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Heterosis in Some Crosses of Bread Wheat under Irrigation and Drought Conditions

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Abstract: Five bread wheat varieties with different characteristics were crossed in a half-diallel model in 2005/2006 season. The five parents and their 10 F1 hybrids were evaluated under normal and water stress conditions during 2006/2007 season, to estimate heterosis of some wheat crosses for drought tolerance and selecting the crosses which could be useful in breeding programs for drought tolerance. The results indicated that, the best crosses over their mid parents at water stress condition for days to heading was Sakha-61×Sakha-93; for flag leaf area were Giza-168×Gemmeiza-9 and Sakha-61×Gemmeiza-9 and for plant height was Sakha-61×Sakha-93. The best crosses over their mid parents at both normal and stress conditions for days to maturity was Sakha-61×Gemmeiza-9; for flag leaf area were Giza-168×Sakha-61, Sakha-8×Gemmeiza-9 and Sakha-93×Gemmeiza-9; for spikes/plant were Sakha-8×Sakha-61, Sakha-8×Gemmeiza-9 and Sakha-61×Sakha-93; for kernels/spike were Giza-168×Sakha-8, Giza-168×Sakha-61, Giza-168×Sakha-93 and Sakha-8×Gemmeiza-9; for 100-kernel weight were Giza-168×Gemmeiza-9, Sakha-61×Sakha-93 and Sakha-93×Gemmeiza-9 and for grain yield/plant were Giza-168×Sakha-93, Sakha-8×Gemmeiza-9 and Sakha-93×Gemmeiza-9. The best crosses over their better parents at water stress condition for flag leaf area were Giza-168×Sakha-8, Giza-168× Gemmeiza-9 and Sakha-8×Gemmeiza-9; for plant height were Giza-168×Gemmeiza-9 and Sakha-8× Sakha-61. The best crosses over better parents at both normal and stress conditions for plant height were Giza-168×Sakha-8, Sakha-8×Gemmeiza-9 and Sakha-93×Gemmeiza-9; for spikes/plant were Sakha-8×Sakha-61, Sakha-61×Sakha-93 and Sakha-8×Gemmeiza-9; for kernels/spike were Giza-168×Sakha-61 and Giza-168×Sakha-93 and for grain yield/plant were Sakha-61×Sakha-93 and Sakha-93×Gemmeiza-9. Estimation of useful heterosis over better parent for grain yield/plant proved that it never exceeds 10.16% at normal condition (cross Giza-168×Gemmeiza-9) and 12.76% at stress condition (cross Sakha-93×Gemmeiza-9). Useful segregate could be selected from such hybrids as hybrids wheat are still under experimentation in Egypt.

Key words: Wheat, heterosis, water stress, normal irrigation

INTRODUCTION

Wheat (*Triticum aestivum* L.) is considered the important winter crop in Egypt. Great efforts of wheat breeders and geneticists must be continue to increase the productivity of unit area to face the gap between the production and consumption in Egypt. Increasing wheat production under abiotic stress condition i.e., drought has become important during recent years, since wheat production in these areas with optimum growth conditions doesn't meet the needs of ever increasing population of Egypt.

Heterosis in self-pollinated crops such as wheat still needs to be exclusively investigated. Crossing of wheat genotypes possessing desired characteristics has so far been the most effective way to achieve progress. Diallel cross technique is a good tool for identification of hybrid combinations that have potentiality of producing maximum improvement and identifying superior lines among the progeny in early segregation generations. Ehdaie and Waines (1996) and Mohamed (2004) revealed significant differences between various genotypes, parents, hybrids and parents versus hybrids for days to heading and days to maturity at normal and water stress conditions. Farhat (2005) showed that mean squares of genotypes, parents, hybrids were highly significant for earliness components except days to maturity and grain filling rate at normal condition. Wheat production under rainfed or minimum irrigation condition became an objective in Egypt as well as many areas world wide due to increasing limitations of water supply. Using yield component as a quantification and selection criterion should be superior to using yield under drought. Different heterosis effects were obtained by many researchers, for days to heading and days to maturity by Hassan and Saad (1996), El-Borhamy (2000), El-Beially and El-Sayed (2002) for days to maturity. Morover, El-Shami *et al.* (1996) reported high heterosis percentage for plant height, number of spikes per plant, number of kernels per spike, 100 kernels weight and grain yield per plant. Sharief *et al.* (2006) found significant and positive heterosis values over mid parents at normal condition for

