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SCREENING OF COTTON GENOTYPES FOR RESISTANCE TO *VERTİCİLLİUM DAHLİAE* KLEB. UNDER GREENHOUSE AND FIELD CONDITIONS

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ABSTRACT

This experiment conducted to determine yield, fibre quality traits and reactions of some cotton genotypes to Verticillium wilt disease. Firstly, ten candidate varieties with susceptible Çukurova 1518 and standard NP ÖZBEK 100 cv and a tolerant Carmen cv were tested to determine reactions against *Verticillium dahliae* Kleb. in a pot experiment. And then, a field trial in a randomized complete block design with four replications was conducted natural infected with Verticillium wilt. Disease severity were determined in leaf at 5-10% and 50-60% of boll opening periods and in stem section after harvest. Also, some yield parameters and fibre quality properties data was obtained. Although all candidate varieties were moderately resistant against Vd11 (non-defoliating pathotype) isolate, they showed low level resistance against PYDV6 (defoliating pathotype) in the pot experiment. In the counting of the disease in three different periods, NMB 27/33 has come to the fore after Carmen variety. Some disease tolerant and susceptible genotypes were in the same statistical grouping for the number of boll, 100 seed weight and ginning out turn values. The highest seed cotton yield belonged to NCCH-10, and Carmen. Fine fibres, and the highest values of fibre length and strength values were obtained from 216 and 95, respectively.

Key words: Cotton, verticillium wilt, tolerant, susceptible, genotype.

INTRODUCTION

Cotton is an important industrial plant in Turkey. Plant fibre constitutes the raw material of about 50 textile industries, with seed occupies an important place in human and animal nutrition. In this country, a total of 495.000 ha of cotton cultivated area on which a total of 450.000 tons of cotton fibre is produced. Currently, cotton is produced in four main areas of the country including Southeast Anatolia, Aegean, Antalya and Çukurova (Anonymous, 2011).

Cotton hosts about 20 important diseases. However, among all of them Verticillium wilt is known the most devastating and destructive pathogen (Pegg, 1984). Besides of cotton, this pathogen can cause wilting symptoms on a series of more than 400 plant species including vegetables, legumes, ornamental plants, industrial plants, fruit trees and weeds (Joaquim and Rowe, 1990). Due to Verticillium wilt, cotton yield loss was reported about 75% in California, 8-10% in Russia and 4% in Syria (Bejarano-Alcazar et al., 1996). In a study in different regions of Turkey showed that disease infection rates in cotton were 27% in Aegean region, 25% in the Çukurova region, 16% in the Southeastern Anatolia Region and 14% in Western Mediterranean Region. Product loss was 12% in İzmir, Aydın and Manisa; 12% in Adana, 4% in Antalya (Sezgin, 1985; Sağır et al., 1995). Today, worldwide estimate of crop loss for Verticillium wilt is estimated as 1.5 million bales annually (Nemli, 2003).

In order to control Verticillium infections growers could benefit from some of disease management tactics such as crop rotation, balanced fertilization and irrigation, weed control and development of resistant

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varieties. Since there is no chemical control, one of the effective ways to control disease is to use resistant varieties (Wilhelm et al., 1974; El-Zik, 1985). In a study performed in a growth chamber by Schnathorst and Cooper (1975), to determine reactions of some cotton genotypes belonging to *Gossypium hirsutum* L. species against Verticillium wilt, showed that the data did not support the field results and there were no significant relations between the test methods due to the fact that seedlings were inoculated at an early stage with non-defoliating pathotype. In a study conducted by Gencer et al. (2001), cv Nazilli 143 was resistant, SG 125, SG 404 and SG 501 were tolerant, and Çukurova 1518 cv was susceptible to the pathogen. Aydın and Sağır (2001), examined disease incidence and disease index at the end of the vegetation period on 26 cotton genotypes and resulted that disease ratio and disease index changed from 23.47 to 58.92% and from 0.25 to 1.40, respectively, while yield in the same study, was between 2570.8 kg ha^{-1} and 4050.9 kg ha^{-1}. In another study testing V76, TS-2, PH and V44 isolates and Pima S-7, Acala Prema, M-315 and Acala 44, Pima S-7 and Acala Prema cv were found highly resistant to disease while Acala 44 cv was susceptible (Bölek et al., 2005). Korkmaz (2005) determined that Erşan 92, Maraş 92, Sayar 314, Stv 453 and Golda cv were resistant, Teks and Carmen cv were tolerant and Çukurova 1518, Karlik and Aktaş cv were susceptible to disease. Moreover, negative but significant correlations were obtained between Verticillium wilt and seed cotton yield, kernel weight, fibre strength and spinning consistency index (Erdoğan and Benlioğlu, 2010). In another study in Diyarbakır, Teks, Golda and Carmen were tolerant while Maraş 92, Sayar 314 and St-453 cv were susceptible for the disease severity in leaf and stem (Karademir et al., 2012).

