



## HETEROSIS AND COMBINING ABILITY OF SOME BREAD WHEAT GENOTYPES

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### ABSTRACT

Twenty one wheat hybrids and their seven parental genotypes were evaluated in the research farm of the Faculty of Agriculture (Ain Shams University, Shoubra El-khema, Cairo, Egypt, in 2016/2017 growing season. The genetic analysis was conducted using Griffing) 1956 (Method 2, model 1).

Significant differences among parent genotypes and their 21 crosses for all the studied traits (days to 50% heading, days to maturity, flag leaf area, plant height, number of spikes/ plant, spike length, number of spikelets/ spike, number of kernels/ spike, 1000-kernel weight and grain yield/ plant) were detected. This indicated that, variability exists among these populations may increase the chance appearance of good new combination that can be isolated in the succeeding generations. Parents versus crosses mean squares as an indication for average heterosis over all crosses were significant for all studied traits.

Mean squares of general (GCA) and specific (SCA) combining abilities were significant for all studied traits except spike length trait for SCA which was insignificant. GCA/SCA ratios were more than unity for all studied traits, which indicating that the additive type of gene action is of great importance in the inheritance of these traits. Heterosis over the better parents showed that, the best hybrids were Gemmiza 9xGiza 168, Sakha 93x Giza, 168, Sakha 94x Jawahir-14, Sakha 94x Bob white, Giza 168xAcsad 925 and Jawahir-14x Bob white for grain yield/ plant trait and some of the other studied traits. The best general combiner parents were Sakha 94, Jawahir-14 and Bob white

for grain yield/ plant trait and some of the other studied traits. The best SCA hybrids were Gemmiza 9x Sakha 93, Gemmiza 9x Giza 168, Sakha 93x Jawahir-14, Sakha 94xJawahir-14, Sakha 94x Acsad 925, Sakha 94xBob white, Giza 168x Jawahir-14, Giza 168x Acsad 925, Jawahir-14x Bob white and Acsad 925x Bob white for grain yield/ plant trait and some of the other studied traits. These result could be used in wheat breeding programs.

Wheat (*Triticum aestivum* L.) is one of the leading cereals and staple food in many countries of the world including Egypt. It plays a remarkable role in meeting the food requirements of the country [Barutcular et al 2017; Ljubičić et al 2017; Singh, S.P. and V. Sharma, 2017; Thomas et al 2017 and Tiwari et al 2017].

In Egypt, wheat is the main winter cereal crop used as a staple food for urban and rural societies and the major source of straw for animal feeding [Ismail 2015, Hamda and Ibrahim 2016 and Kandil et al 2016]. However, total wheat consumption has increased drastically due to over population growth by about 2.5 % per year. Egypt imports about 45 % of its wheat requirements. This reflects the size of the problem and the efforts needed to increase wheat production. Thus, increasing production per unit area appears to be one of the important factors for narrowing the gap between wheat production and consumption.

Information regarding general and specific combining ability of wheat genotypes is a prerequisite to launch a successful wheat-breeding programs. Diallel mating design has been extensively used to analyze the combining ability effects of wheat genotypes and also to provide information regarding genetic mechanisms controlling grain yield and other traits. Knowledge of general and specific combining ability, influencing yield and its

components has become increasingly important for plant breeders in the choice of suitable parents for developing potential possessing varieties in wheat. Many researchers gave reviews, which revealed that both general and specific combining ability were involved in the improvement of yield and its contributing traits in wheat such as [Tiwari et al 2017; Patel, 2017; Ljubičić et al 2017; Kumar et al 2017 and Ahmad et al 2017].

#### The objective of the present investigation is to

Estimate heterosis and combining abilities (GCA and SCA) as basis of improving wheat to identify the best parental genotypes and hybrids that could be used in breeding programs.

## MATERIALS AND METHODS

The present study was carried out in the Research Farm, Fac. of Agric., Ain Shams Univ., Shoubra El-khema, Cairo, Egypt, during the period from 2016 to 2017, in order to evaluate the genetic performance of seven varieties of bread wheat and their F<sub>1</sub> hybrids in the field for some agronomic traits. The seven wheat varieties (*Triticum aestivum* L.) namely; (P1) Gemmiza 9, (P2) Shakha-93, (P3) Sakha 94, (P4) Giza 168, (P5) Jawahir-14, (P6) Acsad 925 and (P7) Bob white and their 21 F<sub>1</sub> hybrids (half diallel crosses) were obtained from the Professor Mohamed Abd-El Salam Rashed Prof. of Genetic, Department of Genetic, Faculty of Agriculture, Ain shams university. The varieties names, origins and pedigree are shown in **Table (1)**.

