Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Estimation of Heterosis and Combining Ability for some White Maize Inbred Lines Using Half-Diallel Crossing

Cross Mark

Abd El-Zaher, I. N.*

Agron. Dept., Fac. of Agric., Al-Azhar Univ., Assiut Branch

ABSTRACT

Eight S_7 white maize inbred lines were derived from selfing of S_5 inbred lines of two populations, i.e., Giza-2 and IW-469 were chosen to be used as parents of a half-diallel crossing and obtained on 28 F_1 crosses, which evaluated along with the 2 check hybrids at Experimental Farm, Faculty of Agriculture, Al-Azhar University, Assiut Branch in 2021 to identify the best parental general combiners and specific combinations to improve maize for earliness and yield. Results manifested that highly significant differences were detected among crosses for all the studied traits. Also, means squares due to GCA and SCA were highly significant for all traits. The ratio of σ^2GCA/σ^2SCA was less than one for all traits. The 4 crosses; P_1 x P_4, P_3 x P_6, P_5 x P_6 and P_7 x P_8 possessed desirable significant positive heterotic effects for increasing grain yield/plant relative to the checks SC-136 and SC-10, and among them the cross P_3 x P_6, also possessed significant negative desirable standard heterotic effects for tasseling and silking earliness relative to both the check hybrids. The parent P_8 possessed significant desirable GCA effects for grain yield and its components with silking earliness. The 14 crosses; $P_1 \times P_2$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_8$, $P_2 \times P_3$, $P_2 \times P_8$, $P_3 \times P_4$, $P_3 \times P_6$, $P_3 \times P_7$, $P_3 \times P_8$, $P_4 \times P_5$, $P_5 \times P_6$, $P_5 \times P_7$ and $P_7 \times P_8$ possessed significant positive desirable SCA effects for high yielding ability and among them the 2 crosses; $P_1 \times P_8$ and $P_2 \times P_3$, also possessed significant desirable SCA effects for tasseling and silking earliness.

Keywords: Maize, combining ability, gene action, heterosis, yield and earliness

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important crops for staple food, livestock feed, edible oil and biofuel (Mackay, 2009). It ranks as the third position among cereal crops after wheat and rice in the world. Maize breeders do their best to explore the genetic material in order to develop new high yielding ability of maize genotypes to face the gap between production and consumption. They need information on heterosis as essential in hybridization programs to develop new superior hybrids. Diallel mating system is one of the most powerful breeding analysis methods to give different genetic variances information about inheritance pattern of any specific trait of specific inbred lines, which give guidance to the suitable breeding system to improve and release high yielding hybrids (Griffing, 1956). The important genetic parameters of diallel analysis are general (GCA) and specific (SCA) combining ability, which are essential in developing plant breeding. Therefore, the concepts of GCA and SCA defined by Sprague and Tatum (1942), which have been used extensively in breeding of several economic species. For maize yield, it could be found that GCA was relatively more important than SCA for non-selected inbred lines, whereas SCA was more important than GCA previously selected lines. The concepts of GCA and SCA became useful for characterization of inbred lines in crosses and often have been in the description of an inbred line (Hallauer and Miranda, 1988). The variances of general and specific combining ability are related to the type of gene action effects. Variance for GCA includes additive portion, while that of SCA includes non-additive portion of total variance arising largely from dominance and epistatic deviations (Rojas and Sprague, 1952).

The objectives of the present investigation were to estimate standard heterosis, as well as GCA and SCA effects of the eight S_7 white maize inbred lines and its 28 cross combinations to identify the best parental general combiners and crosses to improve earliness and yield of maize.

MATERIALS AND METHODS

Eight S_7white maize inbred lines were derived from selfing of S_5 inbred lines of two populations, i.e., Giza-2 (5 S_7 inbred lines; P_1- P_5) and IW-469 (3 S_7 inbred lines; P_6 - P_8) were chosen to be used as parents of a half diallel cross. The name, pedigree and origin of these 8 inbred lines are presented in Table 1.

Table 1. The name, pedigree and origin of the 8 parental inbred lines.

No.	Pedigree	Origin
P_1	Giza-2	Egypt
P_2	Giza-2	Egypt
P_3	Giza-2	Egypt
P_4	Giza-2	Egypt
P_5	Giza-2	Egypt
P_6	QPM POP 68	Mexico
P_7	QPM POP 68	Mexico
P_8	QPM POP 68	Mexico

Procedures and field experiments:

This study was carried out at Experimental Farm, Faculty of Agriculture, Al-Azhar University, Assiut Branch during 4 successive seasons from 2018 to 2021.In 2018and 2019 summer seasons, the self-pollination was done of the S_5 inbred lines from each population to obtain S_6 and S_7 inbred lines, respectively. In 2020 summer season, the 8 S_7 inbred

*** Corresponding author.**
E-mail address: ibrahemnagagh78@gmail.com
DOI: 10.21608/jpp.2021.204904

lines were crossed in a half-diallel mating design and obtained on the 28 F_1 crosses. In 2021 summer season, the 28 F_1crossesalong with the 2 check hybrids, i.e., SC-136 and SC-10 were evaluated. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Planting was carried out on 26th of May. Experimental plot size was one ridge, 3 m in long with 70 cm between ridges. Planting was done in hills spaced 25 cm apart on one side of the ridge. The recommended agricultural practices of maize production were applied at the proper time.

