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Full Length Research Paper

Yield and fiber quality properties of cotton (*Gossypium hirsutum* L.) under water stress and non-stress conditions

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The primary objective of this study was to determine the effect of water stress and non-stress conditions on cotton yield and fiber quality properties. A two-year field study was carried out at the Southeastern Anatolia Agricultural Research Institute (SAARI), in 2009 and 2010, with the aim of evaluating 12 cotton genotypes for yield and fiber quality properties under irrigated and water stress conditions. The experiment was laid out as a randomized split block design (RSBD) with four replications. Significant differences were observed among genotypes and water treatments for seed cotton yield, fiber yield, ginning percentage and all fiber quality properties except fiber uniformity. Yield differences among genotypes under water stress and non-stress conditions were higher during the first season. In both years, SER-18 and Stoneville 468 cotton genotypes produced higher yield under water stress conditions, while Stoneville 468 produced higher yield under well-irrigated conditions. The results during the two years indicated that seed cotton yield decreased (48.04%) and fiber yield decreased (49.41%), due to water stress. Ginning percentage and fiber quality properties were also negatively affected by water stress treatment. Fiber length, fiber strength, fiber fineness and fiber elongation were decreased, while fiber uniformity was not affected by water stress treatment.

Key words: Cotton, yield, fiber quality properties, water stress, non-stress.

INTRODUCTION

Water stress is the most important factor limiting crop productivity and adversely affects fruit production, square and boll shedding, lint yield and fiber quality properties in cotton (El-Zik and Thaxton, 1989). As the global climate changes continue, water shortage and drought have become an increasingly serious constraint limiting crop production worldwide.

The demand for drought tolerant genotypes will be exacerbated as water resources and the funds to access them become more limited (Longenberger et al., 2006). Previous studies revealed that 2 to 4°C increase in temperature and the expected 30% decrease in precipitation may adversely affect crop productivity and water availability by the year 2050 (Ben-Asher et al., 2007). Thus, screening cotton varieties for resistance to drought stress conditions and improving cotton tolerance to this stress conditions will mitigate negative consequences of this adversity. Cotton is normally not classified as a drought tolerant crop as some other plants species such as sorghum which is cultivated in areas normally too hot and dry to grow other crops (Poehlman, 1986). Nevertheless, cotton has mechanisms that make it well adapted to semi-arid regions (Malik et al., 2006). An understanding of the response of cultivars to water deficits is also important to model cotton growth and estimate irrigation needs (Pace et al., 1999). Previous studies reported variation in drought resistance among and within species (Penna et al., 1998). Cotton lint yield is generally reduced because of reduced boll production, primarily because of fewer flowers and also because of increased boll abortions when the stress is extreme and when it occurs during reproductive growth (Grimes and Yamada, 1982; McMichael and Hesketh, 1982; Turner et al., 1986; Gerik et al., 1996; Pettigrew, 2004a; Pettigrew, 2004b). Cook and El-Zik (1992) revealed significant

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differences between genotypes for seedling and first-bloom plant measurements, with Tamcot CD3H and TX-CABUCS-2-1-83 having higher levels of seedling vigor, more rapid root system establishment and lower root-to-shoot ratio. Similar results were also reported by Başal et al. (2005), who suggested that root parameters, initial water content (IWC) and excised leaf water loss (ELWL), can be used as a reliable selection criteria for drought tolerance. In addition, earlier researchers reported that root growth is an important and reliable indicator of the response of drought tolerant varieties and therefore this character could be used at seedling stage; at plant maturity, roots and its characteristics are complex to measure, and screening method is destructive, thus making their use limited in breeding programs (Igbal et al., 2010). Bölek (2007) found Tamcot Sphinx, CUBQHGRPIS-1-92 and CUBQHGRPIH-1-92 cotton genotypes more tolerant to mid-season water stress than the other genotypes and that decline in boll retention was positively associated with a 39% reduction in yield in the water stressed treatment.

The primary objective of this study was to investigate the differential response to yield, fiber quality properties of selected drought tolerant lines and some commercial cotton varieties when grown under water stress and non-stressed conditions.

MATERIALS AND METHODS

The experiment was carried out at the Southeastern Anatolia Agricultural Research Institute's experimental area during 2009 and 2010 growing seasons in Diyarbakir, Turkey. In this study, 12 cotton genotypes were observed in terms of yield and fiber quality properties under water stress and non-stress conditions. Eight advanced cotton lines (BMR-25, SMR-15, TMR-26, BST-1, SER-21, SST-8, CMR-24 and SER-18) developed for tolerance to drought stress, and four commercial cotton varieties (Stoneville 468, BA 119, GW-Teks and Şahin 2000) were used as plant materials.