some crosses, significant and positive heterosis values over mid parents at water stress condition were obtained for some crosses i.e., Line 1×Sakha 61 and Sakha 61×Gemmeiza-9 for number of kernels/spike, 100-kernels weight and grain yield/plant; significant and positive heterosis values over better parents for some crosses i.e., Sakha 61×Gemmeiza 10 for plant height, grain yield/plant at normal condition, number of kernels/spike at water stress condition and 100-kernels weight at both conditions. Also, they found that estimation of useful heterosis over better parent for grain yield/plant proved that it never exceeds 25.26% at normal conditions (Sakha93×Gemmeiza-9) and 23.67% at stress conditions (Sakha 61×Gemmeiza-9). Useful segregate could be selected from such hybrids as hybrid wheat are still under experimentation in Egypt.

The objective of this study was to estimate heterosis of some wheat crosses for drought tolerance and selecting the crosses which could be useful in breeding programs for drought tolerance.

MATERIALS AND METHODS

The materials used in this investigation as parents included five bread wheat varieties (*Triticum aestivum* L.), representing a wide range of diversity for several agronomic characters. The parents' names and pedigrees are presented in Table 1.

The monthly average amount of rainfall of experimental area is presented in Table 2. Mechanical and chemical analysis of experimental site are presented in Table 3.

In 2005/2006 season, the parental genotypes were sown at various dates in order to overcome the differences in flowering time. All possible cross combinations excluding reciprocals were made among the five varieties giving 10 F_1 crosses.

In 2006/2007 season, the fifteen entries (5 parents and 10 F_1) were evaluated in two separate irrigation regime experiments. The first experiment (normal conditions) was irrigated four times after planting irrigation i.e., five irrigation were given through the whole season. The second experiment (drought conditions) was given one surface-irrigation 27 days after the establishment (two irrigations were given through the whole season). Each of the two experiments was fertilized with 15 kg P_2O_5/fad, 24 kg K_2O/fad in one dose during soil preparing and 75 kg N/fad was added in two doses. The first dose was 30% with sowing and the second was 70% with the first irrigation (after 27 days from sowing). The two experiments were designed in randomized complete block design with three replications in the Experimental Farm at the Experimental Station of the Faculty of Agriculture, Mansoura University, El-Dakahlia Governorate, Egypt.

Each replicate consisted of 15 rows (genotypes) as well as two rows (border) 4 m long and 25 cm apart with 20 cm between plants. Twenty grains were planted in each row and manually drilled in the rows. Each experiment was surrounded by a wide border (3 m) to minimize the underground water permeability. All other cultural practices, except irrigation, were applied as recommended for wheat cultivation. The two outside plants for each row and the two external rows of each plot were excluded to eliminate the border effect.

Table 1: Parents names and pedigree

Genotypes	Pedigree
Giza 168 (P_1)	MRL/BUC// Seri CM 93046-8M-04-OM-2Y-OB-062
Sakha 8 (P_2)	Cno 67//SN64/KLRE/3/8156 PK 3418-6S-0S-0S
Sakha 61 (P_3)	INIA/RL4220//7C/Yr"S" CM15430-2S-5S-0S
Sakha 93 (P_4)	Sakha 92/TR8 10328 S.8871-1S-2S-1S-0S
Gemmeiza-9 (P_5)	Ald"S"/Huac//Cmh74A.630/Sx CGM4583-5GM-1GM-0GM

Table 2: Monthly average of total rainfall during (2006/2007) at El-Mansoura City, El-Dakahlia Governorate

Month	Nov. 2006	Dec. 2006	Jan. 2007	Feb. 2007	Mar. 2007	Apr. 2007	May 2007
Rainfall (mL)	4	2	-	14	2	-	-

