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EVALUATION OF THE GENETIC VARIATION FOR SOME GENOTYPES IN COTTON (*GOSSYPIUM BARBADENSE* L.) TO WATER STRESS

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ABSTRACT: ***Sixteen cotton genotypes representing a wide range of cotton characteristics, were used in two concurrent trials (laboratory and field) at Sakha Agric. Res. Station under well-watered and water-limited regimes during 2016 and 2017 seasons. The objectives were to determine genotypic variability among cotton varieties in their response to deficit water stress and to detect the most suitable genotypes, traits and selection procedure for water stress condition. The genotypes were evaluated for water deficit stress in laboratory by the simulation of water potentials with polyethylene glycol-6000 (0.0 and -0.4 MPa), at 25ºC using aerated hydroponic culture box. After 18 days the following seedling traits were measured, root length (cm) (RL), root fresh weight (g) (RFW), root dry weight (g) (RDW), shoot length (cm) (SHL), shoot fresh weight (g) (SHFW) and shoot dry weight (g) (SHDW). Field trail conducted to measure vegetative traits, yield and yield components and fiber traits. Analysis of variance for the growing seasons 2016 and 2017 revealed significant differences with respect to water regimes, genotypes and water regimes x genotypes for most of the studied traits, confirming the presence of genotypic variability among the studied cotton genotypes. Mean values exhibited decreasing in traits from normal to water deficit conditions in all traits except for maturity (M). The relative reduction (RD%) varied from 1.25% for pressley index (PI) to 51.6% for lint yield/plant (LY/P). Fiber traits were the lowest affected traits by water stress. G. 88, G. 93 and Suvin were less affected by water stress for seedling traits. For vegetative traits, G.77, G.94, G.89xG.86, Ashmouni, Menoufi and Suvin showed higher values under water deficit. Regarding to yield and yield components traits G.89xG.86, Menoufi, Suvin and G.86 showed the highest water deficit tolerance with acceptable production under limited water regime. On the other hand, most of extra-long staple cotton varieties G.87, G.88 and G.93 were most susceptible to water deficit stress in production term. Drought susceptibility index (DSI) showed significant negative correlation with yield under water deficit regime suggesting DSI as a useful predictor of drought tolerance in cotton and confirming the need of performing genotype evaluation under water stress in case of breeding for water deficit tolerance. Generally, the extra-long genotypes were more susceptible to water deficit stress than long staple genotypes for fiber traits. Correlation coefficients between all the studied traits under well watered and limited water regimes over two years revealed that, yield was positively correlated with yield components traits and plant height (PH); and negatively correlated with most fiber traits. The path coefficient analysis revealed positive and negative direct effect of traits on seed cotton yield (SCY/P). The highest direct effect on SCY/P was exhibited by bolls/plant (B/P) (1.36) followed by boll weight (BW) (0.91) and lint percentage (L%) (0.53). The highest indirect effect of most of yield and vegetative traits were through B/P and BW. These results confirming that, selection to improve productivity under water deficit stress could be more effective throughout direct selection for B/P and BW. Factor analysis revealed that first three components accounted for about 88.51% % of the total variation among the studied traits. Results exhibited the importance of LI, SI, L%, BW, LY/P, SCY/P and PH traits in factor 1 and B/P, SCY/P and LY/P in factor 2 confirming the***

importance of these traits in the total variance to improve productivity under deficit water stress.

Key words: ***Genotypic Variation, Drought susceptibility index, Cotton.***

INTRODUCTION

Water deficit is the major abiotic stress factor limiting plant growth and crop productivity around the world (Kramer, 1983; Turner, 1997; Sinclair, 2005). Approximately one third of the cultivated area of the world suffers from inadequate supplies of water (Massacci *et al*., 2008). In all agricultural regions, yields of rain-fed crops are periodically reduced by drought (Kramer, 1983), and the severity of the problem may increase due to changing world climatic trends (Le Houerou, 1996). In general, plant water stress is defined as the condition where a plant's water potential and turgor are decreased enough to inhibit normal plant function (Hsiao *et al.,* 1976).The effects of water stress depend on the severity and duration of the stress, the growth stage at which stress is imposed, and the genotype of the plant (Kramer, 1983).

Many studies have reported how cotton reproductive growth, yield and fiber quality are affected by water deficits. Cotton yield is dependent on the production and retention of bolls, and both can be decreased by water stress (Guinn and Mauney, 1984). Under water stress, decrease in seed cotton yield is primarily due to the reduction in number of bolls and boll weight (Pettigrew, 2004 b; Wang *et al*., 2004; Mert, 2005; Basal *et al*., 2009). Water stress affects lint quality in numerous ways, especially during the fiber elongation period, which results in a decrease in fiber length and causes fiber immaturity (Ritchie *et al*., 2004 ; Mert, 2005).

