International Journal of Plant & Soil Science

27(5): 1-7, 2019; Article no.IJPSS.11086
ISSN: 2320-7035

Potentiality of Some Egyptan Cotton Varieties under Drought Stress Conditions

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/IJPSS/2019/v27i530086
Editor(s):
(1) Dr. L. S Ayeni, Adeyemi College of Education, Ondo State, Nigeria.
Reviewers:
(1) Cetin Karademir, Siirt University, Turkey.
(2) Emine Karademir, Siirt University, Turkey.
(3) Jnandabhiram Chutia, Darrang College, Gauhati University, India.
Complete Peer review History: http://www.sdiarticle3.com/review-history/11086

Original Research Article

Received 20 October 2014
Accepted 01 January 2015
Published 12 April 2019

ABSTRACT

This study aimed to investigate the performance of three cotton (*Gossypium barbadense* L.) genotypes as affected by drought stress at three irrigation regimes; 14 (S-0), 21(S-1) and 28 (S-2) days that were started after the first irrigation. To achieve this goal, a field experiment was conducted as split block design at the Experimental Farm of the Faculty of Agriculture, El-Fayoum Univ. The results indicated that the irrigation regimes mean squares of combined data were highly significant for earliness traits, also as well as yield and yield components. Most of fiber properties were not affected by water stress conditions. Significant differences were found among the non-stress (S-0) and the stress treatments (S-1 and S-2) for mean performances of the three earliness traits. Treatment S-2 led to significant decrease in yield and yield components compared to S-0. The results showed that Giza 85 variety gave the highest fiber length, fiber strength and was finer cultivars having the lower micronaire values. The interaction between genotypes and stress treatments was significant for most traits.G1,G2 and G3 cotton varieties exhibited highest seed cotton yield kg ha^{-1} (yield potential) in the non- stress treatment (S-0). Giza 90 variety outyielded the other two varieties under stress treatment (S-2) compared to those of Giza 85 and Giza 83. The superiority of Giza 90 variety could be attributed to its high yield components., while Giza 90 was relatively stress susceptible and similar trend of those obtained using data of relative productivity (%) which confirm that the genotype Giza 83 and Giza 85 are more drought tolerance and could be used as sources of drought stress tolerance in breeding programs and tolerance to water stress conditions.

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Keywords: Productivity; cotton; stress susceptibility index; relative productivity.

1. INTRODUCTION

Drought, like many other environmental stresses, has adverse effects on crop yield. Low water availability is one of the major causes for crop yield reductions affecting the majority of the farmed regions around the world. As water resources for agronomic uses become more limiting, the development of drought- tolerant lines becomes increasingly more important [1]. The performance of cotton genotypes under different irrigation regimes was studied by many investigators [2,3,4,5,6]. They concluded that cotton cultivars showed wide variation in their seed cotton yield while, fiber properties were not affected by relative water stress conditions.

Krieg [7] indicated that the period from square initiation to first flower represents the most critical development period in terms of water supply affecting yield components. The peak flowering period was the most sensitive to drought and at this time water stress led to the greatest decrease in yield. Under water stress, decrease in seed cotton yield is primarily due to the reduction in number of bolls. Water stress affect lint quality; fiber length, strength and micronaire reading as well [8].

In this respect, Dagdelen et al. [9] applied irrigation at five different rates (full irrigation and four deficit rates) to cotton and found that the highest application of water regime producing the highest yield, while Falkenberg et al. [10] reported that no yield reduction in cotton with the deficit water. On the other hand, Detar [11] concluded that over irrigation of cotton can lead to excessive vegetative growth and it can also cause leaching of nutrients out of the root zone, increasing fertilizer costs and contaminating groundwater supplies. Several references showed that cotton yields can actually be reduced by application of excessive water [12,13]. This study was conducted to determine the effect of some irrigation regimes on earliness, yield and yield components and fiber quality characteristics of cotton genotypes.

2. MATERIALS AND METHODS

This investigation was conducted at the Experimental Farm of the Faculty of Agriculture, El-Fayoum Univ., during the two successive growing seasons of 2006 and 2007 to study the effect of water stress on the traits of three cotton genotypes; Giza 90 (G-1), Giza 85 (G-2) and Giza 83 (G-3). Pedigree and main characteristics of cotton genotypes for fiber traits are shown in Table 1.