Table 3: Mechanical and chemical analysis of experimental site during 2006/2007 season

	Mechanical analysis			Soil texture	Chemical analysis				
Season	Sand (%)	Silt (%)	Clay (%)	class	N (ppm)	P (ppm)	K (ppm)	pH	EC (dS m^{-1})
2006/2007	20.0	33.0	47.0	Clayey	17	6	310	7.8	1.65

The studied characters were, days to heading, days to maturity, flag leaf area (cm^2), plant height (cm), number of spikes/plant, number of kernels/spike, 100-kernels weight (g) and grain yield/plant (g). Characters were determined from 10 plants per plot for all characters, except flag leaf area trait was determined from 5 plants per plot.

The data obtained for each trait were analyzed on plot mean basis for both parents and F_1 generation. In order to test the significance among genotypes and irrigation treatments, all obtained data were subjected to the statistical analysis of the randomized complete block design as described by Gomez and Gomez (1984). Combined analysis was performed between the two experiments (normal and water stress conditions) to indict the irrigation effects according to Snedecor and Cochran (1980).

Heterosis as proposed by Mather and Jinks (1982) was determined for individual crosses as the percentage deviation of F_1 means from mid-parent means (MP) and better parent (BP) and expressed as percentages as follows:

$$\text{Heterosis over the mid-parent (\%)} = [\frac{(F_1 - MP)}{MP}] \times 100$$

$$\text{Heterosis over the better-parent (\%)} = [\frac{(F_1 - BP)}{BP}] \times 100$$

The significance of heterosis effect for F_1 values from the mid-parent and better parent were tested according to the following formula:

$$\text{LSD for mid-patent heterosis} = t_{0.05 \text{ or } 0.01} X (3MSe/2r)^{1/2}$$

$$\text{LSD for better-patent heterosis} = t_{0.05 \text{ or } 0.01} X (2MSe/r)^{1/2}$$

where, t is the tabulated t value at a stated level of probability for the experimental error degree of freedom, MSe is mean squares of the experimental error from the analysis of variance and r = No. of replicates.

RESULTS AND DISCUSSION

Results indicated that irrigation mean squares were highly significant for all studied traits, indicating significant differences between the normal and stress conditions for all studied characters (Table 4). Also, mean squares of genotypes were highly significant for all studied traits, indicating significant differences between wheat genotypes for all studied traits.

The irrigation × genotypes interactions were found to be significant for days to maturity, flag leaf area, 100-kernels weight and grain yield per plant.

These results are confirmed by those obtained by Ehdaie and Waines (1996), Mohamed (2004), Farhat (2005) and Sharief *et al*. (2006).

The results in Table 5 indicated that days to maturity, flag leaf area, 100-kernel weight and grain yield/plant had significant interaction between genotypes and irrigation treatments. Suggested that wheat genotypes responded differently to water regime and the possibility of selection for the most tolerant genotypes may be successful and useful. These results are in general agreement with El-Danasory (2005), Farhat (2005) and Sharief *et al*. (2006).

It could be noticed earliest parents for maturity was Sakha-61 and the earliest cross was Giza-168×Sakha-61 at normal irrigation and while, under water stress condition Giza-168 was the earliest of the parents and Giza-168×Sakha-61 was the earliest cross for maturity.

With respect to flag leaf area, results showed that Sakha-61 was the best of the parents under normal and stress conditions and Giza-168×Sakha-61 and Sakha-61×Sakha-93 were the best of the crosses at both conditions.

For weight of 100-kernels the results in Table 5 clearly showed that the parent which had the highest weight of 100-kernels was Sakha-93 and the highest cross was Sakha-93×Gemmeiza-9 at both conditions.

