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Performance and Variation of White Maize Inbred Lines Developed from Different Sources for Yield and Drought Tolerance

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ABSTRACT

Fifty S_1, S_2 and S_3 white maize lines were extracted and developed from five open different populations for searching of new maize inbreds that tolerate drought accompanied with distinct performance as heterotic groups. These lines were evaluated along to ten drought tolerant inbred lines of Maize Section (ARC) under field conditions of normal and stress watering regimes during 2017, 2018 and 2019 seasons, respectively. Anthesis-silking interval (ASI), 100-Kernel weight (K.I), grain yield per plant (GYP) and stress tolerance index (STI) were studied. Watering regimes (W.R) combined across each inbred generation are highly significant source of variation for ASI, KI and GYP. Inbred lines of the three generations varied highly significantly under both watering regimes for K.I, GYP and STI. However, for ASI only all S_1's varied significantly under normal irrigation, but S_3's are highly significant in both irrigation trials. The S_2 and S_3 showed somewhat significantly higher reduction for K.I due to drought stress in all groups of inbreds except those of C.1 and ARC. All the groups of inbred lines of the three generations recorded significantly about 8-14% ratios of GYP depression due to drought. The estimates of STI in S_1 and S_3 over parental origins were higher (1.47 and 1.35) than obtained by S_2 (0.88).The developed maize inbreds exhibited desirable performance accompanied with reliable drought tolerance and sufficient variation that offers further responses to upgrading. The validity of obtained inbreds for rolling in maize hybrids programs will be accomplished by assessing the combining abilities as different heterotic groups.

Keywords: Maize, Inbred lines, Watering Regimes, Heterotic groups

INTRODUCTION

Global agricultural production and consequently food security of field crops threatening by drought which is considered one of the major negative effects of climate change Li *et al.*, (2011) and Song *et al.*, (2019). Inbred lines are the key necessary to create new combination of hybrids Ullah *et al.*, (2015) and Rahman *et al.*, (2012). Developing maize inbred lines by self-pollination and evaluate hybrid performance is the major technique in maize breeding program. Most breeders used ear to row system and selection for many generations with inbreeding. Some maize programs using development based on evaluation for hybrid performance in the early generations of self-pollination, as test the performance of testcrosses of the S0 plants or S1 lines. The genotypes which recorded above-average hybrid performance in these tests are continued in the selfing and selection in next generations Hallauer *et al.*, (1988 & 2010). Recently, Rafique *et al.* (2019) screened some maize inbred lines to multiple abiotic stress such as drought and reported that the response of various plants of maize exposed to stress combination is based on stress interaction.

Drought stresses affecting differently the performance and productivity of maize inbred lines Istipliler *et al.*, (2016), Gazal *et al.*, (2017) and Rafique *et al.*, (2019). Water stress was significantly reflected in delaying silking, and increased the anthesis-silking interval (ASI), with yield failure according to Magorokosho *et al.*, (2003), Campos *et al.*, (2006), Al-Naggar *et al.*, (2011), Kahiu *et al.*, (2013a & b), Gazal *et al.*, (2017), Darwish *et al.*, (2015) and Mohamed *et al.*, (2019).

Darwish *et al.*, (2015) and Mohamed *et al.*, (2019) found that drought tolerance maize hybrid produced low yield and vice versa. They suggest that intercrossing of lines and hybrids may introduce raw material that possessed variable drought and yield potential combinations for selection new inbred lines. The early selection of *per se* abiotic tolerance coupled with selfing and general combining ability test will be accelerating the program progress.

Thus the present studies planned to explore new promising maize inbred lines from variable gene pool that may be exhibited reliable performance under water deficit conditions. Such new inbred lines from different population's sources with high drought tolerance may possess different heterotic groups to create new recombinations in maize breeding programs.

MATERIALS AND METHODS

The field trials of these investigations were carried out at the Agricultural Experiments and Research Farm of the Faculty of Agriculture, Minia University, El-Minia, Egypt during 2016 to 2019 seasons for developing and evaluating new white maize inbred lines under normal and drought irrigation regimes.

Plant Materials:

Five white maize populations from different backgrounds were used for developing inbred lines that may

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exhibited an elite heterotic groups. Three of these populations (I.280×TWC.310, I.278×G.2 and I.273×TWC.310) were chosen as members of promising group of top crosses across variable moisture stress conditions Darwish *et al*., (2015) and Mohamed *et al*., (2019). Cairo seed is the fourth population which Synthesized by intercrossing the old Cairo 1 variety with a mixture all available Egyptian hybrids in 2006 and maintained by open pollination (Prof Darwish, Agron. Dept., Faculty Agric., Cairo University).The fifth population was the Synthetic variety (Giza 2) kindly provided by, Field Crops Research Institute, ARC.

The open-pollinated seeds of these populations were separately sown during the fall of 2016 under field conditions and about 15 plants of each of these populations were selfed produced S_1 ears. According to the sufficient seeds only ten S_1 of each of the five populations were considered for further evaluations and developing S_2 and S_3 lines. The S_1, S_2 and S_3 were descended via single selfed ears. The ten $S_{8\text{-}10}$ inbred lines of drought tolerant material which kindly supported by Maize Section of the ARC and used in previous studies were included in field evaluation experiments. These ARC inbreds included four, four and two lines descended from G.2, Tep. 5 and old open variety A.E. D., respectively.