The experiment was carried out under field conditions as a randomized split block design (RSBD) with two blocks, one was well watered and to the other, water stress was applied, with four replications in each block. Genotypes were randomized within each of the main blocks and replications. Each sub plot consisted of four rows of 12 m in length, between and within the row spacing were 0.70 and 0.20 m, respectively. Between the main plots, 4.2 m space was left to avoid edge interference between the treatments.

Seeds of these cotton genotypes were planted with combined cotton drilling machine on 6th May, 2009 and on 7th May, 2010 and all plots were treated with 20-20-0 composite fertilizer to provide 70 kg N ha^{-1} and 70 kg P_2O_5 ha^{-1}. Just before flowering, 70 kg N ha^{-1} were applied as ammonium nitrate as an additional N dose. Herbicides were used twice in both years. In both years, insect were monitored throughout the experiment and no insect control was necessary during these growing season. Plants were grown under recommended cultural practices for commercial production; the experiment was thinned and hoed three times by hand and two times with a machine.

Experimental plots were irrigated by drip irrigation method. Water treatments consisted of two regimes, one was watered and the other was water-stressed. Throughout the growing season, 378 mm water was given in water stress treatment and 756 mm water was given in non-stress treatment in 2009 and 2010. In the stress application, plants were subjected to water stress from flowering stage to 10% boll opening period. The meteorological data of the experimental site during the study period is presented in Figures 1 and 2.

The sowing time is usually from the end of the April to mid May. It can be seen that the precipitation were inadequate during the two years of experiments when compared with long term precipitation at the sowing time. On the contrary, two years precipitation was higher than that of the long term experiment at the harvesting time (Figure 1). In the second year of the experiment, both maximum temperatures and mean temperatures were higher than that of previous year and long term period (Figure 2).

Plots were harvested twice by hand and the obtained seed cotton from the four rows of the plots were weighed and calculated for seed cotton yield and fiber yield. The first harvest was done on 13th October, 2009 and 7th October, 2010 and the second harvest was done on 10th November, 2009 and 9th November, 2010. After the harvest, seed cotton samples were ginned on a mini-laboratory roller-gin for lint quality. Fiber quality properties were determined by high volume instrument (HVI Spectrum). Statistical analysis were performed using JMP 5.0.1 statistical software (http://www.jmp.com) and the means were grouped with $LSD_{(0.05)}$ test.

RESULTS AND DISCUSSION

The analysis of variance of the investigated characteristics and the obtained findings from the cotton genotypes are presented in Tables 1 to 5. Significant differences were obtained among genotypes and treatments for seed cotton yield, fiber yield, ginning percentage and all fiber technological properties, except fiber uniformity. The effect of year was significant for seed cotton yield, fiber yield, ginning percentage, fiber length and fiber elongation. Year x treatment interaction was significant for seed cotton yield, fiber yield, ginning percentage, fiber length, fiber strength, fiber elongation and fiber uniformity. Year x genotype and year x treatment x genotype interactions were non-significant for all the measured traits. Treatment x genotype interaction was significant for fiber strength (Table 1).

Seed cotton yield and fiber yield were consistently affected by water treatment. The results of the combined analysis over two years indicated that water stress treatment had negative effect on seed cotton yield and fiber yield. Seed cotton yield decreased by 48.04%, and fiber yield by 49.41%, due to water stress on the average. Among the genotypes, highest seed cotton yield was obtained from SER-18, Stoneville 468 and SST-8 in water stress conditions. Stoneville 468 also had the highest yield under well watered conditions (Table 2 and Figure 3). This indicates drought tolerance of these genotypes (SER-18, Stoneville 468 and SST-8) as compared to others. These genotypes also maintained higher fiber yield under stress conditions. In addition, the response to the two water treatment was similar among genotypes, indicating the lack of a significant genotype x treatment interaction. Year differences were significant at 0.01 probability level for seed cotton yield and fiber yield, because there were variability between two years in