Concerning grain yield/plant, results showed that the parent which had the highest grain yield/plant was Giza-168 at both conditions and the highest cross was Giza-168

Table 4: Combined analysis of variance for all studied characters over both conditions

Source of variation	df	Days to heading	Days to maturity	Flag leaf area	Plant height	Spikes/ plant	Kernels/ spike	100-kernels weight	Grain yield/plant
Irrigations	1	71.11**	182.00**	1303.40**	2570.70**	256.70**	173.61**	0.57**	5273.10**
Error	4	0.58	1.29	8.84	14.26	2.11	3.11	0.02	3.59
Genotypes	14	37.90**	23.24**	186.50**	114.52**	6.14**	95.43**	0.37**	22.81**
I×G	14	0.35	0.78**	19.24**	4.34	0.283	0.97	0.03*	4.11**
Error	56	0.35	0.27	0.69	5.41	0.254	0.75	0.01	0.33

*and **significant at 0.05 and 0.01 probability, respectively

Table 5: Means of studied traits as affected by the interaction between wheat genotypes and irrigation treatments

	Days to heading		Days to maturity		Flag leaf area (cm^2)		Plant height (cm)	
Genotypes	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168	91.3	89.3	146.7	142.7	47.30	35.23	113.3	104.0
Skh. 8	94.7	92.3	150.3	146.7	53.47	41.37	104.7	93.0
Skh. 61	90.3	88.7	146.3	144.0	64.37	57.37	110.7	101.7
Skh. 93	92.0	90.3	149.3	146.3	55.47	51.97	107.3	99.0
Gem. 9	100.0	97.3	153.7	149.7	50.47	35.73	120.0	108.0
G. 168 × Skh. 8	91.7	90.7	148.0	145.7	49.13	45.37	111.3	101.0
G. 168 × Skh. 61	91.7	90.0	145.7	143.3	62.07	56.30	114.0	103.7
G. 168 × Skh. 93	90.3	89.0	147.7	144.7	53.47	44.60	111.7	98.7
G. 168 × Gem. 9	93.7	92.3	149.7	146.3	49.03	46.40	117.3	108.7
Skh. 8 × Skh. 61	93.7	91.3	148.3	145.7	58.73	49.40	108.7	97.0
Skh. 8 × Skh. 93	92.3	91.0	149.3	147.0	55.53	47.47	106.7	93.7
Skh. 8 × Gem. 9	96.3	94.0	150.7	148.3	53.37	44.87	112.3	103.0
Skh. 61 × Skh. 93	90.3	88.7	147.3	146.0	59.33	56.30	109.0	95.3
Skh. 61 × Gem. 9	93.7	92.3	149.0	146.0	57.43	49.03	115.0	105.0
Skh. 93 × Gem. 9	95.7	93.7	151.3	148.3	54.80	48.40	112.7	102.7
F-test	NS		**		**		NS	
LSD 0.05	-		0.84		1.36		-	
LSD 0.01	-		1.00		1.62		-	
	No. of spikes/plant		No. of kernels/spike		100 kernels weight (g)		Grain yield/plant (g)	
Genotypes	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168	17.33	14.33	66.67	64.33	4.98	4.80	38.97	25.90
Skh. 8	16.67	13.67	62.00	58.67	4.29	4.56	33.87	22.70
Skh. 61	18.67	14.33	63.33	61.00	4.44	4.33	35.63	19.33
Skh. 93	17.33	14.00	66.00	64.33	5.02	4.87	36.67	20.47
Gem. 9	16.33	13.33	76.33	71.67	4.80	4.63	37.80	22.73
G. 168 × Skh. 8	18.67	14.67	67.33	64.33	4.78	4.49	37.93	24.70
G. 168 × Skh. 61	19.33	16.33	69.33	67.67	4.83	4.65	39.70	23.47
G. 168 × Skh. 93	18.67	15.33	71.67	69.00	5.11	4.90	42.00	25.10
G. 168 × Gem. 9	18.67	15.00	73.33	71.00	5.15	5.01	42.93	25.43
Skh. 8 × Skh. 61	19.67	16.67	64.67	61.67	4.52	4.40	37.97	22.03
Skh. 8 × Skh. 93	18.33	14.67	64.33	62.00	4.82	4.62	37.80	22.87
Skh. 8 × Gem. 9	18.67	15.67	72.67	69.67	4.86	4.65	38.97	23.53
Skh. 61 × Skh. 93	19.67	16.67	66.00	63.00	5.14	4.97	38.80	22.60
Skh. 61 × Gem. 9	19.33	15.67	68.67	64.67	4.69	4.37	39.83	23.83
Skh. 93 × Gem. 9	18.33	14.67	70.67	68.33	5.24	5.04	41.10	25.63
F-test	NS		NS		*		**	
LSD 0.05	-		-		0.17		0.94	
LSD 0.01	-		-		-		1.13	