Experimental Procedures:

Six field Experiments were conducted during 2017, 2018 and 2019 successive summer seasons. In each season, two separate trials were carried out; one was irrigated with 10 days intervals (as normal watering regime) and the second was conducted by irrigation each 20 days (as stressed one). Each watering regime trial included S_1 or S_2 or S_3 along to ARC 10 inbreds during the successive seasons, respectively. The irrigation treatments as normal (N) and stressed (S) were adopted after 2nd irrigation (including Mohyaa irrigation) summed eight and five irrigations, respectively.

First (S_1) and third (S_3) seasons trials was sown as RCBD with two replications, whereas three replications were used in the second season (S_2) experiments. Due to the insufficiency of seeds only 8 S_2 of each population lines plus eight of ARC inbred lines were evaluated in the second season. Each line was represented in each replicate by one ridge with three meters long and 70 cm wide ($2.1m^2$). The seeds were dry planted on 26th, 31st and 18th May in 2017, 2018 and 2019 summer seasons, respectively in one side of the ridge in hills distanced 25 cm. Seedlings were thinned to one plant / hill three weeks after sowing.

During soil preparation, calcium superphosphate fertilizer (15.5% P_2O_5) was added at a rate of 200 kg/feddan. Nitrogen fertilizer was applied at rate of 200 kg/feddan in form of urea (46% N) in two splits at 1st and 2nd irrigation. Weeds were controlled via hoeing three times. All other cultural practices were applied followed recommendations.

Soil Analyses:

The mechanical and chemical analysis of experimental soil conducted in the soil lab of soil Dept., Faculty of Agriculture –El- Minia University, revealed that the soil texture of the experimental site is clay loam. The percentages of clay, silt and sand were 54.7, 35.8 and 9.5, respectively with pH 7.9. Soil samples showed that the wilting points were 13.9%, 12.25 and 12.9% for 2017, 2018 and 2019 seasons, respectively. However, the field capacities were 35.7%, 34.7% and 36.2, in the same order. During the term of investigation, the soil moisture % was determined at three days interval, and the depleted percentages of available soil moistures. Stress watering regimes escaped 3rd, 5th and 7th irrigation which coincided with the period extended from onset flowering to grain filling stages during all seasons. The available soil water declined during this period from about 60 to 90 % in stressed watering regimes trials compared to 55 to 40% in normal one.

The dominated air temperatures and RH at El-Minia location during the 2017, 2018 and 2019 seasons averaged in 10 days intervals are presented in Figs. 1 and 2, respectively. These climatic data were obtained from Mallawi Agricultural climate Station, El-Minia, Egypt.

The dominated degrees of air temperature were somewhat similar among the three seasons during the growing period except in the seedling growth of the 2017 which recorded higher average and maximum degrees than other two seasons. However, RH% showed great variation among the growing periods of the studied seasons. Second season recorded higher RH% in the first 60 days, after that tended to be medium air humidity, whereas first season characterized by medium RH% during 1st two months and higher than other two seasons after that. Dry air could be observed during 2019 season due to lower dominated RH% particularly in grain filling period than other seasons.

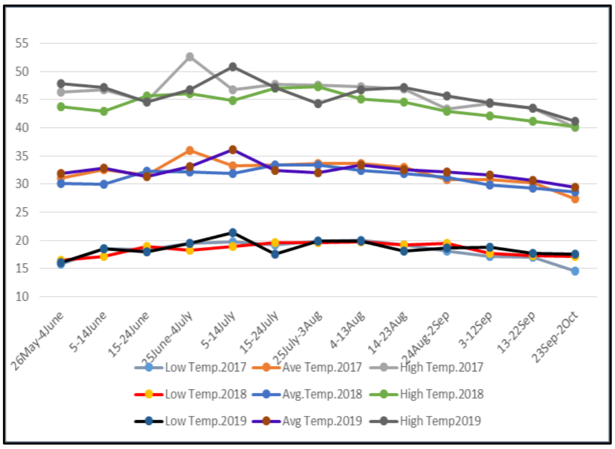

Fig.1. Degrees of temperature (C°) averaged in 10 days intervals during the growing period of field trials in 2017 to 2019 summer seasons at El-Minia location.

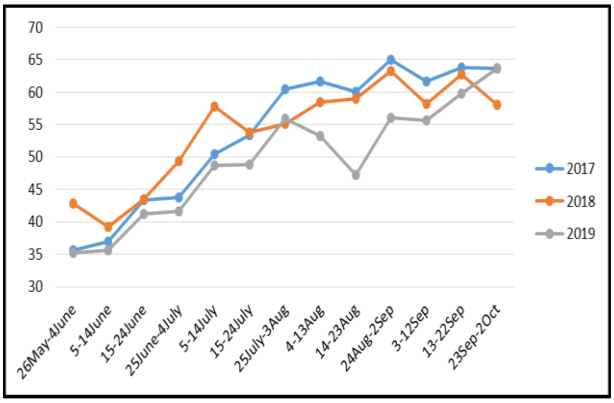

Fig.2. Relative Humidity (RH %) averaged in 10 days intervals during the growing period of field trials in 2017 to 2019 summer seasons at El-Minia location.

