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Combining Ability Analysis of Drought Tolerance Screening Techniques Among Wheat Genotypes (*Triticum aestivum*, L)

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ABSTRACT

In order to study the variations amongeset a half diallel cross using seven varieties for drought characters, estimating combining ability and genetic components. Two field experiments was carried out at the Experimental Farm of faculty of Agricultural- Tanta University during the two seasons 2016/2017 and 2017/2018, seven diverse wheat varieties (Triticum aestivum, L.) and 21 F1's were planted in two experiments. The first experiment was normally irrigated four times at different stages, the second one irrigated only once at tillering stage. The main results can be summarized as follow ; the water stress treatment decreased the means of flag leaf area (FLa), flag leaf angle (FLang), transpiration rate (TR), number of spikes/plant (NS/P), number of grains/spike (NK/S), 1000–grain weight (100-GW) and grain yield/plant (GY/P) for parents and their hybrids. The means of stomatal resistance (SR), chlorophyll a/b ratio (Chl a/b) and leaf temperature (LT) was increased under water stress. Irrigation mean squares were significant for all studied traits, indicating that the two irrigation regimes behaved differently for these characters. In addition, mean squares due to genotypes were highly significant for all traits except for FLA under stress condition. Mean squares of combining ability were highly significant for almost of all the studied traits under the two environments and their combined, indicating the presence of both additive and non additive types of gene effects in the genetic system controlling of these traits. The four parents Gemmeiza 12 (P1), Misr1(P2), Giza 171 (P3) and Giza 168 (P6) could be considered as excellent parents in breeding programs aimed to release parents to drought tolerance. The best parental combinations were ; Giza 168 (P6) x Gemmeiza 11 (P7), Giza171 (P3) x Giza 168 (P6), Giza 171 (P3) x Gemmeiza 11 (P7) and Gemmeiza 12 (P1) x Giza 168 (P6) for almost of the studied traits.

Keywords: *Triticum aestivum*, Drought tolerance, GCA, SCA, Water stress, , , Wheat cultivars.

INTRODUCTION

Wheat (*Triticum aestivum,* L.) is the major cereal crop in Egypt as well as several other countries. The increasing gap between production and consumption necessitates increasing wheat production in Egypt. To overcome this problem is to increasing the productivity of wheat through an efficient breading program.

Drought resistance in genotypes recently developed through breeding programs is mostly related to the plant's ability to protect itself from water loss under dry conditions, rather than plant tolerance against water loss. Protection from water loss is a result from different structural characteristics (root length, seedling power, plant height, leaf area, flowering duration, etc.) related to plant development phenology and physiology (Blum, 2006). Under environments where drought is experienced during the early growth periods, plant characteristics able to ensure germination–emergence and survival of seedlings should be taken into consideration (Monneveux and Ribaut, 2006).

Plant breeders focus on development of high yielding wheat cultivars by crossing good general combining parents and selecting desirable transgressive segregants from resulting hybrids for grain yield and other traits. Some researchers determined that the general combining ability effects for yield and other characters have played a significant role in selecting parents for grain yield (Akbar *et al.,* 2009).

The knowledge of combining ability is useful to assess differences among the genotypes and also, elucidate the nature and magnitude of gene actions involved. It has an important role to select parents and crosses and it helps to decide breeding methods to be followed to choose desirable individuals (Salgotra *et al.,* 2009; Mohammadi *et al*., 2010 and Nouri *et al*., 2011).

The main objectives of the present investigation are amid to assess the variations among seven wheat genotypes and their new combinations for drought tolerance characters, to estimate the magnitude of superiority, general combining ability (GCA) and specific combining ability (SCA) and to determine suitable measurements for drought resistance in wheat genotypes to improve wheat under drought conditions.

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm of faculty of Agricultural, Tanta University during the two seasons 2016/2017 and 2017/2018. Seven diverse wheat varieties (*Triticum aestivum, L*) i.e; Gemeza-12 (P_1), Misr1(P2), Giza-171 (P_3), sakha-94 (P_4), sids-12 (P_5), Giza-168 (P_6), and Gemmeiza 11 (P7) (P_7) representing a wide range of diversity for several agronomic characters and drought tolerance measurements were selected for this study. The commercial names, source and pedigree of the parents used in this study are presented in Table (1).

Table 1. The code No. commercial name, source and pedigree of the parents

CodeNO	genotypes name	Pedigree	Source
1	Gemmeiza 12 (P1)	OTUS /3/SARA/THB/VEE GMSS97YOO227S-5Y-010M-010Y-010M-2Y-1M-0Y-0GM	Egypt
2	Misr 1 (P2)	OASIS / SKAUZ //4*BCN/3/2*PASTOR CMSS00Y01881T-050M-030Y-030M-030WGY-33M-0Y-0S	Egypt
3	Giza 171 (P3)	Sakha 93 / Gemmeiza9 GZ003-101-1GZ-1GZ-2GZ-0GZ GZ003-101-1GZ-1GZ-2GZ-0GZ	Egypt
4	Sakha 94 (P4)	Opta / RayoN // KAVZ	Egypt
5	Sids 12 (P5)	BUC//7C/ALD/5/MAYA74/ON//1160- 147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SX. SD7096-4SD-1SD-0SD	Egypt
6	Giza 168 (P6)	MRl/BUG/SEPICM933046-8M-OY-OM•2Y-O3-OGZ.	Egypt
7	Gemmeiza 11 (P7)	BOW"S"/KVS"S"//7C/SERI82/3/GIZA168 (P6)/SAKHA61 GM-7892-2GM-1GM2GM-1GM-0GM	Egypt

Grains from each of the parental varieties were sown at a various sowing dates in order to overcome the differences in time of heading in 2016/17 growing season. During this season, all possible parental combinations without reciprocals were made among seven parents giving a total of twenty-one crosses.

The seven parents and their twenty one possible F_1 crosses were sown on 15th November in 2017/18 season. Two adjacent experiments were conducted. The first experiment was irrigated four times at the different wheat stages (non stress condition, N) and the second one was irrigated only once at tillering stage (stress condition, S). Each experiment was designed in a randomized complete block design with three replications. Each plot consisted of one row, 3 meters long with 20 cm between rows and plants within row were 20 cm. apart allowing a total of 15 plants per plot. The dry method of sowing (Afir) was used in this concern. The other cultural practices of growing wheat were practiced.

The following characters were recorded at 50 % heading stage for ten guarded plants chosen randomly per plot in each replicate: chlorophyll a/ chlorophyll b ratio (chl a/b), flag leaf area (Fla), flag leaf angle (Flang), stomatal resistance (SR,milimol/m2/s), transpiration rate (TR, milimol/m2/s), leaf temperature (LT,C^o), days to maturity (MD), plant hieght (PH), straw yield/plant (SY), harvest index (HI), No. of spikes/plant (NS/P), 1000- grain weight (1000-KW), No. of grains/spike (NK/S), grain yield/plant (GY), straw yield (Sy) and harvest index (H)) and drought susceptibility index (SI): It was calculated from genotype means for grain yield (SI) using the generalized formula reported by Fisher and Maurer (1978). Monthly average temperature and amount of rainfall are shown in Table (2).

Table 2. Monthly average temperature and amount of rainfall

Months	Temperature C		R.H.	Rain fall
	Max.	Min.	(%)	mm/month
Nov.2017	26.40	14.40	61.73	0.2
Dec.2018	20.70	10.05	64.07	0.7
Jan.2018	18.26	6.75	60.54	1.2
Feb.2018	24.22	9.10	50.50	0.5
Mar.2018	26.35	12.21	43.49	0.1
Apr.2018	34.13	14.44	36.20	0.2
May.2018	35.46	17.56	34.90	----

Statistical analysis:

The data of both experiments were subjected to proper statisical analysis of variance according to Snedecor and Cochran (1967). The combined analysis across the two experiments (stress and normal irrigation) were performed according to Cochran and Cox (1957). For comparason between means. General (GCA) and specific (SCA) combining ability estimates were obtained by employing Griffing (1956) diallel cross analysis designated as method 2 model 1.

RESULTS AND DISCUSSION

Analysis of variances:

Mean squares of different wheat genotypes for all studied characters in each environment and their combined data are presented in Table (3). Statistical analysis revealed significant of irrigation treatments for all studied characters, indicating that the two irrigation regimes behaved differently for these characters.