NS: Non significant, *and** significant at 0.05 and 0.01 probability, respectively

Gemmeiza-9 at normal irrigation condition and Sakha-93×Gemmeiza-9 at water stress condition.

Heterosis over mid-parents: Table 6 showed that the heterosis effects over mid-parents for all studied traits at normal irrigation and water stress conditions. The crosses which had negative significant heterosis values were days to heading, days to maturity and plant height. Also, there were significant positive heterosis values for the other traits. The best crosses over their mid parents at normal condition for days to heading were Sakha-61×Gemmeiza-9, Giza-168×Sakha-8 and Sakha-8×Sakha-93; for days to maturity were Sakha-8×Gemmeiza-9 and Giza-168×Sakha-61; for flag leaf area was Giza-168×Sakha-93.

The best crosses over their mid parents at water stress condition for days to heading was Sakha-61×Sakha-93; for flag leaf area were Giza-168×Gemmeiza-9 and Sakha-61× Gemmeiza-9 and for plant height was Sakha-61×Sakha-93.

The best crosses over their mid parents at both conditions for days to heading were Giza-168×Sakha-93, Giza-168×Gemmeiza-9 and Sakha-8×Gemmeiza-9; for days to maturity was Sakha-61×Gemmeiza-9; for flag leaf area were Giza-168×Sakha-61, Sakha-8× Gemmeiza-9 and Sakha-93×Gemmeiza-9; for spikes number per plant were Sakha-8×Sakha-61, Sakha-8×Gemmeiza-9 and Sakha-61×Sakha-93; for kernels number per spike were Giza-168×Sakha-8, Giza-168×Sakha-61, Giza-168×Sakha-93 and Sakha-8×Gemmeiza-9; for 100-kernel weight were Giza-168×Gemmeiza-9, Sakha-61×Sakha-93 and Sakha-93×Gemmeiza-9 and for grain yield per plant were Giza-168×Sakha-93, Sakha-8×Gemmeiza-9 and Sakha-93×Gemmeiza-9. These results are in agreement with those obtained by Hassan and Saad (1996) for days to heading at normal condition; Mohamed (2004) for heading at normal, days to maturity and plant height at stress; Afiah and Darwish (2002) for plant height at rainfed; El-Beially and El-Sayed (2002) for

Table 6: Percentages of heterosis over mid-parents under normal irrigation and water stress conditions