The dates of flowering were recorded as the numbers of days to silking of 50% plants (SD) and tasseling (TD) per plot. The difference between these dates was considered as anthesis-silking interval (ASI). 100 Kernel Weight (KI) was recorded and grain yield per plant (GYP) adjusted to15.5% grain moisture.

Stress tolerance index (STI) was calculated according to Fernandez (1992) as the following formula:

$$\mathbf{STI} = \frac{(Yp)(Ys)}{(Yp^{-})2}$$

Where:

Yp = the grain yield of a given genotype in normal regime.
Ys = the yield of a given genotype in a stress regime.
Yp¯ = mean yield in non-stress watering regime.

He pointed out that a genotype of larger value of STI may be considered possesses higher stress tolerance and yield potential (under normal environment).

The analyses of variance of RCBD as separate of each population or all lines as factorial were conducted for the studied traits in each trial during three studied seasons Gomaz and Gomaz (1984). Genotypic and phenotypic coefficients of variations were estimated using the partitions of expected mean square of RCBD of each group of lines in each trial as standard deviation and combined across watering regimes. Broad sense heritability (h^2) and expected gain of advance (GA) of selecting the best 10% of lines was calculated as follows:

$$\mathbf{GA} = \mathbf{K} \times \mathbf{h}^2 \times \sqrt{\delta^2 g}$$

The relative of GA (RGA) to corresponding mean performance was presented expressing the remaining variability among the tested lines.

RESULTS AND DISCUSSION

1-Variation of the three inbred generations combined across watering regimes:

Significance of variances of combined analyses across both watering regimes of all investigated S_1, S_2 and S_3 lines for the studied traits during 2017, 2018 and 2019 seasons are presented in Table (1).

Table 1. Significance of mean squares of combined analyses across both watering regimes of all investigated S_1, S_2 and S_3 lines for studied traits during 2017, 2018 and 2019 seasons.

Trait	Trial	Watering Regimes (W.R)	Lines	Lines x W.R
		1	59 (47)	59 (47)
ASI	S_1	81116.20**	2.35 ns	1.76 ns
	S_2	123752.00**	0.66 ns	0.48 ns
	S_3	67057.08**	1.19**	1.32**
KI	S_1	15242547.29**	121.21**	0.39 ns
	S_2	25849712.11**	69.87**	15.91**
	S_3	19268247.38**	67.55**	10.75**
GYP	S_1	185897183.33**	5129.24**	53.04 ns
	S_2	470067286.27**	4120.69**	492.19**
	S_3	373318720.15**	3212.70**	301.97**

ns, * and ** indicate insignificant, significant at 5% and at 1% levels of probability.

Watering regimes (W.R) are highly significant source of variation in performance of the three studied inbred generations for the three tabulated traits.

Maize inbred lines over W.R varied highly significantly in the three generations for kernerl-100 weight (KI) and grain yield per plant (GYP) and only in S_3 for anthesis silking interval (ASI).

The tested S_2 and S_3 maize lines performed differently from watering regime to another for KI and GYP as evidenced of significant lines × W.R interactions. However, such interaction was only significant in S_3 lines for ASI.

The magnitudes of variances proved that the effects of watering regimes are much huge than those detected by lines or lines × watering regimes interactions for all traits. Inbred lines varied significantly over or across watering regimes for yield attributes and ASI particularly with progress the homozygosis.

2. Variation of S_1, S_2 and S_3 inbred lines within each watering regimes:

Mean squares due to RCBD analysis under each irrigation trial (normal or stressed) for studied traits of 6 populations and the total [60 (48)] evaluated inbred lines are presented in Tables (2 and 3).

Results show that all the investigated lines of the three generations varied highly significantly under both watering trials for K.I, GYP and stress tolerance index (STI). However, for ASI only all S_1 lines varied significantly under non-stressed irrigation (N), but S_3 ones is a highly significant source of variation at both irrigation trials.

As presented in The Material and Methods the tested inbred lines (60 of S_1 and S_3 or 48 of S_2) are descended to six origins and considered as Parental origins (PO) of the inbreds in the analyses of variance which distributed randomly within adjacent plots through field evaluation. Thus the degrees of freedom can be partitioned into populations (PO), lines/PO and PO × L.

PO as a source of variation is only significant for ASI in S_1 under normal and S_3 (under both regimes). However, such source of variation, i.e population varied highly significant for tabulated traits under both irrigation regimes. Lines within populations (L/PO) varied highly significantly for all traits of the three inbred generations under both watering irrigations except ASI in all situations.

