Zagazig J.Agric. Res., Vol .31 No.(5) 2004 2187 - 2206

PARTIAL DIALLEL CROSSES AND HETEROSIS IN MAIZE (*Zea mays*, L.)

Abd El-Hadi, A.H.*; Z.A. Kosba*; F.A. El-Zeir** and A.E. Abo Ahmed*

* Dept. of Genetics, Faculty of Agriculture, Mansoura University, Egypt

** Maize Research Program, Field Crops Research Institute, Agricultural Research Center, Egypt

Accepted 29 / 6 / 2004

ABSTRACT: Eight white maize inbred lines were setup in a partial diallel crosses mating design excluding reciprocals to obtain 28 F_1 hybrids. The parental inbreed lines and their F_1 hybrids were evaluated at the three locations Sakha, Gemmeiza and Sids. Heterosis over both mid-parents ($H_{M.P}$ %), better parent ($H_{B.P}$ %), general (GCA) as well as specific (SCA) combining ability effects were estimated for the vegetative, ear, grain yield and other yield components from the combined data over the three locations. The results could be summarized as follows:

Highly significant differences were obtained among locations (L), genotypes (G), parents (P), F_1 crosses (C) and parents *vs* crosses for all studied traits. The interaction effects of locations x genotypes were significant for all studied traits except for ear height and plant height. The interactions of locations x parents and locations x F_1 crosses were significant for most studied traits. Parents *vs* crosses x locations were highly significant for all studied traits except for grain yield per plant and ear length.

The mean squares of GCA and SCA showed significant for all studied traits. In the same time, the interactions between GCA and SCA with locations were highly significant for most studied traits. The ratio of GCA/SCA was more than unity for number of days to 50 % silking, ear length, number of rows per ear and 100-grain weight. This finding indicated the importance of additive genetic

variance for the inheritance of these traits. On the other hand, the other traits were mainly controlled by non-additive genetic variance including dominance.

The results revealed that heterosis values relative to mid-parents ($H_{M.P}$ %) for silking date were negative and highly significant (desirable) for all crosses towards earliness. On the other hand, the results showed positive and highly significant estimates for all studied traits for all crosses except one cross for 100-grain weight and seven crosses for ear diameter. The results demonstrated that most studied crosses versus the better parent ($H_{B.P}$ %) showed positive highly significant differences for all studied traits except number of days to 50 % silking which showed negative highly significant differences for all crosses towards earliness.

The inbred lines Sd-7 and Sd-34 exhibited positive significant GCA effect for grain yield per plant. On the other hand, the inbred line Sk-7025 showed no GCA effects for number of days to 50 % silking date (earliness), plant and ear heights (shortness). The results also illustrated the absence of SCA effects in 17 crosses for number of days to 50 % silking. These parental inbreed lines could be used in maize breeding program to produce superior F_1 hybrid for further improvement of the previous traits. The number of F_1 hybrids exhibited positive and significant SCA effects were 13, 9, 4, 17, 2 and 25 for ear length, ear diameter, number of rows per ear, number of grains per row, 100-grain weight and grain yield per plant, respectively.

INTRODUCTION

The main objective of this study was to evaluate eight maize inbred lines at three locations to point out the earlier, shorter plants and higher yielding.

The variance components obtained from the diallel analysis mating designs could be translated into genetic parameters. The partioning of the total genetic variance to its components would dictate the most suitable breeding program, which could be followed to release new high yielding hybrids. In this respect, Nawar and El-Hosary (1985), Mahmoud (1989), Soliman (1992 & 1997), Gabr (1997) and Abd El-Aal

(2002) studied and estimated general (GCA) and specific (SCA) combining abilities and their role in the inheritance of grain yield and other yield component traits. They found that both GCA (additive) and SCA (non-additive including dominance) effects were of equal importance in the inheritance of most maize traits. On the contrary, Mostafa *et al.* (1996) and Amer *et al.* (1998) indicated that the SCA effects were more important for inheritance of grain yield, number of days to 50 % silking and plant height.

Several investigators obtained high and useful amounts of heterosis versus mid-parents and better parent concerning most studied traits, among them Verma and Singh (1980), Prasad and Singh (1986), Debnath (1987), El-Zeir (1990 & 1998) and Abd-El-Maksoud *et al.*, 2003).

The main objective of this investigation was to estimate: 1) heterosis versus mid-parents as well as better parent, 2) general (GCA), specific (SCA) combining ability effects and their interactions with locations, and 3) the development of superior single crosses with early maturity and high yielding.

MATERIALS AND METHODS

Eight maize inbred lines provided by Maize Research Program, Field Crops Research Institute (FCRI), Agricultural Research Center (ARC) were used in this study. These inbred lines were Sids-7 (Sd-7), Gemmeiza-18 (Gm-18), Sids-34 (Sd-34), Giza-628 (Gz-628), Sakha-7023 (Sk-7023), Sakha-7025 (Sk-7025), Sakha-7041 (Sk-7041) and Sakha-8084 (Sk-8084).

In 1998 growing season, the parental inbred lines were crossed according to a partial diallel crosses mating design excluding reciprocals to obtain 28 F_1 hybrids. In the 1999 growing season, the eight parental inbred lines and their 28 F_1 hybrids were evaluated at three different locations i.e., Sakha, Gemmeiza and Sids Research Stations using a randomized complete blocks design with four replications. Each block consisted of 36 plots. Each plot was one row, 6 m long and 0.8 m apart. The recommended cultural practices were applied at each location as recommended. Data were recorded for: number of days to 50 % silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows per ear, number of grains per row, 100-grain weight (g) and grain yield per plant (g).

Heterosis values were calculated for each cross as:

Heterosis from the mid-parents:

$(H_{M.P}\ \%) = (\bar{F}_1 - M.P) \times 100/M.P$

Heterosis from the better parents:

$(H_{B.P}\ \%) = (\bar{F}_1 - \overline{B.P}) \times 100/\overline{B.P}$

The analyses of variance for each location and the combined data over the locations were done according to Steel and Torri (1980). General and specific combining ability effects were estimated according to Griffing (1956) Method 2 Model I. Only the combined data over the three locations Sakha, Gemmeiza and Sids will be presented and discussed herein.