Table 3. Observed mean squares from analysis of variance for traits studied in field experiments

S.O.V.	d.f.		Chlorophyll a/b ratio			Flag leaf area (FLA)			Flag leaf angle (FLang)		
	S.	Com	NS	S	Com	NS	S	Com	NS	S	Com
Irrigation		1			4.91**			1199.22**			3120.10**
Rep I	2	4	0.01	0.01	0.01	3.59	45.78	24.69	3.46	0.94	2.20
Genotypes	27	27	0.17**	0.14**	0.14**	342.86**	367.33**	358.92**	31.05**	15.86**	25.81*
parent	6	6	0.05*	0.19**	0.08*	221.14**	568.60**	253.42**	19.76	31.30**	29.65**
Cross	20	20	0.20**	0.12**	0.17**	391.66**	325.32**	406.23**	35.12**	10.26*	23.41*
Par.vs.cr.	1	1	0.28**	0.31**	0.00	97.36*	0.09	45.71	17.29	35.06**	50.79**
GI		27			0.17**			351.27**			21.10*
par./I		6			0.16**			536.31**			21.41*
Cr./I		20			0.15**			310.74**			21.98*
Par.vs.cr.Vs.I		1			0.59**			51.75			1.56
Error	54	108	0.01	0.03	0.02	21.35	36.99	29.17	5.53	2.53	4.03
S.O.V.	d.f.		Stomatal resistance (SR)			Transpiration rate (TR)			Leaf temperature (LT)		
	S.	Com	NS	S	Com	NS	S	Com	NS	S	Com
Location		1			111.35**			40.80**			213.46**
Rep/L	2	4	0.42*	5.21**	2.82**	0.25**	0.21*	0.23*	63.46**	0.34	31.90**
Genotypes	27	27	3.25**	4.84**	7.48**	0.86**	1.00**	1.55**	9.67**	14.98**	20.23**
parent	6	6	0.56**	2.06**	2.16**	0.27**	0.56**	0.76**	9.18**	11.36**	17.82**
Cross	20	20	4.16**	5.61**	9.13**	1.04**	1.17**	1.84**	9.80**	16.66**	21.92**
Par.vs.cr.	1	1	1.10**	6.28**	6.32**	0.69**	0.09	0.64**	10.04**	3.05	1.01
G/L		27			0.61*			0.30**			4.41
par./L		6			0.47			0.07			2.72
Cr./L		20			0.64*			0.38**			4.54
Par.vs.cr.Vs.L		1			1.06**			0.14*			12.08*
Error	54	108	0.09	0.16	0.12	0.02	0.05	0.03	1.73	195	1.84

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

Table 3. Con.

S.O.V.	**d.f.**		**Days to maturity (MD)**			**Plant height (PH) cm**			**Straw yield (SY)**			**Harvest index (HI)**		
	S.	**Comb**	**NS**	**S**	**Com**	**NS**	**S**	**Com**	**NS**	**S**	**Com**	**NS**	**S**	**Com**
Location		1			2009.29**			2991.05**			26850.9**			73.23*
Rep/L	2	4	0.62	0.19	0.40	21.19**	11.01	16.10*	41.81	5.72	23.76	31.86	3.40	17.63
Genotypes	27	27	21.77**	2.72**	15.64**	67.28**	94.84**	93.23**	659.80**	162.13**	395.63**	144.03**	118.39**	100.15**
parent	6	6	25.76**	6.30**	25.75**	250.87**	6.52	123.13**	1070.57**	336.84**	686.07**	96.62**	378.16**	165.54**
Cross	20	20	9.94**	1.70**	6.52**	12.09*	84.09**	54.11**	567.16**	111.70**	327.85**	152.60**	41.66	84.54*
Par.vs.cr.	1	1	234.32**	1.59*	137.24**	69.55**	839.83**	696.38**	48.16	122.50**	8.52	257.08**	94.33**	19.98
G/L		27			8.85**			68.89**			426.31**			162.27**
par./L		6			6.32**			134.26**			721.34**			309.24**
Cr./L		20			5.12**			42.07**			351.01**			109.73**
Par.vs.cr.Vs.L		1			98.67**			213.01**		21.24	162.13			331.42**
Error	54	108	0.29	0.35	0.32	2.58	3.47	3.02	63.67	36.4	42.45	10.55	17.11	13.83

S.O.V.	d.f.		No. of spike/ plant (NS/P)			1000 kernel weight (1000-KW)			No. of kernel/spike (NK/S)			Grain yield/plant (GY/P)		
	S.	Comb	NS	S	Com	NS	S	Com	NS	S	Com	NS	S	Com
Location		1			847.94***			961.55**			6476.29**			5671.84**
Rep/L	2	4	2.13	1.22	1.67	13.29**	7.05	10.17*	19.70	0.03	9.86	21.76*	0.32	11.04
Genotypes	27	27	24.86**	7.66**	16.26**	25.75**	24.71**	37.16**	241.5**	267.78**	280.14**	92.87**	27.99**	64.39**
parent	6	6	18.21**	11.60**	22.13**	71.45**	44.98**	112.62**	179.56**	441.69**	424.43**	7.96	24.93**	14.88
Cross	20	20	23.36**	5.92**	14.59**	13.29**	19.50**	16.30**	240.97**	226.04**	224.09**	104.59**	29.97**	70.61**
Par.vs.cr.	1	1	94.76**	18.77**	14.59**	0.86	7.25	1.56	626.25**	59.24**	535.35**	367.94**	6.72	237.05**
G/L		27			16.26**			13.30*			229.23**			56.47**
par./L		6			7.68**			3.81			196.82**			18.01*
Cr./L		20			14.70**			16.49**			242.91**			63.96**
Par.vs.cr.Vs.L		1			98.94**			6.55			150.14**			137.61**
Error	54	108	1.26	0.79	1.02	1.40	2.70	2.05	17.66	12.23	14.94	5.15	3.48	4.32

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

In addition, mean squares due to genotype were highly significant for all traits except for FLA under stress condition, providing evidence for presence of large amount of genetic variability, which considered adequate for further biometrical assessment and possible selection of drought tolerant genotypes under water deficit, similar results were obtained by El-Hosary *et al.* (2012).

The development of any plant breeding program is dependent on the existence of genetic variability, the efficiency of selection and the expression of heterosis, and greatly dependent on the magnitude of genetic variability present in the plant population (Singh and Chaudhary, 1999). Significant differences for most traits were found among the parents at both conditions and their combined.

Meanwhile, significant differences of crosses mean squares were detected for all characters, except for FLA and HI under stress condition, reflecting the diversity of the parents for these studied characters, and that these diversity could be transmitted to the progenies. Also, mean squares of parent vs. crosses showed significant differences for most traits, indicating the presence of hybrid vigor of the studied wheat genotypes.

For all traits, mean squares of genotypes x environments interactions were significant, indicating that genotypes responded differently to water regime for these traits and reflecting the possibility of selecting the most tolerant genotypes. Mean squares of parents x environments, crosses x environment and parent vs. crosses x environment were highly significant for most traits, revealing that the performance of parents and/or most crosses were changed from environment to another, indicating the presence of genetic variation, genetic effects and the possibility of selection under both conditions (Farshadfar *et al.,* 2008).

Mean performances of the seven parents and their F_1 at normal irrigation and stress as well as their combined data for all the studied characters are presented in Table (4).

Results show that, the highest values for CHL a/b were recorded by Misr1(P2) under normal and stress conditions and Gemmeiza12 (P1) under combined analysis. Also hybrids, Giza 168 (P6) X Gemmeiza 11 (P7) followed by Gimmeiza 12 (P1) x Giza 171 (P_3) gave the highest values under non stress condition, Misr 1(P2) x Sids 12 (P_5) followed by Misr1(P2) x Gemmeiza 11 (P7) observed the highest values at stress condition and Giza168 (P6) x Gemmeiza 11 (P7), Misr 1(P2) x Gemmeiza 11 (P7), Misr 1(P2) x Giza 171 (P3) and Giza 171 (P3) x Giza 168 (P6) observed the highest values at the combined analysis, the similar results were obtained by Estehghari and Farshadfar (2014). For flag leaf area (FLA), the highest values were detected by Misr1(P2) under both conditions as well as the combined analysis. Also crosses, Gimmeiza 12 (P1) x Gimmeiza 11 (P7) at non stress condition and the combined data and Giza 168 (P6) x Gimmeiza11 (P7) under stress condition and the combined analysis. In respect to flag leaf angle (FLang), the lowest values were detected for Misr 1(P2) at normal and stress conditions as well as the combined analysis, Sids 12 (P5) x Gimmeiza 11 and Sids 12 (P5) x Giza 168 (P6) under non stress condition and combined analysis, Giza 171 (P3) x Giza 168 (P6) and Giza 171 (P3) x Gimmeiza 11 under stress condition and, Sakha 94 (P4) x Giza 168 (P6) under both conditions and their combined. The reduction in flag leaf angle reached 45.20%. Flag leaf is responsible for more than 70% photosynthesis and thus is very important for grain filling, Tabassum, *et al.,* (2017).

