EVALUATION OF SOME GRAIN SORGHUM GENOTYPES UNDER DROUGHT ENVIRONMENTS

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ABSTRACT

Drought adversely affects growth and yield of crops to various extents. Growing of drought tolerant crops is a good option. For this reason, a field experiment was conducted to evaluate forty grain sorghum hybrids, their parental lines and Shandaweel) as check hybrid under normal and drought conditions (100 and 50% of evapotranspiration (ET)) at Shandaweel Agric. Res. Stat. in 2019 and 2020 growing seasons. The combined analysis of variance over the two environments was done in 2019 and 2020.

The results showed that significant differences were existed among the tow irrigation treatments, genotypes (parents and their F_1, s hybrid) for all studied traits, revealing a large amount of variability among them. Significance of parent vs. crosses indicated the presence of heterotic effects that were highly significant for all the studied traits. Drought susceptibility index indicated that there were nine hybrids were the best drought tolerant ones (ATXTSC-20 x 86 EO-361, ATXTSC-20 x RTX-2817, ICSA-37 x 86 EO-361, ICSA-37 x TAM-428, ICSA-37 x RTX-2817, ICSA-37 x RTX-2895, ATX-407 x TAM-428, ATX-407 x RTX-2817 and ATX-BON-44x RTX-2817). The best drought tolerant parental lines were ATXTSC-20, ICSA-37, TAM-428, RTX-5646, RTX-2817 and ICSR-2908. The best general combiners for grain yield per plant ATXTSC-20 and ICSA-37 the female lines and the 86EO-361 and RTX-2809 male lines showed positive and significant general comping ability (GCA) effects under normal and

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

drought conditions. The best SCA hybrids were nine crosses for grain yield per plant out of four forty hybrids that showed positive and significant SCA effects under drought conditions. Heterosis related to the better parents showed that the best hybrids under drought conditions were nine crosses for grain yield and some of the other studied traits.

Key words: Grain sorghum, Heterosis, Combining ability, Drought Susceptibility index, Drought tolerance.

INTRODUCTION

Grain sorghum (*Sorghum bicolor* L. Moench) is one of the most important cereals in the world as well as in Egypt. Widely grown throughout the world for food, feed and fodder. It is fifth major cereal crop of world following wheat, rice, maize and barley in terms of production and utilization. In Egypt, grain sorghum is the fourth cereal crop ranking after wheat, maize and rice. In 2014 season (Economic affairs sector 2020), the cultivated area of grain sorghum in Egypt was about 353,346 feddan (148,456 ha), producing about 804,000 tons with an average productivity of 16.25 ardab/fed (5.42 ton/ha). Egypt is ranked the first among all grain sorghum producers in the world for average productivity per unit area, followed by China and Argentina, according to FAOSTAT (2017). In Upper Egypt, grain sorghum is a major summer crop concentrated in Assiut and Sohag governorates.

Grain sorghum is mainly consumed for making bread in Upper Egypt, for feeding livestock and poultry and for green fodder and silage. Sorghum grain has a high nutritive value, with 7080% carbohydrate, 11-13% protein, 2-5% fat, 1-3% fiber, and 1-2% ash. Protein in sorghum grain is gluten free and, thus, it is a specialty food for people who suffer from celiac disease (intolerant to food with gluten).

Drought is a serious problem which causes crop yield loss. This problem may be alleviated by developing new cultivars or hybrids tolerant to drought and adapted to dry environments such as the new reclaimed soils. Sorghum is one of the most drought tolerant cereals, due to its dense and deep root system, leaf stay-green, ability to reduce transpiration through leaf curl, stomatal closure and reduced metabolic (Xu *et al.*, 2000).

Even if the mechanisms that confer sorghum tolerance to drought are known, the understanding of how the plant, in different stages of its growth, reacts to factors limiting its development becomes necessary. The use of this information aims to allow the expansion of sorghum cultivation, especially in regions with greater problems of drought.

Sorghum ability to survive and tolerate water stress condition make it the most promising crop for improving water use efficiency among other cereal crops. It is decisive to develop and adapt new technologies to expose variability among sorghum genotypes for stress resistance and to identify the best genotypes, which can increase the water use efficiency under environments of low water supply. Improving an expanding breeding programs for increased water use efficiency in grain sorghum is critical in order to utilize Egypt`s water resources more efficiently.

The discovery of cytoplasmic male sterile lines in sorghum facilitates the production of hybrids in grain sorghum. The use of adapted cytoplasmic male sterile lines which had good combining ability in the economic production of grain sorghum hybrids may be limited because of bad necking, low seed set in the cytoplasmic male sterile lines. Mahdy *et al.*, (2010) found that most of hybrids were significantly earlier, taller, heavier in grain weight and higher in grain yield compared to their parents and checks. Thakare *et al.*, (2014) stated that the line ICS-516A and testers ICSR-44347, AKR-456 were found to be good general combiners for yield contributing traits. The F1 s ICS-40A x ICSR-44347 (5.990), ICS-516 A x ICSR- 44347 (5.196) and ICS-516A x AKR-456 (5.378) were identified with high significant and positive SCA for grain yield. Tafere *et al.*, (2020) results obtained from the analysis positive and significant GCA values among the female lines were recorded by ICSV96143, ICSR93034, IESV92168-DC and ETSL101565. Likewise, tester TX623A were identified as most promising parents having good general combining ability for grain yield and almost all its major yield components. Similarly, for grain yield, 15 hybrid combinations had significant advantage over their respective standard check Melkam.EL-Sherbeny (2019).The best top crosses were (L5 x T3) and (L3 x T3) which significantly out yielded the crosses means, were also tolerant to drought (low DSI). In this respect, one top cross was the most promising hybrid with the maximum desirable heterotic values of 7 traits out of 8 over mid and better parents. Qadir *et al.*,

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

(2015), Erin *et al.*, (2016) and Chikuta *et al.* (2017) stated that the F1 hybrids under normal and drought environments showed range of heterosis with negative and positive values which indicated the potential for developing hybrids superior to their mid and better parent for earliness, plant height, No. of green leaves, leaf area/plant, panicle length, panicle width, 1000 grain weight and grain yield.

Accordingly, the current study aimed to: 1) Develop new grain sorghum hybrids to tolerant the drought conditions that prevalent in tropical areas and the new reclaimed soils where water defect denominates. 2) Estimate general and specific combining objectives to identify the best parental lines that could be used in breeding programs for drought tolerance and the best hybrids.

MATERIALS AND METHODS

The Field experiments were carried out at Shandaweel Station of the Agric. Res. Cent. (ARC) in 2019 and 2020 seasons.