**Table 1.** Names, pedigree and origins of used wheat genotypes

No	Genotype	Pedigree	Origin
P1	Gemmiza 9	Ald's//Huac's//CMH74A.630/5x CGM.4583-5GM-1GM-0GM	Egypt
P2	Sakha 93	Sakha 92/ TR810328 S8871-1S-2S-1S-0S	Egypt
P3	Sakha 94	OPATA / RAYON // KAUZ CMBW90Y3180-0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y-0AP-0S	Egypt
P4	Giza 168	MIL/Buc//Seri CM 93046-8M-04-0M-2Y-0B	Egypt
P5	Jawahir-14	SHUHA-4//NS732/HER	ICARDA
P6	Acsad 925	GEN/3/GOV/AZ//MUS(s)/4/Sannine/Ald(s) ACS-W-9174-10IZ-5IZ-3IZ-0IZ	Syria
P7	Bob white	AU//KAL/BB/3/WOP	CIMMYT

In the 2016/2017 growing season the seeds of the parents and their 21 F<sub>1</sub> hybrids were planted at 15 November 2016 in a randomized complete blocks design (RCBD) with 3 replicates. The experimental plot was one row. Each row was 3 m in length and 25 cm in width. Seeds were spaced at 15 cm within rows, where one plant was left per the hill. There was no previous crop in the summer of 2016. The recommended cultural practices for wheat production were applied throughout the growth period. days to 50% heading, days to maturity, flag leaf area (cm<sup>2</sup>), plant height (cm), number of spikes / plant, spike length (cm), number of spikelets per spike, Number of kernels /spike, 1000 grain weight (g) and grain yield /plant (g) traits were recorded on a sample of 10 guarded plants of each plot. Estimates of combining ability effects

were made estimated by applying **Griffing (1956)**, Method 2 model 1 (one set of F<sub>1</sub>'s and parents). Percentage of heterosis relative to better parent was estimated.

## RESULTS AND DISCUSSION

### 1. Analysis of variance

The analysis of variance estimates for all the studied traits are shown in **Table (2)**. The mean squares for genotypes, parents and crosses exhibited highly significant differences for all studied traits. This result indicated that variability exists among this populations may increase the chance appearance of good new combinations that can be isolated in the succeeding generations. Parents

**Table 2.** Analysis of variance estimates for all studied traits in the seven parents and their half diallel crosses

S.O.V.	d.f	Days to 50% heading	Days to maturity	Flag leaf area	Plant height	No. of spikes/plant
Replications	2	0.44	0.58	1.05	0.42	0.46
Genotypes	27	37.19**	28.4**	96.48**	164.86**	12.42**
Parent	6	93.30**	52.52**	182.46**	385.94**	24.31**
Cross	20	22.04**	20.79**	66.94**	106.25**	9.28**
Par.vs.cr.	1	3.57**	35.81**	171.42**	10.42**	4.06**
Error	54	0.24	0.16	0.53	0.53	0.32
GCA	6	48.34**	33.09**	124.48**	232.57**	17.27**
SCA	21	2.13**	2.71**	5.78**	4.2**	0.39**
GCA/SCA		2.62	1.38	2.46	6.41	6.7

\*, \*\*= Significant at  $p < 0.05$  and  $p < 0.01$  level, respectively.

**Table 2.** cont.

S.O.V.	d.f	Spike length	No. of spikelets per Spike	No. of kernels per spike	1000-kernel weight	Grain yield/plant
Replications	2	0.01	0.05	0.77	0.16	0.57
Genotypes	27	1.41**	2.86**	82.63**	80.93**	167.54**
Parent	6	2.89**	4.57**	135.44**	125.21**	254.93**
Crosses	20	0.94**	2.4**	64.67**	69.27**	135.1**
Par.vs.cr.	1	1.97**	1.72**	124.84**	48.4**	291.96**
Error	54	0.19	0.08	0.57	0.66	0.34
GCA	6	1.79**	3.86**	106.49**	110.77**	222.59**
SCA	21	0.09	0.12**	4.99**	3.04*	8.21**
GCA/SCA		6.89	4.43	2.46	4.36	3.05

\*, \*\*= Significant at  $p < 0.05$  and  $p < 0.01$  level, respectively.

versus crosses mean squares as an indication for average heterosis over all crosses were significant for all studied traits. These findings were in agreements with those reported by **Shehzad et al (2015)**; **Ahmad et al (2017)** and **Tiwari et al (2017)**. The partitioning of genetic variations among parents and their crosses revealed significant differences in general (GCA) and specific (SCA) combining abilities for all studied traits except spike length trait which for SCA was not significant, indicated that both additive and non additive genetic effects were involved in the inheritance of these traits (**Table 5**). Similar conclusion was recorded by **Kumar et al (2017)**; **Patel et al (2017)** and **Tiwari et al (2017)**.

Comparing the relative magnitudes of GCA and SCA variances, the GCA/SCA ratios for all measured traits were more than unity. This indicates that the largest part of the total genetic variability is due to additive gene action for the all studied traits. These results were in agreement with those reported by **Sadeghi et al (2012)**; **Singh et al (2012)**; **Attia et al (2014)** and **Khaled and Abd El-Dayem (2014)**.

