Aswan University Journal of Science and Technology Volume 4, issue 1, March 2024

Genetic Analysis of Yield and Its Components in Diallel Crosses of Wheat (*Triticum aestivum* L.) under normal and Drought Condition

Bakhet,B.R.,[1] M. A. F. Habouh.,[2] M.N.T. Abd El-Kade[3] and M. A.M. Abd El-Galil

1- Department of Agronomy, Faculty of Agriculture, Assiut University.
2- Department of Agronomy, Faculty of Agriculture, Natural Resource, Aswan University.
3- Senior Researcher, Wheat Research Department (WER),Field Crops Res. Inst (FCRI), ARC.
4- Agricultural engineer at the Egyptian Holding Company for Silos and Storage.

ABSTRACT:

The current work was conducted at the agricultural research center in Al-Mattana during the seasons of 2019/2020 and 2020/2021. This work aims to evaluate 28 bread wheat genotypes (*Triticum aestivum L.*) of diverse origin under irrigated (six irrigations) and stressed environment, for yield and related traits. Moreover, to study the genetic analysis of the yield, its components for seven parents (P) and twenty-one F_1-hybrids (F_1) under the aforementioned environments. The data obtained for each character was analyzed on plot mean basis .All obtained results were subjected to the statistical analysis of the randomized complete block design. The data were analyzed to estimate general combining ability (GCA) and specific combining ability (SCA) effects. Under water stress conditions, all genotypes (P+F1) performed lower than normal conditions.under normal condition.

Key words: Bread wheat, genetic components, water stress condition, combining ability.

INTRODUCTION:

Wheat (*Triticum aestivum* L.) is a major cereal crop used in the daily human diet as a main source of carbohydrates and proteins. In addition, the grains provide trace amounts of fats, dietary fibers, minerals[1]. Wheat (*Triticum aestivum* L.) is the world's most frequently farmed food crop, and it is endangered by climate change in the future [2]. Egypt is the largest wheat importer in the world; however, it produces only half of the 20 million tons of wheat that it consumes annually. The population of Egypt is currently growing by 1.94% per year, and projections predict that the demand for wheat will be nearly doubled by 2050. Russia and Ukraine are major wheat exporters to Egypt [3Drought, causes negative effects on crop yield. Drought is a stress whose impact tends to increase in some critical regions. However, the worldwide population is continuously increasing and climate change may affect its food supply in the upcoming years. Therefore, there is an ongoing effort to understand the molecular processes that may contribute to improving drought tolerance of strategic crops. These investigations should contribute to delivering drought-tolerant cultivars by selective breeding[4]. Drought and drought susceptibility Drought tolerance in wild plant species is often defined as survival but in crop species it is defined terms of productivity [5]. Combining

*Corresponding author E-mail: ams.egy.2016@gmail.com
Received March 29, 2024 received in revised form, April 8, 2024, accepted April 13, 2024.
(ASWJST 2021/ printed ISSN: 2735-3087 and on-line ISSN: 2735-3095) https://journals.aswu.edu.eg/stjournal

ability analysis of Griffing (1956) is most widely used as biometrical tool for determining parental lines from where their ability to combine in hybrids. Diallel mating design is one of the tools, which help the breeder to identify the potential genotypes and the promising recombination procedure by combining the parental individuals through GCA and SCA. In diallel mating design the parents are crossed in all possible combinations to identify parents as the best one poor general combiners through GCA and the specific crosses combinations through SCA. In combining ability, the entire genetic variability of each trait can be partitioned into GCA and SCA as defined by **[6]**

The objectives of the current study were to: (1) study the nature of in heritance of some agricultural traits including grain yield and its components, and (2) identify the most drought-tolerant and high yielding genotypes.

MATERIALS AND METHODS

The present investigation was carried out during 2019/2020 and 2020/2021. In the first season (2019/2020) the seven parents (Table 1) were planted on three dates to ensure sufficient seeds from the F1 hybrids.

In the second season (2020/2021), the seven parents and the twenty-one F1 hybrids were grown in a completely randomized plot design under the normal irrigation and drought system. The design of the experiment was in strips, that is, all the genotypes (P+F1) were placed in a strip under the normal irrigation system, as well as another strip for drought, which was grown with one irrigation after three weeks. Data for the studied traits were recorded and analyzed using the method of **Griffing 1956.**

Table 1: pedigree and origin of the seven parental genotypes used in the present investigation.

Parent No.	**Genotypes**	**Pedigree**	**Origin**
P_1	**Giza 168**	**MRL / BUC / SER**	**Egypt**
P_2	**Gemmeiza 11**	**BOW"S"/KVZ//7C/SER182/3/GIZA 168/SAKHA61.GM7892-2GM-1GM-2GM1GM-0GM**	**Egypt**
P_3	**Shandaweel-1**	**SITE/ MO/4/ NAC/ TH.AC// 3*PVN/3/ MIRLO/BUC.**	**Egypt**
P_4	**Giza 171**	**SAKHA 93 / GEMMEIZA 9 S.6-1GZ-4GZ-1GZ-2GZ-0S**	**Egypt**
P_5	**Sids14**	**SW8488*2/KUKUNACGSS01Y00081T-099M-099Y-099M-099B-9Y-0B-0SD.**	**Egypt**
P_6	**MISR 3**	**ROHF07*2/KIRITICGSS05B00123T-099T-0PY-099M-099NJ-6WGY-0B-0BGY0G**	**Egypt**
P7	**MISR 1**	**OASIS/SKAUZ//4*BCN/3/2*PASTOR**	**Egypt**

The following characters were recorded on ten plants:

1- Number of spikes/plant (S/P): determined by counting the number of fertile spikes per plant.