The interactions between population × lines (PO × L) are significant for ASI only for S_3 under stress irrigation trial (of 2019). Thus the periods between anthesis and silking dates varied in advanced generations of inbreeding among parental sources. However, PO × L interaction for 100-kernel weight, GYP and stress tolerance index (STI) differed highly significant in both irrigations trials in the three selfing generations. This proved that the evaluated groups of inbred lines (including the ARC inbreds) performed differently for grain yield traits and drought stress tolerance.

Regarding the analyses of RCBD separate of lines belonged to each parental source, revealed highly significant mean squares of all populations under both watering regimes in the three generations for K.I, GYP and STI (except two cases). These cases are S_2 of I.280 ×TWC310 under normal and S_3 for K.I, I.273×TWC310 for K.I. However, for ASI only the lines of S_3 of I.280×TWC310 and those of I.273×TWC310 recorded significant variances under stress and normal conditions, respectively.

Table 2. Significance of mean squares due to factorial and separate RCBD analyses of inbred lines belonged to parental origins (PO) for anthesis- silking intervals (ASI) and 100-kernel wt (K.I) under normal (N) and stressed (S) watering regimes.

S.O.V	d.f	ASI						K.I					
		S_1		S_2		S_3		S_1		S_2		S_3	
		N	S	N	S	N	S	N	S	N	S	N	S
Lines (L)	59 (47)	2.32*	1.78	0.63	0.51	0.71**	1.81**	63.0**	58.61**	49.05**	36.73**	49.94**	28.35**
PO	5	3.55*	1.71	1.32	0.55	2.75*	2.94	69.0**	66.17**	43.54*	62.71**	56.62**	44.24**
L/PO	9 (7)	2.82	1.39	0.59	0.69	0.69	1.76	49.44**	49.73**	63.37**	16.99**	36.31**	41.77**
PO×L	45 (35)	2.09	1.87	0.27	0.23	0.48	1.68*	65.02**	59.55**	23.49**	18.48**	51.93**	23.90**
I.280×TWC310	9 (7)	1.02	1.38	0.33	0.57	0.20	2.61*	66.78**	54.78**	15.65	12.43**	21.70**	9.58**
G.2	9 (7)	2.49	1.49	0.55	0.52	0.27	1.61	31.71**	29.69**	47.93**	37.51**	67.59**	40.91**
I.278×G.2	9 (7)	2.23	2.42	0.71	0.38	0.44	0.72	97.87**	102.95**	48.92**	30.99**	70.37**	32.58**
I.273×TWC310	9 (7)	1.89	2.23	0.95	0.71	1.45**	1.89	34.97**	30.80**	25.29*	11.10**	20.08**	3.64
C.1 Imp.	9 (7)	4.89	2.31	0.29	0.29	0.42	1.36	69.41**	64.05**	36.38**	22.56**	17.60*	14.18**
ARC Inbreds	9 (7)	0.76	0.89	0.47	0.55	0.31	2.02	73.81**	65.23**	124.07**	87.24**	98.65**	60.39**

*** and ** indicate significant at 5% and at 1% levels of probability.**

Table 3. Significance of mean squares due to factorial and separate RCBD analyses of S_1 , S_2 and S_3 lines belonged to parental origins (PO) for grain yield/plant, g (GYP) under normal (N) or stressed (S) and stress tolerance indices (STI) during 2017, 2018 and 2019 seasons.

S.O.V	d.f	GYP						STI		
		S_1		S_2		S_3				
		N	S	N	S	N	S	S_1	S_2	S3
Lines	59 (47)	2774.6**	2407.6**	2860.7**	1752.2**	2044.5**	1470.2**	0.86**	0.36**	0.24**
PO	5	3380.6**	3024.9**	3023.8**	1877.2**	2456.7*	1654.5*	1.08**	0.33**	0.25**
L/PO	9 (7)	4507.4**	3737.8**	1816.9**	702.1**	1499.6**	1173.9**	1.38**	0.14**	0.16**
PO × L	45 (35)	2360.8**	2073.0**	1523.1**	972.2**	2107.7**	1509.0**	0.73**	0.21**	0.26**
I.280×TWC.310	9 (7)	2676.3**	2397.7**	1372.0**	885.2**	1374.4**	866.0**	0.72**	0.13**	0.11**
G.2	9 (7)	4185.4**	3617.9**	3189.1**	1573.2**	1989.8**	1207.2**	1.33**	0.30**	0.20**
I.278×G.2	9 (7)	3472.0**	3378.0**	2947.0**	1349.6**	2851.7**	13.71.4**	1.18**	0.28**	0.25**
I.273×TWC.310	9 (7)	793.6**	553.4**	3478.8**	1932.5**	1982.2**	1427.9**	0.11**	0.57**	0.34**
C.1 Imp.	9 (7)	1340.7**	1337.7**	1014.9**	670.4**	774.9*	682.0**	0.53**	0.10**	0.08**
ARC Inbreds	9 (7)	3843.2**	2818.2**	5046.0**	4012.9**	30.64.8**	3164.3**	1.17**	0.82**	0.49**

*** and ** indicate significant at 5% and at 1% levels of probability.**

3. Mean performance and expected gain of advance:

The mean performance of S_1, S_2 and S_3 under normal (N) and stressed (S) watering regimes and the ratio of change (N-S/N) due to stress as well as the expected gain of advance relative to corresponding mean of during 2017 to 2019 seasons over parental populations and across each are presented in Tables (4 to 8).