## 2. Mean performance of wheat genotypes

Mean values for all studied traits are presented in **Tables (3 and 4)**. Gemmiza 9 expressed the highest mean value for flag leaf area, plant height,

No. of kernels/spike, spike length and No. of spikelets/spike traits. Sakha 93 parent recorded the highest values for days to 50% heading, days to maturity, flag leaf area, plant height, No. of spikes/plant, spike length and No. of spikelets/spike traits. Sakha 94 parent had the best mean value for days to 50% heading, plant height, No. of kernels/spike, No. of spikelets/spike, 1000-kernel weight and grain yield/plant traits. Giza 168 parent recorded the highest values for days to 50% heading, days to maturity, flag leaf area, plant height, spike length, No. of spikelets/spike and 1000-kernel weight traits. Jawahir-14 parent expressed the highest mean value for days to 50% heading, days to maturity, flag leaf area, No. of spikes/plant, No. of kernels/spike, 1000-kernel weight and grain yield/plant traits. Acsad 925 parent recorded the highest values for 1000-kernel weight traits. Bob white parent expressed the highest mean value for No. of spikes/plant, spike length and grain yield/plant traits.

Regarding hybrid mean performances, it is clear that the highest desirable values were recorded by cross of combination Gemmiza 9 x Jawahir-14 for flag leaf area, plant height, spike length, No. of kernels/spike, No. of spikelets/spike and grain yield/plant traits; Sakha 93xSakha 94 for days to 50% heading, days to maturity, flag leaf area, plant height, No. of spikes/plant, No. of kernels/spike and No. of spikelets/spike traits; Sakha 93xGiza 168 for days to 50% heading, days to maturity, flag leaf area, plant height, spike length and No. of spikelets/spike traits; Sakha 93xBob white for days to 50% heading, days to maturity, flag leaf area, No. of spikes/plant and spike length traits; Sakha 94xGiza 168 for days to 50% heading, plant height, spike length, No. of spikelets/spike and grain yield/plant traits; Sakha 94x Jawahir-14 for days to 50% heading, days to maturity, No. of spikes/plant, No. of kernels/spike, 1000-kernel weight and grain yield/plant traits; Sakha 94xBob white for days to 50% heading, No. of spikes/plant, No. of kernels/spike, spike length and grain yield/plant traits; Giza 168x Jawahir-14 for days to 50% heading, days to maturity, plant height, No. of spikes/plant, No. of kernels/spike, spike length, No. of spikelets/spike and grain yield/plant traits; Giza 168xAcsad 925 for days to 50% heading, spike length and 1000-kernel weight traits; Jawahir-14x Acsad 925 for days to maturity, 1000-kernel weight and grain yield/plant traits; and Jawahir-14xBob white for days to 50% heading, days to maturity, No. of spikes/plant, No. of kernels/spike and grain yield/plant traits.

From these results, it could be concluded that three parents (Sakha 94, Jawahir-14 and Bob white) and four crosses combinations (Sakha 93xJawahir-14, Sakha 94 xJawahir-14, Sakha 94 x Bob white and Giza 168xJawahir-14) seemed to gave the best values for the studied traits among the studied parents and their hybrids since they expressed the most desirable values for grain yield/plant trait and most of the other studied traits. The previous mentioned three parents and four crosses would prospect in bread wheat breeding and therefore may be valuable for improving seed yield via its components traits.

### 3. Heterobeltiosis

Percentage of heterosis relative to the better parent for all the studied traits are presented in **Tables (5 and 6)**. The best hybrid values for the studied traits were Acsad 925xBob white for days to 50% heading trait, Gemmiza 9xSakha 94, Sakha 93xSakha 94, Sakha 93xGiza 168, Sakha 93xBob white, Sakha 94xAcsad 925, Sakha 94xBob white and Acsad 925xBob white for days to maturity trait, Gemmiza 9xJawahir-14, Sakha 94xBob white and Acsad 925xBob white for flag leaf area trait, Acsad 925xBob white for plant height trait, Sakha 93xGiza 168 for No. of kernels/spike trait, and Gemmiza 9xGiza 168, Sakha 93xGiza 168, Sakha 94xJawahir-14, Sakha 94xBob white, Giza 168xAcsad 925 and Jawahir-14xBob white for grain yield / plant trait. These results were in a harmony with those obtained by **Thomas et al (2017); Kalhoro et al (2015) and Ismail (2015)**.

