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Original Research Article

DISSECTION OF YIELD AND FIBER QUALITY TRAITS UNDER DROUGHT CONDITION IN *GOSSYPIUM HIRSUTUM L.*

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Abstract *Water is a significant component in cotton growth and yield. Drought stress is the main factor limiting crop productivity since it harms cotton's ability to produce high-quality fiber as well as square/boll and lint output. Reduced water availability during the development of the bolls could lead to drastic decrease in yield. Four cotton genotypes (MNH-1020, FH-114, BH-178 and CIM-602) were grown under regular irrigation and water-deficit circumstances to examine the tolerance to water scarcity. Four watering treatments were used in this study to further understand the impacts of water shortage: 100% field capacity (control), 70% field capacity, 60% field capacity, and 40% field capacity at the squaring stage till boll formation. As the amount of soil moisture declines, we observed a fall in fiber length, fineness, and strength. Yield/plant reduced under water stress due to less no of flowers and bolls, but also because of reduced boll weight. When the stress was extreme during the reproductive growth stage, MNH-1020 showed drought tolerance by exhibiting maximum yield, boll weight and fiber characters when compared to the other three varieties, while FH-114 was second. CIM-602 showed drought susceptibility as it exhibited least no of bolls/plant, yield/plant, and boll weight.*

Keywords: Cotton; Field Capacity; Yield; Drought; Fiber Quality

Introduction

Cotton fiber originate from cotton seed's epidermal layer. This fiber is woven into fabrics and plays a significant role in textile mills. The oil from cotton seeds is a significant source of cooking oil. Low grade oils are used in the production of several lubricants and the creation of soap. Cotton seed cake is a significant protein source used to make animal feed. The crop offers food and feed in addition to being a source of clothing and shelter. Globally, drought has impacted agriculture, which reduces yields more than all other abiotic pressures combined. Globally, drought and high temperatures are important obstacles to plant growth, survival, and output (Abbas and Khalil 2022; Ali et al., 2016; Boyer, 1982; Loka et al., 2011). As a result of ongoing water shortages and droughts caused by global climate change, crop production is now a growing concern on a global scale. For example, cotton production and growth are considerably hampered, necessitating water use at every stage of plant development. To comprehend the principles of drought tolerance in cash crops like cotton, it is crucial to discover tolerant genetic variants (Hasan *et al.* 2018). Water has a significant role in cotton growth and output, and water stress is the main factor that causes crop production losses. Water stress also negatively impacts crop production of cotton fruit, square and boll shedding, lint yield, and fiber quality (Karademir *et al.*, 2011). When stress is significant and occurs during reproductive growth, cotton lint output is typically decreased because of decreased boll production caused by fewer flowers and more boll abortions. (Ali et al., 2022; Turner *et al.*, 1986; Gerik *et al.*, 1996; Pettigrew, 2004a; Pettigrew, 2004b). Water availability during the various phenological phases of growth is directly correlated with the quality and quantity of fiber produced by cotton plants (Akbar *et al.* 2019 and Abdelraheem *et al.*, 2019). cellulose-rich mature cotton fiber that has been fully stretched. The characteristics of fiber development may be linked to a wide range of variables that are directly or indirectly impacted by drought, which ultimately results in low-quality fiber. Since different morphological features divide upland cotton genotypes into those that are drought tolerant and those that are sensitive to drought stress, it is essential to understand how plants respond to drought stress to increase drought stress tolerance. The primary benefit of employing these morphological features in screening is that no specific equipment is needed to measure them. Many physical features, including plant height, the number of bolls per plant, the length of the roots and shoots, and the weight of the bolls, have been shown to vary significantly. Understanding how these interactions affect fiber formation would provide a clearer picture of fiber elongation under drought, which would be helpful in breeding efforts to increase cotton's tolerance to drought (Singh *et al.* 2018: Sezener *et al.* 2015; Yaseen *et al*., 2022). Fewer bolls can result in significantly lower yields under water shortage conditions (Arshad et al., 2022; Radin *et al.*, 1992; Plaut *et al.*, 1992; de Kock *et al.*, 1990). McMichael *et al.* 1973) Reported that young bolls typically abscise if water stress occurs in the first fourteen days following anthesis, it has been reported. To choose the optimal genotype for tolerating water deficiency stress, the current study evaluated cotton genotypes under both normal and stress settings.

Materials and Methods

Plant Material

Four cotton varieties (FH-114, MNH-1020, BH-178, and CIM-602) were used in this study in glass house condition following CRD design in pots during November 2021 at Cotton Research Institute Multan, Pakistan. Four water treatments—T1: Control, T2: 70% of field capacity, T3: 60% of field capacity, and T4: 40% of field capacity were applied to the experimental materials, each with three replications. For pot preparation, the gravimetric approach of drought imposition was applied**.** Two seeds per pot were used for sowing. Which were thinned to one plant per pot after seedling establishment. Drought was imposed from flowering stage till boll formation (Abideen et al. 2023; Khan et al., 2023).

