Heterosis and Combining Ability for Yield and Its Components through Diallel Cross Analysis in Maize (*Zea mays* L.)

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ABSTRACT

Diallel crosses, without reciprocals, among eight new yellow maize inbred lines derived from different maize populations were made in 2012 season at Experimental Farm, Faculty of Agriculture, Minufiya University at Shebin El-Kom. The resultant 28 crosses along with the check hybrid SC166 were evaluated in a randomized complete block design with three replications conducted at two locations, i.e. Shebin El-Kom and Alexandria in 2013 season. The results indicated that mean squares due to crosses, G.C.A. and S.C.A. were highly significant for all studied traits indicating the importance of both additive and non-additive gene effects in the inheritance of these traits. The parental inbred lines P_1, P_6 and P_7 had significant positive G.C.A. effects for grain yield. For other traits, the best general combiner were P_5 and P_7 for earliness and P4 for both shorter plants and lower ear placement. The best cross combinations for earliness were $P_2 \times P_4$ and $P_3 \times P_6$. Concerning plant and ear heights, the crosses $P_1 \times P_2$, $P_5 \times P_7$ and $P_5 \times P_8$ had the shortest plants with the lowest ear placement. The crosses $P_1 \times P_6$, $P_2 \times P_4$, $P_3 \times P_6$ and $P_7 \times P_8$ had the best S.C.A. effects for grain yield. The crosses $P_1 \times P_6$ and $P_3 \times P_6$ significantly out yielded the check hybrid SC166. The crosses $P_1 \times P_6$ and $P_3 \times P_6$ observed the highest percentage of heterosis for yield over the check variety. Six crosses showed significant negative heterosis for days to 50% silking. For short plant and lower ear placement, the crosses $P_1 \times P_2$ and $P_3 \times P_4$ showed negative heterosis. These promising crosses may be released as commercial hybrids after further evaluation.

Key words: Heterosis, combining ability, gene effect, diallel analysis, maize.

INTRODUCTION

Maize (*Zea mays* L.) is among the most important cereals for both human and animal consumption, where, used as food, feed and fodder. In addition, many products such as oil, starch, gluten, alcohol, glucose and ethanol are obtained as a maize products.

To develop new maize genotypes, breeders need knowledge regarding the type and relative magnitude of genetic variance components along their interaction with environment. This might includes information about heterosis in yield and its components. One of the most informative methodology in this concern is diallel analysis system, which is widely and extensively used for estimating the types of gene action. The two main genetic parameters of diallel analysis are general combining ability (GCA) and specific combining ability (SCA) that are essential in developing breeding strategies. Information on the heterotic patterns and combining ability among maize lines are essential in maximizing the effectiveness of hybrid development. Griffing (1956) gave a complete analysis of diallel crosses for fixed and random set of paraents. El-Shamarka (1995), Abd El-Aty and Katta (2002) and Ibrahim *et al*. (2010) reported that, specific combining ability effects were more important in the inheritance of grain yield and its components.

The goal of the present work were to study GCA, SCA and hterosis that control yield and other important traits in some promising maize inbreed lines as affected by the study location.

MATERIALS AND METHODS

Eight inbred lines with a wide range of diversity for several maize (*Zea mays* L.) traits were hand crossed in a half diallel mating scheme during 2012 summer season at the Experimental farm of the Faculty of Agriculture, Minufiya University at Shebin El-Kom giving a total of 28 cross seeds. The resultant 28 crosses along with the check hybrid SC166 were evaluated in a randomized complete block design with three replications at two locations i.e; Shebin El-Kom and Alexandria University Agric. Res. Stations in 2013 season. The experimental plot was one ridge of six m long and 0.80 m apart. Planting was done in hills evenly spaced at 25 cm with two kernels per hill on one side of the ridge. Later, seedling were thinned to one plant per hill. Other agricultural practices were done as recommended for maize cultivation in each location. Data were recorded for number of days to 50% silking, plant height, ear height, ear diameter, ear length, number of rows per ear, number of kernels per row and grain yield per faddan (4200 m^2) adjusted to 15.5 percent grain moisture and calculated in ardabs (ardab=140 kg seeds). Analysis of variance was performed Steel and Torrie, (1980) for the combined data over the two locations when the assumption of error variances homogeneity had not rejected according to Bartlett, 1937. General and specific combining abilities were computed using method 4, model 1 of Griffing (1956). Mean data were used to estimate heterosis over check variety according to Rai (1979).