RESULTS AND DISCUSSION

The mean performances of the eight parental inbred lines and their 28 F_1 hybrids were obtained from the combined data over the three locations and the results are presented in Table 1. The results indicated that no parental line was superior for all studied traits. The parental line Sd-34 was the highest for all studied traits except number of days to 50 % silking and number of rows per ear. While the two inbred lines Gm-18 and Sk-7041 were the highest for number of days to 50 % silking and number of rows per ear, respectively. On the other hand, the parental line Sk-7025 appeared to be the lowest parent for all studied traits except for number of rows per ear, 100-grain weight and grain yield per plant. Whereas, the parents Sd-7, Sk-7023 and Gm-18 produced the lowest means for rows per ear, 100-grain weight and grain yield per plant, respectively.

The mean performances of the F_1 hybrids over the three locations revealed that no hybrid exhibited the best values for all studied traits. The results showed that the F_1 hybrid Sd-7 x Gm-18 had the highest values for plant height, number of grains per row, 100-grain weight and grain yield per plant with the means of 287.2, 46.5, 44.45 and 706.2, respectively. At the same time, the F_1 hybrid Gm-18 x Sk-7023 had the highest values for number of days to 50 % silking (late) and ear height with the means of 63.5 and 172.5, respectively. Whereas, the F_1 hybrids Gm-18 x Sd-34, Gz-628 x Sk-7041 and Sk-7025 x Sk-7041 had the highest values for ear length, ear diameter and number of rows per ear, with the means of 23.7, 5.24 and 15.9, respectively.

Table 1: Mean performance of the eight parental inbred lines and their 28 F_1 hybrids for all studied traits, data are combined over three locations.

Genotypes	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ ear	Grains/ row	100-grain weight (g)	Grain yield/ plant (g)
					Parents				
Sd-7	68.3	184.7	98.7	16.3	3.96	10.4 L	32.1	33.90	132.72
Gm-18	70.8 H	168.9	103.4	15.3	3.98	12.1	21.1	33.86	76.62 L
Sd-34	65.7	224.4 H	120.3 H	19.4 H	4.46 H	12.9	32.4 H	39.75 H	199.6 H
Gz-628	65.9	175.9	96.0	19.4 H	4.28	13.2	31.6	32.20	197.27
Sk-7023	67.7	194.1	101.9	16.0	3.76	12.7	25.9	22.81 L	108.75
Sk-7025	63.5 L	151.6 L	82.4 L	11.7 L	3.60 L	12.9	19.8 L	29.24	113.39
Sk-7041	65.7	183.8	95.1	14.6	4.33	15.0 H	26.1	30.98	164.81
Sk-8084	70.1	177.0	97.8	16.4	3.76	12.3	22.2	33.27	110.97
					Crosses				
Sd 7 x Gm 18	63.0	287.2 H	160.4	23.3	5.01	13.2	46.5 H	44.45 H	706.2 H
Sd 7 x Sd 34	62.5	286.5	164.9	23.0	4.76	12.1 L	46.5 H	43.56	642.26
Sd 7 x Gz 628	60.7	258.6	149.0	20.3	4.95	13.3	43.0	37.09	529.00
Sd 7 x Sk 7023	61.4	271.5	160.2	20.8	4.93	13.2	43.0	36.64	511.63
Sd 7 x Sk 7025	59.5	254.3	146.5	19.8	4.70	13.4	40.3	38.72	486.60
Sd 7 x Sk 7041	62.7	282.9	159.0	21.0	4.88	14.0	44.3	38.60	576.28
Sd 7 x Sk 8084	62.6	264.8	145.6	21.1	4.80	13.4	42.9	40.12	514.54
Gm 18 x Sd 34	63.0	269.2	159.2	23.7 H	5.05	14.1	42.1	39.65	613.92
Gm 18 x Gz 628	62.0	257.0	148.6	22.3	4.95	14.6	41.9	42.17	554.34
Gm 18 x Sk 7023	63.5 H	272.1	172.5 H	21.5	4.93	15.1	41.0	34.57	513.67
Gm 18 x Sk 7025	61.0	257.7	150.0	19.5	4.91	15.3	35.6 L	38.99	429.23
Gm 18 x Sk 7041	62.3	267.2	153.0	20.9	5.10	15.6	40.2	38.27	518.78
Gm 18 x Sk 8084	62.6	257.5	150.3	22.9	4.90	14.8	40.6	36.93	490.87
Sd 34 x Gz 628	62.1	275.9	162.7	22.1	5.15	14.1	45.3	40.64	661.17
Sd 34 x Sk 7023	61.6	278.5	162.6	21.1	4.73	13.6	43.8	36.00	518.03
Sd 34 x Sk 7025	59.0	263.8	151.6	21.6	4.76	14.1	40.9	38.73	486.01
Sd 34 x Sk 7041	61.0	284.3	161.4	21.2	4.90	14.4	45.3	40.24	636.42
Sd 34 x Sk 8084	61.9	261.4	154.0	23.4	4.81	13.8	45.6	39.68	588.73
Gz 628 x Sk 7023	60.8	263.2	157.8	19.4	4.88	14.9	42.1	34.35	466.90
Gz 628 x Sk 7025	59.4	231.5	136.8	18.4	4.83	14.9	37.2	36.52	434.87
Gz 628 x Sk 7041	60.2	246.4	141.7	18.8	5.24 H	15.3	41.6	36.62	533.56
Gz 628 x Sk 8084	61.3	228.8 L	125.8 L	19.2	4.83	14.9	39.5	36.60	439.11
Sk 7023 x Sk 7025	59.3	241.2	139.5	17.6 L	4.50 L	14.8	37.5	30.81	290.62 L
Sk 7023 x Sk 7041	61.5	263.9	155.2	19.8	4.95	15.2	44.3	34.31	530.25
Sk 7023 x Sk 8084	62.2	259.5	158.2	19.4	4.66	14.4	41.0	32.85	472.30
Sk 7025 x Sk 7041	58.3 L	250.0	137.0	18.8	4.93	15.9 H	36.8	34.25	453.21
Sk 7025 x Sk 8084	59.3	228.9	127.0	18.3	4.81	15.1	37.1	37.36	405.49
Sk 7041 x Sk 8084	62.5	241.5	137.0	18.2	4.70	15.2	36.7	32.42 L	358.61
					Checks				
SC 10	62.7	301.3	166.0	22.2	4.86	12.9	47.0	44.02	692.22
SC 122	61.2	262.6	152.0	21.3	4.71	13.9	46.0	38.99	578.37
LSD at 0.05	**1.045**	**9.434**	**8.444**	**1.037**	**0.221**	**0.648**	**2.445**	**3.603**	**44.306**
0.01	**1.371**	**12.37**	**11.072**	**1.360**	**0.289**	**0.849**	**3.206**	**4.724**	**58.095**

