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Genotypic Variation among Maize S_1 Families of Giza-2 Population under Water Stress Conditions

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Abstract: Sixty three S1 families along with their S0 population (non-inbred) of the white local maize (*Zea mays* L.) open pollinated composite Giza-2 were evaluated in 8 x 8 simple square lattice design during 2012 season under non-stressed and water stressed environments at the Agriculture Experimental Research Station, Fac. Agric., Cairo Univ., Giza in order to examine the genotypic differences in drought tolerance at flowering stage, estimate the effect of inbreeding on performance in the studied population, identify characters of the strongest association with grain yield under water stress and estimate genetic variance (δ2g), broad -sense heritability (h^2b) and expected gain from selection (GA%) under water stress and non-stress conditions. Water stress caused significant reduction in grain yield/plant (GY/P), 100-Kernel weight (100 KW), kernels/row (K/R) and rows/ear (R/E) and significant increase in days to 50% anthesis, days to 50% silking and anthesis silking interval (ASI). Percentage of inbreeding depression, in general, was higher under water stress than non-stress conditions and reached to 34.53 and 33.40% for GY/P and K/R, respectively. In contrast, negative and significant inbreeding depression was observed for ASI (-38.23%) and 50% silking (-9.01%) under water stress. Grain yield showed significant and positive correlation coefficients (r) with shelling% (0.24 and 0.394), 100 KW (0.595 and 0.352), K/P (0.677 and 0.581), R/E (0.421 and 0.463) and plant height (0.469 and 0.382) under non-stressed and water stressed environments, respectively. In contrast, grain yield showed significant and negative r values with 50% anthesis (-0.323 and -0.244) and 50% silking (-0.327 and -0.323) under non-stress and water stress, respectively and significant negative (r) value with ASI (-0.387) only under water stress. Estimate of genotypic (δ2 g) was relatively smaller under water stress than non-stress for GY/P and K/R, while it was larger under water stress than non-stress for 50% anthesis, 50% silking, ASI and plant height. Estimates of h2b and GA were higher under water stress than non-stress for GY/P, 100 KW, 50% anthesis, 50% silking, ASI and plant height.

Key words: Maize (*Zea mays* L.) · Water stress, Inbreeding depression · Correlation coefficient · Genotypic variance · Heritability · Selection gain

INTRODUCTION

Maize is one of the most important cereal crops in the world. Grain maize is used as human food, poultry and livestock feed and in many industrial purposes such as manufacturing starch, cooking oils and fermentation industries. Maize is also grown for green fodder and silage. The horizontal expansion in maize production is only possible through growing maize in the new-reclaimed lands in Egypt, which are mostly sandy soils with limiting water resources. This would expose the maize plants to drought stress which could result in obtaining low grain yields under such conditions. Moreover, the expected future shortage in irrigation water, necessitates that maize breeders should pay great attention to develop drought tolerant maize cultivars that could give high grain yield under both water stress and non-stress conditions.

Maize is susceptible to drought at flowering stage [1- 7]. Westgate and Boyer [8] reported that moisture stress during flowering lengthens the interval between anthesis and silking and decreases the number of silks that are viable for pollen germination to fertilize the embryo. Loss in grain yield is particularly severe when drought stress occurs at flowering stage [9, 10].

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Several investigators emphasized the role of maize genotypes in drought tolerance. Tolerant genotypes of maize were characterized by having shorter anthesis–silking interval, higher number of ears/plant and higher number of kernels/ear than susceptible ones [2, 4-6, 11-13]. The existence of genotypic differences in drought tolerance would help plant breeder in initiating a successful breeding programme to improve such a complicated character.

Many investigators studied the correlations between yield and other plant attributes under soil moisture stress in order to determine rapid and accurate indirect selection criteria for drought tolerance. A strong negative association was reported between grain yield and each of anthesis – silking interval and barren stalk [4-6, 12, 14]. While a strong positive association was found between grain yield and each of the number of ears/plant and number of kernels/row suggested that mentioned traits could be used as indicators of drought tolerance in maize [2, 15-17].

Choosing the optimal environments to achieve maximum genetic gain by selection is an important factor for crop breeders. Some researchers found that genetic variance components and heritability were increased in drought stress environments [2, 11, 18]. In contrast, Blum [19] and Asay and Johnson [20] reported decreases in genetic variance and heritability magnitudes under stress environments.