Table 4. The genotype mean performance for Chla/b, FLA, FLang, SR, TR and LT in both irrigation treatments as well as the combined data.

Traits	Chlorophyll a/b ratio			Flag leaf area (FLA)			Flag leaf angle (FLang)		
Genotypes	NS	S	Com	NS	S	com	NS	S	com
Gemmeiza 12 (P_1)	0.65	1.75	1.20	42.65	42.46	55.8	20.00	11.67	15.83
Misr 1 (P_2)	0.93	1.11	1.02	69.14	69.9	56.27	16.67	6.00	11.33
Giza 171 (P_3)	0.69	1.03	0.86	59.38	44.53	51.95	25.00	10.00	17.50
Sakha 94 (P_4)	0.61	1.38	0.99	48.78	30.39	39.58	18.67	10.00	14.33
Sids 12 (P_5)	0.83	1.07	0.95	51.27	60.87	56.07	18.67	15.00	16.83
Giza 168 (P_6)	0.59	1.16	0.87	50.1	39.62	44.86	20.00	15.00	17.50
Gemmeiza 11 (P_7)	0.60	1.24	0.92	56.29	38.98	47.64	20.00	13.33	16.67
1x2	0.45	0.96	0.71	53.31	32.61	42.96	20.00	10.00	15.00
1x3	1.26	1.18	1.22	49.64	52.38	51.01	21.67	10.00	15.83
1x4	0.74	1.23	0.99	62.06	48.66	55.36	16.67	8.67	12.67
1x5	0.61	1.55	1.08	61.78	46.50	54.14	16.67	8.67	12.67
1x6	0.57	1.18	0.87	55.93	38.52	47.23	23.33	8.67	16.00
1x7	1.03	1.42	1.22	78.25	44.68	61.47	18.33	13.33	15.83
2x3	0.57	0.98	0.77	49.59	39.61	44.60	23.33	10.00	16.67
2x4	0.87	0.94	0.90	48.40	40.56	44.48	18.33	10.00	14.17
2x5	0.95	1.22	1.09	61.02	57.92	59.47	23.33	8.67	16.00
2x6	0.53	1.38	0.96	54.89	37.51	46.20	23.33	13.33	18.33
2x7	0.86	1.18	1.02	35.54	57.34	46.44	20.00	13.33	16.67
3x4	0.74	1.00	0.87	42.21	30.25	36.23	16.67	10.00	13.33
3x5	1.02	1.15	1.08	55.83	61.42	58.62	16.67	9.33	13.00
3x6	1.11	1.31	1.21	57.02	50.17	53.60	16.67	8.00	12.33
3x7	0.93	0.83	0.88	28.80	47.36	38.08	25.00	8.00	16.50
4x5	0.47	0.93	0.70	45.05	34.61	39.83	16.67	13.33	15.00
4x6	0.99	0.99	0.99	50.94	58.68	54.81	15.00	8.00	11.50
4x7	0.66	0.93	0.80	35.24	40.45	37.84	18.33	8.67	13.50
5x6	0.97	0.86	0.91	37.41	54.31	45.86	13.33	10.00	11.67
5x7	0.77	0.90	0.83	55.80	39.09	47.44	13.33	10.00	11.67
6x7	1.39	1.11	1.25	61.87	69.22	65.54	18.33	11.67	15.00
average	0.80	1.14	0.97	52.08	46.74	49.41	19.07	10.45	14.76
Reduction %		-42.50			10.25			45.20	
LSD 5%	0.184	0.267	0.16	14.113	9.931	8.54	3.839	2.599	2.29
LSD 1%	0.245	0.355	0.21	18.771	13.208	11.33	5.106	3.457	3.04

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

Table 4. Con.

Traits	Stomatal resistance (SR) (cm/sec)			Transpiration rate (TR) (µg/cm^2/sec.)			Leaf temperature LT (^{0}C)		
Genotypes	NS	S	C	NS	S	C	NS	S	C
Gemmeiza 12 (P_1)	3.46	4.31	3.89	4.47	3.25	3.86	21.07	22.51	21.79
Misr 1 (P_2)	4.48	6.51	5.34	3.73	2.41	3.07	21.68	25.86	23.77
Giza 171 (P_3)	4.52	5.41	4.97	3.50	2.17	2.84	20.14	23.30	21.72
Sakha 94 (P_4)	3.7	4.91	4.31	4.09	3.19	3.64	22.38	27.41	24.90
Sids 12 (P_5)	3.85	5.34	4.60	4.01	3.17	3.59	22.47	26.38	24.43
Giza 168 (P_6)	3.31	4.29	3.81	3.95	2.84	3.40	24.19	27.26	25.73
Gemmeiza 11 (P_7)	4.21	6.01	5.12	3.99	3.15	3.57	25.19	26.67	25.93
1x2	3.31	5.29	4.31	3.13	2.45	2.79	22.50	22.53	22.52
1x3	3.97	6.23	4.94	4.03	2.70	3.37	21.86	21.55	21.70
1x4	3.4	5.10	4.26	4.57	2.78	3.68	23.48	25.56	24.52
1x5	2.43	4.14	3.79	4.59	2.38	3.49	22.81	23.07	22.94
1x6	3.18	6.44	4.82	3.28	2.00	2.64	19.37	23.32	21.35
1x7	3.49	4.55	4.03	3.37	3.22	3.30	24.17	26.35	25.26
2x3	4.5	7.29	5.90	2.95	2.30	2.63	22.16	27.80	24.98
2x4	4.08	5.71	4.90	3.91	2.79	3.35	22.61	25.06	23.84
2x5	3.8	5.10	4.46	3.37	2.89	3.13	21.59	22.01	21.80
2x6	3.39	5.80	5.10	4.33	3.87	4.10	25.38	24.71	25.05
2x7	3.48	4.72	4.11	4.44	3.80	4.12	22.76	23.97	23.37
3x4	4.13	6.49	5.32	3.79	2.67	3.23	22.56	25.20	23.88
3x5	4.19	6.71	5.46	2.82	1.66	2.24	20.10	21.22	20.66
3x6	7.3	8.73	8.02	3.30	2.13	2.72	23.73	25.05	24.39
3x7	6.7	8.83	7.94	3.25	2.06	2.66	24.97	28.85	26.91
4x5	3.78	4.87	4.33	4.05	3.18	3.62	22.14	25.75	23.95
4x6	3.66	4.86	4.27	3.41	3.24	3.33	24.86	26.36	25.61
4x7	3.48	4.76	4.13	4.52	3.70	4.11	26.10	28.75	27.42
5x6	3.82	5.26	4.55	3.66	3.24	3.45	23.76	28.82	26.29
5x7	3.42	4.76	3.93	4.67	3.49	4.08	26.18	27.61	26.90
6x7	7.29	7.97	6.97	3.38	2.39	2.89	25.03	25.42	25.23
Average	4.08	5.73	4.91	3.81	2.83	3.32	23.04	25.30	24.17
Reduction %		-40.44			25.75			-10.33	
LSD 5 %	0.0001	0.646	0.40	0.252	0.348	0.21	2.147	2.279	1.55
LSD 1 %	0.0001	0.859	0.53	0.335	0.463	0.28	2.855	3.031	2.05

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

It is clear from the data in Table (4) that the highest SR belonged to Giza 171 (P3) under normal condition and Misr1 (P2) at stress condition and combined analysis followed by Gemmeiza 11 (P7). The highest SR was obtained from the following crosses; Giza 171 (P3) x Gemmeiza11 (P7) and Giza 171 (P3) x Giza 168 (P6) and and Giza 168 (P6) x Gemmeiza 11 (P7) at two conditions and their combined. While, Gemmeiza 12 (P1) x Sids 12 (P5) showed the smallest SR under both conditions and their combined. The reduction in stomatal resistance reached -40.44%. The increase in stomatal resistance under water stress condition was due to the stomatal closure, Bousba *et al.* (2009) and Changhai *et al.* (2010). This is commonly found in many species and may indicate a control of stomatal conductance through hydraulic feedback mechanism (Giorio *et al.* 1999). Moreover (West *et al.*1990) showed that, the drought resistance cultivar had a significant higher stomatal resistance plants closed their stomata in response to the slight water stress condition, while the drought sensitive plants kept their stomata open.

With regard to transpiration rate (TR), the parents Giza 171 (P3) and Misr1(P2)showed the lowest values at the two conditions and their combined. While, Gemmeiza 12 (P1) revealed highest value at the two conditions and their combined. Also cross; Giza 171 (P3) x Sids12 (P5) showed the lowest values at the two conditions and their combined. The crosses; Mirs1 x Giza 171 (P3), Gimmeiza 12 x Giza 168 (P6) and Gimmeiza 12 x Misr1(P2) showed the lowest values at non stress, stress conditions and combined analysis respectivlly. Water stress treatment decreased the mean values of TR for parents and their hybrids by about 25.75%. This reduction may be due to the stomatal closure, Bousba *et al.* (2009) and Changhai *et al.* (2010).

