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Combining Ability of Some Bread Wheat Genotypes for yield and its Components under Normal Watering and Water-Stress Conditions

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Cross Mark

ABSTRACT

A diallel cross set was carried out at the Experimental Farm of Gemmeiza Agriculture Research Station, Agriculture Research Center, (ARC), Egypt, during the two winter seasons of 2017/2018 and 2018/2019 to assess the variations among six wheat genotypes and their new combinations to estimate heterosis, general and specific combining abilities to determine suitable measurements for drought tolerance in wheat genotypes. Genotypes and the resulted crosses mean squares were found to be either significant or highly significant for all the studied traits under normal and stress environments as well as the combined analysis, except for chlorophyll-a under drought. General combining ability and specific combining ability were found to be significant for all the studied characters under both conditions, except plant height for (SCA) under normal condition, chlorophyll-a for GCA under normal and drought as well as combined analysis and SCA under water-stress condition. The GCA/SCA ratios were found to be greater than unity, suggesting that, additive was much larger and more important than non-additive gene effects in the inheritance of these traits. The two parents Line 1 and Line 3 could be considered as excellent parents in breeding programs aimed to release drought tolerance cultivars. P_1, P_3, P_4, P_5 and P6 had the lowest drought susceptibility index value and F_1 crosses P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_5, $P_2xP_6$and P_3xP_5would be classified as drought tolerance due to the least reduction in yield under water stress compared to normal condition, such results might be useful for improving drought tolerance in wheat breeding program.

Keywords: Wheat, Heterosis, General and specific combining ability and Drought susceptibility index.

INTRODUCTION

Wheat is considered as the first strategic food crop all over the world as well as in Egypt. Exposure wheat plants to various stresses during the growing season caused reductions in crop yield. Wheat cultivars that can withstand abiotic stresses will be able to fulfill the food demand in coming years (Ali *et al*., 2020). Increasing wheat production under certain abiotic stress condition, i.e., drought stress, has become important during recent years, since wheat production in these areas with optimum growth conditions does not meet the needs of over increasing population of Egypt El-Hawary (2015).

Drought resistance is defined by Hall (1993) as the relative yield of a genotype compared to other genotypes subjected to the same drought stress. On the other hand, drought susceptibility of a genotype is often measured as a function of the reduction in yield under drought stress (Blum, 1988). Productivity improvement of wheat cultivars under drought conditions becomes one of the important objectives in wheat breeding program.

Knowledge of general and specific combining ability along with the mode of gene action in the available breeding material is very important to start the effective wheat breeding programs (Kumar *et al*. 2017). The diallel analysis method has been frequently used for parent selection as an appropriate scheme to obtain genetic information of yield traits in a short period of time, which can be used for improving efficiency in wheat breeding programs (Kohan and Heidari, 2014).

The main objectives of the present investigation were to assess the variations between six wheat genotypes and their new combinations for drought tolerance traits, to estimate the magnitude of superiority, heterosis, general combining ability and specific combining ability for yield and its components and drought susceptibility index for grain yield.

MATERIALS AND METHODS

Plant materials

A diallel cross set was carried out using six bread wheat parents on the Experimental Farm of Gemmeiza Agricultural Research Station, Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Egypt in 2017/2018 and 2018/2019 growing seasons.

The parental genotypes, representing a wide range of diversity for several traits were crossed in a half-diallel mating without reciprocals in 2017/2018 season, giving seeds of 15 F_1 crosses. The names, pedigree and source of the parents used in this study are presented in Table(1). In the second season, 2018/2019, two experiments were conducted. The first experiment (normal irrigation) was irrigated four times after planting irrigation while, the second experiment (stress irrigation) received one irrigation at tillering stage beside the planting irrigation. Each experiment was designed in a randomized complete blocks

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design (RCBD) with three replications. Each plot consisted of one row of 1.5 meters long and 30 cm apart and plants within rows were 10 cm apart totaling 15 plant. Two –row border rows were included. Each treatment was surrounded by a wide border (20 m) to minimize the literal water movement. All other agricultural practices, except irrigation, were applied as recommended for wheat cultivation in the area.

Table 1. Name, pedigree and source of bread wheat genotypes used as parents in this study.

No.	Genotypes	Pedigree and selection history	Origin
1	Gemmeiza11 (P1)	BOW"S"/KVZ"S"//7C/SERI82/3/GIZA168/SAKHA61	Egypt
2	Giza 171 (P2)	Sakha 93/ Gemmeiza 9	Egypt
3	Sakha 95 (P3)	PASTOR//SITE/MO/3/CHEN/AEGILOPS SQUARROSA(TAUS)//BCN/4/WBLL1	Egypt
4	Line 1 (P4)	OPATA M85 /Gem#9	Egypt
5	Line 2 (P5)	PBW343*2/KUKUNA//SRTU/3/PBW343*2/KHVAKI/4/VORB/FISCAL// AKURI #1/5/ PBW343*2/KUKUNA //SRTU/3/ PBW343 *2/KHVAKI	CIMMYT
6	Line 3 (P6)	UP2338*2/SHAMA/3/MILAN/KAUZ//CHIL/CHUM18/4/UP2338*2/ SHAMA*2/5/PBW343*2/KUKUNA*2//FRTL/PIFED	CIMMYT

Ten guarded plants were randomly selected from each plot for subsequent measurements as follows: number of days to heading, number of days to maturity, plant height (cm), number of spikes per plant, 1000-kernel weight (g), number of kernels per spike, grain yield per plant (g), flag leaf area (cm^2) which was measured according to Watson *et al*., (1963), chlorophyll a and chlorophyll b which determined according to Lichtenthaler and Wellburn (1983) using spectrophotometer.

Drought susceptibility index (DSI):

DSI was used to characterize the relative drought tolerance of all genotypes. It must be emphasized that DSI provides a measure of drought tolerance based on minimization of yield loss under stress compared to normal conditions rather than on yield level under dry conditions per se. This index was calculated from genotype means for grain yield (SI) using the generalized formula reported by Fisher and Maurer (1978) in which:

$$\mathbf{DSI = (1 - Yd / Yp) / D.}$$

Where:

Yd = Performance of a genotype under drought stress, Yp = Performance of a genotype under normal irrigation, D = drought stress intensity = 1 - (mean Yd of all genotypes / mean Yp of all genotypes).

The obtained data were statistically analyzed for analysis of variance by using computer statistical program MSTAT-C. General and specific combining abilities estimates were calculated according to Griffing (1956) diallel cross analysis designated as method 2 model 1 (fixed model) for each experiment. The combined analysis of the two experiments was carried out whenever homogeneity test of error variance was detected (Gomez and Gomez, 1976). Heterosis was calculated for individual crosses as the percentage deviation of F_1 mean performance from better-parent value according Mather and Jinks (1971).

RESULTS AND DISCUSSION

The analysis of variance for each normal and stress treatment as well as the combined analysis are presented in Table (2). Irrigation mean squares were found to be highly significant for all studied traits indicating that overall differences between normal and stress condition for all traits.

Genotypes mean squares were found to be either significant or highly significant for most studied traits in normal and stress environments as well as the combined analysis, except chlorophyll a under drought stress, indicating the wide diversity among the parents used in the present study. Parents mean squares were found to be either significant or highly significant for all studied traits under normal and stress conditions as well as the combined analysis, except for days to heading, chlorophyll a and chlorophyll b under normal condition, days to maturity, flag leaf area and chlorophyll a under the stress conditions indicating that these genotypes were genetically different for genes controlling yield and related traits. Crosses mean squares were significant for all studied traits except chlorophyll under normal and stress environments as well as the combined analysis revealing an overall difference between these hybrids. Parents vs. crosses mean squares as an indication to average heterosis overall crosses, were found to be highly significant or significant for number of days to heading, number of spikes per plant, grain yield per plant, flag leaf area and chlorophyll a under normal and stress conditions as well as the combined analysis, plant height was highly significant under drought stress as well as the combined analysis. Also, chlorophyll b was highly significant under normal condition and combined analysis. This mean that the genetic constitutions of the parents as well as their crosses are widely different and the parents had a wide range of genetic variability.

