

Bitki Koruma Bülteni / Plant Protection Bulletin

<http://dergipark.gov.tr/bitkorb>

Orijinal araştırma (Original article)

Determination of the effect of cotton wilt disease (*Verticillium dahliae* Kleb.) on fiber quality

Pamukta solgunluk hastalığı (*Verticillium dahliae* Kleb.)'nın lif kalitesi üzerine etkisinin belirlenmesi

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ARTICLE INFO

Article history:

DOI: [10.16955/bitkorb.1690773](https://doi.org/10.16955/bitkorb.1690773)

Received : 03-05-2025

Accepted : 07-11-2025

Keywords:

Gossypium hirsutum, wilt severity, fiber technology, Diyarbakır

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ABSTRACT

This study was conducted in 2014 in a naturally infested field at the Research Area of the Faculty of Agriculture, Dicle University in Diyarbakır, with the aim of determining the effects of wilt disease on fiber quality in cotton (*Gossypium hirsutum* L.). The experiment was established in a randomized complete block design with four replications. Two cotton cultivars were used Stoneville 468, moderately tolerant to Verticillium wilt, and Beyaz Altın 119, moderately susceptible to Verticillium wilt, in current study. After soil preparation, cotton seeds were sown on May 23, 2014. All necessary agronomic and maintenance practices were carried out until harvest time. At this stage, plants in all plots including Diyarbakır and Batman were cut transversely 5–6 cm above the soil surface and disease severity was scored on scale of 0–3. For each disease scoring level, 40–50 g of seed cotton samples were collected at harvest and transferred to the laboratory. Following ginning, 20-g fiber samples from each category were analyzed using the "HVI 1000 Spectrum" device at the different disease severity level, 100-seed weight showed no significant difference in farmer fields but differed significantly in the experimental field. Among the fiber technological properties examined, fiber fineness, maturity, number of trash particles, and trash area showed significant differences in both the experimental and farmer fields. However, uniformity index, fiber spinnability curve, upper half mean length, number of fibers analyzed, fiber strength, and yellowness degree did not differ significantly in either setting. The short fiber index, fiber elongation, brightness, and degree of whiteness showed no significant difference in farmer fields but differed in the experimental field. In contrast, moisture content differed in farmer fields but was not significantly different in the experimental field.

INTRODUCTION

Cotton is primarily a fiber and secondarily an oil crop and has an important place in Türkiye economy. Thanks to its widespread and mandatory use, it has great economic importance for producer countries, both by generating

added value and by providing employment. Cotton, which is prominent in the textile industry due to its fibers and in the food industry owing to its seeds containing 17–24% oil, is also one of the fundamental raw materials in animal

feed production through its meal, which contains 35–46% protein and 5–6% oil. The oil obtained from cottonseeds meets a significant portion of Türkiye's vegetable oil needs. It is recognized as one of the most important vegetable oil sources worldwide, following soybean and rape. Cotton seed oil is utilized not only as cooking oil but also in various sectors such as soap and detergent. The continuous increase in the world population is steadily enhancing the importance of cotton products alongside food commodities. In addition, the rise in living standards in industrialized and developed societies has increased the preference for environmentally friendly and organic products, which in turn has boosted the consumption of cotton and cotton-based goods. Consequently, the demand for cotton continues to grow steadily (Harem 2014). Although approximately 20 major diseases are known to affect cotton, *Verticillium* wilt is regarded as the most destructive and threatening disease worldwide (Pegg 1984). This disease can cause problems at all developmental stages of the plant, leading to seedling root rot in the early growth phase and vascular wilt in later stages. The pathogen affects over 400 plant species, including various tree species (e.g. olive), cut flowers (e.g. rose, chrysanthemum), horticultural crops (e.g. tomato, eggplant, strawberry), and field crops (e.g. cotton, potato) (Joaquim and Rowe 1990). According to research conducted in Türkiye, the incidence of *Verticillium* wilt in cotton has been reported as 27% in the Aegean Region (İzmir, Aydın, Manisa), 25% in Çukurova (Adana), 16% in Southeastern Anatolia (Adıyaman, Batman, Diyarbakır, Mardin, Şanlıurfa, Siirt), and 14% in the Western Mediterranean (Antalya). The yield losses resulting from the disease have been reported as 12% in the Aegean and Çukurova regions, and 4% in Antalya (Esentepe 1979, Sezgin 1985, Sağır et al. 1995, Çelik et al. 2010). Globally, *Verticillium* wilt is estimated to cause an annual yield loss of 1.5 million tons (Nemli 2003). Studies conducted particularly in Southeastern Anatolia indicate that the disease is widespread and significantly reduces cotton yield. In newly irrigated areas (excluding Mardin, including Kızıltepe, Adıyaman, Batman, Diyarbakır, Siirt, and Şanlıurfa), the average disease prevalence has been determined as 79.28%, with an infection rate of 16.27%. In some fields, this rate can reach up to 86.66%, especially in areas where irrigation has been applied for extended periods without crop rotation, the disease causes increasingly severe damage (Sağır et al. 1995). Similarly, the disease is also prevalent in the Aegean and Mediterranean regions, where it has been reported to cause substantial damage (Karaca et al. 1971, Esentepe 1979). In studies conducted in Diyarbakır, it was reported that the disease severity of GW Teks variety was lower than Stoneville 468. It was shown that the application of cattle manure suppressed *Verticillium* wilt affecting fiber

