J. Plant Production, Mansoura Univ., Vol. 8 (7):729 - 737, 2017

Estimates of Heterosis, Combining Ability and Correlation for Yield and its Components in Bread Wheat

Motawea, M. H.

Department of Agronomy, Faculty of Agriculture, Sohag University, Sohag 82786, Egypt.

ABSTRACT

In order to realize the heterosis, general and specific combining ability of wheat, 28 crosses were synthesised in a 8 × 8 by using half diallel mating system, without reciprocals. Analysis of heterosis over mid parents (MP) as well as better parents (BP) and combining ability were conducted for yield and its contributing traits. The experiment was conducted in 2011–2012 and 2012–2013 seasons at the Experimental Farm of Faculty of Agriculture, Sohag University, Egypt. Heterosis was estimated for grain yield per plant revealed maximum heterosis over the mid parents (68.58% and 81.47%) for the crosses $P_5 \times P_8$ and $P_5 \times P_6$, followed by harvest index (53.32%), No. of spikes per plant (33.38%), biological yield per plant (30.71%), spike length (17.29%), 1000 kernel weight (15.13%),grain weight per spike (14.38%) and plant height (5.96%) for the crosses $P_7 \times P_8$, $P_5 \times P_8$, $P_4 \times P_5$, $P_4 \times P_8$, $P_3 \times P_4$, $P_1 \times P_3$ and $P_7 \times P_8$, respectively. The maximum heterobeltiosis was recorded for grain yield per plant (82.56% and 49.3%) for the crosses $P_5 \times P_8$ and $P_5 \times P_6$, followed by harvest index (40.12%), biological yield per plant (28.29%), No. of spikes per plant (16.9%), 1000 kernel weight (14.05%), grain weight per spike (12.9%), spike length (9.53%) and plant height (4.76%)%) for the crosses $P_5 \times P_8$, $P_5 \times P_6$, $P_2 \times P_5$, $P_3 \times P_4$, $P_1 \times P_3$, $P_2 \times P_6$, and $P_5 \times P_7$, respectively. The results indicated significant differences among the parents for general combining ability and crosses for specific combining ability for all studied traits, which indicated the importance of both additive and non-additive gene effects for these traits. General combining abilities were higher than those of specific combining abilities, then the GCA/SCA ratios were more than unity indicating the prepondorance of additive gene effect which have considerable roles in the inheritance of these traits. In general, The genotypes of P_5 (Sonora 64) confirmed to be good general combiner for plant height, No. of spikes / plant, 1000 - kernel weight, grain weight / spike, biological yield / plant, harvest index, grain yield / plant , and P_4 (Sahel 1) for plant height, spike length, No. of spikes / plant, 1000 - kernel weight, harvest index, grain yield / plant. The crosses $P_6 \times P_7$, $P_5 \times P_6$, $P_7 \times P_8$, $P_5 \times P_8$, $P_2 \times P_6$, $P_4 \times P_8$, were the best specific combiners for grain yield / plant and most of yield components. Grain yield had strong positive correlation with harvest index (0.85), biological yield per plant (0.65) and 1000 - kernel weight (0.59).

Keywords: Wheat, heterosis, combining ability, half diallel, correlation.

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most important crops all over the world. Egypt imports about 45% of its wheat requirement. This reflects the size of the problem and the efforts needed to increase wheat production. So, increasing production per unit area seems to be one of the great factors for narrowing the hole between wheat production and consumption, Ismail (2015). The total cultivated area of wheat in Egypt for the cropping year 2015-2016 was 1.26 Million hectares, with total wheat produce of 8.10 Million metric tons and average grain yield of 6.43 metric tons per hectare (USDA,2017).

Hybrid wheat is an alternative approach to increase the productivity and most important step in the hybrid-breeding program is the identification of suitable parents with high GCA and SCA for grain yield and then the exploitation of heterosis, Pawar *et al.* (2014). So a large number of researches on heterosis for grain yield and its attributes in wheat have been carried out Mosaad *et al.* (1990), Chowdhry *et al.,* (2001), Akbar *et al.,* (2010), Bilgin *et al.,* (2011), Kumar *et al.,* (2011), Singh *et al.,* (2012), Devi *et al.,* (2013), Desale and Mehta (2013), Barot *et al.,* (2014), El-Hosary *et al.,* (2015), Baloch *et al.,* (2016). Heterosis is considered as the superiority of the hybrids in comparisons to either of its parents. Heterosis has been estimated in a range of cultivated crops and has been the purpose of abundant importance to study as mean of increasing productivity of crop plant. It is now well established that heterosis does occur with proper combination of parents, Baloch *et al.,* (2016). Combining ability analysis gives very useful information with respect to selection of parents based on the behavior of their hybrids. Moreover, this analysis supports the breeders to recognize the best combiners which may be hybridized either to utilize heterosis or to reinforcement the favourable genes, Uzair *et al.,* (2016) . Diallel analysis was used by several investigators to appreciation both GCA–and SCA for different traits of wheat. Larik *et al.,* (1995), Kherialla *et al.,* (2001), Al-Kaddoussi *et al.*, (2003), Abd El-Aty and Hamad (2006), Motawea (2006), Hassan *et al.,* (2007), Sharief *et al.*,(2007), Mahpara *et al.,* (2008), El-Hosary *et al.* ,(2009), Çifci and Yağdi (2010), Saad *et al.,* (2010), Kumar *et al.,* (2011), Adel *and* Ali (2013), Desale and Mehta (2013), Barot *et al.,* (2014), Masood *et al.,* (2014), Kumar *et al.,* (2015), Mandal and Madhuri (2016). Most of genetic variances of grain yield trait and its components were controlled by additive genes, Singh *et al.*,(2000), Masood and Kronstad (2000), Singh *et al.,* (2002), Ahmadi *et al.,* (2003), Abd El-Aty and Hamad (2006), Kumar *et al.,* (2011), Blank *et al.,* (2012), Adel and Ali (2013), Barot *et al.,* (2014), and El-Hosary *et al.,* (2015). However some were controlled by non-additive genes Nazir *et al.,* (2005), Mahpara *et al.,* (2008), Masood *et al.,* (2014), Pawar *et al.,* (2014) and Ismail (2015).Correlation coefficient analysis may be used as a vital tool to collect the information about right reason and effective association between yield and associated components (Khan *et al.,*2003).

The objective of the present study was to expose the magnitude of both general (GCA) and specific (SCA) combining abilities as well as heterosis for grain yield and its attributed traits in 28 wheat crosses made among 8 bread wheat genotypes using one way diallel crosses.