RESULTS AND DISCUSSION

A– Analysis of variance:

Analysis of variance for all studied traits over the two locations were presented in Table (1). Locations mean squares were significant ($p \geq 0.01$) for all studied traits except number of rows/ear, indicating that the two locations differed in their environmental conditions. Crosses mean squares were significant ($p \geq 0.01$) for all studied traits indicating a wide diversity between the studied materials. Significant ($p \geq 0.01$) interactions between crosses and locations were detected for all studied traits, indicating that crosses behaved differently from location to another. Mean squares due to G.C.A. and S.C.A. were significant ($p \geq$ 0.01and 0.05) for all studied traits, indicating that both additive and non-additive gene effects were important in the inheritance of the studied traits. The mean squares of interaction between locations G.C.A. and locations S.C.A. were significant for all the studied traits, indicating that, both additive and non-additive gene actions were involved and varied from location to another. These results agree with the finding of several researchers (Amiruzzaman *et al*, 2013; El-Badawy, 2013; Abd El-Mottalb and Gamea, 2014; Saad El-Deen *et al*, 2015). They reported that, both additive and non-additive gene action were important in maize characters inheritance.

B – Mean performance:

Mean performance of the 28 studied crosses along with the check hybrid SC 166 presented in Table (2). For days to 50% silking, seven crosses were significantly earlier than the earliest check hybrid SC166. These crosses were $P_1 \times P_7$, $P_2 \times P_5$, $P_2 \times P_7$, $P_3 \times P_5$, $P_4 \times P_5$, $P_5 \times P_7$ and $P_5 \times P_8$. Whereas, seventeen crosses did not differ significantly from the check hybrid SC166. On the other hand, three crosses were significantly late maturing than the check hybrid SC166. These were $P_1 \times P_2$, $P_3 \times P_4$ and $P_3 \times P_8$.

With respect to plant and ear height, two crosses; ($P_1 \times P_2$ and $P_3 \times P_4$) were significantly shorter than the check hybrid SC166. Also, $P_1 \times P_2$, $P_3 \times P_4$, $P_4 \times P_5$, $P_5 \times P_7$, and $P_5 \times P_8$, crosses showed lower ear height than the check hybrid However, five crosses $P_1 \times P_6$, $P_1 \times P_7$, $P_2 \times P_7$, $P_6 \times P_7$ and $P_6 \times P_8$ recorded the highest values for both traits. Regarding ear diameter, none of the studied crosses significantly surpassed the check hybrid SC166. The highest mean value for this trait detected by the hybrid $P_3 \times P_7$ (4.96 cm). As for ear length, none of the crosses significantly surpassed the check hybrid SC166. Meanwhile , fourteen crosses did not differ significantly from the check hybrid SC166.Among the highest mean values for this trait, was that presented by the hybrid $P_1 \times P_6$ (22.04 cm).

Concerning, number of rows per ear, $P_6 \times P_7$ hybrid gave higher value relative to the check hybrid SC166. In the meantime, the other crosses did not differ significantly from the check hybrid SC166, except for $P_1 \times P_5$, $P_1 \times P_8$, $P_2 \times P_8$, $P_3 \times P_4$, and $P_5 \times P_8$ crosses, that had significantly lower number of rows/ear than the check hybrid. Regarding the number of kernels per row, none of the studied crosses surpassed the highest value that expressed by the check hybrid. The highest mean values for this trait detected by the hybrid. $P_1 \times P_3$ (42.68), $P_1 \times P_4$ (43.24), $P_1 \times P_6$ (44.45), $P_2 \times P_3$ (41.30), $P_2 \times P_4$ (43.15), $P_2 \times P_7$ (40.94), $P_3 \times P_5$ (41.20), $P_3 \times P_6$ (42.30), $P_4 \times P_7$ (42.14), $P_5 \times P_6$ (43.56) and $P_6 \times P_8$ (42.88).