To start a successful program for improving drought tolerance, a large number of maize genotypes should be screened under drought stress conditions to identify the best ones which could be used as source material for extracting the best parental inbred lines for developing drought tolerant single and three-way cross hybrids. The objectives of the present study were to: (i) examine the genotypic differences in drought tolerance at flowering stage among a set of S_1 families derived from the Egyptian open-pollinated population Giza-2, (ii) estimate the effect of inbreeding on performance of the studied population, (iii) identify characters of the strongest association with grain yield under water stress and (iv) estimate genetic variance, heritability in the broad sense and expected gain from selection under soil-moisture stress and non-stress conditions.

MATERIALS AND METHODS

The field experiments of the present study were carried out during 2011 and 2012 seasons at the Agriculture Experimental Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt.

Genetic Materials: Seeds of the white local maize open-pollinated composite Giza-2 were used in the present study. Seeds of this population were obtained from Maize Research Section (MRS), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Giza. In 2011 season, seeds of the population Giza-2 were sown under well-watered (non-stress) conditions. At flowering stage a number of selected plants from this population were selfed to produce S_1 seeds. Selection at flowering was based on vigorous, disease free and short anthesis-silking interval. At harvest, the high yielding plants with resistance to ear rot and stalk lodging were selected. Each selected selfed ear was separately shelled and stored to the next season.

Evaluation Procedure: In 2012 season, a total of 64 entries that included 63 S_1 families beside the S_0 population (non-inbred) were evaluated in 8 × 8 simple square lattice design with two replications according to Cochran and Cox [21]. Sowing date of the S_1's and their source population (Giza –2) was on June 12th in single row plot. Rows were 5 m long, 70 cm wide with single plant per hill that spaced 25cm apart. Separate evaluation of the 64 entries was carried out under two water regime environments, i.e. non-stress (full-irrigation) and water stress at flowering stage where irrigation was prevented for the 4th and 5th irrigations. All cultural practices were applied as recommended by ARC.

Data Recorded: The following data were recorded on 5 guarded plants/plot; grain yield/plant (g) adjusted on the basis of 15.5% grain moisture content, shelling%, 100-Kernel weight (g), kernels/row, rows/ear, ears/plant, plant height (cm), days from planting to 50% anthesis (DTA) and 50% silking (DTS) and anthesis silking interval (ASI). For DTA, DTS and ASI traits, data were recorded on a per plot basis.

Statistical Analysis: Individual analysis of variance was performed for each environment following the analysis of 8 × 8 simple square lattice according to Cochran and Cox [21] using MSTAT-C computer package [22] to obtain adjusted means of treatments and effective errors. After homogeneity test according to Steel *et al*. [23], the adjusted treatment means and a randomized complete block model were used for combined analysis of the two environments according to the procedure described and used by Meseka *et al*. [24], Carena *et al*. [25], Aharizad *et al*. [26] and Shushay *et al*. [27]. Treatment mean comparisons were performed using least significant difference (LSD) at 5% level of probability. Pearson correlation coefficients (simple correlation) under both non-stress and stress conditions were calculated between grain yield/plant and other studied traits according to Steel *et al*. [23].

Superiority (%) in grain yield/plant for the best S_1 families significantly exceeded S_1 generation mean under non-stress and water stress conditions was calculated as follow: Superiority% = [(s_1 family mean– s_1 generation mean)/ s_1 generation mean] x 100. Inbreeding depression under non-stress and water stress conditions was calculated in absolute value and as a percentage as follows: Inbreeding depression in absolute value was calculated as S_0 (non-inbred) minus S_1. The significance of the inbreeding depression was tested by LSD, the standard error (SE) for the LSD was calculated as:

$$SE = \sqrt{\frac{MSe}{n_1} + \frac{MSe}{n_2}}$$

where Mse = error mean square and n_1, n_2 = number of replications on which the mean is based. Percentage of inbreeding depression under each environment was calculated by dividing inbreeding depression in absolute units by the non-inbred mean and multiplying by 100.