For all traits, mean squares of genotypes × treatments interaction were significant except chlorophyll a, indicating that genotypes responded differently to water regime. In addition, mean squares of crosses × treatments interaction were significant for all traits except chlorophyll a. Mean squares of parents × treatments interaction were significant for most traits except chlorophyll a. Meanwhile, significant differences among parents vs. crosses × treatments were detected for plant height and grain yield per plant. These results reveal that the performance of parents and crosses had changed from treatment to another.

The previous results were similar to the present findings by Gomaa *et al.*, (2014), El-Hawary (2015) and El-Gammaal (2018).

Table 2. Mean square estimates of analysis of variance for all studied traits under normal and stress as well as combined data.

S.O.V.	d.f.		Days to heading			Days to maturity			Plant height		
	S.	Comb.	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Treatment (T)		1			430.87**			690.67**			1143.78**
Reps	2		6.49	2.59		2.7	7.54**		3.11	17.93*	
E1		4			4.54			5.13*			10.52
Genotype (G)	20	20	8.02**	7.78**	11.97**	10.05**	3.56**	10.72*	23.99**	34.74**	41.60*
Parents (P)	5	5	2.06	7.69**	5.25*	2.77	2.06	3.31*	25.31**	36.73**	43.56*
Crosses (C)	14	14	8.77**	6.09**	11.00**	12.95**	4.34**	13.99**	24.90**	31.18**	39.72**
P vs C	1	1	27.24**	32.01**	59.15**	5.91*	0.19	1.98	4.56	74.54**	58.00**
G × T		20			3.83*			2.89*			17.13*
C × T		14			3.86**			3.30**			16.36**
P × T		5			4.49			1.51			18.48**
P vs C × T		1			0.096			4.11			21.11*
Error	40	80	2.09	1.87	1.98	1.41	0.92	1.17	5.95	4.48	5.22
Total	62	125									

Table 2, continued

S.O.V.	d.f.		No. of spikes /plant			1000-kernel weight			No. of kernels per spike		
	S	Comb.	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Treatment (T)		1			653.31**			906.41**			4706.78**
Reps	2		1.51	0.02		2.05	2.32		5.66	3.66	
E1		4			0.77			2.19			4.66
Genotype (G)	20	20	13.69**	8.41**	18.46**	30.48**	31.60**	47.84**	152.21**	100.25**	166.10*
Parents (P)	5	5	13.71**	12.24**	20.75**	20.44**	34.64**	39.96**	166.24**	181.29**	303.08**
Crosses (C)	14	14	12.38**	6.81**	16.02**	35.91**	32.70**	53.72**	156.66**	77.42**	129.03**
P vs C	1	1	32.01**	11.74**	41.26**	4.53	0.97	4.86	19.88	14.57	0.21
G × T		20			3.64**			14.23*			86.36*
C × T		14			3.17*			14.89**			105.05**
P × T		5			5.20**			53.72**			44.45
P vs C × T		1			2.49			0.65			34.24
Error	40	80	1.59	1.46	1.53	1.71	2.35	2.03	20.90	19.84	20.37
Total	62	125									

Table 2. continued

S.O.V.	d.f.		Grain yield / plant			Flag Leaf area			Chlorophyll-a			Chlorophyll-b		
	S	Comb.	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Treatment (T)		1			2050.76**			4378.24**			60.55**			88.19**
Reps	2		5.74**	2.45		20.96	8.07		5.99	0.60	3.29	1.84	1.64	
E1		4			4.09*			14.52						1.74
Genotype (G)	20	20	59.89**	29.14**	57.15**	289.91**	143.13**	382.98**	9.56**	5.62	11.96*	5.51**	9.36**	9.36*
Parents (P)	5	5	22.10**	58.57**	71.83**	157.84**	9.33	107.70*	4.61	2.71	6.64	0.84	8.80**	6.83*
Crosses (C)	14	14	69.25**	17.26**	55.44**	342.01**	179.21**	471.20**	4.18	3.16	3.33	6.40**	10.03**	9.77**
P vs C	1	1	117.93**	48.28**	7.65*	220.79**	307.03**	524.28**	109.67**	54.62**	159.54**	16.44**	2.76	16.33**
G × T		20			31.89**			50.06*			3.21			5.51*
C × T		14			31.07**			50.02**			4.01			6.66**
P × T		5			8.85**			59.47**			0.68			2.80
P vs C × T		1			158.55**			3.55			4.75			2.87
Error	40	80	0.86	2.06	1.46	15.40	16.17	15.78	3.79	3.34	3.57	1.56	1.41	1.48
Total	62	125												

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

Mean performance

Mean performance of the six parents and their fifteen crosses under normal and stress conditions as well as combined data for all studied traits are given in Table 3. The data illustrate that the water stress conditions decreased the means of all studied traits in all cases except, the means of chlorophyll b in P2xP6 which was increased under water deficit condition.

Wheat breeders prefer low values of days to heading, and maturity. For heading date wheat cultivar Sakha 95 was the earliest under normal condition. Meanwhile, the parent Gemmeiza 11 gave the earliest heading date under drought condition as well as the combined analysis. Also, the parental combination that incorporated earliness of those F_1 hybrid in heading date was P_1xP_2, P_1xP_3 and p1xp6 under normal condition and p1xp4 under drought condition. The data demonstrated clearly that there were marked differences among genotypes in heading date and also varied in their response to the environmental conditions.

The shortest period of maturity was detected in Sakha 95 under normal condition and Line 1 in stress condition. Also, the parental combination that incorporated earliness of those F_1 hybrids were P_1xP_4 under normal condition and P_1xP_3 and P_3xP_4 under stress condition. These results suggest that the genes controlling early maturity have been transferred from the parents to their F_1 progeny. Therefore, these genotypes are promising ones in breeding for early maturity.

The tallest mean values for plant height was obtained for the parent Line 3 under normal, drought and the combined analysis. Also, the parental combination that incorporated tallest of these F_1 hybrids were p5xp6 under normal condition, $P_3 \times P_5$ under drought stress and P_1xP_6 in combined analysis.

Table 3. Mean performance of all genotypes under normal and stress as well as combined data.

