley. *Agronomy Journal*, *98*(3), 596–602. https://doi.org/10.2134/agronj2005.0219

Barnabás, B., Jäger, K., & Fehér, A. (2008). The effect of drought and heat stress on reproductive processes in cereals. *Plant, Cell and Environment*, *31*(1), 11–38. https://doi.org/10.1111/j.1365-3040.2007.01727.x

Basal, H., Dagdelen, N., Unay, A., & Yilmaz, E. (2009). Effects of deficit drip irrigation ratios on cotton (Gossypium hirsutum L.) yield and fibre quality. *Journal of Agronomy and Crop Science*, *195*(1), 19–29. https://doi.org/10.1111/j.1439-037X.2008.00340.x

Basra, A. S., & Malik, C. P. (1984). *Development of the Cotton Fiber* (G. H. Bourne, J. F. Danielli, & K. W. Jeon (eds.); Vol. 89, pp. 65–113). Academic Press. https://doi.org/https://doi.org/10.1016/S00

74-7696(08)61300-5

Bradow, J. M., & Davidonis, G. H. (2000). Quantitation of Fiber Quality and the Cotton Production-Processing Interface : In *Processing* (Vol. 64, pp. 34–64).

Booker JD, Bordovsky JR, Lascano J, Segarra E (2006) Variable rate irrigation on cotton lint yield and fi ber quality. In: Proceedings of Beltwide Cotton Conference. San Antonio, Texas, pp. 17681776.

Dağdelen, N., Başal, H., Yilmaz, E., Gürbüz, T., & Akçay, S. (2009). Different drip irrigation regimes affect cotton yield, water use efficiency and fiber quality in western Turkey. *Agricultural Water Management*, *96*(1), 111–120. https://doi.org/10.1016/j.agwat.2008.07.003

Derrick M. Oosterhuis. (1990). No Title. In D. M. O. W.N. Miley (Ed.), *Cover crops and Soil Ecosystem Services* (pp. 1–24). https://doi.org/10.2134/1990.nitrogennutritionofcotton.c1

Dias, M. C., Correia, S., Serôdio, J., Silva, A. M. S., Freitas, H., & Santos, C. (2018). Chlorophyll fluorescence and oxidative stress endpoints to discriminate olive cultivars tolerance to drought and heat episodes. *Scientia Horticulturae*, *231*(December 2017), 31–35. https://doi.org/10.1016/j.scienta.2017.12.007

dos Santos, T. B., Ribas, A. F., de Souza, S. G. H., Budzinski, I. G. F., & Domingues, D. S. (2022). Physiological Responses to Drought, Salinity, and Heat Stress in Plants: A Review. *Stresses*, *2*(1), 113–135. https://doi.org/10.3390/stresses2010009

Ekinci, R., & Başbağ, S. (2019). Determination of effects of deficit irrigation on some morphological properties of cotton (G. hirsutum l.). *Yuzuncu Yil University Journal of Agricultural Sciences*, *29*(4), 792–800. https://doi.org/10.29133/yyutbd.621589

Elms MK, Green CJ, Johnson PN (2001) Variability of cotton yield and quality. Commun Soil Sci Plant Anal 32: 351-368.

Gao, M., Snider, J. L., Bai, H., Hu, W., Wang, R., Meng, Y., Wang, Y., Chen, B., & Zhou, Z. (2020). Drought effects on cotton (Gossypium hirsutum L.) fibre quality and fibre sucrose metabolism during the flowering and boll-formation period. *Journal of Agronomy and Crop Science*, *206*(3), 309–321. https://doi.org/10.1111/jac.12389

Gören, H. K., & Başal, H. (2020). Kısıntılı ve Tam Sulama Koşullarında Verim ve Lif Kalitesi Bakımından Üstün İleri Pamuk (Gossypium hirsutum L.) Hatlarının Seleksiyonu. *Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi*, *17*(2), 199–206. https://doi.org/10.25308/aduziraat.702803

Hu, W., Snider, J. L., Wang, H., Zhou, Z., Chastain, D. R., Whitaker, J., Perry, C. D., & Bourland, F. M. (2018). Water-induced variation in yield and quality can be explained by altered yield component contributions in field-grown cotton. *Field Crops Research*, *224*(1), 139–147. https://doi.org/10.1016/j.fcr.2018.05.013