MATERIALS AND METHODS

In this study, eight genetically diverse bread wheat genotypes (Table 1) were evaluated at The Experimental Farm of Faculty of Agriculture, Sohag University, Egypt. In 2011/2012 season, a half-diallel cross was carried out among all genotypes to produce 28 hybrids. In the next season (2012/2013), the parents and their 28 F_1's crosses were sown in 15^{th} November and evaluated using a randomized complete block design (RCBD) experiment with three replicates. Each genotype was sown in one row 2 m long with 20 cm of inter-row spacing and 10 cm spacing between plants in the row. Data were recorded on 10 plants chosen at random from each plot for the following traits: Plant Height (cm), Spike length (cm), No of Spikes per Plant, 1000 Kernel Weight (g), Grain Weight per Spike (g), Biological Yield per Plant (g) , Harvest Index, Grain Yield per Plant (g). Data were subjected to the analysis of variance in order to test the significance of the differences among the 28 F_1 and their parents according to Steel and Torrie (1980). Sum squares of studied genotypes was partitioned according to Griffing`s (1956) as method 2 into sources of variations due to GCA and SCA. The percent increase or decreases of F1 hybrids over mid as well as the best parent was calculated appreciate possible heterotic effects for aforementioned traits (Fonseca and Patterson, 1968) as under.

$$\textbf{Ht (\%)} = F_1 - MP / MP \times 100$$
$$\textbf{Hbt (\%)} = F_1 - BP / BP \times 100$$

Where,

Ht = Heterosis over mid-parent

Hbt = Heterosis over - better parent (Heterobeltiosis)

MP =Mean mid-parent value

BP = Mean better parent value

The't' test was done to define_whether F_1 hybrid means were statistically significant from mid-parents and best parent means as follow (Wynne *et al.*, 1970).

$$\textbf{Heterosis (Ht): } t_{ij} = F_{1ij} - MP / 3/8\ EMS$$
$$\textbf{Heterobeltiosis (Hbt): } t_{ij} = F_{1ij} - BP / 1/2\ EMS$$

Where

F_{ij} = The mean of the ijth F_1 cross

M.Pij = The mid-parents value for the ijth F_1 cross

B.Pij = The better parent values for ijth cross.

EMS = Error mean square

Simple correlation was also calculated to study nature of relationships among various traits following Pearson (1920).

Table 1. The origin of eight wheat genotypes used in this study.

Genotype	Name	Pedigree	Origin
P_1	Debeira	HD 160/5/TOB/CNO67/BB/3/NAI 60*2//TT/SN64/4/HD1954, HD2172.	Sudan
P_2	Sakha-8	CNO67/SN64//KLRE/3/8156PK-3418-65-05-05	Egypt
P_3	Shakha-69	Inia/RL4220//7C/Yr"S"CM15430-25-65-05-05	Egypt
P_4	Sahel-1	N.S.732/Plm/veery"S" D735-4Sd-1Sd-OSd	Egypt
P_5	Sonora-64	YT 54/N10B//2*Y54=somoeng2	Mexico
P_6	Giza-160	Chenab/Giza 155	Egypt
P_7	Giza-165	DMC no/Mfd//Mon"S"CM43339-C-1Y-1M-24- IM-24-OB	Egypt
P_8	Sids-4	Maya"S"/Mon "S"/CMH74.A592/3/Giza157-2	Egypt

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance detected presence of significant differences among all studied genotypes for all traits as shown in Table 2. Consequently, improvement can be made successfully by selection for improving yield and other traits. Genetic parameters were therefore estimated for each of these attributes. These results are assured by those obtained by El-Hosary *et al.,* (2009), Adel and Ali (2013), Al-Naggar *et al.,* (2015), Mahpara *et al.,* (2015) and Ismail (2015).

Table 2. Analysis of variance and mean squares of all genotypes for studied traits.

S.V	D.F	Mean Squares: Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
Rep.	2	0.079	0.026	0.620	0.001	0.023	0.609	1.177	0.789
Genotypes	35	36.985**	2.799**	4.130**	0.082**	0.238**	116.186**	216.926**	107.213**
Error	70	0.55	0.09	0.24	0.001	0.01	1.21	0.82	2.18

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Mean performance

Means performance of the eight parental genotypes and their F_1 crosses for the studied traits are given in Table 3. The cross P_5 x P_7 followed by the cross $P_4 \times P_8$ gave the highest value (107.83 and 107.67 cm) of plant height whereas, the genotype P_1 (Debeira) had the lowest value (95.87 cm) for this trait. The cross $P_4 \times P_8$ and $P_5 \times P_8$ recorded the highest values (15.50 and 14.33 cm) of spike length triat. For No. of spikes per plant, the cross $P_2 \times P_6$ (10.33) followed by the cross $P_6 \times P_7$ (10.00) and the three crosses $P_2 \times P_5$, $P_5 \times P_6$ and $P_7 \times P_8$ (9.67 for each one) recorded the highest values for No. of spikes per plant. For grain weight per spike, the three crosses, $P_4 \times P_5$, $P_5 \times P_8$ and $P_7 \times P_8$ registered the highest and the same values (2.01 g). The cross $P_5 \times P_8$ and $P_2 \times P_6$ registered high values (5.17 and 4.8 g) for 1000 Kernel weight. The cross $P_5 \times P_6$ followed by the three crosses; $P_6 \times P_7$, $P_5 \times P_8$ and $P_2 \times P_6$ recorded the highest values for grain yield per plant ranging from 37.69 to 40.67 g . For biological yield per plant, the three crosses; $P_6 \times P_7$, $P_5 \times P_6$ and $P_5 \times P_8$

recorded the highest values ranging from (93.28 g) to (93.75 g) whereas, the cross $P_1 \times P_5$ had the lowest value (61.49 g) for this trait. For harvest index three crosses; $P_3 \times P_4$, $P_7 \times P_8$ and $P_1 \times P_5$ recorded the highest values (43.70, 44.05 and 44.54, respectively) whereas, the cross $P_1 \times P_4$ had the lowest value (27.37) for this trait. The high grain yield per plant of the former hybrids could be imputed to one or more of yield components, i.e., No. of spikes per plant, 1000 Kernel weight and No. of grains per spike. Contrasting responses in grain yield per plant and some of its attributes were previously announced for F_1 wheat crosses by Khan *et al.,* (2000), Malik *et al*., (2005), Iqbal and Khan (2006), Dagustu (2008), Bhutta and Hanif (2010), Ahmad *et al.,* (2011), and Gogas and Koutsika-Sotiriou (2012).

Table 3. Mean Performances of F_1 hybrids and their parents for all studied traits.