Many studies showed that there is genotypic variability for water-deficit stress in cotton (Quisenberry *et al*., 1981; Lacape *et al*., 1998; Pettigrew and Meredith, 1994). Therefore, selection for drought tolerance is a major interest of plant breeders in cotton. A number of different morphological (leaf, stem and root growth parameters) and physiological traits (more than 30 traits) have been suggested as important selection criteria relative to drought tolerance in cotton (Loka *et al*., 2011). However, none of these physiological traits has so far been consistently correlated positively with drought tolerance (Loka *et al*., 2011). The difficulty in identification of a physiological parameter as a reliable indicator of yield in drought conditions has suggested that yield performance over a range of environments should be used as the main indicator for drought tolerance (Voltas *et al*., 2005).

One of the most commonly methods used to determine the tolerance of plants to abiotic stresses is the evaluation of the germination capacity of seeds under such conditions (Larcher, 2000). Aiming to simulate water stress conditions in the laboratory, germination studies have been carried out with aqueous solutions of polyethyleneglycol-6000 (PEG-6000) and mannitol (Murillo-Amador *et al*., 2002; Costa *et al*., 2004; Fanti and Perez, 2004). Laboratory assays simulating water stress circumstances have aided to the identification of cultivars with an elevated level of resistance to such adverse conditions in cotton (Babu *et al*., 2014 and Megha *et al*., 2017) and other crops, such as maize (Tonin *et al*., 2000) and rice (Pirdashti *et al*., 2003). However, the genotypic differences observed at seedling stage in hydroponic experiments may not necessarily correspond to those observed at the

reproductive stage in the field (Zhu, 2001).

Throughout breeding for improving productivity under stress, two different points of view are considered: selection for high potential yield, accepting the hypothesis that if the yield of a genotype is increased in optimum conditions it will also be increased in non-optimum conditions, or selection for high yield under stress conditions (Blum, 1979).

In order to improve yield under drought conditions such new cultivars, two basic requirements must be available. Firstly, there must be sufficient variability for water stress tolerance in the crop as a whole, and secondly, this variation must be genetically controlled. To develop cotton varieties for drought tolerance, the first step in breeding program is to determine suitable parents. Thus, the main objectives of this work were to: A- determine the genotypic variability between cotton genotypes in response to water deficit stress B- detect the most suitable genotypes under water deficit condition for further using by cotton breeders C- evaluate seedling screening for water stress under hydroponic condition D- detect the most suitable selection criteria for water deficit and to test selection hypothesis (selection under optimum or water stress conditions).

MATERIALS AND METHODS

In the present study, two concurrent trials were conducted at Sakha Agric. Res. Station (seedling trail) at laboratory and (field trail) during 2016 and 2017 seasons.

Seedling trial:

In this trial, seeds of sixteen cotton varieties (Table 1) representing a high range of cotton characteristics, were germinated vertically in two layer filter paper sheets at 25^{o}C, 10 days after sowing the sheets were unrolled and the seeds that had produced normal seedlings were transferred to hydroponic culture of aerated box according to Babu *et al*., 2014, containing Hogland nutrient solution for control treatment (0.0 MPa) and with polyethylene glycol (PEG-6000) solution with final osmotic potential -0.40 MPa for water deficit stress treatment, the concentration of PEG-6000 required to obtain this value of osmotic potential was determined by the equation of Michel and Kaufmann (1973).

After 18 days the following seedling traits were measured: root length (cm) (RL), root fresh weight (g) (RFW), root dry weight (g) (RDW), shoot length (cm) (SHL), shoot fresh weight (g) (SHFW) and shoot dry weight (g) (SHDW). Five seedlings from each variety and replication were uprooted and washed with tap water. Clean and blotted dry seedlings were dissected at the collar point to separate shoot and root. Length of shoots and roots seedlings was measured and fresh weight was taken immediately. Shoots and roots were separately packed in a labeled paper bag, placed in an oven at 70^{o}C for 48 h and dry weights of roots and shoots were taken, this trial was carried out during 2016 and 2017 seasons.

Field trial:

The same sixteen cotton varieties were evaluated under two water regimes well-watered (normal irrigation) and water-limited (deficit irrigation), in the field during 2016 (Y1) and 2017 (Y2) at Sakha Agric. Res. Station.

The two water regimes:

- Well-watered. One irrigation at planting and 6 subsequent irrigations as required for normal crop growth and development.
- Water-limited. One irrigation at planting and three supplemental irrigations 25 , 40 and 55 days after planting.

Table 1. Pedigrees of the 16 cotton genotypes used in this study.

No.	Genotype	Pedigree*	Category	No.	Genotype	Pedigree*	Category
1	Giza 45	Giza 28 x Giza 7	ELS	9	Giza 90	Giza 83 x Dendera	LS
2	Giza 70	Giza 59A x Giza 51B	ELS	10	Giza 92	Giza 84 x (Giza 74 x Giza 68)	ELS
3	Giza 77	Giza 70 x Giza 68	ELS	11	Giza 93	(G. 77 x Pima S6)	ELS
4	Giza 80	Giza 66 x Giza 73	LS	12	Giza 94	Giza 86 x 10229	LS
5	Giza 86	Giza 75 x Giza 81	LS	13	Giza 89 x Giza 86	Giza 89 x Giza 86	LS
6	Giza 87	Giza 77 x Giza 45-A	ELS	14	Ashmouni (Giza 19)	Selected from Giza 2	LS
7	Giza 88	Giza 77 x Giza 45-B	ELS	15	Menoufi (Giza 36)	Wafeer x Sakha 3	ELS
8	Giza 89	Giza 75 x Russian-6022	LS	16	Suvin	Indian variety (Sujata x Vincent)	LS

* Pedigree information from Abdel-Salam (1999).