Five cytoplasmic male sterile lines (A-lines) of grain sorghum and Eight restorer lines (R-lines) the origin of the four (A-lines) and the six (R-lines) of grain sorghum are shown in Table (1) were chosen to produce forty crosses (using line x tester analysis) at 2018 season.

The parental lines, their respective forty hybrids and the check hybrid Shandaweel-6 were evaluated in the field under normal and drought conditions (100% and 50% evapotranspiration (ET)) in two separate experiments at Shandaweel Research Station during 2019 and 2020 growing seasons.

Table (1): The origin of restorer (R-lines) and male sterile lines (A-lines) used in the study

NO.	Line	Origin
	R-lines	
R1	82BDM-499	ICRISAT
R2	86RO-361	,,
R3	TAM428	,,
R4	88V1080	,,
R5	RTX-2817	,,
R6	RTX-2895	Texas U.S.A
R7	RTX-2908	,,
R8	RTX-5646	,,
	A-lines	
A1	ICSA-37	ICRISAT
A2	ATXTSC-20	Texas U.S.A
A3	ATXBON44	,,
A4	ATX-407	,,
A5	ATX-631	,,

Each experiment was conducted in a randomized complete block design with three replications to study the effect of drought stress on growth, yield and yield components. The amount of irrigation water was added every 15 days for the two experiments (100 and 50% ET). The quantity of water applied was calculated according to the modified Penman equation for estimating evapotranspiration as described by Allen *et al.* (1998) and illustrated in Table (2).

$$ET_p = \frac{\Delta}{\Delta + r} Rn + \frac{r}{\Delta + r} Ea$$

Where, Rn is net radiation (energy balance term) for a surface under investigations,

Δ = Slope of the saturation vapour pressure curve at mean air temperature T.

r = the psychometric constant, and taken as 0.49

$$Rn = R_A (1-r) (0.18 + 0.55 \frac{n}{N}) - \sigma\, T_a^4 (0.56 - 0.092 \sqrt{ed} \times (0.10 + 0.90 \frac{n}{N})$$

Where, R_A = mean extra terrestrial radiation mm H_2O/day

r = albedo

n = actual duration of bright sunshine

N = maximum possible duration of bright sunshine

σ = Boltzmann constant, 2.01×10^{-9} mm H_2O/day

T_a^4 = Theoretical black body radiation of mean air temperature

Ea is the aerodynamic term calculated from the basic pattern of the transfer approach.

The aerodynamic component Ea of Penman's equation is defined by the relationship:

$$Ea = 0.35 (e_a - e_d) (1 + 0.0098\, U_2)$$

Where, e_d = Saturation vapour pressure at mean dew point (i.e. actual vapour in the air).

e_a = Saturation vapour pressure at mean air temperature.

U_2 = mean wind speed at 2 meters above the ground in miles/day.

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

Table (2): Amount of irrigation water (m^3) applied for each irrigation treatment based on ET for the 2019 and 2020 seasons

Irrigation	Treatment			
	100% ET		50% ET	
	2019	2020	2019	2020
Sowing irrig.	400	400	400	400
Mohayah	315	315	315	315
3	292.7	312.1	146.4	156.1
4	322.1	345.6	161.1	172.8
5	387.2	403.4	193.6	201.7
6	314.9	367.5	157.5	183.8
7	283.9	307.5	142	153.8
Total	2315.9	2451.1	1515.6	1583.2

The common agricultural practices of growing grain sorghum were properly applied as commended in the district. Days to a 50% heading, plant height (cm) leaf area / plant (cm^2), no. of green leaves and grain yield / plant (g) traits were recorded on a sample of 10 guarded plants in the middle row of each plot. The genetic analysis was conducted by using line x tester analysis according to Steel and Torrie (1980). Homogeneity test for the two seasons data was carried out and consequently combined analysis was performed. General and specific combining abilities were estimated according to Singh and Chaudhary (1985). Hetrosis for check and better parent was estimated according to Bhatt (1971).

The drought susceptibility index (DSI) was used to characterize the relative stress tolerance of all genotypes. The drought susceptibility index was

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

calculated only for grain yield per plant using a generalized formula according to Fischer and Maurer (1978) as follows:

DSI = (1 – Yd/ Yp) / D, where

DSI = An index of drought susceptibility.

Yd = performance of a genotypes under drought stress.

Yp = performance of the same genotype under normal irrigation.

D = Drought intensity = 1-[(mean Yd of all genotypes) / (mean Yp of all genotypes)]. Low drought susceptibility index (DSI □ 1) is synonymous with a high stress tolerance.

RESULTS AND DISCUSSION

Analysis of variance: A combined analysis of variance was conducted to determine the importance of irrigation treatments, genotypes and their interaction effects. The results of combined analysis of variance over two environments in 2019 and 2020 seasons are presented in Table (3 and 4). The results showed that the significant differences existed among irrigation treatments and genotypes (parents and their $F_{1,\ s}$) for all studied traits revealing a large amount of variability among them. The significance of parent vs. crosses indicates interaction value the presence of heterotic effect that were highly significant for all the studied traits. The interaction values of genotypes x irrigation treatments (G x I), parents x irrigation treatments (P x I) and crosses x irrigation treatments (C x I) were significant for all the studied traits. This result reflected that the performance of varied genotypes

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

varies with different drought environments. These results were in a line with those of EL-Sherbeny (2019). Parents vs. crosses x irrigation treatments (P vs. C x E) interaction values were highly significant for plant height and grain yield/plant traits at 2019 season and for all the studied traits except for no. of green leaves trait at 2020 season, suggested that average heterosis values were varied with drought condition environment. Females x irrigation treatments (F x I) interaction was significant for all studied traits and for all studied traits except no. of green leaves trait in 2019 and 2020 seasons respectively, indicating that the females differently behaved in their respective crosses within the different environments. While males x irrigation treatments (M x I) interaction value was significant for all studied traits in 2019 season, and for all studied traits except no. of green leaves trait at 2020 season suggested that the crosses between females and males were differed from environment to another. Mean squares of the 40 crosses were partitioned into males, females and male x female components. Mean squares of males and females general combining ability (GCA) effects were significant for all studied traits. The five females significantly differed in all traits except days to a 50 % heading and a No. of green leaves trait in 2020 season. Moreover, female x male interactions values were highly significant for all studied traits, indicated that female were differed in their order performance in their crosses with each male.