Data were recorded for number of days to 50% tasseling (day), number of days to 50% silking (days), plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows/ear, 100-kernel weight (g) and grain yield/plant (g), which was adjusted on the basis of 15.5% grain moisture content.

Statistical Analysis Procedure:

An ordinary analysis of variance of RCBD for the obtained data was performed according to Snedecor and Cochran (1967) to test the significance of differences among the genotypes and treatments means were compared statistically using the test of the Revised Lest Significant Differences (Rev. LSD). Standard heterosis (relative superior over the check) was determined for each cross as the percentage deviation of F_1 mean from each of the commercial check hybrids mean and expressed as percentage according to Fehr (1991) as follows:

Standard heterosis% = $\frac{\text{F1} - \text{check}}{\text{check}}$ x 100

Appropriate Rev. LSD values were computed according to the following formulae to test the significance of standard heterotic effects:

Rev. LSD for the standard heterosis = t`0.05 or 0.01× $\sqrt{\frac{2\text{MSe}}{\text{r}}}$

General (GCA) and specific (SCA) combining ability estimates were computed according to Griffing's (1956), diallel cross analysis, Method 4, Model 1(fixed model).

RESULTS AND DISCUSSION

Analysis of variance:

Observed mean squares from ordinary analysis and combining ability for number of days to 50% tasseling, number of days to 50%silking, plant height, ear height, ear length, ear diameter, number of rows/ear, 100-kernel weight and grain yield/plant of the 28 F_1 white maize crosses in 2021 season is presented in Table 2. The obtained results exhibited that highly significant differences were detected among crosses for all the studied traits, indicating a wide range of diversity among the parental inbred lines used in the present study and combining ability analysis according to Griffing′s (1956), method 4, model I could be done. Partition sum of squares due to crosses into its components showed that mean squares due to GCA and SCA was highly significant for all the studied traits, indicating the importance of both additive and non-additive gene actions in the inheritance of all the studied traits. These obtained results could be supported with the findings by Aly and Mousa (2011), Attia *et al.* (2013), Singh *et al.* (2014), Sultan *et al.* (2016), Gamea *et al.* (2018), Anees *et al.* (2019), Hussain *et al.* (2019), Ali (2020), Hemada *et al.* (2020) and El-Shahed *et al.* (2021).

The ratio of σ^2GCA/σ^2SCA after subtraction the environmental effect of both GCA and SCA variances as estimated according to Singh and Chaudhary (1979) was less than one for all the studied traits, indicating the non-additive gene action played the major role in the inheritance of all the studied traits, therefore selection procedure in the late or advanced generations will be very important to improve these traits. These obtained results are in the same line with those obtained by Abdel-Moneam *et al.* (2009), Attia *et al.* (2013), Ali (2016), Azad *et al.* (2015), Hassan *et al.* (2019), El Hosary (2020), Hemada *et al.* (2020) and El-Shahed *et al.* (2021).

Table 2. Observed mean squares from ordinary analysis and combining ability for all the studied traits of the 28 F_1 white maize crosses in 2021 season.

S.O.V	D.F	Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Number of rows/ear	100-kernel weight	Grain yield/plant
Replication	2	30.58	7.00	243.00	148.05	2.37	0.14	0.62	93.08	39.23
Crosses	27	6.83**	10.82**	4610.13**	1464.05**	23.24**	1.17**	5.02**	101.21**	9183.79**
Error	54	2.81	2.36	46.30	11.06	1.16	0.01	0.82	7.27	28.28
GCA	7	1.58**	3.16**	841.79**	506.07**	10.89**	0.43**	2.16**	44.98**	2918.20**
SCA	20	2.52**	3.76**	1779.93**	481.70**	6.65**	0.38**	1.50**	29.80**	3111.33**
Error	54	0.02	0.01	0.29	0.07	0.01	0.0001	0.01	0.04	0.17
σ^2GCA		0.11	0.40	137.73	83.73	1.75	0.07	0.31	7.09	484.80
σ^2SCA		1.59	2.98	1764.50	478.01	6.26	0.37	1.23	27.38	3101.91
σ^2GCA/ σ^2 SCA		0.07	0.13	0.08	0.18	0.28	0.19	0.26	0.26	0.16

** indicates to significant at 0.01 level of probability.

Mean performance:

Mean performance values for all the studied traits of the 28 crosses along with the 3 check hybrids, i.e., SC-136 and SC-10 are presented in Table 3. The obtained results exhibited that the five crosses**;** P_1 x P_8, P_2 x P_3, P_3 x P_6, P_3 x P_7 and P_3 x P_8 had significantly the lower mean performance values for both tasseling date with values 50.67, 50.33, 51.00, 50.00 and 50.00 days, respectively and silking date with values 54.33, 54, 54, 54 and 54 days, respectively, as well as were significantly earlier tasseling and silking dates than both the check hybrids, i.e., SC-136 and SC-10. The cross P_3 x P_4had significantly the lowest mean performance value for both plant height and ear height with 199.00 and 77.67cm, respectively and was significantly shorter plant and lower ear placement than both the check hybrids, on the other side the cross P_4 x P_6 had significantly the highest mean performance value for both plant height and ear height with 323.00 and 153.67cm, respectively and was significantly taller plant and higher ear placement than both the check hybrids. The cross P_2 x $P_4$was significantly the longest ear with value 25.00cm and longer ear than both the check hybrids. The cross P_2 x P_7 had significantly the highest mean performance value for both ear diameter and number of rows/ear with 5.30 cm and 16.00rows/ear, respectively and was significantly wider ear and higher rows/ear than both the check hybrids. The cross P_1 x $P_4$was significantly the heaviest kernel weight with value 46.67 g and heavier than both the check hybrids. The 3 crosses; P_1 x P_4, P_5 x P_6 and P_7 x P_8 had significantly the highest grain yield/plant mean performance values with 300.07, 302.07 and 295.10 g, respectively, as well as with the previous 3 crosses the 7 crosses;P_1 x P_5, P_1 x P_8, P_3 x P_6, P_3 x P_7, P_3 x P_8, P_4 x P_6 and P_6 x P_8 with values 266.50, 269.03, 294.40, 269.77, 265.93, 267.40 and 275.17 g, respectively out-yielded significantly both the check hybrids.

Table 3. Mean performance values of the 28 F_1 white maize crosses and the 2 check hybrids i.e., SC-136 and SC-10 for all the studied traits in 2021 season.

Crosses		Days to 50% tasseling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	100-kernel weight (g)	Grain yield/plant (g)
P_1 x P_2		52.67	58.00	210.00	83.33	21.67	4.57	15.33	17.00	253.57
P_1 x P_3		56.00	59.67	242.33	98.33	12.67	4.50	12.67	36.67	89.83
P_1 x P_4		53.33	57.67	255.33	95.00	22.33	5.07	15.33	46.67	300.07
P_1 x P_5		53.33	58.67	252.00	100.00	21.00	4.20	12.67	36.33	266.50
P_1 x P_6		54.67	60.00	295.00	107.67	18.33	4.23	14.00	33.33	239.77
P_1 x P_7		52.33	57.67	304.00	102.00	21.00	4.63	12.67	38.67	238.47
P_1 x P_8		50.67	54.33	307.33	108.67	23.00	4.63	16.00	41.33	269.03
P_2 x P_3		50.33	54.00	305.33	112.67	17.67	4.17	12.00	40.00	199.43
P_2 x P_4		52.67	56.67	248.33	74.67	25.00	5.30	15.33	29.33	180.33
P_2 x P_5		53.00	58.00	246.33	101.00	15.00	4.90	13.33	39.67	89.67
P_2 x P_6		53.33	58.33	305.67	112.67	22.33	2.20	12.67	26.33	225.60
P_2 x P_7		55.67	60.00	316.33	118.33	18.00	5.30	16.00	32.33	169.60
P_2 x P_8		51.00	55.00	303.33	129.00	23.00	4.93	16.00	29.67	254.90
P_3 x P_4		53.00	58.00	199.00	77.67	21.33	5.03	13.33	27.67	240.63
P_3 x P_5		53.00	58.33	224.33	106.00	17.67	4.40	14.00	36.00	201.17
P_3 x P_6		51.00	54.00	248.67	122.00	18.33	4.67	14.67	36.00	294.40
P_3 x P_7		50.00	54.00	215.67	147.00	16.67	4.20	14.67	38.67	269.77
P_3 x P_8		50.00	54.00	312.67	128.00	22.67	5.00	13.33	34.67	265.93
P_4 x P_5		51.67	55.00	312.67	152.00	21.00	4.70	14.00	38.00	258.23
P_4 x P_6		51.67	56.00	323.00	153.67	16.67	3.63	12.00	38.67	267.40
P_4 x P_7		52.33	57.33	312.33	150.33	21.00	5.33	14.67	40.33	245.17
P_4 x P_8		54.33	59.33	212.00	89.33	22.00	4.67	13.33	42.00	160.47
P_5 x P_6		52.67	58.67	279.67	102.00	23.00	5.20	13.33	39.33	302.07
P_5 x P_7		51.67	56.33	317.33	144.33	20.33	4.43	14.00	39.00	242.23
P_5 x P_8		53.33	58.00	287.67	99.33	20.67	4.50	14.67	37.00	216.33
P_6 x P_7		52.00	56.67	233.33	98.67	18.67	4.07	15.33	35.33	211.40
P_6 x P_8		52.33	57.00	247.67	124.33	20.67	4.53	16.00	38.33	275.17
P_7 x P_8		52.33	57.33	272.67	116.67	21.67	5.00	16.00	37.00	295.10
Mean		52.51	57.07	271.07	112.67	20.12	4.57	14.19	35.90	232.94
Checks	SC-136	55.33	58.67	269.33	115.67	20.00	4.50	14.21	31.67	223.52
	SC-10	54.33	57.33	275.67	118.33	20.67	4.65	12.67	38.33	257.29
Rev. L.S.D	0.05	3.22	2.57	9.72	4.75	1.57	0.14	1.43	4.07	7.60
	0.01	4.41	3.40	12.72	6.22	2.06	0.19	1.88	5.35	9.94

Standard heterosis:

Standard heterosis values of the 28 F_1 crosses relative to the two check hybrids, i.e., SC-136 and SC-10 for all the studied traits are presented in Table 4. The obtained results illustrated that the 7 crosses; P_1 x P_8, P_2 x P_3, P_2 x P_8, P_3 x P_6, P_3 x P_7, P_3 x P_8 and P_4 x P_5 possessed significant negative desirable standard heterotic effects for tasseling and silking earliness relative to both the check hybrids, i.e., SC-136 and SC-10. The 6 crosses; P_1 x P_2, P_1 x P_3, P_3 x P_4, P_3 x P_5, P_4 x $P_8$and P_6 x P_7 possessed desirable significant negative heterotic effects for decreasing both plant height and ear height relative to both the check hybrids, while the 6 crosses; P_2 x P_8, P_3 x P_8, P_4 x P_5, P_4 x P_6, P_4 x P_7 and P_5 x P_7 possessed desirable significant positive heterotic effects for increasing both plant height and ear height relative to both the check hybrids. The 11 crosses; P_1 x P_2, P_1 x P_4, P_1 x P_8, P_2 x P_4, P_2 x P_6, P_2 x P_8, P_3 x P_4, P_3 x P_8, P_4 x P_8, P_5 x P_6 and P_7 x P_8possessed desirable significant positive heterotic effects for increasing ear length relative to both the check hybrids. The 7 crosses; P_1 x P_4, P_2 x P_4, P_2 x P_7, P_2 x P_8, P_3 x P_6, P_4 x P_7 and P_7 x P_8 possessed desirable significant positive heterotic effects for increasing both ear diameter and number of rows/ear relative to both the check hybrids. The 5 crosses; P_1 x P_4, P_1 x P_8, P_2 x P_3, P_4 x P_7 and P_4 x P_8 possessed desirable significant positive heterotic effects for increasing kernel weight relative to both the check hybrids. The 4 crosses; P_1 x P_4, P_3 x P_6, P_5 x P_6 and P_7 x P_8 possessed desirable significant positive heterotic effects for increasing grain yield/plant relative to the check hybrid SC-136 with values 34.25, 31.71, 35.14 and 32.02 %, respectively and the check hybrid SC-10 with values 16.63, 14.42, 17.40 and 14.70 %, respectively and among them the crossP_3 x P_6, also possessed significant negative desirable standard heterotic effects for tasseling and silking earliness relative to both the check hybrids, therefore this cross possessed the highest frequency of favorable alleles for high yielding ability with earliness.

Table 4. Standard heterosis values of the 28 F_1 white maize crosses relative to the 2 check hybrids i.e., SC-136 and SC-10 for all the studied traits in 2021 season.

Crosses		Days to 50% tasseling		Days to 50% silking		Plant height		Ear height	
		SC-136	SC-10	SC-136	SC-10	SC-136	SC-10	SC-136	SC-10
P_1 x P_2		-4.81**	-3.06*	-1.14	1.17	-22.03**	-23.82**	-27.96**	-29.58**
P_1 x P_3		1.21	3.07*	1.70	4.08**	-10.02*	-12.09*	-14.99**	-16.90**
P_1 x P_4		-3.61*	-1.83	-1.71	0.59	-5.20	-7.38	-17.87**	-19.72**
P_1 x P_5		-3.61*	-1.83	-0.01	2.33	-6.43	-8.59	-13.55**	-15.49**
P_1 x P_6		-1.20	0.62	2.27	4.66**	9.53*	7.01	-6.92**	-9.01**
P_1 x P_7		-5.42**	-3.68*	-1.71	0.59	12.87**	10.28*	-11.82**	-13.80**
P_1 x P_8		-8.43**	-6.74**	-7.39**	-5.23**	14.11**	11.48*	-6.05*	-8.16**
P_2 x P_3		-9.03**	-7.36**	-7.96**	-5.81**	13.37**	10.76*	-2.59	-4.78*
P_2 x P_4		-4.81**	-3.06*	-3.41**	-1.16	-7.80	-9.92*	-35.45**	-36.90**
P_2 x P_5		-4.21*	-2.45	-1.14	1.17	-8.54	-10.64*	-12.68**	-14.65**
P_2 x P_6		-3.61*	-1.83	-0.57	1.75	13.49**	10.88*	-2.59	-4.78*
P_2 x P_7		0.61	2.46	2.27	4.66**	17.45**	14.75**	2.30	0.00
P_2 x P_8		-7.83**	-6.13**	-6.26**	-4.06**	12.62**	10.03*	11.52**	9.02**
P_3 x P_4		-4.21*	-2.45	-1.14	1.17	-26.11**	-27.81**	-32.85**	-34.36**
P_3 x P_5		-4.21*	-2.45	-0.57	1.75	-16.71**	-18.62**	-8.36**	-10.42**
P_3 x P_6		-7.83**	-6.13**	-7.96**	-5.81**	-7.67	-9.79*	5.47*	3.10
P_3 x P_7		-9.63**	-7.97**	-7.96**	-5.81**	-19.92**	-21.77**	27.09**	24.23**
P_3 x P_8		-9.63**	-7.97**	-7.96**	-5.81**	16.09**	13.42**	10.66**	8.17**
P_4 x P_5		-6.62**	-4.90**	-6.26**	-4.06**	16.09**	13.42**	31.41**	28.45**
P_4 x P_6		-6.62**	-4.90**	-4.55**	-2.32	19.93**	17.17**	32.85**	29.87**
P_4 x P_7		-5.42**	-3.68**	-2.28	0.01	15.97**	13.30**	29.96**	27.04**
P_4 x P_8		-1.80	0.01	1.13	3.49**	-21.29**	-23.10**	-22.77**	-24.51**
P_5 x P_6		-4.81**	-3.06*	-0.01	2.33	3.84	1.45	-11.82**	-13.80**
P_5 x P_7		-6.62**	-4.90**	-3.98**	-1.74	17.82**	15.11**	24.78**	21.97**
P_5 x P_8		-3.61*	-1.83	-1.14	1.17	6.81	4.35	-14.13**	-16.06**
P_6 x P_7		-6.02**	-4.29*	-3.41**	-1.16	-13.37**	-15.36**	-14.70**	-16.61**
P_6 x P_8		-5.42**	-3.68*	-2.85*	-0.58	-8.04	-10.16*	7.49**	5.07*
P_7 x P_8		-5.42**	-3.68*	-2.28	0.01	1.24	-1.09	0.86	-1.40
Rev. L.S.D	0.05	2.95		2.48		9.46		4.68	
	0.01	4.77		3.06		12.38		6.12	