Results showed that the mean values of leaf temperature (LT) for the parents and hybrids under water stress condition were lighter than that under normal condition

With regard to the parents, the lowest values LT were obtained from Giza 171 (P3), Gimmeiza 12 (P1) and Sids12 (P5) under the two conditions and their combined, while, the LT of Gemmiza 11 (P7) at the two conditions and their combined were the lightest. The lowest LT of wheat hybrids were obtained from Gemmeiza 12 (P1) x Giza 168 (P6) and Giza 171 (P3) x Sids 12 (P5) under the two conditions and their combined. The reduction in LT reached -10.33%. . These results were agreement with El-Hosary *et al.* (2012).

Table (5) showed that the lowest days to maturity were showed by Misr1(P2), Sids 12 (P5) and Gemmeiza 12 (P1) under the two conditions and their combined. The crosses; Sakha 94 (P4) x Giza 168 (P6) and Misr1(P2) x Giza 168 (P6) under the two conditions their combined, Sakha 94 (P4) x Sids 12 (P5) and Sakha 94 (P4) x Gemmeiza 11 (P7) under stress condition and Misr 1(P2) x Sids 12 (P5) and Gemmeiza 12 (P1) x Gemmeiza 11 (P7) under the combined analysis gave the lowest values. The reduction in MD reached 7.25%.

For plant height (PH), parents; Sakha 94 (P4), Sids 12 (P5) and Misr1(P2) were recorded the shortest than the other under non stress and stress conditions as well as the combined analysis. While, the tallest parent was Giza 171 (P3) under the two conditions and their combined.

The hybrid Sids12 (P5) x Gemmeiza 11 (P7) gave the lowest values under non stress and stress conditions as well as the combined analysis. While, crosses Miser1 x Sids 12 (P5) under normal condition and Gemmeiza 12 (P1) x Giza 168 (P6) and Giza 171 (P3) x Sakha 94 (P4) under stress condition and combined analysis, respectively, were recorded the highest values. The reduction in PH reached 9.7%. Similar results was reported by previous investigators Magda (2007) and Johari and Maralian(2011).

Yield and yield components:

The results presented in Table (5) clearly showed that water stress condition decreased the mean number of spikes per plant (NS/P), for the parents and hybrids. The highest NS/P belonged to Giza 168 (P6), Sakha 94, Misr 1(P2) and Gemmeiza 12 (P1) at the two conditions and their combined. While, Sids12 (P5) showed the smallest NS/P at the two conditions and their combined. Abd El-Aty and El-Borhamy (2007) found significant differences among wheat genotypes in NS/P. The highest NS/P was obtained from the following crosses; Giza 171 (P3) x Sakha 94 and Giza 171 (P3) x Gemmeiza 11 (P7) under non stress condition, Misr 1(P2) x Giza 171 (P3) under stress condition and Giza 171 (P3) x Giza 168 (P6) under combined data. Moreover, cross Misr 1(P2) x Sakha 94 gave the highest values under stress condition and combined analysis. The reduction in NS/P reached 11.34%.

With regard to number of grains per spike (NK/S), the parents Sids 12 (P5), Giza 171 (P3) and Gemmeiza 11 (P7) showed the highest values at the two conditions and their combined. Also crosses; Sids 12 (P5) x Gemmeiza 11 (P7) under non stress condition and combined analysis had the highest values. While, Giza 171 (P3) x Sids12 (P5) showed the highest values at the stress condition.

Water stress treatment decreased the mean values of NK/S for parents and their hybrids by about 36.5%. This reduction may be due to the effect of water deficit on pollination and fertilization processes, which lead to decreasing grains per spike. Similar results were obtained by Farhat (2005). In addition, several investigators reported that the reduction in NK/S was attributed to reducing seed set under water stress condition (Fisher and Maurer, 1978).

Results showed that the mean values of 1000- grain weight (1000-GW) for the parents and hybrids under water stress condition were lighter than that under normal condition. reported that the reduction of metabolites formation and its translocation from source to sink then 1000-KW was depressed. These results agreed with those obtained by Farhat (2005). With regard to the parents, the heaviest 1000-KW were obtained from Gemmeiza 12 (P1) , Sids 12 (P5) (P5), Misr 1(P2) and Gemmieza11 (P7) under the two conditions and their combined. The heaviest 1000-KW of wheat hybrids were obtained from Giza168 (P6) x Gemmeiza 11 (P7) and Sids12 (P5) x Gemmeiza 11 (P7) under non stress condition, Misr1 (P2) x Giza171 (P3) under stress condition, Gemmeiza 12 (P1) x Giza 168 (P6) under stress condition and combined data and Giza 171 (P3) x Sids 12 (P5) at two conditions and their combined. The reduction in 1000-KW reached 11.27%.

As a result of water stress condition, the average of grain yield/plant (GY/P) for parents and their hybrids was decreased. Several investigators reported that drought stress reduced photosynthesis and translocation rates and increased respiration, which reduced available assimilates for grain filling and finally decreased GY/P. Abd El-Aty and El-Borhamy (2007) found similar results. The highest

GY/P were showed by Misr1(P2) followed by Giza 171 (P3) under the two conditions and their combined. The hybrids, Giza 168 (P6) x Gemmeiza 11 (P7) and Sakha 94 x Sids 12 (P5) yielded more than the other crosses under non stress condition and combined data and Giza 171 (P3) x Sakha 94 (P4) under stress condition. The reduction in GY/P per plant reached 17.65%. Water stress caused significant reductions in most studied traits. These results were agreement with Gomaa *et al.,* (2014).

The highest values of straw yield/plant (SY/P gm) were showed by Sakha 94 (P4), Gemmeiza 12 (P1) and Giza 168 (P6) under the two conditions and their combined , While the lowest values was obtained by Sids 12 (P5) under non stress, stress conditions as well as the combined data. The hybrids, Misr 1 (P2) x Sids 12 (P5), Misr 1 (P2)x Giza 168 (P6), Gemmeiza 12 (P1) x Misr under normal condition, Gemmeiza 12 (P1) x Giza 168 (P6), Misr 1 (P2) x Gemmeiza 11 (P7) and Giza 171 (P3) x Sakha 94 (P4) under stress condition and Misr 1 (P2) x Sids 12 (P5), Misr 1 (P2)x Giza 168 (P6) and Misr 1 (P2)x Gemmeiza 11 (P7) at the combind data gave the highest values. The reduction in SY/P. reached 5.11%.

With regard to harvest index (HI), the highest values were recorded by Giza 171 (P3) followed by Sids12 (P5) under the two conditions and their combined. The crosses; Gemmeiza 12 (P1) x Sids12 (P5) and Giza 168 (P6) x Gemmeiza 11 (P7) under non stress condition and combined data and Misr1(P2)x Giza 168 (P6), Giza 171 (P3) x Gemmeiza 11 (P7) and Giza 171 (P3) x Sakha 94 (P4) under stress condition gave the highest values. The reduction in HI reached 4.26%. Abd El-Kareem, Thanaa and El-Saidy (2011), they found that water stress significantly decreased almost all the traits.

Drought susceptibility index (SI) of all wheat genotypes, which calculated for grain yield are presented in, Table (4). Results indicated that the wheat parents, Sakha 94 (P4), Giza 168 (P6), Giza 171 (P3) and Sids 12 (P5) gave the best desirable susceptibility to drought tolerance.

The susceptibility index for 21 crosses, indicated that the crosses of Gemmeiza 12 (P1) x Giza 171 (P3), Gemmeiza 12 (P1) x Sakha 94 (P4), Giza 171 (P3) x Sakha 94 (P4), Misr 1 (P2) x Giza 168 (P6), and Gemmeiza 12 (P1) x Misr 1 (P2) gave the best desirable susceptibility to drought tolerance. This result indicated that superior genotypes could be selected based on low value of SI. These results were coincident with those reported by Dorostkar *et al*. (2015).

Table 5. The genotype mean performance for MD, PH, SY, HI, NS/P, NK/S, 1000-KW, GY and SI in both irrigation treatments as well as the combined data.