Expected mean squares were used to estimate genotypic (δ^2g), phenotypic (δ^2p) and environmental (δ^2e) variances for each individual environment according to Hallauer and Miranda [28]. Heritability in the broad sense (h_b^2) was estimated using the following formula:

$$h_b^2 = (\sigma_g^2 / \sigma_p^2) \times 100$$

Genetic advance (GA%) from selection was calculated according to Falconer [29] as follows: GA=100.i.h^2_b.$\delta p/\bar{x}$ where $\bar{x}$ = general mean of the appropriate irrigation regime or environment, δp = square root of the phenotypic variance (phenotypic standard deviation) under the appropriate irrigation regime, h_b^2 = applied heritability under appropriate irrigation regime and i = selection differential (i value corresponding to the percentage selected, *i.e*. 10%, in this experiment = 1.76).

RESULTS AND DISCUSSION

Analysis of Variance: Combined analysis of variance (Table 1) revealed highly significant differences among evaluated genotypes (63 S_1 families and S_0 population) for all studied traits, except for ears/plant. Mean squares due to irrigation regimes (environments) were highly significant for all studied characters except for ears/plant, suggesting that soil moisture stress had a significant effect on most studied traits. Mean squares due to genotypes X environments were significant or highly significant for all studied traits, except for 100-Kernel weight and ears/plant. Therefore, the performance of studied genotypes varied under the two water regimes for most agronomic traits, which is in agreement with the results reported by Denmead and Shaw [30], Moss and Downey [31], El-Sayed [32], Atta [3], Al-Naggar *et al.*

Table 1: Mean squares and means of ten maize traits from combined analysis of variance across two environments (non-stress and water–stress) for 64 entries evaluated in 2012 season.

S.O.V.	d.f	Grain yield (g/plant)	Shelling%	100-kerrel weight (g)	Kernels/row	Rows/ear
Environments (E)	1	58351.72**	225.69**	731.72**	3028.91**	42.18**
Reps/environments	2	213.65	30.55	67.53	7.3	0.665
Genotypes (G)	63	1337.67**	17.79**	35.60**	71.02**	2.90**
G X E	63	436.74**	9.34**	9.8	24.98**	2.22**
Pooled error	126	198.77+	5.64+	13.47++	12.61+	1.16+
Non-stress mean		96.11 a§	82.27 a	33.32 a	28.35 a	13.19 a
water stress mean		65.91 b	80.39 b	29.94 b	21.48 b	12.38 b
Reduction%		31.42	2.29	10.14	24.23	6.14
S.O.V.	d.f	Ears/plant	50% anthesis	50% silking	ASI	Plant height (cm)
Environments (E)	1	0	370.62**	859.22**	101.24**	15187.48**
Reps/environments	2	0	50.82	78.7	3.29	173.38
Genotypes (G)	63	0	6.90**	11.75**	1.62**	921.60**
G X E	63	0	4.14**	5.52**	0.85**	230.68*
Pooled error	126	0.00++	2.82+	3.88+	0.58+	180.37+
Non-stress mean		1.00 a	55.82 a	59.53 a	3.71 a	162.46 a
water stress mean		1.00 a	58.23 b	63.19 b	4.97 b	147.06 b
Reduction%		0.00	-4.32	-6.15	-33.96	9.48

*.** indicate significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

+, ++ denote effective error and RCBD error, respectively

Reduction% = (non stress – water stress)/ non stress x 100

§ Means within a column and having different letters are different (0.05 probability level)

Table 2: Means of studied traits for maize S_1 families and S_0 population (non-inbred) under non-stress and water-stress in 2012 season

		Grain yield/plant (g)				Shelling%				100-kernel wt. (g)			
Generation		Non-stress	Water stress	Red.%	LSD 0.05	Non-stress	Water stress	Red.%	LSD 0.05	Non-stress	Water stress	Red.%	LSD 0.05
S0	Mean	111.3	99.86	10.31	+G= 19.54	81.98	81.28	0.85	G = 3.29	34.51	32.86	4.78	G = 5.10
S1	Mean	95.87	65.38	31.8		82.27	80.38	2.97		33.62	29.89	11.10	
	low	51.01	27.66	45.78	G X E = 27.64	75.58	71.46	5.45	G X E = 4.65	26.27	21.11	19.64	G X E = ns
	high	160.21	113.7	29.01		87.58	85.30	2.60		41.64	37.33	10.35	
Generation	Kernels/row		Rows/ear	Ears/Plant									
S0	Mean	33.92	31.99	5.69	G = 4.92	15.34	14.02	8.60	G = 1.49	1.00	1.00	0.00	G = ns
S1	Mean	28.27	21.31	24.62		13.16	12.36	6.10		1.00	1.00	0.00	
	low	16.17	11.82	26.90	G X E = 6.96	11.01	7.87	28.52	G X E = 2.16	1.00	1.00	0.00	G X E = ns
	high	38.45	33.49	12.90		15.82	14.23	10.10		1.00	1.00	0.00	

+ G and G X E indicate genotypes and genotypes X environment interaction, respectively.