2- Number of kernels/spike (K/S): counted as an average number of grains collected per spike.

3-Grain yield/plant: Average grain weight of individual guarded.

4- Biological yield): Average weight of individual guarded plant, (excluding root system), at harvest.

5- 100-kernel weight (KW): recorded in grams (g) by the mean weight of random 100-kernel samples.

6- **Harvest index**: The ratio between grain yield / plant to biological yield / plant.

Statistical and genetic analyses

Mean performance and analysis of variance

Analysis of variance for randomized complete block design was carried out according to **(Snedecor and Cochran, 1967)** using computer software MSTATC program.

Drought tolerance indices

1- Yield stability index (YSI):-

Yield stability index (YSI) was calculated according to the method of [7], **(YSI) = Ys / Yp.**

2- Drought susceptibility index (DSI):-

Drought susceptibility index was calculated according to the method of [8], **D = (1−** $(\bar{Y}s/\bar{Y}p)$**).**

The mean drought susceptibility index (DSI) of individual genotype was calculated as**: DSI = {1−** (Ys/Yp)**} / {1−** $(\bar{Y}s/\bar{Y}p$**}).**

Drought susceptibility index (DSI) which its numerical low amounts (less than one) indicated high tolerance of variety to stress [9].

3- Sensitivity drought index (SDI):-

Sensitivity drought index (SDI) was calculated according to the method of [10]. The mean Sensitivity drought index (SDI) of individual genotype was calculated as : SDI = $(Yp-Ys)$ / Yp

General and specific combining ability(G.C.A & S.C.A)

In the current study, seven parental genotypes were utilized in a half diallel mating design to produce 21 F_1 hybrids to estimate the different genotypic parameters in terms of additive and non-additive genetic variances. The procedures of this analysis were described by **Griffing's method II model I (1956)** and outlined by [11].

I- Component due to GCA:

$1/(n-1)\Sigma_i g_i^2 = (Mg - Me) / (n + 2)$

II- Components due to SCA:

The ratio of GCA variance to SCA variance was calculated as follows: $GCA/SCA=\{1/(n-1)\Sigma igi^2\}/\{2/n(n-1)\Sigma\Sigma_{i<j}Vsij^2\}$.

The general (g^i) and specific ($s^{\wedge}ij$) combining ability was computed for each parents and $2/n\ (n-1)\Sigma\Sigma_{I<J}sij^2 = Ms - Me$.

Table 2. Analysis of variance for the studied genotypes.

S.O.V.	d.f	MS	EMS
Replications (r)	(r-1)	M_3	$\sigma^2e + g\sigma^2r$
Genotypes (g)	(g-1)	M_2	$\sigma^2e + r\frac{\Sigma(G)^2}{(g-1)}$
Error	(r-1) (g-1)	M_1	σ^2e

Results and Discussion

A- Performance of wheat genotypes Parents and F_1-hybrids under normal and drought conditions: -

The analyses of variance for all studied traits of the seven parents and their 21 F1 crosses grown under normal and drought stresses are shown in **Table3.** Our results reveal that mean squares due to genotypes, parents and F1 crosses were highly significant for all studied characters under normal and drought stresses, indicating the wide diversity among the parental materials used in the present study. In addition, the mean squares due to parents vs crosses were significant and highly significant in all characters.

Table3: Mean squares for morphological traits and yield and its components traits of seven parental genotypes and their F1 hybrids grown under normal and water stress conditions.

S.O.V.	d.F.	Number of spikes/plant		Number of kernal/spike		Grain yield/plant (g)		Biological yield/plant (g)		100– grains weight (g)		Harvest index%	
		Irrig.	drought	Irrig.	drought	Irrig.	drought	Irrig.	drought	Irrig.	drought	Irrig.	drought
Rep	2	3.223	0.392	69.270	0.929	66.534	1.013	62.649	11.429	0.020	0.052	39.303	0.058
Genotype	27	5.184**	3.429**	150.204**	151.085**	114.669**	42.410**	248.526**	246.623**	0.270**	0.347**	53.530**	73.570**
Error	54	0.169	0.176	10.328	6.253	6.462	1.240	18.219	9.538	0.032	0.025	4.193	2.331

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

Mean of parents and F1-hybrids of number of spikes/plant are shown in **Table4.** Average of number of spikes/plant for parents was from 8.17 for P2 to 12.50 for P7 and from 6.17 for P3 to 8.37 for P6 for irrigation and drought, respectively, and F1- hybrids from 9.33 for P2× P7 and P3×P5 to 13 for P1× P5 and from 6 for P2× P7 to

10.25 for P4× P7 for irrigation and drought respectively. The percentage decrease in the average number of spikes/plant for parents, F1-crosses and all genotypes due to drought was 20.45, 21.55 and 21.30%, respectively. The results agree with**, [12], [13].**

Average parents and F1 crosses for the number of grains / spike in **Table 4.** For parents, the number of grains /spike ranged from 44.97 for P2 to 65.93 for P7 under normal irrigation conditions and from 40.11 for P2 to 58.67 for P5 under water stress. For F1 hybrids, the number of grains/spike ranged from 48.61 for P2× P7 to 74.33 for P1× P3 and P1× P4 under irrigated environment and ranged from 32.89 for P2× P6 to 59.23 for P1× P3 under drought conditions. Water stress decreased the average number of grains/spike for all parents, crosses and for all genotypes by 17.42, 24.75, and 23.02%, respectively. In this regard, our results were consisted with **[14] ,[15].**

