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COMBINING ABILITY OF SOME YELLOW MAIZE INBRED LINES UNDER TWO SOWING DATES

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ABSTRACT

A half diallel cross among eight yellow inbred lines of maize was made in 2017 growing season. The resulted 28 F_1 crosses along with the check hybrid SC166 were evaluated under two sowing dates, i.e. 15^th^ May (normal sowing date) and 1^st^ July (late sowing date) using a randomized complete block design (RCBD) **with three** ***replications at the Experimental Farm, Faculty of Agriculture, Kafrelsheikh University in 2018 growing season, to estimate general (GCA) and specific (SCA) combining ability effects as well as to identify type of gene action controlling the inheritance of the studied traits. Data were taken on days to 50% silking, plant height, ear height, ear length, ear diameter, No. of rows/ear, No. of kernels/row and grain yield/plant. The results showed that, the mean squares due to genotypes (G) and crosses (C) were significant for all the studied traits. Moreover, general (GCA) and specific (SCA) combining ability mean squares were highly significant for all the studied traits under both sowing dates. The non-additive gene action played an important role in the inheritance of most studied traits under the two sowing dates. The inbred lines P_3 and P_5 showed the best desirable GCA effects for earliness and P_1 and P_2 for shortness and low ear placement. Whereas, the inbred lines P_4, P_5 and P_6 were the best general combiners for grain yield under the two sowing dates. The crosses $P_1 \times P_5$, $P_2 \times P_4$, $P_2 \times P_7$, $P_3 \times P_6$, $P_3 \times P_8$, $P_4 \times P_5$, $P_4 \times P_7$ and $P_7 \times P_8$ had the best SCA effects for grain yield/plant as well as one or more of its components under both sowing dates. The two crosses $P_2 \times P_7$ and $P_4 \times P_6$ had significant and positive superiority over the check hybrid SC 166 under both sowing dates. Therefore, these crosses could be released as commercial hybrids after further evaluation.***

Key words: ***Maize, Sowing dates, Combining ability, Gene action.***

INTRODUCTION

Maize (*Zea mays* L.) is one of the main cereal crops worldwide. The local production of maize is not sufficient to the local consumption in Egypt. Therefore, there is an urgent need to increase its productivity in order to reduce the amount of imported yellow maize grains used for poultry and animal feeding (El-Refaey *et al* 2018). The development of superior hybrids could contribute to the improvement of maize productivity. The genetic parameters general (GCA) and specific (SCA) combining ability are necessary for selection of suitable inbred lines for hybridization and identification of promising hybrids. Different investigators estimated GCA effects for parents and SCA effects for crosses in maize among them Badu-Apraku and Oyekunle (2012), Mousa *et al* (2012), Katta *et al* (2013), Abd El Mottalb and Gamea (2014) and El-Hosary *et al* (2018).The GCA and SCA provide a simple approach to predict additive and non-additive effects, respectively. The additive gene effects have been reported to be important in the inheritance of maize grain yield (Abd El-Mottalb *et al* 2013, Abo El-Haress 2015 and El-Hosary *et al* 2018). However, other researchers reported that the non-additive genetic effects were represented the major role in the genetic expression of maize grain yield and most of its components (Estakhr and Heidari 2012, Abdel-Moneam *et al* 2014, Attia *et al* 2015, Kamara, 2015 and Wani *et al* 2017). There is no agreement among the researchers on the type of gene action controlling the inheritance of maize grain yield or its related traits.

Testing the genetic materials under different environments is valuable to select the high yielding maize hybrids (Murtadha *et al* 2018). Sowing date is one of important factors in maize cultivation (Hefny 2010). In Egypt, Maize is sown successfully from (15 May to 15 June) as optimum period for high production, and grain yield significantly declined after that date (Ahmed 2013). In this concern, El-Shouny *et al* (2005), El-Hosary and El-Gammaal (2013), El-Hosary (2014) and Kamara (2016) found that in most cases the mean values of grain yield and its components were higher under normal sowing date compared with those under late sowing date. The optimum sowing date which gives the highest estimates of genetic components is the best for practicing selection (Abd El-Aty *et al* 2014).

The main objectives of the present study were: (1) to estimate general (GCA) and specific (SCA) combining ability effects under normal and late sowing dates, (2) to determine type of gene action controlling the inheritance of the studied traits and (3) to identify the promising inbred lines and F_1 crosses to be used in maize breeding programs.

MATERIALS AND METHODS

Plant materials

Eight yellow inbred lines of maize (*Zea mays* L.) were used as parents in this study. Four of them namely; CML217 (P_1), CML223 (P_2) CML224 (P_3) and CML225 (P_4) were introduced from CIMMYT. The remaining four inbred lines; Inb. 205 (P_5), Inb. 213 (P_6), Inb. 200 (P_7) and Inb. 202 (P_8) were obtained from Maize Res. Dep., Field Crops Res. Inst., ARC, Egypt.

Field experiments

In 2017 season, a half diallel set of crosses excluding reciprocals was made among the eight inbred lines giving a total of 28 F_1 crosses. In 2018 season, two adjacent experiments were undertaken in two different sowing dates, *i.e.* 15^{th} May (normal or recommended sowing date) and 1^{st} July (late sowing date) at the Experimental Farm, Faculty of Agriculture, Kafrelsheikh University, Egypt. Each experiment included the 28 F_1 crosses along with the commercial check hybrid SC166. The experimental design was randomized complete block design (RCBD) with three replications. Each plot consisted of two ridges of five meters length and 70 cm width. The hills were spaced at 25 cm with two kernels per hill on one side of the ridge. The seedlings were thinned to one plant per hill. The other cultural practices were followed as usual for ordinary maize field in the area.