quality when compared with the farmer practice and the control (Sağır et al. 2019). In addition, a study conducted in the same region reported that *Verticillium* wilt had a negative effect on seed content in cotton (Sakçı et al. 2017). The disease is caused by a soil-borne pathogen, and there is no economically effective chemical control method. Therefore, in addition to cultural practices such as crop rotation to reduce the disease pressure, particular emphasis is placed on the cultivation of tolerant varieties (Karcıoğlu et al. 1982, Sezgin 1985, Sağır et al. 1995). The pathogen can survive in the soil for many years in the form of microsclerotia, thereby enabling new infections in plants (Meschke et al. 2012). As plant organs infected with *Verticillium dahliae* begin to die, microsclerotia, which are the resting structures of the fungus, are formed within the affected tissues. When the stem is cut transversely, dark lesions can be observed in the phloem of the vascular bundles. Wilt development in plants infected with *Verticillium dahliae* is associated with dense colonization of the xylem tissue and the formation of tyloses, which obstruct xylem vessels and thereby impair water and nutrient transport (Figure 1).



Figure 1. Symptoms of *Verticillium dahliae* Infection on Leaves and Stems of Cotton Plants

The present study was conducted to investigate the effect of cotton wilt disease (*Verticillium dahliae* Kleb.) on fiber quality.

MATERIALS AND METHODS

The study was conducted using two approaches. The first part of the research was carried out at the Experimental Field of the Faculty of Agriculture, Dicle University in Diyarbakır, while the second part was conducted under farmer conditions, with cotton samples collected from production fields in the provinces of Diyarbakır and Batman. In the Diyarbakır trial, two cotton cultivars were used to evaluate the effect of *Verticillium dahliae* Kleb. on fiber technological properties: Stoneville 468 (*Verticillium dahliae*) and Beyaz Altın 119 (moderately susceptible). In the farmer fields, the cotton cultivar Stoneville 468 was used. The experiment in Diyarbakır was established on