H = highest value, L = lowest value.

The F_1 hybrid Sk-7023 x Sk-7025 was the lowest for ear length, ear diameter and grain yield per plant with the means of 17.6, 4.50 and 290.62, respectively. Also, the F_1 hybrid Gz-628 x Sk-8084 was the lowest and the shortest for plant height and ear height with the means of 228.8 and 125.8. While, the F_1 hybrids Sk-7025 x Sk-7041, Sd-7 x Sd-34, Gm 18 x Sk-7025 and Sk-7041 x Sk-8084 were the lowest for number of days to 50 % silking (earlier) with the mean of 58.3 days, number of rows per ear with the mean of 12.1, number of grains per row with the mean of 35.6 and 100-grain weight with the mean of 32.42, respectively. Data on number of days to 50 % silking showed that eight out of the 28 F_1 hybrids exhibited low means towards earlines compared with the two checks.

Combined analyses of variance of the parental inbreed lines and their F_1 hybrids in addition to the two checks for all studied traits are shown in Table 2. The results showed the presence of highly significant differences among all genotypes for all studied traits except for number of grains per row which had only significant value. Partitioning of genotypes sum squares indicated that parents (P) and crosses (C) showed highly significant differences for all studied traits. The significant differences among checks (Ch) regarding all studied traits except number of grains per row, indicated the valuable use of the checks data to compare it with the other F_1 hybrids. The interaction of P *vs* F_1 were highly significant for all studied traits. This result indicated that the presence of heterosis in the hybrids were relatively high for all studied traits and are not biased and/or effected by locations, C *vs* Ch showed significant differences for all studied traits except ear diameter. The results also, indicated that the genotypes by locations (G x L) interaction was significant for all studied traits except ear height and ear length. The combined data showed that parents significantly interacted with locations (P x L) for all studied traits except plant height, ear height, ear length and number of grains per row. Insignificant interactions for crosses by locations (C x L) which was observed for ear height, ear diameter, number of rows per ear and number of grains per row. P *vs* C x L was highly significant for all studied traits except grain yield per plant and ear length. These results

Table 2: Analysis of variance of the eight parental inbred lines, their 28 F_1 hybrids and the two checks for all studied traits, data are combined over three locations.

S.O.V.	d.f.	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Rows/ear	Grains/ row	100-Grain weight (g)	Grain yield/ plant (g)
Locations (L)	2	1459.896**	90355.35**	6186.93**	42.714**	14.909**	11.290**	76.58**	1732.80**	433449.9**
Rep/L	9	33.030	973.32	918.68	3.232	0.209	1.502	16.77	51.74	12171.0
Genotypes (G)	37	102.077**	16948.45**	7029.61**	93.474**	1.934**	17.003**	651.97*	227.50**	389803.9**
Parents (P)	7	72.843**	5327.60**	1338.58**	56.346**	1.158**	19.654**	317.84**	277.58**	24023.4**
Crosses (C)	27	24.032**	2389.98**	1579.58**	36.952**	0.292**	9.641**	119.15**	126.56**	100702.2**
Checks (Ch)	1	13.500**	8970.66**	1176.00**	4.335*	0.135**	5.226*	6.00	152.00**	77760.7**
P vs C	1	2594.166**	458354.40**	198320.80**	1943.21**	55.200**	217.527**	17087.8**	2291.91**	104967.0**
C vs Ch	1	9.001*	9931.67**	1424.01*	29.762*	0.177	21.962**	558.40**	351.76**	335295.9**
G x L	74	5.291**	236.08*	177.50	2.273	0.118*	1.542**	16.12*	40.15*	6503.9**
P x L	14	25.791**	189.40	111.98	2.073	0.234*	2.104**	17.86	25.20*	1801.3**
C x L	54	3.044*	172.13*	141.50	2.482*	0.085	0.897	13.20	43.37**	7978.3**
Ch x L	2	0.25	50.04	75.37	0.260	0.005	0.806	14.09	49.12**	3438.6
P vs C x L	2	113.779**	4878.55**	3132.96**	1.209	0.770**	31.906**	81.18**	176.20**	11176.0*
C vs Ch x L	2	3.607	462.34*	483.86*	2.93	0.119	1.558	25.46	0.60	6897.5
Pooled error	333	1.7 07	139.01	111.37	1.681	0.076	0.655	9.34	20.27	3066.0
C.V. %		2.086	4.801	7.505	6.602	5.875	5.778	7.91	12.305	12.571

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

were in common agreement with similar results obtained by Perry (1983), El-Zeir (1990), Mourshed *et al.* (1990), Mousa (1997), Amer *et al.* (1998) and El-Zeir and Amer (1999).