Data were collected for days to 50% silking (day), plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows/ear, number of kernels/row and grain yield/plant (g) adjusted at 15.5% grain moisture content. The obtained data were statistically analyzed for the analysis of variance according to Steel and Torrie (1980). Superiority of grain yield/plant was calculated for individual crosses as the percentage deviation of F_1 mean performance from the check hybrid SC166 average value. General and specific combining ability were estimated according to Griffing (1956), method-4, model-1.

RESULTS AND DISCUSSION

Analysis of variance

Genotypes (G) and crosses (C) mean squares were found to be highly significant for all the studied traits under the two sowing dates (Table 1), indicating a wide diversity among the genetic materials used in the present study. This result corroborates with the findings of Abo El-Haress (2015), Sadek *et al* (2017) and El-Hosary *et al* (2018). They found significant differences among the F_1 hybrids for the different characters in maize. Mean squares due to crosses *vs.* check were significant for ear height at normal sowing date (SD1), ear diameter at late sowing date (SD2) and ear length, No. of rows/ear, No. of kernels/row and grain yield/plant at both sowing dates.

Mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all the studied traits under both sowing dates (Table 1), indicating that both additive and non-additive types of gene action were important in the inheritance of these traits. These results are in general agreement with those previously reported by Makumbi *et al* (2011), Abd El Mottalb *et al* (2013), Mousa (2014) and Sadek *et al* (2017).

To determine the genetic effects of greater importance, GCA/SCA ratio was computed. The GCA/SCA ratio was less than unity for all the studied traits, except No. of rows/ear under normal sowing date (SD1), days to 50% silking and ear height under late sowing date (SD2) and plant height under both sowing dates. These results indicated that these traits were predominantly controlled by the non-additive gene action.

Table 1. Mean squares from ordinary and combining ability analysis of variance for all the studied traits under the two sowing dates.

SOV	df	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ear length (cm)	
		SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
Genotypes (G)	28	21.29**	18.74**	2563.89**	1621.90**	358.80**	346.57**	13.75**	13.43**
F_1 Crosses (C)	27	22.08**	19.19**	2655.02**	1681.91**	361.11**	351.64**	14.00**	13.62**
GCA	7	20.54**	22.05**	3618.55**	1900.48**	344.61**	435.08**	10.73**	6.17**
SCA	20	22.62**	18.19**	2317.78**	1605.42**	366.89**	322.44**	15.14**	16.23**
C *vs.* Check	1	0.03	6.36	103.52	1.50	296.31*	209.45	7.12**	8.27**
Error	56	1.35	1.76	85.47	105.20	49.79	55.17	0.76	0.86
GCA/SCA		0.91	1.21	1.56	1.18	0.94	1.35	0.71	0.38
SOV	df	Ear diameter (cm)		No. of rows/ear		No. of kernels/row		Grain yield/plant (g)	
		SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
Genotypes (G)	28	0.19**	0.24**	5.48**	5.44**	54.21**	58.06**	2092.54**	1666.84**
F_1 Crosses (C)	27	0.19**	0.24**	5.68**	5.57**	54.50**	57.89**	2092.51**	1678.40**
GCA	7	0.17**	0.23**	6.06**	3.32**	52.31**	34.79**	1485.16**	981.50**
SCA	20	0.20**	0.25**	5.54**	6.36**	55.26**	65.98**	2305.08**	1922.31**
C *vs.* Check	1	0.19	0.28*	0.33	1.89	46.51**	62.76**	2093.43**	1354.77**
Error	56	0.06	0.07	0.78	0.49	2.21	3.45	86.38	104.31
GCA/SCA		0.88	0.90	1.1	0.52	0.95	0.53	0.64	0.51

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
SD1= normal or recommended sowing date and SD2 = late sowing date.

These findings are in agreement with those of Mosa (2010), El-Badawy (2013), Katta *et al* (2013), El-Hosary (2014) and Wani *et al* (2017). For the exceptional traits, the ratio of GCA/GCA was more than unity, indicating the preponderance of the additive gene action in controlling the inheritance of these traits. Similarly, Abo El-Haress (2015), Sadek *et al* (2017) and El-Refaey *et al* (2018) recorded predominance of the additive gene effects in controlling the inheritance of days to 50% silking and plant height.

Mean performance

Mean performance of the 28 F_1 crosses and the check hybrid SC166 for all the studied traits under the two sowing dates are presented in Table (2). Generally, the mean values of the 28 F_1 crosses and the check SC166 were higher under normal or recommended sowing date (SD1) than those in late one (SD2) for all the studied traits. The increase of mean values in normal sowing date may be due to the prevailed favorable temperature and day length which led to better vegetative growth, yield and its components of maize plants. Therefore, normal sowing date seemed to be non-stress environment. These results are in good agreement with those reported by El-Shouny *et al* (2005), Ahmed (2013), Abd El-Aty *et al* (2014), El-Hosary (2014) and Kamara (2016).