Genotypes	Days to heading (day)			Days to maturity (day)			Plant height (cm)		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Gemmeiza 11 (p1)	92.67	85.67	89.17	140.33	137.33	138.83	91.80	80.20	86.00
Giza 171 (p2)	93.33	90.00	91.67	140.00	136.33	138.17	92.00	81.73	86.87
Sakha 95 (p3)	91.00	88.00	89.50	139.67	136.00	137.83	88.17	83.93	86.05
Line 1 (p4)	91.67	88.67	90.17	140.00	135.00	137.50	87.77	83.77	85.77
Line 2 (p5)	92.00	90.00	91.00	140.67	137.00	138.83	94.03	84.50	89.26
Line 3 (p6)	91.67	88.33	90.00	142.33	136.67	139.50	94.73	90.43	92.58
P1XP2	88.33	85.67	87.00	138.33	135.33	136.83	92.22	89.77	91.00
P1XP3	88.33	85.33	86.83	138.67	134.33	136.50	91.23	87.86	89.55
P1XP4	89.33	85.00	87.17	137.67	135.67	136.67	91.32	87.80	89.56
P1XP5	91.00	85.33	88.17	139.33	136.33	137.83	96.63	88.18	92.41
P1XP6	88.33	85.33	86.83	140.00	135.33	137.67	96.48	89.93	93.21
P2XP3	92.00	87.33	89.67	141.67	137.33	139.50	90.94	85.57	88.26
P2XP4	93.00	88.00	90.50	144.00	138.00	141.00	88.97	84.16	86.57
P2XP5	92.33	87.67	90.00	142.00	137.67	139.83	89.42	88.07	88.74
P2XP6	90.00	87.67	88.83	142.67	137.67	140.17	92.00	87.79	89.89
P3XP4	89.00	86.00	87.50	140.67	134.33	137.50	89.83	82.87	86.35
P3XP5	90.67	87.33	89.00	142.67	136.00	139.33	92.00	91.93	91.97
P3XP6	91.00	88.00	89.50	140.33	135.33	137.83	91.93	82.24	87.09
P4XP5	91.33	89.00	90.17	143.00	137.33	140.17	87.23	82.77	85.00
P4XP6	93.67	86.00	89.83	142.33	136.33	139.33	92.61	81.00	86.80
P5XP6	90.67	89.33	90.00	144.33	137.00	140.67	97.36	87.60	92.48
L.S.D 5%	2.39	2.26	14.60	1.96	1.59	11.21	4.02	3.49	4.79

Table 3. continued

Genotypes	No. of spikes /plant			1000-kernel weight (g)			No. of kernels per spike		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Gemmeiza 11 (p1)	17.13	10.00	13.57	47.77	38.55	43.16	61.17	55.33	58.25
Giza 171 (p2)	17.67	10.11	13.89	47.91	45.57	46.74	55.13	40.93	48.03
Sakha 95 (p3)	16.00	12.15	14.07	42.25	36.24	39.25	65.50	42.67	54.08
Line 1 (p4)	18.72	14.67	16.69	42.61	39.93	41.27	66.87	53.00	59.93
Line 2 (p5)	16.93	12.67	14.80	45.01	36.65	40.83	46.90	34.73	40.82
Line 3 (p6)	12.53	9.40	10.97	42.74	40.55	41.64	62.00	47.67	54.83
P1XP2	14.75	10.47	12.61	46.18	41.94	44.06	60.33	52.00	56.17
P1XP3	16.33	12.81	14.57	46.00	34.80	40.40	63.56	56.80	60.18
P1XP4	12.33	9.57	10.95	46.21	41.61	43.91	54.97	53.33	54.15
P1XP5	13.00	10.42	11.71	48.36	37.73	43.04	53.00	48.87	50.93
P1XP6	16.75	11.33	14.04	45.07	41.45	43.26	50.27	38.27	44.27
P2XP3	17.33	9.40	13.37	44.27	40.18	42.23	60.00	46.73	53.37
P2XP4	11.90	7.47	9.68	44.73	42.65	43.69	62.33	49.33	55.83
P2XP5	13.67	8.80	11.23	41.50	36.33	38.92	53.00	40.73	46.87
P2XP6	14.67	10.93	12.80	51.58	47.80	49.69	54.93	48.40	51.67
P3XP4	15.67	11.93	13.80	43.18	36.03	39.60	64.07	41.47	52.77
P3XP5	15.27	12.00	13.63	40.97	37.02	39.00	49.13	45.67	47.40
P3XP6	19.33	12.40	15.87	42.04	39.22	40.63	54.17	49.27	51.72
P4XP5	13.53	9.29	11.41	42.03	40.54	41.29	68.96	45.00	56.98
P4XP6	13.37	9.67	11.52	44.74	38.64	41.69	74.22	43.33	58.78
P5XP6	15.89	11.67	13.78	52.79	41.90	47.35	52.33	42.60	47.47
L.S.D 5%	2.08	1.99	12.82	2.16	2.53	5.01	7.54	7.35	7.33

Table 3. continued

Genotypes	Grain yield / plant (g)			Flag leaf area (cm^2)			Chlorophyll-a			Chlorophyll-b		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
Gemmeiza 11 (p1)	23.68	17.13	20.40	50.80	32.71	41.76	14.27	13.48	13.87	8.62	4.94	6.78
Giza 171 (p2)	23.94	15.60	19.77	42.33	34.31	38.32	11.94	11.59	11.76	9.39	8.13	8.76
Sakha 95 (p3)	24.39	21.34	22.86	39.09	33.12	36.10	15.14	13.10	14.12	9.93	8.31	9.12
Line 1 (p4)	29.67	27.55	28.61	55.52	37.19	46.35	13.14	13.04	13.09	9.62	9.36	9.49
Line 2 (p5)	21.48	17.25	19.37	40.47	34.60	37.53	15.12	14.50	14.81	9.86	9.76	9.81
Line 3 (p6)	24.79	21.94	23.36	54.00	36.36	45.18	14.26	13.52	13.89	8.92	8.66	8.79
P1XP2	24.66	19.26	21.96	61.92	41.74	51.83	14.94	14.71	14.83	8.76	7.71	8.23
P1XP3	24.78	21.72	23.25	49.37	36.26	42.81	16.64	14.85	15.75	9.70	9.29	9.49
P1XP4	22.26	15.94	19.10	44.38	40.41	42.39	17.67	15.37	16.52	13.29	9.07	11.18
P1XP5	24.64	17.50	21.07	48.77	36.71	42.74	19.41	13.92	16.66	11.97	8.90	10.44
P1XP6	37.87	23.24	30.56	52.18	39.15	45.67	16.58	16.19	16.38	10.66	10.38	10.52
P2XP3	34.78	17.04	25.91	47.00	32.08	39.54	16.73	16.24	16.49	9.52	9.07	9.30
P2XP4	31.04	15.11	23.08	54.90	45.74	50.32	16.64	13.86	15.25	11.96	8.66	10.31
P2XP5	21.90	15.06	18.48	50.02	43.27	46.64	19.13	15.34	17.24	12.90	9.75	11.33
P2XP6	21.62	17.70	19.66	76.03	55.61	65.82	16.67	15.68	16.17	9.95	10.33	10.14
P3XP4	28.40	16.88	22.64	43.85	32.12	37.98	16.07	15.01	15.54	8.79	8.32	8.56
P3XP5	25.82	20.29	23.06	35.75	28.71	32.23	17.40	17.27	17.33	10.08	10.10	10.09
P3XP6	27.02	16.81	21.91	32.69	28.80	30.75	16.47	16.30	16.39	9.97	9.06	9.52
P4XP5	28.45	19.86	24.15	60.93	49.13	55.03	15.62	14.54	15.08	11.39	8.21	9.80
P4XP6	29.61	16.83	23.22	57.87	37.03	47.45	17.33	13.74	15.53	8.86	8.30	8.58
P5XP6	32.44	19.72	26.08	52.02	47.26	49.64	16.14	15.93	16.04	9.99	2.70	6.35
L.S.D 5%	1.53	2.37	12.54	6.48	6.63	6.91	2.67	2.28	5.29	2.06	1.96	1.98

The parent Line 1 under normal, drought and combined analysis recorded the highest number of spikes per plant Also, the cross P_3xP_6 under normal and the combined analysis, as well as P_1xP_3 under drought stress recorded the highest values.

For 1000-kernel weight, wheat cultivar Giza 171 under normal, drought and their combined analysis recorded the greatest mean value. The crosses P_2xP_6 under drought and combined analysis, as well as P_5xP_6 under normal condition had the highest mean values.