Objective of this study is to determine the reactions of some cotton genotypes against Verticillium wilt and to determine some correlations between Verticillium wilt, seed cotton yield and fibre quality traits tested.

MATERIAL AND METHODS

Origin of plant materials and pathogen used

Plant materials were 10 candidate cotton varieties developed by Cotton Research Station, Aydin, Turkey and three control cotton varieties (Carmen, Çukurova 1518 and NP ÖZBEK 100) developed by Bayer Crop Science AG, Leverkusen, Germany; Çukurova Agricultural Research Institute, Adana, Turkey and Cotton Research Station, Aydın, Turkey, respectively. Carmen was known as tolerant, Çukurova 1518 was susceptible and NP ÖZBEK 100 was considered as a local standard cultivar used in the region. Additionally, a high virulence pathotypes, Vd11 (non-defoliating) and PYDV6 (defoliating) used for an artificial inoculum (Erdoğan, 2009).

Pot trials

Conidial suspension method was used to test the reaction of cotton genotypes against *V. dahliae* Kleb. in pot trials. Experiment was established as randomised plot design with 6 replications in a growth chamber (24±1°C and 12 h light/12 h dark). A 33% soil, 33% sand and 33% peat containing mixture was sterilized in autoclave at 121°C for 1 hour and was filled into 5 cm diameter plastic pots. Of the 4 seeds sown each container, only one left at cotyledonary stage and others were removed. *V. dahliae* cultures having high virulence isolates (Vd11 and PYDV6) were developed on PDA media broth for inoculation. After 2 weeks, spore suspension in the flask were adjusted as 4 x 10^6 spor ml^{-1} with a hemacytometer and 5 ml of adjusted suspension released to the bottom of each plastic pots and the 4-6 leaf stage-plants were placed the pots. The disease progress on plants was followed for 3-5 weeks and assessed based on a 0-4 scale (0 = no symptoms; 1 = 1-33% foliage affected; 2 = 34-66% foliage affected; 3 = 67-100% foliage affected; 4 = dead plants) (Bejarano-Alcazar et al., 1995).

Field trials

Field experiment was carried out in the institute fields, which was naturally infested

with Verticillium wilt (non-defoliating pathotype) in 2010 and 2011. In this site, pathogen inoculum density was 69 microsclerotia g^{-1} (Erdoğan et al., 2011). Experiment was conducted as randomized block design with four replications. Plot size was 4 rows x 0.7 m x 12 m = 33.6 m^2 and above row seeding distance was 20 cm. The distance between the blocks was 2 m. Seed sowing was made with combine cotton drilling machine. Initial soil analysis showed that experimental site had claying soil, slightly alkali, low salinity and rich for lime, organic matter, potassium and phosphorous. In the first year, planting was performed on May 13th, 2010 and the second year on May 19th, 2011. All plots were treated with 20-20-0 composite fertilizer providing 60 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5. Soon before flowering, 60 kg ha^{-1} N (as 33% ammonium nitrate) was applied to the trial as an additional N source.