Traits Genotypes	Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
Debeira(P1)	95.87	11.60	9.33	1.51	4.05	19.91	60.21	33.07
Sakha8 (P2)	103.00	12.07	8.33	1.78	4.29	25.93	75.67	34.27
Shakha69(P3)	102.63	12.57	9.00	1.55	4.19	26.76	78.33	34.17
Sahel 1 (P4)	106.53**	12.10	8.67	1.66	4.27	26.27	64.14	40.95**
Sonora64(P5)	102.93	11.60	7.67	1.99**	4.31	21.01	72.85	28.86
Giza160 (P6)	103.80	12.17	9.00	1.97**	4.45	27.24	70.73	38.53**
Giza165 (P7)	101.60	12.43	9.33	1.94**	4.26	25.04	79.22	31.61
Sids 4 (P8)	98.47	14.33**	5.33	2.04**	4.71**	20.76	80.30**	25.85
P_1 x P_2	102.00	12.17	8.67	1.70	4.26	25.43	70.99	35.83
P_1 x P_3	104.50*	11.67	8.67	1.75	4.15	25.37	83.27**	30.46
P_1 x P_4	100.33	12.33	8.67	1.60	4.44	21.57	78.82	27.37
P_1 x P_5	96.50	11.67	8.33	1.66	4.19	27.38	61.49	44.54**
P_1 x P_6	96.93	11.87	9.00	1.54	4.39	21.50	75.74	28.39
P_1 x P_7	97.60	12.33	9.33	1.59	4.12	23.18	83.07**	27.91
P_1 x P_8	95.93	12.83	6.67	1.70	4.56	22.16	73.90	29.99
P_2 x P_3	105.33**	11.17	8.00	1.62	4.29	28.03	81.38**	34.45
P_2 x P_4	105.00**	13.17**	9.33	1.70	4.39	31.24**	77.41	40.36**
P_2 x P_5	107.33**	12.17	9.67**	1.91*	4.54	33.87**	79.91*	42.37**
P_2 x P_6	104.93**	13.33**	10.33**	1.93*	4.80**	37.69**	92.00**	40.97**
P_2 x P_7	105.33**	12.83	8.33	1.81	4.32	23.26	76.77	30.31
P_2 x P_8	99.50	13.83**	5.67	1.73	4.90**	22.65	71.32	31.77
P_3 x P_4	106.67**	11.83	9.33	1.76	4.87**	37.23**	85.19**	43.70**
P_3 x P_5	106.33**	12.83	8.00	1.56	4.56	22.73	74.37	30.57
P_3 x P_6	103.83	12.33	9.00	1.49	4.19	22.31	72.17	30.91
P_3 x P_7	103.73	10.50	9.33	1.73	4.36	23.81	84.13**	28.30
P_3 x P_8	99.87	13.17**	6.33	1.63	4.84**	23.56	81.72**	28.82
P_4 x P_5	106.33**	12.17	9.67**	2.01**	4.81**	37.10**	89.53**	41.45**
P_4 x P_6	105.83**	12.17	8.33	1.60	4.37	25.43	68.13	37.33
P_4 x P_7	102.33	13.17**	9.00	1.70	4.38	29.00	67.46	42.99**
P_4 x P_8	107.67**	15.50**	9.33	1.91*	4.88**	35.07**	82.80**	42.36**
P_5 x P_6	105.17**	12.67	9.67**	1.91*	4.81**	40.67**	93.46**	43.53**
P_5 x P_7	107.83**	11.67	8.00	1.84*	4.36	25.44	80.12**	31.75
P_5 x P_8	104.67*	14.33**	8.67	2.01**	5.17**	37.90**	93.75**	40.44**
P_6 x P_7	106.17**	12.83	10.00**	1.96**	4.71**	40.30**	93.28**	43.20**
P_6 x P_8	103.53	12.33	6.67	1.83*	4.21	24.36	75.35	32.34
P_7 x P_8	106.00**	13.67**	9.67**	2.01**	4.89**	36.71**	83.35**	44.05**
Means	103.11	12.54	8.56	1.77	4.48	27.72	78.12	35.38
$LSD_{0.05}$	1.20	0.48	0.79	0.05	0.17	1.78	1.46	2.38
$LSD_{0.01}$	1.58	0.63	1.04	0.07	0.22	2.35	1.93	3.15

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Estimates of heterosis

To improve any character, plant breeders heavily rely on the availability of genetic variability generated from different matting designs. It is also well know phenomena that in a hybridization program, certain crosses pass on more favorable genes than the others. Thus, some cross combinations may be superior as compared to their parents for improving any economic trait in wheat breeding (Baloch *et al.,* 2016).

1- Heterosis over mid parents

Estimates of heterosis over mid parents for all studied traits are given in Tables 4. The results exhibited that these values were significantly different among hybrids for all studied characters. Out of 28 crosses, 17 crosses were significantly taller than their mid parents and the maximum heterotic values were 5.29, 4.24, 5.04, 5.44 and 5.96% for the crosses $P_1 \times P_3$, $P_2 \times P_5$, $P_4 \times P_8$, $P_5 \times P_7$ and $P_7 \times P_8$, respectively. In this direction, 11 crosses were significantly longer than their mid parents for spike length with maximum heterotic values of 8.98, 9.98, 6.16, 7.38, 17.29, 6.60 and 10.53% for the crosses $P_2 \times P_4$, $P_2 \times P_6$, $P_3 \times P_5$, $P_4 \times P_7$, $P_4 \times P_8$, $P_5 \times P_6$ and $P_5 \times P_8$, respectively. In addition, 9 crosses revealed the significant values of heterosis over mid parents for number of spike per plant. For this trait, the best crosses were $P_2 \times P_5$, $P_2 \times P_6$, $P_4 \times P_5$, $P_4 \times P_8$, $P_5 \times P_6$, $P_5 \times P_8$ and P7 × P_8 with the heterotic values of 20.88, 19.22, 18.36, 33.29, 16.02, 33.38 and 31.92%, respectively. For grain weight per spike, 6 crosses gave significant heterotic values in relation to mid parents with the highest estimates of 14.38 and 10.14% for the crosses $P_1 \times P_3$and $P_4 \times P_5$, respectively. The results indicated that the heterotic values of 14 crosses over their mid parents were significant for 1000 kernel weight. The most heavier crosses for this trait were $P_2 \times P_6$, P3 × P4, P4 × P5, P5 x P6, P5 x P8 and $P_7 \times P_8$ with the heterotic values of 9.84, 15.13, 12.12, 9.82, 14.63 and 9.03%, respectively. Out of 28 crosses, 17 crosses were significantly better yielding than their mid parents. The promising crosses "P1 × P5, P2 × P4, P2 × P5, P2 × P6, P3 × P4, P4 × P5, P4 × P8, P5 × P6, P5 × P8, P6 × P7 and P7 × P8" exhibited largest useful heterotic values of 33.82, 19.69, 44.31, 41.77, 40.38, 56.94, 49.14, 68.58, 81.47, 54.17 and 60.31% respectively. For biological yield per plant, the heterotic values of 20 crosses were found to be significant over their mid parents. The estimates of heterotic values for this traits ranged from 3.03 to 30.71% for the crosses $P_3 \times P_8$ and $P_4 \times P_5$, respectively. Regarding to harvest index, 13 crosses had significant heterotic values over their mid parents. The highest heterotic values was recorded for the cross $P_7 \times P_8$ (53.32%), while the lowest was obtained from the cross $P_6 \times P_8$ (0.47%).

2- Heterosis over better parent

Table 5 showed heterotic values over better parent for all studied traits. The results showed that 10 crosses out of 28 had significant heterotic values over the taller parent. These estimates ranged from 1.32 to 4.76% for the crosses $P_5 \times P_6$ and $P_5 \times P_7$, respectively. For spike length, the significant heterotic values in relation to better parent were recorded only in 6 crosses. The cross combination P2 × P_6 gave the longest value of 9.53%, while the cross $P_2 \times P_7$ had the shortest value of 3.22%. It could be noticed that 4 out of 28 crosses showed the maximum significant heterotic values over better parent for number of spike per plant. These desirable values were 16.09, 14.78, 11.53, 13.04 % recorded in the crosses $P_2 \times P_5$, $P_2 \times P_6$, $P_4 \times P_5$ and $P_5 \times P_8$, respectively. For grain weight per spike, only 2 promising were significantly higher than their better parent with values of 12.9% ($P_1 \times P_3$) and 6.02% ($P_3 \times P_4$). 12 crosses were significantly heavier than their better parent for 1000 kernel weight with the highest value of 14.05% for the cross $P_3 \times P_4$, while the lowest value was noticed for the cross $P_4 \times P_8$. As for grain yield per plant, it could be noticed that the majority of crosses were significantly more than their better parent. 16 out of 28 cross combination were found to be the best for the desirable direction of biological yield per plant. Regarding to harvest index, 8 crosses were significant in their heterotic values in relation to the better parent. These results are consistent with those obtained by Chowdhry *et al.* (2001), Farooq *et al.* (2005), Akbar *et al.* (2010), Omar *et al.* (2010), Saad *et al.*, (2010), Bilgin *et al.* (2011), Adel and Ali (2013), Devi *et al.* (2013), Hammad *et al.* (2013), Singh *et al.* (2013), Zhongfu *et al.* (2014), Ismail (2015), Kalhoro *et al.* (2015), Mahpara *et al.* (2015) and Ul-Allah *et al.* (2016).

In general, the results of this study showed, the majority of crosses were significantly exceeded their mid and better parents, reflecting the important role of non additive genetic variance in the inheritance of these traits.