Table (3): Mean squares estimates from combined analysis of variance for all studied traits of fifty-four grain sorghum hybrids and their thirteen parental lines under two of irrigation treatments at 2019 and 2020 seasons

Source of Variance	d.f	Days 50% heading	Plant height	No. of green leaves	Grain yield / plant
Irrigation (I)	1	570.68**	55895.14**	236.09**	31250.4**
Replicates	4	1.91	32.6	0.88	3.18
Genotype (G)	52	4.00**	1579.08**	7.27**	671.1**
Parent (P)	12	3.38**	235.01**	6.06**	307.56**
Crosses (C.)	39	2.53**	51.74**	3.86**	321.44**
P Vs. C	1	68.88**	77274.08**	154.84**	18670.46**
Female (F)	4	2.34	112.14**	1.53	492.96**
Male (M)	7	5.08**	37.73*	10.87**	528.64**
F. M	28	1.92*	46.61**	2.45**	528.64**
G. I	52	3.70**	78.66**	1.58**	245.13**
P. I	12	4.77**	62.34**	1.85*	22.96**
C. I	39	3.41**	62.23**	1.5**	60.28**
P Vs. C. I	1	2.24	915.21**	1.44	1477.61**
F. I	4	4.69*	333.83**	0.95	203.12**
M. I	7	5.38**	45.64*	2.1*	112.33**
F. M. I	28	2.74**	27.57*	1.43*	26.87**
Error	208	1.16	17.20	0.88	4.23

*, ** indicate Significant at 0.05 and 0.01 probability levels, respectively.

Table (4): Mean squares estimates from combined analysis of variance for all studied traits of fifty-four grain sorghum hybrids and their thirteen parental lines under two of irrigation treatments at 2019 and 2020 seasons

Source of Variance	d.f	Days 50% heading	Plant height	No. of green leaves	Grain yield / plant
Irrigation (I)	1	751.95**	45888.05**	343.3**	26450.19**
Replicates	4	2.57	21.31	0.85	4.77
Genotype	52	7.51**	1692.22**	9.77**	818.41**
Parent (P)	12	9.12**	287.41**	3.1**	467.29**
Crosses (C.)	39	4.46**	119.02**	5.05**	453.43**
P Vs. C	1	107.08**	79904.71**	274.02**	19266.19**
Female (F)	4	5.79**	376.95**	4.88**	1311.74**
Male (M)	7	3.87*	131.87**	8.47**	1042.12**
F. M	28	4.42**	78.97**	4.22**	183.64**
G. I	52	5.18**	117.45**	1.48*	51.43**
P. I	12	4.97**	78.65**	1.91*	4.65
C. I	39	5.02**	93.47**	1.37*	40.32**
P Vs. C. I	1	14.23**	1518.48**	0.26	1046.21**
F. I	4	4.8*	163.59**	1.03	104.18**
M. I	7	16.89**	254.69**	0.81	83.38**
F. M. I	28	2.08	43.15*	1.56*	20.43**
Error	208	1.56	26.24	0.92	5.92

*, ** indicate Significant at 0.05 and 0.01 probability levels, respectively.

<u>Mean performance and Drought susceptibility index (DSI)</u>: Mean performance values from combined data for all studied traits are presented in Table (4). These results showed the parental variations and the genotypic differential responses from normal to drought conditions. For no. of days to a 50% heading trait, the forty crosses under normal condition mean values were ranged from 66.50 (ATX-407 x 88V1080 and ATX-BON-44 x 88V1080) to

Vol. (51); Iss. (4); No. (); April, 2022
ISSN 1110-0826
ONLINE ISSN 2636 - 3178

69.33 days (ICSA-37 x RTX-5656) with a mean value of 67.95 days while, values were delayed under drought conditions and ranged from 69.67 (ATX-407 x RTX-2908 and ATX-631 x 82 BDM-499) to 73.00 days (ATX-631 x RTX-2908) with a mean value of 71.00 days. This trait values under normal condition were ranged from 69.17 days for ATXTSC-20 female parent to 71.33 days for ICSA-37 female parent with a mean value of 70.13 days and from 67.67 days for RTX-2895 male parent to 71.50 days for RTX-5656 male parent with a mean value of 69.13 days. Days to a 50% heading trait values under drought condition were ranged from 71.50 for ATX-631 female parent to 72.67 days for ATX-407 female parent with a mean value of 72.07 days and from 70.67 days for 88V1080 male parent to 73.00 days for 86 EO-631 male parents with a mean value of 71.75 days. In general, twenty and nineteen hybrid out of the forty hybrids under normal and drought conditions, respectively, were earlier than their respective parents and the check variety Shandaweel-2 these crosses could be used in sorghum breeding program under drought stress environment after testing them in a large scale.

Table (5): Mean performances and drought susceptibility index (DSI) of ten parental lines and their 40 grain sorghum hybrids grown under two irrigation regimes (100% and 50% ET) at Shandaweel across the two seasons

Genotypes	Days 50% heading		Plant height		No. of green leaves		Grain yield/ plant		DSI
	100% ET	50% ET	100% ET	50% ET	100% ET	50% ET	100% ET	50% ET	
Female parents									
ATXTSC-20 (A1)	69.17	72.33	145.83	122.5	6.50	5.17	55.53	45.75	0.63
ICSA-37 (A2)	71.33	72.00	141.67	115.83	6.50	5.33	55.9	44.68	0.72
ATX- 407 (A3)	69.83	72.67	140.50	117.5	6.17	3.5	41.77	31.13	0.92
ATX-BON-44 (A4)	70.33	71.83	134.17	115	4.50	3.5	40.48	28.70	1.05
ATX- 631 (A5)	70.00	71.50	130.00	123.33	5.83	4.33	39.67	26.02	1.25
Females mean	70.13	72.07	138.43	118.83	5.90	4.37	46.67	35.26	0.91
Male parents									
82BDM-499 (R1)	69.50	71.50	140.83	120.00	6.71	4.00	50.78	37.23	1.11
86EO-361 (R2)	69.50	73.00	157.50	136.67	6.75	5.50	60.77	51.57	0.87
TAM-428 (R3)	68.33	71.33	143.17	126.67	6.98	5.00	52.62	36.73	0.61
88V1080 (R4)	68.83	70.67	145.50	131.67	7.26	4.83	56.87	50.12	0.80
RTX-5646 (R5)	71.50	72.67	145.83	132.50	7.21	4.50	55.88	47.30	0.72
RTX-2817 (R6)	68.83	72.50	150.00	132.50	7.48	6.50	57.12	44.15	0.71
RTX- 2895 (R7)	67.67	71.17	142.50	120.83	5.43	4.50	58.32	46.57	0.73
RTX- 2908 (R8)	68.83	71.17	142.83	124.17	6.38	4.50	43.23	47.52	1.09
Males mean	69.13	71.75	146.02	128.13	6.77	4.92	54.45	45.15	0.83

