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The Effects of Verticillium Wilt (*Verticillium dahliae* Kleb.) on Cotton Yield and Fiber Quality

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Abstract: This study was conducted in Aegean Region, western Turkey, in non-infected and naturally infected fields to determine the influence of verticillium wilt on yield and fiber quality parameters. The cotton cultivars, Nazilli 84 S (Aegean Region standard cotton cultivar), Carmen (tolerant to verticillium wilt) and Cukurova 1518 (susceptible to verticillium wilt) were used as a material. It was found that verticillium wilt significantly reduced the seed cotton yield, fiber length and fiber strength. Yield reduction was determined as 15.93%. Finally, Carmen was recommended for yield and fiber quality in infected area.

Key words: Verticillium wilt, infected field, cotton, cultivar, seed cotton yield

INTRODUCTION

Aegean cotton generally is considered to be the best quality and is preferred for its longer staple length by the local textile industry. Cotton production in Aegean Region for 2005 was 254,000 tones at 176,000 ha planting areas and lint yield was 1445 kg ha^{-1} (Ozudogru and Cakaryıldırım, 2005). Cotton diseases are one of the major constraints affecting yield and quality in Aegean Region. Especially, verticillium wilt incited by the soilborne fungus *Verticillium dahlie* Kleb., is found in many cotton fields. Onan and Karcılıoglu (1998) reported that pathotype of pathogen is SS-4 in Aegean Region.

Weather and cultural conditions that generally favor more severe occurrences of Verticillium wilt include prolonged periods of cool, wet weather, cool weather with frequent irrigations and cultural practices (such as excessive fertilization or irrigation) that encourage rank growth and delayed maturity. Continuous cropping with less-tolerant (more susceptible) cotton varieties and less aggressive crop rotations out of cotton has been shown to sustain or even increase levels of microsclerotia. Higher surface soil levels of microsclerotia have been shown to increase the chance of severe infections with more-susceptible varieties (Hutmacher *et al*., 2005).

Symptoms of Verticillium wilt are easily confused with two other widespread diseases, Fusarium wilt or yellows and bacterial wilt. However, Verticillium wilt is found mostly in temperate zones and is prevalent in the northern states having relatively low soil temperatures (optimum 21°C). The disease is most severe during cool to warm weather, but not as prevalent in hot weather. It is not unusual for every plant in a badly infested field to be infected, especially where susceptible crops have been grown for many years. If weather conditions are unfavorable for Verticillium development, only a slight reduction in yield or quality may occur. The fungus produces toxins that cause tyloses or gums to form in the vascular (water-conducting) tissues, resulting in a greatly decreased flow of water from the roots to the foliage (Anonymous, 1997).

The foliar symptoms of verticillium wilt were approximately 27% for Aegean Region, 25% for Cukurova and 16% South Eastern Anatolia in Turkey. The losses of seed cotton yield due to verticillium wilt were estimated 12, 12 and 10% for Aegean Region, Cukurova and South Eastern Anatolia, respectively (Esentepe, 1979; Sezgin, 1985; Sagir and Tatli, 1995).

Bejorano-Alcazar *et al*. (1997) revealed that the greatest yield reduction was observed in plants showing symptoms before opening of first flowers and yield increased with delay in the development of foliar symptoms after opening of the first bolls. Incidence of verticillium wilt foliar symptoms is highly influenced by inoculum density and the virulence of *V. dahlia* pathotypes prevailing in soil, as well as by air and soil temperature and cultivar tolerance (Bejorano-Alcazar *et al*., 1995). The correlation between seed cotton yield and wilt severity was negative, while correlations between lint percentage, fiber length, fiber fineness and

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fiber strength with wilt severity changed by susceptibility of cultivar (Kaymak *et al*., 1976). Fiber quality parameters were nagatively affected by verticillium wilt in especially high yielding cultivars (Yelin and Ersan, 1985; Kechagia and Xanthpoulos, 1998; Abbasi, 1998).

The objective of this study was to determine the influence of veriticillium wilt on yield and fiber quality parameters in two different fields.

MATERIALS AND METHODS

This study was conducted at Nazilli Cotton Research Institute (latitude $37^0 44^l$-$37^0 49^l$ N and longitude $27^0 44^l$-$27^0 50^l$ E) in 2004-2005. The cotton cultivars (*Gossypium hirsutum* L.), Nazilli 84 S (Aegean Region standard cotton cultivar), Carmen (tolerant to verticillium wilt) and Cukurova 1518 (susceptible to verticillium wilt) were used as a material.

Cotton cultivars were planted in two different fields to test the verticillium wilt performance of cultivars. One of the fields were infected field with non-defoliating pathotype *V. dahliae* Kleb., 24 p/g), other was non-infected (control). The experiments were arranged as a randomized complete block design with four replications. The plots were 12 m length and consisted of four each row. In this study, 60 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5 were applied to soils as the pre-planting fertilizer from 20-20-0, 60 kg ha^{-1} N as pre-flowering fertilizer from ammonium nitrate (33%). The cultural managements such as irrigations and plant protection applicants were programmed according to recommended for Aegean Region cotton growing. Measured characteristics were seed cotton yield (kg ha^{-1}), lint percentage (%), fiber length (mm), fiber fineness (mic) and fiber strength (g tex^{-1}). Variance analysis and Fisher's LSD mean separation tests at 0.05 probability level.