	Days to heading		Days to maturity		Flag leaf area (cm^2)		Plant height (cm)	
Crosses	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168 × Skh. 8	-1.43**	-0.18	-0.34	0.69**	-2.49*	18.46**	2.11	2.54
G. 168 × Skh. 61	0.92	1.12*	-0.57*	0.00	11.17**	20.95**	1.79	0.83
G. 168 × Skh. 93	-1.46**	-0.92*	-0.22	0.12	4.06**	2.29	1.27	-2.76
G. 168 × Gem. 9	-2.09**	-1.07*	-0.33	0.11	0.30	30.78**	0.56	2.55
Skh. 8 × Skh. 61	1.26*	0.92*	0.00	0.23	-0.32	0.06	0.93	-0.36
Skh. 8 × Skh. 93	-1.08*	-0.36	-0.33	0.34	1.95	1.71	0.66	-2.40
Skh. 8 × Gem. 9	-1.03*	-0.88*	-0.88**	0.11	2.69*	16.39**	-0.04	2.49
Skh. 61 × Skh. 93	-0.92	-0.93*	-0.34	0.58*	-0.98	2.98*	0.00	-5.00**
Skh. 61 × Gem. 9	-1.57**	-0.72	-0.67*	-0.57*	0.02	5.33**	-0.30	0.14
Skh. 93 × Gem. 9	-0.34	-0.17	-0.11	0.22	3.45**	10.38**	-0.84	-0.77
LSD 0.05	0.89	0.83	0.75	0.75	1.17	1.24	3.62	3.10
LSD 0.01	1.19	1.12	1.00	1.00	1.57	1.66	4.86	4.16
	No. of spikes/plant		No. of kernels/spike		100 kernels weight		Grain yield/plant	
Crosses	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168 × Skh. 8	9.82**	4.79	4.66**	4.60**	3.13**	-4.06	4.15**	1.65
G. 168 × Skh. 61	7.39**	13.96**	6.66**	7.99**	2.55**	1.86	6.43**	3.78
G. 168 × Skh. 93	7.73**	8.22**	8.04**	7.26**	2.20**	1.34	11.05**	8.26**
G. 168 × Gem. 9	10.93**	8.46**	2.56**	4.41**	5.32**	6.26**	11.84**	4.59*
Skh. 8 × Skh. 61	11.32**	19.07**	3.20**	3.07**	3.55**	-1.01	9.27**	4.83*
Skh. 8 × Skh. 93	7.82**	6.04*	0.52	0.81	3.54**	-2.01	7.17**	5.95*
Skh. 8 × Gem. 9	13.15**	16.07**	5.07**	6.91**	6.93**	1.20	8.75**	3.59
Skh. 61 × Skh. 93	9.28**	17.68**	2.06*	0.53	8.67**	8.04**	7.33**	13.57**
Skh. 61 × Gem. 9	10.46**	13.30**	-1.66	-2.51*	1.52**	-2.46	8.48**	13.31**
Skh. 93 × Gem. 9	8.91**	7.35*	-0.70	0.49	6.72**	6.11**	10.38**	18.66**
LSD 0.05	0.70	0.76	1.26	1.26	0.05	0.22	0.62	1.01
LSD 0.01	0.94	1.02	1.69	1.69	0.06	0.29	0.83	1.36

* and ** = significant at 0.05 and 0.01 probability, respectively

Table 7: Percentages of heterosis over better parent under normal and stress water conditions

	Days to heading		Days to maturity		Flag leaf area (cm^2)		Plant height (cm)	
Crosses	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168 × Skh. 8	0.37	1.50**	0.91**	2.10**	-8.12**	9.67**	6.30**	8.60**
G. 168 × Skh. 61	1.48*	1.50**	-0.45	0.46	-3.57**	-2.39	2.98	1.97
G. 168 × Skh. 93	-1.09	-0.37	0.68*	1.40**	-3.61**	-14.18**	4.10*	-0.30
G. 168 × Gem. 9	2.56**	3.36**	2.05**	2.57**	-2.85*	29.86**	3.53	4.52*
Skh. 8 × Skh. 61	3.70**	3.00**	1.37**	1.16**	-8.76**	-13.89**	3.82	4.30*
Skh. 8 × Skh. 93	0.36	0.74	0.00	0.46	0.11	-8.66**	1.91	0.75
Skh. 8 × Gem. 9	1.75**	1.81**	0.23	1.13**	-0.19	8.46**	7.26**	10.75**
Skh. 61 × Skh. 93	0.00	0.00	0.68*	1.39**	-7.83**	-1.87	1.58	-3.71*
Skh. 61 × Gem. 9	3.70**	4.13**	1.82**	1.39**	-10.78**	-14.54**	3.88*	3.24
Skh. 93 × Gem. 9	3.99**	3.70**	1.34**	1.37**	-1.21	-6.87**	5.03*	3.74*
LSD 0.05	1.03	0.96	0.86	0.86	1.35	1.43	4.18	3.58
LSD 0.01	1.38	1.29	1.16	1.16	1.81	1.92	5.61	4.81
	No. of spikes/plant		No. of kernels/spike		100 kernels weight		Grain yield/plant	
Crosses	Normal	Stress	Normal	Stress	Normal	Stress	Normal	Stress
G. 168 × Skh. 8	17.73**	2.37	0.99	9.65**	-4.02**	-6.46*	-2.67**	-4.63*
G. 168 × Skh. 61	3.54	13.96**	3.99**	10.93**	-3.01**	-3.12	1.87*	-9.38**
G. 168 × Skh. 93	7.73**	6.98*	7.50**	7.26**	1.79**	0.62	7.78**	-3.09
G. 168 × Gem. 9	7.73**	4.68	-3.93**	10.37**	3.41**	4.38	10.16**	-1.81
Skh. 8 × Skh. 61	5.36*	16.33**	2.12	5.11**	1.80**	-3.51	6.57**	-2.95
Skh. 8 × Skh. 93	5.77*	4.79	-2.53*	5.68**	-3.98**	-5.13*	3.08**	0.75
Skh. 8 × Gem. 9	12.00**	14.63**	-4.79**	18.75**	1.25*	0.43	3.10**	3.52
Skh. 61 × Skh. 93	5.36*	16.33**	0.00	3.28**	2.39**	2.05	5.81**	10.41**
Skh. 61 × Gem. 9	3.54	9.35**	-10.04**	6.02**	-2.29**	-5.62*	5.37**	4.84
Skh. 93 × Gem. 9	5.77**	4.79	-7.42**	6.22**	4.38**	3.49	8.73**	12.76**
LSD 0.05	0.81	0.88	1.46	1.45	0.05	0.25	0.71	1.17
LSD 0.01	1.08	1.18	1.95	1.95	0.07	0.33	0.96	1.57

