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Full Research Article

Effect of Water Stress on Fiber Quality Traits of Cotton Hybrids and Their Parents

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Abstract

Crop growth and yield are influenced by plant genetic factors as well as environmental factors such as weather conditions, water availability, and soil conditions. Plant water is one of the most important and readily manageable variables for producing a profitable crop. Stresses involving water deficiencies will adversely affect cell turgidity, resulting in reduced crop production. For this experiment was carried out under field conditions as a split block design (SBD) with two blocks, one was well watered and to the other, water stress was applied, with three replications in each block. Cotton fiber quality is being deteriorated due to water stress and affects the fiber length, strength and elongation. All these properties of fiber have also a significant influence on yarn characteristics and thus the yarn quality. The objective of this study was to evaluate the potential of hybrids by comparing them with parents for fiber quality characteristics under drought stress conditions. In present results hybrid G.Cot.16×H-1353/10 and H-1353/10×G.Cot.16 shows less reduction in different fiber quality characters in comparison of other hybrids under stress condition. Therefore, results indicate that under stress different fiber quality characters such as 2.5% span length (mm), uniformity ratio (%), fibre fineness (micronaire), maturity coefficient, fibre strength (g tex^{-1}), short fiber index (SFI) and elongation (%) were significantly different amongst hybrids and parents which is usual. The interaction of genotypes with growing condition was found not significant.

1. Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important fiber-producing plants. In addition, cottonseed is used for live stock feed and for cotton oil extraction. The cultivation of cotton has high economic value and is important in semi-arid areas where it represents a significant source of income for large and small-scale farmers. In India, cotton constituting 80% of the raw materials of textile industry keeps its eminent position with millions of people engaged in its cultivation, processing, marketing and textiles of cotton. 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). Cook and El-Zik (1993) reported that water stress was one of the most critical abiotic factors limiting cotton productivity in semi-arid regions of the World. Cotton is classified as a drought sensitive crop as it is not an efficient water consumer. 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). Marani and Amirav (1971) reported that soil water deficit could reduce fiber length and micronaire. Fiber strength is a major contributing factor to the quality of yarn and spinning performance (Mogahzy et al., 1998; Karademir et al., 2011). Gerik et al. (1996) found that moisture deficits reduced the number of bolls and seed cotton weight per boll. Under inadequate moisture conditions and increasing temperatures, fiber length decreases and fiber micronaire values increase (Reddy et al., 1999). Pettigrew (2004) showed that the lint yield of dry land cotton plants was reduced by 25%, primarily because of a 19% reduction in number of bolls. Apart from low yield and fiber quality, non-irrigated environments are characterized by unpredictable and highly variable seasonal rainfall, hence highly variable yield in cotton. The objectives of this study were to identify the effect of water stress on fiber quality properties of cotton hybrids and their parents subjected to irrigated and non irrigated conditions.

2. Materials and Methods

The field experiment was conducted at Main Cotton Research Station, Navsari Agricultural University, Surat during the *kharif* season of year 2012−13. In this study, Twelve cotton hybrids and four parents were observed in terms of fiber quality properties under water stress and non-stress conditions. The experiment was carried out under field conditions as a split block design (SBD) with two blocks, one was well watered and to the other, water stress was applied, with three replications in each block. All the replicated data obtained from the experiments for study were statistically analyzed as per the procedure given by Gomez and Gomez (1984). The Fiber quality was evaluated in the Central Institute for Research in Cotton Technology (CIRCOT) regional station, Surat using fully automatic HVI machine (Premier Evolvics Pvt. Ltd. Coimbatore) at R.H. 65±2 and Temperature 27.2 °C. 10 g±5 g cotton lint taken and put into micronaire chamber of HVI then chamber is closed; it prepares the comb automatically and scans the sample for various parameters fiber quality parameters. Correlation analysis was done by using SPSS 11.5 package of statistical analysis.