Table 4. Mean performance of S_1, S_2 and S_3 under normal (N) and stressed (S) watering regimes and the ratio of change (N-S/N) as well as the relative expected gain of advance (RGA) to corresponding mean for studied traits.

Trait	Regime	Mean			RGA		
		S_1	S_2	S_3	S_1	S_2	S_3
ASI	N	2.4	2.5	2.2	0.315	0.000	0.217
	S	2.6	2.8	2.8	0.000	0.000	0.269
	(N-S)/N	-0.069*	-0.136*	-0.282*	----	----	----
KI	N	32.7	35.4	36.7	0.194	0.121	0.149
	S	30.4	31.5	31.8	0.201	0.123	0.130
	(N-S)/N	0.070*	0.110*	0.134*	----	----	----
GYP	N	114.1	151.1	161.7	0.376	0.231	0.216
	S	101,0	132.0	141.0	0.389	0.205	0.211
	(N-S)/N	0.115*	0.127*	0.128*	----	----	----
	STI	1.47	0.88	1.35	0.763	0.438	0.429

***indicates significant difference between mean of normal and stress conditions.**

The anthesis-silking intervals (ASI) over parental origins (PO) are significantly increased in stress watering regimes in the three inbred generations, with relative doubled increments doubled from 7% to 14% and to 28% in S_1, S_2 and S_3, respectively. The relative expected gain of advance (RGA) due selecting the best 10% are notable of S_1 under normal irrigation regime and in S_3 under both regimes (Table 4). Concerning the changes in ASI due to stress of studied six PO groups, it's obvious that one, two and two PO groups recorded significantly wider ASI intervals of S_1, S_2 and S_3, respectively (Table 5). The first case of significant ASI change is obvious in S_2 of C.1 which reach to 22.7% with insignificant 14.5% wider in ASI in the following inbred generation (S_3).The second group are ARC lines which recorded 56.3% and 57.1% significant increase in ASI during 2017 and 2019 seasons (evaluated with extracted S_1 and S_3), respectively. The third group comprises S_2 and S_3 of I.280×TWC.310 recorded 21.7 and 93.8% significant increase of ASI due to stress conditions over corresponding normal regime, respectively. It's worthy to mention that is desirable to detect and select inbreds which exhibited insignificant increase of ASI under the drought stress conditions which is reported by several authors (Magorokosho *et al.,* (2003), Campos *et al.,* (2006), Al-Naggar *et al.*, (2011), Kahiu *et al*., (2013a & b), Gazal *et al*., (2017), Darwish *et al*., (2015) and Mohamed *et al*., (2019)). In this regard, four groups of developed S_3 inbreds include 40 lines (out of developed 50 inbreds) seem to be desired for inclusion in maize hybrids program for drought conditions due to not affected ASI by escaping irrigation in flowing stage (Table 5).

In spite of lacking RGA for improving ASI in S_1 under (stress) and in S_2 (under both conditions) over PO (Table 4), variable RGA could be observed in S_1 and S_3 of studied origins (Table 5). Remarkable RGA was recorded in S_3 under stress conditions of all groups of inbreds except those descended from I.278xG.2. Moreover, the inbred lines of G.2 and ARC used in 2017 are expected to respond for selecting to ASI under normal irrigation in contrast to I.280×TWC.310, G.2 and ARC lines evaluated during 2019 under drought stress W.R (Table 5). Thus it may be concluded that selection for improving ASI particularly under stress watering regime may be effective in the inbred lines of particularly those not affected by drought, i.e G.2, I.273xTWC.310 and C.1.

The stressed watering regimes significantly decreased the 100-kernel weight (K.I) over POs by about 7, 11 and 13.4% in S_1, S_2 and S_3, respectively (Table 4). The higher the reduction (13.4%) occurred in the advanced selfing generation than those of S_1 and S_2 indicate that escaping irrigation during flowering and grain filling synchronized the detrimental effects in maize grain weight which reached to about 14% reduction . Trials of 2017 included the S_1's of extracted five groups of inbred lines and those of ARC recoded significantly about 7.0% reductions for KI. The S_2 and S_3 showed somewhat significantly higher percentages of K.I reduction in all groups of inbreds except those of C.1 and ARC. The relative expected gain of selecting the 10% of evaluated S_1 inbred lines either under normal or stressed watering regimes was about 30% of four POs than those of G.2 and I.273×TWC 310 which are about 20% (Table 6). The RGA for KI of S_2 ranged from lower (about 10% in the lines of I.280xTWC.310 and I.273x TWC.310), medium (by about 20% of G.2, I.278xG.2 and C.1) and higher RGA of ARC inbred lines (more than 30%) under both conditions. Similar RGA of S_2 could be observed by S_3 inbred lines except those of C.1 moved to lower group with 10% (Table 6).