Table 2. Mean performance of the 28 F_1 crosses and the check hybrid SC166 for all the studied traits under the two sowing dates as well as superiority percentage relative to the check hybrid SC166 for grain yield/plant.

Cross	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ear length (cm)	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
$P_1 \times P_2$	60.5	57.7	233.3	221.3	125.7	118.6	17.3	15.2
$P_1 \times P_3$	67.3	63.0	227.0	209.3	122.9	110.0	15.0	14.4
$P_1 \times P_4$	68.5	65.3	195.3	184.3	116.8	107.7	18.8	14.0
$P_1 \times P_5$	65.3	59.8	277.0	258.0	141.0	129.8	21.8	18.2
$P_1 \times P_6$	63.5	60.0	225.8	211.8	127.8	120.8	17.5	17.0
$P_1 \times P_7$	65.3	64.0	220.8	193.0	125.5	108.6	21.6	19.5
$P_1 \times P_8$	66.7	63.3	218.3	203.0	123.8	113.3	18.2	15.6
$P_2 \times P_3$	63.5	60.0	187.0	173.0	109.5	100.2	17.2	15.2
$P_2 \times P_4$	65.5	65.0	270.7	231.8	147.3	132.6	20.4	18.9
$P_2 \times P_5$	63.5	62.0	286.3	223.0	127.7	115.6	17.4	15.6
$P_2 \times P_6$	69.0	64.0	218.3	203.0	108.3	104.5	17.9	13.6
$P_2 \times P_7$	68.3	66.5	223.8	214.3	126.5	120.0	22.5	19.9
$P_2 \times P_8$	71.0	65.0	220.0	181.8	140.8	128.2	21.2	18.0
$P_3 \times P_4$	62.6	61.5	262.0	246.8	140.8	135.8	17.6	16.0
$P_3 \times P_5$	59.5	56.5	277.5	253.0	138.3	128.3	20.9	19.0
$P_3 \times P_6$	61.5	59.0	260.8	235.5	146.5	137.0	19.8	19.0
$P_3 \times P_7$	63.0	59.0	240.8	216.3	143.0	135.6	16.6	16.0
$P_3 \times P_8$	65.3	58.5	275.6	248.0	133.3	125.5	18.6	16.4
$P_4 \times P_5$	66.7	61.5	278.7	230.0	130.2	123.3	22.4	21.8
$P_4 \times P_6$	66.0	60.5	265.1	221.8	133.0	127.0	22.0	19.5
$P_4 \times P_7$	64.8	58.5	245.3	219.2	133.3	122.8	16.8	14.2
$P_4 \times P_8$	66.0	61.5	252.8	233.0	148.3	138.0	17.4	15.6
$P_5 \times P_6$	63.5	61.3	300.3	254.3	143.3	128.9	20.2	16.6
$P_5 \times P_7$	68.7	62.7	235.8	218.0	128.2	114.5	18.5	16.5
$P_5 \times P_8$	65.3	63.0	197.0	188.0	122.7	117.0	16.5	14.5
$P_6 \times P_7$	68.0	63.3	219.5	193.8	136.5	125.6	18.2	14.6
$P_6 \times P_8$	65.3	60.3	267.5	253.0	148.7	139.2	16.2	15.8
$P_7 \times P_8$	62.3	59.7	249.5	221.8	128.7	110.3	16.0	14.8
Crosses	65.2	61.5	244.0	219.3	132.1	122.1	18.7	16.6
Check SC166	65.3	63.0	238.0	220.0	142.2	130.6	20.3	18.3
LSD 0.05	1.9	2.2	15.1	16.8	11.5	12.1	1.4	1.5
LSD 0.01	2.5	2.9	20.1	22.3	15.4	16.2	1.9	2.0

Table 2. Cont.