May 13, 2014, in a field with a history of severe *Verticillium* wilt infection. The trial was established in a randomized complete block design (RCBD) with four replications. Each plot consisted of eight rows (4 rows per variety), with plot dimensions of 8 m × 0.7 m × 12 m = 67.2 m². Row spacing was set at 70 cm and intra-row spacing at 15 cm. During sowing, a base fertilizer of 20:20:0 compound fertilizer was applied at 40 kg/da, and 33% ammonium nitrate was applied as top fertilizer at 30 kg/da. Thinning was conducted in the 3 to 5 leaf stage in Diyarbakır. In the farmer fields, base and top chemical fertilizers were applied as follows: in Bıçakçı and Yolağzı villages (Batman city center), 15:15:15 compound fertilizer and 46% urea; in Asmadere and Işıkveren villages (Beşiri District), 20:20:0 compound fertilizer and 33% ammonium nitrate; in Yuvacık village (Silvan District, Diyarbakır), 15:15:15 compound fertilizer and 26% CAN (Calcium Ammonium Nitrate); in Üçtepe and Yuvacık villages (Bismil District), DAP (Diammonium Phosphate) as base and 46% urea as top fertilizer. Thinning in Silvan and Bismil villages was conducted between June 5–9, 2014, and in Batman and Beşiri villages between June 10–15, 2014. Standard agronomic practices, including weed control, were applied throughout the growing season. In the Diyarbakır trial, weed control was conducted mechanically with three tractor cultivations, and the crop was irrigated 12 times during the growing season. The first two irrigations were applied by sprinkler irrigation, whereas the remaining irrigations were conducted using furrow irrigation. In the farmer fields, the following practices were recorded: in Bıçakçı and Yolağzı villages (Batman), 3 hand hoeings and 11 irrigations; in Işıkveren and Asmadere villages (Beşiri), 2 tractor hoeings, 1 hand hoeing, and 10 irrigations; in Yuvacık village (Silvan), 1 tractor and 2 hand hoeings, and 11 irrigations; and in Çöltepe and Üçtepe villages (Bismil), 1 tractor and 2 hand hoeings, and 10 irrigations. All farmer fields were irrigated using the furrow irrigation method. Once disease symptoms were sufficiently developed in both the experimental and farmer fields—at the stage when 50–60% of the bolls had opened—plants were assessed for disease severity. Plants were evaluated on a scale of 0–3, marked with colored strings corresponding to their respective severity levels (Table 3.2). At the end of the season during harvest, the stems of the previously selected plants were cut 5–6 cm above soil level and examined for discoloration in the vascular tissues to confirm disease presence. Plants were evaluated according to the 0–3 scale, and a disease index was determined (Erwin et al. 1976, Table 1). Additionally, boll samples were collected from 10 farmer fields five in Diyarbakır and five in Batman ensuring adequate representation for each disease severity level based on the same scale.

Table 1. Stem cross-section wilt scale (Erwin et al. 1976)

Scale Value	Disease Symptoms
0	Plant is healthy
1	1–33%, browning of vascular bundles
2	34–67%, browning of vascular bundles
3	68–100%, browning of vascular bundles

The values obtained from laboratory analyses were subjected to analysis of variance (ANOVA) using the SPSS statistical software and the means were compared according to LSD ($P \leq 0.05$). In this way, the effect of wilt disease caused by *Verticillium dahliae* fungus on fiber technological properties in cotton was determined.

RESULTS AND DISCUSSION

The results of the analyses for average 100-seed weight, fiber fineness, fiber uniformity, fiber maturity, yarn spinability curve, fiber length, fiber count, short fiber index, fiber tensile strength, moisture content, brightness, whiteness degree, yellowness degree, and trash content of cotton samples collected from the experimental field of the Faculty of Agriculture at Dicle University and from farmers' fields in Diyarbakır and Batman are presented in Tables 2 and 3 respectively.

Table 2.

Table 3.

As a result of this study on cotton, the effects of wilt disease caused by the fungus *Verticillium dahliae* on fiber technological properties were determined. Based on the 0–3 disease severity scale, 100-seed weight was statistically similar in farmer fields but showed significant differences in the experimental field. Among the fiber technological properties evaluated, significant differences were observed in fiber fineness, maturity, trash count, and trash area in both the experimental and farmer fields. However, no significant differences were observed in the uniformity index, yarn spinability curve, upper half mean length, number of fibers analyzed, fiber strength, or degree of yellowness in either the experimental or farmer fields. The short fiber index, fiber elasticity, and brightness/whiteness degree did not differ significantly in farmer fields but showed significant differences in the experimental field. In contrast, moisture content showed significant differences in farmer fields, whereas no significant differences were observed in the experimental field. The study revealed that 100-seed weight differed significantly among disease severity levels in both the farmer fields and the experimental field (Table 2). In the experimental field, the 100-seed weight of the cultivars