Traits	**Days to maturity (MD)**			**Plant height (PH)**			**Straw yield (SY)**			**Harvest index (HI)**		
Genotypes	**NS**	**S**	**Com**	**NS**	**S**	**com**	**NS**	**S**	**com**	**NS**	**S**	**com**
Gemmeiza 12 (P_1)	132.67	123.33	126.33	88.6	92.91	82.15	78.9	40.06	51.83	30.63	31.25	30.94
Misr 1 (P_2)	129.33	122.33	127.5	81.3	72.6	77.11	50.55	28.09	39.57	22.83	25.87	30.90
Giza 171 (P_3)	138.67	124	132.67	101	75.7	86.8	45.75	26.53	39.32	35.92	53.91	38.37
Sakha 94 (P_4)	133.33	123.67	128.5	71.18	71.25	72.77	95.4	46.2	67.73	18.58	30.57	24.57
Sids 12 (P_5)	131.67	122.67	127.83	80.97	72.13	76.11	44.71	14.38	36.14	30.87	32.58	31.73
Giza 168 (P_6)	133.33	126.67	128	87.6	72.84	80.22	57.46	38.96	47.83	27.53	27.55	27.54
Gemmeiza 11 (P_7)	135.33	124.67	130	87.53	72.13	79.83	56.7	34.43	46.64	27.71	17.17	22.44
1x2	129.33	123.67	126.50	86.18	84.46	85.32	71.39	34.78	53.08	17.96	23.37	20.67
1x3	129.67	123.67	126.67	89.07	83.24	86.16	51.63	32.6	42.12	21.62	28.86	25.24
1x4	129.33	123.67	126.50	86.67	81.18	83.92	47.88	42.32	45.1	30.55	28.78	29.67
1x5	128.67	123.67	126.17	84.37	80.57	82.47	23.65	28.51	26.08	47.81	26.98	37.40
1x6	129.33	123.67	126.50	89.83	86.21	88.02	42.51	49.66	46.09	40.57	24.36	32.47
1x7	128.33	123.33	125.83	85.00	85.65	85.33	65.68	40.03	52.86	26.48	27.52	27.00
2x3	128.67	124.33	126.50	91.40	82.91	87.16	58.61	33.21	45.91	31.23	26.23	28.73
2x4	132.67	123.33	128.00	86.13	82.57	84.35	58.41	35.46	46.94	36.54	23.03	29.78
2x5	128.00	123.33	125.67	91.62	81.40	86.51	88.86	33.66	61.26	25.71	32.75	29.23
2x6	128.33	122.33	125.33	88.92	82.55	85.74	81.05	30.94	56	24.02	36.45	30.24
2x7	129.00	124.00	126.50	88.27	81.34	84.81	65.1	43.76	54.43	31.95	29.73	30.84
3x4	128.67	124.67	126.67	87.63	88.14	87.89	52.45	43.48	47.96	33.27	32.60	32.93
3x5	131.67	124.33	128.00	86.91	86.24	86.58	61.36	39.54	50.45	33.24	30.74	31.99
3x6	130.67	124.67	127.67	85.88	82.06	83.97	66.11	37.81	51.96	30.56	31.98	31.27
3x7	130.00	124.33	127.17	87.73	80.64	84.19	69.38	32.01	50.69	27.12	34.31	30.72
4x5	132.67	122.33	127.50	88.69	75.00	81.84	65.25	36.94	51.1	36.18	25.33	30.75
4x6	124.33	122.33	123.33	87.56	75.77	81.67	51.81	27.89	39.85	36.19	29.73	32.96
4x7	130.33	122.33	126.33	88.95	76.47	82.71	62.07	27.12	44.59	30.66	30.50	30.58
5x6	131.33	123.33	127.33	86.35	73.90	80.13	65.23	32.01	48.62	26.78	24.02	25.40
5x7	130.33	123.67	127.00	84.42	70.00	77.21	54.83	36.3	45.57	35.21	26.65	30.93
6x7	130.67	124.33	127.50	87.08	68.43	77.76	48.4	26.5	37.45	43.40	31.36	37.38
Average	133.33	123.67	128.50	87.03	78.59	82.81	60.04	34.76	47.4	30.75	29.44	30.10
Reduction%		7.25			9.7			42.11%			4.26	
LSD 5%	0.873	0.967	0.64	2.624	3.040	1.99	13.03	7.526	7.45	5.303	6.754	4.25
LSD 1%	1.161	1.287	0.86	3.490	4.043	2.64	17.33	10.009	9.87	7.053	8.983	5.64

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

Table 5. Con.

Traits	No. of spike/ plant (NS/P)			1000 kernel weight (1000-KW)			No. of spikelet/ spike (NK/S)			Grain yield/plant (GY/P)			SI
Genotypes	**NS**	**S**	**com**	**NS**	**S**	**com**	**NS**	**S**	**com**	**NS**	**S**	**com**	**0.93**
Gemmeiza12(P_1)	11.86	8.37	10.27	48.61	42.02	45.32	48.61	42.02	43.4	22.11	12.76	17.44	0.71
Misr 1 (P_2)	12.16	10.81	10.75	43.65	38.97	41.31	43.65	38.97	42.16	25.08	17.68	20.03	0.11
Giza 171 (P_3)	7.86	6.63	6.85	43.21	36.71	39.96	43.21	36.71	39.96	23.38	16.69	19.48	0.42
Sakha 94 (P_4)	12.16	10.1	11.13	32.60	30.00	31.30	32.6	30	31.3	21.28	12.05	18.57	1.14
Sids 12 (P_5)	7.06	5.83	6.85	44.77	40.28	42.53	44.77	40.95	42.67	20.45	12.12	16.28	1.00
Giza 168 (P_6)	13.33	11.13	11.27	42.61	35.86	39.24	42.61	35.86	39.24	20.68	14.84	17.76	0.80
Gemmeiza 11 (P_7)	8.99	8.16	9.9	43.38	36.72	40.05	43.38	36.72	41.31	22.05	9.49	15.77	1.16
1x2	13.63	4.93	9.28	40.17	40.81	40.49	40.17	40.81	40.49	15.61	10.51	13.06	1.22
1x3	11.09	5.63	8.36	42.26	40.30	41.28	42.26	39.63	40.95	13.98	13.21	13.60	1.53
1x4	9.96	8.00	8.98	42.71	40.48	41.60	42.71	39.82	41.27	21.08	17.11	19.10	1.02
1x5	11.09	8.76	9.93	39.91	34.31	37.11	39.91	34.64	37.28	21.68	10.54	16.11	0.66
1x6	11.49	8.88	10.19	43.95	40.94	42.45	43.95	40.94	42.45	29.05	15.94	22.50	0.89
1x7	13.83	8.76	11.30	41.57	35.32	38.44	41.57	35.32	38.44	23.65	15.19	19.42	0.63
2x3	14.29	6.16	10.23	42.30	41.03	41.67	42.30	41.03	41.67	26.65	11.74	19.20	0.45
2x4	18.38	7.35	12.87	43.20	39.23	41.22	43.20	39.23	41.22	33.61	10.48	22.05	0.91
2x5	15.97	6.98	11.48	43.53	39.71	41.62	43.53	39.05	41.29	30.55	16.52	23.53	0.85
2x6	11.60	9.86	10.73	42.42	38.16	40.29	42.42	38.16	40.29	25.11	17.74	21.43	0.78
2x7	16.09	7.05	11.57	37.63	36.38	37.00	37.63	36.38	37.00	30.51	17.86	24.19	0.36
3x4	11.31	9.02	10.17	41.32	40.56	40.94	41.32	40.56	40.94	25.95	20.60	23.27	1.48
3x5	12.70	6.40	9.55	45.26	40.93	43.10	45.26	40.93	43.10	30.21	17.61	23.91	1.32
3x6	18.76	8.50	13.63	43.42	37.38	40.40	43.42	37.38	40.40	29.21	17.74	23.48	1.25
3x7	12.80	7.33	10.07	40.35	36.12	38.24	40.35	36.12	38.24	25.75	16.61	21.18	0.90
4x5	13.81	7.13	10.47	40.65	37.11	38.88	40.65	37.11	38.88	37.01	12.24	24.63	1.25
4x6	11.63	7.28	9.46	42.37	34.35	38.36	42.37	35.02	38.70	29.38	11.85	20.62	1.22
4x7	14.09	8.00	11.05	43.98	35.98	39.98	43.98	35.31	39.65	27.41	11.92	19.67	0.62
5x6	9.28	5.30	7.29	42.20	38.14	40.17	42.20	38.14	40.17	23.35	10.04	16.70	1.49
5x7	7.43	7.45	7.44	45.73	35.04	40.39	45.73	35.04	40.39	29.71	12.98	21.35	1.26
6x7	12.51	10.03	11.27	46.67	33.63	40.15	46.67	33.63	40.15	37.11	12.15	24.63	0.93
Average	42.52	37.70	40.11	42.52	37.73	40.12	108.21	103.67	105.94	70.33	57.92	64.12	0.94
Reduction%		11.34			11.27			4.20			17.65		-
LSD 5%	1.831	1.450	1.16	1.931	2.685	1.64	1.931	3.146	1.83	3.707	3.045	2.37	-
LSD 1%	2.436	1.928	1.53	2.569	3.571	2.17	2.569	4.184	2.42	4.930	4.050	3.15	-

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined) , SI= susceptibility index**

Combining ability analysis:

Combining ability implies the capacity of parent to produce good progenies when crossed with the other parent.