3. Results and Discussion

Fiber quality traits are desirable characters for textile industry and spinning technology and premium is paid for this trait. The present results (Table 1) indicate that different fiber quality characters such as 2.5% span length was reduced by significant margin under stress (28.0 mm) compared to irrigated (28.2) although both fall in long stable category. Mean 2.5% span length amongst hybrids and parents was significantly high in hybrid, H-1353/10×G.Cot.16 (31.5 mm) followed by its reciprocal hybrid G.Cot.16×H-1353/10 (31.1 mm) compared to other hybrids and parents. Although all of these were in large staple length (27.5−32.0 mm). The average uniformity ratio under irrigated (45.8%) was reduced by significant margin under stress (44.6%). Mean uniformity ratio was 47.1 in H-1353/10×G.Cot.16 and followed by G.Cot.16×H-1353/10 (46.6%). Minimum uniformity ratio was observed in BS-30 (43.7%) except H-1353/10×G.Cot.16 and

Table 1: Effect of water stress on economic characters (2.5% span length, uniformity ratio and fibre fineness) of cotton hybrids and their parents

Genotype	2.5% span length (mm)		Uniformity ratio (%)		Fibre fineness (Micronaire)	
	IR	RF	IR	RF	IR	RF
G.Cot.16 (T)	29.0	27.0	46.5	45.2	4.2	4.5
H-1353/10 (T)	27.2	25.4	46.8	45.6	4.3	4.6
BS-30 (S)	26.6	25.3	44.2	43.2	4.8	4.4
H-1452/10 (S)	25.0	26.6	44.4	43.3	4.4	4.6
G.Cot.16×BS-30	28.7	27.3	46.1	45.1	4.2	4.1
G.Cot.16×H-1452/10	28.8	27.3	46.5	45.7	4.6	4.4
G.Cot.16×H-1353/10	30.9	31.3	47.0	46.2	3.9	4.2
H-1353/10×BS-30	27.0	27.9	46.4	45.2	4.4	4.8
H-1353/10×H-1452/10	27.7	30.5	46.6	45.0	4.6	3.8
H-1353/10×G.Cot.16	31.9	31.1	47.5	46.7	3.6	4.5
BS-30×G.Cot.16	29.2	29.7	45.9	44.1	4.2	4.5
BS-30×H-1353/10	30.6	30.8	45.0	43.9	5.0	4.8
BS-30×H-1452/10	25.8	25.2	45.0	43.9	4.7	4.3
H-1452/10×G.Cot.16	26.7	28.0	45.7	43.6	4.8	4.8
H-1452/10×H-1353/10	27.8	26.8	44.9	43.3	4.1	4.7
H-1452/10×BS-30	29.0	28.5	45.4	43.9	4.4	4.6
Mean	28.2	28.0	45.8	44.6	4.4	4.5
SEm±	0.03		0.20		0.01	
CD (p=0.05)	0.19		1.20		0.09	

*IR=Irrigated, RF=Rainfed

all hybrids was average to good (46–47). The average fibre fineness under irrigated (4.4) was reduced significant margin under stress (4.5). Mean fibre fineness amongst the hybrids and parents was average (4.0–4.9) but hybrids H-1353/10×G. Cot.16, G.Cot.16×H-1353 exhibited greater fineness in that category. Minimum fibre fineness was observed in BS-30×H-1353/10 (4.9). The average maturity coefficient under irrigated (0.83) was increased by significant margin under stress (0.84). Mean maturity coefficient was highest in hybrid, G.Cot.16×H-1353/10 and G.Cot.16 (0.86) and it is followed by parent, G.Cot.16 and its reciprocal hybrid H-1353/10×G. Cot.16 (0.85) (Table 2). Minimum maturity coefficient was observed in G.Cot.16×BS-30 (0.81). All of them however come in very good maturity category. The average fibre strength (g tex^{-1}) under irrigated (21.9 g tex^{-1}) was reduced significant margin under stress (20.2 g tex^{-1}). Mean fibre strength amongst the hybrids and parents was significantly high in hybrid G.Cot.16×H-1353/10 (22.7 g tex^{-1}) followed by its reciprocal hybrid H-1353/10×G.Cot.16 (22.5 g tex^{-1}). Minimum fibre strength was observed in BS-30×H-1452/10 and H-1452/10×BS-30 (19.6 g tex^{-1}). The strength of the fiber was weak (16.0–20.0 g tex^{-1}) to average (20.1–23.0 g tex^{-1}). The average short fiber index (SFI) under irrigated (9.0) improved by significant margin under stress (8.1). Mean short fiber index (SFI) was highest in hybrid G.Cot.16×H-1353/10 (11.0) followed by its reciprocal cross, H-1353/10×G.Cot.16 (10.6) whereas least short fiber index (SFI) was observed in BS-30×H-1452/10 (5.9). The average elongation per cent under irrigated (5.9%) was reduced by significant margin under stress (5.7%). Mean elongation (%) amongst the hybrids and parents was significantly high in hybrid H-1353/10×G.Cot.16 and its reciprocal hybrid G.Cot.16×H-1353/10 (6.4%) followed by both its parents and H-1353/10×BS-30 (6.1%). Minimum elongation (%) was observed in BS-30×H-1353/10 (5.4%). The interaction was not significant indicating that all the four parents and twelve hybrids responded to the stress in similar way as the overall effect.