Cross	Ear diameter (cm)		No. of rows/ear		No. of kernels/row		Grain yield/plant (g)		Superiority% relative to SC166 for grain yield/plant	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
P_1×P_2	5.2	4.7	15.1	13.3	39.6	34.7	117.8	107.9	-29.6**	-26.6**
P_1×P_3	4.5	4.1	14.2	13.3	36.4	31.9	113.8	101.3	-32.1**	-31.1**
P_1×P_4	4.5	3.9	13.2	11.5	40.3	31.0	127.8	120.5	-23.7**	-18.0**
P_1×P_5	4.3	3.9	16.8	15.5	37.1	32.8	180.8	158.7	8.0	7.9
P_1×P_6	4.6	4.3	13.7	12.3	36.7	31.0	143.9	115.3	-14.1**	-21.6**
P_1×P_7	4.8	4.3	15.3	13.3	39.5	33.2	123.7	107.9	-26.1**	-26.6**
P_1×P_8	4.3	3.7	13.3	12.3	30.6	26.5	128.7	113.2	-23.2**	-23.0**
P_2×P_3	4.7	4.1	16.0	14.2	31.6	27.0	101.7	83.3	-39.3**	-43.4**
P_2×P_4	4.5	4.3	16.9	15.9	41.9	37.0	178.9	153.8	6.9	4.6
P_2×P_5	4.6	4.3	13.5	12.0	34.2	32.3	125.8	109.5	-24.8**	-25.5**
P_2×P_6	4.6	3.9	14.7	11.0	39.2	30.3	159.4	138.3	-4.8	-5.9
P_2×P_7	5.3	4.8	18.0	16.7	45.8	42.7	184.8	167.3	10.4*	13.8*
P_2×P_8	4.5	4.3	13.0	11.3	38.2	32.3	119.3	116.3	-28.7**	-20.9**
P_3×P_4	4.8	4.6	16.0	13.3	30.8	29.5	122.5	113.8	-26.8**	-22.6**
P_3×P_5	5.0	4.5	15.0	13.0	36.5	33.3	140.5	130.9	-16.1**	-11.0
P_3×P_6	4.8	4.7	16.3	14.0	40.2	40.8	173.1	143.9	3.4	-2.1
P_3×P_7	5.2	4.5	15.8	13.8	36.2	27.9	124.6	118.2	-25.6**	-19.6**
P_3×P_8	4.9	4.3	15.7	14.0	43.8	38.0	167.3	159.7	-0.1	8.6
P_4×P_5	5.0	4.5	13.7	13.2	45.4	41.3	179.7	160.4	7.3	9.1
P_4×P_6	4.7	4.3	16.2	15.0	44.9	40.8	183.0	163.9	9.3*	11.5*
P_4×P_7	4.7	3.9	13.0	12.4	37.8	34.3	112.3	103.3	-32.9**	-29.8**
P_4×P_8	4.9	4.0	14.4	12.8	39.5	30.3	126.5	119.2	-24.4**	-18.9**
P_5×P_6	4.9	4.3	13.3	12.7	37.2	29.3	159.3	149.7	-4.9	1.8
P_5×P_7	4.5	4.3	15.3	14.0	40.2	34.5	151.7	123.7	-9.4*	-15.9**
P_5×P_8	4.8	4.5	13.7	13.0	30.1	27.5	116.7	105.0	-30.3**	-28.6**
P_6×P_7	4.7	4.3	14.3	13.0	40.7	31.8	121.5	107.0	-27.4**	-27.2**
P_6×P_8	4.7	4.1	13.7	12.7	35.0	32.0	104.4	88.7	-37.6**	-39.7**
P_7×P_8	4.9	4.7	16.0	15.3	40.0	34.1	145.8	130.1	-12.9**	-11.5*
Crosses mean	4.7	4.3	14.9	13.4	38.2	33.1	140.5	125.4	-	-
Check SC166	5.0	4.6	15.2	14.2	42.2	37.8	167.4	147.0	-	-
LSD 0.05	0.4	0.4	1.4	1.1	2.4	3.0	15.2	16.7	-	-
LSD 0.01	0.5	0.6	1.9	1.5	3.2	4.0	20.2	22.2	-	-

Where; SD1= normal or recommended sowing date and SD2 = late sowing date.
*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Concerning the performance of the F_1 crosses in comparison with the check hybrid SC166, data in Table 2 showed that, the crosses P_3×P_4 at normal sowing date (SD1), P_1×P_5, P_1×P_6, P_2×P_3, P_3×P_8, P_4×P_6 and P_6×P_8 at late sowing date (SD2) and P_1×P_2, P_3×P_5, P_3×P_6, P_3×P_7 and P_7×P_8 under both sowing dates were found to be significantly earlier than the check hybrid SC166. Earliness in maize is favorable for saving water irrigation and escaping destructive injuries caused by the stem corn borers (El-Hosary 2014). The eight crosses P_1×P_4, P_1×P_7, P_1×P_8, P_2×P_3, P_2×P_6, P_2×P_8, P_5×P_8 and P_6×P_7 under the two sowing dates were significantly shorter than the check hybrid SC166. As for ear height, the crosses P_1×P_2 and P_2×P_7 under normal sowing date (SD1), P_2×P_5, P_5×P_7 and P_7×P_8 under late sowing date (SD2) and P_1×P_3, P_1×P_4, P_1×P_7, P_1×P_8, P_2×P_3, P_2×P_6 and P_5×P_8 under both sowing dates had significantly lower ear placement than the check hybrid SC166. Concerning ear length, the crosses P_1×P_5 and P_4×P_6 at normal sowing date (SD1) and P_2×P_7 and P_4×P_5 under the two sowing dates significantly surpassed the check hybrid SC166. Regarding ear diameter, none of the crosses significantly surpassed the check hybrid SC166. Meanwhile, the two crosses P_1×P_2 and P_2×P_7 did not differ significantly from the check hybrid SC166. The three crosses P_1×P_5, P_2×P_4 and P_2×P_7 under both sowing dates gave the highest mean value for No. of rows/ear and significantly surpassed the check hybrid SC166. The four crosses P_1×P_5, P_2×P_7, P_4×P_5 and P_4×P_6 under both sowing dates possessed higher No. of kernels/row than the check hybrid SC166. Superiority percentage for grain yield/plant relative to the check hybrid SC166 (Table 2) revealed that the two crosses P_2×P_7 and P_4×P_6 under both sowing dates had positive and significant superiority percentage over the check hybrid SC166. Moreover, the four crosses P_1×P_5, P_2×P_4, P_3×P_6 and P_4×P_5 gave positive superiority percentage over the check hybrid SC166 under the two sowing dates, but it was not significant. Therefore, it could be concluded that these crosses offer possibility for improving grain yield of maize. These results are in harmony with those reported by El-Ghonemy (2015), Sadek *et al* (2017) and El-Hosary *et al* (2018). They found positive and significant superiority percentages compared to the check hybrids for maize grain yield.