Analysis of variance for combining ability as out lined by Griffing (1956) method 2 model 1 in each environment as well as their combined for all the studied traits are presented in Table (6). The results indicate that mean squares of general combining ability (GCA) and specific combining ability (SCA) were highly significant for all the studied traits under the two environments and their combined, indicating the presence of both additive and non-additive types of gene effects in the genetic system controlling of these traits. Gomaa *et al.* (2014) found the similar results.

Table 6. Observed mean squares from general and specific combining ability from diallel cross analysis for all studied traits

S.O.V.	d.f.		Chlorophyll a/b ratio			Flag leaf area (FLA)			Flag leaf angle (FLang)		
	S.	**Com**	**NS**	**S**	**Com**	**NS**	**S**	**Com**	**NS**	**S**	**Com**
GCA	6	6	0.03**	0.08**	0.03**	170.08**	132.96**	137.91**	15.31**	5.10**	5.67**
SCA	21	21	0.06**	0.04**	0.05**	98.35**	119.44**	114.42**	8.93**	5.34**	9.44**
GCA x L		6			0.07**			165.13**			14.74**
SCA x L		21			0.05**			103.37**			4.83**
Error	54	108	0.00	0.01	0.01	7.12	12.33	9.72	1.84	0.84	1.34
GCA/SCA			0.43	2.14	0.68	1.86	1.11	1.21	1.71	0.96	0.60
GCA x L/GCA					2.09			1.20			2.60
SCA x L/SCA					0.97			0.90			0.51

S.O.V.	d.f.		Stomatal resistance (SR)			Transpiration rate (TR)			Leaf temperature (LT)		
	S.	Com	NS	S	Com	NS	S	Com	NS	S	Com
GCA	6	6	1.96**	2.96**	4.81**	0.39**	0.62**	0.91**	8.12*	10.06**	17.09**
SCA	21	21	0.83**	1.23**	1.83**	0.26**	0.25**	0.40**	1.82*	3.54**	3.79**
GCA x L		6			0.12**			0.10**			1.09
SCA x L		21			0.23**			0.10**			1.58**
Error	54	108	0.03	0.05	0.04	0.01	0.02	0.01	0.58	0.65	0.61
GCA/SCA			2.36	2.41	2.62	1.52	2.47	2.26	4.45	2.84	4.51
GCA x L/GCA					0.02			0.10			0.06
SCA x L/SCA					0.13			0.25			0.42

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

Table 6. Con.

S.O.V.	d.f.		Days to maturity (MD)			Plant height (PH)			Straw yield (SY)			Harvest index (HI)		
	S.	Com	NS	S	Com	NS	S	Com	NS	S	Com	NS	S	Com
GCA	6	6	5.74**	2.61**	7.03**	39.81**	134.3**	133.74**	215.46**	36.40**	120.54**	31.11**	75.18**	60.39**
SCA	21	21	7.69**	0.42**	4.69**	17.46**	17.51**	26.39**	221.21**	59.08**	135.11**	52.84**	29.26**	43.14**
GCA x L		6			1.33**			46.93**			131.32**			45.89**
SCA x L		21			3.41**			40.37**			145.18**			38.95**
Error	54	108	0.10	0.12	0.11	0.86	1.39	1.12	21.22	7.08	14.15	3.52	5.70	4.61
GCA/SCA			0.75	6.26	1.50	2.28	7.67	8.58	0.97	0.62	0.89	0.59	2.57	1.40
GCA x L/GCA					0.19			0.35			1.09			0.76
SCA x L/SCA					0.73			1.53			1.07			0.90
S.O.V.	d.f.		No. of spike/ plant (NS/P)			1000 kernel weight (1000-KW)			No. of kernel/spike (NK/S)			Grain yield/plant (GY/P)		
	S.	Comb	NS	S	Com	NS	S	Com	NS	S	Com	NS	S	Com
GCA	6	6	9.55**	4.62**	10.64**	10.94**	17.13**	19.78**	95.73**	160.30**	227.64**	34.12**	10.26**	20.43**
SCA	21	21	7.93**	2.10**	4.62**	7.91**	5.70**	10.27**	76.19**	68.96**	55.02**	30.05**	9.06**	22.78**
GCA x L		6			3.53**			8.28**			28.39**			23.95**
SCA x L		21			5.40**			3.34**			90.13**			16.34**
Error	54	108	0.42	0.26	0.34	0.47	0.90	0.68	5.89	4.08	4.98	1.72	1.16	1.44
GCA/SCA			1.20	2.20	2.30	1.38	3.01	1.93	1.26	2.32	4.14	1.14	1.13	0.90
GCA x L/GCA					0.33			0.67			0.12			1.17
SCA x L/SCA					1.17			0.81			1.64			0.72

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

The mean squares of interaction between environment and each of GCA and SCA were significant for all the studied traits, except GCA x Env. for leaf temperature, revealing that the magnitudes of different type of gene action were varied from one environment to another.

The ratios of GCA/SCA were greater than unity under the two environments and the combined analysis for all traits, except chlorophyll a/b under non stress and the combined analysis, straw yield/plant under both environments and their combined analysis, flag leaf angle under stress condition and combined data. These results suggested predominant role of additive type of gene action for these traits and the potential for obtaining further improvements of these traits by using pedigree selection program. These results were coincident with those reported by Abd El-Aty and El-borhamy (2007), El-Hosary *et al.* (2009), El Nady (2009).

General combining ability effects:

Estimates of GCA (ĝi) effects of all wheat parental cultivars for each trait in combined data are presented in Table (7). Such effects are being used to compare the average performance of each parent with the other and facilitate selection of parents for further improvement to drought tolerance.

Table 7. Estimates of general combining ability effects for parental in both environments as well as the combined analysis.

Enotypes	Chlorophyll a/b ratio			Flag leaf area (FLA)			Flag leaf angle (FLang)		
	NS	S	com	NS	S	com	NS	S	com
Gemmeiza 12 (P1)	-0.05*	0.21**	0.08**	9.18**	-2.85*	3.17 **	0.46	-0.11	0.17
Misr 1 (P2)	-0.03	-0.03	0.03**	-3.18**	3.49**	0.16	1.01*	-0.70*	0.16
Giza 171 (P3)	0.07**	-0.07*	0.00	-1.64	-0.40	-1.02*	1.94**	-0.92**	-0.51**
Sakha 94 (P4)	-0.08**	-0.04	0.06**	-3.91**	-6.66**	- 5.28**	-1.51**	-0.55	1.03**
Sids 12 (P5)	0.00	-0.04	0.02	0.31	4.63**	2.47 **	-1.69**	0.71*	0.49**
Giza 168 (P6)	0.04	0.00	0.02	0.18	1.53	0.86 *	-0.29	0.67*	0.19
Gemmeiza 11 (P7)	0.05*	-0.03	0.01	-0.95	0.25	-0.35	0.08	0.89**	0.49**
gi	0.04	0.06	0.02	1.65	2.17	0.82	0.84	0.57	0.30
gi	0.05	0.08	0.03	2.19	2.88	1.11	1.11	0.75	0.41
gi-gj	0.06	0.09	0.04	2.52	3.31	1.44	1.28	0.87	0.54
gi-gj	0.08	0.12	0.05	3.35	4.40	1.95	1.70	1.15	0.73
Genotypes	Stomatal resistance (SR)			Transpiration rate (TR)			Leaf temperature (LT)		
	NS	S	Com	NS	S	com	NS	S	com
Gemmeiza 12 (P1)	-0.59**	-0.61**	-0.60**	0.16**	-0.06	0.05**	-0.89**	-1.67**	-1.28**
Misr 1 (P2)	-0.09	0.12	0.02	-0.10**	0.03	0.03*	-0.44	-0.51*	-0.48**
Giza 171 (P3)	0.80**	1.03**	0.91**	-0.37**	-0.53**	0.45**	-0.97**	-0.68**	-0.82**
Sakha 94 (P4)	-0.30**	-0.47**	-0.39**	0.22**	0.24**	0.23**	0.24	1.01**	0.63**
Sids 12 (P5)	-0.32**	-0.48**	-0.40**	0.08**	0.06	0.07**	-0.32	-0.13	-0.22*
Giza 168 (P6)	0.25**	0.20**	0.23**	-0.13**	0.00	0.07**	0.68**	0.65*	0.67**
Gemmeiza 11 (P7)	0.25**	0.20**	0.23**	0.13**	0.26**	0.20**	1.69**	1.32**	1.51**
gi	0.11	0.14	0.05	0.05	0.08	0.03	0.47	0.50	0.21
gi	0.14	0.19	0.07	0.07	0.10	0.04	0.62	0.66	0.28
gi-gj	0.16	0.22	0.09	0.08	0.12	0.05	0.72	0.76	0.36
gi-gj	0.22	0.29	0.13	0.11	0.15	0.07	0.95	1.01	0.49

