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Estimation of general and specific combining ability in bread wheat (*Triticum aestivum* L.)

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Abstract

To estimate the general and specific combining ability in wheat for yield and its components i.e. number of spikes/plant, spike length, number of grains/spike, 1000-grain weight and grain yield/plant, were studied using 8×8 diallel crosses, excluding reciprocals. The studied genotypes were; *i.e.* Sides 12, Gemmiza 11, Miser 1, Miser 2, Shandaweel 1, Giza 168, Sakha 93 and Sakha 94. In the second season 2013/2014, the eight parental and28 F_1's was evaluated. Results revealed that mean squares of general and specific combining ability were significant for all studied characters. Wheat cultivars Sids12 was the best general combiner for all studied characters except number of spikes/plant; Gemmiza 11 for all studied characters except 1000– grain weight; Miser 1 for spike length and 1000- grain weight wheat. The three crosses were the best combinations, Sides 12 ×Miser 1 for spike length, Sides 12 ×Miser2 for number of spikes/plant and 1000-Kernel weight and Miser 2 × Shandaweel 1 for number of spikes/spike, 1000-kernel weight and Kernel yield/plant. The mean squares of types of gene action indicated that additive and dominance genetic variance were significant for all the studied characters except b for 1000- grain weight. Obtained results are great interest for bread wheat breeder to improve grain yield through its components.

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Introduction

In the initial stages of breeding program breeders need general knowledge about genetic system and gene action controlling the genetic variance of the studied characters. The diallel analysis programs provide detailed genetically information about specific genotypes before including in breeding programs. Many researches indicated the importance of diallel technique to obtain genetically information about yield and yield component characters in wheat, in this respect Eissa *et al.* (1994), Al-Kaddussi (1996), Esmail (2002). The additive genetic component was of importance in the genetic control of grain yield/plant (Salama *et al.*, 2005; Salama *et al.,* 2006; Jinbao *et al.*, 2014; Ahmed *et al.*, 2015; Shahid *et al.*, 2015 and Nassem *et al.,* 2015). The importance of additive and non-additive gene effects controlling of genetic control of yield and yield components of wheat were indicated by Sharma *et al.* (1998), Salama (2000), Al-Kaddoussi *et al.* (2003) and Adel and Ali (2013). Sharief *et al.* (2007) reported that It could be recommended that the parent Line 1 and the cross Line1 × Sakha 94 could be used in breeding program for drought tolerance. Sharief *et al.* (2006) and Sultan *et al.* (2006) found that estimation of useful heterosis over better parent for grain yield/plant proved that it never exceeds 25.26% at normal conditions (cross Sakha 93× Gemmeiza 9). The present investigation was undertaken to obtain information about gene action, combining ability and heritability for yield and its components of eight wheat genotypes in half diallel excluding reciprocals using Model 1 Method 2 (Grifnfing, 1956).

Materials and methods

Eight genetically diverse bread wheat genotypes (Table 1) were evaluated and crossed in 2013/2014, season, to produce F1 seeds of diallel cross, excluding reciprocals. In the next season (2014/2015) the parents and their 21 F_1's crosses were sown in 15th November at Tag El-Ezz research station, Dakahlia governorate and evaluated using a randomized complete block design experiment with three replicates. Each plot consisted of 6 rows (2 rows for each parent and F_1). The row length was 2 m, and 20 cm apart. Plant to plant spacing was 10 cm. Data were recorded on 10 individual plants for each the parent and F_1. to study, number of spikes/plant, spike length (cm), number of grains/spike, 1000-grain weight (g) and grain yield/plant (g). Description of the studied parental wheat genotypes in Table 1. The obtained data were subjected, firstly to two-way analysis of variance (Steel and Torrie, 1980). The general and specific combining ability variances were estimated using model 1, method 2 of Griffing (1956). The type of gene action was computed according to Jones (1956) and Maher and Jinks (1982) were described in

Table 1. Description of the studied parental wheat genotypes.