During both seasons each water regime experiment was conducted using a split-plot design with four replications were used with water regimes as the main plot and genotypes were randomly assigned as the sub-plots. Each plot consisted of one row of 5.0 meter long with 30 cm hill space, while row to row width was 70 cm apart. Two plants were left per hill at thinning time. The experiment received the recommended agronomic treatments of the commercial area.

Plants were picked by hand, the central ten guarded plants were used to determine the following yield and yield component traits: seed cotton yield (g)/plant (SCY/P), lint cotton yield (g)/plant (LCY/P), bolls/plant (B/P), boll weight (g) (BW), lint percentage (L%), seed index (g) (SI) and lint index (g) (LI). Five of these central ten guarded plants were used to determine the following vegetative and morphological traits: plant height (cm) (PH), number of vegetative branches/ plant (VB/P), number of fruiting branches/ plant (FB/P), leaf area (cm^2) (LA), leaf fresh weight (g) (LFW) and leaf dry weight (g) (LDW). (Leaf traits were carried out on the fourth leaf from plant tip.

Fiber sample of each genotype and treatment were used to measure micronaire reading (MR), fiber length at 2.5% span length (2.5%SL) in mm, maturity ratio (M) and pressley index (PI) during the two seasons.

Drought susceptibility index (DSI) was calculated for yield modifying original Fischer & Maurer, (1978) equation to detect genotype water stress susceptibility as:

$$DSI = 1 - (Y_D/Yp) / SI, \text{ while } SI = 1 - (\hat{Y}_D/\hat{Y}p)$$

Whereas SI is stress intensity and $\hat{Y}_D$ and $\hat{Y}p$ are the means of all genotypes under water stress and normal conditions, respectively.

Statistical analysis:

The recorded data were subjected to analysis of variance technique (Steel & Torrie, 1960) to obtain level of significance among the genotypes and water regime.

Correlation between all the studied traits under normal and water stress conditions was calculated; path coefficient analysis as formulated by Dewey and Lu (1959) was estimated for yield, yield components and some vegetative traits. Factor analysis of the contributed characters was expressed with eigen value and manifested in eigen vector for yield, yield components and some vegetative traits in each factor (Hair *et al*., 1987). All these computations were performed using SPSS (1995) computer procedure.

RESULTS AND DISCUSSIONS

Mean square and means

1. Seedling traits:

Analysis of variance for seedling traits during growing seasons 2016 and 2017 revealed significant (*P* ≤ 0.05) variation with respect to water regimes, genotypes and the interaction of these two seasons (Table 2). However, the water regime was not significant for SHDW in 2016. Similar results were reported by Pettigrew, (2004a); Pettigrew, (2004b) and Başal *et al.* (2005).

Means of the relative reduction due to water stress (RD %) in seedling traits over two years (Table 3) ranged from 15.2% for SHL to 21.7% for SHFW, similar finding were reported by Carlos *et al*., (2011) studying on exposing the cotton seedlings with different levels of PEG-6000 revealed that differential viability and vigor between cultivars were observed under the water stress levels. Regarding to root traits, G.93 exhibited higher values under water stress for root traits. However, G. 80 was most affected genotype by water stress. In respect of shoot traits, G. 88, G. 93, and Suvin were less affected by water stress; in the otherwise G. 89 was most affected by water stress and showed reduction to 37.6%, 52.9% and 48.1% for SHL ,SHFW and SHDW, respectively. It could be concluded that the genotypes G.93 was less affected by water stress for seedling traits. Although the relative reduction (RD%) of G. 94 was high for all seedling traits and considered as water deficit affected genotype, but its means performance maintained as one of the highest genotype under water deficit stress across all seedling traits, also Menoufi genotype showed the same trend for root traits.

2. Vegetative traits

Analysis of variance for vegetative traits during growing seasons 2016 and 2017 revealed significant (*P* ≤0.05) variation with respect to water regimes except for LA during 2016; and LFW and LDW during 2017, genotypes except for LA during 2016 and the interaction of these two parameters except for PH during two years and LA during 2017 (Table. 2).

Mean values of vegetative traits of the genotypes in the well-watered and water limited regimes for 2016 and 2017 are presented in Table 3. Means of the relative reduction due to water stress (RD %) in vegetative traits over two years (Table 3) ranged from 12.31 % for LFW to 36.80% for FB/P, similar results of the effect of water deficit on vegetative traits in cotton are revealed by (McMichael and Hesketh, 1982; Jordan, 1986; Turner *et al*., 1986; Ball *et al*., 1994; Gerik *et al*., 1996; Arbab *et al*., 2015). Regarding to PH and FB/P, the relative reduction (RD%) revealed that G.89xG.86 genotype was the least affected by water stress, but G. 87 was the most affected one. Also, G.89, G.93 and G.77 were less affected by water stress for VB/P, but G. 80 and Menoufi were the most affected

Table 2

Table 3 (1

Table 3(2

Table 3(3

Table 3(4

genotypes. For leaf traits, G.77and G.94 showed the highest means for LA and LFW under water deficit condition, where G.88, G.89, Menoufi and Suvin showed the highest means for LDW under water deficit condition. The results of vegetative traits concludes that G.77, G.94, G.89xG.86, Ashmouni, Menoufi and Suvin showed higher values under water deficit condition for most of vegetative traits.

