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HETEROSIS AND COMBINING ABILITY IN DIALLEL CROSS AMONG SIX EGYPTIAN AND EXOTIC VARIETIES OF BREAD WHEAT.

BY

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ABSTRACT

Grain yield and its components were recorded and evaluated during the genotypes studies. Then these parameters were used as indices in selection breeding program. The genotypes Sakha 93 and Gemmiza 7 were the most productive ones in grain yield and number of kernels per plant, while Line 8 results in poor yielding for number of spikes per m^2. Line 6 showed lowest values for grain yield and number of kernels per spike.The other genotypes showed different behavior and revealed variability between them under recommended conditions. A diallel cross set involving six wheat genotypes (Gemmiza 7, Sakha 69, Sakha 93, Sakha 8, Line 1 and Line 2) was conducted in order to estimate the expression of heterosis and combining ability. The results showed that parents and their F_1 hybrids differed significantly for all the studied characters. The best heterotic hybrids were (Gemmiza 7 x Sakha 93 and Line 1 x Line 2) exhibited significant positive heterosis over both mid and better parent for grain yield. The diallel analysis indicated that the Gemmiza 7 was the best general combiner parent for grain yield, number of spikes per plant and 1000-kernel weight. While, Sakha 93 was the best combiner for number of spikes per plant and 1000-kernel weight. The hybrids, Gemmiza 7 x Sakha 93, Sakha 93 x Sakha 8 and Gemmiza 7 x Sakha 93 showed the best specific combining ability (SCA) for grain yield and number of spikes per plant. Heritability estimates for grain yield was 84% and 73% for number of spikes per m^2, while heritability values were similar for number of kernels per spike and 1000-kernel weight (82% and 81%), respectively.

INTRODUCTION

Heterosis in open pollinated species had received high attention from breeders because its effect on yield improvement. This phenomena attracted their attention to use it in self fertilized crops such as wheat. Hence, hybrid combination between cultivars have been known to display heterosis, So, commercial production of hybrid wheat depends on a maximum degree of heterosis. Hybrid vigour often occurs in hybrid in one or more of its characters, Briggle et al., (1967). Numerous investigations had provided information on the inheritance and genetic of yield and yield components and other important characters. Analysis of combining ability will be more interested especially those obtained by diallel crosses.

Ansari (1990) showed that one hybrid revealed an increase in grain yield per plant by 139.98% and 119.36% over its mid and better parent, respectively. Bhowmik *et al.*, (1991) concluded that GCA and SCA variances were highly significant for grain yield per plant. Darwish (1992) studied crosses among five parental lines of wheat. The results showed that GCA and SCA men squares were significant for grain yield/plant. However, El Marakby *et al.*, (1992) concluded that little or no heterotic effects for this trait. Borghi and Perenzin (1994) found that GCA effects was highly significant for grain yield, while SCA effects was statistically significant for grain yield and GCA was greater than SCA. Ibrahim (1994) indicated that heterosis was generally more pronounces for grain yield/plant than any of its components. Morever, variance due to GCA or SCA was significant for grain yield/plant. El-Adl *et al.*, (1996) indicated that heterosis values for F_1 hybrids over the mid-parents and better-parent values were 51.57% and 29.27% for grain yield/plant, respectively. The GCA mean squares were highly significant and larger than those of SCA for this trait. Ageez and El-Sherbeny (1998) reported that the majority of crosses exhibited highly significant heterosis estimates over mid and better-parent for grain yield/plant. El-Maghraby (1998) concluded from his results, significant differences for both GCA and SCA, Moreover, heterosis was detected in some F_1 cross combinations over mid or better-parent for grain yield/plant. Similar studies were revealed by Afiah (1999), Salama (2000), Budak (2001), Abdel Aty and Katta (2002), Atiq-ur-Rehman *et al.*, (2002), Joshi *et al.*, (2003), Mavi *et al.*, (2003) and Solomon *et al.*, (2004).

Darwish (1992) showed that GCA and SCA mean squares were significant for number of spikes per plant. Uddin *et al.*, (1992) reported that only one cross showed high mid-parent (23.3%) and high better-parent (20.4%) heterosis for number of spikes per plant. El-Adl *et al.*, (1996) results showed that mean squares of GCA were highly significant and larger than those of SCA for this trait. Afiah (1999) indicated that the variance due to both GCA and SCA were highly significant for number of spikes/plant. Moreover, the ratio of GCA/SCA exceeded the unity for this trait confirming the importance of additive genes effects in the inheritance of this trait. Similar results were found by Salama (2000), Zalewski (2001), Abdel-Aty and Katta (2002).

For number of Kernels per spike, El-Marakby *et al.*, (1993) results indicated little or no heterotic effect were observed relative to both better and mid-parents values for this trait. El-Shami *et al.*, (1996), Salama (2000), Atiq-ur-Rehman (2002) and Wang CuiLing *et al.*, (2003) indicated that the GCA and SCA mean squares were significant for this trait. El-Maghraby (1998) found significant differences for both GCA and SCA, the heterosis observed in some F_1 cross combinations over mid or better-parent for number of kernels/spike. Abdel-Aty and Katta (2002) observed that the majority of crosses exhibited highly significant heterosis estimates over mid-parents and better-parent for this trait.