Analysis of variances for general (GCA) and specific (SCA) combing ability from the combined data over the three locations for all studied traits are presented in Table 3. The mean squares of locations were highly significant for all studied traits indicating the presence of different effects of locations. The variation of genotypes (G) was also highly significant for all studied traits. GCA and SCA mean squares were highly significant for all studied traits. This indicated that both GCA (additive genetic variance) and SCA (non-additive genetic variance including dominance) play an important role in the expression of these traits. Moreover, on the calculated ratio of GCA/SCA variances, the results showed that it exceeded the unity in number of days to 50 % silking, ear length, number of rows per ear and 100-grain weight. This means that GCA variance (additive genetic variance) is more important than of the SCA (non-additive genetic variance including dominance) in the inheritance of these traits. The reverse was true in cases of plant height, ear height, ear diameter, number of grains per row and grain yield per plant, in which GCA/SCA ratios were less than unity indicating that the SCA variance was more important in the inheritance of these traits. These results are in agreement with those of Dhillon and Singh (1976), Rama-Murthy *et al.* (1981), Nawar and El-Hosary (1985), Attia (1986), Abd El-Aziz (1991), Gabr (1997), Soliman (1997) and Abd El-Aal (2002). However, Leon *et al.* (1989) and Mahmoud (1989) obtained the opposite disagreed with the obtained results. They found that SCA variance was more important than GCA variance in the inheritance of ear diameter and number of grains per row.

The results also, cleared that the interaction between GCA x location was highly significant for all studied traits except 100-grain weight which was significant. On the other hand, ear length and ear diameter showed insignificance. Whereas, the SCA x location was highly significant for all studied traits except for ear length, ear diameter and number of grains per row. These results indicated that the additive and non-additive

Table 3: Analysis of variance for general (GCA) and specific (SCA) combining abilities from diallel cross for all studied traits, data are combined over three locations.

S.O.V.	d.f.	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Rows/ear	Grains/ row	100- Grain weight (g)	Grain yield/ plant (g)
Locations (L)	2	141430**	83930.25**	56905.06**	36.84**	14.235**	11.793**	80.468**	1631.54**	397489.51**
Rep / L	9	33.10	1004.94	822.49	3.191	0.194	1.359	17.06	48.03	12601.68
Genotypes (G)	35	107.22**	16699.35**	7152.56**	95.295**	2.034**	17.583**	643.708**	218.638**	382379.14**
GCA	7	142.41**	14038.16**	5571.30**	161.114**	1.544**	49.175**	639.271**	627.443**	226571.72**
SCA	28	98.43**	17364.65**	7547.88**	78.841**	2.157**	9.685**	644.818**	116.437**	421331.00**
G X L	70	5.37**	239.71**	176.31**	2.346	0.124	1.568**	16.340*	41.019**	6674.63**
GCA x L	14	6.65**	295.41**	193.45**	1.948	0.115	1.588**	26.848**	38.720*	8598.98**
SCA x L	56	5.06**	225.79**	172.03**	2.446	0.126	1.564**	13.714	41.594**	6193.47**
Pooled error	315	1.75	131.01	108.78	1.741	0.079	0.647	9.667	20.554	2969.87
GCA / SCA	--	1.446	0.808	0.738	2.043	0.715	5.077	0.991	5.388	0.537
GCA x L / SCA x L	--	1.314	1.308	1.124	0.796	0.912	1.015	1.957	0.930	1.388

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

genetic variances were affected by environment (L). The ratio of GCA x L /SCA x L were more than unity for all studied traits except ear length, ear diameter and 100-grain weight, indicating that the additive genetic effects were more interacting with environments (L) than non additive genetic effects for these traits. These results are in agreement with those of Matzinger *et al.* (1959) and Amer *et al.* (1998). They suggested that the additive effects were more biased by interaction with environments (L) than the non additive effects.

Heterosis relative to mid-parents ($H_{M.P}$ %) was determined from the combined data over the three locations for all studied traits and the results are shown in Table 4. The results indicated that heterosis versus to the mid-parents for number of days to 50% silking was desirably negative and highly significant for all crosses and ranged from -11.2 % in the cross Sk-7025 x Sk-8084 to -6.4 % in the cross Sd-34 x Gz 628. The highest hetrosis value for plant height was 62.4 % obtained from the cross Sd-7 x Gm-18 and the lowest value was 29.7 % for the cross Gz-628 x Sk-8084. Similarly the obtained heterosis values versus the mid-parents ranged from 7.3 to 47.5, 11.4 to 30.7, 3.2 to 22.4, 33.7 to 87.5, 0.9 to 81.3 and 160.1 to 878.1 % for ear length, ear diameter, number of rows per ear, number of grains per row, 100-grain weight and grains yield per plant, respectively. These findings indicated the possibility of increasing the productivity, yield and its components over mid-parents through hybridization program. Similar results were obtained by Verma and Singh (1980), Prasad and Singh (1986), Debnath (1987), El-Zeir (1990 & 1998) and Abd El-Maksoud *et al.* (2003 & 2004).

The amounts of heterosis versus the better parent ($H_{B.P}$ %) for all studied traits were obtained from the combined data over three locations and the results are presented in Table 5. Most studied crosses versus the better parent showed positive and highly significant estimates for all studied traits except number of days to 50 % silking which showed desirable negative highly significance for all crosses. The two crosses Sd-7 x Sk-7023 and Gm-18 x Sk- 8084 were earlier than their better parents with the heterosis values of -9.3 and -10.7 %, respectively. Heterosis values versus the better parent ranged from -10.7 to -3.9,