3. Yield and yield components

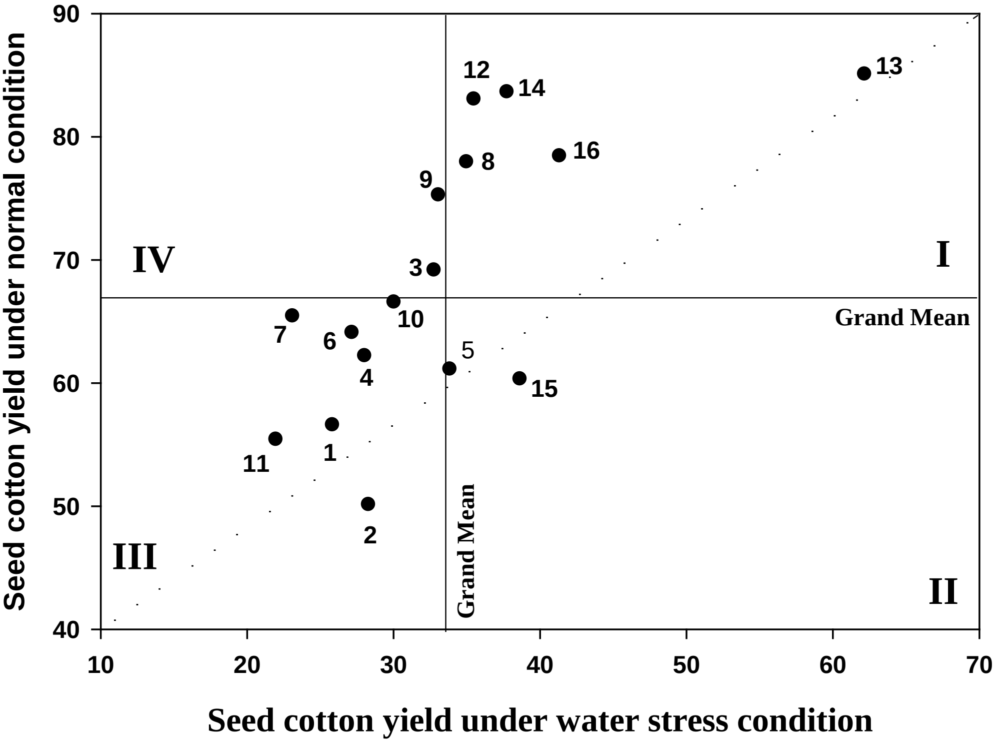
The analysis of variance for yield and yield components traits during the growing seasons 2016 and 2017 are presented in Table 2. Water regime and genotype mean squares were significant ($P \leq 0.05$) for all yield and yield components traits except for L% (Y_1 and Y_2) and LI (Y_2) in water regime . In the same trend, the interaction of water regime x genotype was significant for SCY/P, LY/P and L% in Y_1 , B/P in Y_2 and BW in both Y_1 and Y_2. Detecting of genotypic variability of yield and yield components were reported in many studies (Quisenberry *et al*., 1981; Pettigrew and Meredith, 1994; Lacape *et al*., 1998).

Mean values of yield and yield components in well watered and water limited regimes over two years are presented in Table 3. The results revealed that all yield and yield components traits showed significant reduction under water limited regime except for L%; relative reduction ranged from 51.6% for LY/P to 12.9% for SI. All genotypes revealed relative reduction under water limited regimes for all traits except for L%. These results confirm the negative effect of water deficit on yield and yield components and the presence of genotypic variation for water stress tolerance in the examined materials, similar results of the effect of water deficit on yield and yield components traits in cotton are revealed by (Pettigrew, 2004b; Wang *et al*., 2004; Mert, 2005; Basal *et al*., 2009). Variation in SCY/P occurred among the 16 genotypes under a well-watered regime with values ranging from 50.1 g/P for Giza 70 to 85.0 g/P for G.89xG.86. When the genotypes experienced water-deficit stress, the genotype G.89xG.86 showed the highest yield and experienced the lowest reduction in yield with RD% of 26.9%, followed by Menoufi with RD% of 35.8%.

Biplot between SCY/P under water deficit stress and the control (no stress) is presented in figure 1. A significant positive relationship between yield under optimum condition and under water deficit stress was observed ($r=0.68$, $P<0.01$, $n=16$), supported the hypothesis that genotypic advantages selected under near-optimum growing conditions may be obtained under less favorable growing environments (Quisenberry *et al*., 1980). Genotypes G.89xG.86, Ashmouni, Suvin, G. 94 and G. 89 had the highest yield in both treatments. Genotypes G. 87, G. 88 and G. 93 suffered substantial yield losses under water-deficit than the other genotypes. Meanwhile, genotypes G.89xG.86, Menoufi, G. 86 and G. 70 were less affected by water stress.