* and ** = significant at 0.05 and 0.01 probability, respectively

plant height, number of kernels per spike and grain yield at normal conditions; El-Maghrapy (1998) for number of kernels per spike and grain yield at water stress and Shareif *et al.* (2006) for most of studied traits under normal and water stress conditions.

Heterosis over better parent: Results indicated that, the best crosses over their better parents at normal irrigation condition for plant height were Giza-168×Gemmeiza-9 and Sakha-61×Gemmeiza-9; for spikes number/plant were Giza-168×Sakha-8, Giza-168×Gemmeiza-9 and Sakha-93×Gemmeiza-9; for 100 kernel weight were Sakha-93×Gemmeiza-9, Giza-168×Gemmeiza-9, Sakha-61× Sakha-93, Sakha-8× Sakha-61 and Giza-168×Sakha-93; for grain yield per plant were Giza-168×Gemmeiza-9, Sakha-93×Gemmeiza-9, Giza-168×Sakha-93 and Sakha-8× Sakha-61 (Table 7).

The best crosses over their better parents at water stress condition for flag leaf area were Giza-168×Sakha-8, Giza-168× Gemmeiza-9 and Sakha-8×Gemmeiza-9; for plant height were Giza-168× Gemmeiza-9 and Sakha-8× Sakha-61.

The best crosses over better parents at both conditions for plant height were Giza-168×Sakha-8, Sakha-8×Gemmeiza-9 and Sakha-93×Gemmeiza-9; for spikes number/plant were Sakha-8× Sakha-61, Sakha-61×Sakha-93 and Sakha-8×Gemmeiza-9; for kernels number/spike were Giza-168×Sakha-61 and Giza-168×Sakha-93 and grain yield/plant were Sakha-61×Sakha-93 and Sakha-93×Gemmeiza-9.

These results are in agreement with those obtained by Ageez and El-Sherbeny (1998) for plant height at normal condition; El-Beially and El-Sayed (2002) for plant height, number of kernels per spike, grain yield at normal condition; EL-Shami *et al.* (1996) for number of kernels per spike and grain yield at normal condition and Mohamed (2004) for plant height at stress condition and Shareif *et al.* (2006) for most of studied traits under normal and water stress conditions.

Estimation of useful heterosis over better parent for grain yield/plant proved that it never exceeds 10.16% at normal condition (cross Giza-168×Gemmeiza-9) and 12.76% at stress condition (cross Sakha-93×Gemmeiza-9). Useful segregate could be selected from such hybrids as hybrid wheat is still under experimentation in Egypt.

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