Table 4. Estimates heterosis over mid parents for all studied traits.

Crosses	Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
$P_1 \times P_2$	2.58**	2.83	-1.81	3.34*	2.16	10.95**	4.49**	6.39*
$P_1 \times P_3$	5.29**	-3.43	-5.07	14.38**	0.73	8.70*	20.21**	-9.41**
$P_1 \times P_4$	-0.86	4.05*	-3.67	0.95	6.73**	-6.58	26.77**	-26.05**
$P_1 \times P_5$	-2.92**	0.60	-2.00	-5.14**	0.24	33.82**	-7.58**	43.84**
$P_1 \times P_6$	-2.91**	-0.13	-1.80	-11.49**	3.29	-8.80**	15.69**	-20.70**
$P_1 \times P_7$	-1.15*	2.62	0.00	-7.83**	-0.84	3.14	19.16**	-13.67**
$P_1 \times P_8$	-1.28*	-1.04	-9.00	-4.23**	4.11*	8.97*	5.19**	1.80
$P_2 \times P_3$	2.45**	-9.33**	-7.67	-2.70*	1.18	6.38*	5.69**	0.66
$P_2 \times P_4$	0.22	8.98**	9.76*	-1.16	2.57	19.69**	10.74**	7.31**
$P_2 \times P_5$	4.24**	2.83	20.88**	1.33	5.58**	44.31**	7.61**	34.23**
$P_2 \times P_6$	1.48**	9.98**	19.22**	2.93*	9.84**	41.77**	25.68**	12.55**
$P_2 \times P_7$	2.96**	4.73**	-5.66	-2.69*	1.05	-8.73**	-0.87	-8.01*
$P_2 \times P_8$	-1.23*	4.77**	-16.98**	-9.42**	8.89**	-2.98	-8.55**	5.69
$P_3 \times P_4$	2.00**	-4.09*	5.60	9.66**	15.13**	40.38**	19.59**	16.33**
$P_3 \times P_5$	3.45**	6.16**	-4.02	-11.86**	7.29**	-6.66*	-1.61*	-3.05
$P_3 \times P_6$	0.60	-0.32	0.00	-15.34**	-3.01	-17.39**	-3.17**	-14.98**
$P_3 \times P_7$	1.58**	-16.00**	1.80	-0.86	3.20	-8.09**	6.80**	-13.97**
$P_3 \times P_8$	-0.68	-2.08	-11.65*	-9.19**	8.76**	-0.86	3.03**	-3.98
$P_4 \times P_5$	1.53**	2.70	18.36**	10.14**	12.12**	56.94**	30.71**	18.75**
$P_4 \times P_6$	0.63	0.29	-5.72	-11.85**	0.23	-4.95	1.03	-6.06*
$P_4 \times P_7$	-1.67**	7.38**	0.00	-5.56**	2.70	13.04**	-5.89**	18.50**
$P_4 \times P_8$	5.04**	17.29**	33.29**	3.24**	8.69**	49.14**	14.65**	26.83**
$P_5 \times P_6$	1.75**	6.60**	16.02**	-3.54**	9.82**	68.58**	30.19**	29.19**
$P_5 \times P_7$	5.44**	-2.87	-5.88	-6.36**	1.75	10.49**	5.37**	5.01
$P_5 \times P_8$	3.94**	10.53**	33.38**	-0.25	14.63**	81.47**	22.43**	47.83**
$P_6 \times P_7$	3.38**	4.31*	9.11*	0.26	8.15**	54.17**	24.41**	23.18**
$P_6 \times P_8$	2.37**	-6.94**	-6.91	-8.73**	-8.08**	1.50	-0.22	0.47
$P_7 \times P_8$	5.96**	2.17	31.92**	1.01	9.03**	60.31**	4.50**	53.32**

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Table 5. Estimates heterosis over better parent for all studied traits .

Crosses	Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
P_1 x P_2	-0.97	0.83	-7.07	-4.49**	-0.70	-1.93	-6.18**	4.52
P_1 x P_3	1.82**	-7.16**	-6.75	12.90**	-0.95	-5.23	6.31**	-10.88**
P_1 x P_4	-5.82**	1.90	-7.07	-3.61*	3.98*	-17.89**	22.89**	-33.16**
P_1 x P_5	-6.25**	0.60	-10.72*	-16.58**	-2.78	30.32**	-15.59**	34.68**
P_1 x P_6	-6.62**	-2.47	-3.54	-21.83**	-1.35	-21.07**	7.08**	-26.32**
P_1 x P_7	-3.94**	-0.80	0.00	-18.04**	-3.29	-7.43*	4.86**	-15.57**
P_1 x P_8	-2.58**	-10.47**	-28.51**	-16.67**	-3.18	6.74	-7.97**	-9.31*
P_2 x P_3	2.26**	-11.14**	-11.11*	-8.99**	0.00	4.71	3.89**	0.53
P_2 x P_4	-1.44*	8.84**	7.61	-4.49**	2.33	18.92**	2.30*	-1.44
P_2 x P_5	4.20**	0.83	16.09**	-4.02**	5.34**	30.62**	5.60**	23.64**
P_2 x P_6	1.09	9.53**	14.78**	-2.03	7.87**	38.36**	21.58**	6.33*
P_2 x P_7	2.26**	3.22*	-10.72*	-6.70**	0.70	-10.30**	-3.09**	-11.58**
P_2 x P_8	-3.40**	-3.49*	-31.93**	-15.20**	4.03*	-12.65**	-11.18**	-7.30*
P_3 x P_4	0.13	-5.89**	3.67	6.02**	14.05**	39.07**	8.76**	6.72*
P_3 x P_5	3.30**	2.07	-11.11*	-21.61**	5.80**	-16.70**	-5.06**	-10.59**
P_3 x P_6	0.03	-1.91	0.00	-24.37**	-5.84**	-18.10**	-7.86**	-19.78**
P_3 x P_7	1.07	-16.47**	0.00	-10.82**	2.35	-11.06**	6.20**	-17.20**
P_3 x P_8	-2.69**	-8.09**	-29.67**	-20.10**	2.76	-11.99**	1.77	-15.68**
P_4 x P_5	-0.19	0.58	11.53*	1.01	11.60**	41.23**	22.90**	1.22
P_4 x P_6	-0.66	0.00	-7.44	-18.78**	-1.80	-6.64*	-3.68**	-8.84**
P_4 x P_7	-3.94**	5.95**	-3.54	-12.37**	2.58	10.39**	-14.84**	4.98
P_4 x P_8	1.07	8.16**	7.61	-6.37**	3.61*	33.50**	3.11**	3.44
P_5 x P_6	1.32*	4.11*	7.44	-3.05*	8.09**	49.30**	28.29**	12.98**
P_5 x P_7	4.76**	-6.11**	-14.26**	-5.15**	1.16	1.60	1.14	0.44
P_5 x P_8	1.69**	0.00	13.04*	-1.47	9.77**	82.56**	16.75**	40.12**
P_6 x P_7	2.28**	3.22	7.18	1.03	5.84**	47.94**	17.75**	12.12**
P_6 x P_8	-0.26	-13.96**	-25.89**	-10.29**	-10.62**	-10.57**	-6.16**	-16.07**
P_7 x P_8	4.33**	-4.61**	3.64	-1.47	3.82*	46.61**	3.80**	39.35**

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Combining ability analysis

The analysis of variance and the mean squares of combining ability for all studied traits are presented in Table 6. The results showed that mean squares of general combining ability (GCA) and specific combining ability (SCA) were highly significant for all studied traits. This finding indicate that both additive and non-additive gene action are involved in the expression of these traits. However, the ratios of GCA / SCA were found to be greater than unity for all studied traits, suggesting the predominance of the additive gene action in controlling of studied traits. Therefore, selection based on the accumulation of additive genes would be effective in this set of genetic materials. Our results are in accordance with those obtained by Mosaad *et al.,* (1990), Kherialla *et al.,* (2001), Mavi *et al.,* (2003), Saad *et al.,* (2010), Singh *et al.,* (2012), Al-Naggar *et al.* , (2015) and Ismail (2015).