### 4. General (GCA) and specific (SCA) combining ability effects

#### I- General combining ability effects

Estimates of GCA effects of each parental genotypes for the different studied traits are presented in **Tables (7 and 8)**. The best general combiner parental genotypes were Sakha 93, Sakha 94, Giza 168 and Jawahir-14 parents for days to 50% heading trait, Sakha 93, Giza 168 and Jawahir-14 parents for days to maturity trait, Gemmiza 9, Sakha 93 and Giza 168 parents for flag leaf area trait, Gemmiza 9, Sakha 93, Sakha 94 and Giza 168 parents for plant height trait, Sakha 93, Sakha 94, Jawahir-14 and Bob white parents for number of spikes per plant trait, Gemmiza 9, Giza 168

**Table 3.** Mean performance of the seven bread wheat parental genotypes and their F<sub>1</sub> crosses for days to 50% heading, days to maturity, flag leaf area, plant height and no. of spikes/plant traits

Parents and Crosses	Days to 50% heading	Days to maturity	Flag leaf area (cm <sup>2</sup> )	Plant height (cm)	No. of spikes/plant
P1:Gemmiza 9	107.33	155.00	45.35	112.37	7.30
P2:Sakha 93	97.00	148.67	49.07	101.52	10.50
P3:Sakha 94	95.67	151.00	36.57	104.21	9.85
P4:Giza 168	93.33	147.67	43.17	107.21	8.90
P5:Jawahir-14	90.33	142.00	39.57	92.54	11.61
P6:Acsad 925	101.33	153.00	27.35	87.47	3.80
P7:Bob white	99.33	149.67	31.01	81.00	12.01
Parents mean	97.76	149.57	38.87	98.04	9.14
Gemmiza 9 x Sakha 93	100.33	151.00	49.66	108.51	9.01
Gemmiza 9 x Sakha 94	97.00	147.33	41.93	106.89	8.80
gemmiza 9 x Giza 168	98.33	149.67	45.76	108.39	8.37
Gemmiza 9 x Jawahir-14	101.00	151.67	46.68	103.21	9.97
Gemmiza 9 x Acsad 925	103.33	154.33	38.96	96.31	6.29
Gemmiza 9 x Bob white	102.33	151.67	38.86	100.81	9.24
Sakha 93 x Sakha 94	96.33	146.67	49.25	103.92	10.15
Sakha 93 x Giza 168	95.67	146.33	48.07	103.82	9.18
Sakha 93 x Jawahir-14	92.00	143.33	47.75	94.91	10.98
Sakha 93x Acsad 925	98.67	149.33	43.02	91.54	6.73
Sakha 93 x Bob white	96.67	147.00	44.55	92.20	12.22
Sakha 94 x Giza 168	95.00	148.00	41.93	105.81	9.52
Sakha 94 x Jawahir-14	95.67	146.00	38.86	98.49	11.62
Sakha 94 x Acsad 925	97.67	148.33	35.44	98.41	8.06
Sakha 94 x Bob white	96.33	148.00	38.87	96.71	12.40
Giza 168 x Jawahir-14	93.67	145.00	42.21	100.49	10.90
Giza 168 x Acsad 925	96.33	148.00	42.55	96.36	8.38
Giza 168 x Bob white	97.00	148.33	43.32	97.25	11.06
Jawahir-14 x Acsad 925	97.00	145.33	35.77	91.03	9.04
Jawahir-14 x Bob white	95.33	145.00	39.83	90.14	12.51
Acsad 925 x Bob white	97.33	149.00	32.27	90.82	8.12
Crosses mean	97.29	148.06	42.17	98.86	9.65
General mean	97.40	148.44	41.34	98.65	9.52
<b>L.S.D 5%</b>	<b>0.81</b>	<b>0.66</b>	<b>1.2</b>	<b>1.19</b>	<b>0.92</b>

**Table 4.** Mean performance of the seven bread wheat parental genotypes and their F<sub>1</sub> crosses for spike length, no. of spikelets/spike, no. of kernels/spike, 1000-kernel weight and grain yield/plant traits

Parents and Crosses	Spike length (cm)	No. of spikelets per spike	No. of kernels per spike	1000-kernel weight (g)	Grain yield/plant (g)
P1:Gemmiza 9	12.69	21.87	70.63	41.53	19.33
P2:Sakha 93	12.00	22.60	63.11	40.08	23.19
P3:Sakha 94	10.50	21.53	72.80	45.37	30.60
P4:Giza 168	13.33	23.00	61.60	47.14	21.75
P5:Jawahir-14	11.10	21.00	75.13	51.90	39.35
P6:Acsad 925	11.57	19.73	56.32	55.78	10.17
P7: Bob white	12.53	20.00	65.80	38.00	27.77
Parents mean	11.96	21.39	66.49	45.68	24.59
Gemmiza 9 x Sakha 93	12.84	22.93	71.88	41.35	23.16
Gemmiza 9 x Sakha 94	12.02	22.00	73.82	44.19	26.50
Gemmiza 9 x Giza 168	13.30	22.93	70.59	45.07	24.23
Gemmiza 9 x Jawahir-14	12.52	22.07	73.59	48.94	32.90
Gemmiza 9 x Acsad 925	12.53	21.73	68.68	46.73	17.93
Gemmiza 9 x Bob white	12.66	21.07	71.44	40.91	24.78
Sakha 93 x Sakha 94	11.24	22.93	71.11	43.99	28.17
Sakha 93 x Giza 168	12.79	23.13	67.94	44.71	24.44
Sakha 93 x Jawahir-14	11.94	21.67	75.90	48.07	38.04
Sakha 93x Acsad 925	12.13	21.00	60.71	53.45	19.82
Sakha 93 x Bob white	12.61	21.13	64.81	39.36	28.16
Sakha 94 x Giza 168	12.67	22.80	70.44	48.10	29.83
Sakha 94 x Jawahir-14	11.24	21.60	75.24	50.68	41.83
Sakha 94 x Acsad 925	11.60	21.60	67.36	52.40	25.31
Sakha 94 x Bob white	12.37	21.13	71.70	42.86	35.83
Giza 168 x Jawahir-14	12.41	22.13	73.38	51.56	38.32
Giza 168 x Acsad 925	12.60	21.47	61.53	53.93	25.06
Giza 168 x Bob white	13.13	21.87	63.40	42.59	26.87
Jawahir-14 x Acsad 925	12.15	20.07	66.34	56.02	30.12
Jawahir-14 x Bob white	11.61	20.80	73.41	48.58	40.91
Acsad 925 x Bob white	12.23	20.07	62.04	52.72	24.71
Crosses mean	12.31	21.72	69.30	47.44	28.90
General mean	12.23	21.64	68.60	47.00	27.82
<b>L.S.D 5%</b>	<b>0.72</b>	<b>0.50</b>	<b>1.23</b>	<b>1.33</b>	<b>0.96</b>