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ISSN 1110-0826
ONLINE ISSN 2636 - 3178

Cont. Table (5):

Hybrid									
ATXTSC-20 x 82BDM-499	68.33	71.67	179.67	151.00	8.33	5.67	72.55	51.95	1.02
ATXTSC-20 x 86 EO-361	66.83	71.50	181.67	159.17	8.17	6.17	88.87	70.88	0.72
ATXTSC-20 x TAM-428	67.33	70.50	183.33	154.17	9.17	6.67	86.42	65.77	0.85
ATXTSC-20 x 88V1080	67.67	72.33	184.00	155.00	8.17	6.67	66.00	48.33	0.96
ATXTSC-20 x RTX-5646	67.83	71.33	180.67	154.67	7.83	6.00	74.82	53.17	1.04
ATXTSC-20 x RTX-2817	69.17	72.50	188.83	160.00	7.33	5.00	85.22	73.43	0.50
ATXTSC-20 x RTX- 2895	68.17	70.50	189.17	153.67	7.83	6.83	74.00	54.07	0.97
ATXTSC-20 x RTX- 2908	67.83	70.50	188.33	155.83	8.67	7.17	73.57	48.65	1.22
ICSA-37 x 82BDM-499	69.17	70.00	178.67	153.33	8.83	6.83	65.75	39.38	1.44
ICSA-37 x 86 EO-361	68.50	71.67	183.67	166.33	7.67	7.00	84.37	69.47	0.63
ICSA-37 x TAM-428	67.67	70.83	181.67	157.50	8.50	7.00	82.18	67.15	0.66
ICSA-37 x 88V1080	67.50	70.17	185.00	155.83	8.50	6.67	65.45	47.85	0.96
ICSA-37 x RTX-5646	69.33	71.00	179.83	157.17	8.50	6.67	73.12	54.77	0.90
ICSA-37 x RTX-2817	68.00	70.83	186.67	160.00	9.17	6.83	82.93	66.33	0.72
ICSA-37 x RTX- 2895	68.83	71.67	185.83	157.17	7.50	6.33	84.02	65.57	0.79
ICSA-37 x RTX- 2908	68.83	69.83	186.67	155.83	6.67	5.50	74.83	51.78	1.11
ATX- 407 x 82BDM-499	69.00	71.83	199.17	154.00	8.33	6.50	69.67	43.33	1.36
ATX- 407 x 86 EO-361	67.17	71.50	188.17	159.17	8.83	6.83	82.75	60.42	0.96
ATX- 407 x TAM-428	67.00	70.17	183.33	158.33	7.67	6.00	78.85	63.90	0.68
ATX- 407 x 88V1080	66.50	71.00	191.83	160.83	8.67	7.17	63.18	46.37	0.96
ATX- 407 x RTX-5646	68.67	71.17	187.33	160.00	9.83	6.50	73.02	55.95	0.84
ATX- 407 x RTX-2817	68.17	71.00	190.00	154.17	9.67	7.50	74.60	59.18	0.74
ATX- 407 x RTX- 2895	67.33	70.67	192.33	156.83	8.67	7.00	76.97	55.60	1.00
ATX- 407 x RTX- 2908	67.83	69.67	191.33	153.33	8.33	7.00	65.93	39.30	1.45
ATX-BON-44 x 82BDM-499	68.00	70.83	180.83	155.83	7.35	5.33	75.62	47.23	1.37
ATX-BON-44 x 86 EO-361	67.67	70.50	185.83	158.33	10.55	6.67	70.03	50.62	0.99
ATX-BON-44 x TAM-428	67.33	71.17	179.83	158.33	8.60	6.50	70.12	50.45	1.00
ATX-BON-44 x 88V1080	66.50	71.17	186.67	158.33	9.02	6.17	63.47	44.18	1.09
ATX-BON-44 x RTX-5646	67.67	70.67	181.00	153.33	8.69	6.83	70.13	47.20	1.17
ATX-BON-44 x RTX-2817	68.50	70.83	182.17	155.83	7.46	7.00	65.33	51.38	0.77
ATX-BON-44 x RTX- 2895	68.33	70.33	175.50	155.00	8.52	6.33	74.40	52.35	1.07
ATX-BON-44 x RTX- 2908	68.00	70.83	185.33	163.33	9.20	6.83	74.52	51.72	1.10
ATX- 631 x 82BDM-499	68.00	69.67	181.67	148.33	7.71	5.83	74.35	37.23	1.80
ATX- 631 x 86 EO-361	67.17	70.17	178.67	161.83	8.05	5.67	76.92	51.57	1.19
ATX- 631 x TAM-428	68.00	70.50	184.50	158.33	8.34	6.67	64.57	36.73	1.55
ATX- 631 x 88V1080	66.83	72.17	181.33	159.17	8.84	6.83	74.73	50.12	1.18
ATX- 631 x RTX-5646	68.67	71.67	176.50	150.33	9.40	6.17	67.47	47.30	1.07
ATX- 631 x RTX-2817	68.33	71.67	177.67	155.83	8.68	7.33	69.17	44.15	1.28
ATX- 631 x RTX- 2895	67.33	71.00	182.83	162.50	8.25	6.17	79.70	46.57	1.49
ATX- 631 x RTX- 2908	69.17	73.00	178.50	155.00	8.07	5.50	71.20	47.52	1.18
Hybrids mean	67.95	71.00	184.15	156.83	8.44	6.48	74.02	52.72	1.04
Shandaweel-6 (Check)	68.83	72.5	179.67	163.5	94.4	79.29	83.23	81.56	1.05
LSD 0.05	1.78	2.03	7.99	8.21	1.49	1.53	4.29	3.88	

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ONLINE ISSN 2636 - 3178

With respect to plant height the forty hybrids under normal condition was ranged from 175.50 cm (ATX-BON-44 x RTX-2908) to 199.17cm (ATX-407 x 82 BDM 499) to with a mean value of 184.15 cm, while under drought condition the plant height was reduced. The shortest hybrid was 148.33 cm (ATX-631 x 86 EO-631), while the tallest one was 166.33 cm (ATX-37 x 86 EO-631). The female lines under a 100% of irrigation water were ranged from 130.00 cm (ATX-631) to 145.83 cm (ATXTSC-20) with a mean value of 138.43 cm and from 140.83 cm for (82 BDM-499) male parent to 157.50 cm for (86 EO-631) male parent with a mean value of 146.02 cm. The female lines under a 50% of irrigation water were ranged from 115.00 cm (ATX-BON-44) to 123.33 cm (ATX-631) with a mean value of 118.83 cm and from 120.00 cm for (82 BDM-499) male parents to 136.67 cm for (86 EO-631) male parents with a mean of value 128.13 cm. The average reductions in plant height trait under water stress were 27.33, 19.60 and 18.69 cm for the hybrids, females and males, respectively. Similar results were obtained by Hafez (2010), Mahmoud et al. (2013), EL-Kady (2015), Qadir et al. (2015), Adams and Erickson (2017) and EL-Sherbeny (2019).