Table 6. The analysis of variance and mean squares for combining ability for all studied traits.

S.V	D.F	Mean squares: Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
GCA	7	114.73**	7.80**	10.27**	0.25**	0.54**	131.83**	223.51**	155.03**
SCA	28	17.55**	1.55**	2.60**	0.041**	0.16**	112.26**	215.28**	95.26**
GCA/SCA		6.54	5.03	3.95	6.10	3.38	1.17	1.04	1.63
Error	70	0.55	0.09	0.24	0.001	0.01	1.21	0.82	2.18

***, ** Significant at 5% and 1% levels of eventuality, respectively**

General combining ability effects (g_i)

Estimates of general combining ability effects (g_i) for each parent are given in Table 7. The results showed that Sakha 8 (P_2), Sakha 69 (P_3), sahel 1 (P_4) Sanora 64(P_5) were seemed to be excellent general combiners for tallness. As for spike length and number of spikes per plant, Sids 4 (P_8) and Giza 165 (P7) were considered to be good general combiners for these traits, respectively. It could be noticed that Sanora 164 (P_5), Giza 165 (P_7) and Sids 4 (P_8) were found to be good general combiners for grain weight per spike. The results indicated that Sids 4 (P_8) was the best general combiner for 1000 kernel weight. Regarding to grain yield per plant, Sahel 1 (P_4), Sanora 64 (P_5) and Giza 160 (P_6) were good generals combiners. In the same time, Sakha 69 (P_3), Sanora 64 (P_5), Giza 160 (P_6), Giza 165 (P_7) and Sids 4 (P_8) were the excellent general combiners for biological yield per plant. Moreover, Sahel 1 (P_4), Sanora 64 (P_5) and Giza 160 (P_6) were the best general combiners for harvest index. Whereas, Debeira (P_1) was the poorest general combiner for all studied traits except for number of spikes per plant It could be suggested that most studied parents posses additive genes and could be utilized in breeding program to improve these traits. Similar results were obtained by Motawea (2006), Singh *et al.,* (2012), Desale and Mehta, (2013), Yao *et al.,* (2014), Singh *et al.,* (2014) and Kumar *et al.,* (2015).

Table 7. Estimates of general combining ability effects (g_i) for each parent of all studied traits.

Parents	Plant height	Spike length	No of spikes/plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
P_1(Debeira)	-4.247**	-0.478**	0.092	-0.133**	-0.211**	-4.306**	-5.538**	-2.780**
P_2(Sakha 8)	0.743*	-0.005	-0.042	0.005	-0.025	0.457	-0.195	0.615
P_3(Shakha69)	0.753*	-0.422**	-0.042	-0.127**	-0.067	-1.290*	1.581**	-2.288**
P_4(Sahel 1)	1.922**	0.168	0.392	-0.030*	0.035	1.970**	-2.546**	3.902**
P_5 (Sonora64)	1.203**	-0.215	0.025	0.096**	0.074	1.765**	1.524**	1.393*
P_6(Giza 160)	0.599	-0.098	0.392	0.029	0.005	1.727**	0.850*	1.528*
P_7 (Giza165)	0.419	-0.098	0.525*	0.061**	-0.066	0.232	2.354**	-0.670
P_8 (Sids 4)	-1.391**	1.148**	-1.342**	0.099**	0.254**	-0.555	1.971**	-1.698*
SE(gi)	0.016	0.003	0.007	0.000	0.0003	0.035	0.024	0.064
SE (Gi – Gj)	0.037	0.0058	0.016	0.0001	0.0007	0.080	0.055	0.15

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Specific combining ability effects (s_{ij})

Estimates of specific combining ability effects (s_{ij}) for each cross combination for all studied traits are presented in Table 8. The results revealed that 8 out of 28 crosses showed positive significant SCA effects for plant height. As for yield and its components, 4, 5, 8,7,and 10 out of 28 crosses gave positive significant SCA effects for spike length, number of spikes per plant, grain weight per spike, 1000 kernel weight and grain yield per plant, respectively. The results indicated that 10 and 10 out of 28 crosses showed positive significant SCA effects for biological yield per plant and harvest index, respectively.

It is interesting to notice that the excellent cross combinations were obtained from (good x good) , (good x poor) and (poor x poor) general combiners. Consequently, it is not necessary that parents having estimates of GCA effects would also give high estimates of SCA effects in their respective cross combinations. Generally, the promising cross combinations which exhibited desirable SCA effects, showed also high useful heterosis as previously mentioned for all studied traits. This finding indicates that non-additive gene action played an important role in the expression of these traits. Similar results were reported by Saeed *et al*.,(2005), Hasnain *et al*., (2006), Mahpara *et al.,* (2008) and Kumar *et al*., (2011).

Table 8. Estimates of specific combining ability effects (s_{ij}) for each cross combination of all studied traits.

Crosses	Plant height	Spike length	No of spikes/Plant	Grain weight/spike	1000 Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
P_1 x P_2	2.393**	0.111	0.052	0.061*	0.019	1.563	-1.394	2.609
P_1 x P_3	4.883**	0.028	0.052	0.243**	-0.049	3.243**	9.110**	0.149
P_1 x P_4	-0.454	0.104	-0.381	-0.001	0.132	-3.817**	8.783**	-9.135**
P_1 x P_5	-3.567**	-0.179	-0.348	-0.070*	-0.150	2.205	-12.617**	10.548**
P_1 x P_6	-2.530**	-0.096	-0.048	-0.119**	0.119	-3.640**	2.310*	-5.740**
P_1 x P_7	-1.684*	0.371	0.152	-0.101**	-0.084	-0.462	8.137**	-4.019*
P_1 x P_8	-1.540	-0.376	-0.648	-0.030	0.036	-0.698	-0.653	-0.915
P_2 x P_3	0.726	-0.946**	-0.481	-0.027	-0.095	1.146	1.874	0.741
P_2 x P_4	-0.777	0.464	0.419	-0.041	-0.097	1.096	2.030	0.457
P_2 x P_5	2.276**	-0.152	1.119*	0.039	0.007	3.928**	0.464	4.980**
P_2 x P_6	0.480	0.898**	1.419**	0.133**	0.336**	7.786**	13.227**	3.445*
P_2 x P_7	1.060	0.398	-0.715	-0.022	-0.073	-5.146**	-3.506**	-5.021**
P_2 x P_8	-2.964**	0.151	-1.515**	-0.144**	0.193	-4.972**	-8.580**	-2.529
P_3 x P_4	0.880	-0.452	0.419	0.147**	0.422**	8.833**	8.038**	6.707**
P_3 x P_5	1.266	0.931**	-0.548	-0.176**	0.073	-5.462**	-6.855**	-3.920*
P_3 x P_6	-0.630	0.314	0.085	-0.181**	-0.231*	-5.847**	-8.378**	-3.715*
P_3 x P_7	-0.550	-1.519**	0.285	0.027	0.016	-2.849*	2.072	-4.121*
P_3 x P_8	-2.607**	-0.099	-0.848	-0.108**	0.169	-2.318	0.051	-2.576
P_4 x P_5	0.096	-0.326	0.685	0.177**	0.217*	5.648**	12.434**	0.769
P_4 x P_6	0.200	-0.442	-1.015*	-0.169**	-0.153	-5.987**	-8.295**	-3.482*
P_4 x P_7	-3.120**	0.558	-0.481	-0.101**	-0.066	-0.926	-10.465**	4.379*
P_4 x P_8	4.023**	1.644**	1.719**	0.074*	0.114	5.932**	5.254**	4.770*
P_5 x P_6	0.253	0.441	0.685	0.015	0.254*	9.462**	12.965**	5.230*
P_5 x P_7	3.100**	-0.559	-1.115*	-0.087**	-0.129	-4.277**	-1.882	-4.352*
P_5 x P_8	1.743*	0.861**	1.419**	0.048	0.358**	8.970**	12.135**	5.366**
P_6 x P_7	2.036*	0.491	0.519	0.104**	0.291**	10.621**	11.952**	6.960**
P_6 x P_8	1.213	-1.256**	-0.948	-0.068*	-0.529**	-4.531**	-5.592**	-2.876
P_7 x P_8	3.860**	0.078	1.919**	0.084**	0.218*	9.313**	0.908	11.032**
SE(Sij)	0.15	0.024	0.066	0.0003	0.003	0.33	0.22	0.60
SE (Sij –Sik)	0.329	0.052	0.144	0.0006	0.0067	0.72	0.49	1.31