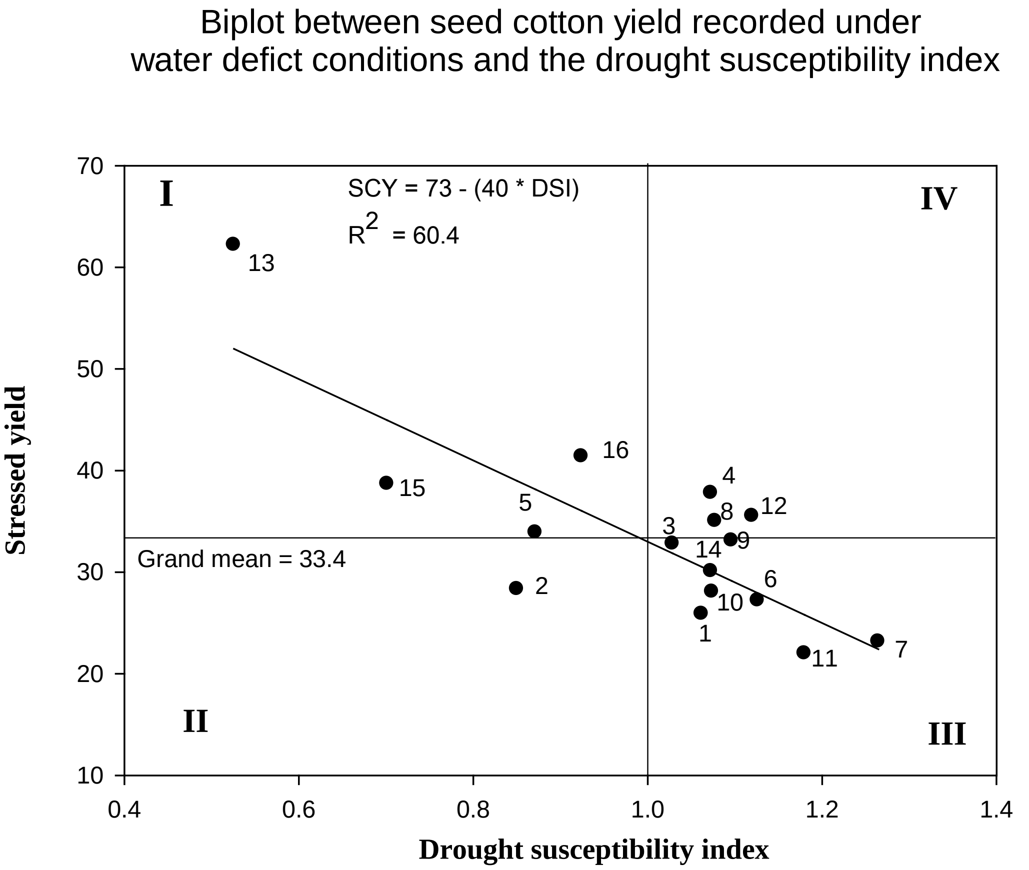
The drought susceptibility index (DSI) was also calculated (Table 3) to provide an additional measurement of drought tolerance of the genotypes with respect to yield. DSI ranged from 0.53 to 1.26, the relationship between DSI and the production under stressed conditions is presented in Figure 2. Drought stress tolerant genotypes were those with DSI values lower than the unit, while susceptible ones were those with DSI values greater than the unit. The result of

a biplot analysis is shown in Figure 2 which is divided into four quadrants. In biplot quadrant I demonstrate four genotypes which are not only water stress tolerant but also give high seed cotton yield ((G.89xG.86), Suvin, Menoufi and G.86). Quadrant II, includes one genotype (G.70) which is fairly tolerant to water stress but produced lower production. Quadrant III, represents three genotypes which are susceptible to water stress but produced relatively high yield in limited water regime (G.89, G.94 and Ashmouni). Quadrant IV corresponds to susceptible eight genotypes with lower yields (G.45, G.77, G.80, G.87, G.88, G.90, G.92 and G.93). These results confirm that most of high productivity genotypes under water deficit condition belong to long stable cotton; and in the otherwise the most susceptible and low productivity genotypes belong to extra-long staple cotton.



1. Giza 45
2. Giza 70
3. Giza 77
4. Giza 80
5. Giza 86
6. Giza 87
7. Giza 88
8. Giza 89
9. Giza 90
10. Giza 92
11. Giza 93
12. Giza 94
13. Giza G89 x G86
14. Ashmouni
15. Menoufi
16. Suvin

Figure 1. Genotypic productivity of seed cotton under water stress conditions versus productivity under normal condition



1. Giza 45
2. Giza 70
3. Giza 77
4. Giza 80
5. Giza 86
6. Giza 87
7. Giza 88
8. Giza 89
9. Giza 90
10. Giza 92
11. Giza 93
12. Giza 94
13. Giza G89 x G86
14. Ashmouni
15. Menoufi
16. Suvin

Figure 2. Biplot between seed cotton yield recorded under water deficit conditions and the drought susceptibility index