Table 4: Percentage of mid-parents heterosis ($H_{M.P}$%) for all studied traits, data are combined over three locations.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ ear	Grains/ row	100-grain weight (g)	Grain yield/ plant (g)
Sd 7 x Gm 18	- 9.4**	62.4**	58.7**	47.5**	26.29**	17.3**	74.8**	31.2**	574.7**
Sd 7 x Sd 34	- 6.7**	40.1**	50.6**	28.9**	13.1**	3.8**	44.2**	81.3**	286.5**
Sd 7 x Gz 628	- 9.5**	43.4**	53.1**	13.7**	20.1**	12.2**	35.0**	12.2**	220.6**
Sd 7 x Sk 7023	- 9.7**	43.4**	59.7**	28.8**	27.7**	14.3**	43.3**	29.2**	323.8**
Sd 7 x Sk 7025	- 9.7**	51.2**	61.8**	41.6**	24.3**	15.0**	55.3**	22.6**	295.4**
Sd 7 x Sk 7041	- 6.4**	53.5**	64.1**	35.9**	17.6**	10.2**	52.2**	18.9**	287.4**
Sd 7 x Sk 8084	- 9.5**	46.4**	48.2**	29.1**	24.4*	18.1**	58.0**	19.4**	322.3**
Gm 18 x Sd 34	- 7.7**	36.9**	42.3**	39.6**	19.7*	12.8**	57.4**	7.7**	344.5**
Gm 18 x Gz 628	- 9.3**	49.1**	49.1**	28.5**	19.9*	15.4**	33.7**	27.7**	304.8**
Gm 18 x Sk 7023	- 8.3**	49.9**	68.1**	37.4**	27.4*	21.8**	74.5**	21.9**	454.2**
Gm 18 x Sk 7025	- 9.2**	60.8**	61.5**	44.4**	29.6*	22.4**	74.1**	23.6**	878.1**
Gm 18 x Sk 7041	- 8.7**	51.5**	54.2**	39.8**	22.9**	15.1**	70.3**	18.0**	329.8**
Gm 18 x Sk 8084	-11.1**	48.9**	49.4**	44.5**	26.6**	21.3**	87.5**	10.0**	423.4**
Sd 34 x Gz 628	- 5.6**	37.9**	50.4**	13.9**	17.8**	8.0**	41.6**	12.9**	233.2**
Sd 34 x Sk 7023	- 7.6**	33.1**	46.4**	19.2**	15.1*	6.3**	50.3**	15.1**	235.9**
Sd 34 x Sk 7025	- 8.7**	40.3**	49.6**	38.9**	18.1**	9.3**	56.7**	12.3**	210.5**
Sd 34 x Sk 7041	- 7.2**	39.3**	49.9**	24.7**	11.4*	3.2**	54.9**	13.8**	249.3**
Sd 34 x Sk 8084	- 8.8**	30.2**	41.2**	30.7**	17.0**	9.5**	67.0**	8.7**	279.1**
Gz 628 x Sk 7023	- 9.0**	42.3**	59.5**	9.6**	21.4**	15.1**	46.4**	24.9**	205.1**
Gz 628 x Sk 7025	- 8.2**	41.4**	53.4**	18.3**	22.6**	14.1**	44.7**	18.9**	179.9**
Gz 628 x Sk 7041	- 8.5**	37.0**	48.3**	10.6**	21.6**	8.5**	44.2**	15.9**	194.7**
Gz 628 x Sk 8084	- 9.9**	29.7**	29.8**	7.3**	20.1**	16.9**	46.8**	11.8**	184.9**
Sk 7023 x Sk 7025	- 9.6**	39.5**	51.4**	27.1**	22.3**	15.6**	64.1**	18.4**	161.7**
Sk 7023 x Sk 7041	- 7.8**	39.7**	57.6**	29.4**	22.2**	9.7**	70.3**	27.6**	287.7**
Sk 7023 x Sk 8084	- 9.7**	39.9**	58.4**	19.6**	23.9**	15.2**	70.5**	17.2**	329.9**
Sk 7025 x Sk 7041	- 9.8**	49.1**	54.4**	42.9**	24.2**	13.9**	60.3**	13.7**	225.8**
Sk 7025 x Sk 8084	-11.2**	39.3**	40.9**	30.2**	30.7**	19.8**	76.7**	19.6**	261.5**
Sk 7041 x Sk 8084	- 8.0**	33.9**	42.0**	17.4**	25.0**	11.4**	51.9**	0.9	160.1**
LSD at 0.05	0.91	8.17	7.31	0.898	0.191	0.561	2.118	3.12	38.37
0.01	1.18	10.71	9.59	1.178	0.250	0.735	2.777	4.09	50.31