Red.% = (non stress – water stress)/ non stress x 100

Table 2: Continue:

		50% anthesis				50% silking			
Generation		Non-stress	Water stress	Red.%	LSD 0.05	Non-stress	Water stress	Red.%	LSD 0.05
S0	Mean	56.68	56.52	0.28	G = 2.33	60.10	60.22	-0.20	G = 2.72
S1	Mean	55.81	58.25	-4.37		59.52	63.24	-6.25	
	low	52.78	54.54	-3.33	G X E = 3.86	56.50	58.45	-3.45	G X E = 3.86
	high	60.10	61.82	-2.86		63.65	68.34	-7.37	
		ASI*				Plant height (cm)			
S0	Mean	3.47	3.61	-4.03	G = 1.05	174.51	165.10	5.39	G = 18.62
S1	Mean	3.71	4.99	-34.50		162.27	146.77	9.55	
	low	2.56	3.30	-28.91	G X E = 1.49	121.70	109.81	9.77	G X E = 26.32
	high	5.52	7.00	-26.81		192.93	185.90	3.64	

* ASI denote anthesis silking interval

[4 -6] and Salih *et al.* [7], who mentioned that maize genotypes ranked differently under different water regimes.

Mean Performance: Data presented in Table (2) revealed that average grain yield/plant was decreased under water stress by 10.31 and 31.80% as compared to non-stress for S_0 population and S_1 families, respectively. Maximum reduction in yield from water stress reached 45.78% in some S_1 families. However, some S_1families exhibited minimal reduction in grain yield due to water stress of only 29.01%. Average shelling% was decreased due to water stress by 0.85 and 2.97% for S_0 and S_1s , respectively. Maximum reduction in shelling% reached in some S_1's to 5.45%. On the Other hand, some S_1's showed minimal reduction of 2.60% due to water stress. Reduction in kernels/row due to drought stress was 5.69 and 24.62% on average for S_0 and S_1's, respectively. Maximum reduction was 26.90% in kernels/row. On the other hand, minimum reduction due to drought stress was 12.90%. Average number of rows/ear decreased due to water stress by 8.60 and 6.10% for S_0 and S_1's, respectively. Maximum reduction reached to 28.52% in rows/ear for some S_1's. While, minimum reduction was 10.10%.

Ears/plant (Table 2) did not exhibit any change due to water stress. On the other hand, plant height decreased by 5.39 and 9.55% due to water stress for S_0 and S_1's, respectively. Water stress is expected to cause reduction in grain yield and its components, especially when this stress occurs at flowering stage [3-7, 9, 10, 32]. In contrast, water deficit significantly increased number of days from planting to 50% anthesis by 4.37% only for S_1's. Average number of days to 50% silking slightly increased by 0.20% for S_0 and significantly increased by 6.25% for S_1's. Anthesis silking intervals showed significant increase of 4.03 and 34.50% for S_0 and S_1's, respectively. Elongation of ASI in maize as a result of drought stress was also reported by several investigators [3-7, 14, 32].

Superiority in grain yield/plant as a percentage is presented in Table (3). Under non-stress only 15 S_1 families out of 63 S_1's (23.81%) were significantly outyielded of S_1 generation mean. Maximum yield superiorities (41.86 and 67.15%) were observed for family number 36 and family number 41, respectively. On the other hand, under water stress only 9 families out of 63 S_1's (14.29%) significantly outyielded S_1 generation mean. Maximum yield superiorities (66.10 and 73.96%) were observed for family number 56 and family number 61,

Table 3: Superiority (%) in grain yield/plant for the best S_1 families significantly exceeded S_1 generation mean under non-stress and water stress conditions