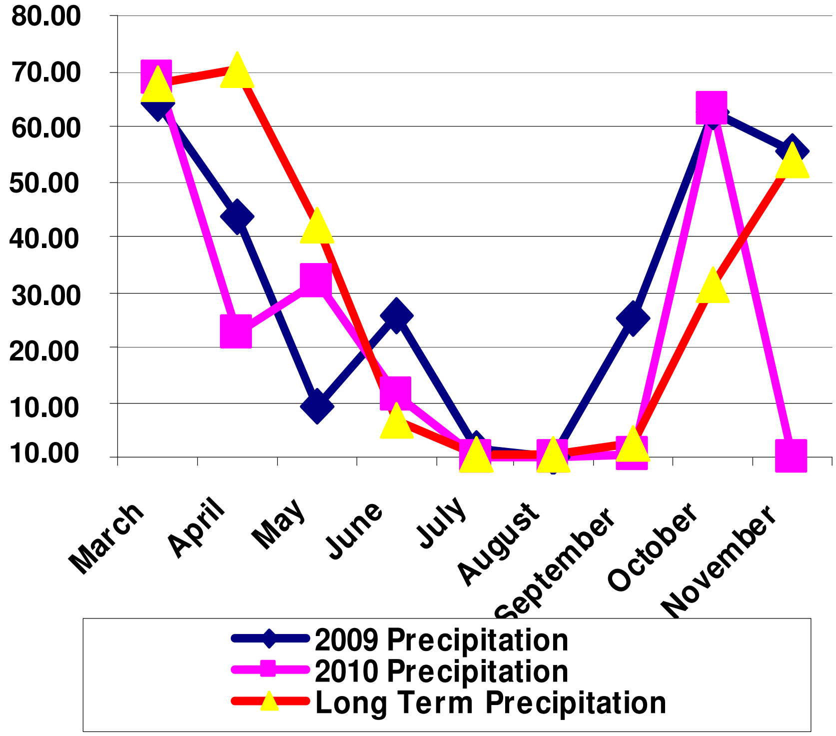

Figure 1. Average precipitation levels (mm) of 2009, 2010 and long term.

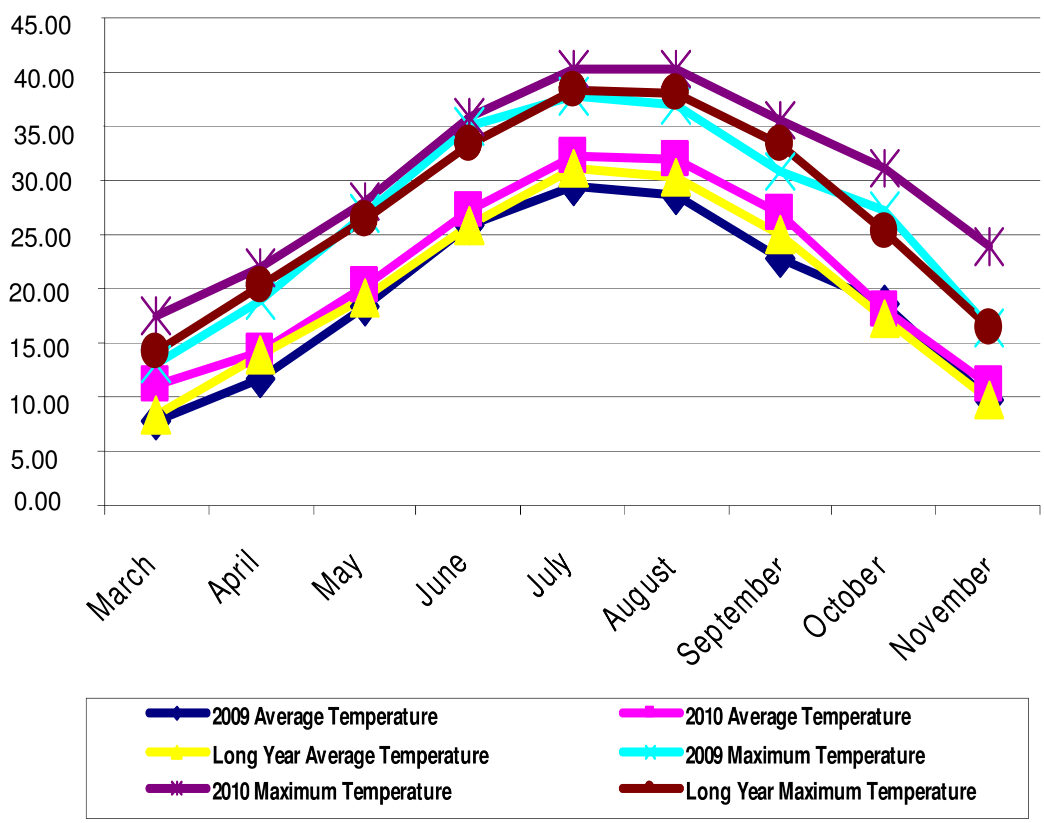

Figure 2. Monthly average and maximum temperature of 2009, 2010 and long term.