The studied inbred generations (S_1, S_2 and S_3) showed significantly similar ratios of depression in grain yield per plant (GYP) due to stressed watering regimes by about 12% (Table 4). All the groups of inbred lines of the three generations recorded significantly about 8-14% ratios of GYP depression due to drought except S_2 and S_3 inbreds of G.2 which exhibited higher ratio of GYP depression (≈ 19%) than other groups, (Table 7). The RGA in the S_1's over PO was higher (about 38%) than those of S_2 and S_3 (about 20%) under both adopted watering regimes, (Table 4). The S_1 lines of I.280×TWC.310, G.2 and I.278×G.2 recorded higher RGA (about more than 60 %) than those of ARC inbreds (about 50%) under both conditions, (Table 7).

However, S_1 lines of I.273 x TWC.310 and C.1 exhibited medium RGA (ranged 35-42%) under both watering regimes. Such RGA's in GYP of S_2 and S_3 were slightly lower than those obtained by S_1 lines except of ARC lines under both conditions. In spite of this slight reduction of available genetic variation expressed as relative expected gain of selecting the best yielded 10% of evaluated lines, there is remained encouraging variation for further improvement using S_3 either under normal watering regimes or stressed one.

The estimates of stress tolerance index (STI) in S_1 and S_3 over POs was higher (1.47 and 1.35) than this obtained by S_2 (0.88), whereas the RGA of this index was higher in S_1 (76.3%) than those calculated by S_2 and S_3 (≈ 43%), (Table 4). Variable means and RGA of STI were obtained by different groups of inbreds and generations (Table 8). This may be due to that the obtained estimates of STI are greatly affected by environmental conditions and the level yield performance included in the equation.

The evaluated groups of inbred lines (including those of ARC) introduce encouraging opportunity to select proper inbreds from different origins or combinations. Similar findings of obtaining useful variation of maize inbred lines were obtained by different groups of researchers (Gazal *et al*., (2017, Magorokosho *et al.* (2003), Campos *et al.* (2006), Ullah *et al.*, (2015), Kahiu *et al.* (2013a & b)). The usefulness of such inbreds which possessing promising attributes in producing promising drought tolerant hybrids could be accomplished by assessing combining abilities (Rahman *et al*,. (2012), Darwish *et al*. (2015), Mohamed *et al.* (2019)). Such procedure of searching and developing maize inbred lines from different sources and combinations resulted in desirable *per se* attributes which could be required for improving specific characters of maize hybrids. The upgrading the yield potential of these hybrids could be guaranteed by assessing the combining abilities of trait/s specific inbred lines from different heterotic groups.

Table 5. Mean performance of populations under normal (N) and stressed (S) watering regimes and the ratio of change (N-S/N) as well as the relative expected gain of advance under each condition (RGAN & RGAS) of S_1, S_2 and S_3 lines for anthesis-silking interval (ASI).

Population	S_1					S_2					S_3				
	N	S	(N-S)/N	RGAN	RGAS	N	S	(N-S)/N	RGAN	RGAS	N	S	(N-S)/N	RGAN	RGAS
I.280×TWC.310	2.2	2.5ns	-0.136	0.000	0.000	2.3	2.8*	-0.217	0.000	0.000	1.6	3.1*	-0.938	0.000	0.363
Giza 2	2.6	3.1ns	-0.192	0.291	0.000	2.4	2.7ns	-0.129	0.000	0.000	2.1	2.5ns	-0.190	0.017	0.169
I.278×G.2	2.7	2.6ns	0.037	0.015	0.000	2.4	2.8ns	-0.167	0.000	0.000	2.5	2.6ns	-0.040	0.000	0.000
I.273×TWC 310	2.7	2.2ns	0.185	0.000	0.075	2.7	2.7ns	0.000	0.000	0.000	2.7	2.9ns	-0.074	0.416	0.264
C.1 Improved	2.7	2.6ns	0.037	0.559	0.383	2.2	2.7*	-0.227	0.000	0.000	2.1	2.3ns	-0.095	0.145	0.078
ARC inbreds	1.6	2.5*	-0.563	0.197	0.000	2.8	3.1ns	-0.107	0.000	0.000	2.1	3.3*	-0.571	0.000	0.263

ns and * indicate insignificant and significant at 5% of differences between both couples of each population.

Table 6. Mean performance of populations under normal (N) and stressed (S) watering regimes and the ratio of change (N-S/N) as well as the relative expected gain advance (RGA) under each condition of S_1, S_2 and S_3 lines for 100-kernel weight (KI).

Population	S_1					S_2					S_3				
	N	S	(N-S) /N	RGAN	RGAS	N	S	(N-S) /N	RGAN	RGAS	N	S	(N-S) /N	RGAN	RGAS
I.280×TWC.310	31.5	29.5*	0.063	0.298	0.284	33.9	28.6*	0.156	0.055	0.117	34.0	28.8*	0.153	0.135	0.106
Giza 2	33.9	31.8*	0.062	0.167	0.173	36.4	32.4*	0.110	0.164	0.211	38.4	32.4*	0.156	0.235	0.221
I.278×G.2	35.7	33.1*	0.073	0.328	0.364	37.3	32.7*	0.123	0.205	0.178	38.2	32.3*	0.155	0.231	0.183
I.273×TWC 310	31.2	28.7*	0.080	0.191	0.201	35.8	30.9*	0.137	0.110	0.102	37.3	32.7*	0.123	0.103	0.006
C.1 Improved	31.0	28.6*	0.077	0.316	0.334	34.0	31.8*	0.065	0.174	0.152	35.5	32.1*	0.096	0.091	0.110
ARC inbreds	32.8	30.7*	0.064	0.309	0.310	35.1	32.8*	0.066	0.345	0.334	36.9	32.6*	0.117	0.292	0.273

ns and * indicate insignificant and significant at 5% of differences between both couples of each population.