Non significant correlation between DSI and SCY/P under normal condition was detected (Table 4); however DSI showed significant negative correlation with SCY/P. LY/P, B/P, BW and PH under water stressed conditions ranged from (r=-0.59, P<0.05, for B/P) to (r=-0.79, P<0.001, for SCY) (Table 4) also regression analysis between DSI and seed cotton yield under water deficit stress was negative (Figure 2) and the determination coefficient was 60.4% confirming the negative relation between DSI and stressed yield. These results clearly suggested DSI as a useful predictor of drought tolerance in cotton and confirming the need of performing genotype evaluation under water stress when breeding for water deficit tolerance. These findings also supported by Rashid *et al.*, (1999), Moinuddin *et al.*, (2005), Ullah *et al.*, (2006) and Sezener *et al.*, (2015) they reported that DSI might provide a more effective mean to assess drought tolerance in crops. Regarding to G.89, G.94 and Ashmouni, these

genotypes showed high relative reduction (RD%) and values of DSI higher than the unit, and from these point of view are classified as susceptible genotypes, in the same time these genotypes had values of SCY/P exceeded the general mean of SCY/P under water deficit stress. These results suggest the possibility to use these genotypes as high yield potential genotypes under water deficit stress.

LY/P had approximately the same trend of SCY/P, and other yield components were also affected by water deficit stress, L% was the lowest affected trait, while some genotypes exhibited higher L% under water stress than normal condition. G. 89, G. 92 and Menoufi showed higher L% under water limited stress than normal condition, where G. 45 and G. 77 were the most affected genotypes.

Regarding to B/P, G.45 and G. 70 showed the lowest reduction in bolls / plant under water deficit stress, but G. 80 and G. 88 showed the highest reduction under water stress.

G. 70 and G.89xG.86 showed the lowest reduction in BW under water deficit stress; but G. 88 and G.93 showed the highest reduction in BW.

Referring to SI and LI, G. 94 showed the highest value and low reduction under limited water regime; however Suvin showed the highest reduction.

These results for yield and its components clearly indicate a significant magnitude of variation in the response of various cotton genotypes to water stress, and in most cases G.89xG.86, Menoufi, Suvin and G. 86 showed the highest water deficit tolerance with acceptable production under limited water regime. On the other hand most of extra-long staple cotton varieties G.87, G.88 and G.93 were most susceptible to water deficit stress in production term.

4. Fiber traits

Analysis of variance for fiber traits under the growing seasons 2016 and 2017 revealed significant ($P \leq 0.05$) variation with respect to water regimes except for maturity during two years and for PI in 2016. Both genotype and water regime x genotype mean squares were significant for all fiber traits under Y_1 and Y_2. (Table 2).

Mean values of fiber traits in well watered and water limited regimes over two years are presented in Table 3. Most of fiber traits exhibited relative reduction (RD%), ranged from 0.04 for M to -4.2 for MR, confirming the negative effect of water deficit on fiber properties. Similar results were obtained by Pettigrew, (2004b); Mert, (2005); Mahmood *et al.,* (2006) and Osborne and Banks, (2006) . For Micronaire reading (lower values are desirable), G.77, G.87 and G.93 were the most affected genotypes by water deficit stress and showed higher values under water deficit stress, however G.70, G.86 and G.89 were less affected by water stress and showed lower values under water deficit stress.

Regarding to fiber length (2.5% SL), G.77, G.86, G. 92 and Suvin were the most affected genotype, however G.70, G.80 and G.89xG.86 showed relatively higher 2.5% SL under water deficit stress.

Most of genotypes exhibited low maturity change under water stress, indicating the little effect of water stress on maturity trait.

G.86, G.87 and Suvin were the most affected genotypes by water deficit stress exhibiting higher change for PI; however G.89xG.86 and Menoufi showed higher value for PI under water deficit stress.

These results of fiber traits clearly indicate the effect of water deficit stress on these traits, and some of these traits were more affected than others. G.86 suffered reduction in 2.5% SL and PI; G.87 suffered reduction in all fiber traits, however G.89xG.86 exhibited better results under water stress, in general most of the extra-long genotypes were more susceptible to water deficit stress than long stable genotypes.

Correlation and Path analysis:

Correlation coefficients between all the studied traits and DSI under well watered (upper value) and limited water regimes (lower values) over two years are presented in Table 4. Seedling traits showed positive correlations between most of their traits under the two regimes, all of the seedling traits tended to correlate negatively with VB/P under limited water regime showing significant for RL under the two regimes and for SHFW under water limited regimes. Most of seedling traits tended to correlate positively with LY/P, L%, SI and LI under well watered regime, however shoot traits showed this correlation trend with SI and LI under limited water regime. Most of fiber traits except MR, showed negative correlation with seedling traits specially root and shoot weights under both water regimes, indicating the possibility to use seedling traits to select for fiber traits under well water and limited water regimes.