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

General combining ability effects:

Estimates of the general combining ability (GCA) effects for all the studied traits of the 8 S_7 parental inbred lines are presented in Table5.The obtained data exhibited that none of the parents possessed significant negative desirable GCA effect for tasseling earliness, while the 2 parents; P_3 and P_8 possessed significant negative desirable GCA effects for silking earliness. The parent P_1 had significant negative desirable GCA effects in direction to plant shortness and low ear placement, on the contrary the 3 parents; P_5, P_6 and P_7 had significant positive desirable GCA effects in direction to plant heightens and ear placement heightens. The 2 parents; P_4 and P_8had significant positive desirable GCA effects for ear length. The 2 parents; P_7 and P_8 possessed significant positive desirable GCA effects toward increasing both ear diameter and number of rows/ear. The 4parents; P_4, P_5, P_7 and P_8 had significantly favorable alleles for kernel heaviness. The 5 parents; P_1, P_4, P_6, P_7 and P_8 had significantly favorable alleles for high yielding ability and among them the parent P_8, also possessed significant positive desirable GCA effects for yield components; ear length, ear diameter, number of rows/ear and 100-kernel weight, as well as silking earliness, therefore this parent could be considered as good general combiner for developing high yielding ability with earliness white maize genotypes.

Table 5. General combining ability (GCA) effects of the eight S_7 parental lines for all the studied traits in 2021 season.

Parents		Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Number of rows/ear	100-kernel weight	Grain yield/plant
P_1		0.90*	1.08**	-5.25**	-15.61**	-0.14	-0.03	-0.11	-0.22	4.45**
P_2		0.18	0.08	6.31**	-9.50**	0.31	-0.11**	0.22	-6.17**	-42.91**
P_3		-0.71	-1.25**	-24.92**	0.50	-2.31**	-0.01	-0.78**	-0.28	-11.57**
P_4		0.24	0.08	-5.81**	0.67	1.42**	0.29**	-0.22	1.89**	3.62**
P_5		0.18	0.58	3.75*	2.67**	-0.36	0.06*	-0.56**	2.33**	-9.06**
P_6		0.01	0.19	5.92**	5.39**	-0.47*	-0.58**	-0.22	-0.67	30.87**
P_7		-0.21	-0.03	12.36**	14.78**	-0.58	0.16**	0.67**	1.67**	6.86**
P_8		-0.60	-0.75*	7.64**	1.11	2.14**	0.21**	1.00**	1.44*	17.73**
L.S.D (gi)	0.05	0.74	0.68	3.00	1.47	0.47	0.05	0.40	1.19	2.34
	0.01	0.98	0.90	3.99	1.95	0.63	0.07	0.53	1.58	3.12

* and ** indicate to significant at 0.05 and 0.01 levels of probability, respectively. L.S.D is least significant difference.

Specific combining ability effects:

Estimates of the specific combining ability (SCA) effects of the 28 F_1 white maize crosses for all the studied traits are presented in Table6.The obtained results illustrated that the 2 crosses; $P_1\times P_8$ and $P_2\times P_3$ possessed significant negative desirable SCA effects for both tasseling and silking earliness. The8 crosses; $P_1\times P_2$, $P_2\times P_4$, $P_2\times P_5$, $P_3\times P_4$, $P_3\times P_5$, $P_4\times P_8$, $P_6\times P_7$ and $P_7\times P_8$ possessed significant negative desirable SCA effects for both plant shortness and low ear placement, on the other hand the 10 crosses; $P_1\times P_6$, $P_1\times P_8$,