For 1000-Kernel weight, El-Marakby *et al.*, (1993) and El-Saied (1996) reported that 1000-kernel weight showed negative and significant heterosis values in all crosses of bread wheat except some crosses. El-Maghraby (1998) revealed significant differences for both GCA and SCA, seven crosses from 28 F_1's hybrids showed heterotic effects over mid or better-parent for 1000-kernel weight. Salama (2000) indicated that the ratio of the GCA/SCA was less than unity indicating that the greater value of dominance gene effects in controlling this trait. Abdel-Aty and Katta (2002) reported that the majority of crosses exhibited highly significant heterosis over mid-parents and better-parent for this trait. Atiq-ur-Rehman (2002) reported that SCA variance was greater than GCA variance, indicating the importance of non-additive gene actions for all characters included 1000-kernel weight.

The main objectives of the research work were to evaluate the parental genotypes for their yielding ability. Also, studying the heterosis and general and specific combining ability for yield and yield components as well as genetic variability among these genotypes.

MATERIALS AND METHODS

1. Plant materials

Ten wheat (*Triticum aestivum* L.) genotypes were selected for this investigation, Table 1. The present investigation was carried out at Nubaria Agriculture Research Station, Agriculture Research Center.

In both seasons 1999/2000 and 2000/2001, the ten genotypes were evaluated in each season, the experiment was designed in a randomized complete block design with three replications. Each plot consisted of 6 rows, 2.5m long with 20 cm between rows. Seeds were drilled in the row by hand on 19th and 28th of November in the first and second seasons, respectively. The dry method of planting was used in this concern. Weed control had done as hand weeding. After evaluation of ten genotypes, six genotypes for wide range of yield and yield components were selected. These genotypes were Gemmiza 7, Sakha 8, Sakha 69, Sakha 93, Line 1 and Line 2.

In 2001/2002 growing season, grains from each of the six parental varieties and/or lines were sown at a various planting dates in order to overcome the differences in times of heading. During this season, all possible parental cross combinations without reciprocals were made between the these six parents giving a total of 15 F_1 crosses.

In 2002/2003 growing season, all of 15 F_1 crosses were sown to get F_2 seeds. Two adjacent experiments were sown in 2003/2004 growing season, the first was parents and F_1 and the second was F_2 crosses in a randomized complete block design (RCBD) with three replications. Each replicate consisted of two rows for each parent, one row for each F_1 cross in the first experiment and ten rows for each F_2 crosses in the second experiment. Each row was two meter long with 30 cm between rows and plants within row were 20 cm apart allowing a total of 10 plants per row.

Data were recorded on an individual plant on five characters; grain yield per plant of F_1's and F_2's populations and grain yield per plot (kg/Feddan) for evaluated parents, number of spikes per plant for F_1's and F_2's populations and the same data per m^2 for evaluated parents in the first part, number of kernels per main spike, 1000-kernel weight (gm) and biological yield in parents.

The data were subjected to proper statistical analysis of variance according to Snedcore and Cochran (1967). The combined analysis was conducted when the homogeneity test between error variance was detected according to Cochran and Cox (1957). Heterosis for each trait computed as parents vs. hybrids sums of squares was obtained by partioning the genotypes sums of squares to its components (Cochran and Cox 1957). In this procedure genotypes were subdivided to parents, hybrids, and parents vs. hybrids. This procedure made it possible to test the significance of the probable heterosis as an average over all the studied crosses. Heterosis was also calculated for individual crosses as the percentage deviation of F_1 mean performance from its midparent and betterparent average values.

General and specific combining ability estimates were obtained by employing Griffing's (1956b) diallel cross analysis designated as method 2 model I. Analysis of variance for each trait of the 21 genotypes (6 parents and 15 F_1 crosses). Potence ratio (P) as outlined by Smith (1952) was estimated as a criteria for nature and degree of dominance. Heretability in broad sense (h_b^2) was estimated according to Lush (1949).

Table (1): Name and pedigree of the studied bread wheat genotypes.

Genotype	Pedigree	Origin
Gemmiza 7	CMH 74A.630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM	**Egypt**
Sakha 8	Indus 66/ Norteno"S" PK 3418-6S-1SW-0S	**Egypt**
Sakha 61	Inia/RL 4220//17c/Y_{50} CM 15430-2S-6S-0S	**Egypt**
Sakha 69	Inia/RL 4220//17c/Y"s" CM 15430-2S-6S-0S	**Egypt**
Sakha 93	Sakha 92/ TR 810328 S 8871-1S-2S-1S-0S	**Egypt**
Sids 6	Maya "S"/Mon"S"//CMH 74A.592/3/Giza 157* SD 10002-4SD-3SD-1SD-0SD	**Egypt**
Line 1	KAUZ"S"/Kauz"S" ICW91-0493-0TS-5AP-0TS-1AP-0AP-O...	**CIMMYT**
Line 2	KAVZ'S'//Kea'S'/Tan'S' ICW90-0335-0AP-1AP-0TS-2AP-0L-O...	**CIMMYT**
Line 6	Opata/Bow//Bau/3/Opata/Bow CMBW89Y00819-0TOPM-0AP-0TS-2AP-0TS-3AP-O...	**CIMMYT**
Line 8	Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/Mn72252/5/Rmn F12-1/Jup'S' ICW92-0012-0AP-4AP-0L-0AP-O...	**CIMMYT**