The average weight of 100 grains (**Table 4) showed that,** for parents, under normal irrigation conditions ranged from 4.00 g for P1 to 5.05 g and for P2 and F1 hybrids from 4.02 g for P3×P5 to 5.03 g for P4×P5 and also under stress for parents from 3.12 g for P3 to 4.05 g for P2 and F1 -hybrid from 2.80 g for P2×P4 to 4.22 g for P2×P3. Water stress decreased the average weight of 100 grains for all parents, crosses and for all genotypes by 19.76, 22.56, and 21.91%, respectively. These results were similar to those founded by **[16], [17]** found reduction in grain weight by drought stress under irrigated environments. **[18], [19]**

Mean of the parents and F1-hybrids for Biological yield/plant (**Table 4)** showed that the parents under irrigated environment were ranged from 65.34 g for P1 to 89.87 g for P7 and F1-hybrids from78.01 g for P2×P7 to 100.51 g for P5× P6. While under stressed environment, the parents were ranged from 38.85 g for P1 to 59.99 g for P2 and the hybrids ranged from 40.71 g for P2× P4 to 72.13 g for Giza 168× P5. The reduction in the average biological yield/plant for the parents were 36.39 % and for the hybrids 39.48 % and for all genotypes 38.8. These results are in line with those reported **[20].**

Evaluation of the parents and F1-hybrids revealed that highly significant differences were found for harvest index among the studied genotypes (Table 4) as revealed in other traits, mean of the parents and F_1-hybrids under irrigated environment (**Table 5).** Harvest index of the parents were ranged from 24.41 for P2 to 36.14 for P7, and the F_1- hybrids ranged from 27.75 for P2× P7 to 43.20 for P1×P5. Moreover, under stressed environment harvest index of the parents were ranged from 19.99 for P2 to 33.94 for Giza 168, and the F1-hybrids ranged from 18.84 for P2× P7 to 36.77 for Giza 168×P6. In general, drought led to a decrease in the average harvest index in plants for parents 14.74% and the F1-hybrids 23.87% and all genotypes 21.84%. These results are in line with those reported by **[15]**

Grain yield/plant of the parents under irrigated environment was ranged from 18.94 for P2 to 32.52g for P7and F1-hybrid from21.68 for P2×P7 to 42.84g for P1×P5. While under stressed environment the parents were ranged from 9.37for P3 to 16.30 g for P7 and the hybrids ranged from 8.37 for P2× P4 to 22.13g for Giza 168× P5 (**Table 5).** The reduction in the average Grain yield/plant under drought conditions for the parents, crosses and all genotypes were 46.13, 53.8 and 52.27 when compared under normal irrigation conditions, respectively. These results are in agreement with [15] ,[20],[21]

Table4. Mean performance and reduction % (R) of the seven parents and F_1-crosses for No. of spikes/plant, No. of grains/spike, 100-grain weight and Biological yield/plant under normal (N) and drought (D) irrigation.