Table 1. The analysis of variance of the investigated characteristics.

Source	df	Seed cotton yield (kg ha^{-1})	Fiber yield (kg ha^{-1})	Ginning percentage (%)	Fiber length (mm)	Fiber fineness (mic.)	Fiber strength (g tex^{-1})	Fiber elongation (%)	Fiber uniformity (%)
Year	1	665.81**	464.22**	40.39**	8.64*	1.01	0.37	20.92**	0.39
Replication (year)	6	5.93*	5.53*	0.71	0.49	1.88	0.61	1.08	0.43
W. Treatment	1	2076.15**	1845.82**	11.89*	14.14**	27.91**	16.43**	66.41**	3.27
Year x W. treatment	1	701.67**	645.03**	15.30**	12.27*	3.89	10.17*	24.97**	7.94*
Replication x W. treatment [Year] and random	6	1.03	1.26	4.56**	2.64*	2.37*	3.72**	1.04	1.21
Genotype	11	3.48**	8.14**	46.02**	7.30**	4.45**	13.81**	9.55**	1.25
Year x genotype	11	0.98	1.06	0.92	1.35	1.02	1.06	0.65	0.74
W. Treatment x genotype	11	0.81	1.23	0.63	0.96	1.00	2.07*	0.76	1.60
Year x W. treatment x genotype	11	0.64	0.96	1.03	1.61	0.47	0.85	0.64	0.92

* and **Significant at the 0.05 and 0.01 probability level, respectively.

Table 2. Average values of seed cotton and fiber yields of cotton genotypes and statistical groups of each year and over the two years.

Genotype	Seed cotton yield (kg ha^{-1})							Fiber yield (kg ha^{-1})						
	2009		2010		2009-2010		Average	2009		2010		2009-2010		Average
	Stress	Non stress	Stress	Non stress	Stress	Non stress		Stress	Non stress	Stress	Non stress	Stress	Non stress	
BMR-25	1940	4755	2076	2764	2008	3760	2884^{cd}	746	1937	865	1143	806	1540	1173^{d}
SMR -15	1986	4898	1835	2968	1910	3933	2922^{cd}	722	1908	728	1141	725	1525	1125^{d}
TMR-26	2087	5076	2003	2840	2045	3958	3001^{bc}	782	2014	812	1152	797	1583	1190^{d}
BST-1	2006	5017	1962	2622	1984	3819	2902^{cd}	762	1992	806	1068	784	1530	1157^{d}
SER-21	2053	5045	1945	2780	1999	3913	2956^{cd}	795	2047	807	1144	801	1596	1198^{cd}
SST-8	2145	4992	2064	2815	2104	3904	3004^{bc}	818	1982	826	1142	822	1562	1192^{cd}
CMR-24	2056	4767	1935	2542	1996	3655	2825^{cd}	780	1942	790	1060	785	1501	1143^{d}
SER-18	2258	4979	2307	3147	2282	4063	3173^{ab}	875	1974	946	1288	911	1631	1271^{bc}
STV 468	2099	5213	2418	3246	2259	4230	3244^{a}	868	2261	1081	1439	974	1850	1412^{a}
BA 119	1899	5111	2184	2834	2041	3972	3007^{bc}	784	2197	968	1269	876	1733	1305^{b}
GW-TEKS	1597	4972	1849	2724	1723	3848	2786^{d}	650	2093	793	1164	721	1629	1175^{d}
ŞAHİN 2000	2093	5115	1980	2733	2036	3924	2980^{b-d}	801	2088	807	1088	804	1588	1196^{cd}
Mean	2018	4995	2047	2835	2032^{b}	3915^{a}		782	2036	853	1175	817^{b}	1606^{a}	
Year (Y)	3507^{a}		2441^{b}					1409^{a}		1014^{b}				

Table 2 Contd.

CV (%)	9.44	9.32
LSD (0.05)		
Genotype (G)	195.73**	78.74**
Treatment (T)	100.79**	44.77**
Y x T	142.54**	63.31**
Y x G	ns	ns
T x G	ns	ns
Y x T x G	ns	ns

* and **Significant at the 0.05 and 0.01 probability level, respectively.