Concerning grain yield, two crosses had significant superiority over the check hybrid SC166. These were hybrids $P_1 \times P_6$ and $P_3 \times P_6$ with mean value of 25.79 and 26.20 ard/fad, respectively. These crosses showed high values of one or more of yield component traits. These traits included ear diameter, ear length, number of rows per ear and number of kernels per row. Meanwhile, fifteen crosses did not differ significantly from the check hybrid SC166. However, the hybrid $P_3 \times P_4$ showed the lowest mean value for grain yield (5.63 ard/fad). These crosses might be used as commercial hybrids after further testing and evaluation. Amer, 2002; Hefiny, 2010; Mousa, 2014 ; Abd El-Mottalb and Gamea 2014; El-Koomy, 2015, have recorded significant differences among maize genotype for grain yield and its components.

C- Combining ability effects:

1- General combining ability (GCA) effects:

Estimates of general combing ability (GCA) effects of the eight parental inbred lines for the eight studied traits over the two locations has given in Table (3). The parental inbred line P_1 showed significant positive estimates for grain yield and undesirable effects for days to 50% silking and number of rows per ear. The parental inbred line P_2 exhibited significant negative effects for plant and ear heights, indicating that, this inbred line might be considered as a good combiner for developing short stemed genotypes. Conversely, this line showed undesirable effects for grain yield. The parental inbred line P_4 behaved as the best combiner for short plant and ear heights. The parental inbred P_5 , expressed significant negative effects for days to 50% silking, plant and ear heights. In addition, it is exhibited significant negative effects for ear diameter.

Table 1: Combined analysis of variance for studied traits over the two locations, 2013 season.

S.O.V	d.f	M.S							
		Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	No. of rows/ ear	No. of kernels/ row	Grain yield (ard fad^{-1})
Locations(L)	1	2040.07**	183143.0**	69301.79**	3.30**	90.91**	1.13	277.24**	4582.96**
Rep. / Loc.	6	7.74	985.37	713.69	0.26	13.38	1.91	43.19	54.64
Crosses (C)	27	50.78**	1637.84**	841.63**	0.63**	17.74**	9.42**	145.68**	142.09**
G.C.A	7	82.95**	2940.29**	1888.54**	1.08**	9.77**	25.41**	58.77*	313.41**
S.C.A.	20	39.53**	1181.98**	475.22**	0.47*	20.53**	3.83**	176.09**	82.13**
C X L	27	4.17**	451.76**	262.20**	0.44**	10.03**	2.64**	57.93**	92.88**
G.C.A X L	7	3.13*	1258.44**	586.75**	0.37**	11.32**	4.04**	60.02**	155.01**
S.C.A X L	20	4.54**	169.42**	148.61**	0.45**	9.58**	2.14**	57.19**	71.13**
Combined error	162	1.48	146.79	88.30	0.13	2.20	1.07	13.94	9.83

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 2: Mean performance of 28 crosses and the check hybrid SC 166 for all studied traits, during 2013 season.

crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	No. of rows/ ear	No. of kernels/ row	Grain yield (ard fad^{-1})
P_1 x P_2	75.88	142.50	73.75	4.33	14.80	14.73	26.83	13.75
P_1 x P_3	69.13	186.25	100.63	4.30	19.57	14.68	42.68	17.90
P_1 x P_4	69.75	185.00	96.25	4.80	20.87	14.75	43.24	16.92
P_1 x P_5	67.87	185.00	91.25	4.57	19.11	14.04	39.55	21.82
P_1x P_6	69.50	196.87	107.50	4.88	22.04	15.14	44.45	25.79
P_1 x P_7	67.50	207.50	110.00	4.73	19.73	15.57	37.61	22.90
P_1x P_8	68.75	188.75	103.13	4.16	19.20	12.67	40.05	16.51
P_2 x P_3	68.50	181.87	98.13	4.73	19.97	15.97	41.30	16.08
P_2 x P_4	68.25	173.75	90.63	4.74	20.98	16.10	43.15	18.71
P_2 x P_5	66.63	187.50	93.75	4.60	19.47	14.95	40.38	18.49
P_2 x P_6	68.63	188.13	101.25	4.95	20.27	15.87	40.53	19.83
P_2 x P_7	67.13	210.00	113.75	4.95	20.22	16.20	40.94	21.23
P_2 x P_8	68.88	183.13	102.50	4.14	19.60	12.50	40.67	13.93
P_3 x P_4	76.13	151.88	88.13	3.94	15.34	13.83	25.23	5.63
P_3 x P_5	67.75	185.00	93.75	4.55	20.92	14.70	41.20	17.45
P_3 x P_6	68.63	191.88	105.63	4.83	20.30	15.45	42.30	26.20
P_3 x P_7	67.87	185.63	95.00	4.96	19.37	16.42	40.14	18.82
P_3 x P_8	74.00	178.13	94.38	4.66	20.05	14.97	39.08	11.45
P_4 x P_5	67.62	172.50	85.63	4.30	19.37	14.88	38.44	16.95
P_4 x P_6	71.25	187.50	106.87	4.94	20.54	16.09	38.77	20.66
P_4 x P_7	68.25	190.00	97.50	4.73	20.10	16.05	42.14	18.83
P_4 x P_8	72.00	185.00	103.13	4.50	18.86	14.73	40.20	15.53
P_5 x P_6	67.87	185.63	97.50	4.70	20.08	16.53	43.56	21.30
P_5 x P_7	67.00	186.25	87.50	4.33	18.00	15.94	38.84	19.63
P_5 x P_8	66.75	171.88	83.13	4.15	19.58	13.90	40.33	18.16
P_6 x P_7	69.25	203.13	115.63	4.70	20.20	16.90	37.50	20.64
P_6 x P_8	71.37	201.87	119.37	4.64	20.08	15.40	42.88	21.18
P_7 x P_8	68.13	195.63	104.37	4.68	19.16	15.93	40.48	22.71
Check	72.87	183.75	98.13	4.73	21.28	15.65	43.22	21.22
L.S.D 0.5	1.19	11.92	9.23	0.35	1.45	1.02	3.66	3.07

Table 3: Estimates of GCA (gi) effects of eight inbred lines for all studied traits combined over the two locations, during 2013 season.

Parents	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	No. of rows/ear	No. of kernels/ row	Grain yield (ard fad^{-1})
P1	0.55*	-0.85	-1.25	-0.06	-0.27	-0.77**	-0.62	0.98*
P2	-0.19	-5.03**	-2.71*	0.05	-0.26	0.02	-0.72	-1.29**
P3	1.15**	-6.07**	-2.39	-0.03	-0.24	-0.03	-1.03*	-2.70**
P4	1.36**	-8.57**	-3.65**	-0.03	-0.15	0.03	-1.16*	-2.75**
P5	-2.26**	-3.88*	-9.58**	-0.15**	-0.07	-0.22	0.69	0.67
P6	0.24	9.66**	10.63**	0.25**	1.09**	0.86**	1.97**	4.31**
P7	-1.66**	13.52**	5.63**	0.16**	-0.03	1.13**	-0.07	2.49**
P8	0.80*	1.22	3.33**	-0.19**	-0.07	-1.02**	0.93	-1.71**
L.S.D0.5 Gi	0.32	3.23	2.51	0.09	0.39	0.27	0.99	0.84
L.S.D0.5 Gi-Gj	0.49	4.88	3.78	0.14	0.59	0.42	1.51	1.26