Table 2. Fiber technological properties according to disease severity

Fiber technological properties	Disease severity	Producer field		Trial field			
		Stoneville 468		Stoneville 468		Beyaz Altın 119	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
100 seed weight (g)	0	8.62a	0.73833	8.83a	0.68147	9.04a	0.32496
	1	8.46a	0.76459	8.77a	0.33206	30	0.29642
	2	8.35b	0.75136	8.52b	0.53367	30	0.53104
	3	8.51a	0.77677	8.43b	0.28542	8.39c	0.20494
	Average	8.49	0.75776	8.63	0.45815	8.76	0.33934
Fiber fineness values (microneir)	0	4.38a	0.29831	5.02a	0.16256	4.82b	0.26887
	1	4.41a	0.24286	4.75a	0.35528	5.07a	0.20801
	2	4.32ab	0.35945	4.40b	0.31627	4.65c	0.20216
	3	4.06b	0.33902	4.64b	0.52501	4.54c	0.40885
	Average	4.29	0.30991	4.70	0.33978	4.77	0.27197
Uniformity index values (%)	0	84.09	1.04400	86.40a	1.50555	86.42a	1.05948
	1	84.62	1.09930	85.40b	0.40825	86.20a	1.56844
	2	84.96	1.21920	84.50c	0.77030	84.85c	0.75939
	3	84.40	1.92810	84.10c	0.84853	85.50b	1.48997
	Average	84.52	1.32265	85.10	0.88315	85.74	1.21932
Maturity values (%)	0	0.90a	0.01033	0.93a	0.014140	0.92a	0.01258
	1	0.90a	0.01229	0.91b	0.017080	0.92a	0.00577
	2	0.89ab	0.02697	0.89c	0.015000	0.90b	0.01732
	3	0.88b	0.02739	0.91b	0.021600	0.90b	0.02160
	Average	0.89	0.019245	0.91	0.016950	0.91	0.01432
Yarn spinnability curve	0	150.40	17.5702	157.50a	8.69870	158.50a	8.66030
	1	154.30	9.09270	154.25ab	4.57350	151.75b	9.42960
	2	159.36	7.69770	151.75b	13.2004	148.25b	11.2361
	3	151.89	13.8424	145.00c	10.3602	150.50b	7.18800
	Average	153.99	12.0507	152.13	9.20820	152.25	9.12850
Upper half average length values (mm)	0	28.87	1.57501	29.24a	0.65581	29.64b	0.61671
	1	28.99	0.66524	29.30a	0.97250	29.00c	0.70159
	2	29.38	0.89849	28.26b	1.33737	29.43a	1.06097
	3	28.65	0.99555	28.19b	0.53746	28.67c	0.43767
	Average	28.97	1.03357	28.75	0.87578	29.19	0.70423
Number of fibers analyzed (number)	0	751.30ab	64.23400	666.75ab	202.2398	622.25a	140.57120
	1	695.80b	114.0622	609.00b	151.0386	570.00b	107.27850
	2	779.00a	48.81800	671.75ab	126.0010	677.00a	155.13650
	3	730.78ab	69.36460	700.50a	92.78110	656.50a	74.388600
	Average	739.22	74.11970	662.00	143.01513	631.44	119.34370
Short fiber index values (%)	0	8.67b	0.79729	6.60c	1.20280	6.52c	0.85000
	1	8.25ab	0.66708	7.40b	0.42430	6.57c	0.32020
	2	7.55a	1.07314	8.12a	1.11470	7.92b	0.57370
	3	8.63b	1.66132	8.55a	0.43590	7.32a	1.15870
	Average	8.26	1.04970	7.67	0.79442	7.09	0.72565

*Significant at 0.05 (P≤ 0.05)