Table 7. Mean performance of populations under normal (N) and stressed (S) watering regimes and the ratio of change (N-S/N) as well as the relative expected gain advance under each conditions (RGA) of S_1, S_2 and S_3 lines for grain yield per plant (GYP).

Population	S_1					S_2					S_3				
	N	S	(N-S) /N	RGAN	RGAS	N	S	(N-S) /N	RGAN	RGAS	N	S	(N-S) /N	RGAN	RGAS
I.280×TWC.310	108.1	94.5*	0.126	0.584	0.631	136.0	118.8*	0.125	0.286	0.262	147.0	127.1*	0.137	0.243	0.247
Giza 2	122.7	108.9*	0.112	0.646	0.675	162.0	129.8*	0.197	0.421	0.362	174.0	141.4*	0.188	0.293	0.280
I.278×G.2	116.5	106.8*	0.083	0.618	0.663	164.0	142.2*	0.130	0.383	0.266	166.0	144.7*	0.128	0.347	0.261
I.273×TWC 310	92.0	79.0*	0.141	0.375	0.353	156.0	141.1*	0.094	0.447	0.361	173.0	154.9*	0.105	0.297	0.286
C.1 Improved	115.6	104.9*	0.093	0.383	0.420	141.0	127.2*	0.099	0.252	0.201	153.0	137.4*	0.101	0.162	0.201
ARC inbreds	129.6	112.0*	0.136	0.585	0.480	149.0	132.6*	0.108	0.553	0.559	157.0	140.3*	0.105	0.371	0.424

ns and * indicate insignificant and significant at 5% of differences between both couples of each population or mean.

Table 8. Mean performance of populations of S_1, S_2 and S_3 lines belonged to the studied populations for calculated stress tolerance indices (STI) and expected gain advance relative (RGA) to corresponding mean of during 2017 to 2019 seasons.

Population	S_1			S_2			S_3		
	Mean	GA	RGA	Mean	GA	RGA	Mean	GA	RGA
I.280×TWC.310	1.30	1.02	0.786	0.70	0.40	0.565	1.10	0.36	0.323
Giza 2	1.70	1.41	0.828	0.90	0.64	0.716	1.40	0.51	0.366
I.278×G.2	1.60	1.33	0.828	1.00	0.59	0.586	1.40	0.55	0.390
I.273×TWC 310	0.90	0.36	0.396	1.00	0.91	0.909	1.60	0.69	0.431
C.1 Improved	1.50	0.88	0.584	0.80	0.33	0.418	1.20	0.29	0.239
ARC inbreds	1.80	1.20	0.669	0.90	1.06	1.177	1.40	0.74	0.526

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أداء وتباين من سلالات الذرة الشامية البيضاء مستنبطة من مصادر مختلفة للمحصول وتحمل الجفاف