Table 3. Average values of ginning percentage (%) and fiber length (mm) of cotton genotypes and statistical groups of each year and over the two years.

Genotype	Ginning percentage (%)							Fiber length (mm)						
	2009		2010		2009-2010		Average	2009		2010		2009-2010		Average
	Stress	Non stress	Stress	Non stress	Stress	Non stress		Stress	Non stress	Stress	Non stress	Stress	Non stress	
BMR-25	38.43	40.74	41.69	41.42	40.06	41.08	40.57^{c}	26.16	27.27	26.78	26.56	26.47	26.92	26.69^{fg}
SMR -15	36.31	38.97	39.70	38.48	38.01	38.73	38.37^{f}	27.64	28.75	27.01	27.82	27.33	28.28	27.81^{ab}
TMR-26	37.25	39.71	40.50	40.58	38.88	40.15	39.51^{e}	27.16	27.43	26.17	26.28	26.66	26.85	26.76^{e-g}
BST-1	37.98	39.73	41.15	40.78	39.55	40.25	39.91^{de}	27.22	27.72	27.00	26.83	27.11	27.27	27.19^{c-f}
SER-21	38.66	40.62	41.55	41.19	40.10	40.90	40.50^{cd}	26.80	28.18	27.01	27.09	26.90	27.64	27.27^{b-e}
SST-8	38.15	39.71	40.04	40.57	39.09	40.14	39.62^{e}	26.89	29.28	27.60	26.29	27.25	27.78	27.51^{a-d}
CMR-24	37.98	40.76	40.77	41.78	39.37	41.27	40.32^{cd}	26.73	27.86	26.42	27.05	26.57	27.46	27.01^{d-f}
SER-18	38.61	39.64	40.99	40.98	39.80	40.31	40.05^{c-e}	27.63	28.52	26.97	27.31	27.30	27.92	27.61^{a-c}
STV 468	41.24	43.38	44.68	44.35	42.96	43.87	43.41^{a}	26.72	28.23	26.77	26.58	26.74	27.41	27.08^{c-f}
BA 119	41.20	43.02	44.32	44.75	42.76	43.89	43.32^{a}	25.21	27.52	26.14	26.10	25.68	26.81	26.24^{g}
GW-TEKS	40.64	42.12	42.89	42.77	41.77	42.44	42.10^{b}	26.46	28.94	27.89	28.52	27.17	28.73	27.95^{a}
ŞAHİN 2000	38.04	40.86	40.76	39.83	39.40	40.34	39.87^{de}	27.63	28.88	27.77	27.66	27.70	28.27	27.96^{a}
Mean	38.71	40.77	41.59	41.46	40.15^{b}	41.11^{a}		26.85	28.21	26.96	27.01	26.71^{b}	27.61^{a}	
Year (Y)	39.74^{b}		41.52^{a}					27.53^{a}		26.98^{b}				
CV (%)				2.21							2.89			
LSD (0.05)														
Genotype (G)				0.63**							0.55**			
Treatment (T)				0.68*							0.43**			

Table 3 Contd.

Y x T	0.95**	0.63*
Y x G	ns	ns
T x G	ns	ns
Y x T x G	ns	ns

*and ** Significant at the 0.05 and 0.01 probability level, respectively.

Table 4. Average values of fiber fineness (mic.) and fiber strength (g tex^{-1}) of cotton genotypes and statistical groups of each year and over the two years.