Characteristics	No. of spikes/plant			No. of grains/spike			100-grain weight			Biological yield/plant		
	N	D	R	N	D	R	N	D	R	N	D	R
Giza 168 (P1)	8.67	7.50	13.49	63.50	50.33	20.74	4.00	3.50	12.50	65.34	38.85	40.54
Gemmeiza 11 (P2)	8.17	7.38	9.67	44.97	40.11	10.81	5.05	4.05	19.80	75.83	59.99	20.89
Shandaweel-1 (P3)	9.75	6.17	36.72	56.00	48.57	13.27	4.07	3.12	23.34	73.85	43.37	41.27
Giza 171 (P4)	8.67	7.00	19.26	61.55	49.60	19.42	4.22	3.47	17.77	73.81	47.70	35.37
Sids14 (P5)	8.67	7.83	9.69	63.73	58.67	7.94	4.80	3.32	30.83	86.51	56.61	34.56
MISR 3 (P6)	9.67	8.37	13.44	55.33	41.90	24.27	4.50	3.57	20.67	76.07	49.50	34.93
MISR 1 (P7)	12.50	8.33	33.36	65.93	50.23	23.81	4.43	3.90	11.96	89.87	48.30	46.26
$P_1 \times P_2$	9.50	8.21	13.58	69.00	57.47	16.71	4.43	3.62	18.28	78.80	49.01	37.80
$P_1 \times P_3$	10.25	8.58	16.29	74.33	59.23	20.31	4.67	3.70	20.77	97.62	72.12	26.12
$P_1 \times P_4$	11.17	8.54	23.55	74.33	54.67	26.45	4.82	3.98	17.43	100.32	68.60	31.62
$P_1 \times P_5$	13.00	10.07	22.54	68.67	55.60	19.03	4.80	3.95	17.71	99.17	72.13	27.27
$P_1 \times P_6$	12.00	9.00	25.00	67.67	55.23	18.38	4.62	3.63	21.43	89.49	49.03	45.21
$P_1 \times P_7$	9.67	7.00	27.61	64.33	50.00	22.28	4.93	3.53	28.40	93.06	59.38	36.19
$P_2 \times P_3$	9.92	8.00	19.35	64.00	50.50	21.09	4.55	4.22	7.25	82.96	57.67	30.48
$P_2 \times P_4$	9.67	8.73	9.72	67.71	34.33	49.30	4.65	2.80	39.78	89.81	40.71	54.67
$P_2 \times P_5$	10.67	8.54	19.96	60.11	42.67	29.01	4.85	3.13	35.46	92.14	49.75	46.01
$P_2 \times P_6$	11.33	7.07	37.60	52.63	32.89	37.51	4.50	3.75	16.67	80.05	43.03	46.25
$P_2 \times P_7$	9.33	6.00	35.69	48.61	41.60	14.42	4.78	3.47	27.41	78.01	45.98	41.06
$P_3 \times P_4$	10.00	8.00	20.00	59.40	50.33	15.27	4.93	3.46	29.82	81.63	50.58	38.04
$P_3 \times P_5$	9.33	8.33	10.72	67.33	48.00	28.71	4.02	3.60	10.45	80.63	55.09	31.68
$P_3 \times P_6$	10.67	7.87	26.24	65.67	38.67	41.11	4.21	3.55	15.68	81.48	40.77	49.96
$P_3 \times P_7$	11.67	8.50	27.16	56.13	51.67	7.95	4.80	3.95	17.71	90.41	55.97	38.09
$P_4 \times P_5$	11.33	8.33	26.48	58.33	46.33	20.57	5.03	3.00	40.36	95.11	45.93	51.71
$P_4 \times P_6$	12.00	9.67	19.42	64.67	54.67	15.46	4.83	4.02	16.77	95.18	61.52	35.36
$P_4 \times P_7$	11.67	10.25	12.17	60.00	50.33	16.12	4.88	3.53	27.66	92.02	60.58	34.17
$P_5 \times P_6$	12.33	10.01	18.82	68.00	41.67	38.72	4.83	3.90	19.25	100.51	56.24	44.05
$P_5 \times P_7$	11.33	9.17	19.06	53.67	42.53	20.76	4.62	3.92	15.15	84.53	50.63	40.10
$P_6 \times P_7$	11.33	9.13	19.42	64.33	41.67	35.22	4.50	3.37	25.11	83.88	45.13	46.20
Mean (p)	**9.44**	**7.51**	**20.44**	**58.72**	**48.49**	**17.42**	**4.44**	**3.56**	**19.82**	**77.33**	**49.19**	**36.39**
Mean (C)	**10.87**	**8.52**	**21.62**	**63.28**	**47.62**	**24.75**	**4.68**	**3.62**	**22.65**	**88.90**	**53.80**	**39.48**
Mean (G)	**10.51**	**8.27**	**21.31**	**62.14**	**47.84**	**23.01**	**4.62**	**3.61**	**21.86**	**86.00**	**52.65**	**38.78**
LSD'05	**0.67**	**0.69**	—	**5.30**	**4.13**	—	**0.30**	**0.260**	—	**7.04**	**5.09**	—
Red.% (P)	**20.44**			**17. 42**			**19.82**			**36.39**		
Red.% (C)	**21.62**			**24. 75**			**22. 65**			**39.48**		
Red.% (G)	**21.31**			**23.01**			**21.86**			**38.78**		

Table 5 Mean performance and reduction% (R) of the seven parents and F_1-crosses for Harvest index and Grain yield/plant under normal (N) and drought (D) irrigation and Yield stability index (YSI), Stress susceptibility index (SSI) and Sensitivity drought index (SDI).

Characteristics	Harvest index			Grain yield/plant					
Genotypes	N	D	R	N	D	R	YSI	DSI	SDI
Giza 168 (P1)	33.67	32.20	4.37	22.01	13.18	40.12	**0.60**	**0.77**	**0.40**
Gemmeiza 11 (P2)	24.41	19.99	18.11	18.49	11.99	35.15	**0.65**	**0.67**	**0.35**
Shandaweel-1 (P3)	30.07	21.57	28.27	22.18	9.37	57.75	**0.42**	**1.10**	**0.58**
Giza 171 (P4)	30.47	25.29	17.00	22.47	12.04	46.42	**0.54**	**0.89**	**0.46**
Sids14 (P5)	30.61	26.99	11.83	26.51	15.27	42.40	**0.58**	**0.81**	**0.42**
MISR 3 (P6)	31.68	25.28	20.20	24.07	12.50	48.07	**0.52**	**0.92**	**0.48**
MISR 1 (P7)	36.19	33.78	6.66	32.53	16.30	49.89	**0.50**	**0.95**	**0.50**
P_1 x P_2	36.94	34.78	5.85	29.13	17.01	41.61	**0.58**	**0.80**	**0.42**
P_1 x P_3	36.41	26.05	28.45	35.62	18.79	47.25	**0.53**	**0.90**	**0.47**
P_1 x P_4	39.84	27.10	31.98	39.98	18.60	53.48	**0.47**	**1.02**	**0.53**
P_1 x P_5	43.20	30.64	29.07	42.84	22.13	48.34	**0.52**	**0.92**	**0.48**
P_1 x P_6	41.89	36.77	12.22	37.49	18.03	51.91	**0.48**	**0.99**	**0.52**
P_1 x P_7	32.97	20.86	36.73	30.73	12.38	59.71	**0.40**	**1.14**	**0.60**
P_2 x P_3	34.99	29.47	15.78	28.96	17.00	41.30	**0.59**	**0.79**	**0.41**
P_2 x P_4	33.92	20.64	39.15	30.47	8.37	72.53	**0.27**	**1.39**	**0.73**
P_2 x P_5	33.76	22.85	32.32	31.14	11.41	63.36	**0.37**	**1.21**	**0.63**
P_2 x P_6	33.58	20.23	39.76	27.05	8.69	67.87	**0.32**	**1.30**	**0.68**
P_2 x P_7	27.75	18.84	32.11	21.68	8.65	60.10	**0.40**	**1.15**	**0.60**
P_3 x P_4	35.94	27.54	23.37	29.30	13.91	52.53	**0.47**	**1.00**	**0.53**
P_3 x P_5	31.32	26.20	16.35	25.30	14.43	42.96	**0.57**	**0.82**	**0.43**
P_3 x P_6	36.14	26.40	26.95	29.48	10.77	63.47	**0.37**	**1.21**	**0.63**
P_3 x P_7	34.74	30.92	11.00	31.41	17.31	44.89	**0.55**	**0.86**	**0.45**
P_4 x P_5	35.04	25.24	27.97	33.44	11.60	65.31	**0.35**	**1.25**	**0.65**
P_4 x P_6	39.41	34.46	12.56	37.52	21.18	43.55	**0.56**	**0.83**	**0.44**
P_4 x P_7	37.01	30.07	18.75	34.02	18.24	46.38	**0.54**	**0.89**	**0.46**
P_5 x P_6	40.26	28.83	28.39	40.51	16.24	59.91	**0.40**	**1.15**	**0.60**
P_5 x P_7	33.25	30.38	8.63	28.20	15.30	45.74	**0.54**	**0.88**	**0.46**
P_6 x P_7	39.12	28.38	27.45	32.88	12.80	61.07	**0.39**	**1.17**	**0.61**
Mean (p)	**31.01**	**26.44**	**14.74**	**24.04**	**12.95**	**46.13**	-	-	-
Mean (C)	**36.07**	**27.46**	**23.87**	**32.25**	**14.90**	**53.80**	-	-	-
Mean (G)	**34.81**	**27.21**	**21.84**	**30.19**	**14.41**	**52.27**	-	-	-
LSD'05	**3.37**	**3.51**	-	**4.19**	**1.83**	-	-	-	-
Red.% (P)	**14.74**			**46.13**			-	-	-
Red.% (C)	**23.87**			**53.80**			-	-	-
Red.% (G)	**21.84**			**52.27**			-	-	-