When plants reaches about 5-10% and 50-60% boll opening period, all the plants in the two middle rows of every parcel were screened for wilt disease symptoms on the leaves using 0-4 wilt scale (0 = no symptoms; 1 = 1-33% foliage affected; 2 = 34-66% foliage affected; 3 = 67-100% foliage affected; 4 = dead plants) (Bejarano-Alcazar et al., 1995). In order to determine the stem section based wilt disease severity all mentioned plants were cut at 10 cm above the ground level (after harvest). The plant cuts were applied to color changes of vascular system based of the 0-3 scale (0 = no discoloration xylem on trunk sectional area; 1 = 1-33% discoloration xylem; 2 = 34-67% discoloration xylem; 3 = 68-100% discoloration xylem) (Buchenauer and Erwin, 1976). Disease rates were calculated and obtained data were subjected to Arcsin for transformation (Karman, 1971).

The number of bolls (NB) was then determined by counting the bolls expected to reach maturity on five randomly selected plants in each plot. The four rows of each plot were harvested to determine of seed cotton yield (SCY, kg ha^{-1}). Ginning out turn (GOT, %) was calculated after roller ginning approximately 150 g samples of the harvested seed cotton and GOT (%) was computed by using the following formula given by Singh (2004).

GOT (%) = (Weight of lint in sample / Weight of seed cotton in that sample) x 100.

100 seed weight (SW, g) were randomly taken from each of the 4 replicates of field plots. After ginning, 100 g fibre samples were used for determination of various quality parameters. fibre quality parameters were determined in high volume instruments (HVI) USTER spectrum: (a) fibre fineness (FF); expressed in standard micronaire units, (b) fibre length (FL); fibre length is reported to the nearest millimetre (mm), (c) fibre strength (FS) as force (g tex^{-1}) necessary to break the fibre bundle. All fibre tests were carried out at the Nazilli Cotton Research Institute's cotton fibre technology laboratory, Nazilli.

During the investigation, meteorological data were recorded from planting date to harvest date and are presented in Table 1. In the Aegean Region of Turkey, mid-term climatic findings showed that there was 575 mm total rainfall. The average maximum temperature can reach 38.0ºC in July, average minimum temperature can reach 22.2ºC in July and rainfall can reach 34.7 mm in May.

Table 1. Maximum temperature, minimum temperature and total rainfall during the investigation

Months	Maximum temperature (°C)			Minimum temperature (°C)			Total rainfall (mm)		
	2010	2011	Average	2010	2011	Average	2010	2011	Average
May	27.4	27.6	27.5	12.9	14.0	13.4	1.1	68.4	34.7
June	32.6	35.8	34.2	18.0	20.0	19.0	1.4	1.0	1.2
July	37.4	38.6	38.0	21.1	23.3	22.2	-	-	-
August	37.1	37.5	37.3	21.5	21.9	21.7	-	-	-
September	34.8	33.7	34.2	17.4	17.0	17.2	0.5	-	0.25
October	24.0	27.8	25.9	10.0	14.0	12.0	3.2	7.8	5.5
November	17.6	19.6	18.6	3.8	12.9	8.3	-	17.6	8.8

Source: Turkish State Meteorological Service, Nazilli.

Data collected on different parameters were analysed statistically by using JMP statistical software program (5.0.1, SAS Institute, Cary, NC) for analysis of variance and means were compared using Fisher's protected least significance difference (LSD) test at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Results from the analysis of variance for observed characteristics in the experiment are presented in Table 2. Differences between genotypes were significant at (P>0.05) probability level for all the investigated traits. Variance analysis showed that genotype and year were significant for DSl (5-10%), DSl (50-60%), DSss, NB, FF, FL and FS; only genotype were significant DSpt, SW, SCY and GOT, while year x genotype interactions were not significant for all the investigated characteristics.