RESULTS AND DISCUSSION

Results from the analysis of variance for observed characters were showed in Table 1. The differences between two years were found to be significant for fiber length and fiber strength, while yearly difference was non-significant for seed cotton yield. The effects of infected field or verticillium wilt on seed cotton yield, fiber length and fiber strength were significant. Also, the interaction of year × field were found to be significant for seed cotton yield and fiber strength. The differences among cultivars were significant for all characteristics and these differences changed year to year for all characters except fiber length.

The mean values of seed cotton yield for cultivars, years, fields and significant interactions were presented in Table 2. The highest seed cotton yields were obtained from non-infected field in both years. The seed cotton yield of 2005 infected field was higher than that of 2004. Therefore, it can be said that weather conditions and cultural applications during growing season affected occurrences of verticillium wilt (Hutmacher *et al*., 2005).

The difference between non-infected (4722.5 kg ha^{-1}) and infected field (3969.9 kg ha^{-1}) was 752.6 kg ha^{-1} or yield reduction was 15.93%. This loss of seed cotton yield due to verticillium wilt was higher than that of reported by Esentepe (1979) Sezgin (1985) and Sagir and Tali (1995). There was a significant interaction between year and cultivar. In both years, Carmen and Nazilli 84 S followed each other. Seed cotton yields of Cukurova 1518 were the lowest in both years. Because of non-significant interaction between field and cultivar, it can be said that cultivars showed similar reaction to verticillium wilt. Moreover, the differences among cultivars resulted from their yield capacity. Galanopoulou (2006) revealed that although there are not immune *hirsutum* varieties, there is great variability among them.

The differences among cultivars and year × cultivar interaction for lint percentage were found to be significant. The means of lint percentage were presented in Table 3. In both years, Nazilli 84 S had the highest lint percentage values (43.66%; 42.77%) and was followed by Carmen in 2004. Non-significant differences between non-infected and infected field and non-significant interaction between field and cultivar showed that lint percentage not

Table 1: Variance analysis of yield and fiber quality characters

		Mean square				
Source of variance	df	Seed cotton yield	Lint percentage	Fiber length	Fiber fineness	Fiber strength
Year	1	3239.99	0.0033	33.68*	0.17	98.90*
Field	1	67962.79*	1.47	7.52*	0.093	88.83*
Year × Field	1	40265.98*	0.563	1.035	0.005	56.55*
Block	12	978.51	1.272*	0.566	0.064	1.971
Cultivar	2	36046.71*	26.227*	12.114*	0.662*	105.026*
Year × Cultivar	2	9811.92*	5.436*	0.173	0.318*	4.516*
Field × Cultivar	2	2481.20	0.151	2.961*	1.294*	3.591
Year × Field × Cultivar	2	1226.93	0.425	0.750	0.153	2.663
Error	24	1064.13	0.5709	0.36295	0.055618	1.3985

*, **; significant at probability level 0.05 and 0.01, respectively

Table 2: The mean of seed cotton yields about years, fields, cultivars and their interactions

Source of variation	Seed cotton yield (kg ha^{-1})	Source of variation	Seed cotton yield (kg ha^{-1})
2004 non-infected field	5094.3a^{+}	2004 Carmen	4952.2a
2005 non-infected field	4350.7b	2004 Nazilli 84 S	4728.5ab
2005 infected field	4177.4b	2005 Carmen	4422.5bc
2004 infected field	3762.5c	2005 Nazilli 84 S	4365.9c
Non-infected field	4722.5a	2005 Cukurova 1518	4003.8d
Infected field	3969.9b	2004 Cukurova 1518	3604.5e
		Carmen	4687.3a
		Nazilli 84 S	4547.2a
		Cukurova 1518	3804.1b

$^{+}$; Means in columns followed by the same letter are not significantly different (p>0.05)

Table 3: The means of lint percentage about cultivar and year × cultivar interaction

Source of variation	Lint percentage (%)
2004 Nazilli 84 S	43.46a^{+}
2005 Nazilli 84 S	42.77a
2004 Carmen	41.62b
2005 Cukurova 1518	41.32b
2005 Carmen	41.00b
2004 Cukurova 1518	39.96c
Nazilli 84 S	43.11a
Carmen	41.31b
Cukurova 1518	40.64c

$^{+}$; Means in columns followed by the same letter are not significantly different (p>0.05)

Table 4: The fiber length values for years, fields, cultivars and significant interactions

Source of variation	Fiber length (mm)
2004	29.20a^{+}
2005	27.50b
Non-infected field	28.79a
Infected field	28.00b
Carmen	29.39a
Nazilli 84 S	28.02b
Cukurova 1518	27.78b
Non-infected field Carmen	29.75a
Infected field Carmen	29.05b
Non-infected field Cukurova 1518	28.63bc
Infected field Nazilli 84 S	28.03cd
Non-infected field Nazilli 84 S	28.02d
Infected field Cukurova 1518	26.94e