Line 1 under normal and the combined analysis as well as Gemmeiza 11 at stress condition recorded the highest number of kernels per spike. While, the crosses P_4xP_6 under normal condition showed the highest mean values, as well as P_1xP_3 under stress and the combined analysis showed the highest mean values.

For grain yield per plant, parent Line 1 under normal, drought and the combined analysis had the greatest mean values. The cross P_1xP_6 under normal, drought and the combined analysis had the greatest mean value. These results suggest that these genotypes were more tolerant to drought stress.

The parent Line 1 under normal, drought and the combined analysis expressed the highest values of flag leaf area. Also, P_2xP_6 under normal, drought and the combined analysis recorded the high mean values of flag leaf area.

For chlorophyll a, the parent Sakha 95 under normal condition as well as Line 2 under drought stress and the combined analysis recorded the highest mean values. The crosses P_1xP_5 under normal condition as well as p3xp5 under drought stress and the combined analysis had the greatest mean value.

The parental Sakha 95 under normal condition as well as Line 2 under drought stress and the combined analysis expressed the highest values of chlorophyll b. Also, P_1xP_4 under normal condition, P_1xP_6 under drought stress and P_2xP_5 under the combined analysis recorded higher mean values of chlorophyll b.

In general, the mean values under normal condition were found to be relatively higher than that under drought stress in most studied traits under investigation. A similar conclusion was reported by previous investigators Abd El-Rahman (2007) and Gomaa *et al*., (2014**).**

Heterosis

Useful Heterosis expressed as the percentage deviation of F_1 mean performance of the better parent for all studied traits is presented in Table (4).

Table 4. Heterosis percentage relative to better parent values for the studied characters under normal and stress as well as combined analysis in wheat crosses studied.

Genotypes	Days to heading			Days to maturity			Plant height		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
P1XP2	-4.68**	0.00	-2.43	-1.19	-0.73	-0.97	0.24	9.84**	4.76
P1XP3	-2.93	-0.39	-2.62	-0.72	-1.23	-0.97	-0.62	4.68*	4.06
P1XP4	-2.55	-0.78	-2.24	-1.67	0.49	-0.61	-0.53	4.81*	4.14
P1XP5	-1.09	-0.39	-1.12	-0.71	-0.49	-0.72	2.77	4.36*	3.52
P1XP6	-3.64*	-0.39	-2.62	-0.24	-0.98	-0.84	1.85	-0.55	0.68
P2XP3	1.10	-0.76	0.19	1.43	0.98	1.21	-1.15	1.95	1.60
P2XP4	1.45	-0.75	0.37	2.86**	2.22*	2.55**	-3.30	0.47	-0.35
P2XP5	0.36	-2.59	-1.10	1.43	0.98	1.21	-4.90	4.22*	-0.59
P2XP6	-1.82	-0.75	-1.30	1.90*	0.98	1.45	-2.89	-2.93	-2.91
P3XP4	-2.20	-2.27	-2.23	0.72	-0.49	0.00	1.89	-1.27	0.35
P3XP5	-0.37	-0.76	-0.56	2.15*	0.00	1.09	-2.16	8.80**	3.03
P3XP6	0.00	0.00	0.00	0.48	-0.49	0.00	-2.96	-9.06**	-5.94*
P4XP5	-0.36	0.38	0.00	2.14*	1.73	1.94*	-7.23**	-2.04	-4.78*
P4XP6	2.18	-2.64	-0.19	1.67	0.99	1.33	-2.24	-10.43**	-6.24*
P5XP6	-1.09	1.13	0.00	2.61**	0.24	1.32	10.93**	4.57*	7.82**
L.S.D 5%	2.92	1.95	2.80	2.40	1.37	2.15	4.93	3.03	4.55

Table 4. continued

Genotypes	No. of spikes /plant			1000-kernel weight			No. of kernels per spike		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
P1XP2	-16.51	3.52	-9.22	-3.61	-7.97**	-5.74	-1.36	-6.02	-3.58
P1XP3	-4.67	5.42	3.53	-3.72	-9.72**	-6.40	-2.97	2.65	3.31
P1XP4	-34.11**	-34.77**	-34.40**	-3.27	4.20	1.73	-17.80*	-3.61	-9.65
P1XP5	-24.12**	-17.76*	-20.89*	1.22	-2.13	-0.28	-13.35	-11.69*	-12.56
P1XP6	-2.24	13.33	3.50	-5.65*	2.22	0.23	-18.92*	-30.84**	-24.01**
P2XP3	-1.89	-22.61**	-5.02	-7.60**	-11.82**	-9.66**	-8.40	9.53	-1.33
P2XP4	-36.42**	-49.09**	-41.99**	-6.65*	-6.41*	-6.53*	-6.78	-6.92	-6.84
P2XP5	-22.64**	-30.53**	-24.10**	-13.38**	-20.27**	-16.74**	-3.87	-0.49	-2.43
P2XP6	-16.98*	8.13	-7.84	7.64**	4.89	6.30*	-11.40	1.54	-5.78
P3XP4	-16.30*	-18.64**	-17.32*	1.34	-9.76**	-4.03	-4.19	-21.76**	-11.96
P3XP5	-9.84	-5.26	-7.88	-8.98**	1.01	-4.49	-24.99**	7.03	-12.36
P3XP6	20.83*	2.09	12.74	-1.63	-3.26	-2.42	-17.30*	3.36	-5.68
P4XP5	-27.69**	-36.67**	-31.64**	-6.62*	1.52	0.04	3.12	-15.09*	-4.93
P4XP6	-28.58**	-34.09**	-31.00**	4.68	-4.70	0.11	11.00	-18.24**	-1.93
P5XP6	-15.11*	-20.45**	-17.46*	23.90**	4.94	14.73**	-21.73**	-19.62**	-20.80**
L.S.D 5%	2.55	1.73	2.46	2.65	2.19	2.84	9.24	6.37	8.98

Table 4. continued

Genotypes	Grain yield / plant			Flag leaf area			Chlorophyll-a			Chlorophyll-b		
	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb	Normal	Stress	Comb
P1XP2	2.99	12.46*	7.63	21.88**	21.66*	24.12*	4.74	9.15	6.89	-6.75	-5.12	-6.00
P1XP3	1.62	1.80	1.70	-2.83	9.47	2.52	9.96	10.21	11.56	-2.36	11.76	4.07
P1XP4	-24.98**	-42.15**	-33.25**	-20.05**	8.65	-8.54	23.87	14.08	19.11	38.21**	-3.15	17.81
P1XP5	4.07	1.45	3.28	-4.01	6.10	2.35	28.37*	-4.03	12.51	21.36	-8.76	6.38
P1XP6	52.79**	5.95	30.80**	-3.36	7.68	1.08	16.21	19.79*	17.97	19.60	19.78*	19.68
P2XP3	42.62**	-20.16**	13.32*	11.02	-6.51	3.17	10.53	24.02*	16.79	-4.14	9.12	1.90
P2XP4	4.59	-45.15**	-19.36**	-1.11	23.01**	8.56	26.68	6.33	16.54	24.38	-7.51	8.65
P2XP5	-8.51*	-12.72*	-6.52	18.15	25.05**	21.71*	26.52*	5.80	16.37	30.80*	-0.04	15.46
P2XP6	-12.77**	-19.33**	-15.85**	40.80**	52.96**	45.70**	16.89	15.98	16.45	5.99	19.20	15.36
P3XP4	-4.31	-38.75**	-20.89**	-21.01**	-13.64	-18.06*	6.15	14.59	10.06	-11.51	-11.15	-9.84
P3XP5	5.87	-4.89	0.85	-11.66	-17.02*	-14.13	14.92	19.07*	17.03	1.45	3.48	2.84
P3XP6	9.01*	-23.38**	-6.20	-39.46**	-20.77*	-31.94**	8.83	20.63*	16.09	0.40	4.52	4.31
P4XP5	-4.13	-27.93**	-15.58**	9.76	32.12**	18.73*	3.34	0.23	1.82	15.47	-15.88	-0.12
P4XP6	-0.21	-38.91**	-18.84**	4.23	-0.42	2.37	21.54	1.63	11.85	-7.80	-11.36	-9.56
P5XP6	9.32**	-28.42**	-8.85*	-6.30	27.07**	7.08	22.89	22.22*	22.55	3.90	-71.15**	-33.13**
L.S.D 5%	1.87	2.05	2.40	7.93	5.75	7.91	3.93	2.61	3.76	2.52	1.69	2.42