**Table 5.** Percentage of heterosis relative to the better parent for days to 50% heading, days to maturity, flag leaf area, plant height and no. o spikes per plant traits

Crosses	Days to 50% heading	Days to maturity	Flag leaf area	Plant height	No. of spikes/plant
Gemmiza 9 x Sakha 93	3.44**	1.57**	1.20	-3.43**	-14.19**
Gemmiza 9 x Sakha 94	1.39**	-2.43**	-7.54**	-4.88**	-10.66*
Gemmiza 9 x Giza 168	5.36**	1.35**	0.89	-3.54**	-5.96
Gemmiza 9 x Jawahir-14	11.81**	6.81**	2.94*	-8.15**	-14.13**
Gemmiza 9 x Acsad 925	1.97**	0.87**	-14.10**	-14.29**	-13.88*
Gemmiza 9 x Bob white	3.02**	1.34**	-14.31**	-10.29**	-23.07**
Sakha 93 x Sakha 94	0.70	-1.35**	0.37	-0.28	-3.30
Sakha 93 x Giza 168	2.5**	-0.9**	-2.04	-3.16**	-12.57*
Sakha 93 x Jawahir-14	1.85**	0.94**	-2.69*	-6.51**	-5.40
Sakha 93x Acsad 925	1.72**	0.45*	-12.33**	-9.83**	-35.90**
Sakha 93 x Bob white	-0.34	-1.78**	-9.20**	-9.18**	1.80
Sakha 94 x Giza 168	1.79**	0.23	-2.86*	-1.31*	-3.38
Sakha 94 x Jawahir-14	5.9**	2.82**	-1.80	-5.49**	0.14
Sakha 94 x Acsad 925	2.09**	-1.77**	-3.10	-5.56**	-18.21**
Sakha 94 x Bob white	0.70	-1.11**	6.28**	-7.19**	3.28
Giza 168 x Jawahir-14	3.69**	2.11**	-2.23	-6.27**	-6.06
Giza 168 x Acsad 925	3.21**	0.23	-1.43	-10.12**	-5.81
Giza 168 x Bob white	3.93**	0.45*	0.36	-9.29**	-7.88*
Jawahir-14 x Acsad 925	7.38**	2.35**	-9.60**	-1.63*	-22.11**
Jawahir-14 x Bob white	5.54**	2.11**	0.64	-2.59**	4.22
Acsad 925 x Bob white	-2.01**	-0.45*	4.07*	3.83**	-32.40**
<b>Mean</b>	<b>3.12</b>	<b>0.66</b>	<b>-3.17</b>	<b>-5.67</b>	<b>-10.74</b>

\*and\*\* indicate significance at 0.05 and 0.01 probability levels, respectively

**Table 6.** Percentage of heterosis relative to the better parent for spike length, no. of spikelets/spike, no. of kernels/spike, 1000-kernel weight and grain yield/plant traits