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

The parental inbred line P_6, seemed to be the best combiner for ear diameter, ear length, number of rows per ear, number of kernels per row and grain yield. The parental inbred line P_7, exhibited significant negative effects for days to 50% silking, along with desirable effects for ear diameter, number of rows per ear and grain yield. The parental inbred line P_8, expressed significant positive effect for days to 50% silking and showed undesirable effects for the other traits. The recent result, indicated that, parental line P_5 and P_7 might be considered as combiners for the improvement of earliness. Parental lines P_2, P_3, P_4 and P_5 might be considered as combiners for short –stem plant type. P_6 and P_7 for ear diameter and grain yield. P_6 for ear length and number of kernels per row. Mousa (2014) and Abd El-Mottalb and Gamea (2014), reported that GCA effects were desirable and significant for earliness, grain yield and its components. Selection of inbreds with good combining ability, might result in an increased grain yield in the F_1 hybrids (Johnson 1974).

2- Specific combining ability (SCA) effects:

Estimates of specific combining ability (SCA) effects for 28 F_1crosses for all studied traits over the two locations were shown in Table (4).

Table 4: Estimates of SCA(sij) effects of 28 crosses for all studied traits combined over the two locations, during 2013 season.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	No. of rows/ ear	No. of kernels/ row	Grain yield (ard fad^{-1})
P_1 x P_2	6.23**	-36.90**	-20.86**	-0.26*	-4.22**	0.31	-11.57**	-4.47**
P_1 x P_3	-1.88**	7.88*	5.69*	-0.20	0.52	0.32	4.61**	1.09
P_1 x P_4	-1.46**	9.14*	2.57	0.30**	1.73**	0.32	5.28**	0.16
P_1 x P_5	0.29	4.45	3.51	0.19	-0.11	-0.15	-0.26	1.63
P_1x P_6	-0.59	2.78	-0.45	0.09	1.65**	-0.12	3.36**	1.97*
P_1 x P_7	-0.69	9.55**	7.05*	0.04	0.45	0.04	-1.42	0.89
P_1x P_8	-1.89**	3.09	2.47	-0.17	-0.02	-0.71*	0.01	-1.28
P_2 x P_3	-1.75**	7.67*	4.66	0.11	0.92*	0.81**	3.32**	1.53
P_2 x P_4	-2.21**	2.05	-1.59	0.13	1.84**	0.88**	5.29**	4.22**
P_2 x P_5	-0.21	11.12**	7.47**	0.11	0.25	-0.03	0.68	0.57
P_2 x P_6	-0.71	-1.80	-5.24	0.06	-0.11	-0.18	-0.47	-1.72
P_2 x P_7	-0.32	16.22**	12.26**	0.15	0.96*	-0.12	2.01	1.48
P_2 x P_8	-1.02**	1.64	3.30	-0.30**	0.38	-1.67**	0.74	-1.61
P_3 x P_4	4.31**	-18.77**	-4.40	-0.59**	-3.84**	-1.35**	-12.32**	-7.45**
P_3 x P_5	-0.44	9.66**	7.16*	0.14	1.67**	-0.23	1.80	0.95
P_3 x P_6	-2.06**	2.99	-1.18	0.01	-0.12	-0.55	1.62	6.06**
P_3 x P_7	-0.92*	-7.11	-6.80*	0.24*	0.07	0.15	1.51	0.48
P_3 x P_8	2.75**	-2.32	-5.13	0.29**	0.79	0.85**	-0.55	-2.67**
P_4 x P_5	-0.77*	-0.34	0.28	-0.11	0.03	-0.12	-0.83	0.49
P_4 x P_6	0.35	1.12	1.32	0.13	0.03	0.02	-1.78	0.56
P_4 x P_7	-0.75*	-0.24	-3.05	0.01	0.71	-0.28	3.65**	0.55
P_4 x P_8	0.54	7.05	4.86	0.14	-0.49	0.54	0.70	1.46
P_5 x P_6	0.60	-5.45	-2.11	0.13	-0.51	0.71*	1.16	-2.22*
P_5 x P_7	1.62**	-8.68*	-7.11*	-0.27*	-1.47**	-0.15	-1.51	-2.08*
P_5 x P_8	-1.09**	-10.76**	-9.19**	-0.09	0.15	-0.04	-1.03	0.66
P_6 x P_7	1.37**	-5.34	0.80	-0.29**	-0.43	-0.27	-4.13**	-4.71**
P_6 x P_8	1.04**	5.69	6.85*	-0.01	-0.51	0.39	0.24	0.05
P_7 x P_8	-0.32	-4.40	-3.15	0.13	-0.30	0.64*	-0.10	3.39**
L.S.D0.5 (Sij)	0.72	7.13	5.55	0.21	0.88	0.61	2.20	1.85
L.S.D0.5 (Sij-Sik)	1.09	10.92	8.47	0.32	1.34	0.93	3.37	2.83
L.S.D0.5 (Sij-Skl)	0.98	9.77	7.57	0.29	1.19	0.84	3.01	2.53