Regarding number of green leave trait, the hybrids under a 100%of irrigation level were varied from 6.67 (ICSA-37 x RTX-2908) to 10.55 (ATX-BON-44 x 86 EO-361) with mean value of 8.44 and under a 50% of irrigation the hybrid were ranged from 5.00 (ATXTSC-20 x RTX-2817) to 7.50 (ATX-407 x RTX-2817) with a mean value of 6.48. Female lines were

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varied from 4.50 (ATX-BON-44) to 6.50 (ATXTSC-20 and ICSA-37) with a mean value of 5.90 and from 5.43 for RTX-2895 male parent to 7.48 for (RTX-2817) male parent with a mean value of 6.77. Under a 50% of irrigation level, female lines were ranged from 3.50 (ATX-407 and ATX-BON-44) to 5.33 (ICSA-37) with a mean value of 4.37 and from 4.00 for (82 BDM-499) male parent to 6.50 for (RTX-2817) the male parent with a mean value of 4.92.

With respect to grain yield per plant trait, the hybrids under normal condition were ranged from 63.18 g (ATX-407 x 88V1080) to 88.87 g (ATXTSC-20 x 86 EO-361) with a mean value of 74.02g, while values were ranged for the female parents from 39.67 g (ATX-631) to 55.90 g (ICSA-37) with a mean of 46.67 g and values were ranged for the male parents from 43.23 g (RTX-2908) to 60.77 g (86 EO-361) with a mean of 54.45g. Under a 50% of irrigation water the hybrids were ranged from 36.73 g(ATX-631 x TAM-428) to 73.43g (ATXTSC-20 x RTX-2817) with a mean value of 52.72g, while values were ranged for the female lines from 26.02g (ATX-631) to 45.75 g (ATXTSC-20) with the mean of 35.26 g and ranged for the male parents from 36.73 g (TAM-428) to 51.47 g (86 EO-361) with a mean of 45.15 g. seven best crosses (ATXTSC-20 x 86 EO-361, ATXTSC-20 x TAM-428, ATXTSC-20 x RTX-2817, ICSA-37 x 86 EO-361, ICSA-37 x TAM-428, ATX-407 x 86 EO-361 and ATX-407 x TAM-428) gave the highest yield over the two seasons under both irrigation levels. In addition, these crosses were drought tolerance and significantly out yielded from the check hybrid Shandaweel-6. These crosses could be evaluated in a large scale and considered as promising crosses under drought stress conditions.

Drought susceptibility index (DSI) trait gave values that measure drought sensitivity hence, the smaller value of DSI was the greater degree of tolerance of a given genotype. DSI values (Table 3) varied between parental lines and their respective hybrids as shown in grain yield per plant trait. DSI values were ranged from 0.64 (ATXTSC-20 x RTX-2817) to 1.80 (ATX-631 x 82 BDM-499) for the hybrids, from 0.63 (ATXTSC-20) to 1.25 (ATX-631) for the female lines and from 0.61 (TAM-428) to 1.11(82 BDM-499) for the male lines. Nine hybrids were the best drought tolerant ones (ATXTSC-20 x 86 EO-361, ATXTSC-20 x RTX-2817, ICSA-37 x 86 EO-361, ICSA-37 x TAM-428, ICSA-37 x RTX-2817, ICSA-37 x RTX-2895, ATX-407 x TAM-428, ATX-407 x RTX-2817 and ATX-BON-44x RTX-2817). While the best drought tolerant parental lines were (ATXTSC-20, ICSA-37, TAM-428, RTX-5646, RTX-2817 and ICSR-2908).

In general, mean values of days to a 50% of heading that for the hybrids and their parents were increased by increasing water stress, but plant height, leaf area, no. of green leaves and grain yield per plant trait of the hybrids and their parents were decreased with increasing water stress. Morover, the F1 hybrids had taller plants and higher grain yield per plant than the best parents.

These results are in harmony with those obtained by Hafez (2010), Mahmoud *et al.* (2013), EL-Kady *et al.* (2015) and EL-Sherbeny (2019).

Heterosis:

Table (6) represented percentage values of heterosis that relative to the better parent under the two irrigation levels (100% and 50% ET). For days to a 50% of heading trait, negative significant heterotic values were desirable. Under normal and drought conditions, most of the hybrids were highly significant for heterosis values that relative to the better parent. With respect to plant height trait, under a 100% of irrigation level values were ranged from 13.44 (ATXT631x 86 EO-361) to 41.42% (ATX- 407 x 82BDM-499). While under drought condition heterosis values were ranged from 13.46% (ATX-631 x RTX-5646) to 31.54% (ATX-BON-44 x RTX- 2908). All the hybrids under normal and drought conditions manifested notable heterotic effects. Concerning number of green leaves trait, most of the hybrids under normal irrigation had negative and highly significant heterosis, while under a 50% of irrigation level values were ranged from -23.08 % (ATXTSC-20 x RTX-2817) to 62.50 % (ATX-407 x 82 BDM-499). Most of the hybrids under drought condition manifested notable heterotic effects. With respect to grain yield / plant trait under normal irrigation values were ranged from 11.11 % (ATX-407 x 88V1080) to 72.36% (ATX-BON-44 x RTX-2908) and all hybrids showed positive significant heterosic effects. Under drought condition for the same trait values were ranged from -15.94 % (ATX-631 x

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ONLINE ISSN 2636 - 3178

TAM-428) to 71.15 (ATX-BON-44 x RTX-2908), and most of the hybrids showed desirable heterotic effect. These results were in a harmony with those obtained by Hovny *et al.* (2001), Taye *et al.* (2016), Chikuta *et al.* (2017) and EL-sherbeny *et al* (2019). Generally, nine hybrids were the best under drought conditions (ATXTSC-20 x 86 EO-361, ATXTSC-20 x TAM-428, ICSA-37 x TAM-428, ICSA-37 x RTX-2817, ICSA-37 x RTX-2895, ATX-407 x TAM-428, ATX-BON-44 x 82 BDM-499, ATX-BON-44 x RTX-2908 and ATX-631 x RTX-2908) that related to the better parent for grain yield and some of the other studied traits.