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

High positive values of Heterosis would be of interest in all studied traits except for heading and maturity dates where negative values would be useful from the wheat breeder point of view. As for days to heading, two out of the fifteen studied crosses showed significant negative useful heterotic effects under normal condition. The useful Heterosis ranged from -3.64 to -4.68% relative to respective better parent values. These superior two crosses were P_1xP_2 and p1xp6. Hence, it could be concluded that these crosses may be valuable in breeding for earliness. As for days to maturity, no useful heterosis was found in normal and drought as well as combined analysis. Concerning plant height, heterotic effects were found in P5xP6 in normal and P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_5, P_2xP_5 and P_3xP_5 under stress condition. Most of the hybrid combinations studied were found to be taller than their respective better parents. However, crosses P_4xP_5 at normal and combined analysis as well as P_3xP_6 and P_4xP_6 under stress and their combined data showed significant negative heterosis. Wheat breeders are interested with short stem uniform plants because of their lodging resistance and positive response to chemical fertilizers and irrigation.

Significant positive heterosis relative to the better parent for number of spikes per plant, the cross P_3xP_6 exhibited significant useful heterosis under normal condition. Concerning 1000-kernel weight two hybrid combinations P_2xP_6 and P_5xP_6 showed significant heterosis under normal and combined analysis.

No useful heterosis was found in number of kernels per spike, in normal, drought as well as combined analysis.

Concerning grain yield per plant, crosses P_1XP_6 and P_2XP_3 under normal condition and their combined data as well as P_3XP_6 and P_5XP_6 under normal condition only and P_1xP_2 under drought stress showed significant heterosis. The heterosis was found in grain yield / plant could be attributed the heterosis in one or more yield component such as number of spikes per plant and 1000-grain weight.

For flag leaf area, crosses P_1XP_2 and P_2XP_6 under normal condition and drought stress as well as their combined data and P_2xP_5 under drought stress as well as combined data and P_2xP_4 under drought stress showed significant heterosis.

Significant useful heterosis for chlorophyll a recorded for the crosses p1xp5 and p2xp5 under normal condition as well as P_1XP_6, P_2XP_3, P_3XP_5, P_3XP_6 and P_5XP_6 under drought stress. Concerning chlorophyll-b, three hybrid combinations P_1XP_4 and P_2XP_5 under normal condition as well as P_1XP_6 at stress showed significant heterosis.

The development of high yielding varieties of bread wheat depends upon the recovery of desirable segregates from crosses among high yielding cultivars. The inheritance of heterosis can help to isolate some superior parents and their cross combinations further, exploitation in a breeding program for selecting desirable segregates. Significant favorable heterosis was also reported by previous investigators such as, Omar *et al*., (2010), Nassar *et al*., (2012), Adel and Ali (2013) and Gomaa *et al*., (2014).

Combining ability analysis:

Analysis of variance of the general (GCA) and specific (SCA) combining ability for all the studied traits are presented in Table 5. GCA and SCA were found to be significant for all studied characters under both conditions, except plant height for SCA under normal condition, chlorophyll-a for GCA under normal and stress as well as combined analysis and SCA under stress condition. Also, chlorophyll-b at stress as well as combined analysis for GCA. These results are in general agreement with those previously reported by Abd EL-Hamid (2013), Katta *et al*., (2013), Gomaa *et al*., (2014), El-Hawary (2015) and El-Shamy *et al*., (2019)

The importance of both additive and non-additive genetic variance in determining the performance of all studied traits. GCA / SCA ratio as used to clarify the nature of the genetic variance involved in most the studied traits under both conditions. The GCA / SCA ratios were found to be greater than unity, suggesting that, the additive gene effect was much larger and more important than non-additive gene effects in the inheritance of these traits. These results are in agreement with those obtained by Burungale *et al*., (2011) Mandal and Madhuri (2016) and Ljubičić *et al*., (2017). It is interesting to note that breeding procedures that take advantage of additive genetic variance would be recommended for wheat breeding programs to improve tolerance for water stress traits.

General combining ability (GCA) effects

It is primarily a function of additive genetic variance; it helps in the selection of suitable good general combining parents for hybridization. Estimates of GCA effects of studying traits are presented in Table 6. Data showed that Gemmeiza 11 appeared highly significant negative GCA effects for heading date under normal and stress conditions as well as combined data and maturity date under normal as well as combined data, revealing that this variety may be considered as good combiners for developing early genotypes..

Table 5. Mean squares for general and specific combining ability under normal and stress conditions of all studied traits.

S.O.V.	d.f.		Days to heading			Days to maturity			Plant height		
	S	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
GCA	5	5	2.51**	6.53**	7.98**	6.36**	1.85**	6.21**	21.66**	8.87**	28.21**
SCA	15	15	2.72**	1.28*	2.66**	2.34**	0.97**	2.69**	3.44	12.48**	9.08**
Error	40	80	0.70	0.62	0.66	0.47	0.31	0.39	1.98	1.49	1.74
GCA /SCA			0.92	5.08	3.00	2.71	1.92	2.30	6.30	0.71	3.10

Table 5. continued

S.O.V.	d.f.		No. of spikes /plant			1000-kernel weight			No. of kernels per spike		
	S	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
GCA	5	5	2.32**	3.23**	4.08**	13.78**	27.56**	32.52**	104.10**	64.10**	129.39**
SCA	15	15	5.31**	2.66**	6.85**	8.95**	4.86**	10.42**	32.95**	23.19**	30.69**
Error	40	80	0.53	0.49	0.51	0.57	0.78	0.68	6.97	6.61	6.79
GCA /SCA			0.44	1.21	0.60	1.54	5.67	3.12	3.16	2.76	4.22

Table 5. continued

S.O.V.	d.f.		Grain yield / plant			Flag leaf area			Chlorophyll-a			Chlorophyll-b		
	S	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
GCA	5	5	11.15**	10.21**	18.54**	162.05**	66.57**	205.31**	1.54	1.42	2.66	1.38*	0.93	1.11
SCA	15	15	22.90**	9.55**	19.22**	74.83**	41.42**	101.78**	3.73**	2.02	4.43**	1.99**	3.85**	3.79**
Error	40	80	0.29	0.69	0.49	5.13	5.39	5.26	1.26	1.11	1.19	0.52	0.47	0.49
GCA /SCA			0.49	1.07	0.96	2.17	1.61	2.02	0.41	0.70	0.60	0.70	0.24	0.29

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

Table 6. Estimates of general combining effects for parents evaluated under normal and stress as well as combined data.