RESULTS AND DISCUSSION

Separate analysis of variance was carried out for yield and yield components in each season under recommended condition at Nubaria (Table 2). The analysis of variance indicated highly significant variation and the genotypes taken in consideration revealed differences for all characters studied in this experiment. Test of homogeneity of the error variance was insignificant. Thus, the hypothesis of homogenous error variances over the two seasons cannot be rejected.

Table (3) represents the mean and combined over the two seasons of 1999/2000 and 2000/2001 of the ten genotypes for yield and its components. Table (3) shows that the genotypes Sakha 93 and Gemmiza 7 were the most productive, while Line 6 and 8 results in poor yielding. The other genotypes showed different behavior and revealed variability between them under recommended conditions. Average of number of spikes per m2 ranged from 202 for Line 8 which produced the smallest number of spikes per m2 to 426 for Sakha 93 which showed the highest number of spikes per m2. This range revealed a high variability of spikes number among the ten genotypes. Number of kernels per spike was varied from 32 for Line 6 to 47 for Gemmiza 7. However, all genotypes except Gemmiza 7 were varied for number of kernels per spike under recommended conditions. The mean of 1000-kernel weight varied from 55 gm for Gemmiza 7 to 41 gm for Line 2, Sakha 93 produced heavy kernels almost like Sids 6.

The statistical analysis of parental genotypes data revealed significant differences in grain yield and yield components. The change in some other agronomic traits on yield components is taken in at consideration because yield is usually the result of multitude of factors and their favorable and unfavorable interaction at different growth stages in the cycle of the plant. The effect of interaction between seasons and wheat genotypes were highly significant for all the traits under study except number of kernels per spike, this results may be due to the differences between genetic materials and environmental conditions. Biological yield is shown in Table (3). Sakha 93 produced high biological yield (9.55 Ton/Fed.) followed by Gemmiza 7 and Sakha 69 (9.09 and 8.45 Ton/Fed.), respectively. Low biological yield was exhibited by line 8 and line 6 (5.12 and 5.40 Ton/Fed., respectively).

The results indicated that varieties, Sakha 93 was the first rank, followed by Gemmiza 7 and Sakha 69 for grain yield. Highly productive for these varieties was due to their high productive and rank for biological yield, number of spikes per m^2 as shown in case of Sakha 93 (first rank), followed by Sakha 69 and Gemmiza 7 were the second rank. On the other hand, Gemmiza 7 was substituted by Sakha 93 in the first rank for number of kernels per spike and 1000-kernel weight followed by Sakah 69 in the third rank. Line 6 and line 8 showed the lowest values for grain yield and yield components and were ranked in the last comparing to all genotypes. The previous results indicated that the variability amongst all parental genotypes under study were noticed and the differences in grain yield referred to the differences in yield components such as number of spikes per m^2, number of kernels per spike and 1000-kernel weight. These results are in accordance with those obtained by Abd EL-Mogeid (1995), Afaf (1994), Aglan (2003), Hamada (1988) and El-Maghraby (1998).

Table (2): Mean square values of analysis of variance among parental genotypes for yield and its component (Mean of two years).

S.O.V.	D.F	Mean.Square.				
		Grain Yield	Biological Yield	No.of spike / plant	No of kernels /spike	1000-kernel weight
Years	1	0.071	0.538	32109.06**	0.816	026.93*
Rep	2	0.007	0.036	4155.01*	4.86	001.15
Genotypes	9	1.262**	7.504**	34558.3**	117.42**	124.02**
Genotypes x Years	9	0.167**	1.660**	15064.4**	13.85	020.94**
Error	36	0.017	0.214	1223.15	10.129	004.808

*, ** significant at P< 0.05 and 0.01 respectively.

Table (3): Performance of parental genotypes means for yield and its components (Means of two years).

Genotype	Grain Yield Ardab*/ Fed.	Biological Yield Ton / Fed.	Number of Spike / m2	Number of kernels/ spike	1000-kernel weight
1- Gemmiza7	19.3 b	9.09 b	338 c	47 a	55 a
2- Sakha 61	13.1 d	6.75 c	327 cd	36 cd	47 cd
3- Sakha 69	17.7 bc	8.45 b	381 b	40 bc	50 bc
4- Sids 6	14.9 d	6.71 c	264 ef	36 cd	52 b
5- Sakha 8	16.8 c	6.93 c	368 bc	42 b	47 cd
6- Sakha 93	21.4 a	9.55 a	426 a	43 b	52 b
7- Line 1	13.0 d	6.33 c	301 de	36 cd	42 e
8- Line 2	11.2 e	5.53 c	311 d	36 cd	41 e
9- Line 6	10.2 ef	5.40 d	244 f	32 e	47 d
10- Line 8	9.3 f	5.12 d	202 g	38 cd	46 d

Means with the same latter are not significant.
* Ardab= 150 kg

The analysis of variance of diallel experiment indicated highly significant differences due to genotypes under recommended conditions for yield and its components (Table 4). Differences in the level of heterosis (SCA) for all traits were detected among 15 hybrids.