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

The most desirable and significant SCA effects were obtained for earliness in the crosses; $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_8$, $P_2 \times P_3$, $P_2 \times P_4$, $P_2 \times P_8$, $P_3 \times P_6$, $P_4 \times P_5$, $P_4 \times P_7$ and $P_5 \times P_8$, for plant height, $P_1 \times P_2$, $P_3 \times P_4$, $P_5 \times P_7$ and $P_5 \times P_8$, for ear height, $P_1 \times P_2$, $P_3 \times P_7$, $P_5 \times P_7$ and $P_5 \times P_8$, for ear diameter, $P_1 \times P_4$, $P_3 \times P_7$ and $P_3 \times P_8$, for ear length, $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_3 \times P_8$, $P_5 \times P_6$ and $P_7 \times P_8$, for number. of rows per ear, $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$ and $P_4 \times P_7$, for number of kernels per row, $P_1 \times P_6$, $P_2 \times P_4$, $P_3 \times P_6$, and $P_7 \times P_8$ for grain yield.

$P_2 \times P_4$ and $P_3 \times P_6$ Crosses were the best desirable combination for improving earliness and grain yield, while crosses $P_1 \times P_6$, $P_2 \times P_4$ and $P_7 \times P_8$ were good combination for improving grain yield and its components in maize. General (GCA) and specific (SCA) combining abilities were highly significant for most traits, indicating that, additive and non-additive gene effects were important in controlling the studied traits.

Commonly, it might be concluded that, the most superior crosses for grain yield and its components were $P_1 \times P_6$, $P_2 \times P_7$, $P_3 \times P_6$, $P_5 \times P_6$ and $P_7 \times P_8$. Meanwhile, the crosses; $P_1 \times P_3$, $P_2 \times P_3$, $P_3 \times P_4$ and $P_4 \times P_5$ were promising for earliness and short stem. Inbred line P_4 showed desirable general combining ability effects for plant and ear heights. While, P_5 was a good combiner for earliness besides short stature and ear height. Line P_6 was a good combiner for ear diameter, ear length, number of rows per ear, number of kernels per row and grain yield. These lines with favorable alleles for grain yield and other studied traits might be utilized in developing new yellow maize hybrids(Amer, 2002 and Mousa *et al*, 2012).

D- Heterosis:

Standard Percent heterosis expressed by F_1 hybrids over the check hybrid SC166 for all studied traits over the two locations were presented in Table 5.