Three irrigation intervals were started after the first irrigation after sowing irrigation *i.e.* irrigation every 14 days (S-0), irrigation every 21 days (S-1) and irrigation every 28 days (S-2). A split-plot design with four replications was used where the irrigation regimes and the cotton genotypes were allocated in the main and sub plots, respectively. Sowing date was on the 15th of March in both seasons. The relative humidity and air temperature are shown in Table 2 for the time of application.

The Experimental unit was 3 x 7m = 21 m^2. The cultural practices were applied as recommended for cotton production in Fayoum region except for the variables under study. Ten individual random guarded plants were mentored and tagged to collect data. The studied traits were; days to first flower appearance, days to first boll opening, earliness index, number of open bolls, seed cotton yield (g/plant), seed cotton yield (kg ha^{-1}), boll weight, seed index ,lint index, fiber fineness, fiber strength and fiber length at (2.5**%** S.L.).

Drought susceptibility index (SI) was calculated to characterized the relative drought tolerance of all genotypes. It must be emphasized that SI provides a measure of drought tolerance based on minimization of yield loss under dry condition compared to moist one rather than on yield level under dry conditions. The index was calculated or genotype yield means (SI) using a generalized formula of Fisher and Maurer [14]. The scale of S rating was suggested and applied by Khanna-Chopra and Viswanatahn [15] on *Triticum aestivum* L:

$$SI = (1-(Y_d/Y_p))/D$$

Where:

Y_d= mean yield in drought environment, Y_p = mean yield in normal condition = (potential yield), D=drought stress intensity = 1-(mean Y_d all genotypes /mean Y_p of all genotypes).

The S used to characterize the relative water stress tolerance of various genotypes were (SI < 1.00) is synonymous with high stress tolerance (T), 0.5 < S ≤ 1.00 moderately stress tolerant (M) and S > 1.00 susceptible (S).The obtained data were subjected to analysis of variance (ANOVA) according to Gomez and Gomez [16] using MSTAT and means of treatments were compared using LSD at significance level of (0.05).

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

Mean squares for all traits studied in the combined data over both years are presented in Table 3. Mean squares for stress treatments (ST), years x stress treatments (Y x ST), stress treatments x genotypes (ST x G) and year x genotypes x stress treatments (Y x G x ST) interactions were highly significant for the two earliness traits, indicating different responses of cotton genotypes under the experimental drought stresses and years conditions. The results revealed that irrigation regime mean squares were highly significant for yield and yield components indicating different genotypic performances due to the stress treatments, while they were not significantly affected by genotypes(G) except seed index as well as stress treatments x genotypes (ST x G) interaction, except seed cotton yield (kg ha^{-1}). The two exception traits may be greatly influenced by genotypes and their interaction with stress treatments. Combined analysis of data over the two seaons revealed insignificant mean squares for of most fiber attributes indicating that these traits responded similarly to irrigation treatments. Insignificant of mean squares fiber properties were found by Abdel-Hamid and Esmail [6].

3.2 Mean Performance

Results present in Table 4, show the mean performance of the studied traits for the three cotton genotypes under water stress. The data showed that there were significant differences between genotypes for earliness trait of days to first flower appearance, while insignificant differences for days to first boll opening and earliness index (%) were detected. Significant differences were found among the non- stress (S-0) and the two stress treatments (S-1 and S-2) for all earliness traits where the obtained values were 86.98, 81.33, 77.04 days, 142.95, 134.33, 127.42 days, 66.76%, 76.69% and 86.37% for the above mentioned three traits in the treatments; S-0, S-1 and S-2, respectively (Table 4). In this respect, Krieg [7] indicated that the period from square initiation to first flower represents the most critical development period in terms of water supply affecting yield components. Significant differences between S-1 and S-2 treatments were significant for yield and yield components compared with S-0 (normal irrigation). Treatment S-2 led to significant decreases in yield and yield components compared to S-0 where the values were 12.78 and 16.47 for number of open bolls, 5.54 and 7.51 for seed cotton yield (kg ha^{-1}), 2.30 and 2.82 for boll weight (g), 10.01and 10.68 for seed index (g),5.03 and 6.10 for lint index in S-0 and S-2,respectively. These results were in harmony with those obtained by Radwan and Mohamed [17], Esmail and Abdel- Hamid [4], Darwish and Hegab [5] and Pettigrew [18], while Falkenberg et al. [10] and Wanjura et al. [13] reported that no yield reduction in cotton with the deficit water.