Genotype	Fiber fineness (micronaire)							Fiber strength (g tex^{-1})						
	2009		2010		2009-2010		Average	2009		2010		2009-2010		Average
	Stress	Non stress	Stress	Non stress	Stress	Non Stress		Stress	Non stress	Stress	Non stress	Stress	Non stress	
BMR-25	4.00	4.59	4.14	4.62	4.07	4.61	4.34^{a-d}	24.80	28.30	27.62	27.10	26.21	27.70	26.95^{de}
SMR -15	4.18	4.67	4.35	4.49	4.26	4.58	4.42^{ab}	26.87	31.95	26.85	30.20	26.86	31.07	28.96^{b}
TMR-26	3.95	4.42	4.02	4.47	3.99	4.44	4.22^{cd}	23.92	29.92	26.90	26.80	25.41	28.36	26.88^{de}
BST-1	4.25	4.68	4.23	4.72	4.24	4.70	4.47^{a}	26.37	29.62	28.87	29.32	27.62	29.47	28.55^{bc}
SER-21	4.17	4.46	4.33	4.53	4.23	4.50	4.37^{a-c}	25.05	30.05	26.77	27.97	25.91	29.01	27.46^{c-e}
SST-8	3.99	4.43	4.04	4.24	4.01	4.33	4.17^{c-e}	27.82	30.15	26.25	27.70	27.03	28.92	27.98^{b-d}
CMR-24	3.86	4.37	4.27	4.52	4.07	4.44	4.25^{b-d}	24.12	28.47	26.35	27.52	25.23	28.00	26.61^{e}
SER-18	4.00	4.48	4.28	4.30	4.14	4.39	4.27^{a-d}	27.25	28.82	27.32	27.60	27.28	28.21	27.75^{c-e}
STV 468	4.21	4.44	4.23	4.16	4.22	4.30	4.26^{b-d}	28.77	29.02	28.97	27.70	28.87	28.36	28.61^{bc}
BA 119	3.86	4.17	4.26	4.32	4.06	4.25	4.15^{d-f}	26.82	30.50	27.60	27.35	27.21	28.92	28.06^{b-d}
GW-TEKS	3.38	4.28	3.97	4.21	3.67	4.25	3.96^{f}	30.00	34.85	32.70	32.45	31.35	33.65	32.50^{a}
ŞAHİN 2000	3.82	4.33	3.89	3.98	3.85	4.15	4.00^{ef}	25.95	27.97	26.45	25.95	26.20	26.96	26.58^{e}
Mean	3.97	4.44	4.16	4.38	4.07^{a}	4.41^{b}		26.48^{b}	29.97^{a}	27.72^{b}	28.13^{b}	27.10^{b}	29.05^{a}	
Year (Y)	4.21		4.27					28.22		27.93				
CV (%)				6.83							6.12			
LSD (0.05)														
Genotype (G)				0.19**							1.20**			
Treatment (T)				0.14**							1.17**			
Y x T				ns							1.65*			
Y x G				ns							ns			
T x G				ns							1.69*			
Y x T x G				ns							ns			

* and **Significant at the 0.05 and 0.01 probability level, respectively.

Table 5. Average values of fiber elongation (%) and fiber uniformity (%) of cotton genotypes and statistical groups of each year and over the two years.

Genotype	Fiber elongation (%)							Fiber uniformity (%)						
	2009		2010		2009-2010		Average	2009		2010		2009-2010		Average
	Stress	Non stress	Stress	Non stress	Stress	Non stress		Stress	Non stress	Stress	Non stress	Stress	Non stress	
BMR-25	5.20	6.25	5.37	5.67	5.28	5.96	5.62^{b}	80.82	83.82	82.57	82.12	81.70	82.97	82.33
SMR -15	5.35	5.67	5.47	5.45	5.41	5.56	5.48^{bc}	81.97	85.10	83.05	82.77	82.51	83.93	83.22
TMR-26	5.27	5.95	5.10	5.65	5.18	5.80	5.49^{bc}	79.52	84.52	82.40	83.20	80.96	83.86	82.41
BST-1	5.10	5.65	5.17	5.40	5.13	5.52	5.33^{cd}	81.10	84.27	83.20	84.40	81.15	84.33	83.24
SER-21	5.02	5.65	5.02	5.17	5.02	5.41	5.21^{d}	81.32	83.52	81.30	83.92	81.31	83.72	82.51
SST-8	5.12	5.97	5.50	5.22	5.31	5.60	5.45^{b-d}	81.55	83.55	82.17	82.07	81.86	82.81	82.33
CMR-24	5.05	5.77	5.25	5.50	5.15	5.63	5.39^{b-d}	81.67	83.92	81.55	82.80	81.61	83.36	82.48
SER-18	5.42	6.27	5.22	5.50	5.32	5.88	5.60^{b}	82.47	83.62	83.40	82.57	82.93	83.10	83.01
STV 468	5.92	6.67	5.82	5.90	5.87	6.28	6.08^{a}	81.75	82.87	83.55	70.82	82.65	76.85	79.75
BA 119	5.95	6.50	5.80	6.15	5.87	6.32	6.10^{a}	81.52	83.80	83.12	82.75	82.32	83.27	82.80
GW-TEKS	5.52	6.02	5.37	5.40	5.45	5.71	5.58^{bc}	81.92	86.32	83.22	85.00	82.57	85.66	84.11
ŞAHİN 2000	5.55	6.65	5.65	5.80	5.60	6.22	5.91^{a}	81.17	83.87	82.57	82.62	81.87	83.25	82.56
Mean	5.37^{c}	6.08^{a}	5.39^{bc}	5.56^{b}	5.38^{b}	5.82^{a}		81.40^{b}	84.10^{a}	82.67^{a}b	82.08ab	82.03	83.09	
Year (Y)	5.73^{a}		5.48^{b}					82.75		82.38				
CV (%)				6.42							4.43			
LSD (0.05)														
Genotype (G)				0.23**							ns			
Treatment (T)				0.12**							ns			
Y x T				0.17**							2.00*			
Y x G				ns							ns			
T x G				ns							ns			
Y x T x G				ns							ns			