***, ** Significant at 5% and 1% levels of eventuality, respectively**

Estimates of Correlation coefficient

Estimates of correlation coefficient between all studied characters are shown in Table 9. The results showed that grain yield per plant was significantly and positively correlated with plant height (0.57), spike lenght (0.30), No of spikes per plant (0.55), grain weight per spike (0.54), 1000 kernel weight (0.59), biological yield per plant (0.65) and harvest index (0.85). Biological yield per plant was significantly and positively correlated with No. of spikes per plant (0.28), plant height (0.41), spike lenght (0.25), 1000 kernel weight (0.58), and grain weight per spike (0.52) but non-significantly associated with harvest index(0.15) . It could be noticed that harvest index was significantly and positively correlated with No. of spikes per plant (0.51),plant height (0.46), Spike Length (0.21), 1000 kernel weight(0.35) and grain weight per spike (0.34). No of spikes per plant was significantly and positively correlated only with plant height (0.36) while it was negatively associated with spike length (-0.17) and 1000 kernel weight (-0.04) as well as positively correlated with grain weight per spike (0.07). Moreover, plant height was significantly and positively correlated with 1000 kernel weight (0.27) and grain weight per spike (0.37). In the same time, spike Length was significantly and positively correlated with 1000 kernel weight (0.59) and grain weight per spike (0.36). 1000 kernel weight were significantly and positively correlated with grain weight per spike (0.52). These results are in agreement with those announced by Mohsin *et al.,* (2009) and Fellahi *et al.,* (2013).

Table 9. Estimates of correlation coefficient between all studied traits.

Traits	Spike length	No of spikes/plant	Grain weight/spike	1000-Kernel weight	Grain yield/plant	Biological yield/plant	Harvest index
Plant height	0.06	0.36**	0.37**	0.27**	0.57**	0.41**	0.46**
Spike length		-0.17	0.36**	0.59**	0.30**	0.25**	0.21*
No. of spikes/plant			0.07	-0.04	0.55**	0.28**	0.51**
Grain weight/spike				0.52**	0.54**	0.52**	0.34**
1000- Kernel weight					0.59**	0.58**	0.35**
Grain yield/plant						0.65**	0.85**
Biological yield/plant							0.15

***, ** Significant at 5% and 1% levels of eventuality, respectively**

In conclusion, significant of genetic variability among all studied genotypes were detected for all traits. The results exhibited that the majority of crosses were significantly higher than both mid and better parents. These promising crosses which showed high useful heterosis values, exhibited also desirable SCA effects. However, the ratios of GCA / SCA were found to be greater than unity for all studied traits, suggesting the predominance of the additive gene action in controlling of studied traits. Therefore, selection program for improvement yield and its components in this set of wheat materials could be practiced in segregated generation.

REFERENCES

Abd El-Aty, M.S.M. and S.M. Hamad (2006). General and specific combining ability and their interaction with three nitrogen levels for grain yield and related traits in bread wheat (*Triticum aestivum L.*). J. Agric. Sci. Mansoura Univ., 31(9): 5517 5533.

Adel, M.M. and E.A. Ali (2013). Gene action and combining ability in a six parents diallel crosses of wheat. Asian Journal of Crop Sciences 5, 14-23.

Ahmad, F., S. Khan, S. Q. Ahmad, H. Khan, A. Khan and F. Muhammad (2011). Genetic analysis of some quantitative traits in bread wheat across environments. African Journal of Agricultural Research, 6(3): 686-692.

Ahmadi, J.; A. Zali; B. Samadi; A. Talei; M. Channadha and A. Saeidi (2003). A study of combining ability and gene effect in bread wheat under drought stress conditions by diallel method. Iranian J. Agri. Sci., 34:1-8.

Akbar, M.; J. Anwar; M. Hussain; M.M. Iqbal and W. Sabir (2010). Heterosis and heterobeltiosis for grain yield improvement in bread wheat. J. Agric. Res., 48:15-23.

Al-Kaddoussi, A.R.; M.M. Eissa; M. Nachit; Abdulla and A.S. El-Sebae (2003). Gene action of some quality characters in durum wheat (Triticum Turgidum var. durum). Zagazig Journal Agricultural Research 30, 1809-1821.

Al-Naggar, A. M. M.; R. Shabana; M. M. Abd El-Aleem and Z. A. El-Rashidy (2015). Performance and combining ability for grain yield and quality traits of wheat (Triticum aestivum L.) F1 diallel crosses under low-N and high-N environments. Scientia Agriculturae, 12(1), 13-22.**þ**

Barot, H.G.; M.S. Patel; W.A. Sheikh; L.P. Patel and C.R. Allam (2014). Heterosis and combining ability analysis for yield and its component traits in wheat (Triticum aestivum L.). Electr. J. Plant Breed., 5(3): 350- 359.

Baloch, M.; A. Baloch; N. Siyal; S. Baloch; A. Soomro; S. Baloch and N. Gandahi (2016). Heterosis Analysis in F1 Hybrids of bread wheat.Sindh University Research Journal-SURJ (Science Series), 48(2): 261-264.

Bhutta, W.M. and M. Hanif (2010). Genetic variability of salinity tolerance spring wheat (Triticum aestivum L.). Acta Agric. Scandinavica, 60: 256-261.

Bilgin, O., A. Balkan, K.Z. Korkut and I. Baser (2011). Heterosis and heterobeltiosis potentials of bread wheat (Triticum aestivum L.) hybrids for yield and yield components. J. Tekirdag. Agri. Fac., 8:133-142.

Blank A.F.; Y.R.S. Rosa, J.L.S. Carvalho Filho, C.A. Santos, M.F. ArrigoniBlank, E.S. Niculau and P.B. Alves (2012). A diallel study of yield and essential oil constituents in basil (Ocimum basilicum L.). Ind Crops Prod. 38:93-98.

Chowdhry, M.A., M. Iqbal, G.M. Subhani and I. Khaliq (2001). Heterosis, inbreeding depression and line performance in crosses of Triticum aestivum . Pak. J. Biol. Sci., 4:56-58.

Çifci, E.A. and K. Yağdi (2010). The research of the combining ability of the agronomic traits of bread wheat in F1 and F2 generations. J. Agri. Faculty of Uludag Uni., 24: 85-92.