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

Table 5: Percentage of better parent heterosis ($H_{B.P}$%) for all studied traits, data are combined over three locations.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ ear	Grains/ row	100-grain weight (g)	Grain yield/ plant (g)
Sd 7 x Gm 18	- 7.8**	70.0**	62.5**	42.9**	25.9**	9.1**	44.8**	3.1	432.1**
Sd 7 x Sd 34	- 4.9**	55.1**	67.1**	18.6**	6.7**	-6.2**	43.5**	9.6**	221.8**
Sd 7 x Gz 628	- 7.9**	47.0**	55.2**	4.6**	15.7**	0.8**	33.9**	9.4**	168.2**
Sd 7 x Sk 7023	- 9.3**	47.0**	62.3**	27.6**	24.5**	3.9**	33.9**	8.1**	285.5**
Sd 7 x Sk 7025	- 6.3**	67.7**	77.8**	21.4**	18.7**	3.8**	25.5**	14.2**	266.6**
Sd 7 x Sk 7041	- 4.6**	53.9**	67.2**	28.8**	12.7**	6.6**	38.0**	13.9**	249.7**
Sd 7 x Sk 8084	- 8.3**	49.6**	48.9**	28.6**	21.2**	8.9**	33.6**	18.3**	287.7**
Gm 18 x Sd 34	- 4.1**	59.4**	53.9**	22.2**	13.2**	9.3**	29.9**	0.3	207.6**
Gm 18 x Gz 628	- 5.9**	52.2**	54.8**	14.9**	15.7**	10.6**	32.6**	24.5**	181.0**
Gm 18 x Sk 7023	- 6.2**	61.1**	69.3**	24.4**	23.9**	18.9**	58.3**	2.1	372.3**
Gm 18 x Sk 7025	- 3.9**	70.0**	82.0**	27.5**	23.4**	18.6**	68.7**	15.2**	719.5**
Gm 18 x Sk 7041	- 5.2**	58.2**	60.8**	36.6**	17.8**	4.0**	54.0**	13.0**	214.8**
Gm 18 x Sk 8084	-10.7**	52.5**	53.7**	39.6**	23.1**	20.3**	82.8**	9.1**	342.3**
Sd 34 x Gz 628	- 5.5**	56.9**	69.5**	13.9**	15.5**	6.8**	39.8**	2.2	231.2**
Sd 34 x Sk 7023	- 6.2**	43.5**	59.6**	8.8**	6.1**	5.4**	35.2**	9.4**	159.5**
Sd 34 x Sk 7025	- 7.1**	74.0**	83.9**	11.3**	6.7**	9.3**	26.2**	2.6	143.5**
Sd 34 x Sk 7041	- 7.2**	54.7**	69.7**	9.3**	9.8**	4.0**	39.8**	1.2	218.8**
Sd 34 x Sk 8084	- 5.8**	47.7**	57.5**	20.6**	8.0**	6.9**	40.7**	0.2	194.9**
Gz 628 x Sk 7023	- 7.7**	49.6**	64.4**	00.0	14.0**	12.9**	33.2**	6.7**	136.7**
Gz 628 x Sk 7025	- 6.5**	52.7**	66.0**	-5.2**	12.9**	12.9**	17.7**	13.4**	120.4**
Gz 628 x Sk 7041	- 8.4**	40.1**	49.0**	-3.1**	21.0**	2.0**	31.6**	13.7**	170.5**
Gz 628 x Sk 8084	- 7.0**	30.1**	31.0**	1.0*	12.9**	12.8**	25.0**	10.0**	122.6**
Sk 7023 x Sk 7025	- 6.6**	59.1**	83.1**	10.0**	19.7**	14.7**	44.8**	5.4**	156.3**
Sk 7023 x Sk 7041	- 6.4**	43.6**	63.2**	23.8**	14.3**	1.3**	69.7**	10.7**	221.7**
Sk 7023 x Sk 8084	- 8.1**	46.6**	61.8**	18.3**	23.9**	13.4**	58.3**	1.3	325.6**
Sk 7025 x Sk 7041	- 8.2**	64.9**	66.3**	28.8**	13.9**	6.0**	41.0**	10.6**	174.9**
Sk 7025 x Sk 8084	- 6.6**	51.0**	54.1**	11.6**	27.9**	17.1**	67.1**	12.3**	257.6**
Sk 7041 x Sk 8084	- 4.9**	36.4**	44.6**	11.0**	8.5**	1.3**	40.6**	- 2.6	117.6**
LSD at 0.05	1.04	9.43	8.44	1.037	0.221	0.648	2.445	3.60	44.31
0.01	1.37	12.37	11.07	1.360	0.289	0.849	3.206	4.72	38.10

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

30.1 to 74.0, 31.0 to 83.9, -5.2 to 42.9, 6.1 to 27.9, -6.2 to 20.3, 17.7 to 82.8, -2.6 to 24.5 and 117.6 to 719.5 % for number of days to 50 % silking, plant height, ear height, ear length, ear diameter, number of rows per ear, number of grains per row, 100-grain weight and grain yield per plant, respectively. The high hetetrotic values obtained in this study would reflect high degree genetic diversity among the parental inbreed lines and support the important role of non-additive gene action controlling these traits. Several investigators obtained high and economical amounts of heterosis versus the mid-parents and better parent, among them Abo-Dheaf (1987), Soliman (1992), Abd El-Aziz *et al.* (1994), Gomes *et al.* (1995) and Abd El-Maksoud *et al*. (2003&2004).

The estimates of general (GCA) combining ability effects of the eight parental inbred lines for the combined data over the three locations are presented in Table 6. Either positive or negative estimates, indicated that a given parental inbred line is better or worse than the average of that group of the inbred lines involved within the diallel crosses mating design. The parental inbred lines with negative estimates for silking date, plant and ear heights are considered to be better because this indicate that they are more earlier in maturity, shorter in height and more resistant to stralk breakage. Results on GCA effects for number of days to 50 % silking cleared that the inbred line Gm-18 had positive and highly significant GCA effects (undesirable), whereas Sk-7025 possessed negative and highly significant GCA effects (desirable). Concerning plant and ear heights, the parental line Sk-7025 had negative and highly significant GCA effects (desirable). In case of plant height three of the eight parental inbred lines showed negative and highly significant estimates for GCA effects (shortness). Three parental inbred lines showed negative and significant values for GCA effect for ear height. The parental line Sd-7 had positive highly significant GCA effects (desirable) for ear length, number of grains/row, 100-grain weight and grain yield/plant. The parental inbred line Sk-7025 had undesirable GCA effects for most yield and yield component traits with negative and significant estimates.

Specific combining ability (SCA) effects for all F_1 crosses are

Table 6: Estimates of general combining ability effects of the eight parental inbred lines for all studied traits, data are combined over three locations.

Parental inbred lines		Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Rows/ear	Grains/ row	100- grain weight (g)	Grain yield/ Plant (g)
Sd-7 (P_1)		0.525*	8.387**	2.716	0.653**	-0.022	-1.2660**	2.747**	2.017**	36.523**
Gm-18 (P_2)		1.533**	1.429	4.500**	0.925**	0.066	0.0931	-1.333*	1.596*	11.353
Sd-34 (P_3)		-0.133	17.687**	10.125**	1.953**	0.094*	-0.4132**	3.084**	3.122**	67.907**
Gz-628 (P_4)		-0.550*	- 7.837**	- 4.125*	-0.613**	0.120*	0.2440	1.031	0.159	14.680
Sk-7023 (P_5)		0.208	4.679*	5.400**	-0.385	-0.107*	0.0601	0.100	- 4.162**	- 34.577**
Sk-7025 (P_6)		-2.091**	-16.087**	-10.266**	-1.789**	-0.153**	0.3231*	-3.854**	- 1.292*	- 65.386**
Sk-7041 (P_7)		-0.383	1.229	- 2.125	-0.754**	0.116*	0.9572**	-0.200	- 1.011	7.005
Sk-8084 (P_8)		0.891**	- 9.487**	- 6.225**	0.011	-0.113*	0.0002	-1.575**	- 0.428	- 37.507**
LSD 0.05	gi	0.433	3.831	3.491	0.442	0.094	0.2692	1.041	1.208	18.242
	gi-gj	0.667	5.792	5.278	0.668	0.142	0.4071	1.573	2.294	27.579
LSD 0.01	gi	0.578	5.004	4.560	0.579	0.123	0.3530	1.365	1.980	23.919
	gi-gj	0.874	7.566	6.894	0.876	0.187	0.5338	2.063	3.008	36.162