Crosses	Spike length	No. of spikelets per spike	No. of kernels per spike	1000-kernel weight	Grain yield/plant
Gemmiza 9 x Sakha 93	1.16	1.47	1.77*	-0.44	-0.14
Gemmiza 9 x Sakha 94	-5.31	0.61	1.40	-2.62	-13.41**
Gemmiza 9 x Giza 168	-0.23	-0.29	-0.06	-4.39**	11.39**
Gemmiza 9 x Jawahir-14	-1.37	0.91	-2.05*	-5.70**	-16.40**
Gemmiza 9 x Acsad 925	-1.29	-0.61	-2.77**	-16.23**	-7.27**
Gemmiza 9 x Bob white	-0.21	-3.66**	1.15	-1.50	-10.77**
Sakha 93 x Sakha 94	-6.36*	1.47	-2.33*	-3.05*	-7.96**
Sakha 93 x Giza 168	-4.05	0.58	7.66**	-5.15**	5.40*
Sakha 93 x Jawahir-14	-0.50	-4.13**	1.03	-7.38**	-3.33*
Sakha 93x Acsad 925	1.06	-7.08**	-3.80**	-4.17**	-14.55**
Sakha 93 x Bob white	0.61	-6.49**	-1.50	-1.79	1.40
Sakha 94 x Giza 168	-4.98	-0.87	-3.25**	2.05	-2.54
Sakha 94 x Jawahir-14	1.32	0.31	0.14	-2.35	6.30**
Sakha 94 x Acsad 925	0.23	0.31	-7.48**	-6.05**	-17.31**
Sakha 94 x Bob white	-1.30	-1.86	-1.51	-5.55**	17.09**
Giza 168 x Jawahir-14	-6.88*	-3.77**	-2.33*	-0.66	-2.62*
Giza 168 x Acsad 925	-5.48*	-6.67**	-0.12	-3.32*	15.24**
Giza 168 x Bob white	-1.50	-4.93**	-3.65**	-9.64**	-3.25
Jawahir-14 x Acsad 925	4.98	-4.44**	-11.70**	0.44	-23.46**
Jawahir-14 x Bob white	-7.34*	-0.95	-2.28*	-6.39**	3.96**
Acsad 925 x Bob white	-2.39	0.33	-5.71**	-5.49**	-11.02**
<b>Mean</b>	<b>-1.90</b>	<b>-1.89</b>	<b>-1.78</b>	<b>-4.25</b>	<b>-3.49</b>

\*and\*\* indicate significance at 0.05 and 0.01 probability levels, respectively.

**Table 7.** Estimates of general combining ability effects of the seven parents for days to 50% heading, days to maturity, flag leaf area, plant height and no. of spikes/plant traits

Parents	Days to 50% heading	Days to maturity	Flag leaf area	Plant height	No. of spikes per plant
P1:Gemmiza 9	4.19**	3.13**	2.42**	6.63**	-1.10**
P2:Sakha 93	-0.62**	-0.72**	5.52**	0.97**	0.35**
P3:Sakha 94	-1.1**	-0.13	-1.26**	3.27**	0.46**
P4:Giza 168	-1.84**	-0.76**	2.16**	4.15**	-0.10
P5:Jawahir-14	-2.66**	-3.02**	-0.06	-2.88**	1.34**
P6:Acsad 925	1.53**	1.42**	-5.34**	-5.54**	-2.44**
P7: Bob white	0.49**	0.09	-3.45**	-6.59**	1.49**
S.E(gi)	0.09	0.07	0.13	0.13	0.10
LSD(gi-gj) 0.05	0.18	0.14	0.26	0.26	0.20
0.01	0.24	0.19	0.35	0.35	0.27

\*and\*\* indicate significance at 0.05 and 0.01 levels, respectively.

**Table 8.** Estimates of general combining ability effects of the seven parents for spike length, no. of spikelets/spike, no. of kernels/spike, 1000-kernel weight and grain yield/plant traits

Parents	Spike length	No. of spikelets per spike	No. of kernels per spike	1000-kernel weight	Grain yield per plant
P1:Gemmiza 9	0.38**	0.37**	2.50**	-2.86**	-3.83**
P2:Sakha 93	-0.03	0.54**	-1.13**	-2.77**	-1.60**
P3:Sakha 94	-0.63**	0.23**	2.94**	-0.34*	2.90**
P4:Giza 168	0.64**	0.80**	-2.03**	0.47**	-1.15**
P5:Jawahir-14	-0.41**	-0.31**	4.37**	3.52**	8.69**
P6:Acsad 925	-0.16*	-0.86**	-5.50**	5.65**	-6.59**
P7: Bob white	0.21**	-0.78**	-1.15**	-3.66**	1.58**
S.E(gi)	0.08	0.05	0.13	0.14	0.10
LSD(gi-gj) 0.05	0.16	0.10	0.26	0.28	0.20
0.01	0.21	0.13	0.35	0.37	0.27

\*and\*\* indicate significance at 0.05 and 0.01 levels, respectively.

and Bob white parents for spike length trait, Gemmiza 9, Sakha 93, Sakha 94 and Giza 168 parents for number of spikelets per spike trait, Gemmiza 9, Sakha 94 and Jawahir-14 parents for number of kernels per spike trait, Giza 168, Jawahir-14 and Acsad 925 parents for 1000 grain weight trait, Sakha 94, Jawahir-14 and Bob white parents for grain yield per plant trait. This would indicated that the previous mentioned parental genotypes could be used in breeding programs for improving wheat productivity.

### II-Specific combining ability effects

Specific combining ability effects for the studied traits are presented in **Tables (9 and 10)**. For days to 50% heading trait, seven out of the studied

twenty one wheat crosses (Gemmiza 9xSakha 93, Gemmiza 9xSakha 94, Gemmiza 9xGiza 168, Sakha 93xJawahir-14, Sakha 93xBob white, Giza 168xBob white and Acsad 925xBob white) showed negative (desirable) and significant specific combining ability effects, which indicating tendency towards earliness.