General combining ability (GCA) effects

Estimates of general combining ability ($\hat{g}_i$) effects of the eight inbred lines under the two sowing dates are presented in Table (3). High positive values of ($\hat{g}_i$) effects would be of interest from the breeder point of view for all the studied traits, except days to 50% silking, plant and ear heights, where high negative values would be favored. The parental inbred line P_1 showed highly significant and negative ($\hat{g}_i$) effects for plant and ear heights under both

Table 3. General combining ability ($\hat{g}_i$) effects of the eight inbred lines for all the studied traits under the two sowing dates.

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ear length (cm)	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
P_1	0.09	0.42	-18.42**	-9.03**	-6.85**	-7.65**	-0.15	-0.41*
P_2	0.78**	1.59**	-11.43**	-14.48**	-6.47**	-5.83**	0.46*	0.01
P_3	-2.31**	-2.19**	3.79	7.83**	1.62	2.95	-0.90**	-0.06
P_4	0.57*	0.53	10.34**	5.30*	4.18**	5.42**	0.71**	0.61**
P_5	-0.69**	-0.63*	24.12**	14.88**	1.13	0.45	1.10**	0.98**
P_6	0.03	-0.35	8.22**	6.35**	3.25*	4.72**	0.11	-0.04
P_7	0.64*	0.51	-12.09**	-9.77**	-0.48	-2.88	-0.15	-0.14
P_8	0.89**	0.12	-4.53*	-1.08	3.62*	2.80	-1.17**	-0.94**
LSD (0.05) gi	0.51	0.58	4.05	4.50	3.09	3.26	0.38	0.41
LSD (0.01) gi	0.68	0.77	5.38	5.97	4.10	4.32	0.51	0.54
LSD (0.05) gi-gj	0.77	0.88	6.13	6.80	4.68	4.92	0.58	0.62
LSD (0.01) gi-gj	1.02	1.17	8.13	9.02	6.20	6.53	0.77	0.82
Inbred line	Ear diameter (cm)		No. of rows/ear		No. of kernels/row		Grain yield/plant (g)	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
P_1	-0.17**	-0.19**	-0.40*	-0.35*	-1.19**	-1.83**	-7.90**	-8.80**
P_2	0.03	0.06	0.52**	0.12	0.53	0.71	0.65	-0.21
P_3	0.11*	0.13*	0.83**	0.33*	-1.98**	-0.61	-6.73**	-4.44
P_4	-0.02	-0.09	-0.12	0.07	2.21**	2.03**	7.82**	9.54**
P_5	-0.02	0.05	-0.45*	-0.07	-1.11**	-0.17	11.78**	10.04**
P_6	-0.04	-0.02	-0.32	-0.51**	1.09**	0.66	10.12**	4.85*
P_7	0.15**	0.13*	0.63**	0.79**	2.14**	1.08**	-3.23	-3.38
P_8	-0.04	-0.07	-0.71**	-0.38*	-1.69**	-1.89**	-12.52**	-7.60**
LSD (0.05) gi	0.11	0.12	0.39	0.31	0.65	0.81	4.08	4.48
LSD (0.01) gi	0.14	0.15	0.51	0.41	0.86	1.08	5.41	5.94
LSD (0.05) gi-gj	0.16	0.17	0.59	0.46	0.98	1.23	6.16	6.77
LSD (0.01) gi-gj	0.21	0.23	0.78	0.61	1.31	1.63	8.17	8.98

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
SD1= normal or recommended sowing date and SD2 = late sowing date.

sowing dates. However, it gave significant undesirable or insignificant ($\hat{g}_i$) effects for other traits. The parental inbred line P_2 gave highly significant and negative ($\hat{g}_i$) effects for plant and ear heights under both sowing dates as well as showed highly significant and positive ($\hat{g}_i$) effects for ear length and No. of rows/ear under normal sowing date (SD1). The parental inbred line P_3 exhibited the highest significant and negative ($\hat{g}_i$) effects for days to 50% silking, indicating that this inbred line could be considered as a good combiner for earliness. Also, it gave significant and positive ($\hat{g}_i$) effects for ear diameter and No. of rows/ear under the two sowing dates. The parental inbred line P_4 seemed to be suitable combiner for ear length, No. of kernels/row and grain yield/plant under both sowing dates, due to its positive and highly significant ($\hat{g}_i$) values in this concern. The parental inbred line P_5 expressed highly significant and negative ($\hat{g}_i$) effects for days to 50% silking and showed highly significant and positive ($\hat{g}_i$) effects for ear length and grain yield/plant under both sowing dates. The parental inbred line P_6 recorded highly significant and positive ($\hat{g}_i$) effects for No. of kernels/row under normal sowing date (SD1) and grain yield/plant under both sowing dates. However, it gave significant undesirable or non-significant ($\hat{g}_i$) effects for other traits. The parental inbred line P_7 expressed highly significant and negative ($\hat{g}_i$) effects for plant height and showed significant and positive ($\hat{g}_i$) effects for ear diameter, No. of rows/ear and No. of kernels/row under both sowing dates. The parental inbred line P_8 was marked as bad combiner under both sowing dates, since it had either significant undesirable or non-significant ($\hat{g}_i$) effects for all the studied traits. From the obtained results, it could be concluded that, the best combiners under both sowing dates were the inbred lines P_3 and P_5 for earliness, P_1, P_2 and P_7 for short plants and low ear placement as well as P_4, P_5 and P_6 for grain yield and some of its components. Such results indicated that these inbred lines possess favorable genes and that improvement in respective traits may be attained if they are incorporated in maize hybridization program. Katta *et al* (2013), El-Shamarka *et al* (2015) and El-Hosary *et al* (2018) found desirable and significant ($\hat{g}_i$) effects for earliness, grain yield and its components.