B- Drought tolerance indices:-

Yield stability index (YSI), stress susceptibility index (SSI) and the sensitivity drought index (SDI) for parents and their F_1-hybrids for grain yield/plant are illustrated in **Table 5.**

1 - Yield stability index (YSI) :-

On the basis of yield stability index (YSI) results for the parents showed that six parents; P1, P2, P4, P5, P6 and P7 were drought tolerant and gave medium yields compared to the crop under normal irrigation conditions. Regarding F_1-hybrids, the data exhibited that the nine F_1-hybrids; $P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_5$, $P_2 \times P_3$, $P_3 \times P_5$, $P_3 \times P_7$, $P_4 \times P_6$, $P_4 \times P_7$, and $P_5 \times P_7$ were tolerant for drought since they gave intermediate yield compared to yield under normal irrigation conditions.

2 - Stress susceptibility index (SSI) and sensitivity drought index (SDI)

The data showed that two parents, P1 and P2 possess stress susceptibility index (SSI) values of 0.77 and 0.67, respectively. These parents could be considered average susceptible to drought, these parents (P1 and P2) were less sensitivity drought index (SDI) according to sensitivity drought index of **[10] which** measures the difference in the performance of a genotype under two environments relative to the performance of a genotype under normal environment.

Results of SSI and SDI of the parents and the F1- hybrids indicated that all the parents were tolerant Drought except P3 (1.10) because the values of SSI was the greater than one. Low stress susceptibility (DSI < 1) is synonymous with higher stress tolerance. The parents with the highest drought tolerance based on the stress susceptibility Index (SSI) and the Drought Sensitivity Index (SDI) were Gemmeiza11 and P1with a value of (0.67, 0.77, 0.35, and 0.40) respectively and among the genotypes ten crosses were drought tolerant. The first parent, Giza 168, participated in four of them, and the seventh parent had three hybrids. The obtained results expressed the genetic difference among the studied hybrids, which offer chance to the selection for superior hybrids for grain yield. These results are in agreement with**[22], [23] ,[19]**

Combining ability variances:-

In Table 6. Mean squares due to GCA and SCA were highly significant for all studied traits under irrigated and drought. This reveals that the importance of the additive and non-additive effects for inheritance of these studied traits. These results are in harmony with those reported by **[24]**who found that both GCA and SCA mean squares were highly significant for all studied yield traits**. [25], [26]**

Table6. Mean squares of GCA and SCA for earliness and yield and its components traits.

SOV	d f	Number of spikes/plant		Biological yield /plant		No. of kernels/spike		100-grain weight		Grain yield /plant		Harvest index	
		Irrig	Stress	Irrig	Stress	Irrig	Stress	Irrig	Stress	Irrig	Stress	Irrig	Stress
GCA	6	2.30**	1.35**	67.22**	40.31**	89.93**	109.22**	0.10**	0.05**	42.65**	14.83**	28.79**	34.59**
SCA	21	1.56**	1.08**	87.30**	94.18**	38.68**	33.54**	0.09**	0.13**	36.96**	13.94**	14.72**	21.65**
Error	54	0.06	0.06	6.07	3.18	3.44	2.08	0.01	0.01	2.15	0.41	1.40	0.78
$\Sigma g^2i/\Sigma s^2ij$	-	0.165	0.140	0.084	0.045	0.273	0.378	0.130	0.041	0.129	0.118	0.229	0.180