The mean values of the tested genotypes for fiber properties studied under the three irrigation intervals are presented in Table 4. Results indicated that all cotton fiber properties, except fiber fineness were not significantly affected by irrigation intervals. These results indicated that most of these traits are highly heritable and not affected by water stress conditions used in the present investigation. Similar conclusions were previously reported by Afiah and Ghoneim [2], Abdel- Hamid and Esmail [6] and McWilliams [8]. Consequently in other words, the genotypic fiber traits were not affected by increased the irrigation intervals from 14 to 28 days after the first irrigation. Results revealed that the variety Giza 85 gave the highest fiber length, fiber strength and was finer cultivars having the lower micronaire values (Table 4). Irrigation regime treatments (ST) found to be significantly affected all studied traits, except fiber length and strength, in favour to S-1.

Table 1. Pedigree and main characteristics of cotton genotypes for fiber traits*

Genotypes	Pedigree	HVI measurements		
		UHM(mm)	Strength(g/tex)	Micronaire (unit)
Giza 90	Giza 83 x Dandara	30.50	35.80	4.0
Giza 85	Giza 67 x C.B 58	30.50	40.80	3.9
Giza 83	Giza 72 x Giza 67	30.90	37.30	4.6

**Spinning test report on the Egyptian cotton crop of 2006, Cotton Research Institute, ARC, Egypt*

Table 2. Relative humidity and air temperature at Fayoum region (average over the two growing seasons)*

Intervals Month	Relative humidity	Maximum (Temp.)	Minimum (Temp.)
16/3 - 31/3	80.0	26.15	9.95
1/4 - 15/4	79.0	28.00	11.35
16/4 - 30/4	77.5	32.45	14.95
1/5 - 15/5	78.5	32.05	15.85
16/5 - 31/5	78.0	35.50	17.75
1/6 - 15/6	77.0	35.95	19.95
16/6 - 30/6	79.5	37.25	20.45
1/7 - 15/7	80.0	37.85	21.75
16/7 - 31/7	80.0	37.90	21.40
1/8 - 15/8	79.5	38.30	22.25

**Meteorology station of the Agricultural Research Center in Giza*

Table 3. Mean squares of earliness, yield and yield components and fiber quality traits of cotton genotypes over the two growing seasons (combined data)

Source of variation	d.f.	Days to first flower	Days to first boll opening	Earliness index	Number of open bolls	Seed cotton yield/plant	Seed cotton yield Kg./ha^{-1}
Rep /years	3	0.590	8.004	8.813	0.072	6.562	0.013
Years	1	4.224	72.24*	0.222	0.064	1.013	0.363
Error (a)	3	5.394	2.84	0.685	0.176	1.243	0.091
ST	2	556.2**	1452.9**	2144.4**	97.03**	1882.0**	23.26**
Y x ST	2	11.21**	74.17**	10.65*	0.011	8.427	0.184
Error (b)	12	0.306	3.35	1.58	0.212	3.997	0.146
Genotypes (G)	2	24.00**	2.686	2.066	1.743	20.88	0.187
Y x G	2	7.32**	1.520	22.50**	0.986	8.583	0.115
ST x G	4	14.89**	8.956**	4.594	0.558	0.829	0.550**
Y x G x ST	4	26.25**	12.49**	2.886	0.637	3.109	0.180
Error (c)	36	1.34	1.478	3.326	0.616	8.200	0.079
Source of variation		Boll weight	Seed index	Lint index	Fiber fineness	Fiber strength	Fiber length
Rep /years	3	0.018	0.021	0.324	0.002	0.405	0.536
Years	1	0.011	2.607**	0.748	0.005	0.420	0.045
Error (a)	3	0.006	0.021	0.080	0.004	0.189	0.392
ST	2	1.610**	2.790**	6.799**	0.038*	0.396	0.024
Y x ST	2	0.039*	0.292*	1.724**	0.027*	1.001	0.143
Error (b)	12	0.010	0.054	0.080	0.007	0.465	0.324
Genotypes (G)	2	0.014	0.475**	0.075	0.025	0.118	0.220
Y x G	2	0.003	0.318*	0.115	0.013	2.193**	0.020
ST x G	4	0.008	0.451**	0.120	0.023*	1.805**	0.201
Y x G x ST	4	0.014	0.192*	0.092	0.010	0.920	0.044
Error (c)	36	0.012	0.062	0.210	0.008	0.414	0.236