Table 2: Effect of water stress on economic characters (Maturity coefficient, fibre strength, short fiber index and elongation %) of cotton hybrids and their parents

Genotype	Maturity coefficient		Fibre strength (g tex^{-1})		Short fiber index (SFI)		Elongation %	
	IR	RF	IR	RF	IR	RF	IR	RF
G.Cot. 16 (T)	0.85	0.86	23.0	21.9	9.2	8.4	6.2	5.9
H-1353/10 (T)	0.84	0.84	23.1	21.3	10.1	9.4	6.2	5.9
BS-30 (S)	0.82	0.83	20.0	19.8	8.2	7.8	5.7	5.6
H-1452/10 (S)	0.83	0.84	21.0	19.2	8.6	7.8	5.9	5.5
G.Cot. 16×BS-30	0.81	0.81	22.2	20.1	8.4	7.7	5.8	5.6
G.Cot. 16×H-1452/10	0.84	0.84	21.0	20.1	10.2	9.4	5.8	5.6
G.Cot. 16×H-1353/10	0.86	0.86	23.7	21.7	11.5	10.5	6.5	6.3
H-1353/10×BS-30	0.84	0.83	22.1	20.4	8.2	7.1	6.2	6.0
H-1353/10×H-1452/10	0.85	0.81	22.4	20.5	8.6	7.9	5.9	5.7
H-1353/10×G.Cot.16	0.85	0.84	23.9	21.2	11.0	10.2	6.4	6.3
BS-30×G.Cot.16	0.84	0.82	23.0	20.0	9.6	8.3	5.6	5.4
BS-30×H-1353/10	0.82	0.85	20.8	19.2	7.7	7.2	5.5	5.3
BS-30×H-1452/10	0.81	0.84	20.4	18.9	6.5	5.2	5.8	5.5
H-1452/10×G.Cot.16	0.84	0.85	22.9	20.9	8.4	7.7	5.9	5.7
H-1452/10×H-1353/10	0.82	0.84	20.1	19.3	8.6	7.5	5.9	5.7
H-1452/10×BS-30	0.84	0.85	20.3	18.8	9.1	7.5	5.6	5.3
Mean	0.83	0.84	21.9	20.2	9.0	8.1	5.9	5.7
SEm±	0.0005		0.27		0.13		0.03	
CD (p=0.05)	0.003		1.62		0.82		0.21	

*IR=Irrigated, RF=Rainfed

Phenotypic correlation of fiber quality traits with seed cotton yield under irrigated and rainfed condition are presented in Table 3 and 4. The character seed cotton yield showed non significant negative correlation with 2.5% span length (r=-

Table 3: Phenotypic correlations between seed cotton yield and various fiber quality traits under rainfed condition

	2.5% span length	Uniformity ratio %	Fibre fineness (micronaire)	Fibre strength (g tex^{-1})	Elongation %	Maturity coefficient	Short fiber index (SFI)	Yield
2.5% span length	1.00							
Uniformity ratio%	-0.35^{NS}	1.00						
Fibre fineness	-0.52^{*}	0.58^{*}	1.00					
Fibre strength	-0.27^{NS}	0.84^{**}	0.48^{NS}	1.00				
Elongation%	0.17^{NS}	0.64^{**}	0.09^{NS}	0.65^{**}	1.00			
Maturity coefficient	-0.48^{NS}	0.80^{**}	0.87^{**}	0.83^{**}	0.40NS	1.00		
(SFI)	-0.77^{**}	-0.32^{NS}	0.14^{NS}	-0.32^{NS}	-0.64^{**}	-0.08^{NS}	1.00	
Yield	-0.34^{NS}	-0.09^{NS}	-0.10^{NS}	-0.26^{NS}	-0.07^{NS}	-0.19^{NS}	0.44^{NS}	1.00