	Non-stress			Water-stress	
Family No.	Family mean	*Superiority%	Family No.	Family Mean	Superiority%
17	116.43	21.44	1	85.78	31.20
25	118.50	23.60	47	85.83	31.28
61	119.45	24.50	23	89.25	36.51
26	119.70	24.86	18	90.83	38.93
4	119.70	24.86	4	91.63	40.15
55	120.30	25.48	45	91.91	40.57
49	122.60	27.88	46	95.77	46.48
60	123.20	28.51	56	108.58	66.10
33	123.58	28.90	61	113.74	73.96
5	124.44	29.80	---	---	---
11	125.00	30.38	---	---	---
43	126.17	31.60	---	---	---
16	129.75	35.34	---	---	---
36	136.70	41.86	---	---	---
41	160.25	67.15	---	---	---

* Superiority% = [(s_1 family mean – s_1 generation mean)/ s_1 generation mean] x 100

Table 4: Inbreeding depression in absolute units and as percentage of generation means in S_1's of Giza-2 population under non-stress and water stress conditions

	Non-stress		Water stress	
Traits	$S_o - S_1$	$\frac{S_o - S_1}{S_o}\times 100$	$S_o - S_1$	$\frac{S_o - S_1}{S_o}\times 100$
Grain yield/plant (g)	15.47	13.90	34.48**	34.53
Shelling%	-0.29	-0.35	0.90	1.11
100-kernel weight (g)	0.89	2.58	2.97	9.04
Kernels/row	5.65*	16.66	10.68**	33.40
Rows/ear	2.18**	14.21	1.66*	11.84
Ears/plant	0.00	0.00	0.00	0.00
50% anthesis	0.87	1.53	-1.73	-3.06
50% silking	0.58	0.97	-3.02*	-9.01
Anthesis-Silking interval (ASI)	-0.24	-6.92	-1.38*	-38.23
Plant height (cm)	12.24	7.01	18.33	11.10

*, ** indicate significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

respectively. It is worth noting that family number 61 was superior in grain yield/plant over S_1 generation mean under both non-stressed and stressed environments, followed by the family number 4. Superiority in grain yield/plant was accompanied by increasing in one or more of yield components, i.e., 100-kernel weight, kernels/row, rows/ear and shelling percentage.

Inbreeding depression values is presented in Table (4). Under non-stress, there was insignificant and positive inbreeding depression for all studied traits, except for shelling% and ASI which was negative. Significant and highest positive inbreeding depression under non-stress was shown for kernels/row and rows/ear (16.66 and 14.21%, respectively).

On the other hand, under water stress there were significant and highest positive values of inbreeding depression for grain yield/plant (34.53%), kernels/row (33.40%) and rows/ear (11.84%). Insignificant and positive values of inbreeding depression were exhibited in plant height, 100-kernel weight and shelling%. In contrast, significant and negative values of inbreeding depression were observed for 50% silking (-9.01%) and ASI (-38.23%). Also negative but insignificant value of inbreeding depression was detected for 50% anthesis. Inbreeding is expected to reduce yield and its components, reduce plant size and increase time to flowering [28, 33, 34]. Highest inbreeding depression in the present study was reported for grain yield under water stress followed by kernels/row

Table 5: Simple correlation coefficient among grain yield/plant and other studied traits under non-stress and water-stress conditions

Traits	Non-stress	Water-stress
Shelling%	0.240**	0.394**
100- kernel weight	0.595**	0.352**
Kernels/row	0.677**	0.581**
Rows/ear	0.421**	0.463**
Ears/plant	0.000	0.000
50% anthesis	-0.323**	-0.244**
50% silking	-0.327**	-0.323**
ASI	0.002	-0.387**
Plant height	0.469**	0.382**

*, ** indicate significance at 0.05 and 0.01 levels of probability, respectively.