Regarding days to maturity trait, eleven out of the studied twenty one wheat crosses (Gemmiza 9x Sakha 94, Gemmiza 9x Giza 168, Sakha 93x Sakha 94, Sakha 93xGiza 168, Sakha 93x Jawahir-14, Sakha 93xBob white, Sakha 94xAcsad 925, Giza 168x Acsad 925, Jawahir-14x Acsad 925, Jawahir-14xBob white and Acsad 925xBob white) exhibited negative (desirable) and significant specific combining ability effects, indicating tendency towards earliness. The results of flag leaf area trait

**Table 9.** Estimates of specific combining ability effects of the 21 wheat crosses for days to 50% heading, days to maturity, flag leaf area, plant height and no. of spikes/plant traits

Crosses	Days to 50% heading	Days to maturity	Flag leaf area	Plant height	No. of spikes per plant
Gemmiza 9 x Sakha 93	-0.65*	0.16	0.37	2.27**	0.24
Gemmiza 9 x Sakha 94	-3.50**	-4.10**	-0.58	-1.66**	-0.08
Gemmiza 9 x Giza 168	-1.43**	-1.13**	-0.17	-1.03**	0.05
Gemmiza 9 x Jawahir-14	2.06**	3.12**	2.97**	0.80*	0.2
Gemmiza 9 x Acsad 925	0.2	1.34**	0.53	-3.43**	0.3
Gemmiza 9 x Bob white	0.24	0.01	-1.45**	2.12**	-0.68*
Sakha 93 x Sakha 94	0.64*	-0.92**	3.65**	1.03**	-0.17
Sakha 93 x Giza 168	0.73**	-0.62**	-0.96*	0.06	-0.58
Sakha 93 x Jawahir-14	-2.13**	-1.36**	0.94*	-1.83**	-0.23
Sakha 93x Acsad 925	0.36	0.19	1.49**	-2.55**	-0.70*
Sakha 93 x Bob white	-0.61*	-0.81**	1.14**	-0.83*	0.87**
Sakha 94 x Giza 168	0.54*	0.45*	-0.31	-0.26	-0.35
Sakha 94 x Jawahir-14	2.02**	0.71**	-1.17**	-0.56	0.31
Sakha 94 x Acsad 925	-0.16	-1.40**	0.69	2.03**	0.52
Sakha 94 x Bob white	-0.47	-0.40	2.23**	1.38**	0.94**
Giza 168 x Jawahir-14	0.76**	0.34	-1.24**	0.57	0.15
Giza 168 x Acsad 925	-0.76**	-1.10**	4.39**	-0.9*	1.41**
Giza 168 x Bob white	0.95**	0.56**	3.27**	1.04**	0.15
Jawahir-14 x Acsad 925	0.72**	-1.51**	-0.18	0.79*	0.62*
Jawahir-14 x Bob white	0.09	-0.51*	1.99**	0.95*	0.16
Acsad 925 x Bob white	-2.09**	-0.95**	-0.29	4.29**	-0.46
S.E(sij)	0.26	0.21	0.38	0.38	0.29
LSD (sij-sik) 0.05	0.67	0.55	0.99	0.98	0.77
0.01	0.85	0.69	1.25	1.24	0.97
LSD (sij-skl) 0.05	0.62	0.51	0.93	0.92	0.72
0.01	0.78	0.65	1.17	1.16	0.91

\*and\*\* indicate significance at 0.05 and 0.01 levels, respectively.

(Table 9) indicated that, positive and significant SCA effects were observed in only nine crosses out of the 21 studied crosses (Gemmiza 9x Sakha 93, Sakha 93xSakha 94, Sakha 93xJawahir-14, Sakha 93xAcsad 925, Sakha 93xBob white, Sakha 94xBob white, Giza 168xAcsad 925, Giza 168xBob white and Jawahir-14xBob white). Therefore, these hybrids are considered as good F1-cross combinations for this trait. Concerning plant height trait, ten out of the studied twenty one wheat crosses (Gemmiza 9xSakha 93, Gemmiza 9xJawahir-14, Gemmiza 9xBob white, Sakha 93xSakha 94, Sakha 94xAcsad 925, Sakha 94xBob white, Giza 168xBob white, Jawahir-14xAcsad 925, Jawahir-14xBob white and Acsad 925xBob white) exhibited positive and significant specific combining ability effects. Therefore, these crosses were considered as good cross combinations for this trait. These

results were in a harmony with those obtained by Attia et al (2014); Raiyani et al (2015) and Ahmad et al (2017). Regarding No. of spikes per plant trait only four cross out of the 21 studied crosses (Sakha 93xBob white, Sakha 94xBob white, Giza 168x Acsad 925 and Jawahir-14x Acsad 925) exhibited positive and significant specific combining ability effects. For spike length trait, only two out of studied twenty one wheat crosses (Sakha 94xBob white and Jawahir-14xAcsad 925) showed positive and significant specific combining ability effects. With respect to number of spikelets per spike trait, only five out of twenty the studied one wheat crosses (Gemmiza 9xSakha 93, Gemmiza 9xJawahir-14, Pxacsad 925, Sakha 93x Sakha 94 and Sakha 94x Acsad 925) showed positive and significant specific combining ability effects.