Table 3. Fiber technological properties according to disease severity levels

Fiber technological properties	Disease severity	Producer field		Trial field			
		Stoneville 468		Stoneville 468		Stoneville 468	
		Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
humidity values (%)	0	5.17b	0.30930	5.62	0.49920	5.32	0.23630
	1	5.51a	0.23310	5.55	0.45090	5.35	0.19150
	2	5.42a	0.31250	5.57	0.42720	5.25	0.33170
	3	5.39ab	0.26190	5.52	0.45000	5.35	0.28870
	Average	5.37	0.27920	5.57	0.45680	5.32	0.26205
brightness whiteness degree values	0	71.32	4.06720	71.67a	2.09980	70.22a	1.20381
	1	70.32	2.05040	69.75b	2.55799	69.82a	2.35708
	2	69.57	3.03320	69.03b	1.32750	68.52b	0.20616
	3	68.52	2.78920	67.87c	2.99597	67.92b	1.51079
	Average	69.93	2.98500	69.58	2.24531	69.13	1.31946
degree of jaundice values	0	9.40	0.79580	9.75a	0.100000	9.32a	0.20620
	1	9.94	0.60590	9.66a	0.678200	9.50a	0.31620
	2	9.90	0.72390	9.45b	0.499200	8.92b	0.34030
	3	10.03	0.91790	9.01c	0.613100	9.47a	0.58520
	Average	9.82	0.76087	9.47	0.472625	9.31	0.36197
number of trash cans (pcs)	0	26.50b	23.10480	35.00c	27.04320	38.75c	25.61740
	1	35.90ab	15.62370	75.75b	25.38210	51.50b	26.66460
	2	41.82ab	19.09350	61.25b	24.28130	48.00ab	28.03570
	3	49.00a	29.49580	122.25a	46.94230	86.50a	48.45960
	Average	38.30	21.82945	73.56	30.91222	56.19	32.19432
trash area values (%)	0	0.27b	0.20979	0.46c	0.43749	0.59c	0.36262
	1	0.36ab	0.23972	1.14b	0.59470	0.95b	0.62750
	2	0.54ab	0.38798	1.23b	0.48699	0.62bc	0.43813
	3	0.74a	0.41653	1.70a	1.02478	1.53a	1.10976
	Average	0.48	0.31350	1.13	0.63599	0.69	0.63450
fiber breaking strength values (g/ tex)	0	32.56	3.24150	32.92	2.43770	32.67a	1.54780
	1	33.02	1.70670	33.07	1.12360	32.02a	1.71930
	2	33.74	2.18600	33.17	1.79700	31.90a	2.48060
	3	32.22	2.38580	32.92	1.81540	31.72b	1.37450
	Average	32.88	2.38000	33.03	1.79342	32.08	1.78055
fiber elasticity values (%)	0	5.91ab	0.38140	6.40a	0.58310	6.30b	0.29440
	1	6.10a	0.33990	6.20b	0.24490	6.47a	0.23630
	2	5.81b	0.20710	6.10b	0.14140	6.27b	0.41130
	3	5.95ab	0.32830	5.80c	0.08160	6.00c	0.21600
	Average	5.94	0.31417	6.13	0.26275	6.26	0.28950

*Significant at 0.05 (P≤ 0.05)

Stoneville 468 and Beyaz Altın 119 decreased as disease severity increased. Sağır and Başbağ (2002) also reported that the 100-seed weight of diseased plants was lower than that of healthy plants in their study conducted in Diyarbakır using the cotton cultivars Carmen, Delta Pine 90, Maraş 92, and SG 125.

Although fiber fineness and fiber elongation differed significantly across the 0–3 disease severity scale in both the farmer fields and the experimental area (Tables 2 and 3), no significant differences were observed in fiber uniformity, fiber strength, or the yellowness index in either environment (Tables 2 and 3). The lack of significant differences in fiber uniformity, fiber strength, and the yellowness index suggests that environmental and management conditions can affect the outcomes of studies examining these traits. In their study conducted in farmer fields in Diyarbakır using the cotton cultivars Carmen, Delta Pine 90, Maraş 92, and SG 125, Sağır and Başbağ (2002) reported that diseased plants exhibited lower fiber fineness, fiber elongation, fiber strength, yellowness, and fiber uniformity compared to healthy plants, while ginning outturn and fiber brightness were higher in diseased plants. While upper half mean length values did not show significant differences in the farmer fields, a gradual decline was observed in both cultivars (Stoneville 468 and Beyaz Altın 119) under experimental conditions (Table 2). For example, in the experimental field, the upper half mean length values of Stoneville 468 were recorded as 29.24%, 29.30%, and 28.26% for scale values 0, 1, 2, and 3, respectively. For Beyaz Altın 119, the corresponding values were 29.64%, 29.00%, and 29.43%. El-Zik (1985) demonstrated that an increasing percentage of wilted plants in a population leads to reduced fiber yield and that wilt severity is significantly negatively correlated with fiber length and strength. In the study, among the evaluated characteristics, maturity, trash count, and trash area showed significant differences both in the farmers' fields and in the experimental area (Tables 2), whereas the degree of fiber brightness and whiteness showed significant variation only in the experimental area (Table 3). Indeed, studies conducted by Uygun et al. (1978) reported a close relationship between the severity of cotton wilt disease and yield loss, indicating that the disease causes substantial yield reductions in cotton and negatively affects some technological properties of the fibers.

In the study, although the yarn spinnability curve was found to be statistically significant according to disease severity values in the experimental area, it was determined to be insignificant in the farmers' fields. For example, in the experimental area, the highest average was found to be 157.50 for the Stoneville 468 variety and 158.50 for the Beyaz

Altın 119 variety. The lowest average was recorded as 145.00 for Stoneville 468 and 148.25 for Beyaz Altın 119 (Table 2). Erdoğan and Benlioğlu (2007), in the study conducted in Nazilli during 2005-2006, reported a significant negative correlation between disease severity and yarn index.