In relation to vegetative traits, PH showed positive significant correlation with FB/P under the two water regimes and leaf traits also showed positive significant correlation with their traits. Also, PH showed positive significant correlation with yield and most of yield components under limited water regime; however LDW showed positive and significant correlation with BW, SI and LI under limited water regime. These results indicate the possibility to use PH and LDW as selection criteria to improve yield and some of yield components under limited water regime. Fiber traits did not exhibit significant correlation with any of vegetative traits.

Yield and yield components traits exhibited positive and significant correlation between their traits. Most of fiber traits except MR tended to correlate negatively with yield and yield components under the two water regimes, this negative correlation confirm the difficulty to improve productivity and fiber properties in the same time under water deficit stress. This finding concludes that, breeding method to improve productivity under water deficit stress should break the negative linkage between yield and fiber properties or at least maintain fiber properties out of deterioration.

The correlation coefficients between SCY/P under deficit water stress condition and yield components traits and some vegetative traits were partitioned into direct and indirect effects. The path coefficient analysis (Table 5) revealed positive and negative direct effect of traits on SCY/P. The highest direct effect on seed cotton yield was exhibited by B/P (1.362) followed by BW (0.908) and L% (0.534). The highest indirect effect of most of yield and vegetative traits were through B/P and BW, however most of the studied traits exhibited negative indirect effect throw LY/P and LI. These results confirm that, selection to improve productivity under water deficit stress could be more effective through direct selection for boll number and boll weight, these two traits which consider the most important yield components under water deficit stress. Similar results were obtained by El-Dahan *et al.,* (2002); Iqbal *et al.,* (2006) and Ahuja *et al.,* (2006).

Factor Analysis:

In order to identify vital components that contribute to total variation, factor analysis was conducted. Table 6 shows

Table 4

Table 5. Direct (diagonal) and indirect effects for yield and yield related traits on seed cotton yield under water deficit condition.

Trait	LY/P	B/P	BW	L%	SI	LI	PH	VB/P	FB/P	r (SCY)
LY/P	-0.896	-0.735	-0.672	-0.484	-0.582	-0.618	-0.448	-0.170	-0.045	0.98**
B/P	1.117	1.362	0.368	0.177	0.449	0.395	0.340	0.558	0.150	0.86**
BW	0.681	0.245	0.908	0.536	0.718	0.727	0.618	-0.118	0.073	0.72**
L%	0.288	0.069	0.315	0.534	0.230	0.411	0.069	-0.123	-0.155	0.39
SI	0.166	0.084	0.201	0.110	0.255	0.222	0.186	-0.115	0.069	0.64**
LI	-0.473	-0.199	-0.548	-0.527	-0.596	-0.685	-0.432	0.288	-0.068	0.60**
PH	0.106	0.053	0.144	0.028	0.155	0.134	0.212	-0.047	0.125	0.54*
VB/P	-0.008	-0.017	0.006	0.010	0.019	0.018	0.009	-0.042	-0.002	0.23
FB/P	-0.001	-0.003	-0.002	0.008	-0.007	-0.003	-0.015	-0.001	-0.026	0.12

* and ** significant at 0.05 and 0.01 level of probability, respectively.

Table 6. Eigen values, percent variation and cumulative % for 10 factors.

Factor	Eigen Value	Variation%	Cumulative%
1	5.26	52.61	52.61
2	2.00	20.03	72.65
3	1.59	15.87	88.51
4	0.53	5.31	93.83
5	0.39	3.86	97.68
6	0.14	1.44	99.12
7	0.08	0.76	99.88
8	0.0107	0.1071	99.99
9	0.0011	0.0111	100.00
10	0.0001	0.0009	100.00

total variance of each factor in percentage, which shows its importance in interpretation of total variation of data. Therefore, the contribution of each trait according to other traits is obtained. Three classes of independent factors were chosen based on Eigen value > 1, which together compose 88.51% of total variation. Contribution of these three factors in total was 52.61, 20.03 and 15.87%, respectively.

A principal factor matrix after Varimax rotation (Kaiser, 1958) for these three factors given in Table 7. To interpret the results, only those factors loading having greater values are considered. Factor 1, which account for about 52.61% of the variation consists of LI, SI, L%, BW, LY/P, SCY/P and PH. The suggested name of this factor is yield components due to the strong association between most of yield components and this factor. However the second factor which accounts for about 20.03% of the total variation was strongly associated with B/P, SCY/P and LY/P so the suggested name of this factor is yield factor. The third factor which accounts for about 15.87% of the total variance was strongly associated with PH and FB/P and the suggested name of this factor is vegetative factor. Factor analysis exhibited the contribution of yield components in Factor 1 and 2 to improve productivity under deficit water stress.

Table 7. Rotated factor loadings and communalities for yield and yield related traits.