Parents		Days to heading			Days to maturity			Plant height		
		Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Gemmeiza 11 (p1)		-0.81**	-1.65**	-1.23**	-1.53**	-0.31	-0.92**	1.08*	0.41	0.74**
Giza 171 (p2)		0.65*	0.64*	0.65**	0.22	0.57**	0.40**	-0.67	-0.24	-0.45*
Sakha 95 (p3)		-0.51	-0.15	-0.33*	-0.44	-0.60**	-0.52**	-1.33**	-0.30	-0.81**
Line 1 (p4)		0.32	0.01	0.17	0.10	-0.31	-0.10	-2.18**	-1.82**	-2.00**
Line 2 (p5)		0.36	0.93**	0.65**	0.72**	0.53**	0.62**	0.97*	0.86*	0.92**
Line 3 (p6)		-0.01	0.22	0.10	0.93**	0.11	0.52**	2.12**	1.09**	1.60**
LSDĝi	0.05	0.54	0.52	0.25	0.45	0.36	0.19	0.92	0.80	0.40
	0.01	0.73	0.69	0.33	0.60	0.48	0.25	1.23	1.07	0.54
LSD ĝi –ĝj	0.05	0.84	0.80	0.40	0.69	0.56	0.31	1.42	1.24	0.66
	0.01	1.13	1.07	0.54	0.93	0.75	0.41	1.90	1.65	0.87

Table 6. continued

Parents		No. of spikes /plant			1000-kernel weight			No. of kernels per spike		
		Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Gemmeiza 11 (p1)		-0.02	-0.14	-0.08	1.42**	-0.48	0.47**	-0.81	4.32**	1.75**
Giza 171 (p2)		0.01	-1.05**	-0.52**	1.01**	2.70**	1.86**	-1.26	-0.79	-1.02*
Sakha 95 (p3)		1.04**	0.89**	0.97**	-1.88**	-2.34**	-2.11**	1.37	-0.01	0.68
Line 1 (p4)		-0.42	0.19	-0.11	-1.23**	0.11	-0.56**	5.92**	1.64	3.78**
Line 2 (p5)		-0.30	0.22	-0.04	-0.04	-1.45**	-0.75**	-5.09**	-4.13**	-4.61**
Line 3 (p6)		-0.31	-0.11	-0.21	0.71**	1.46**	1.09**	-0.13	-1.02	-0.58
LSD ĝi	0.05	0.48	0.46	0.22	0.49	0.58	0.25	1.72	1.68	0.80
	0.01	0.64	0.61	0.29	0.66	0.77	0.34	2.30	2.24	1.06
LSD ĝi –ĝj	0.05	0.74	0.71	0.35	0.76	0.89	0.41	2.67	2.60	1.30
	0.01	0.99	0.94	0.47	1.02	1.20	0.54	3.57	3.48	1.72

Table 6. continued

Parents		Grain yield / plant			Flag leaf area			Chlorophyll-a			Chlorophyll-b		
		Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
Gemmeiza 11 (p1)		-0.77**	0.08	-0.34**	1.03	-0.97	0.03	0.17	-0.09	0.04	0.03	-0.56*	-0.26*
Giza 171 (p2)		-0.73**	-1.99**	-1.36**	3.07**	2.45**	2.76**	-0.56	-0.46	-0.51**	0.06	0.26	0.16
Sakha 95 (p3)		0.23	0.52	0.37**	-7.89**	-5.40**	-6.65**	0.14	0.39	0.27	-0.43	0.35	-0.04
Line 1 (p4)		1.42**	1.06**	1.24**	2.88**	1.42	2.15**	-0.35	-0.52	-0.43*	0.27	0.20	0.24*
Line 2 (p5)		-1.44**	-0.54*	-0.99**	-2.69**	0.86	-0.92*	0.69	0.41	0.55**	0.58*	-0.06	0.26*
Line 3 (p6)		1.30**	0.86**	1.08**	3.60**	1.64*	2.62**	-0.09	0.27	0.09	-0.51*	-0.20	-0.35**
LSD ĝi	0.05	0.35	0.54	0.21	1.48	1.51	0.70	0.73	0.69	0.33	0.47	0.45	0.22
	0.01	0.47	0.72	0.28	1.98	2.03	0.93	0.98	0.92	0.44	0.63	0.60	0.29
LSD ĝi –ĝj	0.05	0.54	0.84	0.35	2.29	2.35	1.14	1.14	1.07	0.54	0.73	0.69	0.35
	0.01	0.72	1.12	0.46	3.06	3.14	1.51	1.52	1.43	0.72	0.97	0.93	0.46

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

For plant height, the parental varieties Line 2 and Line 3 showed significant positive GCA effects under normal and stress conditions as well as combined data proving to be good combiners for tallness. On the other hand, Line 1 exhibited the negative GCA effects, i.e. for decreasing plant height of its F_1 crosses, under normal and stress conditions as well as combined data proving to be good combiners for shorting. Concerning number of spikes per plant, Sakha 95 exhibited significant GCA effects under normal and stress conditions as well as combined data

For 1000-kernel weight, the two parental varieties Giza 171 and Line 3 showed highly significant estimates of GCA effects under normal and stress conditions as well as combined data. For number of kernels per spike the parental Gemmeiza 11 at stress condition as well as combined data and Line 1under normal condition and combined data showed significant GCA effects. For grain yield per plant, Line 1 and Line 3 exhibited highly significant GCA effects under normal and stress conditions as well as combined data. Proving to be a good combiner for in this grain yield per plant. For flag leaf area, Giza 171 and Line 3 exhibited highly significant GCA effects under normal and stress conditions as well as combined data. Concerning chlorophyll-a, the parental Line 2 exhibited significant GCA effects at combined data. For chlorophyll-b Line 2 exhibited significant general combining ability effects in normal conditions and combined data.

Specific combining ability (SCA) effects

It is mainly a function of dominance variances; it helps in the identification of superior cross combination for commercial exploitation of heterosis. The estimates of SCA effects of F_1 hybrids were determined for all studied traits are illustrated in Table 7.

Table 7. Estimate of specific combining ability effects for the fifteen crosses studied under normal and stress as well as combined data.

Genotypes	Days to heading			Days to maturity			Plant height		
	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
P1XP2	-2.53**	-0.64	-1.58**	-1.35*	-1.23*	-1.29**	-0.03	3.79**	1.88*
P1XP3	-1.36	-0.18	-0.77	-0.35	-1.07*	-0.71	-0.36	1.94	0.79
P1XP4	-1.20	-0.68	-0.94	-1.89**	-0.02	-0.96*	0.58	3.40**	1.99*
P1XP5	0.43	-1.26	-0.42	-0.85	-0.19	-0.52	2.74*	1.11	1.92
P1XP6	-1.86*	-0.55	-1.21*	-0.39	-0.77	-0.58	1.45	2.62*	2.03*
P2XP3	0.85	-0.47	0.19	0.90	1.06*	0.98*	1.10	0.28	0.69
P2XP4	1.01	0.03	0.52	2.70**	1.43**	2.07**	-0.03	0.40	0.19
P2XP5	0.30	-1.22	-0.46	0.07	0.27	0.17	-2.73*	1.63	-0.55
P2XP6	-1.65*	-0.51	-1.08*	0.53	0.68	0.61	-1.29	1.12	-0.09
P3XP4	-1.82*	-1.18	-1.50**	0.03	-1.07*	-0.52	1.49	-0.83	0.33
P3XP5	-0.20	-0.76	-0.48	1.40*	-0.23	0.59	0.51	5.56**	3.03**
P3XP6	0.51	0.61	0.56	-1.14	-0.48	-0.81	-0.70	-4.37**	-2.53**
P4XP5	-0.36	0.74	0.19	1.20	0.81	1.00*	-3.41**	-2.08	-2.75**
P4XP6	2.35**	-1.55*	0.40	0.32	0.23	0.27	0.82	-4.09**	-1.63
P5XP6	-0.70	0.86	0.08	1.70**	0.06	0.88*	2.42	-0.16	1.13
LSD5%(sij)	1.50	1.41	1.01	1.23	0.99	0.78	2.52	2.19	1.64
LSD1%(sij)	2.00	1.89	1.34	1.65	1.33	1.03	3.38	2.93	2.18
LSD5%(sij-sik)	2.23	2.11	1.51	1.84	1.48	1.16	3.77	3.27	2.45
LSD1%(sij-sik)	2.99	2.83	2.01	2.46	1.98	1.54	5.04	4.37	3.25
LSD5%(sij-ski)	2.07	1.95	0.57	1.70	1.37	0.44	3.49	3.03	0.93
LSD1%(sij-ski)	2.77	2.62	0.76	2.27	1.84	0.58	4.66	4.05	1.23