**Table 10.** Estimates of specific combining ability effects of the 21 wheat crosses for spike length, no. of spikelets/spike, no. of kernels/spike, 1000-kernel weight and grain yield/plant traits

Crosses	Spike length	No. of spikelets perspike	No. of kernels per spike	1000-kernel weight	Grain yield per plant
Gemmiza 9 x Sakha 93	0.26	0.38*	1.92**	-0.02	0.76**
Gemmiza 9 x Sakha 94	0.04	-0.24	-0.22	0.39	-0.40
Gemmiza 9 x Giza 168	0.05	0.12	1.53**	0.46	1.38**
Gemmiza 9 x Jawahir-14	0.32	0.36*	-1.88**	1.28**	0.21
Gemmiza 9 x Acsad 925	0.08	0.58**	3.08**	-3.05**	0.52
Gemmiza 9 x Bob white	-0.15	-0.16	1.50**	0.44	-0.79*
Sakha 93 x Sakha 94	-0.33	0.53**	0.70	0.1	-0.95**
Sakha 93 x Giza 168	-0.05	0.15	2.51**	0.01	-0.63*
Sakha 93 x Jawahir-14	0.16	-0.21	4.07**	0.32	3.13**
Sakha 93x Acsad 925	0.09	-0.33*	-1.26**	3.57**	0.19
Sakha 93 x Bob white	0.2	-0.27	-1.50**	-1.21**	0.36
Sakha 94 x Giza 168	0.43	0.13	0.93*	0.97*	0.25
Sakha 94 x Jawahir-14	0.06	0.04	-0.68	0.5	2.42**
Sakha 94 x Acsad 925	0.16	0.59**	1.31**	0.09	1.18**
Sakha 94 x Bob white	0.57*	0.05	1.31**	-0.14	3.53**
Giza 168 x Jawahir-14	-0.04	0	2.44**	0.57	2.95**
Giza 168 x Acsad 925	-0.11	-0.12	0.46	0.81	4.98**
Giza 168 x Bob white	0.06	0.21	-2.01**	-1.22**	-1.39**
Jawahir-14 x Acsad 925	0.50*	-0.41**	-1.13**	-0.14	0.19
Jawahir-14 x Bob white	-0.41	0.25	1.60**	1.73**	2.81**
Acsad 925 x Bob white	-0.04	0.07	0.09	3.74**	1.90**
S.E(sij)	0.23	0.15	0.39	0.42	0.3
LSD (sij-sik) 0.05	0.6	0.39	1.02	1.09	0.79
0.01	0.76	0.49	1.29	1.38	1
LSD (sij-skl) 0.05	0.56	0.36	0.95	1.02	0.74
0.01	0.71	0.46	1.21	1.29	0.94

\*and\*\* indicate significance at 0.05 and 0.01 levels, respectively.

Regarding number of kernels per spike trait, only ten out of the studied twenty one wheat crosses (Gemmiza 9xSakha 93, Gemmiza 9xGiza 168, Gemmiza 9xAcsad 925, Gemmiza 9xBob white, Sakha 93x Giza 168, Sakha 93x Jawahir-14, Sakha 94x Giza 168, Sakha 94x Acsad 925, Sakha 94xBob white and Giza 168xJawahir-14) exhibited positive and significant specific combining ability effects. Therefore, these crosses were considered as good cross combinations for this trait. This results were in a harmony with those obtained by **Jatoi et al (2012); Singh et al (2012); Attia et al (2014) and Raiyani et al (2015)**. Concerning 1000-kernel weight trait (Table 13), only five crosses out of the 21 studied crosses (Gemmiza 9xJawahir-14, Sakha 93xAcsad 925, Sakha 94xGiza 168, Jawahir-14xBob white and Acsad 925xBob white) showed positive significant SCA

effects, which indicating a tendency for heavier 1000-kernel weight. Similar results were obtained by many investigators such as **Khodadadi et al (2012); Sadeghi et al (2012) and Attia et al (2014)**. Finally grain yield per plant trait (Table 9), only ten out of the studied twenty one wheat crosses (Gemmiza 9xSakha 93, Gemmiza 9xGiza 168, Sakha 93xJawahir-14, Sakha 94xJawahir-14, Sakha 94xAcsad 925, Sakha 94xBob white, Giza 168xJawahir-14, Giza 168xAcsad 925, Jawahir-14xBob white and Acsad 925xBob white) showed positive and significant specific combining ability effects. Therefore, these crosses were considered as good cross combinations for this trait. These results were similar with the results of **Attia et al (2014), Raiyani et al (2015) and Kumar et al (2017)**.

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