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

1- General combining ability effects (gi) :-

The estimates of general combining ability effects of each parent for morphological traits, yield and its components are presented in **Table7.** The estimates of general combining ability effects proved that, the parental P1 was found to be good general combiner for number of kernels/spike, grain yield per plant, harvest index under two environments, biological yield /plant and 100-kernel weight under drought conditions. Data obtained indicated also, that, the parental P2 as good general combiner for 100-kernel weight under normal irrigation, while P4 was good general combiner for number of spikes/plant under drought. P5 was good general combiner for biological yield /plant and grain yield /plant under two environments and number of spikes/plant and number of kernels/spike under drought. P6 was good general combiner for number of spikes/plant and harvest index under two environments, while grain yield /plant under the normal irrigation. P7 was good general combiner for number of spikes/plant, under normal irrigation100-kernel weight and harvest index under drought. Similar results were reported by [27]

Table7. Estimates of general combining ability effects GCA of six parents for morphological and yield and its components traits.

Genotypes	Number of spikes/plant		No. of kernels/ Spikes		Biological yield / plant (g)		Grain yield / plant (g)		100 grain weight(g)		Harvest index	
	Irrig.	Droug	Irrig.	Drough	Irrig.	Drought	Irrig.	Drought	Irrig.	Drough	Irrig.	Droug
P_1	-0.13	0.03	5.36**	5.57**	0.12	2.97**	2.03**	2.00**	-0.08*	0.06*	2.24**	2.88**
P_2	-0.81**	-0.54**	-5.01**	-4.78**	-3.84**	-1.67**	-4.01**	-2.24**	0.10**	0.03	-3.19**	-3.48**
P_3	-0.30**	-0.51**	0.19	1.43**	-2.84**	-0.25	-1.90**	-0.48*	-0.18**	-0.02	-0.98*	-0.94**
P_4	-0.10	0.15*	1.16**	0.80	1.52	0.24	0.90	0.08	0.07*	-0.13**	0.41	-0.28
P_5	0.14	0.44**	0.72	1.27**	4.12**	2.42**	1.43**	0.71**	0.09**	-0.08**	-0.04	0.00
P_6	0.55**	0.37**	-0.39	-3.79**	-0.59	-2.94**	1.28**	-0.29	-0.05	0.05	1.70**	0.83**
P7	0.66**	0.06	-2.02**	-0.49	1.51	-0.77	0.27	0.22	0.05	0.08**	-0.14	0.98**
L.S.E (gi)0.05%	0.15	0.15	1.16	0.90	1.54	1.11	0.92	0.40	0.06	0.06	0.74	0.55
L.S.E (gi)0.01%	0.20	0.20	1.55	1.20	2.06	1.49	1.22	0.54	0.09	0.08	0.99	0.74

***and **: significant at 0.05 and 0.01 levels of probability, respectively**

2- Specific combining ability effects (S_{ij}):-

The estimates of specific combining ability effects (S_{ij}) of each cross for morphological traits, yield and its components traits are presented in **Table8**. The results showed that all studied traits exhibited significant specific combining ability affects either positive or negative sings in most cases. For Number of spikes/plant Under both condition, seven hybrids showed positive and significant or highly significant for SCA effects i.e. (P1× P5), (P2 × P3), (P2× P5) ,(P3× P7),(P4 × P6),(P4× P7) and (P5× P6) While (P1× P4), (P1× P4),(P1× P4) and (P1× P4) under irrigated condition and (P1× P2) ,(P1 × P3), (P2× P4), (P5 × P7) , and (P6× P7) under drought condition.

Nine hybrids that gave positive and significant values for the effects of specific ability were obtained out of 21 hybrids under irrigation conditions. While five hybrids were obtained that gave positive and significant values for the effects of specific ability out of 21 hybrids under drought conditions for No. of kernels/Spike.
The results showed that the best hybrids in terms of SCA effects for Biological yield / plant is (P1× P3) , (P1 × P4) , (P1 × P5) (P1× P7) , (P3 × P7) , (P4 × P6) and (P5 × P6) under irrigation and drought conditions, As for the grain yield / plant, we find the best hybrids for SCA effects is (P1 × P3), (P1 × P4), (P1 × P5) , (P1 × P6), (P2 × P3) (P3 × P7), (P4 × P6), (P4 × P7) and (P5 × P6) under irrigation and drought conditions . This hybrid was good SCA

effects (P1× P4), (P1 × P5), (P3 × P7), (P5 × P6) for both environments, (P1× P3), (P1 × P7) and (p3× p4) under irrigation conditions and (P2 × P3) (P4× P5), (P4 × P6) and (p5× p7) under drought environment for the weight of 100 grains. Eleven hybrids were obtained that gave positive and significant values for the effects of SCA out of 21 hybrids under irrigation conditions. Eight hybrids were obtained that gave positive and significant values for the effects of SCA out of 21 hybrids under drought conditions in relation to the harvest index. Similar findings were obtained by][14],[28]

Table8. Estimates of specific combining ability effects (Sij) of each F1 cross for morphological and yield and its components traits.