Yield Attributes

To assess the performance of genotypes under various moisture levels, the following yield components were recorded. The details of the traits recorded are given below.

Number of bolls per plant

Data for the number of bolls/plants was recorded from 140 days old cotton plants replication wise, and mean values were computed.

Average boll weight (g)

The average boll weight of the plant was calculated by dividing the seed cotton yield of the plant by its number of picked bolls which was expressed in grams.

Yield per plant (g)

Using an electronic balance, the seed cotton yields of each tagged plant were measured in grams by picking all opened bolls of each genotype treatment-wise.

Fiber quality parameters

Lint samples were collected from each entry, and the following fiber traits (Fiber length (mm), Fiber fineness (Micronaire), Fiber strength (g/tex**))** were analyzed through High Volume Instrument (Uster Model: HVI 1000) available at Cotton Research Institute Multan, Pakistan.

Results and Discussion

Number of bolls per plant: The number of bolls per plant data revealed a substantial variance between treatments but not between varieties and their interactions (Table 1& 2). In control settings, MNH-1020 had the greatest mean value (12.62 bolls/plant), whereas CIM-602 displayed the lowest value (6.23 bolls/plant), FH-114 exhibited (11.32 bolls/plant) and BH-178 (8.92 bolls/plant). At 70% of the field's capacity, MNH-1020 and FH-114 displayed the same number of bolls per plant (10.43 bolls/plant), followed by BH-178 (7.32 bolls/plant) and CIM-602 (5.43 bolls/plant). Whereas at 60% field capacity the number of bolls per plant for MNH-1020 (7.23 bolls/plant) followed by FH-114 (6.45 bolls/plant), BH-178 (5.21 bolls/plant) and CIM-602 exhibited least no of bolls/plant (4.32). At 40% FC all genotypes showed decrease in no of bolls/plant. MNH-1020 gave (6.2 boll/plant) followed by FH-114 (4.3 bolls/plant), BH-178 (3.4 bolls/plant) and CIM-602 exhibited the least value for no of bolls/plant (3.4). The treatments showed substantial differences in the number of bolls per plant. The influence of reduced moisture levels on this parameter was the cause of the treatments' considerable variances. Grimes et al. (1969) found a strong positive correlation between number of bolls and yield (Fig-1). Similar findings were reported by Abbas et al., (2016); Bhutta et al. (2015); Zafar et al., (2022); Abbas et al., (2015).

Average boll weight (g)

The Average number of bolls differed significantly among treatments and varieties. The highest means was found in MNH-1020 (4.5g) in the control condition, followed by FH-114 (3.5g), BH-178 (3.2g) and CIM-602 (2.8g). At 70 and 60% field capacity, the difference for boll weight was marginal with a range of (4.0-4.2g) for MNH-1020, FH-114 (3.0-3.2g), BH-178 (2.8-3.0g) and CIM-602 (2.3-2.6g) Whereas at 40% field capacity there was significant reduction in boll weight. CIM-602 exhibited lowest value for boll weight (2.0g), whereas MNH-1020 exhibited highest value for boll weight (3.8g) followed by FH-114 (2.8g) and BH-178 (2.7g). (Fig-1)**.** Similar findings were reported by Abbas et al., (2013); Abbas et al., (2016); Zafar et al., (2022); Abbas et al., (2015).

Yield per plant (g)

Yield per plant of genotypes differ significantly between treatments. Suggesting that moisture stress affected cotton yield per plant. At control, MNH-1020 exhibited value for yield of (46.2g/plant) followed by FH-114 (35.2 g/plant), BH-178 (28.2 g/plant), and CIM-602 displayed least value for yield of (18.7 g/plant). Highest value for yield per plant was recorded for MNH-1020 at all three water treatment levels with a value of (44.2g/plant) at 70% and 60% FC and (23.56g) at 40% FC. Followed by FH-114 (31.29g/plant) at 70% FC, (33.37g/plant) at 60% FC, and (12.9g/plant) at 40% FC. Similarly, BH-178 exhibited the same pattern of steady yield reduction with (20.4g/plant) at 70% FC, (15.6g/plant) at 60% FC and (7.8g/plant) at 40% FC. CIM-602 gave a yield of (14.4g/plant) at 70% FC, (9.9g/plant) and (7.8g/plant). Drought stress severely affected yield/plant. All genotypes displayed a declining yield pattern under drought stress (Fig-1). Similar findings were reported by Abbas et al., (2013); Abbas et al., (2016); Majid et al., (2020); Zafar et al., (2022); Abbas et al., (2015).