Within the scope of the study, although the number of fibers analyzed and the short fiber index values were found to be statistically significant according to disease severity scale in both the farmers' fields and the experimental area, the moisture content of the fibers showed statistically significant differences only in the farmers' fields (Tables 2 and 3). Similarly, Uygun et al. (1978) reported that the wilt disease caused considerable yield losses in cotton and had negative effects on certain technological fiber properties.

As a result, the study conducted under farmer conditions in Batman and Diyarbakır, as well as in the research area of Dicle University Faculty of Agriculture, it was determined that cotton wilt disease adversely affected some technological fiber properties, whereas other properties were not significantly affected. It was concluded that future breeding studies should focus on this issue and that further research should be carried out using different varieties.

ACKNOWLEDGEMENTS

This study is derived from a master thesis. It was supported by the Scientific Research Projects Coordination Unit of Dicle University (DUBAP) under project number 14-ZF-31. We would like to thank them for their support.

ÖZET

Bu çalışma, solgunluk hastalığının pamuk (*Gossypium hirsutum* L.) lif kalitesi üzerindeki etkilerini belirlemek amacıyla, 2014 yılında Diyarbakır'da Dicle Üniversitesi Ziraat Fakültesi Araştırma Alanı'nda, *Verticillium dahliae* ile doğal olarak bulaşık olan bir tarlada yürütülmüştür. Deneme, Tesadüf Blokları Deneme Desenine göre 4 tekerrürlü olarak kurulmuştur. Araştırmada, solgunluk hastalığına karşı orta derecede tolerant olan Stoneville 468 ve orta derecede duyarlılık gösteren Beyaz Altın 119 çeşitleri kullanılmıştır. Toprak işlenerek ekime hazır hale getirildikten sonra, pamuk tohumları 23 Mayıs 2014 tarihinde ekilmiştir. Hasat dönemine kadar gerekli tüm kültürel işlemler ve bakım uygulamaları gerçekleştirilmiştir. Hasat sırasında her parseldeki bitkiler toprak seviyesinden 5–6 cm yukarıdan gövdeleri enine kesilerek 0–3 hastalık skalasına göre değerlendirilmiştir. Aynı değerlendirme, Diyarbakır ve Batman'daki 5'er üretici tarlasındaki bitkilerde de uygulanmıştır. Her bir hastalık skala değeri için hasatta 40–50 g kütlü pamuk örneği alınarak laboratuvara getirilmiş, çırçır işleminden sonra lif kalite özelliklerinin belirlenmesi amacıyla her karakter için 20 g lif örneği "HVI 1000

Spectrum" cihazında analiz edilmiştir. 0-3 hastalık şiddeti skala değerine göre, 100 tohum ağırlığı üretici tarlalarında farklılık göstermezken, deneme alanında istatistiksel olarak farklı bulunmuştur. Lif teknolojik özelliklerinden lif inceliği, olgunluk, çepel sayısı ve çepel alanı hem deneme alanında hem de üretici tarlalarında anlamlı farklılık gösterirken; uniformite indeksi, iplik eğrilebilirlik eğrisi, üst yarı ortalama uzunluk, analiz edilen lif adedi, lif kopma dayanıklılığı ve sarılık derecesi bakımından herhangi bir farklılık gözlenmemiştir. Kısa lif indeksi, lif elastikiyeti, parlaklık ve beyazlık derecesi üretici tarlalarında benzer bulunmuş, ancak deneme alanında farklılık göstermiştir. Nem oranı ise üretici tarlalarında farklılık gösterirken, deneme alanında farksız bulunmuştur.

Anahtar kelimeler: *Gossypium hirsutum*, solgunluk şiddeti, lif teknolojisi, Diyarbakır

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- Cite this article:** Sakçı, N., & Sağır, A. (2026). Determination of the effect of cotton wilt disease (*Verticillium dahliae* Kleb.) on fiber quality. *Plant Protection Bulletin*, 66-1. DOI: 10.16955/bitkorb.1690773
- Atf için:** Sakçı, N., & Sağır, A. (2026). Pamukta solgunluk hastalığı (*Verticillium dahliae* Kleb.)'nın lif kalitesi üzerine etkisinin belirlenmesi. *Bitki Koruma Bülteni*, 66-1. DOI: 10.16955/bitkorb.1690773