Genotypes	Number of spikes/plant		No. of kernels/ Spike		logical yield / plant		Grain yield / plant		100 grain weight		Harvest index	
	Irrig.	Drought	Irrig.	drought	Irrig.	drought	Irrig.	Drought	Irrig.	drought	Irrig	drought
$P_1 \times P_2$	-0.07	0.45*	6.52**	8.84**	-3.48	-4.94**	0.92	2.84**	-0.21**	-0.08	3.09**	8.11**
$P_1 \times P_3$	0.17	0.79**	6.64**	4.40**	14.33**	16.75**	5.30**	2.86**	0.31**	0.05	0.34	-3.16**
$P_1 \times P_4$	0.89**	0.09	5.68**	0.46	12.67**	12.74**	6.86**	2.11**	0.20*	0.44**	2.40*	-2.77**
$P_1 \times P_5$	2.48**	1.33**	0.45	0.92	8.92**	14.08**	9.18**	5.01**	0.17*	0.36**	6.20**	0.49
$P_1 \times P_6$	1.07**	0.33	0.56	5.61**	3.95*	-3.65*	3.99**	1.90**	0.12	-0.09	3.15**	5.79**
P1× p7	-1.37**	-1.36**	-1.14	-2.92*	5.42**	4.52**	-1.77	-4.26**	0.34**	-0.21**	-3.94**	-10.28**
$P_2 \times P_3$	0.53**	0.77**	6.68**	6.02**	3.65	6.94**	4.68**	5.31**	0.01	0.60**	4.35**	6.62**
$P_2 \times P_4$	0.07	0.85**	9.43**	-9.52**	6.13**	-10.50**	3.39**	-3.88**	-0.14	-0.71**	1.89*	-2.86**
$P_2 \times P_5$	0.83**	0.37*	2.27	-1.66	5.86**	-3.65*	3.53**	-1.47**	0.04	-0.42**	2.18*	-0.93
$P_2 \times P_6$	1.09**	-1.03**	-4.10**	-6.38**	-1.52	-5.01**	-0.41	-3.19**	-0.17*	0.06	0.26	-4.39**
P2 × P7	-1.02**	-1.79**	-6.50**	-0.96	-5.66**	-4.22**	-4.77**	-3.74**	0.01	-0.24**	-3.73**	-5.93**
$P_3 \times P_4$	-0.10	0.08	-4.09**	0.27	-3.05	-2.06	0.10	-0.09	0.43**	-0.01	1.70	1.48*
$P_3 \times P_5$	-1.01**	0.13	4.28**	-2.53*	-6.65**	0.27	-4.43**	-0.21	-0.51**	0.09	-2.46**	-0.13
$P_3 \times P_6$	-0.09	-0.27	3.72*	-6.81**	-1.09	-8.69**	-0.09	-2.87**	-0.17*	-0.10	0.61	-0.76
P3 × P7	0.80**	0.67**	-4.18**	2.90*	5.74**	4.34**	2.85*	3.16**	0.32**	0.28**	1.05	3.60**
$P_4 \times P_5$	0.78**	-0.53**	-5.68**	-3.57**	3.46	-9.37**	0.91	-3.60**	0.26**	-0.40**	-0.13	-1.75*
$P_4 \times P_6$	1.04**	0.88**	1.76	9.82**	8.25**	11.57**	5.14**	6.98**	0.19*	0.48**	2.50**	6.64**
P4 × P7	0.60**	1.77**	-1.28	2.19	2.99	8.46**	2.65*	3.53**	0.15	-0.03	1.93*	2.10**
$P_5 \times P_6$	1.14**	0.93**	5.53**	-3.65**	10.97**	4.11**	7.60**	1.41**	0.18*	0.32**	3.80**	0.73
P5 × P7	0.03	0.40*	-7.17**	-6.08**	-7.11**	-3.67*	-3.70**	-0.04	-0.14	0.31**	-1.37	2.13**
P6 × P7	-0.38*	0.43*	4.60**	-1.89	-3.05	-3.81**	1.14	-1.55**	-0.12	-0.37**	2.75**	-0.71
L.S.E	0.37	0.37	2.86	2.23	3.80	2.75	2.27	0.99	0.16	0.14	1.82	1.36
L.S.E	0.50	0.50	3.83	2.98	5.09	3.68	3.03	1.33	0.21	0.19	2.44	1.82

*, and **, significant at 0.05 and 0.01 levels of probability, respectively. *and **: significant at 0.05 and 0.01 levels of probability, respectivel.

REFERENCES

[1]**Roohi, E., Mohammadi, R., Niane, A. A., Niazian, M., and Niedbała, G. (2022).** Agronomic performance of rainfed barley genotypes under different tillage systems in highland areas of dryland conditions. Agronomy, 12(5), 1070.

[2]**Pequeno, D. N., Hernandez-Ochoa, I. M., Reynolds, M., Sonder, K., MoleroMilan, A., Robertson, R. D., ... and Asseng, S. (2021).** Climate impact and adaptation to heat and drought stress of regional and global wheat production. Environmental Research Letters, 16(5), 054070.

[3] **Abdalla, A., Stellmacher, T., and Becker, M. (2022).** Trends and prospects of change in wheat self-sufficiency in Egypt. Agriculture, 13(1), 7.

[4]**Adel, S., and Carels, N. (2023)**. Plant Tolerance to Drought Stress with Emphasis on Wheat. *Plants*, *12*(11), 2170.

[5]**Fischer, R. A., and Wood, J. T. (1979)**. Drought resistance in spring wheat cultivars. III.* Yield associations with morpho-physiological traits. Australian Journal of Agricultural Research, 30(6), 1001-1020.

[6]**Griffing, B. (1956).** A generalised treatment of the use of diallel crosses in quantitative inheritance. Heredity, 10(1), 31-50. (Triticum aestivum L.). *Tropical Plant Res*, *3*(2), 449-459.