Fiber length (mm)

Significant differences in fiber length were observed among the varieties and treatments. All four genotypes showed fiber length of (28mm) at the control and 70% field capacity except BH-178, which showed a reduction in length (27.5mm) at 70% FC. Whereas at 60% field capacity fiber length of MNH-1020 and FH-114 remained same (28mm), but BH-178 displayed a reduction in fiber length (27.0mm) followed by CIM-602 (26.3mm). At 40% field capacity all genotypes showed a reduction in fiber length in such a pattern MNH-1020 (27.3mm) followed by FH-114 (27.0mm), BH-178 (26.0mm) and CIM-602 (25.3mm) (Fig-2). Similar findings were reported by Abbas et al., (2016); Abbas et al., (2013); Rehman et al., (2017); Zafar et al., (2022); Abbas et al., (2015).

Fiber strength (g/tex)

Fiber strength data was significant in varieties, treatments and their interactions. Highest value of fiber strength was recorded in MNH-1020 (33.23g/tex) at control, (32.14g/tex) at 70% of field capacity (30.20g/tex) at 60% of field capacity, and (29.31) at 40% field capacity. Similar values were recorded for FH-114 and BH-178. In comparison, CIM-602 displayed the lowest values at control (26.28g/tex), at 70% of field capacity (24.10g/tex), at 60% of field capacity (22.26g/tex), and at 40% field capacity (20.50g/tex) (Fig-2). Similar findings were reported by Abbas et al., (2013); Abbas et al., (2016); Rehman et al., (2017); Zafar et al., (2022); Abbas et al., (2015).

Fiber fineness (Micronaire)

At 100 percent field capacity (control), the highest fiber fineness was observed in MNH-1020 (4.8), and the lowest was in BH-178 (3.2), but FH-114 and CIM-602 displayed the same values under control (3.7). When the water level was reduced from 100% to 70% field capacity, MNH-1020 displayed the highest (3.8), whereas FH-114 and CIM-602 observed the same fiber fineness (3.5), and BH-178 showed the least value (2.9). At 60% field capacity MNH-1020 exhibited fiber fineness as (3.4), followed by FH-114 (3.0), CIM-602 (3.1), and the lowest value by BH-178 (2.7). Whereas at 40% fiber fineness was recorded as MNH-1020 (3.0) followed by FH-114 (2.7), CIM-602 (2.5), and BH-178 (2.2). Results showed that increasing drought stress reduced the fineness value (Fig-2). Similar findings were reported by Abbas et al., (2013); Abbas et al., (2016); Zafar et al., (2022); Abbas et al., (2015).

Conclusion and Recommendations

Drought is one of the major crop growth limiting factor. Water stress at the reproductive stage of cotton results in the shedding of squares, flowers and ultimately reduces no of bolls and boll weight. Fiber quality characters are also badly affected by drought imposition. Hence there is a dire need to develop drought-tolerant cotton varieties that can perform well even under limited moisture condition. Farmers are advised to choose drought-tolerant varieties for cultivation to get maximum yield output from limited water resources.

Table 1: Analysis of variance (ANOVA) under control condition

Source	BW	NBP	Y/P	FF	FL	FS
Rep (MS)	0.086	23.112	48.3	0.038	6.722	21.765
Variety (MS)	0.791	88.267	66370.2	0.122	3.312	11.134
Error (MS)	0.060	1.860	127.5	0.020	0.778	1.725
F-value	10.52	37.72	359.45	11.54	1.387	6.65
P-value	0.0000	0.0000	0.0000	0.0000	0.0373	0.0002
CV (%)	7.42	3.14	6.58	3.67	2.43	3.79

BW = Average boll weight; NBP = Number of bolls per plant; percentage; FF = Fiber fitness; FL = Fiber length; FS = Fiber strength; Y = Yield

Table 2: Analysis of variance (ANOVA) under drought condition

Source	BW	NBP	Y	FF	FL	FS
Rep (MS) (control)	0.0068	5.340	4825	0.087	1.322	14.124
Rep (MS) 70%FC	0.0057	4.230	3715	0.077	1.212	13.114

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Rep (MS) 60%FC	0.0046	3.210	2614	0.066	1.210	12.013
Rep (MS) 40%FC	0.0032	2.231	1714	0.075	0.211	9.022
Variety (MS) (c)	0.7213	50.021	2154	0.211	1.801	8.311
Variety (MS) 70% FC	0.6112	45.020	2154	0.101	1.600	6.211
Variety (MS) 60% FC	0.5110	40.020	1150	0.110	1.500	4.210
Variety (MS) 40% FC	0.3110	35.011	1130	0.101	0.702	2.721
Error (MS)	0.0887	4.962	21881	0.061	0.905	1.807
F-value	9.40	13.33	14.07	5.43	2.11	5.22
P-value	0.0000	0.0000	0.0000	0.0003	0.0684	0.0004
CV(%)	11.84	11.87	10.98	7.34	3.45	4.36