Disease severity values of cotton genotypes in leaves and stem section in pot trials were given in Table 3. Genotypes were significantly different at 5% level for disease severity (index) results of the leaf at 5-10% and 50-60% of boll opening period, in stem sections after harvest and in pot experiments. Based on the severity of the disease in the leaves, the control Carmen (0.70) was the most tolerant variety with 5-10% boll opening time followed by NMB 27/33 (0.95). The highest intensity of disease was found in susceptible cultivar, Çukurova 1518 (2.06). Other candidate varieties had index values between 1.06 and 1.40. At 50-60% boll opening period, Carmen variety (1.03) was in the first place and followed by NMB 27/33 (1.41). Again the highest intensity of disease was determined in susceptible cultivar Çukurova 1518 (2.78). The index values for other candidate varieties changed from 1.48 to 1.73. The tolerant Carmen variety sustained the highest stem section with 1.08 index value, followed by NMB 27/33 (1.47). The highest disease intensity value was observed in Çukurova 1518 (2.53) according to the severity of the disease. In the pot experiment, Carmen variety with a 1.19 index value showed the lowest disease severity and followed by NMB 27/33 (1.53) for Vd11 isolate according to the severity of foliar disease. The highest disease severity values were determined in susceptible Çukurova 1518 (2.70) variety. While the lowest disease severity was reported in cultivar Carmen, the highest was in Çukurova 1518 (3.56) isolate PYDV6 (Table 3).

Since pathotypes were different in field and pot experiments, disease incidences were graded at seedling stage in pot experiment. Therefore, the amount of inoculum caused the pot experiment to sustain more differences and higher disease incidence values than the field experiments (Table 3). In a study by Devey and Rosielle (1986), concluded that the differences of the field and greenhouse results may be due to disease counts done later stage of plant development in the field. In a study to determine the effects of T-1 (defoliation pathotype) and SS-4 (non-defoliating pathotype) Giza 45, Giza 75 and Aşkabat cultivars were found resistant to T-1 in field while others except DPL 15/21, Çukurova 1518 and Sayar 314 showed moderate to high resistance against SS-4 (Kurt and Biçici, 1998). In another experiment to test reactions of cotton genotypes against different *V. dahliae* pathotypes in a growth chamber and field, cultivars showed the different levels of reactions against both pathotypes and all varieties were found susceptible to defoliating pathotype of disease in growth chamber. In addition, Carmen cultivar responded differently against both pathotypes (Göre et al., 2009). In a genotype reaction study by Erdoğan et al. (2011), concluded that chamber studies of disease severity values were higher than that of field trials.

All candidate varieties had moderate resistance against Vd11 isolate, but low durability against PYDV6 in the pot experiment. The reason may be due to having high virulence of pathotype, absence of resistant cultivar, rapid progress of infection within the plant (Korolev et al., 2001; Zhengjun et al., 1998). Galbieri et al. (2008), tested 25 cotton genotypes under greenhouse conditions to evaluate resistance to Verticillium wilt and found that the

majority of genotypes have different levels of resistance. In a study by Bölek et al. (2011), to determine tolerant and susceptible cotton genotypes against Verticillium wilt in the growth chamber, they found that the difference between genotypes was statistically significant ($P<0.01$) and the most tolerant genotype was Carmen while the most susceptible one was Çukurova 1518.

Table 2. Results of variance analysis for the investigated characters and mean of sum of squares

Source	Df	DSl (5-10%)	DSl (50-60%)	DSss	NB (number plant^{-1})	SW (g)	SCY (kg ha^{-1})	GOT (%)	FF (mic.)	FL (mm)	FS (g tex^{-1})	Df	DSpt
Replication (R)	3	0.01	0.001	0.003	0.35	1.60	5778.22	14.79	0.04	8.08	8.85	5	0.83
Year (Y)	1	0.07*****	0.14*****	0.02*****	6.11*****	0.14	1759.36	4.20	0.36*	13.81*	21.78*	1	0.02
Genotype (G)	12	3.07*****	4.83*****	3.14*****	37.01*	55.5*****	91746.0*	172.43*	6.01*	92.52*	227.85*****	12	5.68*
Y x G	12	0.01	0.08	0.02	2.26	2.06	833.62	24.24	0.74	8.85	34.36	12	0.03
Error	75	0.04	0.03	0.08	14.10	21.20	62391.84	104.79	4.06	57.83	185.21	125	9.38
Total	103	3.23	5.02	3.26	59.85	80.52	162509.1	320.47	11.23	181.1	478.07	155	15.93