**and ** Significant at $P < 0.05$ and 0.01 levels of probability, respectively.*ST denotes stress treatments of irrigation at 14, 21 and 28 day's intervals, respectively*

Table 4. Mean performance of earliness, yield and yield components and fiber quality traits of cotton as affected by genotypes (G), stress treatments (ST) and their interactions over the two growing seasons (combined data)

Genotypes	Stress treatments (ST)	Days to first flower	Days to first boll opening	Earliness index	Number of open bolls	Seed cotton yield/plant	Seed cotton yield Kg./ha^{-1}
G-1	S-0	87.72	142.22	66.93	16.37	46.76	2905.09
	S-1	84.07	135.91	76.59	14.81	38.65	2376.55
	S-2	77.68	127.63	85.77	12.74	29.26	2159.14
Mean		83.16	135.25	76.43	14.64	38.22	2481.51
G-2	S-0	86.43	143.48	67.08	16.34	45.32	2751.40
	S-1	80.76	133.45	76.54	14.87	37.46	2410.29
	S-2	76.38	126.84	86.67	12.74	27.48	2084.17
Mean		81.19	134.59	76.76	14.65	36.75	2414.03
G-3	S-0	86.80	143.16	66.26	16.70	47.36	2788.88
	S-1	79.16	133.63	76.93	15.14	38.48	2552.73
	S-2	77.06	127.79	86.67	12.85	29.61	1986.71
Mean		81.01	134.86	76.62	14.90	38.48	2444.02
Mean (ST)	S-0	86.98	142.95	66.76	16.47	46.48	2815.12
	S-1	81.33	134.33	76.69	14.94	38.20	2447.77
	S-2	77.04	127.42	86.37	12.78	28.78	2076.67
	G	0.226	N.S.	N.S.	N.S.	N.S.	N.S.
L.S.D.	ST	0.347	1.151	0.791	0.289	1.257	0.240
0.05	ST × G	1.171	1.228	N.S.	N.S.	N.S.	0.289
Genotypes	**Stress treatments(ST)**	**Boll weight**	**Seed index**	**Lint index**	**Fiber fineness**	**Fiber strength**	**Fiber length**
G-1	S-0	2.85	10.83	6.14	4.03	32.25	29.02
	S-1	2.60	10.60	5.54	4.04	33.14	28.86
	S-2	2.29	10.09	4.83	4.08	31.95	28.75
Mean		2.58	10.51	5.50	4.05	32.45	28.88
G-2	S-0	2.77	10.57	6.02	3.90	32.28	29.06
	S-1	2.51	10.22	5.45	4.08	32.58	28.90
	S-2	2.31	10.31	5.15	4.04	32.79	29.21
Mean		2.53	10.37	5.54	4.01	32.55	29.06
G-3	S-0	2.83	10.65	6.14	4.06	32.58	28.91
	S-1	2.54	10.38	5.59	4.06	32.10	29.08
	S-2	2.30	9.63	5.11	4.08	32.50	28.90
Mean		2.56	10.22	5.61	4.07	32.39	28.96
Mean (ST)	S-0	2.82	10.68	6.10	4.00	32.37	29.00
	S-1	2.55	10.40	5.53	4.06	32.61	28.95
	S-2	2.30	10.01	5.03	4.07	32.41	28.95
	G	N.S.	0.145	N.S.	N.S.	N.S.	N.S.
L.S.D.	ST	0.062	0.146	0.177	0.052	N.S.	N.S.
0.05	ST × G	N.S.	0.251	N.S.	0.090	0.650	N.S.