Table 5: Heterosis of 28 crosses for all studied traits combined over the two locations during 2013 season.

crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	No. of rows/ ear	No. of kernels/ row	Grain yield (ard fad^{-1})
P_1 x P_2	4.26**	-22.45**	-24.84**	-8.46*	-30.45**	-5.88	-37.92**	-35.20**
P_1 x P_3	-5.02**	1.36	2.55	-9.09	-8.04*	-6.20	-1.25	-15.65*
P_1 x P_4	-4.16**	0.68	-1.92	1.48	-1.93	-5.75	0.05	-20.26**
P_1 x P_5	-6.75**	0.68	-7.01	-3.38	-10.20**	-10.29**	-8.49*	2.83
P_1x P_6	-4.51**	7.14*	9.55*	3.17	3.57	-3.26	2.85	21.54**
P_1 x P_7	-7.25**	12.93**	12.10*	0.00	-7.28*	-0.51	-12.98**	7.92
P_1x P_8	-5.54**	2.72	5.10	-12.05**	-9.77**	-19.04**	-7.33	-22.20**
P_2 x P_3	-5.88**	-1.02	0.00	0.00	-6.16	2.04	-4.44	-24.22**
P_2 x P_4	-6.22**	-5.44	-7.64	0.21	-1.41	2.88	-0.16	-11.83
P_2 x P_5	-8.45**	2.04	-4.46	-2.75	-8.51*	-4.47	-6.57	-12.87
P_2 x P_6	-5.70**	2.38	3.18	4.65	-4.75	1.41	-6.22	-6.55
P_2 x P_7	-7.76**	14.29**	15.92**	4.65	-4.98	3.51	-5.28	0.05
P_2 x P_8	-5.36**	-0.34	4.45	-12.47**	-7.89*	-20.13**	-5.90	-34.35**
P_3 x P_4	4.60**	-17.34**	-10.19*	-16.70**	-27.91**	-11.63**	-41.62**	-73.47**
P_3 x P_5	-6.91**	0.68	-4.46	-3.81	-1.69	-6.07	-4.67	-17.77*
P_3 x P_6	-5.70**	4.42	7.64	2.11	-4.61	-1.28	-2.13	23.47**
P_3 x P_7	-6.75**	1.02	-3.19	4.86	-8.98*	4.92	-7.13	-11.31
P_3 x P_8	1.68*	-3.06	-3.82	-1.48	-5.78	-4.35	-9.58*	-46.04**
P_4 x P_5	-7.09**	-6.12	-12.74**	-9.09*	-8.98*	-4.92	-11.06*	-20.12**
P_4 x P_6	-2.10*	2.04	8.91	4.44	-3.48	2.81	-10.30*	-2.64
P_4 x P_7	-6.22**	3.40	-0.64	0.00	-5.55	2.56	-2.50	-11.26
P_4 x P_8	-1.07	0.68	5.10	-4.86	-11.37**	-5.88	-6.99	-26.81**
P_5 x P_6	-6.75**	1.02	-0.64	-0.63	-5.64	5.62	0.79	0.38
P_5 x P_7	-7.94**	1.36	-10.83*	-8.46*	-15.41**	1.85	-10.13*	-7.49
P_5 x P_8	-8.29**	-6.46	-15.29**	-12.26**	-7.99*	-11.18**	-6.69	-14.42
P_6 x P_7	-4.85**	10.55**	17.83**	-0.63	-5.08	7.99	-13.23**	-2.73
P_6 x P_8	-1.94*	9.86**	21.64**	-1.90	-5.64	-1.60	-0.79	-0.19
P_7 x P_8	-6.39**	6.47	6.36	-1.06	-9.96**	1.79	-6.34	7.02
LSD .05	1.64	6.49	9.41	7.40	6.81	6.52	8.47	14.47
LSD .01	2.17	8.59	12.47	9.94	9.07	8.63	11.22	19.18

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Days to 50% silking, determine the earliness or lateness of a hybrid. Negative heterosis is desirable for this trait. Significant negative heterosis for days to 50% silking recorded in most tested hybrids. Negative heterosis is also desirable for plant and ear heights which helps for developing short plants with less lodging. Two crosses showed significant negative heterosis for both traits. These were $P_1 \times P_2$ and $P_3 \times P_4$. While, $P_1 \times P_7$, $P_2 \times P_7$, $P_6 \times P_7$ and $P_6 \times P_8$ crosses showed maximum positive heterosis for plant and ear height. Literature regarding maize traits heterosis had presented by Singh (1979), for earliness associated with days to 50% silking and the shorter plants with low ear height are associated with resistance to lodging.