Table (6): Estimates of better parent heterosis of all studied traits under the two irrigation levels (100% and 50% ET) over the two seasons

Hybrids	Days 50% heading		plant height		no. of green leaves		grain yield / plant	
	100% ET	50% ET	100% ET	50% ET	100% ET	50% ET	100% ET	50% ET
ATXTSC-20 x 82BDM-499	-1.68	-0.92	23.2**	23.27**	24.22**	9.68	30.64**	13.55***
ATXTSC-20 x 86 EO-361	-3.84**	-2.05*	15.34**	16.46**	20.99*	12.12	46.24**	54.32**
ATXTSC-20 x TAM-428	-2.65**	-2.53**	25.71**	21.71**	31.36**	29.03**	55.61**	43.75**
ATXTSC-20 x 88V1080	-2.17*	0	26.17**	17.72**	12.51	29.03**	16.06**	5.65
ATXTSC-20 x RTX-5646	-5.13**	-1.83*	23.89**	16.73**	8.62	16.13	33.88**	16.21**
ATXTSC-20 x RTX-2817	0	0	25.89**	20.75**	-1.94	-23.08**	49.2**	60.33**
ATXTSC-20 x RTX- 2895	-1.45	-2.53**	29.71**	25.44**	20.51*	32.26**	26.89**	16.86**
ATXTSC-20 x RTX- 2908	-1.93*	-2.53**	29.14**	25.5**	33.33**	38.71**	32.47**	6.34
ICSA-37 x 82BDM-499	-3.04**	-2.78**	26.12**	27.78**	31.68**	28.13**	17.62**	-11.86**
ICSA-37 x 86 EO-361	-3.97**	-1.83*	16.61**	21.71**	13.58	27.27**	38.84**	51.23**
ICSA-37 x TAM-428	-5.14**	-1.62*	26.89**	24.34**	21.81**	31.25**	47.02**	50.28**
ICSA-37 x 88V1080	-5.37***	-2.55**	27.15**	18.35**	17.11*	25**	15.09**	7.09*
ICSA-37 x RTX-5646	-3.03**	-2.29**	23.31**	18.62**	17.86*	25**	30.8**	22.38**
ICSA-37 x RTX-2817	-4.67**	-2.30**	24.44**	20.75**	22.58**	5.13	45.2***	44.83**
ICSA-37 x RTX- 2895	-3.50**	-0.46	30.41**	30.07**	15.38	18.75*	44.07**	41.71**
ICSA-37 x RTX- 2908	-3.50**	-3.01**	30.69**	25.5**	2.56	3.12	33.87**	15.89**
ATX- 407 x 82BDM-499	-1.19	-1.15	41.42**	28.33**	24.22**	62.5**	37.18**	24.28**
ATX- 407 x 86 EO-361	-3.82**	-2.05*	19.47**	16.46**	30.86**	24.24**	36.18**	31.53**
ATX- 407 x TAM-428	-4.06**	-3.44**	28.06**	25**	9.86	20*	49.86**	46.22**
ATX- 407 x 88V1080	-4.77**	-2.29**	31.84**	22.15**	19.4*	48.28**	11.11**	4.9
ATX- 407 x RTX-5646	-3.96**	-2.06*	28.46**	20.75**	36.35**	44.44**	30.66**	25.03**
ATX- 407 x RTX-2817	-2.39*	-2.29**	26.67**	16.35**	29.26**	15.38*	30.61**	29.22**
ATX- 407 x RTX- 2895	-3.58**	-2.75**	34.97**	29.79**	40.54**	55.56**	31.98**	20.17**
ATX- 407 x RTX- 2908	-2.86**	-4.13**	33.96**	23.49**	30.65**	55.56***	52.51**	26.23**
ATX-BON-44 x 82BDM-499	-3.32**	-1.39	28.4**	29.86**	9.49	33.33**	48.9**	35.47**
ATX-BON-44 x 86 EO-361	-3.79**	-3.42**	17.99**	15.85**	56.35**	21.21*	15.25**	10.2**
ATX-BON-44 x TAM-428	-4.27**	-0.93	25.61**	25**	23.19**	30**	33.26**	15.45**
ATX-BON-44 x 88V1080	-5.45**	-0.93	28.29**	20.25**	24.32**	27.59**	11.61**	-0.04
ATX-BON-44 x RTX-5646	-5.36**	-2.75**	24.11**	15.72**	20.5**	51.85**	25.5**	5.47
ATX-BON-44 x RTX-2817	-2.61**	-2.3**	21.44**	17.61**	-0.2	7.69	14.39**	12.19**
ATX-BON-44 x RTX- 2895	-2.84**	-2.09*	23.16**	28.28**	56.99**	40.74**	27.58**	13.15**
ATX-BON-44 x RTX- 2908	-3.32**	-1.39	29.75**	31.54**	44.16**	51.85***	72.36**	71.15**
ATX- 631 x 82BDM-499	-2.86**	-2.56**	28.99**	20.27**	14.91	34.62**	46.41**	6.79
ATX- 631 x 86 EO-361	-4.05**	-3.88**	13.44**	18.41**	19.26*	3.03	26.58**	12.26**
ATX- 631 x TAM-428	-2.86**	-1.4	28.87**	25**	19.54*	33.33**	22.71**	-15.94**
ATX- 631 x 88V1080	-4.52**	0.93	24.63**	20.89**	21.84**	41.38**	31.42**	13.39**
ATX- 631 x RTX-5646	-3.96**	-1.3	21.03**	13.46**	30.28**	37.04**	20.73**	5.7
ATX- 631 x RTX-2817	-2.38*	-1.1	18.44**	17.61**	16.02*	12.82	21.1**	-3.6
ATX- 631 x RTX- 2895	-3.81**	0	28.3**	30.00**	41.4**	37.04**	36.67**	0.65
ATX- 631 x RTX- 2908	-1.19	2.10*	24.97**	24.00**	26.47**	22.22*	64.69**	57.25**

*, ** indicate Significant at 0.05 and 0.01 probability levels, respectively.