Table 7. continued

Genotypes	No. of spikes /plant			1000-kernel weight			No. of kernels per spike		
	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
P1XP2	-0.61	0.84	0.12	-1.39*	-0.06	-0.73	3.70	1.99	2.84
P1XP3	-0.06	1.24	0.59	1.31	-2.16**	-0.42	4.29	6.01*	5.15**
P1XP4	-2.60**	-1.30*	-1.95**	0.88	2.20**	1.54*	-8.85**	0.90	-3.97
P1XP5	-2.05**	-0.48	-1.27**	1.83**	-0.12	0.86	0.20	2.20	1.20
P1XP6	1.71*	0.77	1.24**	-2.21**	0.69	-0.76	-7.50**	-11.51**	-9.51**
P2XP3	0.91	-1.25*	-0.17	0.00	0.04	0.02	1.18	1.05	1.12
P2XP4	-3.06**	-2.49**	-2.77**	-0.19	0.06	-0.06	-1.03	2.00	0.49
P2XP5	-1.41*	-1.19	-1.30**	-4.61**	-4.69**	-4.65**	0.64	-0.83	-0.09
P2XP6	-0.40	1.28*	0.44	4.71**	3.87**	4.29**	-2.39	3.73	0.67
P3XP4	-0.33	0.03	-0.15	1.15	-1.52	-0.18	-1.93	-6.64**	-4.28**
P3XP5	-0.85	0.07	-0.39	-2.25**	1.03	-0.61	-5.85*	3.33	-1.26
P3XP6	3.24**	0.81	2.02**	-1.94**	0.33	-0.80	-5.78*	3.82	-0.98
P4XP5	-1.12	-1.94**	-1.53**	-1.83**	2.10*	0.13	9.42**	1.01	5.22**
P4XP6	-1.27	-1.23	-1.25**	0.12	-2.71**	-1.29*	9.73**	-3.76	2.98
P5XP6	1.13	0.74	0.94*	6.97**	2.12**	4.55**	-1.15	1.27	0.06
LSD5%(sij)	1.30	1.25	0.89	1.35	1.59	1.03	4.73	4.61	3.25
LSD1%(sij)	1.75	1.67	1.18	1.81	2.12	1.36	6.33	6.16	4.31
LSD5%(sij-sik)	1.95	1.87	1.33	2.02	2.37	1.53	7.06	6.88	4.85
LSD1%(sij-sik)	2.61	2.50	1.76	2.70	3.17	2.03	9.44	9.20	6.43
LSD5%(sij-ski)	1.80	1.73	0.50	1.87	2.19	0.58	6.53	6.37	1.83
LSD1%(sij-ski)	2.41	2.31	0.67	2.50	2.93	0.77	8.74	8.52	2.43

Table 7. continued

Genotypes	Grain yield / plant			Flag leaf area			Chlorophyll-a			Chlorophyll-b		
	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.	Normal	Stress	Comb.
P1XP2	2.41**	0.88	7.82**	2.05	4.94*	-0.73	0.59	-0.07	-1.47	-1.53*	-0.52	-1.03*
P1XP3	2.37**	0.44	6.23**	4.42*	5.33*	0.27	-0.12	0.07	0.05	-0.10	0.97	0.44
P1XP4	-3.95**	-4.58**	-9.52	1.75	-3.89	1.79	1.31	1.55	1.44*	2.80**	0.90	1.85**
P1XP5	-0.79	-0.38	0.43	-1.38	-0.47	2.49	-1.08	0.71	1.43*	1.16	1.00	1.08*
P1XP6	3.54**	7.03**	-2.45**	0.27	-1.09	0.44	1.34	0.89	1.05	0.95	2.61**	1.78**
P2XP3	-0.25	4.11**	1.83**	-3.18	-0.68	1.08	1.64	1.36	-0.16	-0.31	-0.07	-0.19
P2XP4	-2.71**	0.41	-1.04*	3.66	1.31	1.49	0.17	0.83	2.08**	1.43*	-0.33	0.55
P2XP5	-1.17*	-1.95*	-0.36	1.75	0.70	2.93*	0.72	1.83	1.32	2.06**	1.03	1.54**
P2XP6	0.07	-2.85**	19.36**	13.31**	16.34**	1.25	1.20	1.22	0.64	0.21	1.74**	0.97*
P3XP4	-3.45**	-1.76*	-1.13*	-2.11	-1.62	0.21	0.46	0.34	-1.18	-1.24	-0.75	-1.00*
P3XP5	1.56**	0.89	-3.66**	-4.95*	-4.30*	0.50	1.79	1.15	-0.25	-0.27	1.29*	0.51
P3XP6	-3.33**	-2.33**	-13.01**	-5.64**	-9.33**	0.36	0.97	0.66	0.57	0.72	0.38	0.55
P4XP5	0.59	1.12	10.76**	8.65**	9.70**	-0.77	-0.03	-0.40	0.52	0.34	-0.46	-0.06
P4XP6	-3.84**	-1.89*	1.39**	-4.23*	-1.42	1.71	-0.69	0.51	-1.07	-1.09	-0.23	-0.66
P5XP6	0.65	3.20**	1.11*	6.55**	3.83	-0.52	0.58	0.03	-0.30	-0.28	-5.57**	-2.92**
LSD5%(sij)	0.96	1.49	0.87	4.06	4.16	2.86	2.01	1.89	1.36	1.29	1.23	0.88
LSD1%(sij)	1.28	1.99	1.15	5.43	5.56	3.79	2.69	2.53	1.80	1.73	1.64	1.16
LSD5%(sij-sik)	1.43	2.22	1.30	6.06	6.21	4.27	3.00	2.82	2.03	1.92	1.83	1.31
LSD1%(sij-sik)	1.91	2.97	1.72	8.11	8.30	5.66	4.02	3.78	2.69	2.58	2.45	1.73
LSD5%(sij-ski)	1.32	2.05	0.49	5.61	5.75	1.61	2.78	2.61	0.77	1.78	1.69	0.49
LSD1%(sij-ski)	1.77	2.75	0.65	7.51	7.69	2.14	3.72	3.50	1.02	2.38	2.27	0.66

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

Significant negative SCA effects would be the best cross combinations of days to heading, and would be useful from the breeder point of view. It could be concluded that the best cross combinations for heading date (earliest) were (P_1XP_2), (P_1XP_6), (P_2XP_6) and (P_3XP_4) under normal condition as well as combined data, (P_4XP_6) under stress condition showed significant and negative SCA effects. For days to maturity, (P_1XP_2) under normal, stress as well as combined data, (P_1XP_3) under stress, (P_1XP_4) under normal as well as combined data and (P_3XP_4) at stress condition showed significant and negative SCA effects.