Dagustu, N. (2008). Genetic analysis of grain yield per spike and some agronomic traits in diallel crosses of bread wheat (Triticum aestivum L.). Turk. J. Agric., For 32:249-258.

Desale, C. S. and D. R. Mehta (2013). Heterosis and combining ability analysis for grain yield and quality traits in bread wheat (Triticum aestivum L.). Electronic Journal of Plant Breeding 4(3), 1205–1213.

Devi, E.L., Swati, P. Goel, M. Singh and J. P. Jaiswal (2013). Heterosis studies for yield and yield contributing traits in bread wheat (Triticum aestivum L.). The Bioscan. 8:905- 909.

EL-Hosary, A. A., A. Gehan and N. El Deen (2015).Genetic analysis in the F1 and F2 wheat generations of diallel crosses. Egypt. J. Plant Breed. 19 (2):355 –373.

El-Hosary A.A., S.A. Omar and A.H.Wafaa (2009). Improving wheat production under drought conditions by using diallel crossing system. Proc. 6th Plant Breed. Conf. May 3-5. Egypt. J. Plant Breed. 12(1): 127-141.

Farooq, J., I. Habib and I. Khaliq (2005). Diallel analysis to predict utilization of heterosis and heterobeltiosis in yield and yield components of bread wheat. J. Agric. Res., 43:171-182.

Fellahi, Z., A. Hannachi, H. Bouzerzour and A. Boutekrabt (2013). Correlation between traits and path analysis coefficient for grain yield and other quantitative traits in bread wheat under semi arid conditions. Journal of Agriculture and Sustainability, 3(1), 16-26.

Fonseca, S. and F.L. Patterson, (1968). Hybrid vigour in seven parental diallel crosses in common wheat (Triticum aestivum L.). Crop Sci., 8: 85–88.

Gogas, J.A. and M. Koutsika-Sotiriou (2012). Phenotyping and genotyping through F1 and F2 generation the promising crosses. Int. J. Plant Breed. Genet. 6:217-227.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. Austr. J. Biol. Sci., 9,463-493.

Hammad, G.; M. Kashif, M. Munawar, U. Ijaz, M. Saleem and Abdullah (2013). Genetic analysis of quantitative yield related traits in spring wheat (Triticum aestivum L.). Am-Euras.J.Agric & Environ. Sci. 13:1239-1245.

Hassan, G.; F. Mohammad, S.S. Afridi, and I. Khalil (2007). Combining ability in the F1 generation of diallel crosses for yield and yield components in wheat. Sarhad J. Agric., 23: 937-942.

Hasnain, Z.; G. Abbas, A. Saeed, A. Shakeel, A. Muhammad and M. A. Rahim (2006). Combining ability for plant height and yield related traits in wheat, Triticum aestivum L. Pak. J. Agric. Res. 44(3):167-173.

Iqbal, M. and A. A. Khan (2006). Analysis of combining ability for spike characteristics in wheat (Triticum aestivum L.). Int. J. Agric. Biol., 8:684-687.

Ismail, S. K. (2015). Heterosis and combining ability analysis for yield and its components in bread wheat (Triticum aestivum L.) Int. J. Curr. Microbiol. App. Sci. , 4(8): 1-9.

Kalhoro, F.A.; A.A. Rajpar, S.A. Kalhoro, A. Mahar, A. Ali, S.A. Otho, R.N. Soomro, F. Ali and Z.A. Baloch (2015). Heterosis and combing ability in F1 population of hexaploid wheat (Triticum aestivum L.). American Journal of Plant Sciences, 6, 1011-1026.

Khan, A. S.; M. R. Khan and T. M. Khan (2000). Genetic analysis of plant height, grain yield and other traits in wheat (Triticum aestivum L.). Int. J. Agric. Biol., 2 (1-2), 129-132.

Khan, A.K.; I. Salim and Z. Ali (2003). Heritability of various morphological traits in wheat. International Journal of Agriculture and Biology, 5, 138-140.

Kheiralla, K.A.; M.A. El-Morshidy and M.M. Zakeria (2001). Inheritance of earliness and yield in bread wheat under favorable and sowing dates. The second Plant Breed. Conf., October 2, Assiut Univ. 2001(1): 219 – 239.

Kumar, A.; V.K. Mishra, R.P. Vyas and V. Singh (2011). Heterosis and combining ability analysis in bread wheat (Triticum aestivum L.). J. Pl. Breed. and Crop. Sci., 3(10): 209 - 217.

Kumar, P.; G. Singh, Y. P. Singh, D. Abhishek and S. S. Nagar (2015). Study of combining ability analysis in half diallel crosses of spring wheat (Triticum estivumL.). International Journal, 3(9), 1363-1370.**þ**

Larik, A.S.; A.R. Mahar and H.M.I. Hafiz (1995). Heterosis and combining ability estimates in diallel crosses of six cultivars of spring wheat. Wheat Inform. Services, No. 80: 12-19.

Malik, M. F. A.; S. I. Awan and S. Ali (2005). Genetic behavior and analysis of quantitative traits in five wheat genotypes. J. Agric. Soc. Sci., 1(4), 313-315.

Mosaad, M. G.; M. A. El-Morshidy, B. R. Bakheit and A. M. Tamam (1990). Genetical studies of some morpho-physiological traits in durum wheat crosses. Assiut Journal of Agricultural Sciences, 21(1), 79-94.

Masood, M.S. and W. Kronstad (2000). Combining ability analysis over various generations in a diallel crosses of bread wheat. Pakistan J. Agric. Res., 16(1):1-4.

Masood S.A.; S. Ahmad, M. Kashif and Q. Ali (2014). Role of combining ability to develop higher yielding wheat (Triticum aestivum L.) genotypes: An overview. Natural Sciences 12: 155–161.

Mahpara, S., Z. Ali and M. Ahsan (2008). Combining ability analysis for yield and yield related traits among wheat varieties and their F1 hybrids. Int. J. Agric. Biol., 10:599-604.

Mahpara, S.; Z. Ali, J. Farooq, S. Hussain and R. Bibi (2015). Heterosis and heterobeltiosis analysis for spike and its related attributes in different wheat crosses. Pakistan Journal of Nutrition, 14(7), 396-400.

Mandal A.B. and G. Madhuri (2016). Combining ability analysis for morphological and yield traits in wheat (Triticum aestivum L.). J. Plant Sci. Res.;3(2): 03 157.

Mavi, G.S., G.S. Nanda, V.S. Sohu, S. Sharma, and S. Kaur (2003). Combining ability analysis of yield and its components (T. aestivum L.) in two nitrogen regimes. Crop Imp. 30: 50-57.

Mohsin, T., N. Khan and F. N. Naqvi (2009). Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in synthetic elite lines of wheat. J. Food Agric. Environ, 7(3&4), 278-282.

Motawea, M. H. (2006). Inheritance of earliness, yield and yield components in wheat (T. aestivum L. em. Thell). Assuit Journal of Agricultural Sciences, 37(2): 35-52.

Nazir, S., A.S. Khan and Z. Ali (2005). Combining ability analysis for yield and yield contributing traits in bread wheat. J. Agric. Soc. Sci. 1(2):129-132.

Omar, S.A., A.A. El-Hosary and A.H. Wafaa (2010). Improving wheat production under drought conditions by using diallel crossing system Drought Index (DI). Options Méditerranéennes, 95, 117-121.

Pawar, K. K.; S. K. Yadav, K. S. Baghel and A.K. Singh (2014). Study of diallel analysis in bread wheat for yield and its components. IJSR, Volume : 3 , Issue : 3. ISSN No 2277 – 8179.