$^{+}$; Means in columns followed by the same letter are not significantly different (p>0.05)

Table 5: The fiber fineness values for years, fields, cultivars and significant interactions

Source of variation	Fiber fineness (mic)
Nazilli 84 S	4.90a^{+}
Carmen	4.70b
Cukurova 1518	4.50c
2004 Nazilli 84 S	4.90a
2005 Nazilli 84 S	4.80ab
2005 Carmen	4.70b
2005 Cukurova 1518	4.70b
2004 Carmen	4.60b
2004 Cukurova 1518	4.30c
Non-infected field Nazilli 84 S	5.06a
Infected field Cukurova 1518	4.88ab
Non-infected field Carmen	4.80bc
Infected field Nazilli 84 S	4.78bc
Infected field Carmen	4.60c
Non-infected field Cukurova 1518	4.14d

$^{+}$; Means in columns followed by the same letter are not significantly different (p>0.05)

affected by verticillium wilt. The correlation between lint percentage and verticillium wilt was changed by susceptibility of cultivar (Kaymak *et al*., 1976).

The differences between two years and fields for fiber length were found to be significant (Table 4). The fiber length value for non-infected field was significantly 2.82% higher and Carmen showed statistically significant performance (29.39 mm). Also, the interaction of field × cultivar demonstrated that Carmen was first rank in non-infected field and were followed Carmen in infected field and Cukurova 1518 in non-infected field. It can be said that Carmen was slightly affected from verticillium infection when a comparison among cultivars were evaluated. Similarly, Yelin and Ersan (1985) and El-Zik (1985) revealed that there was negative correlation between verticillium wilt and fiber length and fiber length shortened as infection of verticillium wilt increased.

Aegean standard cotton cultivar, Nazilli 84 S, had the thickest fiber (4.90 mic) depending on their very high lint percentage and this cultivar followed by Carmen (4.70 mic) (Table 5). Also, the interaction of year × cultivar showed that although Nazilli 84 S were first rank in both years, Carmen and Cukurova 1518 in 2005 and Carmen in 2004 were second statistically group. Similarly, Nazilli 84 S in non-infected field had the thickest fiber, but other ranks changed. These results showed that although effects of year and verticillium infection on fiber fineness were significant, any factors not changed thick of Nazilli 84 S. On the other hand, it can be said that Carmen and Nazilli 84 S B were thicker in non-infected, while Cukurova 1518 in infected field had thicker fiber.

Both non-infected and infected field in 2004 and non-infected field in 2005 were statistically first group. The disease is most severe during cool to warm weather, but not as prevalent in hot weather. If weather conditions are unfavorable for verticillium development, only a slight reduction in yield or quality may occur (Anonymous, 1997). In this study, the interaction of year × field showed that infection severity of verticillium wilt changed year to year depending on weather conditions. Although 2005 was most suitable for verticillium wilt, fiber strength

Table 6: The fiber strength values for years, fields, cultivars and significant interactions

Source of variation	Fiber strength (g tex^{-1})
2004	32.05a^{+}
2005	29.17b
Non-infected Field	31.9a
Infected field	29.2b
2004 Non-infected Field	32.3a
2004 Infected field	31.7a
2005 Non-infected Field	31.6a
2005 Infected field	26.7b
Carmen	33.50a
Nazilli 84 S	29.73b
Cukurova 1518	28.60c
2004 Carmen	35.50a
2005 Carmen	31.40b
2004 Nazilli 84 S	31.03b
2004 Cukurova 1518	29.60c
2005 Nazilli 84 S	28.45cd
2005 Cukurova 1518	27.61d

$^{+}$; Means in columns followed by the same letter are not significantly different (p>0.05)

values of Carmen in both years were the most strength (35.5-31.4 g tex^{-1}). These values followed by Nazilli 84 S (31.03 g tex^{-1}) and then Cukurova 1518 (29.60 g tex^{-1}) in 2004 (Table 6).

When yield and quality parameters of non-infected and infected fields were compared, verticillium wilt significantly reduced the seed cotton yield, fiber length and fiber strength. Yield reduction was determined as 15.93%. These effects changed year to year and the weather and soil conditions of 2005 increased the damage of verticillium wilt. The seed cotton yields of Carmen were the highest in both years. It was concluded that Carmen was slightly affected by verticillium wilt and Cukurova 1518 was determined as the most susceptible cultivar.

Non-significant differences between non-infected and infected field and non-significant interaction of field × cultivar showed that lint percentage not affected by verticillium wilt. In both years, Nazilli 84 S had the highest lint percentage values. If all fiber quality parameters were evaluated together, field × cultivar interaction for fiber length and fiber fineness, year × field and yield × cultivar interaction for fiber strength showed that the effects of verticillium wilt changed regarding to cultivars and years. It should be recommended that Carmen was the best cultivar for yield and fiber quality in infected area.

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