*Significant at the 0.05 probability level; Df = degrees of freedom; DSl (5-10%) = disease severity in leaves 5-10% boll opening; DSl (50-60%) = disease severity in leaves 50-60% boll opening; DSss = disease severity in stem section; DSpt = disease severity in pot trials; NB = number of bolls (number plant^{-1}); SW = 100 seed weight (g); SCY = seed cotton yield (kg ha^{-1}); GOT = ginning out turn (%); FF = fibre fineness (microniare); FL = fibre length (mm); FS = fibre strength (g tex^{-1}).

Table 3. The average values of disease severity for cotton genotypes

Genotypes	DS in leaves		DS in stem section	DS in pot trials	
	% 5-10 Boll opening	% 50-60 Boll opening		Vd11	PYDV6
NAMSI 288/3	1.15 de	1.63 d	1.67 c	1.84 bc	2.35 bc
MNABL 146/1	1.06 h	1.48 f	1.54 e	1.69 bc	2.19 c
NMB 27/33	0.95 ı	1.41 g	1.47 f	1.53 cd	2.21 c
MTA 12/33	1.14 fg	1.49 f	1.55 e	1.68 bc	2.20 c
Carmen (K)	0.70 j	1.03 h	1.08 g	1.19 d	1.71 d
Çukurova1518 (K)	2.06 a	2.78 a	2.53 a	2.70 a	3.56 a
NCCH-10	1.40 b	1.68 c	1.77 b	2.02 b	2.71 b
NP ÖZBEK 100 (K)	1.11 g	1.49 f	1.57 e	1.70 bc	2.20 c
95	1.25 d	1.60 d	1.68 c	1.85 bc	2.37 bc
140	1.20 ef	1.56 ef	1.64 cd	1.85 bc	2.37 bc
149	1.15 de	1.49 f	1.58 de	1.68 bc	2.21 c
155	1.38 b	1.73 b	1.79 b	2.02 b	2.71 b
216	1.34 c	1.71 bc	1.78 b	2.01 b	2.71 b
LSD	0.025*	0.022*	0.034*	0.221*	0.213*

*Different letters between genotypes denote significant differences at 5% probability level; DS = disease severity.

In this experiment, the initial symptoms of Verticillium wilt genotypes was seen at 5-10% boll opening period and signs of disease has steadily increased toward harvest. After disease counts at three different periods, Carmen variety was found as the most tolerant variety and drought-resistant candidate variety, followed by NMB 27/33. The highest intensity of disease was identified as expected in susceptible Çukurova 1518, a control variety (Table 3). Such a difference to occur between genotypes of *G. hirsutum* L. cultivars in field and climate chamber trails shows different reactions of genotypes to the wilt disease. In studies conducted in this regard; Gossypium species differ in terms of Verticillium wilt resistance (El-Zik, 1985), and five cotton genotypes had different degrees of susceptibility against

Verticillium wilt under greenhouse conditions (Corato et al., 2000). In another study conducted in Nazilli, the difference between lines and cultivars were statistically significant and Carmen (control) was the most tolerant cultivar in terms of disease severity and followed by candidate cultivars NGC, M25 G and GSN 12 (Erdoğan, 2009).

Table 4. Number of bolls, 100 seed weight, seed cotton yield and ginning out turn values of cotton genotypes

Genotypes	NB (number plant^{-1})	SW (g)	SCY (kg ha^{-1})	GOT (%)
NAMSI 288/3	11.9 a	11.2 bc	4090.9 bc	39.8 bcde
MNABL 146/1	10.9 c	12.3 a	3900.1 cd	38.8 ef
NMB 27/33	10.9 c	12.6 a	3860.7 cdef	39.5 cde
MTA 12/33	11.8 a	12.2 a	4260.5 ab	39.0 def
Carmen (K)	11.9 a	10.9 bcde	4340.7 ab	40.9 b
Çukurova1518 (K)	10.4 d	11.4 b	3460.4 g	39.1 def
NCCH-10	12.1 a	11.1 bcd	4460.2 a	40.1 bcd
NP ÖZBEK 100 (K)	11.4 b	10.6 def	3760.9 def	39.9 bcde
95	11.1 bc	12.2 a	3870.7 cde	38.0 f
140	10.4 d	10.5 ef	3580.1 fg	42.8 a
149	10.4 d	11.3 bc	3590.1 efg	40.5 bc
155	10.9 c	10.3 f	3760.1 def	42.1 a
216	11.2 bc	10.8 cdef	3710.7 defg	39.0 def
LSD	0.432*	0.529*	28.728*	1.177*