Table 6: Estimates of genotypic (δ^2_g) variance, heritability (h^2_b) and genetic advance under selection (GA%) under non-stress and water-stress in 2012 season

	Non-stress			Water stress		
Traits	δ^2_g	h^2_b	GA%	δ^2_g	h^2_b	GA%
Grain yield/plant (g)	375.63	68.76	29.43	256.02	75.1	37.02
Shelling%	3.16	55.11	2.82	3.16	40.35	2.47
100- kernel weight (g)	4.6	37.69	6.96	4.64	44.17	8.41
Kernels/row	20.98	75.48	24.7	14.4	71.3	26.27
Rows/ear	0.73	61.51	8.9	0.68	48.96	8.18
Ears/plant	0	0	0	0	0	0
50% anthesis	0.81	34.67	1.67	1.89	59.32	3.2
50% silking	1.11	43.66	2.1	3.64	59.76	4.11
ASI	0.08	28.92	7.05	0.58	59.42	20.77
Plant height (cm)	180.18	67.13	11.91	215.59	70.1	14.71

and rows/ear under both non-stressed and water stressed environments. On the other hand, highest negative values of inbreeding depression were observed for 50% silking and ASI and medium negative value for 50% anthesis. Falconer [29] pointed out that inbreeding and heterosis are primarily due to directional of dominance, i.e., loci without dominance cause neither inbreeding depression nor heterosis. Hallauer and Sears [33] reported that inbreeding depression results from an increase in the frequency of homozygous recessive deleterious loci. Since inbreeding cases significant reduction in the means of the traits, hence, genes controlling large plant size and ear traits were primarily dominant to those for smaller size, while those controlling earliness, as measured by days to flower, were dominant to later flowering [33-36]. These findings agree with those reported in the present study especially under water stress than non-stress conditions.

Interrelationships Between Traits: Data of Table 5, showed that grain yield/plant had a significant and positive association with shelling%, 100-kernel weight, kernels/row, rows/ear and plant height under both non-stress and water stress conditions. In contrast, grain yield/ plant had a significant and negative association with 50% anthesis and 50% silking under both environments. ASI had negative and significant correlation with grain yield only under stress environment. Under non-stress conditions, the magnitude of correlation coefficient (r) between the grain yield and other studied traits was greater than that under stress conditions for 100-kernel weight, kernels/row and plant height and was greater under stress than under non-stress conditions for shelling% and rows/ear. An increased ASI (or asynchrony), has usually been associated with reduction in grain yield as reported by several authors [3-7, 9-13, 31].

Genotypic Variance, Heritability and Expected Selection Gain: Changes in the magnitude of genotypic (δ^2_g) variances, broad sense heritability (h^2_b) and expected genetic advance (GA%) from selection (based on 10% selection intensity) of studied traits under non-stress and water stress are presented in Table (6). In general, changes in magnitude of (δ^2_g) from non-stress to water stress were in the same direction and of similar magnitude for most studied traits.

The magnitude of δ^2_g was relatively smaller under water stressed than non-stressed environments for grain yield/plant and kernels/row. On the other hand, the magnitude of δ^2_g was larger under water stress than non–stress for 50% anthesis, 50% silking, ASI and plant height. This indicates that selection for grain yield/plant and kernels/row is predicted to be more efficient under non-stressed than water stressed environment. While selection for 50% anthesis, 50% silking, ASI and plant height seems to be more efficient under water stressed rather than non-stressed environment.

Magnitude of broad sense heritability (h^2_b) estimates (Table 6), under water stress was high for grain yield/plant, kernels/row and plant height and medium for 50% anthesis, 50% silking and ASI. Low estimates of h^2_b were observed for shelling%, 100-kernel weight and rows/ear and very low value (0.00%) was observed for ears/plant. On the other hand, under non-stress the magnitude of broad sense heritability (h^2_b) was high for kernels/ row, grain yield/plant, plant height and rows/ear, medium for shelling% and low for ASI, 50% anthesis, 100-kernel weight and 50% silking.

The expected genetic advance (GA%) from selection for studied traits under non-stress and water stress were calculated for direct selection by applying 10% selection intensity (Table 6). The magnitude of GA was higher under non-stress than under water stress for shelling% (2.82 vs. 2. 47%) and rows/ear (8.90 vs. 8.18%). In contrast, the expected GA from direct selection was higher under water stress than under non-stress for grain yield/plant (37.02 vs. 29.43), 100-kernel weight (8.41 vs. 6.96%), kernels/row (26.27 vs. 24.70%), 50% anthesis (3.20 vs. 1.67%), 50% silking (4.11 vs. 2.10%), ASI (20.77 vs. 7.05%) and plant height (14.71 vs. 11.91%). These results indicated that predicted selection gain would be higher if selection was practiced under water stressed environment for shorter ASI, higher 100-kernel weight, higher number of kernels/row and higher plant height and under non-stressed environment for shelling% and higher number of rows/ear. It is worthy to mention that direct selection under water stressed environment would ensure the preservation of alleles of drought tolerance, especially for ASI (37) and the direct selection under non-stressed environment would take advantage of the high heritability; especially for grain yield [19, 38- 40].