* and ** : significant at the 0.05 and 0.01 probability level, respectively.

terms of climatic factors. For treatment, first year's yield differences were higher than that of the second year. It is estimated that these differences may be as a result of year differences due to higher temperature that occurred during the second year of the experiment.

These seed cotton yield and fiber yield reductions are similar to those reported (El-Fouly et al., 1971; Marur, 1991; Cook and El-Zik, 1993; Rajamani, 1994; Pettigrew, 2004b; Bölek, 2007; Alishah and Ahmadikhah, 2009). Some researchers revealed that water stress at different growing stage reduced cotton yield, with the greatest effect at the flowering and fruiting stages (Luz et al., 1997).

Significant differences were obtained between treatments and genotypes for ginning percentage. Ginning percentage was generally decreased in

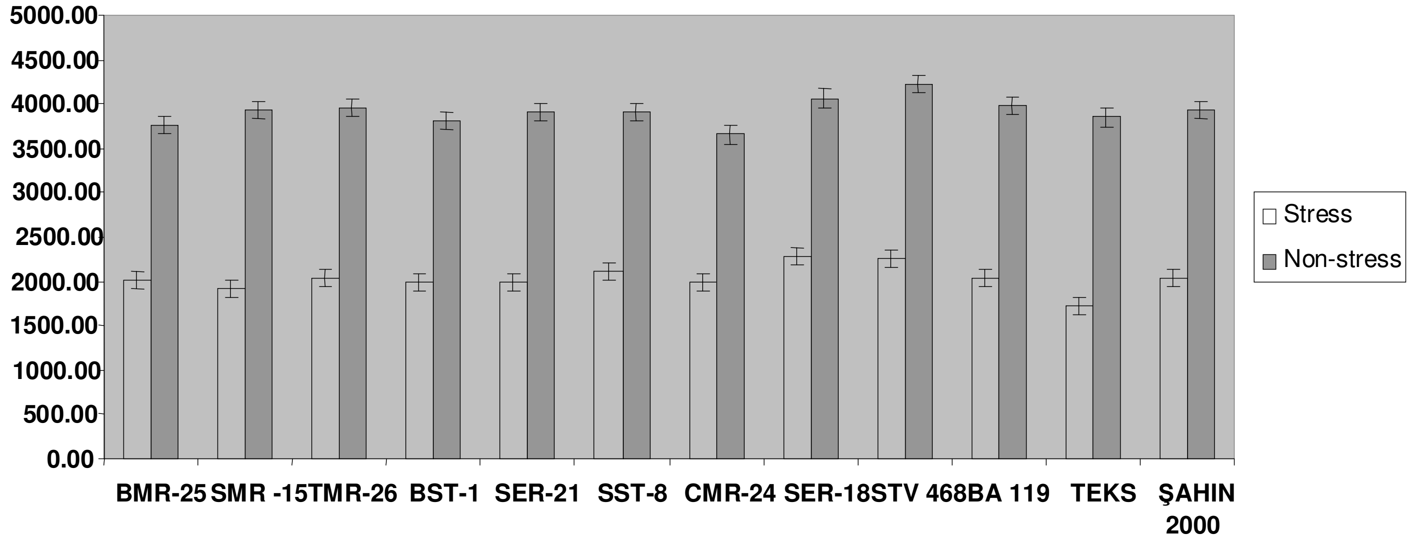

Figure 3. Seed cotton yield (kg ha^{-1}) of genotypes under water stress and non stress conditions.

response to water stress treatment. Under water stress conditions, average of genotypes for ginning percentage was 40.15%, and under non-stress conditions, it was 41.11%. Non stressed plots ginned out were 2.39% higher than the plots subjected to water stress treatments. The genotypes ginning percentage ranged from 38.37 to 43.41%. Ginning percentage was highest for Stoneville 468 (43.41%) and BA 119 (43.32%) with respect to both treatments (Table 3). Same results relating to ginning percentage was reported by Osborne and Banks (2006).