The heterosis for grain yield per plant is presented in Table (5). The results indicated that positive heterosis was exhibited for 13 and 4 crosses, out of 15 crosses, over mid-parents (MP) and better parent (BP), respectively. 8 crosses showed significant positive heterosis over mid-parents. Of these eight hybrids, 6 F_1 showed highly significant positive heterosis and two crosses showed significant positive heterosis over MP. With regard to heterosis over better parent, out of 4 F_1 showed positive heterosis, only one hybrid, *i.e.* cross 15 (Line 1 x Line 2) was highly significant positive heterosis and one cross, *i.e.* cross 2 (Gemmiza 7 x Sakha 93) was significant positive heterosis. The two crosses, *i.e.* number 2 and 15 (Gemmiza 7 x Sakha 93 and Line 1 x Line 2) exhibited significant positive heterosis over both mid and better parent (Table 5).

With respect to heterosis for number of spikes per plant, 9 F_1's showed positive heterosis over mid-parents, while 6 F_1's showed positive heterosis over better parent. Of these nine crosses, 6 hybrids were highly significant positive heterosis over MP, while 2 crosses, *i.e.* number 3 and 8 (Gemmiza 7 x Sakha 8 and Sakha 69 x Line 1) were highly significant positive heterosis and two crosses, *i.e.* number 1 and 6 (Gemmiza 7 x Sakha 69 and Sakha 69 x Sakha 93) were significant positive heterosis over better-parent. Three crosses, i.e. number 1, 6 and 8 showed significant or highly significant positive heterosis over both mid and better parent.

Heterosis over MP for number of kernels per spike was generally positive. Six crosses showed highly significant positive heterosis over mid-parent. The two crosses, *i.e.* number 13 and 15 (Sakha 8 x Line 1 and Line 1 x Line 2) were highly significany positive heterosis for both mid and better parent. Only one cross showed significant positive heterosis over better paent, cross number 3 (Gemmiza 7 x Sakha 8).

In general, heterosis for 1000-kernel weight was positive over mid-parents except 4 crosses showed negative heterosis. Out of these 11 hybrid showed positive heterosis, 8 F_1's were highly significant positive heterosis over MP and two crosses were significant positive heterosis. Six crosses showed significant and highly significant over both mid and better parent, *i.e.* crosses number 5, 6, 10, 11, 12 and 14.

As shown in Table (5), potence ratio was exceeding unity for some crosses, *i.e.* cross number 2, 3, 10 and 15, while it was less than unity for the other crosses, in case of grain yield per plant. Out of 15 hybrids for number of spikes per plant, seven hybrids were exceeding unity, *i.e.* cross number 1, 2, 3, 4, 6, 8 and 10 and the rest of crosses were less than unity.

With regard to potence ration for number of kernels per spike, almost half of the fifteen hybrids were less than unity and the other half crosses were exceeding unity. In case of 1000-kernel weight, only three crosses were less than unity, *i.e.* cross number 1, 9 and 15 for potence ratio and 12 crosses were exceeding unity.

Analysis of variance for combining ability mean square for all traits are presented in table (4). The analysis indicates that general combining ability (GCA) mean square were highly significant for yield and yield components, except 1000-kernel weight. On the other hand, specific combining ability (SCA) mean square were highly significant for yield and yield components.

In relation to grain yield per plant, the general combining ability effects of parental means are listed in Table (6). All parents exhibited either negative or positive GCA effects estimated from F_1, except for the parents Gemmiza 7 gave positive (GCA) and Line 2 showed significant negative or positive GCA effects. This Table shows that Gemmiza 7 gave the highest significant positive GCA effects (1.404) followed by Sakha 8 (0.352) and Sakha 93 (0.286). However, Line 2 has a significant negative combining ability which revealed (-2.586).

Table (4): Mean square values of analysis of variance among genotypes (parents and F_1) for yield and yield components in diallel cross.