Significant negative SCA effects may be the best crosses for plant height (shortness). The best cross for plant height was (P_2XP_5) under normal condition, (P_3XP_6) at stress and combined conditions, (P_4XP_5) under normal as well as combined data and (P_4XP_6) at stress condition, where it recorded significant and negative SCA effects for this trait.

Significant positive SCA effects would be the best crosses for number of spikes per plant and would be useful from the breeder point of view. The best cross combinations were (p1xp6) under normal as well as combined, (p2xp6) under stress and (p3xp6) under normal as well as combined as they exhibited significant and positive SCA effects for this trait.

For 1000-kernel weight, (p1xp4) at stress as well as combined, (p1xp5) under normal, (p2xp6) at both condition as well as combined, (p4xp5) and (p5xp6) at both condition as well as combined showed significant positive estimates of SCA effects.

For number of kernels per spike, (p1xp3) at stress as well as combined, (p4xp5) under normal as well as combined and (p4xp6) under normal exhibited significant positive estimates of SCA effects.

The preferable significant SCA for grain yield were observed in (p1xp2) and (p1xp3) under normal as well as combined, (p1xp6) at both conditions, (p2xp3) at stress condition as well as combined, (p2xp6) at combined data, (p4xp6) at combined data and (p5xp6) at stress condition as well as combined.

Significant positive SCA values may be the best crosses for flag leaf area. The best cross combinations were (p1xp2) at stress condition, (p1xp3) at both condition, (p2xp5) at combined, (p2xp6) at both condition, (p4xp5) at both condition and (p5xp6) under normal condition.

For chlorophyll-a, positive estimates of SCA effects were detected in (p1xp4), (p1xp5) and (p2xp4) at combined data.

For chlorophyll-b, (p1xp4) under normal condition as well as combined, (p1xp5) at combined, (p1xp6) at stress condition as well as combined, (p2xp5) under normal and combined data, (p2xp6) at stress condition as well as combined and (p3xp5) at stress condition.

The obtained results here concerning general and specific combining ability effects could indicate 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 × high, high × low and low × 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. Similar conclusion was also drawn by El-Seidy *et al*., (2009), El-Gammaal, (2018) and Es'haghi *et al*., (2019)

Drought susceptibility index:

Drought susceptibility index (DSI) was used to estimate the relative stress injury because it accounted for variation in yield potential and stress intensity. Mean performance of drought susceptibility indices (DSI) are presented in Table 8. Results indicated that P_1, P_3, P_4, P_5 and P_6 had values lower than unity. The results indicated that the larger value of (DSI) represented relatively more sensitivity to water stress, thus a smaller value of (DSI) were favored.

The F1 crosses showed the lowest values of DSI were P_1XP_2, P_1XP_3, P_1XP_4, P_1XP_5, P_2XP_6 and P3XP5. The other tested crosses exhibited high degree of susceptibility to drought and showed more reduction in grain yield more compared by the non-stress traits. Selection based on (DSI) favors genotypes with a relatively low yield potential under non stress treatment and a relatively high yield under stress treatment. These results agree with those obtained by Mohammadi, *et al*., (2012), Gomaa *et al*., (2014), El-Hawary, (2015), and Elmassry *et al*., (2016).

Table 8. Drought Susceptibility index (DSI) for grain yield per plant.

Genotype	Normal	Stress	DSI
Gemmeiza 11 (P1)	23.68	17.13	0.919
Giza 171 (P2)	23.94	15.60	1.158
Sakha 95 (P3)	24.39	21.34	0.416
Line 1 (P4)	29.67	27.55	0.238
Line 2 (P5)	21.48	17.25	0.655
Line 3 (P6)	24.79	21.94	0.382
P1XP2	24.66	19.26	0.728
P1XP3	24.78	21.72	0.410
P1XP4	22.26	15.94	0.944
P1XP5	24.64	17.50	0.963
P1XP6	37.87	23.24	1.284
P2XP3	34.78	17.04	1.695
P2XP4	31.04	15.11	1.706
P2XP5	21.90	15.06	1.038
P2XP6	21.62	17.70	0.603
P3XP4	28.40	16.88	1.348
P3XP5	25.82	20.29	0.712
P3XP6	27.02	16.81	1.256
P4XP5	28.45	19.86	1.003
P4XP6	29.61	16.83	1.434
P5XP6	32.44	19.72	1.303

Generally, the results indicated that the parents and crosses had values lower than unity were less sensitive to water stress, such results might be useful for improving drought tolerance in wheat breeding program.

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تقدير القدرة على التألف لمحصول الحبوب ومكوناته فى بعض التراكيب الوراثية من قمح الخبز تحت الظروف الطبيعية والإجهاد المائى

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أجريت هذه الدراسة فى المزرعة البحثية بمحطة البحوث الزراعية بالجميزة باستخدام ستة آباء متباعدة المصدر خلال موسمين 2018/2017 و 2019/2018وقد تم تقييم الآباء والهجن الناتجة فى تجربتين إحداهما تحت ظروف الري العادي والثانية تحت ظروف الإجهاد المائي. وقد أظهرت النتائج أن التباين الراجع للتراكيب الوراثية كان معنويا لجميع الصفات المدروسة تحت ظروف الري العادي والإجهاد المائي والتحليل المشترك بينهما فيما عدا صفة نسبة الكلوروفيل أ تحت ظروف الإجهاد المائي. وكان التباين الراجع للآباء معنويا لجميع الصفات المدروسة تحت ظروف الري العادي والإجهاد المائي و التحليل المشترك بينهما فيما عدا كلا من صفة عدد الأيام حتي طرد السنابل والكلوروفيل تحت ظروف الري العادي ، ومساحة سطح الورقة تحت ظروف الري العادي والإجهاد المائي و التحليل المشترك بينهما. وقد أظهرت الهجن p1xp6 وp2xp3 قوة هجين تحت ظروف الري العادي والتحليل المشترك بينهما و الهجن p3xp6 و p5xp6 تحت ظروف الري العادي والهجين p1xp2 تحت ظروف الإجهاد المائي بالنسبة لصفة وزن محصول النبات الواحد. كان التباين الراجع للقدرة العامة (GCA) والخاصة علي الإئتلاف (SCA) معنويا في الصفات المدروسة فيما عدا صفة نسبة كلوروفيل أ تحت ظروف الري العادي والإجهاد المائي و التحليل المشترك بينهما وصفة نسبة كلوروفيل ب تحت ظروف الإجهاد المائي و التحليل المشترك بينهما بالنسبة للقدرة العامة علي الإئتلاف وصفة نسبة كلوروفيل ب تحت ظروف الإجهاد المائي بالنسبة للقدرة الخاصة علي الإئتلاف. أظهرت كل من السلالة 1 والسلالة 3 قدرة عامة على التآلف موجبة و معنوية بالنسبة لصفة محصول الحبوب تحت ظروف الري العادي والإجهاد المائي و التحليل المشترك بينهما. وهذا التآلف الواضح ربما يكون ذا ميزة نسبية في برامج التربية والمستهدفة إنتاج سلالات نقية ذات قدرة تألف عالية. أوضح تقييم دليل الحساسية للجفاف إلى أن القيم المنخفضة فى تلك التراكيب الوراثية تكون مرغوبة ، كما أن الإنتخاب بناءً على هذه القيم يساعد فى برنامج التربية لاستنباط أصناف تتحمل الإجهاد المائى.