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

GCA (ĝi) in this study was found to be significantly differed from zero in all traits. High positive values would be highly appreciated under all the studies traits, except flag leaf angle, leaf temperature, transpiration rate, days to maturity and plant height where high negative effects would be useful from the breeder's point of view. The part of variance due to SCA was greater than GCA for most of the characters indicating the importance of non-additive gene action (Akram *et al.* 2011)

It could be concluded that the traits which the negative direction are interested the parent Giza 171 (P3) was the best combiners for flag leaf angle, transpiration rate and leaf temperature, parent Gemmeiza12 (P1) for days to maturity and leaf temperature and two parents Sakha94 (P4) and Sids12 (P5) for plant height indicating that these varieties considered as a good tolerant combiner for drought. With respect to the traits, which the positive direction are interested, one parent Gemmeiza12 (P1) for chlorophyll a/b ratio, flag leaf area and 1000 grains weight, Sakha 94 (P4) for No. of spike per plant and straw yield/plant Giza 171 (P3) for harvest index and grain yield/plant and Sids 12 (P5) for No. of grain per spike, three parents Giza 171 (P3) , Giza 168 (P6) and Gemmeiza 11 (P7) for stomatal resistance, four parents Miser1 (P_2), Giza 171 (P3), Sakha 94 (P4) and Giza 168 (P6) for grain yield/plant. Therefore, the four parents Gemmeiza 12 (P1), Misr1(P2), Giza 171 (P3) and Giza 168 (P6) could be considered as excellent parents in breeding programs aimed to release parents to drought tolerance.

Table 7. Con.

Genotypes	**Days to maturity (MD)**			**Plant height (PH)**			**Straw yield (SY)**			**Harvest index (HI)**		
	NS	**S**	**com**	**NS**	**S**	**com**	**NS**	**S**	**com**	**NS**	**S**	**com**
Gemmeiza 12 (P1)	-0.37**	-0.04	-0.20**	0.23	5.31**	2.77**	-8.50**	0.67	3.91**	0.02	-1.46	0.72*
Misr 1 (P2)	-1.11**	-0.19	-0.65**	-0.20	0.12	-0.001	3.61*	0.29	1.95**	-3.66**	-1.35	-2.51**
Giza 171 (P3)	1.33**	1.11**	1.22**	-3.82**	5.52**	4.67**	4.11**	-3.41**	0.35	0.32	6.34**	3.33**
Sakha 94 (P4)	-0.37**	-0.30**	-0.33**	-3.14**	-1.97**	-2.55**	5.37**	1.70*	3.53**	-0.61	-0.49	-0.55
Sids 12 (P5)	0.37**	-0.44**	-0.04	-1.33**	-3.11**	-2.22**	-3.30*	-2.00*	2.65**	2.29**	-0.43	0.93**
Giza 168 (P6)	-0.37**	-0.37**	-0.37**	0.51	-2.75**	-1.12**	-1.31	0.52	0.4	1.17*	-0.27	0.45
Gemmeiza 11 (P7)	0.52**	0.22*	0.37**	0.03	-3.12**	-1.54**	0.01	2.23**	1.12*	0.47	-2.34**	-0.94**
gi	0.19	0.21	0.09	0.57	0.66	0.26	2.84	1.64	0.99	1.16	1.47	0.56
gi	0.25	0.28	0.12	0.76	0.88	0.36	3.78	2.18	1.34	1.54	1.96	0.76
gi-gj	0.29	0.32	0.15	0.87	1.01	0.46	4.34	2.51	1.74	1.77	2.25	0.99
gi-gj	0.39	0.43	0.20	1.16	1.35	0.63	5.78	3.34	2.36	2.35	2.99	1.35
Genotypes	No. of spike/ plant (NS/P)			1000 kernel weight (1000-KW)			No. of grain /pike (NK/S)			Grain yield/plant (GY/P)		
	NS	S	com	NS	S	com	NS	S	com	NS	S	com
Gemmeiza 12 (P1)	-0.42*	-0.12	-0.27**	0.85**	1.59**	1.22**	-1.94*	-4.64**	-3.29**	-4.10**	-0.58	-2.34**
Misr 1 (P2)	1.74**	-0.03	0.86**	-0.40	1.27**	0.44**	-4.34**	-1.43*	-2.89**	0.67	0.78**	0.72**
Giza 171 (P3)	-0.22	-0.72**	-0.47**	0.13	0.88**	0.51**	1.86*	0.21	1.03**	-0.85*	1.96**	0.56**
Sakha 94 (P4)	0.54**	0.62**	0.58**	-2.30**	-1.57**	-1.93**	-2.00**	-0.22	-1.11**	1.20**	-0.54	0.33*
Sids 12 (P5)	-1.58**	-1.00**	-1.30**	0.74**	0.44	0.59**	4.40**	6.95**	5.67**	0.80	-1.00**	-0.10
Giza 168 (P6)	0.37	1.03**	0.70**	0.68**	-0.84**	-0.08	-1.47	-4.59**	-3.03**	0.93*	0.22	0.57**
Gemmeiza 11 (P7)	0.43*	0.24	-0.10	0.28	-1.77**	-0.74**	3.50**	3.72**	3.61**	1.34**	-0.84*	0.25
gi	0.40	0.31	0.15	0.42	0.59	0.22	1.50	1.25	0.58	0.81	0.66	0.31
gi	0.53	0.42	0.21	0.56	0.78	0.29	1.99	1.66	0.79	1.08	0.88	0.43
gi-gj	0.61	0.48	0.27	0.64	0.90	0.38	2.29	1.90	1.03	1.24	1.02	0.55
gi-gj	0.81	0.64	0.37	0.86	1.19	0.52	3.04	2.53	1.40	1.64	1.35	0.75

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

Specific combining ability effects (Sij):

SCA (Sij) of the parental combinations computed for all traits in combined analysis are presented in Table (8).

In the combined analysis; significant positive SCA effects under non stress and stress conditions as well as the combined analysis were found in the crosses ; Giza171 (P3) x Giza168 (P6) for Chlorophyll a/b ratio, Giza 168 (P6) x Gemmeiza11 (P7), Giza171 (P3) x Sids 12 (P5) and Gemmieza 12 x Sakha 94 (P4) for falg leaf area, Gzia 171(P3) x Giza 168 (P6), Giza 171 (P3) x Gemmeiza 11 (P7) and Giza 168 (P6) x Gemmeiza 11 (P7) for stomatal resistance, Gemmieza 12 (P1) x Giza 171 (P3) for plant height, Gemmeiza 12 (P1) x Gemmeiza 11 (P7) for straw yield/plant, Giza 168 (P6) x Gemmeiza11 (P7) for harvest index, Gemmeiza 12 (P1) x Sids 12 (P5) for No. of spike per plant, Gemmeiza 12 (P1) x Sakha 94 (P4) for No. of grains per spike, Gemmeiza 12 (P1) x Sakha94 (P4), Misr 1 (P2) x Sakha94 (P4) and Giza 171 (P3) x Sids (P5) for 1000 grains weight and Gemmeiza 12 (P1) x Giza 168 (P6), Misr1(P2) x Sids 12 (P5), Misr1(P2) x Gemmeiza 11 (P7) and Giza171 (P3) x Sids 12 (P5) for grain yield per plant. Significant negative SCA effects were detected in some parental combinations for these traits under non stress and stress conditions and their combined; Giza 171 (P3) x Giza 168 (P6), Sids12 (P5) x Giza 168 (P6) and Sids12 (P5) x Gemmeiza 11 (P7) for flag leaf angle, Gemmeiza 12 (P1) x Misr1(P2), Gemmiza 12 x Giza 168 (P6), Giza 171 (P3) x Sids12 (P5) and Giza 168 (P6) x Gemmeiza 11 (P7) for transpiration rate, Gemmeiza 12 (P1) X Giza 168 (P6) for leaf temperature, Sakha 94 (P4) x Giza 168 (P6) for days to maturity and Misr1(P2) x Sakha 94 (P4) and Misr1(P2) x Sids 12 (P5) for plant height. EL-Hosary *et al.* (2012) found similar results.