REFERENCES

1. Chapman, S.C., G.O. Edmeades and J. Crossa, 1996. Pattern analysis of grains from selection for drought tolerance in tropical maize population. In plant adaptation and crop improvement (ED. By Cooper, M. and Hammer, G.L.). Walling ford. UK, CAB INTERNATIONAL, 513-527.
2. Ribaut, J.M., C. Jiang, D. Gonzatez-de-Leon, G.O. Edmeades and D.A. Hoisington, 1997. Identification of quantitative trait loci under drought conditions in tropical maize. II- Yield components and marker-assisted selection strategies. Theor. Appl. Genet., 94: 887-896.
3. Atta, M.M.M., 2001. A study of combining ability and heterosis for drought tolerance in some maize populations. Ph.D. Thesis, Fac. Agric., Cairo Univ., Egypt.
4. Al- Naggar, A.M.M., R. Shabana, S.E. Sadek and S.A.M. Shaboon, 2004. S_1 recurrent selection for drought tolerance in maize. Egypt. J. Plant Breed., 8: 201-225.
5. Al-Naggar, A.M.M., W.A. El-Murshedy and M.M.M. Atta, 2008. Genotypic variation in drought tolerance among fourteen Egyptian maize cultivars. Egypt. J. of Appl. Sci., 23(2B): 527-542.
6. Al-Naggar, A.M.M., S.M. Soliman and M.N. Hashimi, 2011. Tolerance to drought at flowering stage of 28 maize hybrids and populations. Egypt. J. Plant Breed., 15(1): 69-87.
7. Salih A.I., S. Awadalla, A. Abdelmula, M.A. Bashir, S. Baloch, S. Baloch and W. Bashir, 2014. Genetic variation of flowering trait in maize (*Zea mays* L.) under drought stress at vegetative and reproductive stages. J. Bio. Agric. and Healthcare, 4(20): 108-113.
8. Westgate, M.E. and J.S. Boyer, 1986. Reproduction at low silking and pollen water potentials in maize. Crop Sci., 26: 951-956.
9. Claassen, M.M. and R.H. Shaw, 1970. Water deficit effect on corn. 1-Vegetative components. Agron. J., 62: 649-652.
10. Grant, R.F., B.S. Jakson, J.R. Kiniry and G.F. Arkin, 1989. Water deficit timing effects on yield components in maize. Agron. J., 81(1): 61-65.
11. Bolanos, J. and G.O. Edmeades, 1996. The importance of the anthesis–silking interval in breeding for drought tolerance in tropical maize. Field Crops Res., 48: 65-80.
12. Edmeades, G.O., J. Bolanos, M. Hernandez and S. Ballo, 1993. Causes for silk delay in a low land tropical maize population. Crop Sci., 33: 1029-1035.
13. Hall, A.J., F. Viella, N. Trapani and C. Chimenti, 1982. The effects of water stress and genotype on the dynamics of pollen shedding and silking in maize. Field crops Res., 5: 349-363.
14. Bolanos, J. and G.O. Edmeades, 1993. Eight cycles of selection for drought tolerance in low land tropical maize. I. responses in grain yield, biomass and radiation utilization. Field Crop Res., 31: 233-252.