Genotypes	Pedigree
Sides 12	BUC//7C/ALD/5/MAYA74/ON//1160 -147/3/BB/GLL /4/CHAT"S"/ 6/MAYA/VUL//CMH74A. 630/4*SX.SD7096-4SD-1SD-1SD-0SD.
Gemmiza 11	BoW"S"/KVZ"S"//7C/SER182/3GIZA 168/SAKHA61.GM7892-2GM---1GM-2GM-1GM-0GM.
Miser 1	OASIS/SKAUZ//4*BCN/3/2*PASTOR .CMSSOOYO1881T-050M-030Y-030M-030WGY-33M-0Y-0S
Miser 2	SKAUZ/BAV92.CMSS96M03611S-1M-010SY-010M-010SY-8M-0Y-0S
Shandaweel 1	SITE//MO/4/NAC/TH.AC//3*PVN/3 MIRLO/BUC.CMSS93B00567S-72Y-010M-010Y-010M-0HTY-0SH.
Giza 168	MRL/BUC//SERICM93046-8M-0Y-0M-2Y-0B-0GZ.
Sakha 93	SAKHA92/TR810328.S.8871-1S-2S-1S-0S
Sakha 94	OPATA/RAYON // KAUZ.CMBW90Y3180- 0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y-0AP-0S.

Table 2. Analysis of variance for method 2, model 1 and expectations of mean squares Griffing (1956).

S.O.V.	D.F.	S.S	M.S	E.M.S
General combining ability	p – 1	Sg	Mg	2δe + (p – 2)(1/p-1)∑gi2
Specific combining ability	p (p – 1)/2	Ss	Ms	2δe + 2/p(p – 1) ∑i∑j Sij2
Error	(c – 1) (r – 1)	Se	Me	2 δe

Where:

Sg = 1/(p+2){∑i(Xi + Xii)2 – 4/Px..2}

Ss = ∑i ∑j Xij2 – {1/(p+2) ∑i (Xi + Xii)2} + {2(p+1)(p+2)} X..2

Se = the error mean squares for the randomized complete block design divided by number of replicates.

The mathematical model for combining ability analysis was as follows:

Xij = μ + gj + gi + Sij + (1/be) ∑k ∑ieijk 1

Where:

Xij = is the value of the cross between parent (i) and parent (j).

μ = is the population mean.

gi and gi = are the general combing ability effects for the parent (i)and parent (j), respectively.

Sij = is specific combing ability effects (SCA) for the cross between the (i)and (j) parents.

eijk 1 = is the environmental effects peculiar to the ijk 1 observation.

The following restricting were imposed on the combing ability:

Elements: ∑I gi = O, and ∑j Sij + Sij = O (for each i)

Various effects were estimated follows:

gi = {1/(p+2)} {Xi+Xii – (2/p) X..} and

Sij = Xij – 1 (p+2)(Xi +Xii+Xj+Xij) + 2/(p+1)(p+2) X

2- Jones approach:

Partitioning the total genetic variance to its separate parts of additive and dominance gene effects was carried out using the analysis of variance of half diallel Tables as development by Jones (1956). The degree of freedom and expected general equivalent of mean squares half diallel analysis of variance Table are presented in Tables 3.

Table 3. Degree of freedom and genetic equivalent for the genetical items derived from the analysis of variance of diallel.

Genetical items	Degrees of freedom	Genetical equivalent
(a)	n – 1	D – f + 1 + 1 – H2
(b)	1/2 n (n – 1)	H2
b1	1	n2
b2	n – 1	H1 – H2
b3	1/2 n (n – 3)	Residual
Error		

Where:

n = number pf parental genotypes.

a = Measures additive effects.

b = measures the total non-additive (dominance) effects.

b1 = estimates the mean deviation of F1 from their mid-parents (Heteretic effects).

b2 = test whether the mean dominance deviation of the F1 from their mid-parental value within each array differ over arrays.

b3 = detect existence of unique dominance of each F1, i.e presence of considerable amount of heterotic effects specific to some crosses.