		Traits			
S.O.V	**D.F**	**Grain Yield / Plant**	**No. of Spikes / Plant**	**No. of Kernels / Spike**	**1000-Kernel Weight (gm)**
Blocks	2	51.52**	04.78*	34.47	26.21
Genotypes	20	42.69**	12.44**	110.41**	59.63**
GCA	5	44.50**	13.19**	119.17**	36.90**
SCA	15	42.08**	12.19**	107.49**	67.20**
Error	40	2.81	0.46	4.18	6.42
GCA / SCA		1.05	1.08	1.11	0.55

*, ** significant at P< 0.05 and 0.01 respectively

With regard to specific combining ability effects (SCA), all F_1 crosses exhibited either positive or negative SCA effects. Table (7) indicates that 3 crosses gave only significant positive SCA effects, these crosses were resulted from a cross between parents have positive general combining ability effects (Gemmiza 7, Sakha 93 and Sakha 8). The crosses between best parental genotypes based on GCA effects (Gemmiza 7 and Sakha 93) and (Sakha 93 and Skha 8) gave positive estimate (7.660 and 2.572), while (Gemmiza 7 and Sakha 8) gave a negative estimates (-3.879). On the other hand, the results shows that the cross between positive parent and negative parent (Gemmiza 7 and Line 6) and (Sakha 8 and Sakha 69) based on GCA effects, gave a significant positive SCA effect (3.932 and 5.843).

For number of spikes per plant, the GCA effects of parental means are listed in Table (6). All parents exhibited either positive or negative GCA effects estimated from F_1, except the parents Gemmiza 7 and Sakha 93 which considered a good combiner and were significant positive GCA effects (0.443 and 0.973, respectively) and followed by Line 1 which was insignificant positive GCA effect (0.382). While Sakha 8 and Line 2 had highly significant negative GCA effects and Sakha 69 showed insignificant negative GCA effect.

Results of SCA effects are shown in Table (7), all F_1 exhibited either positive or negative SCA effects for number of spikes per plant. The cross between the two best parental genotypes based on their GCA effects (Gemmiza 7 and Sakha 93) gave a highly significant positive SCA estimated (2.608). While, the cross between one parent considered as a good combiner and parent as a bad combiner (Line 1 and Sakha 69) and (Sakha 93 and Line 2) gave a significant positive SCA effects (4.248 and 1.586). On the other hand, crosses (Sakha 93 and Sakha 8) and (Sakha 93 and Line 1) revealed highly significant negative SCA effects (-2.691 and -3.317), and the cross (Sakha 69 and Line 2) gave a highly significant negative SCA effect (-1.799).

Table (5): Heterosis and potence ratio for yield and yield components in F_1 by mid-parent (MP) and better parents (BP).

Crosses	Grain yield			Number of spikes / plant			Number of kernels / spike			1000-kernel weight		
	Heterosis		Potence Ratio	Heterosis		Potence Ratio	Heterosis		Potence Ratio	Heterosis		Potence Ratio
	MP	BP		MP	BP		BP	BP		BP	BP	
$P_1 x P_2$	-11.80*	-29.50**	-0.47	16.40**	10.00*	2.80	02.90	-04.60	0.37	-02.10	-07.10*	-00.37
$P_1 x P_3$	17.90**	14.50*	6.14	16.00**	05.40	1.60	07.10**	02.50	1.60	11.80**	03.00	01.40
$P_1 x P_4$	09.03*	06.90	2.14	-25.70**	-35.00**	-1.80	11.50**	06.80*	2.60	04.40	01.10	01.30
$P_1 x P_5$	27.10**	-08.90	0.68	21.20**	07.70	1.70	04.20	-09.10**	0.28	09.60**	01.40	01.20
$P_1 x P_6$	38.90**	-06.88	0.78	21.40**	-05.55	0.75	-08.80**	-18.50**	-0.74	25.30**	06.30*	01.40
$P_2 x P_3$	04.46	-14.50**	0.20	26.3**	09.09*	1.60	-06.50*	-09.70**	-1.80	26.80**	23.10**	09.03
$P_2 x P_4$	24.60**	-01.93	0.90	-15.00**	-29.20**	-0.75	05.30	01.60	1.40	05.80*	03.40	02.60
$P_2 x P_5$	04.31	-10.10	0.30	24.00**	16.20**	3.60	-04.80	-10.70**	-0.72	-05.50	-07.90*	-02.20
$P_2 x P_6$	06.80	-16.20*	0.20	07.60	-12.50*	0.33	-02.10	-05.70	-0.53	-01.50	-12.50**	-00.12
$P_3 x P_4$	12.40**	06.90	2.44	-30.40**	-33.30**	-7.00	04.40	04.40	3.80	31.00**	24.50**	05.90
$P_3 x P_5$	11.70*	-18.40**	0.30	-14.40**	-30.00**	-0.65	08.90**	-01.20	0.87	22.10**	21.50**	52.50
$P_3 x P_6$	-04.40	-35.20**	-0.10	-08.70	-33.60**	-0.23	09.50**	01.80	1.26	37.90**	26.00**	04.00
$P_4 x P_5$	10.10	-22.00**	0.24	04.20	-17.50**	0.16	24.30**	12.70**	2.70	07.50*	02.60	01.58
$P_4 x P_6$	05.20	-30.20**	0.10	-05.80	-33.30**	-0.14	-01.50	-08.30*	-0.24	22.20**	06.60*	01.50
$P_5 x P_6$	62.30**	44.80**	5.17	11.60	-04.28	0.77	14.40**	11.30**	5.20	-01.10	-10.00*	-00.11
LSD 0.05	01.95	02.39		00.79	00.96		02.38	02.90		02.95	03.60	
LSD 0.01	02.60	03.20		01.05	01.29		03.18	03.90		03.94	04.80	

In relation to number of kernels per spike trait, the GCA effects of parental means are listed in Table (6). Sakha 8 and Line 1 were highly significant positive GCA effects (2.256 and 1.722) and considered as best combiner parents based on GCA effect. While Sakha 69 was highly significant negative GCA effect (-3.944) and considered bad combiner, and other parents were insignificant either positive and negative GCA effect.