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

Table 7: Estimates of specific combining ability effects of the eight parental inbred lines for all studied traits, data are combined over three locations.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ ear	Grains/ row	100-grain weight (g)	Grain yield/ plant (g)
Sd 7 x Gm 18	-1.650**	33.90**	13.63**	2.249**	0.283*	0.395	6.907**	4.521*	228.65**
Sd 7 x Sd 34	-0.567	16.97**	12.50**	0.920	0.005	-0.246	2.539	2.112	108.201**
Sd 7 x Gz 628	-1.900**	14.58**	10.917*	0.771	0.162	0.311	1.075	-1.400	48.165*
Sd 7 x Sk 7023	-1.992**	14.98**	12.56**	1.010	0.373**	0.395	2.023	2.472	80.054**
Sd 7 x Sk 7025	-1.609**	18.50**	14.47**	1.480**	0.186	0.332	3.294*	1.685	85.828**
Sd 7 x Sk 7041	-0.067	29.77**	18.83**	1.595**	0.099	0.331	3.607*	1.287	103.124**
Sd 7 x Sk 8084	-1.425*	22.40**	9.600*	0.995	0.246	0.655	3.599*	2.221	85.897**
Gm 18 x Sd 34	-1.075	6.600	5.050	1.332*	0.233	0.408	2.237	-1.374	105.033**
Gm 18 x Gz 628	-1.659**	19.87**	8.717	2.483**	0.074	0.217	4.022**	4.104*	98.677**
Gm 18 x Sk 7023	-0.834	22.52**	23.11**	1.438*	0.285*	0.968**	4.063**	0.827	107.261**
Gm 18 x Sk 7025	-1.034	28.87**	16.27**	0.842	0.315*	0.905*	2.642	2.373	53.643*
Gm 18 x Sk 7041	-1.492*	21.059**	11.050*	1.207	0.227	0.537	3.604*	1.375	70.794**
Gm 18 x Sk 8084	-2.434**	22.109**	12.48**	2.457**	0.258*	0.728*	5.313**	-0.548	87.390**
Sd 34 x Gz 628	0.174	22.534**	17.17**	1.271*	0.245	0.291	3.072*	1.045	148.95**
Sd 34 x Sk 7023	-1.084	12.600*	7.567	0.043	0.056	-0.024	2.437	0.734	55.072*
Sd 34 x Sk 7025	-1.450**	18.70**	12.23**	1.980**	0.136	0.178	3.474*	0.589	53.854*
Sd 34 x Sk 7041	-1.159	21.88**	13.84**	0.529	-0.001	-0.155	4.253**	1.816	131.87**
Sd 34 x Sk 8084	-1.517*	9.684	10.609*	1.979**	0.146	0.168	5.913**	0.675	128.70**
Gz 628 x Sk 7023	-1.500*	22.87**	16.98**	0.919	0.180	0.584	2.789*	2.047	57.164*
Gz 628 x Sk 7025	-0.617	11.892*	11.650*	1.315*	0.177	0.337	1.893	1.343	55.947*
Gz 628 x Sk 7041	-1.492*	9.492	8.425	0.663	0.315*	0.145	2.581	1.162	82.242**
Gz 628 x Sk 8084	-1.684**	2.625	- 3.390	0.363	0.137	0.644	1.848	0.563	32.304
Sk 7023 x Sk 7025	-1.459*	9.125	4.792	0.253	0.071	0.438	3.058*	- 0.041	- 39.051*
Sk 7023 x Sk 7041	-0.917	14.47**	12.40**	1.435*	0.250*	0.204	6.271**	3.176	128.19**
Sk 7023 x Sk 8084	-1.525*	20.86**	19.50**	0.335	0.198	0.362	4.313**	1.127	114.756**
Sk 7025 x Sk 7041	-1.867**	21.32**	9.900*	1.872**	0.280*	0.591	2.658	0.248	81.960**
Sk 7025 x Sk 8084	-2.142**	10.959*	3.917	0.572	0.395**	0.732*	4.351**	2.773	78.756**
Sk 7041 x Sk 8084	-0.684	6.309	5.859	-0.579	0.007	0.197	0.280	- 2.449	- 40.517*
LSD at 0.05 Sij	1.181	10.216	9.310	1.178	0.251	0.718	2.775	3.221	38.717
LSD at 0.05 Sij-sik	2.008	17.377	15.835	2.003	0.427	1.221	4.720	5.478	82.737
LSD at 0.05 Sij-skl	1.894	16.384	14.929	1.889	0.402	1.151	4.450	5.165	78.005
LSD at 0.01 Sij	1.548	13.397	12.160	1.544	0.329	0.938	3.639	5.306	63.784
LSD at 0.01 Sij-sik	2.635	22.786	20.763	2.627	0.560	1.601	6.189	9.025	108.487
LSD at 0.01 Sij-skl	2.483	21.482	19.575	2.476	0.528	1.510	5.836	8.509	102.282

*,** indicate significant at 0.05 and 0.01, levels of probability, respectively.

shown in Table 7. Desirable and negative significant and highly significant effects were obtained for 7 and 10 crosses for number of days to 50 % silking. These results were desirable and indicated earliness for this trait in these crosses. In case of plant and ear heights, the SCA effects were significant in 22 and 20 out of 28 crosses, respectively. It is evident that the numbers of F_1 hybrids exhibiting positive significant and desirable SCA effects were 13, 9, 4, 17, 2 and 25 crosses in ear length, ear diameter, number of rows per ear, number of grains per row, 100-grain weight and grain yield per plant, respectively.