Results and discussion

Combining ability is one of the powerful tools in identifying best combiners which may be hybridized either to exploit heterotic or to accumulate fixable genes (additive). Mean squares of general combining ability (G.C.A). and specific combining ability (S.C.A.) are given in Table (4). Value of GCA and SCA variables were highly significant, indicating that additive and non – additive gene action played a great role in the genetics of all the studied characters except S.C.A for grain yield/ plant. The ratio of σ^2 GCA/ σ^2 S.C.A. was more than one, suggesting the prevalence of additive gene action in the inheritance for these characters. Therefore, selection would be effective when improving these characters in breeding program. Similar results were reported by Al-

Kaddussi *et al.* (1994), Adel and Ali (2013) and Shahid *et al.* (2015) in bread wheat.

The G.C.A. effects for the studied characters (Table 5) indicated positive and significant G.C.A. effects for Sids12, Gemmeiza 11and Misr1, thus it contains a considerable amount of additive gene effects for spike length. Thus it could be improved spike length by selection in early generation. While, for number of spikes /plant indicated that the wheat cultivars Gemmeiza 11, Shadwell 1, Giza 168 and Sakha 94 were good combiners these were positive and significant value of G.C.A. The gca for number of spikes / plant indicated that the cultivars Sids12, Gemmeiza11 and Misr1 were good combiners in general. The wheat cultivars Sids 12, Misr 1 and Sakha 93 were good combiner in general for 1000- grain wheat. The value of G.C.A. was positive and significant for these parents and it could be considered adequate for further improvement of wheat Kernel yield. But for grain yield /plant indicated the two cultivars of wheat, Sids 12, Gemmeiza 11 and Sakha 93 were good combiner. The S.C.A. effects were positive and significant for spike length i.e. Sids12X Shandweel1, Gemmeiza 11 X (Shandweel1, Giza 168 and Sakha93), Misr1 X (Misr 2 and Shandweel 1), Misr 2X (Shadwell 1 and Sakha 94) Shadwell 1 X Giza 168, and Sakha 93 X Sakha 94. indicate these crosses could be used it in breeding programmer of wheat.

Generally, the wheat cultivars Sides 12 was the best general combiner for all studied characters except number of spikes/plant, Gemmiza 11 for all studied characters except 1000–grain weight, Miser 1 for spike length and 1000-grain weight, wheat Shandawell 1, Giza 168 and Sakha 94 for number of spikes

Table 4. Mean squares of general (GCA) and specific combining ability (SCA) for yield and yield Components.

S.O.V.	d. f	Spike length(cm)	Number of Spikes/plant	Number of grain/spike	1000-grain weight (g)	grain Yield/plant (g)
G.C.A.	7	5.712**	1.411**	122.15**	17.262**	28.92**
S.C.A.	28	3.141**	1.652**	60.77**	4.622**	20.75**
Error	70	0.201	0.214	7.521	1.533	3.651

Table 5. General combining ability (GCA) for yield and yield components.

Crosses	Spike length(cm)	Number of spikes/plant	Number of grain/spike	1000-grain weight (g)	Grain yield/plant
Sides 12	1.512**	-0.425**	5.519**	1.660*	2.11**
X'	12.16	8.38	69.13	47.15	26.16
Gemmiza 11	0.533**	0.298*	4.190**	-1.011	2.510**
X'	13.14	9.02	69.91	48.22	26.82
Miser 1	0.421**	-0.361**	1.449	0.837	-0.547
X'	12.57	8.59	73.75	45.13	23.87
Miser 2	-0.516	-0.190*	-1.458	0.788	-1.625*
X'	13.61	8.50	69.18	41.69	21.170
Shandaweel 1	-1.453**	0.463*	-5.462**	-2.68**	-3.561**
X'	13.14	6.89	88.15	49.66	22.89
Giza 168	-0.236	0.352**	-3.312**	-0.821	-0.017
X'	12.19	6.10	79.93	46.46	23.64
Sakha 93	-0.178	-0.503	0.256	1.051**	0.167
X'	13.06	8.88	76.31	43.51	25.2
Sakha 94	-0.083	0.366	-1.182	0.617	0.961
X'	12.78	8.70	76.68	42.12	26.66
S.Egi	0.109	0.144	0.756	0.321	0.500