**G-1,G-2 and G-3 denote cotton genotypes Giza 90, Giza 85 and Giza 83 , respectively;*ST; (S-0, S-1 and S- 2) denote irrigation at 14, 21and 28 days intervals, respectively*

Table 5. Relative productivity (%) and stress susceptibility index (SI) of cotton genotypes at the stress treatments, S-1 and S-2 in the two Growing seasons 2006 and 2007 and combined data over both seasons

Genotypes	2006		2007		Combined		Mean
	S-1	S-2	S-1	S-2	S-1	S-2	
Relative productivity (R.P. %)							
G-1	83.08	74.17	80.59	74.52	81.82	74.34	78.08
G-2	83.07	70.01	92.51	81.79	87.71	74.73	81.64
G-3	92.40	70.32	90.54	72.17	91.47	71.24	81.35
Stress susceptibility index (SI)							
G-1	1.22	0.91	1.58	1.06	1.39	0.98	1.19
G-2	1.22	1.05	0.61	0.76	0.94	0.92	0.91
G-3	0.55	1.04	0.77	1.16	0.65	1.10	0.87

**R.P.%, Calculated using the following relationship: R.P.% = (Ys / Y) x 100, where Ys and Y are stressed and irrigated genotype yield, respectively. *S-1 and S-2 denote irrigation at 21 and 28 days intervals, respectively*

The interaction between genotypes and stress treatments was significant for days to first flower appearance, days to first boll opening, seed cotton yield (kg ha^{-1}) and seed index, fiber fineness and fiber strength. The cotton genotypes produced the highest seed cotton yield kg ha^{-1} (yield potential) in the non- stress treatment (S-0) as compared to stress treatments (S-1 and S-2) where, the obtained values were 2905.09, 2751.40 and 2788.88 Kg./ha^{-1}, respectively. The variety Giza 90 outyielded the other two varieties under stress treatment (S-2) where it gave 2159.14 Kg./ha^{-1} compared to 2084.17of Giza 85 and 2076.67 Kg./ha^{-1} of Giza 83. The superiority of Giza 90 variety could be attributed to its high yield components.

4. RELATIVE PRODUCTIVITY AND STRESS SUSCEPTIBILITY INDEX

Relative productivity (%) was used in this study to detect the differences existed among cotton genotypes under stress treatments S-1 and S-2. In the first season, Giza 83 variety gave the highest relative productivity (%) under S-1 (92.40%) indicating its drought tolerance whereas the variety Giza 85 at S-2 showed the lowest relative productivity of 70.01% (Table 5). However in the second season, both varieties under S-1 and Giza 85 under S-2 surpassed Giza 90 in their relative productivity, indicating that Giza 85 followed by Giza 83 were the most stress tolerant varieties. These findings were confirmed by the mean of combined data. These results indicated that both Giza 85 and Giza 83 varieties are more suitable under drought condition and promising for production under limited irrigation resources.

The stress susceptibility index (SI) values based on seed cotton yield (kentar/fed.) were calculated separately for stress treatments in first and second seasons and combined for each genotype (Table 5).

The mean of S values were 0.87 for Giza 83, 0.91 for Giza 85 and 1.19 for Giza 90 indicating that Giza 83 and Giza 85 were tolerant to stress, while Giza 90 was relatively stress susceptible. These results are in similar trend of relative productivity (%) summarized in Table (5) which confirm that the genotypes Giza 83 and Giza 85 are more drought tolerant and could be used as sources of drought stress tolerance in breeding programs and / or factors increasing general adaptation. Drought tolerant genotypes with low relative reduction in seed cotton yield had (SI) values lower than unity and found reasonable agreement among S across different stress in the cotton genotypes are acceptable [14]. However, Khanna-Chopra and Viswanatahn [15] reported large shifts in the S values across stress environments. They associated this variation with differing genotypes and / or genotype x environment interactions and added that genotypes with low values of S are presumed to be drought resistant or tolerant, because they exhibited smaller reductions in yield in stress environment.

5. CONCLUSION

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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