Trait	Communality	Factor 1	Factor 2	Factor 3
SCY/P	0.981	0.535	0.823	0.135
LY/P	0.995	0.621	0.780	0.026
B/P	0.861	0.154	0.911	0.085
BW	0.810	0.837	0.304	0.131
L%	0.815	0.766	0.106	-0.466
SI	0.897	0.870	0.133	0.350
LI	0.947	0.963	0.124	0.074
PH	0.895	0.595	0.154	0.719
VB/P	0.802	-0.549	0.706	-0.052
FB/P	0.848	-0.019	0.047	0.920

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تقييم التباين الوراثي لبعض التراكيب الوراثية لقطن البربادنس للإجهاد المائي

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الملخص العربي

يهدف هذا البحث إلي تقدير تباين التراكيب الوراثيه في قطن الباربادينس للاستجابة لظروف الإجهاد المائي و كذلك تحديد انسب التراكيب الوراثيه و الصفات و أساليب الانتخاب للإجهاد المائي.ولتحقيق ذلك تم استخدام ستة عشر تركيب وراثي تشكل مدى واسع من الخصائص المحصوليه و الغزليه في تجربتين متلازمتين (معمليه و حقليه) في محطة البحوث الزراعية بسخا خلال الموسمين ٢٠١٦ و ٢٠١٧ و ذلك تحت ظروف الري العادية و تحت ظروف الاجهاد المائي . بالنسبه للتجربه المعملية تم محاكاة الاجهاد المائي عن طريق استخدام البولي ايثيلين جليكول- ٦٠٠ لإستحثاث ضغط اسموزي يقترب من الصفر و -٠.٤ ميجا باسكال لمحاكاة الظروف العادية و ظروف الاجهاد المائي على التوالي. وتم دراسة صفات البادرة (طول الجذير, الوزن الرطب للجذير, الوزن الجاف للجذير, طول المجموع الخضري, الوزن الرطب للمجموع الخضري و الوزن الجاف للمجموع الخضري). و بالنسبه للتجربه الحقليه فتم قياس صفات المحصول و مكوناته و بعض الصفات الخضرية و بعض صفات التيلة و قد أظهرت النتائج ما يلي:

١. أظهر تحليل التباين لموسمي الدراسه ٢٠١٦ و ٢٠١٧ وجود فروق معنويه لأنظمة المياه و للتراكيب الوراثيه و التفاعل بين هذين العاملين لمعظم الصفات المدروسة مما يؤكد تباين التراكيب الوراثيه تحت الظروف المائيه المختلفه.

٢. أظهرت قيم المتوسطات و جود انخفاض لكل الصفات المدروسه نتيجه للإجهاد المائي مقارنة بالظروف الطبيعية, ما عدا صفة النضج و تراوح الانخفاض النسبي من ١.٢٥% لصفة المتانه الى ٥١.٦% لصفة محصول القطن الشعر للنبات. كما تلاحظ أن صفات التيلة كانت اقل الصفات تأثرا بالإجهاد المائي.

٣. بالنسبة لصفات البادرة اظهرت التراكيب الوراثيه جيزة ٨٨ و جيزة ٩٣ و الاشموني و سوفين تحملا للإجهاد المائي.

٤. بالنسبه للصفات الخضريه اظهرت التراكيب الوراثيه جيزة ٧٧ ، جيزة ٩٤ ، جيزة ٨٩x جيزة ٨٦ ، الأشموني ، المنوفي والسوفين تحملا تحت ظروف الإجهاد المائي.

٥. بالنسبه للمحصول و مكوناته اظهرت التراكيب الوراثيه جيزة ٨٩x جيزة ٨٦ ، المنوفي ، السوفين وجيزه ٨٦ تحملا تحت ظروف الاجهاد المائي مع محصول مرضي ومن ناحية أخرى معظم الاصناف فائقة الطول مثل جيزة ٨٧ ، جيزة ٨٨ و جيزة ٩٣ كانت من اكثر الاصناف حساسية للإجهاد المائي من وجهة النظر المحصوليه.

٦. اظهر معامل حساسية الجفاف (DSI) ارتباط معنوي سالب مع المحصول تحت ظروف الاجهاد المائي مما يؤكد امكانية استخدام هذا المعامل لتحديد الاصناف المتحمله للإجهاد المائي وكذلك ضرورة اجراء تقييم التراكيب الوراثيه تحت ظروف الاجهاد عند التربيه لتحمل الاجهاد المائي.

٧. أظهرت معظم الأصناف فائقة الطول حساسية أكثر للإجهاد المائي بالنسبة لصفات التيلة.

٨. اظهر معامل الارتباط قيما موجبة ومعنوية بين محصول القطن الزهر للنبات وكل من معظم الصفات المحصوليه و ارتفاع النبات و كان الارتباط سالب مع معظم صفات التيلة.

٩. اظهر تحليل معامل المرور ان اعلى تأثير مباشر على صفة محصول القطن الزهر كانت لصفات عدد اللوز على النبات (١.٣٦٢) و يتبعها وزن اللوزه (٠.٩٨) ثم معدل الحليج (٠.٥٣٤) و اعلى تأثير غير مباشر لمعظم صفات المحصول و الصفات الخضريه كانت من خلال صفتي عدد اللوز على النبات و وزن اللوزه.مما يؤكد ان الإنتخاب لتحسين الإنتاجيه تحت ظروف الإجهاد المائي قد تكون اكثر فاعليه خلال الانتخاب المباشر لصفتى عدد اللوز / النبات و وزن اللوزه.

١٠. اكد التحليل العاملي على اهمية الصفات المحصوليه و ارتفاع النبات لتحسين الإنتاجية تحت ظروف الإجهاد المائي.

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