**: Significant at $p\leq0.01$. *: Significant at $p\leq0.05$

Table 4: Phenotypic correlations between seed cotton yield and various fiber quality traits under irrigated condition

	2.5% span length	Uniformity ratio%	Fibre fineness (micronaire)	Fibre strength (g tex^{-1})	Elongation %	Maturity coefficient	Short fiber index (SFI)	Yield
2.5% span length	1.00							
Uniformity ratio%	-0.76^{**}	1.00						
Fibre fineness	-0.60^{*}	0.76^{**}	1.00					
Fibre strength	-0.29^{NS}	0.60^{*}	0.41^{NS}	1.00				
Elongation%	-0.05^{NS}	0.55^{*}	0.52^{*}	0.65^{**}	1.00			
Maturity coefficient	-0.57^{*}	0.84^{**}	0.89^{**}	0.73^{**}	0.67^{**}	1.00		
(SFI)	-0.49^{NS}	-0.18^{NS}	-0.10^{NS}	-0.37^{NS}	-0.66^{**}	-0.25^{NS}	1.00	
Yield	-0.47^{NS}	0.42^{NS}	0.56^{*}	0.03^{NS}	0.26^{NS}	0.54^{*}	0.13^{NS}	1.00

**: Significant at $p\leq0.01$. *: Significant at $p\leq0.05$

0.34), uniformity ratio (r=-0.09), fiber fineness (r=-0.10), fiber strength (r=-0.26), elongation % (r=-0.07) and maturity coefficient (r=-0.19). Short fiber index (r=0.44) showed the non significant positive correlation with seed cotton yield under rainfed condition. Similarly, under irrigated condition seed cotton yield showed significant positive correlation with fiber fineness (r=0.56), maturity coefficient (r=0.54) and non significant correlation with uniformity ratio (r=0.42), fiber strength (r=0.03), elongation % (r=0.26) and short fiber index (r=0.13). 2.5% span length (r=-0.47) showed non significant negative correlation with seed cotton yield under irrigated condition.

Stress affected all the fibre quality traits significantly however none changed the category of norms set by CIRCOT, like 2.5% span length, uniformity ratio, MIC, tenacity and elongation reduced due to stress but remained in the same category of norms. The reduced fiber elongation under water stress conditions observed here was similar to the findings reported by Pettigrew (2004b) but not other researchers (Luz et al., 1997). 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). Fiber strength of the water stress treatment was lower than that of the non stress treatment. Similar findings were reported by Osborne and Banks (2006). The present results are more or less in tune with these reports.

Cotton fiber quality is defined as the combination of physical fiber properties, i.e. fiber length, strength, fineness and uniformity that affect the efficiency of yarn-spinning, weaving or dyeing processes and end-product quality. Cotton growers are interested in the production of higher cotton fiber quality traits in order to obtain better prices and satisfy the requirements of new spinning and weaving technologies in the textile industry. The effect of water stress on fiber length depends on the duration and timing of water stress during the fiber elongation stage. Water shortage during the early flowering period does not influence fiber length. However, the occurrence of moisture deficits shortly after flowering and during the fiber elongation period can reduce fiber length due to the direct mechanical and physiological processes of cell expansion (Bradow and Davidonis, 2000; Pettigrew, 2004a; Balkcom et al., 2006; Basal et al., 2009; Dagdelen et al., 2009). 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). Fiber length is a desirable character for textile industry and spinning technology, and premium is paid for this trait. Some researchers revealed that water stress had adverse effect on fiber length (Marur, 1991; Pettigrew, 2004b; Osborne and Banks, 2006; Mahmood et al., 2006).

However, some researchers revealed that growing cotton under nonirrigated conditions resulted in the production of shorter and weaker fiber with reduced micronaire (Mert, 2005). Fiber uniformity was not affected by genotypes or water stress; similar results were reported by Marur (1991); Luz et al. (1997) and Pettigrew (2004b).

4. Conclusion

Water stress significantly affected cotton yield and fiber quality properties. Water stress causes negative consequences on fiber quality properties. Due to the 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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