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تم استنباط وتطوير خمسين سلالة من سلالات الذرة الشامية البيضاء في أجيال التربية الذاتية الأولي والثانية والثالثة، من خمس عشائر متباينة مفتوحة التلقيح وذلك بهدف الوصول الى سلالات جديدة ذات تحمل للجفاف وتميزاً فى الأداء وأن تمثل مجموعات هجينيه مختلفة يمكن أن تكون ذات فائدة لبرامج تحسين هجن الذرة الشامية. ولقد تم تقييم كل جيل من سلالات الأجيال الثلاثة بالإضافة الي عشر سلالات من مركز البحوث الزراعية متحملة للجفاف (في جيل التربية الداخلية ٨-١٠) تحت ظروف الري العادي (كل ١٠ ايام) وظروف الإجهاد الجفافى (الري كل ٢٠ يوم) خلال مواسم ٢٠١٧، ٢٠١٨ و ٢٠١٩ علي التوالي. في كل موسم تم تنفيذ تجربتين منفصلتين لنظامى الرى .تم دراسة صفات الفترة بين انتثار اللقاح وطرد الحريرة، دليل وزن الحبوب (وزن الـ ١٠٠ حبة) و محصول النبات و دليل تحمل الجفاف. أظهرالتحليل الاحصائى المتجمع لبيانات كل موسم (جيل تربية داخلية) أن نظامى الرى خلال كل موسم من الثلاث مواسم كانا ذو تاثيراً على المعنوية على كل من الفترة بين انتثار اللقاح وطرد الحريرة ودليل وزن الحبوب ومحصول النبات. كان تباين السلالات سواء فوق أو من خلال نظامى الرى معنوياً لصفات وزن الحبوب النوعى و المحصول ، الا أن صفة الفترة بين اللقاح والحريرة الا بتقدم أجيال التربية الداخلية. كانت قيمة التباينات الراجعة لأنظمة الري عظيمة القيمة مقارنة بتلك الراجعة للسلالات او بالتفاعل بين السلالات وانظمة الري لكل الصفات. كان تأثير المجموعات الأبوية معنوياً على أداء الفترة بين اللقاح و الحريرة لسلالات الجيل الأول فى تجربة الرى العادى، بينما كان معنوياً على تلك الصفة فى تجربتى الرى ، فى حين كان تأثير الاصول الأبوية عالى المعنوية على أداء كل جيل من الثلاث أجيال على صفات وزن الـ ١٠٠ حبة ومحصول النبات ودليل تحمل الجفاف. ولقد كان تباين السلالات فى المجموعات الأبوية عالى المعنوية لكل صفات كل جيل من الثلاث أجيال فى تجربتى الرى فيما عدا صفة الفترة بين اللقاح و ظهور الحريرة. بينما كان ذلك التأثير للسلالات معنوياً على صفة الفترة بين انتثار اللقاح و الحريرة فى الجيل الاول مع تجربة الري العادي فقط بينما كان تأثير سلالات الجيل الثالث عالى معنوياً فى كلا تجربتي الرى. كان التفاعل بين الاصول الأبوية والسلالات معنوياً لصفة الفترة بين اللقاح والحريرة فقط للجيل الثالث تحت ظروف الاجهاد في حين اختلف معنوياً تحت كلا تجربتى الري لكل الصفات المدروسة للأجيال الثلاثة.اظهرت اربعة مجاميع من الخمسة التي تم استنباطها في الجيل الثالث أداءاً مرغوب للنمو تحت ظروف الجفاف نتيجة لعدم وجود فروق معنوية بين الفترة بين اللقاح والحريرة تحت ظروف الجفاف ونظيرتها تحت ظروف الري العادي. كما أن حسابات قيم التحسين المتوقع بالإنتخاب فى سلالات الجيل الثالث لصفة الفترة بين انتثار اللقاح و ظهور الحريرة تحت ظروف الاجهاد كنسبة مئوية من المتوسط المناظر أظهرت قيماً ملحوظة مشجعة لكل مجاميع السلالات فيما تلك المنحدرة من العشيرة I.278×G.2 . أظهرت سلالات الجيل الثاني والثالث تدهوراً معنوي في وزن الـ ١٠٠ حبة نتيجة الإجهاد المائي فيما عدا مجموعة سلالات كل من العشيرة القاهرة ١ وسلالات مركز البحوث الزراعية. كانت قيم التحسين النسبى المتوقع لوزن المائة حبة فى سلالات الجيل الاول تحت ظروف الري العادي والاجهاد حوالي ٣٠% فى اربع عشائر أعلى من ذلك المقدر فى سلالات العشيرتين الباقيتين (جيزة ٢ و I.273×TWC310) والذى يبلغ حوالى ٢٠%.بالنسبة لتقدير لمقدار التحسين النسبى المتوقع لإنتخاب أفضل ١٠% من سلالات الجيل الثاني والثالث لوزن الحبوب النوعى فلقد أختلفت بين مجموعات السلالات الأبوبة مما يبرهن على إمتلاكهم لقيم مختلفة من التباينات الوراثية بين السلالات المستنبطة من كل منهما. سجلت مجاميع السلالات في أجيال التربية الداخلية الثلاث نسب معنوية من تدهور محصول الحبوب (٨-١٤%) نتيجة للإجهاد فيما عدا سلالات الجيل الثاني والثالث للعشيرة جيزة ٢ والتي سجلت نسب أعلى (حوالي ١٩%) من تدهور كل المجاميع الأبوية الاخرى. أما فيما يخص قيم التقدم النسبى المتوقع لتحسين صفة محصول حبوب النبات بالإنتخاب لسلالات الجيل الاول للعشائر كانت الأعلى (٣٨%) من تلك المتحصل عليها عن كل من الجيلين الثاني والثالث (حوالي ٢٠%) فى تجربتى الرى المستخدمة. كانت قيم دليل تحمل الجفاف لكل من سلالات الجيل الاول والثالث (١,٤٧ و ١,٣٥) أعلى من تلك المحسوبة لسلالات الجيل الثاني (٠,٨٨). بينما كان قيم التحسين المتوقع النسبى لأدلة تحمل الجفاف لسلالات الجيل الاول (٧٦,٣%) هى الأعلى من نظيرتها المقدرة لكل من سلالات الجيلين الثانى و الثالث (حوالي ٤٣%).لقد أظهرت سلالات الذرة الشامية فى الدراسة الحالية المستنبطة من مصادر وتوافيق مختلفة أداءا مرغوباً وتحملًا معتبراً للجفاف مصحوبا بذلك بتباينات كافية تساعد على تحسين خصائص و صفات تلك السلالات كمجاميع هجينية و الذى يمكن التحقق منه من خلال تقييم قدرتهم الائتلافية لتحسين هجن الذرة الشامية.