Combining ability effects:

Estimates of general combining ability (GCA) effects for each inbred line in each studied trait under normal and drought conditions are presented in Table (6). For all studied traits, high positive GCA values were detected, except for days to a 50% of heading trait, where high negative values would be useful for a breeder's perspective. Regarding days to a 50% of heading trait, values showed that the 88V1080 male line had negative and significant GCA values under normal conditions, The ICSA-37 and ATX-407 female lines and the TAM-428 male line had negative and insignificant GCA under the two irrigation levels. These lines could be considered as the best combiners for earliness which means that these lines had favor gene action for earliness. For plant height trait, the ATX-407 female line and the 86EO-361 male line exhibited positive and significant GCA effects under normal and drought conditions. Concerning no. of green leaves trait, the 88V1080 male line showed positive and significant GCA effects under drought conditions. For grain yield per plant trait, the ATXTSC-20 and ICSA-37 female lines and the 86EO-361 and RTX-2809 male lines showed positive and significant GCA effects under normal and drought conditions. These results were in a line with those reported by Mahmoud (2007) who obtained high general combiner lines under normal and drought conditions.

Specific combining ability (SCA) effects for all studied traits under normal and drought conditions are presented in Table (6). Under drought conditions only one cross (ATX-631 x 82BDM-499) for days to a 50% of heading out of the studied forty hybrids showed negative and significant specific combining ability effects. Two crosses (ATX-407 x 82BDM-499 and ATX-407 x TAM-428) for plant height trait, one crosses (ATX-BON-44 x 86 EO-361) for no. of green leaves and five crosses (ATXTSC-20 x TAM-428, ATXTSC-20 x RTX-2817, ATX-BON-44 x 82BDM-499, ATX-BON-44 x RTX-2908 and ATX-631 x 88V1080) for grain yield per plant trait out of four forty hybrids showed positive and significant SCA effects under normal conditions. On the other hand, nine crosses (ATXTSC-20 x 82BDM-499, ATXTSC-20 x RTX-2817, ICSA-37 x TAM-428, ICSA-37 x RTX-2895, ATX-407 x TAM-428, ATX-BON-44 x 82BDM-499, ATX-BON-44 x RTX-2908, ATX-631 x 88V1080 and ATX-631 x RTX-2908) for grain yield per plant trait out of the studded forty hybrids showed positive and significant SCA effects under drought conditions. Such crosses could be useful under drought conditions and were considered to be promising for grain yield per plant trait, as they showed high SCA effects and involved at least one parent as a good general combiner. However, (Mahmoud (2007), Amir (2008), Hafez (2010), El-Dardeer (2011), Mahmoud *et al.* (2013), EL-Kady *et al.* (2015) EL-sherbeny *et al* (2019) and Tafere *et al.*, (2020)) reported some sorghum crosses that had positive and significant SCA effects under normal and drought conditions.

Table (7): Estimates of general and specific combining ability effects for all the studied traits under two irrigation levels at Shandaweel across two seasons

Genotypes	Days 50% heading		Plant height		No. of green leaves		Grain yield/ plant	
	100%ET	50% ET	100%ET	50% ET	100%ET	50% ET	100%ET	50% ET
General combining ability								
Female parents								
ATXTSC-20 (A1)	-0.06	0.35	0.31	-1.39	-0.25	-0.21	3.66**	5.56**
ICSA-37 (A2)	0.53	-0.25	-0.65	1.07	-0.27	0.12	2.56*	5.06**
ATX- 407 (A3)	-0.25	-0.13	6.29**	0.26	0.31	0.32	-0.89	0.28
ATX-BON-44 (A4)	-0.20	-0.21	-2.00*	0.47	0.23	-0.03	-3.57**	-3.33**
ATX- 631 (A5)	-0.02	0.23	-3.94**	-0.41	-0.02	-0.21	-1.77	-7.56**
S. E. (gi)	0.33	0.29	0.99	1.11	2.16	1.74	1.02	0.79
S. E. (gi-gi)	0.46	0.41	1.4	1.57	3.05	2.47	1.44	1.11
Male parents								
82BDM-499 (R1)	0.55	-0.2	-0.15	-4.33**	-0.33	-0.45	-2.43	-8.89**
86EO-361 (R2)	-0.48	0.07	-0.55	4.14**	0.22	-0.02	6.57**	7.87**
TAM-428 (R3)	-0.48	-0.38	-1.62	0.51	0.02	0.08	2.42	4.07
88V1080 (R4)	-0.95*	0.37	1.62	1.01	0.2	0.22	-7.45**	-5.35**
RTX-5646 (R5)	0.47	0.18	-3.08*	-1.73	0.41	-0.05	-2.31	-1.05
RTX-2817 (R6)	0.47	0.37	0.92	0.34	0.02	0.25	1.44	6.18**
RTX- 2895 (R7)	0.058	-0.17	0.98	0.21	-0.28	0.05	3.79**	2.11*
RTX- 2908 (R8)	0.38	-0.23	1.88	-0.16	-0.25	-0.08	-2.01	-4.93**
S. E. (gi)	0.42	0.37	1.25	1.4	2.73	2.21	1.82	1.41
S. E. (gi-gi)	0.59	0.52	1.77	1.98	3.86	3.12	2.88	2.23

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ISSN 1110-0826
ONLINE ISSN 2636 - 3178

Cont. Table (7):