Mahmood et al. (2006) also reported that water deficits had remarkable decreasing effect on ginning out turn. These findings were similar to earlier researchers' report.

Genotype, year, treatment and year x treatment interactions were significant for fiber length. The plots in non stress conditions produced 0.9 mm longer fiber than the stress plots. As seen in Table 3, fiber length in water stress treatment was 26.71 mm, but non stress treatment was 27.61 mm. Genotypic differences were also found to be significant. Fiber length was highest for Şahin 2000, GW-Teks and SMR-15, and lowest for BA 119 genotype. Fiber length was also affected by year differences. Fiber length was 1.99% lower in 2010 than in 2009. As mentioned earlier, high temperatures occurred during the 2010 cotton growing season and may affect fiber length development. The lack of interaction between genotype x treatment, indicate similar response of cotton genotypes to different water treatment. Fiber length is a desirable character for textile industry and spinning technology, and premium is paid for this trait (Table 3). Some researchers revealed that water stress had adverse effect on fiber length (Marur, 1991; Pettigrew, 2004b; Osborne and Banks, 2006; Mahmood et al., 2006); but some of the researchers revealed that water treatment had no significant effect on fiber length (Luz et al., 1997). These contradictory results may be as a result of variety and year differences.

Water stress had a significant ($p<0.01$) influence on fiber fineness. Average fiber fineness of stressed plot was 4.07 mic., but non-stressed plot was 4.41 mic. There were significant differences among genotypes, the values ranged from 3.96 to 4.47 mic., and year, year x genotype, genotype x treatment and year x treatment x genotype interactions were non significant for this trait (Table 4). The findings obtained from fiber fineness (mic) are similar to those reported by other authors (Marur, 1991; Pettigrew, 2004b; Mahmood et al., 2006). Osborne and Banks (2006) reported that water stress event during mid-bloom caused a trend of increased micronaire as compared to the non-stressed plots. However, some researchers revealed that growing cotton under non-irrigated conditions resulted in the production of shorter and weaker fiber with reduced micronaire (Mert, 2005).

For fiber strength, significant differences were observed among genotypes, treatment, year x treatment and treatment x genotype interaction. Year x treatment interactions indicated that year to year variability among climatic factors affected this trait. Fiber strength of all the genotypes was generally decreased in response to water stress, except Stoneville 468. Under water stress conditions, fiber strength (27.10 g tex^{-1}) was markedly reduced as compared to non stress conditions (29.05 g tex^{-1}) in the average of two years. Fiber strength of the water stress treatment was lower (6.71%) than that of the non stress treatment. Among the genotypes, fiber strength ranged from 26.58 g tex^{-1} (Şahin 2000) to 32.50 g tex^{-1} (GW-Teks) and the highest fiber strength values were obtained from GW-Teks, SMR-15, Stoneville 468 and BST-1, respectively (Table 4). Similar results were reported by Osborne and Banks (2006). However, Pettigrew (2004b) revealed that fiber quality response to irrigation was inconsistent throughout the duration of the experiment and irrigation had no effect on fiber strength.

Year, treatment, year x treatment and genotype was significant at p<0.01 probability level for fiber elongation. Fiber elongation was increased with non stress treatment as compared to water stress treatment (Table 5). The reduced fiber elongation under water stress conditions was similar to the findings reported by Pettigrew (2004b); but not other researchers (Luz et al., 1997). Among the genotypes, BA 119, Stoneville 468 and Şahin 2000 had higher fiber elongation than the others.

Fiber uniformity was not affected by genotypes or water stress (Table 5); similar results were reported by Marur (1991), Luz et al. (1997) and Pettigrew (2004b).

Conclusion

From this study, it can be concluded that the water stress significantly affected cotton yield and fiber quality properties. Seed cotton (48.04%) and fiber yields decreased (49.41%), due to water stress treatment. Among the cotton genotypes, SER-18, Stoneville 468 and SST-8 had the highest yield under water stress conditions and also Stoneville 468 had the highest yield under well watered conditions. Water stress had negative consequences on fiber quality properties, and due to water stress fiber length, fiber fineness, fiber strength and fiber elongation decreased, however fiber uniformity was not affected. Physiological parameters such as leaf hairiness, leaf water content, root length, fast root growth, root/shoot ratio, chlorophyll content, photosynthesis and stomatal conductance should be measured in order to learn the mechanism of the drought stress.

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