Hussein, F., Janat, M., & Yakoub, A. (2011). Assessment of yield and water use efficiency of drip-irrigated cotton (Gossypium hirsutum L.) as affected by deficit irrigation. *Turkish Journal of Agriculture and Forestry*, *35*(6), 611–621. https://doi.org/10.3906/tar-1008-1138

Karademir, C., Karademir, E., Ekinci, R., & Berekatoğlu, K. (2011). Yield and fiber quality properties of cotton (Gossypium hirsutum L.) under water stress and non-stress conditions. *African Journal of Biotechnology*, *10*(59), 12575–12583. https://doi.org/10.5897/ajb11.1118

Keten, M., Değirmenci, H., & Güvercin, R. Ş. (2019). Kısıntılı Sulama Koşullarında Bazı Pamuk (Gossypium hirsutum L.) Genotiplerinin Kuraklık Toleransının Belirlenmesi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, *22*(5), 685–693. https://doi.org/10.18016/ksutarimdoga.vi.509483

Kumar, R., Pareek, N. K., Kumar, U., Javed, T., Al-Huqail, A. A., Rathore, V. S., Nangia, V., Choudhary, A., Nanda, G., Ali, H. M., Siddiqui, M. H., Youesf, A. F., Telesiński, A., & Kalaji, H. M. (2022). Coupling

Effects of Nitrogen and Irrigation Levels on Growth Attributes, Nitrogen Use Efficiency, and Economics of Cotton. *Frontiers in Plant Science*, *13*(May), 1–12. https://doi.org/10.3389/fpls.2022.890181

Lokhande, S., & Reddy, K. R. (2014). Reproductive and fiber quality responses of upland cotton to moisture deficiency. *Agronomy Journal*, *106*(3), 1060–1069. https://doi.org/10.2134/agronj13.0537

Mert, M. (2005). Irrigation of cotton cultivars improves seed cotton yield, yield components and fibre properties in the Hatay region, Turkey. *Acta Agriculturae Scandinavica Section B: Soil and Plant Science*, *55*(1), 44–50. https://doi.org/10.1080/09064710510008658

Odabasıoglu, C., & Copur, O. (2023). The effect of different nitrogen doses and water levels on the yield and yield components of cotton. *Journal of Plant Nutrition*, *46*(15), 3643–3652. https://doi.org/10.1080/01904167.2023.2209119

Ödemiş, B., Kazgöz, D. C., Dellice, H., & Karazincir, K. (2018). Hatay Koşullarında Farklı Su Stres Düzeylerinin Pamuk (Gossypium Hirsutum L.) Bitkisinde Verim ve Vejetatif Özelliklere Etkilerinin Belirlenmesi. *Mustafa Kemal Üniversitesi Ziraat Fakültesi Dergisi*, *23*(1), 58–75.

Osborne, S., & Banks, J. C. (2006). *the Effects of Water Stress During Bloom*. 2005–2006.

Papastylianou, P. T., & Argyrokastritis, I. G. (2014). Effect of limited drip irrigation regime on yield, yield components, and fiber quality of cotton under Mediterranean conditions. *Agricultural Water Management*, *142*, 127–134. https://doi.org/10.1016/j.agwat.2014.05.005

Pettigrew, W. T. (2004). Moisture deficit effects on cotton lint yield, yield components, and boll distribution. *Agronomy Journal*, *96*(2), 377–383. https://doi.org/10.2134/agronj2004.3770

Peynircioğlu C. (2014). *Kuraklik Stresine Dayanikli Pamuk (Gossypium Hirsutum L.) Çeşit Islahinda Kullanilacak Pamuk Genotiplerinin Belirlenmesi*. 149.

Radin J.W., Reaves, L.L., Mauney, J.R., French, O. F. (1992). Yield Enhancement in Cotton by Frequent Irrigations during Fruiting. *Agronomy Journal*, *84*(4), 551–557. https://doi.org/10.2134/agronj1992.00021962008400040002x

Ramey, H. H. (n.d.). *The Meaning And Assessment Of Cotton Fibre Fineness Physical Meaning of Fibre Fineness*.