[7]**Bouslama, M., and Schapaugh Jr, W. T. (1984).** Stress tolerance in soybeans. I. Evaluation of three screening techniques for heat and drought tolerance 1. *Crop science*, *24*(5), 933-937.

[8]**Fischer, R. A., and Maurer, R. (1978).** Drought resistance in spring wheat cultivars. I. Grain yield responses. Australian Journal of Agricultural Research, 29(5), 897-912.

[9]**Choukan, R., Hossainzadeh, A., Ghannadha, M. R., Warburton, M. L., Talei, A. R., and Mohammadi, S. A. (2006**). Use of SSR data to determine relationships and potential heterotic groupings within medium to late maturing Iranian maize inbred lines. *Field Crops Research*, *95*(2-3), 212-222.

[10]**Khalili, M., Naghavi, M. R., Aboughadareh, A. P., and Talebzadeh, S. J. (2012).** Evaluating of drought stress tolerance based on selection indices in spring canola cultivars (Brassica napus L.). *Journal of Agricultural Science*, *4*(11), 78.

[11]**Singh, R.K and B.D Chaudhury (1985).** Biometrical Methods in Quantitative Genetic Analysis. New Delhi-Ludhiana

[12]**Eid, M. H. (2009).** Estimation of heritability and genetic advance of yield traits in wheat (Triticum aestivum L.) under drought condition. International Journal of Genetics and Molecular Biology, 1(7), 115-120.

[13]**Moustafa, A., and Hussein, A. H. A. (2020).** Performance of some bread wheat cultivars under new land conditions at Middle Egypt. Egyptian Journal of Plant Breeding, 24(4), 721-742.

[14]**Abo-Sapra, H.M., Kheiralla, K.A., Abo-Elwafa, A., Hassaballa, E.A., and Habouh, M.A.F. (2018).** Performance and Combining Ability of Some Agronomic Traits of Bread Wheat Under Normal and Water Stress Conditions. Assiut Journal of Agricultural Sciences, 49(4), 1-14.

[15]**Qaseem, M. F., Qureshi, R., and Shaheen, H. (2019).** Effects of pre-anthesis drought, heat and their combination on the growth, yield and physiology of diverse wheat (Triticum aestivum L.) genotypes varying in sensitivity to heat and

[16]**Tawfelis, M. B. (2006).** Using biplot technique in wheat breeding under different environmental stresses. Egypt J. Plant Breed, 10(2), 167-200.

[17]**Ismail, A., A Ahmed, T., B Tawfils, M., and MA Khalifa, E. (2006).** Gene action and combining ability analysis of diallel crosses in bread wheat under moisture stress and non-stress conditions. Assiut Journal of Agricultural Sciences, 37(2), 17-33.

[18]**Nassar, S. M. A. M. (2013).** Genetic variance and combining ability in bread wheat under drought stress conditions (Doctoral dissertation, PhD. Thesis, Fac. Agric., Assiut Univ., Egypt).

[19]**Emam, M. A., Abd EL-Mageed, A. M., Niedbała, G., Sabrey, S. A., Fouad, A. S., Kapiel, T., ... and Mahmoud, S. A. (2022)**. Genetic characterization and agronomic evaluation of drought tolerance in ten egyptian wheat (Triticum aestivum L.) Cultivars. Agronomy, 12(5), 1217.

[20]**Rijal, B., Baduwal, P., Chaudhary, M., Chapagain, S., Khanal, S., Khanal, S., and Poudel, P. B. (2021)**. Drought stress impacts on wheat and its resistance mechanisms. Malays. J. Sustain. Agric, 5, 67-76.

[21]**Drwish, M. A., Mohamed, M. M., Ghalab, E., and Fares, W. M. (2023)**. Yield Productivity of Sixteen Egyptian Bread Wheat Varieties Grown under Middle Egypt and West West El-Minya Conditions. Journal of Plant Production, 14(6), 283-293.

[22]**Kadam, S., Shukla, Y., Subhash, N., Singh, C., and Suthar, K. (2017).** Screening of wheat genotypes (Triticum durum L.) in response to drought stress by some physiological and biochemical indices. Int. J. Pure App. Biosci, 5(3), 969-977.

[23]**Arifuzzaman, Mohammed, Berman, S. Haider, S. Azad, MAK, Turin, MTS, Amzad, MA, Masuda, MS (2020)**. subjected to multivariate analysis. Grain Communications, 48, 301-308.

[24]**El-Borhamy, H. S. A. 2005.** Estimation of heterosis and combining ability in some bread wheat crosses (*Triticum aestivum* L.). J. Agric. Sci. Mansoura Univ., 30(2): 755 - 762.

[25]**Shamsabadi E. E., H. Sabouri, H. Soughi, S. J. Sajadi (2020).** Genetic analysis of spike traits in wheat (Triticum aestivum L.)).- Genetika, Vol 52, No.2, 559-569.

Snedecor, G. W. and Cochran W. G (1967) Statistical methods, Eighth Edition, Iowa State University Press, USA.

[26]**Dragov, R. G. (2022).** Combining ability for quantitative traits related to productivity in durum wheat. Vavilov Journal of Genetics and Breeding, 26(6), 515.

[27]**Verma, S., Maurya, R., and Maurya, S. (2016).** Prediction of gene action and

[28]**Salam , M. A. ; Hammadi, H. J. and M. R. Azzam1(2019).** Estmation of Heterosis and combining ability for yield and its components of wheat. Vol. 19, Supplement 1, pp. 2691-2696, 2019**.**