*Different letters between genotypes denote significant differences at 5% probability level; NB = number of bolls (number plant^{-1}); SW = 100 seed weight (g); SCY = seed cotton yield (kg ha^{-1}); GOT = ginning out turn (%).

The number of bolls of genotypes (number plant^{-1}), 100 seed weight (g), seed cotton yield (kg ha^{-1}) and ginning out turn (%) values are given in Table 4. Genotypes were significantly different at 5% statistical level in terms of the number of bolls, 100 seed weight, seed cotton yield and ginning out turn. Genotypes NCCH-10 (12.1 bolls plant^{-1}), NAMSİ 288/3 (11.9 bolls plant^{-1}) and Carmen (11.9 bolls plant^{-1}) had maximum number of bolls, while genotypes 140 (10.4 bolls plant^{-1}), 149 (10.4 bolls plant^{-1}) and Çukurova 1518 (10.4 bolls plant^{-1}) had the lowest number of bolls. The highest 100 seed weight belonged to early maturing genotypes NMB 27/33 (12.6 g), MTA 12/33 (12.3 g) and 95 (12.3 g), while the lowest one belonged to genotype 155 (10.3 g). The highest yield was obtained from the early maturing candidate variety NCCH-10 (4460 kg ha^{-1}), tolerant Carmen variety (4340.7 kg ha^{-1}) and drought tolerant genotype MTA 12/33 (4260.5 kg ha^{-1}), which felt into the same statistical group. The control susceptible cultivar Çukurova 1518 (3460.4 kg ha^{-1}) produced the lowest yield. The highest ginning out turn value was obtained from genotypes 140 (42.8%) and 155 (42.1%); the lowest value belonged to 95 (38.0%) (Table 4). Some genotypes determined as tolerant and susceptible against Verticillium wilt were in the same statistical group for number of bolls, 100 seed weight and ginning out turn values. This may be attributed to parental status of disease resistance at early infection (beginning at squaring or flowering). Indeed, the highest boll numbers were found in Carmen, NCCH-10, MTA 12/33 and NAMSİ 288/3 having different disease incidence values. The highest seed cotton yield was obtained from earlier maturing candidate variety NCCH-10 and tolerant Carmen cultivar, while the lowest seed cotton yield was found in susceptible cultivar Çukurova 1518 (Table 4). However, in these yield studies not only disease severity, but also the effect of climatic factors and cultural practices on the genotype should not be ignored. When the leaves developed symptoms before first flowering period in plants, the total number of bolls and opened bolls and thus yield were decreased but when the symptoms developed after the time of first

open boll the effects of disease on yield were negligible (Bejarano-Alcazar et al., 1997). Hutmacher et al. (2005), reported that in disease infested cotton field, the climatic factors and cultural practices other than Verticillium wilt on the yield would be effective during the growing season. In a study by Erdoğan et al. (2006), conducted in Nazilli/Turkey in naturally infested field with disease and non-infested fields, the disease caused 15.93% reduction in the yield. In addition, parameters such as seed cotton yield, fibre yield and number of bolls per m^2 were higher in tolerant cultivars than that of susceptible ones (Jun-jie et al., 2010). On the other hand, susceptible cultivars such as ST-453 and Deltaopal were also high yielding as reported by Karademir et al. (2010). This may be due to being early maturing cultivars or to the fact that disease was effective in the late stages of plant development. Arabsalmani et al. (2011), investigated the effect of Verticillium wilt on qualitative and quantitative characters of cotton and they found that disease reduced the yield and number of bolls on the plant. In this experiment, our findings regarding kernel weight and ginning turnout were comparable with the findings of El-Zik (1985), but not with those of Sağır and Başbağ (2002), who reported that disease caused reduction of kernel weight and ginning out turn in cotton.