Specific combining ability								
Crosses								
ATXTSC-20 x 82BDM-499	-0.11	0.51	-4.64	-0.11	0.47	-0.15	-2.69	2.57
ATXTSC-20 x 86 EO-361	-0.58	0.08	-2.24	-0.41	-0.24	-0.09	4.62	4.74*
ATXTSC-20 x TAM-428	-0.08	-0.49	0.49	-1.78	0.96	0.31	6.33*	3.41
ATXTSC-20 x 88V1080	0.73	0.61	-2.08	-1.46	-0.22	0.18	-4.23	-4.59*
ATXTSC-20 x RTX-5646	-0.54	-0.19	-0.71	0.95	-0.77	-0.22	-0.55	-4.07
ATXTSC-20 x RTX-2817	0.79	0.78	3.46	4.22	-0.88	-1.52*	6.11*	8.99**
ATXTSC-20 x RTX- 2895	0.23	-0.69	3.73	-1.98	-0.07	0.51	-7.48*	-6.32**
ATXTSC-20 x RTX- 2908	-0.44	-0.62	1.99	0.55	0.73	0.98	-2.10	-4.70*
ICSA-37 x 82BDM-499	0.14	-0.55	-4.68	-0.24	0.99	0.68	-8.39**	-9.51**
ICSA-37 x 86 EO-361	0.51	0.85	0.72	4.29	-0.72	0.41	1.22	3.81
ICSA-37 x TAM-428	-0.33	0.45	-0.22	-0.9	0.32	0.31	3.19	5.29*
ICSA-37 x 88V1080	-0.03	-0.95	-0.12	-3.07	0.13	-0.15	-3.68	-4.58*
ICSA-37 x RTX-5646	0.38	0.08	-0.58	0.99	-0.08	0.12	-1.16	-1.97
ICSA-37 x RTX-2817	-0.96	-0.28	2.25	1.76	0.98	-0.02	4.92	2.37
ICSA-37 x RTX- 2895	0.31	1.08	1.35	-0.94	-0.38	-0.32	3.64	5.67*
ICSA-37 x RTX- 2908	-0.03	-0.68	1.28	-1.9	-1.25	-1.02	0.26	-1.07
ATX- 407 x 82BDM-499	0.75	1.16	8.88**	1.24	-0.09	0.14	-1.02	-0.77
ATX- 407 x 86 EO-361	-0.05	0.56	-1.72	-2.06	-0.13	0.04	3.06	-0.45
ATX- 407 x TAM-428	-0.22	-0.34	-5.48	0.74	-1.09	-0.89	3.32	6.82**
ATX- 407 x 88V1080	-0.25	-0.24	-0.22	2.74	-0.28	0.14	-2.49	-1.29
ATX- 407 x RTX-5646	0.48	0.12	-0.02	4.64	0.67	-0.26	2.21	3.99
ATX- 407 x RTX-2817	-0.02	-0.24	-1.35	-3.25	0.89	0.44	0.048	0.01
ATX- 407 x RTX- 2895	-0.42	-0.04	0.91	-0.46	0.2	0.14	0.05	0.49
ATX- 407 x RTX- 2908	-0.25	-0.98	-0.98	-3.59	-0.16	0.27	-5.17	-8.78**
ATX-BON-44 x 82BDM-499	-0.29	0.24	-1.16	2.87	-0.99	-0.68	7.59*	6.74**
ATX-BON-44 x 86 EO-361	0.4	-0.36	4.24	-3.1	1.66*	0.23	-6.98*	-6.64**
ATX-BON-44 x TAM-428	0.07	0.74	-0.69	0.53	-0.09	-0.04	-2.74	-3.02
ATX-BON-44 x 88V1080	-0.29	0.01	2.9	0.03	0.15	-0.51	0.47	0.14
ATX-BON-44 x RTX-5646	-0.56	-0.29	1.93	-2.23	-0.39	0.42	1.99	-1.15
ATX-BON-44 x RTX-2817	0.27	-0.32	-0.89	-1.8	-1.23	0.29	-6.54*	-4.18
ATX-BON-44 x RTX- 2895	0.53	-0.29	-7.63**	-2.5	0.13	-0.18	0.15	0.85
ATX-BON-44 x RTX- 2908	-0.13	0.28	1.31	6.2	0.78	0.46	6.07*	7.25**
ATX- 631 x 82BDM-499	-0.48	-1.36	1.61	-3.76	-0.38	0.01	4.52	0.98
ATX- 631 x 86 EO-361	-0.28	-1.129	-0.99	1.27	-0.58	-0.59	-1.91	-1.45
ATX- 631 x TAM-428	0.55	-0.36	5.91*	1.41	-0.09	0.31	-10.10**	-12.49**
ATX- 631 x 88V1080	-0.15	0.57	-0.49	1.741	0.23	0.35	9.92**	10.32**
ATX- 631 x RTX-5646	0.25	0.27	-0.63	-4.36	0.57	-0.05	-2.48	3.19
ATX- 631 x RTX-2817	-0.08	0.07	-3.46	-0.93	0.24	0.8	-4.53	-7.17**
ATX- 631 x RTX- 2895	-0.65	-0.06	1.64	5.88	0.12	-0.15	3.64	-0.68
ATX- 631 x RTX- 2908	0.85	2.00*	-3.5	-1.26	-0.09	-0.68	0.95	7.29**
S. E. (Sij)	0.93	0.82	2.79	3.14	6.11	4.93	2.88	2.23
S. E. (Sij-SKI)	1.31	1.16	3.96	4.44	8.64	6.98	4.08	3.15

*, ** indicate Significant at 0.05 and 0.01 probability levels, respectively.

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تقييم بعض التراكيب الوراثية من ذرة الحبوب الرفيعة تحت البيئات الجافة

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المستخلص

يؤثر الجفاف سلباً على نمو وانتاجية المحاصيل بدرجات متفاوتة فتعتبر زراعة المحاصيل التى تتحمل الجفاف امر هام. لهذ السبب تم إجراء هذه الدراسة تم تقييم اربعين هجيناً من الذرة الرفيعة وآبائهم تحت الظروف المثلى وظروف الإجهاد المائي (١٠٠% و٥٠% من المقنن المائي) بمحطة

ISSN 1110-0826
ONLINE ISSN 2636 - 3178

بحوث شندويل التابعة لمركز البحوث الزراعية وذلك في الموسمين المتتالين 2019 و2020. كان متوسط مجموع المربعات الراجع لكل من الرى والتراكيب الوراثية والآباء والهجن عالية المعنوية لكل الصفات المدروسة مما يدل على وجود تباين فيما بينها. أوضح تباين التفاعل بين كل من القدرة العامة والخاصة على التآلف والبيئة أنة عالي المعنوية لمعظم الصفات تحت الدراسة. اظهر معامل الحساسية للجفاف وجود تسعة هجن متحملة للجفاف هي:
(ATXTSC-20 x 86 EO-361, ATXTSC-20 x RTX-2817, ICSA-37 x 86 EO-361, ICSA-37 x TAM-428, ICSA-37 x RTX-2817, ICSA-37 x RTX-2895, ATX-407 x TAM-428, ATX-407 x RTX-2817 and ATX-BON-44x RTX-2817).

وكانت أفضل السلالات الأبوية المتحملة للجفاف هي:
ATXTSC-20, ICSA-37, TAM-428, RTX-5646, RTX-2817 and ICSR-2908

كانت أحسن التراكيب الوراثية الأبوية بالنسبة للقدرة العامة على التالف في صفة محصول النبات من الحبوب وبعض الصفات الأخرى هي السلالات الأمية ICSA-37, ATXTSC-20 والسلالات الأبوية RTX-2809 , 86 EO-361 تحت كلا من الظروف المثلى وظروف الإجهاد المائي. اعطى تسعة هجن من اربعين بالنسبة للقدرة الخاصة على التالف لصفة محصول النبات من الحبوب تحت ظروف الجفاف. أظهرت قوة الهجين بالنسبة لأفضل الآباء أن تسعة هجن من الاربعين هجين أفضل هجن تحت ظروف الجفاف لصفة محصول النبات من الحبوب وبعض الصفات الأخرى.

الكلمات المفتاحية: الذرة الرفيعة للحبوب, قوة الهجين, القدرة علي الأتلاف, دليل الحساسية للجفاف, تحمل الجفاف.