15. Guei, R.G. and C.E. Wassom, 1992. Inheritance of some drought adaptive traits in maize: 1. Interrelationship between yield, flowering and ears per plant. Maydica, 37: 157-164.
16. Terrazas, J.M., W. Velasco, G. Avila, L.G. Avila and P.I.M. Cespedes, 1995. Response to irrigation and water stress conditions during the first stage of crop development in full-sib families of a maize variety from the highland zone. Memories de la lll. Reunion Lation Americana YXVI reunion de la zona anddina de irwestigadores en maize. Cochabamba Santa Cruz, Bolivia, Tomol., pp: 249-266.
17. Weerathaworn, P., R. Thiraporn, A. Sobleti and P. Stamp, 1992. Yield and agronomic characters of tropical maize (*Zea mays* L.) cultivars under different irrigation regimes. J. Agron. and Crop Sci., 168(5): 326-336.
18. Troyer, A.F. and R.W. Rosenbrook, 1983. Utility of higher plant densities for corn performance testing. Crop Sci., 23: 863-867.
19. Blum, A., 1988. Breeding crop varieties for stress environments. Crit. Rev. Plant Sci., 2: 199-238.
20. Asay, K.H. and D.A. Johnson, 1990. Genetic variance for forage in crested wheat grass at six levels of irrigations. Crop Sci., 30: 79-82.
21. Cochran, W.G. and G.M. Cox, 1957. Experimental designs. John Wiley, New York, USA.
22. Freed, R.S.P., S. Einensmith, S. Gutez, D. Reicoskv, V.W. Smail and P. Wolberg, 1989. MSTAT-C analysis of agronomic research experiments. Michigan Univ. East Lansing, USA.
23. Steel, R.G.D., J.H. Torri and D.A. Dickey, 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd ed, Mc Graw- Hill, New York, pp: 666.
24. Meseka, S.K., A. Menkir, A.E.S. Ibrahim and S.O. Ajala, 2006. Genetic analysis of performance of maize inbred lines selected for tolerance to drought under low nitrogen. Maydica, 51: 487-495.
25. Carena, M.J., G. Bergman, N. Riveland, E. Eriksmoen and M. Halvorson, 2009. Breeding maize for higher yield and quality under drought stress. Maydica, 54: 287-296.
26. Aharizad, S., A.K. Fard, S.A. Mohammadi and S. Sedaghat, 2012. Evaluation of bread wheat recombinant inbred lines under drought conditions. Annals of Biological Research, 3(12): 5744-5747.
27. Shushay, W.A., Z.Z. Habtamu and W.G. Dagne, 2013. Line x tester analysis of maize inbred lines for grain yield and yield related traits. Asian Journal of Plant Science and Research, 3(5): 12-19.
28. Hallauer, A.R. and J.B. Miranda, 1988. Quantitative genetics in maize breeding. 2nd ed. The Iowa State University Press-Ames., IW, USA.
29. Falconer, D.S., 1960. Introduction to Quantitative Genetics. The Ronald Press Company. New York., pp: 257.
30. Denmead, O.T. and R.H. Shaw, 1960. The effect of soil moisture stress at different stages of growth on the development and yield of corn. Agron. J., 52: 272-274.
31. Moss, G.I. and L.A. Downey, 1971. Influence of drought stress on female gametophyte development in corn (*Zea mays* L.) and subsequent grain yield. Crop Sci., 11: 368-372.
32. El-Sayed, M.Y.M., 1998. Studies on drought tolerance in maize. M. Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.
33. Hallauer, A.R. and J.H. Sears, 1973. Changes in quantitative traits associated with inbreeding in a synthetic variety of maize. Crop Sci., 13: 327-330.
34. Atta, M.M.M., 1994. Studies on corn improvement. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.
35. Dudley, J.W., R.J. Lambert and D.E. Alexander, 1974. Seventy generations of selection for oil and protein concentration in the maize, pp. 181-201 in Dudley, J.W. (ed.) seventy generations of selection for oil and protein in maize. Crop Sci. Soc. of Am., Madison, WIS, USA.
36. Good, R.L. and A.R. Hallauer, 1977. Inbreeding depression in maize by selfing and full-sibbing. Crop Sci., 17(16): 935-940.
37. Langer, I., K.J. Frey and T. Bailey, 1979. Association among productivity, production response and stability indexes in oat varieties. Euphytica, 28: 17-24.
38. Allen, F.L., R.E. Comstock and D.C. Rasmusson, 1978. Optimal environments for yield testing. Crop Sci., 18: 747-751.
39. Smith, M.E., W.R. Coffman and T.C. Baker, 1990. Environmental effects on selection under high and low input conditions. In M.S. Kang (ed.). Genotype-by environment interaction and plant breeding. Louisiana State Univ., Baton Rouge, pp: 261-272.
40. Braun, H., W.H. Preiffer and W.G. Pollmer, 1992. Environment for selecting widely adapted spring wheat. Corp Sci., 32: 1420-1427.