BW = Average boll weight; NBP = Number of bolls per plant; percentage; FF = Fiber fitness; FL = Fiber length; FS = Fiber strength; Y = Yield

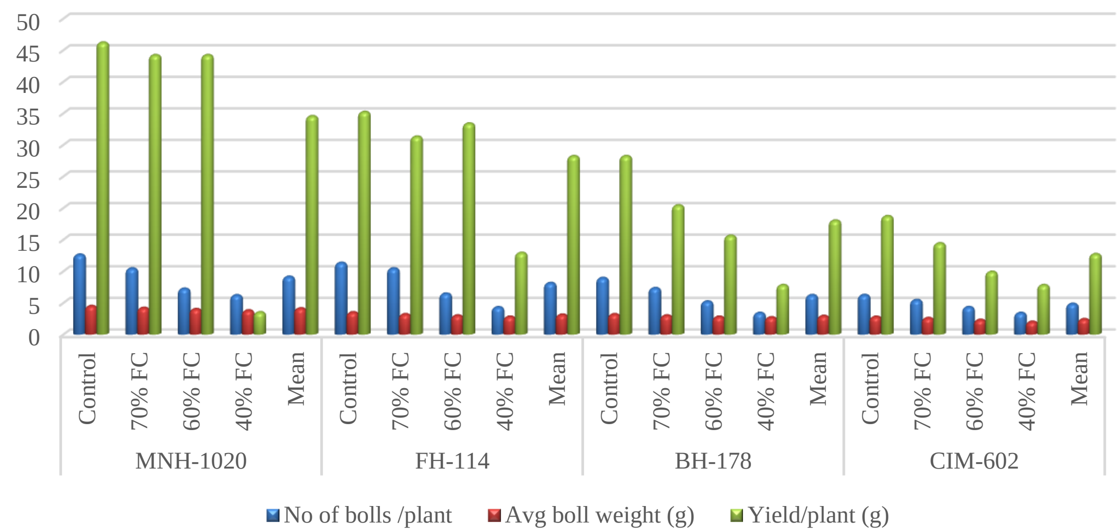

Figure 1. Effect of various moisture levels on number of Bolls, Av boll weight (g) and yield per plant

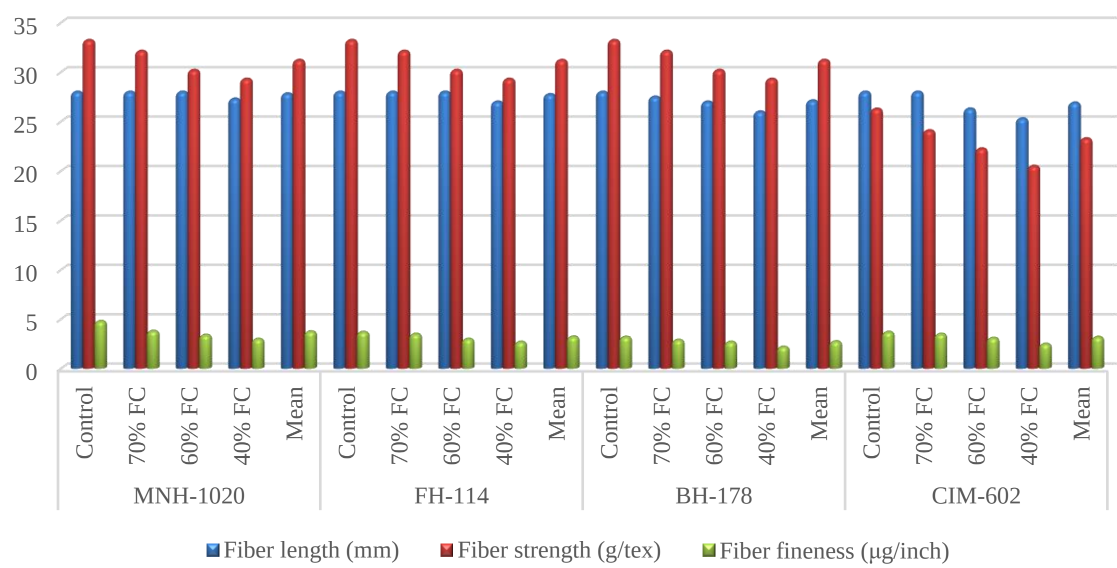

Figure 2. Effect of various moisture levels on Fiber length, Fiber strength and Fiber fineness

Conflict of interest

The authors declared absence of conflict of interest.

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