Table 5. Fibre fineness, fibre length and fibre strength values of cotton genotypes

Genotypes	FF (micronaire)	FL (mm)	FS (g tex^{-1})
NAMSI 288/3	4.7 bc	30.7 cde	30.2 g
MNABL 146/1	4.6 c	30.5 cde	30.8 efg
NMB 27/33	4.9 b	30.7 cde	31.4 defg
MTA 12/33	4.9 b	30.1 ef	32.2 bcde
Carmen (K)	4.8 bc	31.3 bc	33.7 b
Çukurova1518 (K)	4.8 bc	30.4 de	31.3 defg
NCCH-10	4.8 bc	28.8 g	30.5 fg
NP ÖZBEK 100 (K)	4.4 d	29.4 fg	31.8 cdef
95	4.8 bc	32.6 a	35.6 a
140	5.3 a	31.2 bcd	32.9 bcd
149	4.8 bc	30.7 cde	33.7 b
155	4.8 bc	30.4 de	31.6 cdefg
216	4.3 d	31.9 ab	33.2 bc
LSD	0.231*	0.875*	1.565*

*Different letters between genotypes denote significant differences at 5% probability level; FF = fibre fineness (micronaire); FL = fibre length (mm); FS = fibre strength (g tex^{-1}).

Fibre fineness of cotton genotypes (micronaire), fibre length (mm) and the fibre strength (g tex^{-1}) values are given in Table 5. The genotypes were significantly different at the 5% level for fibre fineness (micronaire), fibre length (mm) and fibre strength (g tex^{-1}). Based on the fibre fineness, candidate variety 140 (5.3 micronaire) had the coarse fibres while 216 (4.3 micronaire) and standard NP ÖZBEK 100 variety (4.4 micronaire) had the thinnest fibres. For fibre length the genotypes were placed in the mid-long classes. The longest fibre value was in genotype 95 (32.6 mm) while early maturing variety NCCH-10 (28.8 mm) and the standard NP ÖZBEK 100 cultivar (29.4 mm) had the shortest fibre length. In terms of fibre strength, candidate variety 95 (35.6 g tex^{-1}) gave with the highest fibre strength value while NAMSİ 288/3 (30.2 g tex^{-1}) and early maturing genotype NCCH-10 (30.5 g tex^{-1}) had the lowest fibre strength. Genotypes having different disease severity values were in the same statistical grouping for fibre fineness and fibre length. This may be caused by planting and cultural practices, as well as genotype by environment interactions. In this study, effect of Verticillium wilt on fibre strength varied among genotypes. This difference may be due to the variations in earliness of genotypes, disease times and disease infection rates. Verticillium wilt negatively affected the

quality of fibre and the fibre technological characteristics were not at the desired level for the cultivars that are found resistant (Yelin and Erşan, 1985). Of the fibre quality parameters, fibre length was less affected by disease incidence and the difference in fibre fineness highly depended on genotype; in addition, the effect of Verticillium wilt on fibre strength was different between cultivars (Kechagia and Xanthpoulos, 1998; Azaddisfani and Zangi, 2007). Aguado et al. (2010), found significant differences among genotypes grown in a Verticillium infested field and they concluded that the difference on fibre fineness and fibre length came especially from genotype by environment interaction.

CONCLUSIONS

In the experiment, late and mid-early maturing genotypes had significantly lower disease severity value than the early maturing genotypes according to 5-10%, 50-60% boll opening periods and stem section results. Of the inspected parameters number of bolls, 100 seed weight, ginning out turn, fibre fineness and fibre length values were more affected by genotype, climatic conditions and cultural practices rather than severity of the disease. The results obtained will be guidance to the incoming studies on the reactions of genotypes against Verticillium wilt.

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