Generally the best parental combinations were ; Giza 168 (P6) x Gemmeiza 11 (P7), Giza171 (P3) x Giza 168 (P6), Giza 171 (P3) x Gemmeiza 11 (P7) and Gemmeiza 12 (P1) x Giza 168 (P6) for most studied traits. These crosses could be successfully need for breeding to drought tolerant in wheat. The results obtained herein concerning general and specific combining ability effects indicated that the excellent hybrid combinations were obtained from the three possible combinations between the parents of high and low general combining ability effects *i.e.* high x high , high x low and low x low. Consequently it could be concluded that general combining ability effects of the parental lines were generally unrelated to the specific combining ability effects of their respective crosses.

Table 8. Estimation of specific combining ability for crosses from a half diallel in wheat in both environments

Crosses	Chlorophyll a/b ratio			Flag leaf area (FLA)			Flag leaf angle (FLang)		
	NS	S	Com	NS	S	Com	NS	S	Com
P_1 x P_2	-0.26**	-0.36**	0.31**	-4.77**	-14.78**	-9.77**	-0.54	0.35	-0.09
P_1 x P_3	0.44**	-0.11	0.17	-9.98**	8.90**	-0.54	0.20	0.57	0.39
P_1 x P_4	0.06	-0.08	0.01	4.71**	11.43**	8.07*	-1.35	-1.13	-1.24
P_1 x P_5	-0.14*	0.24**	0.05	0.21	-2.02	-0.91	-1.17	-2.39**	-1.78
P_1 x P_6	-0.22**	-0.18*	0.20*	-5.51*	-6.89*	-6.20	4.09**	-2.35**	0.87
P_1 x P_7	0.23**	0.10	0.16	17.94**	0.55	9.24**	-1.28	2.09*	0.41
P_2 x P_3 x P	-0.27**	-0.06	0.17	2.33	-10.21**	-3.94	1.31	1.17	1.24
P_2 x P_4	0.18**	-0.14	0.02	3.40	-3.02	0.19	-0.24	0.80	0.28
P_2 x P_5	0.18**	0.15	0.17	11.81**	3.06	7.43*	4.94**	-1.80*	1.57
P_2 x P_6	-0.27**	0.27**	0.001	5.80*	-14.25**	-4.23	3.54**	2.91**	3.22
P_2 x P_7	0.05	0.09	0.07	-12.41**	6.86**	-2.78	-0.17	2.69**	1.26
P_3 x P_4	-0.05	-0.03	0.04	-4.32	-9.43**	-6.87*	-2.83*	1.02	-0.91
P_3 x P_5	0.15*	0.12	0.13	5.08*	10.45**	7.77*	-2.65*	-0.91	-1.78
P_3 x P_6	0.21**	0.23**	0.22*	6.41**	2.31	4.36	-4.06**	-2.20**	-3.13*
P_3 x P_7	0.02	-0.21*	0.10	-20.68**	0.78	-9.95**	3.91**	-2.43**	0.74
P_4 x P_5	-0.26**	-0.13	0.19*	-3.43	-10.11**	-6.77*	0.80	2.72**	1.76
P_4 x P_6	0.23**	-0.11	0.06	2.59	17.07**	9.83**	-2.28	-2.57**	-2.43
P_4 x P_7	-0.11	-0.14	0.12	-11.99**	0.12	-5.93	0.69	-2.13*	-0.72
P_5 x P_6	0.12*	-0.24**	0.06	-15.16**	1.42	-6.87*	-3.76**	-1.83*	-2.80*
P_5 x P_7	-0.09	-0.17	0.13	4.36	-12.52**	-4.08	-4.13**	-2.06*	-3.09*
P_6x P_7	0.50**	0.00	0.25**	10.56**	20.71**	15.63**	-0.54	-0.35	-0.44
Sij	0.12	0.17	0.17	4.79	6.30	6.72	2.44	1.65	2.50
Sij	0.16	0.23	0.24	6.37	8.38	9.12	3.24	2.19	3.39
sij-sik	0.17	0.25	0.15	7.11	9.36	5.76	3.62	2.45	2.14
sij-sik	0.23	0.33	0.20	9.46	12.45	7.82	4.81	3.26	2.91
sij-ski	0.16	0.24	0.05	6.65	8.76	2.04	3.39	2.29	0.76
sij-ski	0.22	0.31	0.07	8.85	11.65	2.76	4.50	3.05	1.03

***and ** significant at 0.05 and 0.01 respectively NS= Normal irrigation S= one irrigation Com=(Combined)**

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تحليل القدرة على التألف لتكنيك فرز التحمل للجفاف بين التراكيب الوراثية للقمح

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تهدف الدراسة الى تقيم التراكيب الوراثية للقمح فى تجرتين الأولى تحت ظروف الرى العادى والثانية تحت ظروف الجفاف فى ثلاث مكررات كاملة العشوائية. وفيما يلى أهم ملخص لأهم النتائج: اظهرت النتائج ان التباين الراجع لكل من التراكيب الوراثية والاباء والهجن معنويا لكل من النسبة بين كلورفيل أ ، كلوروفيل ب (a/b) –وزاوية الورقة العلم، مقاومة الثغور، ومعدل النتح، ، وعدد السنابل لكل نبات، ون الالف حبة و عدد الحبوب لكل سنبلة تحت ظروف الرى العادى والجفاف والتحليل المشترك. اظهرت النتائج ان السلالات الابوية مصرا(P1) ،وسدس 12(P5) ، جيزة 171(P3) وجميزة 12 (P1) أفضل القيم لمعظم الصفات تحت الدراسة مثل محصول الحبوب، وزن الالف حبة، عدد السنابل للنبات، عدد الحبوب/سنبلة، ودليل الحساسية للجفاف، ودليل الحصاد وعدد الايام حتى النضج الفسيلوجى تحت ظروف ظروف الرى العادى والجفاف والتحليل المشترك. اظهرت النتائج ان الهجن جيزة171 x سدس12، جيزة 168 x جميزة11 افضل القيم لصفات.دليل الحساسية للجفاف ، دليل الحصاد، ومعدل النتح، ودرجة حرارة الورقة، ومساحة الورقة العلم، وزن الالف حبة، عدد السنابل للنبات الفردى و محصول الحبوب للنبات الفردى و عدد الحبوب لكل سنبلة تحت ظروف الرى العادى والجفاف والتحليل المشترك. اشارت النتائج ان التباين الراجع للقدرة العامة (GCA) والخاصة على الائتلاف (SCA) معنويا فى الصفات تحت الدراسة. اظهرت النتائج ان النسبة بين القدرة العامة/القدرة الخاصة أعلى من الوحدة لجميع الصفات تحت الدراسة ما عدا الصفات نسبة كلوروفيل أ/ كلوروفيل ب ودليل الحصاد ومحصول القش للنبات تحت ظروف الرى العادى والجفاف والتحليل المشترك، زاوية الورقة العلم تحت ظروف الجفاف والتحليل المشترك ومحصول الحبوب للنبات الفردى تحت التحليل المشترك. اظهرت النتائج ان النسبة بين القدرة العامة وتفاعلها مع معاملات الرى/القدرة العامة اقل من القدرة الخاصة وتفاعلها مع معاملات الرى/القدرة الخاصة لمعظم الصفات تحت الدراسة مما يدل على ان التفاعل الجينى السيادى هو السائد فى توريث معظم الصفات تحت الدراسة.
اوضحت النتائج ان السلالت الابوية جميزة 12، مصر1، جيزة171 وجيزة 168 قدرة عامة على الائتلاف موجبة ومعنوية لصفات وزن الالف حبة، محصول الحبوب للنبات الفردى، مقاومة الثغور وعدد السنابل/النبات واظهرت كل من السلالات الابوية جميزة12،مصر، جية171، سخا94 وجية 168 قدرة عامة سالبة لصفات عدد الايام حتى النضج الفسيولوجى ، معدل النتح، ودرجة حرارة الورقة وارتفاع النبات أظهرت الهجن جيزة 168 x جميزة11، جيزة 171 x جيزة 168 ، جيزة x171 جميزة 11 وجميزة x12 جيزة 168 قدرة خاصة على الائتلاف لمعظم الصفات تحت الدراسة تحت ظروف الرى العادى والجفاف والتحليل المشترك. توصى الدراسة بادخال الاباء ذات قدرة عامة عالية على التالف مثل جميزة 12، مصر1، جيزة171 وجيزة 168 وكذلك الهجن ذات القدرة الخاصة العالية على التالف كاباء وهجن مبشرة فى برامج التربية لتحمل الجفاف.