$P_2 \times P_3$, $P_2 \times P_6$, $P_2 \times P_8$, $P_3 \times P_8$, $P_4 \times P_5$, $P_4 \times P_6$, $P_4 \times P_7$ and $P_5 \times P_7$ possessed significant positive desirable SCA effects for both plant heightens and ear placement heightens. The 9 crosses; $P_1 \times P_2$, $P_1 \times P_5$, $P_1 \times P_7$, $P_2 \times P_4$, $P_2 \times P_6$, $P_3 \times P_4$, $P_3 \times P_8$, $P_5 \times P_6$ and $P_5 \times P_7$ possessed significant positive desirable SCA effects for increasing ear length. The 6 crosses; $P_1 \times P_2$, $P_1 \times P_4$, $P_2 \times P_4$, $P_2 \times P_7$, $P_3 \times P_6$ and $P_6 \times P_8$ possessed significant positive desirable SCA effects for increasing both ear diameter and number of rows/ear. The 5 crosses; $P_1 \times P_4$, $P_1 \times P_8$, $P_2 \times P_3$, $P_2 \times P_5$ and $P_4 \times P_8$ possessed significant positive desirable SCA effects for kernel heaviness. The 14 crosses; $P_1 \times P_2$, $P_1 \times P_4$, $P_1 \times P_5$, $P_1 \times P_8$, $P_2 \times P_3$, $P_2 \times P_8$, $P_3 \times P_4$, $P_3 \times P_6$, $P_3 \times P_7$, $P_3 \times P_8$, $P_4 \times P_5$, $P_5 \times P_6$, $P_5 \times P_7$ and $P_7 \times P_8$ possessed significant positive desirable SCA effects for high yielding ability and among them the 2 crosses; $P_1 \times P_8$ and $P_2 \times P_3$, also possessed significant desirable SCA effects for tasseling and silking earliness, therefore these 2 crosses could be considered as good combinations for high yielding ability with earliness.

Table 6. Specific combining ability (SCA) effects of the 28 F_1 white maize crosses for all the studied traits in 2021 season.

Crosses		Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Number of rows/ear	100-kernel weight	Grain yield/plant
P_1 x P_2		-0.93	-0.24	-62.13^{**}	-4.22^{*}	1.38^{*}	0.13^{*}	1.03^{*}	-12.52^{**}	59.09^{**}
P_1 x P_3		3.29^{**}	2.76^{**}	1.43	0.78	-5.01^{**}	-0.04	-0.63	1.26	-135.98^{**}
P_1 x P_4		-0.32	-0.57	-4.68	-2.72	0.94	0.23^{**}	1.48^{**}	9.10^{**}	59.06^{**}
P_1 x P_5		-0.26	-0.07	-17.57^{**}	0.28	1.38^{*}	-0.40^{**}	-0.86	-1.68	38.18^{**}
P_1 x P_6		1.24	1.65^{*}	23.26^{**}	5.22^{**}	-1.17^{*}	0.27^{**}	0.14	-1.68	-28.49^{**}
P_1 x P_7		-0.87	-0.46	25.82^{**}	-9.83^{**}	1.60^{**}	-0.07	-2.08^{**}	1.32	-5.78^{*}
P_1 x P_8		-2.15^{*}	-3.07^{**}	33.87^{**}	10.50^{**}	0.88	-0.12^{*}	0.92^{*}	4.21^{**}	13.92^{**}
P_2 x P_3		-1.65^{*}	-1.90^{*}	52.87^{**}	9.00^{**}	-0.45	-0.29^{**}	-1.63^{**}	10.54^{**}	20.97^{**}
P_2 x P_4		-0.26	-0.57	-23.24^{**}	-29.17^{**}	3.16^{**}	0.55^{**}	1.14^{*}	-2.29	-13.32^{**}
P_2 x P_5		0.13	0.26	-34.79^{**}	-4.83^{**}	-5.06^{**}	0.38^{**}	-0.52	7.60^{**}	-91.30^{**}
P_2 x P_6		0.63	0.98	22.37^{**}	4.11^{*}	2.38^{**}	-1.69^{**}	-1.52^{**}	-2.74^{*}	4.70
P_2 x P_7		3.18^{**}	2.87^{**}	26.60^{**}	0.39	-1.84^{**}	0.67^{**}	0.92^{*}	0.93	-27.29^{**}
P_2 x P_8		-1.10	-1.40	18.32^{**}	24.72^{**}	0.44	0.26^{**}	0.59	-1.52	47.14^{**}
P_3 x P_4		0.96	2.10^{**}	-41.35^{**}	-36.17^{**}	2.10^{**}	0.18^{**}	0.14	-9.85^{**}	15.64^{**}
P_3 x P_5		1.02	1.93^{*}	-25.57^{**}	-9.83^{**}	0.21	-0.22^{**}	1.14^{*}	-1.96	-11.15^{**}
P_3 x P_6		-0.82	-2.02^{**}	-3.40	3.44^{*}	0.99	0.68^{**}	1.48^{**}	1.04	42.15^{**}
P_3 x P_7		-1.60	-1.79^{*}	-42.85^{**}	19.06^{**}	-0.56	-0.53^{**}	0.59	1.37	41.53^{**}
P_3 x P_8		-1.21	-1.07	58.87^{**}	13.72^{**}	2.71^{**}	0.22^{**}	-1.08	-2.40	26.83^{**}
P_4 x P_5		-1.26	-2.74^{**}	43.65^{**}	36.00^{**}	-0.17	-0.22^{**}	0.59	-2.13	30.73^{**}
P_4 x P_6		-1.10	-1.35	51.82^{**}	34.94^{**}	-4.40^{**}	-0.65^{**}	-1.75^{**}	1.54	-0.03
P_4 x P_7		-0.21	0.21	34.71^{**}	22.22^{**}	0.05	0.31^{**}	0.03	0.87	1.74
P_4 x P_8		2.18^{**}	2.93^{**}	-60.90^{**}	-25.11^{**}	-1.67^{**}	-0.40^{**}	-1.63^{**}	2.76^{*}	-93.82^{**}
P_5 x P_6		-0.04	0.82	-1.07	-18.72^{**}	3.71^{**}	1.15^{**}	-0.08	1.76	47.32^{**}
P_5 x P_7		-0.82	-1.29	30.15^{**}	14.22^{**}	1.16^{*}	-0.35^{**}	-0.30	-0.90	11.49^{**}
P_5 x P_8		1.24	1.10	5.21	-17.11^{**}	-1.23^{*}	-0.34^{**}	0.03	-2.68^{*}	-25.27^{**}
P_6 x P_7		-0.32	-0.57	-56.02^{**}	-34.17^{**}	-0.40	-0.09	0.70	-1.57	-59.27^{**}
P_6 x P_8		0.40	0.48	-36.96^{**}	5.17^{**}	-1.12^{*}	0.33^{**}	1.03^{*}	1.65	-6.37^{*}
P_7 x P_8		0.63	1.04	-18.40^{**}	-11.89^{**}	-0.01	0.06	0.14	-2.02	37.57^{**}
L.S.D (Sij)	0.05	1.63	1.50	6.64	3.25	1.05	0.12	0.88	2.63	5.19
	0.01	2.17	1.99	8.83	4.32	1.40	0.15	1.17	3.50	6.90