Table (7) shows results of specific combining ability (SCA) effects for number of kernels per spike. All F_1 exhibited either positive and negative SCA effects, 5 crosses revealed significant positive SCA effects and 3 crosses were highly significant negative SCA effects. The crosses between best parents based on GCA effect were highly significant positive SCA effect (6.233) and significant positive SCA effect (3.908). The crosses which were highly significant positive SCA effect, only one of their parents was best or good combiner for GCA effect.

The GCA effects are listed in Table (6) for 1000-kernel weight, Two parents exhibited significant positive GCA effects (Gemmiza 7 and Sakha 93). Line 1 was significant negative GCA effect (-1.799), all other parents showed either positive and negative GCA effects. Gemmiza 7 exhibited highly significant positive GCA and considered as a best combiner (2.272) and Sakha 93 exhibited significant GCA and considered as a good combiner (1.747) followed by Sakha 8 (0.943).

The results of SCA effects as shown in Table (7), indicated that four crosses gave highly significant positive SCA effects. Only one cross, Sakha 93 x Sakha 8 gave (7.478). Two crosses has significant positive SCA effect, Gemmiza 7 x line 2 (4.774) and Sakha 69 x Sakha 93 (4.354), one of their parents was a good combiner and the other parent was a bad combiner. While one cross (5.278) resulted from a cross between two bad combiners parents (Line 1 and Line 2). All other crosses exhibited either positive or negative SCA effects.

The phenomenon of heterosis has been generally associated with the increased yield and vigor obtained by crossing highly selected inbred lines from heterozygous cross-pollinating crops. With the recent realization of the possibility of producing F_1 hybrids on a large scale increasing attention has been given to heterosis in self-pollinating crops. Breeders of wheat are concerned with, first, whether or not it is possible to obtain sufficient heterosis for characters of economic importance under conditions which also give high yields per unit of land, secondly, whether or not it is possible to fix such heterosis in pure breeding lines.

Heterotic F_1 hybrids (*i.e.* superior to the better parent), may result from one or more of the following genetic situations: (1) The accumulated action of favorable dominant or semi dominant genes dispersed in the two parents, i.e. dominance. (2) Complementary interaction of additive, dominance or recessive genes at different loci, i.e. non allelic interaction or epistasis. (3) Favorable interaction between two alleles at the same locus, i.e. intra locus, or inter-allelic interaction, referred to as overdominance.

It will be possible to recover homozygous lines as good as the heterotic F_1 hybrids if either or both of the first two situations are causing heterosis, although the ease with which such lines can be recovered will depend on the linkage relationships of the genes involved and the ability to identify the recombinants when they arise. This will be particularly difficult with close linkage and when heterosis is expressed by a slight improvement in each of the main yield components.

Table (6): Estimation of general combining ability (GCA) effects for yield and its components.

Genotype	Traits			
	Grain Yield / Plant	No. of spikes / plant	No. of kernels / spike	1000-kernel weight
1-Gemmiza 7	1.404	0.443	0.431	2.272
2-Sakha 69	-0.632	-0.062	-3.944	-0.081
3-Sakha 93	0.286	0.973	0.447	1.747
4-Sakha 8	0.352	-0.878	2.256	0.943
5-Line 1	-0.089	0.382	1.722	-1.799
6-Line 2	-2.586	-0.838	-0.911	-1.044
SE ± gi 0.05	1.09	0.44	1.33	1.65
SE ± gi 0.01	1.46	0.59	1.78	2.20

*, ** significant at P< 0.05 and 0.01 respectively.

Table (7): Estimation of specific combining ability (SCA) effects for yield and its components.

Crosses	Traits			
	Grain Yield / Plant	No. of spikes / plant	No. of kernels / spike	1000-kernel weight
P_1 x P_2	-3.149	-0.194	-3.008	-3.818
P_1 x P_3	7.660	2.608	1.067	-2.551
P_1 x P_4	-3.879	-0.376	2.192	-0.080
P_1 x P_5	2.352	0.198	2.225	2.895
P_1 x P_6	3.932	0.251	1.025	4.774
P_2 x P_3	-2.924	0.575	-5.958	4.354
P_2 x P_4	5.843	-0.260	7.067	-2.189
P_2 x P_5	1.258	4.248	-10.400	0.420
P_2 x P_6	0.731	-1.799	9.233	-0.601
P_3 x P_4	2.572	-2.691	3.908	7.478
P_3 x P_5	-3.113	-3.317	2.042	2.853
P_3 x P_6	-2.083	1.586	6.042	3.632
P_4 x P_5	-3.613	-1.035	6.233	-0.643
P_4 x P_6	1.784	0.378	-6.200	0.670
P_5 x P_6	0.725	-1.441	2.100	5.278
C.D.(Sij-Sik)	3.00	1.20	3.66	4.53
C.D.(Sij-Skl)	4.01	1.60	4.89	6.05

*, ** significant at P< 0.05 and 0.01 respectively.