Specific combining ability (SCA) effects

Estimates of specific combining ability ($\hat{s}_{ij}$) effects of the 28 F_1 crosses for all the studied traits under the two sowing dates are presented in Table (4).

Table 4. Estimates of specific combining ability ($\hat{S}_{ij}$) effects of the 28 F_1 crosses for all the studied traits under the two sowing dates.

Cross	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ear length (cm)	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
$P_1 \times P_2$	-5.60**	-5.87**	19.12**	25.57**	6.93*	9.98**	-1.74**	-1.02*
$P_1 \times P_3$	4.33**	3.25**	-2.35	-8.74	-3.95	-7.40*	-2.67**	-1.75**
$P_1 \times P_4$	2.60**	2.86**	-40.57**	-31.21**	-12.62**	-12.17**	-0.49	-2.82**
$P_1 \times P_5$	0.70	-1.48*	27.32**	32.87**	14.63**	14.90**	2.13**	1.01*
$P_1 \times P_6$	-1.85**	-1.59*	-8.03	-4.85	-0.69	1.63	-1.19**	0.83
$P_1 \times P_7$	-0.63	1.55*	7.28	-7.47	0.75	-2.97	3.18**	3.43**
$P_1 \times P_8$	0.45	1.27	-2.78	-6.17	-5.05	-3.95	0.79	0.33
$P_2 \times P_3$	-0.20	-0.92	-49.34**	-39.63**	-17.74**	-19.02**	-1.09*	-1.37**
$P_2 \times P_4$	-1.09	1.36*	27.81**	21.65**	17.50**	10.91**	0.49	1.66**
$P_2 \times P_5$	-1.82**	-0.48	29.65**	3.32	0.95	-1.12	-2.89**	-2.00**
$P_2 \times P_6$	2.95**	1.25	-22.52**	-8.15	-20.57**	-16.49**	-1.41**	-2.99**
$P_2 \times P_7$	1.68**	2.88**	3.29	19.22**	1.36	6.61	3.46**	3.41**
$P_2 \times P_8$	4.09**	1.77**	-8.02	-21.97**	11.56**	9.13*	3.18**	2.31**
$P_3 \times P_4$	-0.90	1.63*	3.89	14.35**	2.91	5.33	-0.94*	-1.17*
$P_3 \times P_5$	-2.73**	-2.20**	5.61	11.01*	3.46	2.80	1.98**	1.46**
$P_3 \times P_6$	-1.45*	0.02	4.76	2.04	9.55**	7.23*	1.86**	2.48**
$P_3 \times P_7$	-0.56	-0.84	5.07	-1.00	9.78**	13.43**	-1.07*	-0.42
$P_3 \times P_8$	1.52**	-0.95	32.36**	21.97**	-4.02	-2.35	1.94**	0.78
$P_4 \times P_5$	1.55**	0.08	0.23	-9.46	-7.20*	-4.67	1.86**	3.60**
$P_4 \times P_6$	0.16	-1.20	2.54	-9.18	-6.52	-5.24	2.44**	2.31**
$P_4 \times P_7$	-1.62**	-4.06**	3.07	4.36	-2.49	-1.84	-2.49**	-2.89**
$P_4 \times P_8$	-0.70	-0.67	3.02	9.50	8.41*	7.68*	-0.87*	-0.69
$P_5 \times P_6$	-1.07	0.80	24.01**	13.73**	6.83	1.63	0.26	-0.95*
$P_5 \times P_7$	3.48**	1.27	-20.26**	-6.39	-4.54	-5.17	-1.17**	-0.95*
$P_5 \times P_8$	-0.10	2.00**	-66.57**	-45.09**	-14.14**	-8.35*	-2.16**	-2.15**
$P_6 \times P_7$	2.09**	1.66*	-20.61**	-22.03**	1.65	1.66	-0.49	-1.84**
$P_6 \times P_8$	-0.82	-0.95	19.84**	28.44**	9.75**	9.58**	-1.47**	0.16
$P_7 \times P_8$	-4.44**	-2.48**	22.15**	13.32**	-6.52	-11.72**	-1.41**	-0.74
LSD 5% (s_{ij})	1.13	1.29	8.97	9.95	6.85	7.21	0.85	0.90
LSD 1% (s_{ij})	1.50	1.71	11.90	13.20	9.08	9.56	1.12	1.20
LSD 5% (s_{ij}-s_{ik})	1.72	1.97	13.71	15.21	10.46	11.01	1.29	1.38
LSD 1% (s_{ij}-s_{ik})	2.28	2.61	18.18	20.17	13.87	14.60	1.72	1.83
LSD 5% (s_{ij}-s_{kl})	1.54	1.76	12.26	13.60	9.36	9.85	1.16	1.23
LSD 1% (s_{ij}-s_{kl})	2.04	2.37	16.26	18.29	12.41	13.29	1.53	1.66

Table 4. Cont.