* and ** indicate to significant at 0.05 and 0.01 levels of probability, respectively.
L.S.D is least significant difference.

REFERENCES

Abdel-Moneam, M. A., A. N. Attia, M. I. EL-Emery and E. A. Fayed (2009). Combining ability and heterosis for some agronomic traits in crosses of maize. Pakistan, J. of Bio. Sci.12(5): 433-438.

Ali, M. (2020). Diallel analysis of maize inbreds for grain yield, protein and tryptophan content. Egypt, J. Agron. 42(1): 1-17.

Ali, M. M. A. (2016). Estimation of some breeding parameters for improvement grain yield in yellow maize under water stress. J. Plant Prod., Mansoura, Univ., 7(12): 1509 -1521.

Aly, R. S. H. and S. Th. M. Mousa (2011). Combining ability for grain yield and other yield component traits using half diallel crosses of maize inbred lines. J. Agric. Chem. and Biotech., Mansoura, Univ., 2(12): 317- 329.

Anees, A., K. Al-Zubaidy, W. AL-Rawi and S. Al-Dawody (2019). Study of genetic behavior for some productivity and morphology traits in half diallel cross of maize. Syrian, J. of Agric., Res., SJAR 6(1): 134-150.

Attia, A. N. E., M. A. Badawi, A. M. Salama, M. A. Abd El-Moneam and A. A. A. Leilah (2013). Combining ability and heterosis for maize grain yield and some agronomic characters. J. Plant Prod., Mansoura, Univ., 4(4): 551-560.

Azad, A. K., Mohammad, Biswas, B. Kumar, Alam, Nazmu, Alamand S. Shamimu (2015). Combining ability and heterosis for some quantitative traits in experimental maize hybrids. Plant Breed. and Seed Sci., 70, 41-54.

El Hosary, A. A. A. (2020). Diallel analysis of some quantitative traits in eight inbred lines of maize and Gge biplot analysis for elite hybrids. J. of Plant Prod., Mansoura Univ., 11(3): 145-151.

El-Shahed, H. M., A. M. Abu Shosha, M. A. M. El-Ghonemy and R. H. A. Alsebaey (2021). Diallel analysis of eight yellow maize inbred lines for earliness and grain yield. J. of Plant Prod., Mansoura Univ., 12 (3): 329-332.

Fehr, W .R. (1991). Principles of cultivar development. Theory and technique. MacMillan publishing Co., 1:536.

Gamea, H., M. Darwich and H. A. Aboyousef (2018). Combining ability for some inbred lines in half-diallel crosses of maize under two different locations conditions. Arch. of Agric., sci., 1(3): 14-25.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. of Biol. Sci., 9: 463-493.

Hallauer, A. R. and J. B. Miranda (1988). Quantitative genetics in maize breeding.2nd ed. Iowa State Univ. Press. IA.

Hassan, A. A., A. A. Jama, O. H. Mohamed and B. K. Biswas (2019). Study on combining ability and heterosis in maize (*Zea mays* L.) using partial diallel analysis. Inter. J. of Plant Breed. and Crop Sci.,6 (2): 520-526.

Hemada S.Sh., H. E.Yassien, I. N.Abd El-Zaher andM. H. Haridy (2020). Combining ability and genetic parameters of some white maize (*Zea mays* L.) inbred lines using diallel analysis. Arch. of Agric. Sci. J., 3(3): 82-100.

Hussain, M. A., Rezgaridreessaaed, H. A. Askandar and B. Alokhcther (2019). Estimation of some genetic parameters and heterosis in maize by using half diallel cross. J. of Univ., of Duhok., Agri., and Sci., 22(2): 37-48.

Mackay, T. F. C. (2009). A-maize-ing diversity. Science 325, 688–689. doi: 10.1126/science.1178420.