The present study revealed that all traits were highly significant for all F_1 crosses and most of hybrids showed heterosis (positive or negative) for either Mid-parents or Better-parnet for grain yield and yield components. The present study suggested that F_1 hybrids such as Gemmiza 7 x Sakha 93, Sakha 93 x Sakha 8, Gemmiza 7 x Line 1 and Line 1 x Line 2 represent a desirable degree of useful heterosis. This desirable F_1 hybrids could be used commercially if the other problems of commercial wheat hybrids seed production have been solved. The present results indicated that the parents Gemmiza 7, Sakha 93 and Sakha 8 were the best combiner parents based on GCA effect. The highest SCA effects were given by Gemmiza 7 x sakha 93, Gemmiza 7 x Line 2 and Sakha 93 x Sakha 8 . These results, beside, those obtained for the previous heterotic effects, suggest that grain yield was controlled by loci with additive and non-additive gene effects. The results indicated that the overdominance and partial dominance gene effects were more important in inheritance of this trait due to exceeding unity for potence ratio in some crosses. These results are in harmony with those obtained by Ansari (1990), Bhowmik *et al.*, (1991), Darwish (1992), Borghi and Perenzin (1994), El-Adl *et al.*, (1996),El-Maghraby (1998), Budak (2001) and Atiq-ur-Rehman *et al.*, (2002).

For number of spikes per plant, the results showed that F_1 crosses Gemmiza 7 with each of Sakha 69 and Sakha 93 and Line 1 and F_1 cross Sakha 93 x Sakha 69 exhibited heterotic effect for mid-parents and better parent. The test of additive and dominance variation indicated that GCA and SCA effect were highly significant which reflected on genetic components. Additive variance was higher than dominance variance which indicated the importance of additive genetic effect governing the number of spikes per plant. These results were in same trend with Uddin *et al.*, (1992), Afiah (1999), Salama (2000) and Mavi *et al.*, (2003).

In regard to hybrid vigor for number of kernels per spike, the overall parental range was larger as compared with the range of the hybrids and the mean heterosis was positive trend. The test of additive and dominance variation indicated that GCA and SCA effect were highly significant which reflected on genetic components. Additive variance was higher than dominance variance which indicated the importance of additive genetic effect governing the number of kernels per spike. These results are in harmony with El-Marakby *et al.*, (1993), El-Shami *et al.*, (1996) and Abdel-Aty and Katta,(2002)

For 1000-kernel weight, the results showed that the mean heterosis was positive. The test of additive and dominance variation indicated that SCA effect was highly significant, while the additive effect was insignificant. Non-additive component was higher than additive component indicating the importance of non-additive portion for inheritance of this trait. Similar results are obtained by El-Maghraby (1998), Salama (2000) and Atiq-ur-Rehman (2002).

Heritability values in broad sense in F_2 generation for yield and its components estimated in 15 crosses are presented in Table (8). According to the results in Table (8), the highest value of heritability was estimated in F_2 generation for grain yield per plant trait (59%). With regard to number of spikes per plant trait, all crosses revealed the lowest value of heritability in broad sense (37%) comparing to grain yield per plant. Heritability value for each of number of kernels per spike and 1000-kernel weight were nearby and gave a medium values (56% and 54%) between grain yield per plant and number of spikes per plant, respectively.

Heritability is one of the most important factors in the formulation of effective breeding programs for improving crops and it is acknowledges of the relative contribution made by genes to the variability of trait under consideration. Improvement of complex characters such as grain yield may be accomplished through the component approach of breeding.

The analysis of variances for yield and yield components were highly significant in F_2 genotypes. Heritability was estimated in broad-sense in F_2 generation for grain yield and its components. High h^2_b have been previously reported by Mitkees *et al.*,(1986), Hamada (1988), Afaf (1994), El-Maghraby (1998) and Talbert (2001). This value suggest that selection for grain yield should be under recommended condition in late generation will be useful.

Table (8): Heritability in broad sense for yield and its component in F_2 generation.

	Grain Yield	No. of spike/plant	No of kernels /spike	1000-kernel weight
δ^2 g	34.66	04.62	46.40	47.93
δ^2 p	41.08	06.29	56.00	58.50
h_b^2	00.84	00.73	00.82	00.81

Heritability estimates in broad-sense for number of spikes per plant was 37%, respectively. This moderate value of h^2_b indicate that a large portion of the total variation in F_2 are attributed to genetic causes. For each of number of kernels per spike and 1000-kernel weight, heritability estimates in broad-sense were high (56% and 54%). These values indicated that environmental effects have a considerable contribution in the expression of these traits and a higher magnitude of the total variation was genetically in nature. These results are in harmony with those obtained by Awaad (2002), Talbert (2001), Ageez and El-Sherbeny (1998), Abd El-Mogeid (1995), Afaf (1994), Dawam *et al.*, (1990) and Mahdy (1988).