Cross	Ear diameter (cm)		No. of rows/ear		No. of kernels/row		Grain yield/plant (g)	
	SD1	SD2	SD1	SD2	SD1	SD2	SD1	SD2
$P_1 \times P_2$	0.60**	0.54**	0.11	0.17	2.07**	2.67**	-15.46**	-8.44
$P_1 \times P_3$	-0.19	-0.13	-1.10*	-0.04	1.37	1.15	-12.16**	-10.80*
$P_1 \times P_4$	-0.05	-0.11	-1.18**	-1.61**	1.09	-2.35*	-12.69**	-5.59
$P_1 \times P_5$	-0.25*	-0.25	2.83**	2.52**	1.21	1.65	36.41**	32.06**
$P_1 \times P_6$	0.06	0.22	-0.48	-0.20	-1.39	-0.98	1.10	-6.15
$P_1 \times P_7$	0.08	0.07	0.24	-0.51	0.36	0.80	-5.74	-5.27
$P_1 \times P_8$	-0.24*	-0.33*	-0.42	-0.33	-4.71**	-2.93**	8.53	4.19
$P_2 \times P_3$	-0.19	-0.38**	-0.22	0.39	-5.14**	-6.25**	-32.79**	-37.47**
$P_2 \times P_4$	-0.25*	0.04	1.63**	2.32**	0.97	1.11	29.91**	19.13**
$P_2 \times P_5$	-0.15	-0.10	-1.43**	-1.44**	-3.41**	-1.39	-27.14**	-25.70**
$P_2 \times P_6$	-0.14	-0.43**	-0.40	-2.00**	-0.61	-4.22**	8.05	8.32
$P_2 \times P_7$	0.38**	0.32*	1.98**	2.36**	4.94**	7.76**	46.79**	45.47**
$P_2 \times P_8$	-0.24*	0.02	-1.67**	-1.79**	1.17	0.33	-9.35*	-1.31
$P_3 \times P_4$	-0.04	0.27*	0.42	-0.46	-7.63**	-5.07**	-19.13**	-16.73**
$P_3 \times P_5$	0.16	0.04	-0.24	-0.66	1.39	0.93	-5.08	-0.07
$P_3 \times P_6$	-0.02	0.30*	0.95*	0.79*	2.89**	7.60**	29.15**	18.13**
$P_3 \times P_7$	0.20	-0.05	-0.50	-0.68*	-2.16**	-5.72**	-5.95	0.62
$P_3 \times P_8$	0.08	-0.05	0.68	0.66	9.27**	7.35**	45.96**	46.33**
$P_4 \times P_5$	0.30*	0.25*	-0.62	-0.22	6.11**	6.29**	19.53**	15.47**
$P_4 \times P_6$	0.01	0.12	1.77**	2.06**	3.41**	4.96**	24.52**	24.13**
$P_4 \times P_7$	-0.17	-0.43**	-2.38**	-1.85**	-4.74**	-1.96*	-32.80**	-28.28**
$P_4 \times P_8$	0.21	-0.13	0.36	-0.24	0.79	-2.99**	-9.34*	-8.12
$P_5 \times P_6$	0.21	-0.01	-0.79	-0.14	-0.98	-4.34**	-3.18	9.41
$P_5 \times P_7$	-0.37**	-0.16	0.29	-0.12	0.97	0.44	2.59	-8.36
$P_5 \times P_8$	0.11	0.24	-0.03	0.06	-5.29**	-3.59**	-23.12**	-22.81**
$P_6 \times P_7$	-0.15	-0.10	-0.88*	-0.67	-0.73	-3.09**	-25.93**	-19.87**
$P_6 \times P_8$	0.03	-0.10	-0.17	0.17	-2.59**	0.08	-33.72**	-33.96**
$P_7 \times P_8$	0.05	0.35**	1.25**	1.47**	1.36	1.76	21.04**	15.69**
LSD 5% (s_{ij})	0.23	0.25	0.86	0.68	1.44	1.80	9.02	9.91
LSD 1% (s_{ij})	0.31	0.33	1.14	0.90	1.91	2.39	11.96	13.15
LSD 5% ($s_{ij}-s_{ik}$)	0.36	0.39	1.31	1.03	2.20	2.75	13.78	15.14
LSD 1% ($s_{ij}-s_{ik}$)	0.47	0.51	1.74	1.37	2.92	3.65	18.27	20.08
LSD 5% ($s_{ij}-s_{kl}$)	0.32	0.34	1.17	0.93	1.97	2.46	12.32	13.54
LSD 1% ($s_{ij}-s_{kl}$)	0.42	0.47	1.55	1.25	2.61	3.32	16.34	18.28

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
SD1 = normal or recommended sowing date and SD2 = late sowing date.