Pearson, K. (1920). Notes on the history of correlation. Biometrika. 13: 25-45.

Saad, F. F.; S. R. E. Abo-Hegazy, E. A. M. EL-Sayed and H. S. Suleiman (2010). Heterosis and combining ability for yield and its components in diallel crosses among seven bread wheat genotypes. Egypt. J. Plant Breed. 14 (3): 7 – 22.

Saeed, M.S., M.A. Chowdhry and M. Ahsan (2005). Genetic analysis for some metric traits in aestivum species. Asian J. Plant Sci. 4(4):413-416.

Sharief A.E.; M.H. EL-Hindi, M.S. Sultan, A.H. Abdel EL-Latif and EL- Hawary (2007). Response of some bread wheat genotypes to irrigation treatments. The Sixth Jordanian Agricultural Scientific Conf. 9-12 April, Jordan pp. A-28.

Singh, B.; P. Majumdar and K. Prasad (2000). Combining ability for yield and its components in late sown wheat. Journal of Applied Biology, 10(2):119-126.

Singh, S.P., L.R. Singh, V.K. Yadav; G. Singh; R. Kumar; P.B. Singh and G. Singh (2002). Combining ability analysis for yield traits in bread wheat (Triticum aestivum L. em Theils). Progressive Agri, 2: 119-121.

Singh, V; R. Krishna and S. Singh (2012). Combining ability and heterosis analysis for yield traits in bread wheat (Triticum aestivum L.). Indian Journal of Agricultural Sciences. 82 (11): 916–921.

Singh, M. A.; E. L. Devi, S. Aglawe, N. Kousar and C. Behera (2013). Estimation of heterosis in different crosses of bread wheat (Triticum aestivum L.). The Bioscan, 8(4), 1393-1401.

Singh, M. K., P. K. Sharma, B. S. Tyagi and G. Singh (2014). Combining ability analysis for yield and protein content in bread wheat (Triticum aestivum L.). Indian Journal of Agricultural Sciences, 84 (3): 328–336.

Steel, R. G. D. and J. H. Torri (1980). Principles and procedures of statistical biometrical approaches. 2nd McGraw-Hill Book Company, New York, London.

Ul-Allah, Iqbal, Sharif, Naeem, Ijaz, Nabi and Sattar (2016). Heterosis and inheritance pattern of yield traits in bread wheat (Triticum aestivum L.) J. Glob. Innov. Agric. Soc. Sci., 4(2): 70-76.

USDA(2017). World Agricultural Production ,Office of Global Analysis, FAS.

Uzair, M., Z. Ali, T. Mahmood, I. Karim, U. Akram, N. Mahmood and R. Kalsoom (2016). Genetic basis of some yield related traits in wheat (Triticum aestivum L.) under drought conditions. Imperial Journal of Interdisciplinary Research, 2(11).**þ**

Wynne, J.C., D.A. Emery and P.H. Rice (1970). Combiniting ability estimation in Arachis hypogaea L. H. field performance of F1 hybrids. Crop Sci., 10: 713–5.

Yao, J. b., H. X. Ma, X. Yang, G. U. Yao and M. Zhou (2014). Inheritance of grain yield and its correlation with yield component in bread wheat (Triticum aestivum L.). African journal of biotechnology, 13 (12): 1379- 1385.

Zhongfu, N., Y. Yao, H. Peng, Z. Hu and S. Qixin (2014) Genomics and Heterosis in Hexaploid Wheat. Journal of Crop Science, 23, 215-220.

تقدير قوة الهجين والقدرة على التألف والارتباط للمحصول ومكوناته في قمح الخبز

محمد حلمى مطاوع
كلية الزراعة - جامعة سوهاج

أجرى هذا البحث بهدف دراسة قوة الهجين والقدرة على التألف في القمح بإستخدام 28 هجين تم توليفهم بين 8× 8 آباء بنظام التهجين الدائري فى اتجاه واحد (بدون الهجن العكسية) . أجرى تحليل قوة الهجين بناءاً على متوسط الأبوين والأب الأفضل و القدرة على الائتلاف للمحصول ومكوناته . أجريت التجارب في موسمى 2011/2012و 2012/2013 في مزرعة كلية الزراعة بجامعة سوهاج بجمهورية مصر العربية . أظهرت تقديرات قوة الهجين بناءاً على متوسط الأبوين والأب الأفضل أعلى قوة هجين لمحصول حبوب النبات ، بناءاً على متوسط الأبوين (68.58) **و** (% 81.47 وذلك للهجينين P5 × P8 و P5 × P6 يليه معامل الحصاد) (% 53.32، عدد سنابل النبات (% 33.38) ، المحصول البيولوجي للنبات (% 30.71) **)** ، طول السنبلة (% 17.29) ، وزن الألف حبه (% 15.13) ، وزن حبوب السنبلة (% 14.38) وإرتفاع النبات (% 5.96) وذلك للهجن P7 × P8، P5 × P8، P4 × P5، P4 × P8، P3 × P4، P1 × P3 و P7 × P8 بالترتيب **.** كانت أعلى قوة هجين بناءاً على الأب الأفضل لمحصول حبوب النبات % 82.56) و **(** % 49.3 للهجينينP8 × P5 **و**P6 × P5 يليه معامل الحصاد) (% 40.12، المحصول البيولوجي للنبات (% 28.29) ، عدد سنابل النبات (% 16.9) ، وزن الألف حبه (% 14.05) ، وزن حبوب السنبلة (% 12.9) ، طول السنبلة (% 9.53) وإرتفاع النبات (% 4.76) وذلك للهجن P5 × P8 ، P5 × P6 ، P2 × P5 ، P3 × P4 ، P1 × P3 ، P2 × P6 و P5 × P7 بالترتيب **.**أظهرت النتائج اختلافات معنوية بين الآباء بالنسبة للقدرة العامة على الائتلاف وبين الهجن بالنسبة للقدرة الخاصة على الائتلاف وذلك لكل الصفات المدروسة مما يشير الى أهميه كلا من الفعل الإضافي وغير الإضافي للجينات بالنسبة لكل الصفات **.** كانت القدرة العامة على الائتلاف أعلى من القدرة الخاصة على الائتلاف وعليه كانت نسبه GCA/SCA أعلى من الوحدة مما يشير الى سيادة تأثير الفعل المضيف للجينات والذى يلعب دورا هاما في وراثة هذه الصفات **.**في الغالب أظهرت التراكيب الوراثية P5 (Sonora 64) أفضل قدره عامه لصفات إرتفاع النبات ، عدد سنابل النبات ، وزن الألف حبه ، وزن حبوب السنبلة ، المحصول البيولوجي للنبات ، معامل الحصاد ووزن حبوب النبات و P4 (sahel 1 **)** لصفات إرتفاع النبات ، طول السنبلة ، عدد سنابل النبات ، وزن الألف حبه ، معامل الحصاد ووزن حبوب النبات**.** أظهرت الهجن P6 × P7 ، P5 × P6 ، P7 × P8 ، P5 × P8 ، P2 × P6 **و** P4 × P8 أعلى قدره خاصة على الائتلاف لمحصول النبات ومكوناته وتضمنت هذه الهجن أب مرتفع × أب منخفض القدرة العامة فيما يتعلق بمختلف الصفات المدروسة في البحث والتي من الممكن أن تستخدم للحصول على إنعزالات وراثيه فائقة في الأجيال الإنعزالية التالية للمحصول ومكوناته **.** إرتبط المحصول إرتباطاً قوياً وموجباً مع كل من معامل الحصاد (00.85) ، المحصول البيولوجى للنبات (00.65) ووزن الألف حبه . (00.59)