Rojas, B. A. and G. F. Sprague (1952). A comparison of variance components in corn yield trials: III. General and specific combining ability and their interaction with locations and years, Agro. J., (44): 462-466.

Singh, R. K. and B. D. Chaudhary (1979). Biometrics techniques in genetics and breeding. Publishes. PP. 118

Singh, P. K., R. Ranjan, J. P. Shahi, A. K. Singh (2014). Studies on combining ability analysis in white kernel color of quality protein maize (*Zea mays* L.). Agric. Sci. Digest., 34(1):21-25.

Snedecor, G. W. and W. G. Cochran (1967). Statistical Methods. 6thEd., Iowa State Univ., Press, Ames, Iowa, U.S.A. pp.

Sprague, G. F. and L. A. Tatum. (1942). General versus specific combining ability in single crosses of corn. J. Amer. Soc. Agron., 34: 923-932.

Sultan. M. S., M. A. Abdel-Moneam, A. M. Khalil and H. E. El-Wady (2016). Combining ability of some maize inbred lines and its crosses under non-stressed and water stressed conditions. J. of Plant Prod., Mansoura Univ., 7 (12): 1431-1436.

تقدير قوه الهجين والقدرة على التآلف لبعض سلالات الذرة الشامية البيضاء باستخدام التهجين النصف تبادلي

إبراهيم نجاح عبد الظاهر

قسم المحاصيل ـ كليه الزراعة ـ جامعه الأزهر – فرع أسيوط

أجريت هذه الدراسة خلال الفترة من 2018- 2021 بمزرعة كلية الزراعة جامعة الأزهر فرع أسيوط لتقدير قوة الهجين القياسية والقدرة العامة والخاصة على التآلف لــ 28 هجين فردي و8من سلالات الجيل الذاتي السابع S_7من الذرة الشامية البيضاء الحبوب المستنبطة من عشيرتين هما جيزة - 2 بعدد 5 سلالات (P_5-P_1) والعشيرة IW-469بعدد 3 سلالات (P_8-P_6). في موسمي 2018 و2019 تم إجراء التلقيح الذاتي لسلالات الجيل الذاتي الخامس S_5والسادس S_6 للحصول على سلالات الجيل الذاتي السابعS_7.في موسم 2020 تم إجراء التهجين بين الـ 8 سلالات S_7بكل الطرق الممكنة بدون إجراء الهجن العكسية لإنتاج حبوب الـ 28 هجين فردى. في موسم 2021 تم تقييم الـ 28 هجين فردي مع اثنين من هجن المقارنة هما الهجين الفردي 136 والهجين الفردي 10باستخدام تصميم القطاعات الكاملة العشوائية في ثلاث مكررات. تم تحليل البيانات وراثيا تبعا للطريقة الرابعة، الموديل الأول للعالم جريفنج1956. تم تسجيل البيانات لصفات، عدد الأيام حتى ظهور 50٪ من النورة المذكرة، عدد الأيام حتى ظهور 50٪ من النورة المؤنثة، ارتفاع النبات، ارتفاع الكوز، طول الكوز، قطر الكوز، عدد صفوف الكوز، وزن الـ 100 حبة ومحصول حبوب النبات. كان التباين الراجع إلى الهجن عالي المعنوية لجميع الصفات المدروسة. كان التباين الراجع إلى القدرة العامة والخاصة على التآلف عالي المعنوية لجميع الصفات المدروسة، مما يشير إلى أهمية كلا من فعل الجين المضيف وغير المضيف في وراثتها. كانت نسبة تباين القدرة العامة على التآلف إلى تباين القدرة الخاصة على التآلف أقل من واحد لجميع الصفات المدروسة، مما يشير إلى أن الفعل الجيني غير المضيف لعب الدور الأهم في توريثها. تفوقت الهجن الأربعة، $P_1 \times P_4$ ، $P_3 \times P_6$، $P_5 \times P_6$ ، $P_7 \times P_8$ معنويًا في محصول حبوب النبات نسبة إلى كلا من هجيني المقارنة بزيادة قدرها 34،25 ، 31،71 ، 35،14، 32،02 % عن الهجين الفردي 136على التوالي و 16،63 ، 14،42 ، 17،40 ، 14،70 % عن الهجين الفردي 10 على التوالي. امتلك الأب P_8 تأثير قدرة عامة على التآلف معنوي ومرغوب لمحصول حبوب النبات وتبكير النورة المؤنثة وطول الكوز وقطر الكوز وعدد صفوف الكوز ووزن الـ 100 حبة. امتلك الـ14 هجينًا ($P_1 \times P_2$،$P_1 \times P_4$،$P_1 \times P_5$،$P_1 \times P_8$،$P_2 \times P_3$،$P_2 \times P_8$،$P_3 \times P_4$،$P_3 \times P_6$،$P_3 \times P_7$،$P_3 \times P_8$،$P_4 \times P_5$،$P_5 \times P_6$، $P_5 \times P_7$، $P_7 \times P_8$) قدرة خاصة على التآلف موجب ومعنوي لزيادة محصول حبوب النبات وأظهرا الهجينين $P_1 \times P_8$،$P_2 \times P_3$ أيضا قدرة خاصة على التآلف سالبة ومعنوية لتبكير النورتين المذكرة والمؤنثة.