Negative and significant estimates of ($\hat{S}_{ij}$) effects toward earliness were exhibited by the crosses $P_2 \times P_5$ under normal sowing date (SD1), $P_1 \times P_5$ under late sowing date (SD2) and $P_1 \times P_2$, $P_1 \times P_6$, $P_3 \times P_5$, $P_4 \times P_7$ and $P_7 \times P_8$ under both sowing dates. The crosses $P_2 \times P_6$ and $P_5 \times P_7$ under normal sowing date (SD1), $P_2 \times P_8$ under late sowing date (SD2) and $P_1 \times P_4$, $P_2 \times P_3$, $P_5 \times P_8$ and $P_6 \times P_7$ under both sowing dates showed significant and negative ($\hat{S}_{ij}$) effects for plant height towards short plants. Moreover, the crosses $P_4 \times P_5$ under normal sowing date (SD1), $P_1 \times P_3$ and $P_7 \times P_8$ under late sowing date (SD2) and $P_1 \times P_4$, $P_2 \times P_3$, $P_2 \times P_6$ and $P_5 \times P_8$ under both sowing dates exhibited negative and significant estimates toward low ear placement. Regarding to ear length, the crosses $P_3 \times P_8$ under normal sowing date (SD1), $P_2 \times P_4$ under late sowing date (SD2) and $P_1 \times P_5$, $P_1 \times P_7$, $P_2 \times P_7$, $P_2 \times P_8$, $P_3 \times P_5$, $P_3 \times P_6$, $P_4 \times P_5$ and $P_4 \times P_6$ under both sowing dates had positive and significant ($\hat{S}_{ij}$) effects. The crosses $P_1 \times P_2$, $P_2 \times P_7$ and $P_4 \times P_5$ under both sowing dates and $P_3 \times P_4$, $P_3 \times P_6$ and $P_7 \times P_8$ under late sowing date (SD2) had positive and significant ($\hat{S}_{ij}$) effects for ear diameter. Moreover, positive and significant ($\hat{S}_{ij}$) effects under both sowing dates were obtained by the crosses $P_1 \times P_5$, $P_2 \times P_4$, $P_2 \times P_7$, $P_3 \times P_6$, $P_4 \times P_6$ and $P_7 \times P_8$ for No. of rows/ear, $P_1 \times P_2$, $P_2 \times P_7$, $P_3 \times P_6$, $P_4 \times P_5$ and $P_4 \times P_6$ for No. of kernels/row and $P_1 \times P_5$, $P_2 \times P_4$, $P_2 \times P_7$, $P_3 \times P_6$, $P_3 \times P_8$, $P_4 \times P_5$, $P_4 \times P_7$ and $P_7 \times P_8$ for grain yield/plant. The previous crosses might be fruitful in future maize breeding programs as most of them involved at least one good combiner for the traits in view. It is worth noting that the two crosses $P_2 \times P_7$ and $P_4 \times P_6$ showed significant and positive SCA effects coupled with positive and significant superiority percentage over the check hybrid SC166 for grain yield, hence it might be used for commercial hybrid development after further evaluation.

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القدره على التآلف لبعض سلالات من الذرة الشامية الصفراء تحت ميعادين من الزراعة

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١. قسم المحاصيل- كلية الزراعة- جامعة كفر الشيخ- مصر

٢. قسم المحاصيل- كلية الزراعة- جامعة الزقازيق- مصر

تم إجراء التهجين النصف دائرى بين ثمانية سلا لات مرباه داخلياً من الذرة الشامية الصفراء فى موسم ٢٠١٧. تم تقيم ال٢٨ هجين فردى الناتجة بالإضافة الى هجين المقارنة (هجين فردى ١٦٦) فى تصميم القطاعات الكاملة العشوائية بثلاث مكررات تحت ميعادين من الزراعة بمزرعة كلية الزراعة – جامعة كفر الشيخ فى موسم ٢٠١٨. وذلك لتقدير تأثيرات القدرة العامة والخاصة على التآلف ولتحديد الفعل الجينى المتحكم فى وراثة الصفات تحت الدراسة. تم دراسة الصفات التالية: عدد الأيام حتي ظهور ٥٠% من الحراير، إرتفاع النبات، إرتفاع الكوز، طول الكوز، قطر الكوز، عدد الصفوف/كوز، عدد الحبوب/صف ومحصول الحبوب/النبات. أظهرت النتائج أن التباين الراجع لكل من التراكيب الوراثية والهجن كان معنوياً لجميع الصفات تحت الدراسة. كان التباين الراجع للقدرة العامة والخاصة على التآلف معنوياً لجميع الصفات تحت الدراسة فى كلا الميعادين. كان الفعل الجينى غير المضيف هو الاكثر اهمية فى وراثة معظم الصفات تحت الدراسة فى كلا الميعادين. أظهرت السلالات الأبوية P_3 و P_5 أفضل القيم لتأثيرات القدرة العامة على الائتلاف للتبكير والسلالات P_1 و P_2 لقصر إرتفاع النبات وإنخفاض موقع الكوز بينما أظهرت السلالات P_4 و P_5 و P_6 قدرة عامة جيدة على التآلف لصفة محصول الحبوب/ النبات. كانت أفضل الهجن فى تأثيرات القدرة الخاصة على التآلف هى هجن $P_1×P_5$، $P_2×P_4$، $P_2×P_7$، $P_3×P_6$، $P_3×P_8$، $P_4×P_5$ و $P_7×P_8$ لصفة محصول الحبوب وواحد أو أكثر من مكوناتة فى كلا الميعادين. تفوق محصول الهجينان $P_2×P_7$ و $P_4×P_6$ تفوقاً معنوياً على محصول هجين المقارنة (هجين فردى ١٦٦) فى كلا الميعادين ومن ثم فإن هذه الهجن تعتبر مبشرة ويمكن إدخالها فى مراحل التقييم المختلفة تمهيدا لاطلاقها كهجن تجارية مستقبلا .

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