Results in Table (6) show that the S.C.A. effects were positive and significant for spike length i.e. Sids12X Shandweel1, Gemmeiza 11 X (Shandweel1, Giza 168 and Sakha93), Misr1 X (Miser 2 and Shandweel 1), Miser 2X (Shandweel 1 and Sakha 94) Shandweel 1 X Giza 168, and Sakha 93 X Sakha 94. indicate these crosses could be used it in breeding programmer of wheat. But for number of spikes/plant the crosses Sides 12 X Misr1, Gemmeiza 11 X (Misr2, Giza 168 and Sakha 93) Misr1X (Misr2, Shandweel 1 and Sakha 94) Miser 2 X (Giza 168 and Sakha 94), Giza 168 X (Sakha 93 X Sakha 94) and Sakha 93 X Sakha 94were good combinations.

The S.C.A. effects for number of grains/spike showed positive and significant heterotic effects for crosses; Sids12 X (Shandweel 1and Sakha 93), Gemmeiza 11X (Misr1, Shandweel 1 and Giza 168), Misr1X Shandweel 1 and Giza 168, Miser 2 X (Sakha 94, Shandweel 1and Giza 168, Giza 168 X Sakha 93 and Sakha 93 X Sakha 94indicating less environmental influence enhancing its valuable as a promising one for improving number of grains/spike. The crosses; Sides 12X (Misr1, Misr2 and Sakha 94), Gemmeiza 11X (Shandweel 1 and Giza 168), Misr1X (Shandweel 1 and Giza 168), Misr2 X (Giza 168 and Sakha 94) and Giza 168 X (Sakha 93 X Sakha 94) were positive and significant combinations for 1000 grain weight. The S.C.A. effects for –grain yield/ plant showed highest specific combining ability effects for crosses; Sids 12 X Sakha 93, Gemmeiza 11X Giza 168, Misr 1X (Misr2, Shandweel 1 and Giza 168), Shandweel 1X Sakha 94 and Giza 168 X Sakha 94. Thus, it could be considered adequate for further improvement of wheat Kernel yield.

Generally, the SCA effects were positive and significant and the best crosses combinations displayed fair amount of heterotic effects were obtained**,** Misr1 x Giza168 for all characters, Sids 12 X Misr1 for spike length, Sids 12 X Miser 2 for number of spikes/plant and 1000-Kernel weight and Miser 2 X Shandweel1 for number of spikes/spike, 1000-Kernel weight and Kernel yield/ These results are in agreement with those obtained by Salama *et al.* (2005) and Salama *et al.* (2006), Adel and Ali (2013). for grain yield/plant in bread wheat.

Table 6. Specific combining ability effects (SCA) for yield and yield components.

Crosses	Spike length (cm)	Number of spikes/ plant	Number of kernels/ spike	1000 grain weight (g)	Grain yield/ plant (g)
Sides 12 ×Gemmiza 11	0.513	0.512	-0.111	0.310	-0.256
Sides 12 × Misr1	0.236	-0.131	-0.252	-0.252*	-0.216*
Sides 12 × Misr2	-1.526**	1.072**	0.214	2.711**	-0.866
Sides 12 × Shandaweel 1	1.142**	0.236	2.171**	2.561**	-0.562
Sides 12 × Giza 168	0.502	-0.410	-0.311	1.522	-0.411
Sides 12 × Sakha 93	-0.713*	-0.234	3.751**	-0.384	3.204*
Sides 12 × Sakha 94	-0.613	0.517	-0.762	1.202	-0.851
Gemmiza 11 × Miser 1	0.514	-0.211	2.631**	0.326	-1.77
Gemmiza11 × Miser 2	1.428**	1.622**	3.611**	0.156	1.582
Gemmiza 11 ×Shandaweel 1	1.361**	-0.112**	5.573**	2.822	1.566
Gemmiza11 ×Giza 168	0.752	1.566**	0.311	2.341*	2.801
Gemmiza 11 ×Sakha 93	-0.314	1.041**	-0.611	-0.952	0.988
Gemmiza 11 ×Sakha 94	-0.672	-1.052**	-0.068	-0.251	-3.677*
Miser 1 × Miser 2	2.582**	0.712*	-1.082	0.683**	5.812**