These results cleared that parents possessing poor GCA may exhibit good SCA. Also, data revealed that the best SCA effect for ear length, ear diameter, rows per ear and number of grains per row was obtained from the crosses between parents with poor GCA. In other words, the best desirable SCA effects in case of these traits were obtained from parents having good and desirable GCA effects. These breeding materials could be used in the production of maize hybrids in the best breeding program for further improvement of the previous traits. Similar findings were obtained by Nawar and El-Hosary (1985), Mahmoud (1989), Soliman (1992 & 1997), Gabr (1997), Abd El-Aal (2002) and Abd El-Maksoud *et al*. (2003 & 2004).

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التهجين نصف الدائرى وقوة الهجين فى الذرة الشامية

أشرف حسين عبد الهادى* ــ زكريا عبد المنعم كسبة* ــ فتحى أحمد الزير** ــ أحمد ابراهيم أبو أحمد*

*قسم الوراثة ــ كلية الزراعة ــ جامعة المنصورة ــ مصر.

** برنامج بحوث الذرة الشامية ــ معهد بحوث المحاصيل الحقلية ــ مركز البحوث الزراعية.

تم إجراء كافة الهجن الممكنة فى اتجاه واحد (غير شاملة على الهجن العكسية) بين ثمان سلالات من الذرة الشامية بيضاء الحبوب وذلك لإنتاج ٢٨ هجينا فرديا. وفى الموسم التالى تم تقييم الجيل الأول الهجين وسلالات الآباء فى ثلاث تجارب أجريت فى مزارع ثلاث محطات بحوث مختلفة هى: سخا والجميزة وسدس (مركز البحوث الزراعية). تهدف هذه الدراسة لتقدير قوة الهجين مقارنة بمتوسط الآباء وأحسن الآباء والقدرة العامة والخاصة على التآلف لبعض الصفات الخضرية ومحصول الحبوب ومكوناته.

ويمكن تلخيص النتائج المتحصل عليها كما يلى:

أوضحت نتائج تحليل التباين للبيانات المجمعة للثلاثة مواقع وجود فروق عالية المعنوية بين المواقع ، التراكيب الوراثية ، الآباء ، الهجن ، الآباء مقارنة بالجيل الأول الهجين وذلك لجميع الصفات محل الدراسة عدا صفتى ارتفاع الكوز وطول الكوز. بينما كان التفاعل بين (المواقع × الآباء) ، (المواقع × الهجن) معنويا لمعظم الصفات محل الدراسة. أما فيما يخص التفاعل بين الآباء مقارنة بالهجن والمواقع فقد كانت الفروق معنوية لكل الصفات محل الدراسة فيما عدا محصول الحبوب لكل نبات وطول النبات.

أظهرت قيم التباين الراجع للقدرة العامة والخاصة على التآلف وجود فروقا عالية المعنوية لكل الصفات محل الدراسة كما أظهر التفاعل بين كل من القدرة العامة والخاصة على التآلف والمواقع (البيئات) فروقا عالية المعنوية لست صفات من التسع صفات محل الدراسة

كما كانت النسبة بين تباين القدرة العامة على التآلف إلى القدرة الخاصة على التآلف تزيد عن الواحد الصحيح مما يؤكد أهمية التباين الوراثي المضيف فى توريث صفات عدد الأيام حتى ظهور ٥٠ % حريرة وطول الكوز وعدد الصفوف بالكوز ووزن الـ ١٠٠ حبة.

أظهرت جميع هجن الجيل الأول مقارنة بمتوسط الآباء قيما سالبة وعالية المعنوية لقوة الهجين بالنسبة لصفة عدد الأيام حتى ظهور ٥٠ % حريرة وهى قيم مقبولة ومفضلة حيث أنها تعبر عن التبكير فى التزهير، وعلى النقيض من هذه النتائج فقد أظهرت قوة الهجين مقارنة بمتوسط الآباء قيما موجبة وعالية المعنوية لجميع الهجن فى جميع الصفات محل الدراسة عدا الهجين الأول والسابع لصفتى وزن الـ ١٠٠ حبة وقطر الكوز على الترتيب.

كما أظهرت النتائج أيضا أن معظم الهجن مقارنة بأعلى الآباء أعطت قيما لقوة الهجين موجبة وعالية المعنوية لكل الصفات محل الدراسة فيما عدا صفة عدد الأيام حتى ظهور ٥٠ % حريرة التى أظهرت قيما معنوية سالبة لجميع الهجن وهى نتائج مقبولة حيث تعبر عن التبكير فى خروج الحريرة.

السلالتان النقيتان سدس ٧ ، سدس ٣٤ هما أكثر الآباء قدرة على التآلف حيث أظهرتا قيما موجبة ومعنوية لصفة محصول الحبوب لكل نبات. السلالة النقية سخا ٧٠٢٥ أظهرت قيما سالبة وعالية المعنوية بالنسبة للقدرة العامة على التآلف لصفة عدد الأيام حتى ظهور ٥٠ % حريرة، فهى نتائج مفضلة حيث أنها تعبر عن التبكير فى التزهير وكذا صفتى ارتفاع النبات وارتفاع الكوز وهى مقبولة ومفضلة أيضا حيث تعبر عن قصر أطوال نباتات الهجن فتصبح أكثر مقاومة للرقاد. وتشير النتائج إلى إمكانية استخدام هذه السلالات النقية المستخدمة كأباء فى برنامج تربية الذرة الشامية لإنتاج هجن الجيل الأول المتفوقة فى معظم الصفات محل الدراسة. أظهرت معظم هجن الجيل الأول قيما سالبة ومعنوية (مفضلة) للقدرة الخاصة على التآلف لصفة عدد الأيام حتى ظهور ٥٠ % حريرة لعدد ١٧ هجينا أكثر تبكيرا. كما أظهر عدد ١٤ و ٩ و ٤ و ١٧و ٢و ٢٥ هجينا من اجمالى ٢٨ هجينا موضع التقييم وجود قيم موجبة ومعنوية للقدرة الخاصة على التآلف لصفات طول الكوز وقطر الكوز وعدد الصفوف بالكوز وعدد الحبوب بالصف ووزن الـ ١٠٠ حبة ومحصول الحبوب لكل نبات مما يؤكد تفوق هذه الهجن فى الصفات محل الدراسة.