Among the 28 F_1s, two crosses; $P_1 \times P_6$ and $P_3 \times P_6$ (21.54% - 23.47%), respectively, exhibited significant positive heterosis for grain yield. Appreciable percentage of heterosis had reported by Alam *et al*; 2008, Mousa *et al.* 2012, El-Badawy, 2013 and Amiruzzaman *et al*,2013 for grain yield.

From the study, it might be concluded that, parents having good combining for yield were P_1 , P_6 and P_5 and P_7 for earliness, P_2, P_4 and P_5 for short plant and low ear height P_6 is a good combiner for the other studied traits. These parents might be used as donor for obtaining high yielding with desirable traits hybrids. Also, the results of this recent study proved the incidence of both additive and non-additive gene effects in grain yield and other studied traits. The cross combinations $P_1 \times P_6$ and $P_3 \times P_6$ that showed significant positive SCA effects coupled with excellent heterosis for grain yield, might be used for commercial hybrid development.

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الملخص العربى

قوة الهجين والقدرة على التآلف للمحصول ومكوناته من خلال تحليل الهجن التبادلية في الذرة الشامية

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تم اجراء جميع الهجن الممكنة(في اتجاه واحد) بين ثمانية سلالات جديدة من الذرة الشامية الصفراء والتي تم عزلها من عشائر مختلفة من الذرة الشامية وذلك بمزرعة كلية الزراعة بشبين الكوم (جامعة المنوفية) في الموسم الزراعي ٢٠١٢. تم تقييم هجن الجيل الأول وعددها ٢٨ هجين مع صنف تجارى للمقارنة هو (هجين فردى ١٦٦) في تجربة ذات تصميم قطاعات كاملة العشوائية في ثلاث مكررات أقيمت في مزرعة كلية الزراعة بشبين الكوم- جامعة المنوفية ومزرعة كلية الزراعة بجامعة الإسكندرية في الموسم الزراعي ٢٠١٣ حيث تم دراسة الصفات التالية: عدد الأيام حتى طرد ٥٠% من النورة المؤنثة، طول النبات، ارتفاع الكوز، قطر الكوز، عدد صفوف الكوز، عدد الحبوب بالصف، المحصول بالأردب/فدان.

وتتلخص اهم النتائج فيما يلي:

١- أظهرت النتائج وجود اختلافات عالية المعنوية بالنسبة لكل من القدرة العامة والخاصة على التآلف لكل الصفات المدروسة.

٢- تشير النتائج الى ان السلالات الأبوية P_1, P_6, P_7 كانت افضل السلالات من حيث تأثيرات القدرة العامة على التالف لصفة المحصول والسلالتين P_5, P_7 لصفة التبكير، بينما كانت السلالة الأبوية P_4 لقصر طول النبات وانخفاض موقع الكوز.

٣- تشير نتائج القدرة الخاصة على التآلف ان الهجن $P_7 \times P_8, P_3 \times P_6, P_2 \times P_4, P_1 \times P_6$ قد أظهرت قدرة خاصة عالية المعنوية لصفة محصول الحبوب وكذلك الهجين $P_1 \times P_2, P_5 \times P_7, P_5 \times P_8$ لكل من صفتي قصر النبات وانخفاض موقع الكوز ثم الهجينين $P_2 \times P_4 , P_3 \times P_6$ لصفة التبكير في النضج.

٤- أوضحت النتائج ان الهجينين $P_1 \times P_6 , P_3 \times P_6$ سجلا اعلى قوة هجين لصفه المحصول، وان سته هجن كانت معنوية وسالبة لصفة التبكير، كما ان الهجينين $P_1 \times P_2 , P_3 \times P_4$ سجلا اعلى قوة هجين سالبة لصفتي قصر النبات وانخفاض موقع الكوز. هذا ويمكن إدخال تلك الهجن المبشرة في مراحل التقييم المختلفة لإطلاقها كهجن تجارية جديدة مستقبلا.