Analysis of variance of half diallel for studied characters shown in Table (7) indicated that; the "a" item was significant for all studied characters, indicating that additive gene important in the inheritance for these characters. The dominance gene effects "b" was significant for all characters except 1000-grain weight. Similar results were reported by Awaad (2002), Hamada (2003) and Salama *et al.* (2005). Where they found significant additive and dominance gene effects for yield and its components in bread wheat. The differences between F_1 and the average of parent (p) indicated herterotic effects (significant b_1 item) for all characters except spike length. Also, significant b_2 item for the studied characters except 1000-grain weight, indicating that dominance were equally distributed and superior genotypes could be isolated. The b_3 which refer to specific combining ability (Griffing, 1956) indicated the presence of considerable heterotic effects specific to some crosses combinations for spike length and grain yield/plant.

Table 6. Continue

Crosses	Spike length (cm)	Number of spikes/plant	Number of grains/spike (g)	1000-grain weight (g)	Grain yield/plant (g)
Misr1 X Shandaweel 1	1.616**	0.662*	4.513**	2.167**	2.422*
Miser 1 × Giza 168	-0.232	-1.256**	3.711**	1.651*	2.66**
Miser 1 × Sakha 93	-0.217	-0.512	-0.231	0.161	-1.77
Miser 1 × Sakha 94	-0.314	-1.650**	-0.321	0.101	1.250
Miser 2 × Shandaweel 1	1.081*	-0.11	-0.512**	1.310	-0.011
Miser 2 × Giza 168	0.413	-1.256**	1.651	2.362**	0.1362**
Miser 2 × Sakha 93	0.110	0.513	-0.623	0.252	0.141
Miser 2 × Sakha 94	1.302**	0.371**	2.536**	1.252	1.072
Shandaweel 1 × Giza 168	1.412**	0.361	0.522	0.173**	0.566**
Shandaweel 1 × Sakha 93	-0.211	-0.571	0.172	0.5622**	-1.83
Shandaweel 1 × Sakha 94	-0.113	-0.156	0.130**	-0.178	5.322**
Giza 168 × Sakha 93	-0.913**	1.711**	-0.252	2.682**	-0.565
Giza 168 × Sakha 94	-0.762	2.171**	4.568*	2.841**	2.66**
Sakha 93 × Sakha 94	0.756*	2.051**	0.660	-0.825	-0.633
S.Egi	0.320	0.307	1.107	0.602	1.010

Table 7. Mean square for the half diallel analysis of variance for yield and yield components.

S.O.V	d. f.	Spike length (cm)	Number of spikes/plant	Number of grains/spike	1000-grain weigh t(g)	Grain yield/plant
a	7	5.712**	1.411**	122.15**	17.262**	28.92**
b	28	0.448*	0.651*	18.320*	2.179	15.770*
b_1	1	0.277	3.817**	40.256**	9.816**	27.911**
b_2	7	0.499*	0.516**	18.361**	1.923	9.225**
b_3	20	0.666**	0.267	0.361*	1.990	7.856
Error	70	0.201	0.214	7.521	1.533	3.651

n = number pf parental genotypes. a = Measures additive effects., b = measures the total non-additive (dominance) effects., b1 = estimates the mean deviation of F1 from their mid-parents (Heteretic effects). b2 = test whether the mean dominance deviation of the F1 from their mid-parental value within each array differ over arrays., b3 = detect existence of unique dominance of each F1, i.e presence of considerable amount of heterotic effects specific to some crosses.

Conclusions

Generally, it could be concluded from results of the diallel analysis of these study, Sids12 cultivar could be considered good combiner for studied characters. The best crosses combinations displayed fair amount of heterotic effects were obtained, Misr1 x Giza168 for all studied characters.

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