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قوة الهجين و القدرة على التآلف في تهجين دائرى بين ستة أصناف قمح مصرية وأجنبية

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بالنسبة لقوة الهجين،أظهر تحليل التباين وجود اختلافات معنوية بين التراكيب الوراثية فى الجيل الأول. بالنسبة لصفة محصول الحبوب، أظهرت الهجن جميزة ٧ مع سخا ٩٣ وكذلك سلالة ١ مع سلالة ٢ قوة هجين بالنسبة لمتوسط وأحسن الأبوين. فى حين أظهرت الهجن جميزة ٧ مع كل من سخا ٨ و سلالة ١ و سلالة ٢ وكذلك الهجين سخا ٦٩ مع سخا ٨ والهجين سخا ٩٣ مع سخا ٨ قوة هجين بالنسبة لمتوسط الأبوين. بالنسبة لصفة عدد السنابل للنبات الفردى، أظهرت الهجن (جميزة ٧ x سخا ٦٩) و (سخا ٦٩ x سخا ٩٣) قوة هجين بالنسبة لمتوسط وأحسن الأبوين. فى حين أظهرت الهجن (جميزةx سخا ٩٣) و(جميزة ٧ x سلالة ١) و(جميزة ٧ x سلالة ٢) قوة هجين بالنسبة لمتوسط الأبوين. بالنسبة لصفة عدد الحبوب فى السنبلة، أظهرت الهجن (جميزة ٧ x سخا ٨) و(سخا ٨ x سلالة١) و (سلالة ٢ x سلالة١) قوة هجين بالنسبة لمتوسط وأحسن الأبوين. بالنسبة لصفة وزن الألف حبة، أظهرت الهجن (جميزة ٧ x سلالة ٢) و(سخا ٦٩ x سخا ٩٣) و(سخا ٩٣ x سخا ٨) و (سخا ٩٣ x سلالة ١) و (سخا ٩٣ x سلالة ٢) و(سلالة ٢ x سخا ٨).

بالنسبة للفعل الجينى، ساد تأثير السيادة الجزئية بالنسبة لصفة محصول الحبوب بينما كانت السيادة الفائقة بالنسبة لصفة وزن الألف حبة. تساوى تأثير السيادة الجزئية و السيادة الفائقة بالنسبة لصفات عدد السنابل للنبات الفردى وعدد الحبوب فى السنبلة. بالنسبة للقدرة العامة على الائتلاف، كانت التأثيرات الراجعة للقدرة العامة على الائتلاف عالية المعنوية لكل الصفات تحت الدراسة ما عدا صفة وزن الألف حبة حيث كانت غير معنوية. أظهرت الآباء سخا ٩٣، جميزة ٧، سخا ٨ أنها أفضل الآباء من حيث القدرة العامة على الائتلاف. بالنسبة للقدرة الخاصة على الائتلاف، كانت التأثيرات الراجعة للقدرة العامة على الائتلاف عالية المعنوية لكل الصفات تحت الدراسة. أظهرت الهجن (جميزة ٧ x سخا ٩٣) ، (جميزة ٧ x سلالة ٢) و(سخا ٦٩ x سخا ٨) قدرة خاصة على الائتلاف بالنسبة لمحصول الحبوب. أظهرت الهجن (جميزة ٧ x سخا ٩٣) ، (سخا ٦٩ x سلالة ١) ، (سخا ٩٣ x سلالة ٢) قدرة خاصة على الائتلاف بالنسبة عدد السنابل للنبات الفردى. أظهرت الهجن (سخا ٨x سخا ٩٣)، (سخا ٦٩ x سلالة ٢) ، (سخا ٦٩ x سخا ٨) ،(سخا ٩٣ x سلالة ٢) ،(سلالة ١ x سخا ٨) قدرة خاصة على الائتلاف بالنسبة عدد الحبوب فى السنبلة. أظهرت الهجن (سخا ٨x سخا ٩٣) ، (سخا ٦٩ x سخا ٩٣) ،(جميزة ٧ x سلالة ٢) و(سلالة ١ x سلالة ٢) قدرة خاصة على الائتلاف بالنسبة لصفة وزن الألف حبة. عند تقييم الجيل الثانى، أظهر تحليل التباين وجود اختلافات معنوية بين التراكيب الوراثية فى الجيل الثانى بالنسبة للصفات تحت الدراسة. بالنسبة إلى المكافئ الوراثى بمعناه الواسع ، أظهرت النتائج إلى وجود التأثير المضيف والتأثير الغير مضيف للجينات فى كل الصفات المدروسة. قيم معامل التوريث فى المدى الواسع لصفة المحصول كانت ٨٤ % تقريبا و٧٣% لصفة عدد السنابل للنبات الفردى و٨٢% بالنسبة عدد الحبوب فى السنبلة و ٨١% بالنسبة لصفة وزن الألف حبة.