Roth, G., Harris, G., Gillies, M., Montgomery, J., & Wigginton, D. (2013). Water-use efficiency and productivity trends in Australian irrigated cotton: A review. *Crop and Pasture Science*, *64*(11–12), 1033–1048. https://doi.org/10.1071/CP13315

Ruan, Y. L. (2007). Goldacre paper: Rapid cell expansion and cellulose synthesis regulated by plasmodesmata and sugar: Insights from the single-celled cotton fibre. *Functional Plant Biology*, *34*(1), 1–10. https://doi.org/10.1071/FP06234

Saini, Hargurdeep S., M. E. W. (1999). Reproductive Development in Grain Crops during Drought. *Advances in Agronomy*, *68*, 59–96. https://doi.org/https://doi.org/10.1016/S0065-2113(08)60843-3

Saleem, M. F., Raza, M. A. S., Ahmad, S., Khan, I. H., & Shahid, A. M. (2016). Understanding and mitigating the impacts of drought stress in cotton- A review. *Pakistan Journal of Agricultural Sciences*, *53*(3), 609–623. https://doi.org/10.21162/PAKJAS/16.3341

Shareef, M., Gui, D., Zeng, F., Ahmed, Z., Waqas, M., Zhang, B., Iqbal, H., & Fiaz, M. (2018). Impact of drought on assimilates partitioning associated fruiting physiognomies and yield quality attributes of desert grown cotton. *Acta Physiologiae Plantarum*, *40*(4), 1–12. https://doi.org/10.1007/s11738-018-2646-3

Snowden, C., Ritchie, G., Cave, J., Keeling, W., & Rajan, N. (2013). Multiple irrigation levels affect boll distribution, yield, and fiber micronaire in cotton. *Agronomy Journal*, *105*(6), 1536–1544. https://doi.org/10.2134/agronj2013.0084

Tunali, S. P., Gürbüz, T., Akçay, S., & DAĞDELEN, N. (2019). Aydın Koşullarında Pamuk Çeşitlerinde Su Stresinin Verim Bileşenleri ile Lif Kalite Özellikleri Üzerine Etkileri. *ÇOMÜ Ziraat Fakültesi Dergisi*, *7*(1), 161–168. https://doi.org/10.33202/comuagri.548023

Tuylu, G. İ., & Akin, S. (2023). Farklı sulama suyu seviyelerinin pamuk bitkisinin verim, verim bileşenleri ve lif kalite parametreleri üzerine etkisi. *Akademik Ziraat Dergisi*, *12*(1), 91–98. https://doi.org/10.29278/azd.1139409

Ullah, A., Sun, H., Yang, X., & Zhang, X. (2017). Drought coping strategies in cotton: increased crop per drop. *Plant Biotechnology Journal*, *15*(3), 271–284. https://doi.org/10.1111/pbi.12688

Üzen, N., Çetin, Ö., Temiz, M. G., & Başbağ, S. (2019). Farklı damla sulama sistemleri ve sulama yönetiminin pamuk lif verimi, verim öğeleri ve lif kalitesine etkisi. *Mediterranean Agricultural Sciences*, *32*(3), 387–393. https://doi.org/10.29136/mediterranean.458025

Wang, R., Gao, M., Ji, S., Wang, S., Meng, Y., & Zhou, Z. (2016). Carbon allocation, osmotic adjustment, antioxidant capacity and growth in cotton under long-term soil drought during flowering and boll-forming period. *Plant Physiology and Biochemistry*, *107*, 137–146. https://doi.org/10.1016/j.plaphy.2016.05.035

Wendel, J. F., & Cronn, R. C. (2003). P Olyploidy and the E Volutionary. *Advances*, *78*, 139–186.

Zhang, D., Luo, Z., Liu, S., Li, W., WeiTang, & Dong, H. (2016). Effects of deficit irrigation and plant density on the growth, yield and fiber quality of irrigated cotton. *Field Crops Research*, *197*, 1–9. https://doi.org/10.1016/j.fcr.2016.06.003