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COMBINING ABILITY AND SUPERIORITY FOR YIELD AND SOME RELATED TRAITS IN HALF-DIALLEL CROSSES OF NINE NEW YELLOW MAIZE INBRED LINES UNDER TWO LOCATIONS

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ABSTRACT

A half diallel cross among nine new yellow maize inbred lines, *i.e.* Gm. 500, Gm. 505, Gm. 507, Gm. 508, Gm. 509, Gm. 515, Gm. 518, Gm. 520 and Gm. 522 was made in 2014 summer season. Parental inbred lines and their F_1 crosses along with two yellow commercial check hybrids, SC162 and SC168 were evaluated in randomized complete block design with four replications at two locations (Gemmeiza and Sids) in 2015 summer season to study the combining ability in order to identify the most superior parental inbred lines that produce superior hybrids and develop high yielding new yellow single crosses. Results indicated that mean squares among crosses exhibited highly significant for all studied traits at both locations and their combined. Mean squares due to general combining ability (GCA) and specific combining ability (SCA) were significant or highly significant for all studied traits at both locations and their combined, except GCA for ear height at Gemmaiza and SCA for plant height and ear height at Sids. The ratio of GCA/SCA was more than unity for all studied traits at both locations and their combined, except plant height and ear height at Gemmaiza, days to 50% silking at Sids and plant height at the combined data. These results indicating that the additive genetic effects were more important and played the major role in the inheritance of these studied traits. Based on combinedP_1 (Gm.500) and P_5 (Gm.509) could be considered as the best combiners for earliness, as well as P_2 (Gm.505), P_4 (Gm.508), P_7 (Gm.518) and P_8 (Gm.520) for increasing grain yield. At combined four crosses ($P_1 \times P_7$, $P_2 \times P_3$, $P_2 \times P_4$ and $P_7 \times P_8$) exhibited desirable ($\hat{s}_{ij}$) towards earliness, and seven crosses ($P_1 \times P_3$, $P_1 \times P_7$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_6$, $P_4 \times P_8$ and $P_7 \times P_8$) exhibited desirable ($\hat{s}_{ij}$) towards high grain yield. Two new crosses No. 34 (Gm. 518 × Gm. 520 and 25 (Gm. 508 × Gm. 520) were the best combinations, where they recorded the highest percentages of superiority in grain yield over both commercial hybrids SC 162 and SC 168.

Key words: Maize, diallel, combining ability.

INTRODUCTION

The identification of parental inbred lines that perform superior hybrids is the most costly and time consuming phase in maize hybrid development. Performance of maize inbred lines does not predict the performance of maize hybrids for grain yield (Hallauer and Miranda, 1981). Plant breeders and geneticists often use diallel mating designs to obtain genetic information about a trait of interest from a fixed or randomly chosen set of parental lines (Murray *et al*., 2003). The diallel analysis is an important method to know gene actions and it is frequently used by crop breeders to choose the parents with a high general combining ability (GCA) and hybrids with high specific combining ability (SCA) effects (Yingzhong, 1999). Large genotype × environment effects tend to be viewed as problematic in breeding because the lack of a predictable response hinders progress from selection (Dudley and Moll, 1969), influence the environment and interaction between genotype and environment (Novoselovic *et al.*, 2004). Abdel-Moneam *et al* (2009) found that mean squares for general combining ability (GCA) and specific combining ability (SCA) were highly significant

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for most studied traits of maize under both normal and drought stress conditions, furthermore Abdel-Moneam and Ibraheem (2015b) indicated that mean squares due to crosses were highly significant for all studied traits under both low and high N fertilization rates, indicating significant genotypic differences among the studied crosses and suggest that almost all variables exhibited some degree of heterosis. Crosses (B73 × CML103) and (B73 × Tzi8) were the best and recorded the highest percentages of heterosis over the studied commercial check varieties (Pioneer SC 3084 and SC 10) with significant values in grain yield per plant and most of studied yield components and yield-related physiological traits under both low and high N conditions. Breeders still contend, however, that dominance effects caused by genes with over dominant gene action are also important (Horner *et al*., 1989). Most of the literature about maize, suggests that additive effects of genes with partial to complete dominance are more important than dominance effects in determining grain yield (Lamkey and Lee, 1993). On the other side, Mosa (2003), Motawei (2005), Mosa (2006) and Mosa *et al.* (2006) found that non-additive gene action was more important expression for grain yield.

The objectives of this study were evaluation of nine parental inbred lines and their crosses throught half-diallel, estimate of GCA and SCA, identify the best crosses for grain yield, earliness and shortness, lower ear placement ,determine the best allot for these crosses and identify type of gene action controlling the inheritance of the studied traits.

MATERIALS AND METHODS

Nine new yellow maize (*Zea mays* L.) parental inbred lines were involved in the present study: *i.e.* Gm. 500, Gm. 505, Gm. 507, Gm. 508, Gm. 509, Gm. 515, Gm. 518, Gm. 520 and Gm. 522. These lines were differed considerably in gene expression of various agronomy traits.

These inbredlines were crossed at Gemmeiza Research Station in a half-diallel to give 36 crosses (excluding reciprocal crosses) in the summer of 2014. The 36 F_1 hybrids and two check hybrids (single cross 162 and single cross 168) were evaluated at two locations (Gemmeiza and Sids) in a randomized complete block design (RCBD) with four replications during 2015 summer season. Kernels were hand – sown at 2 to 3grains per hill then thinned to one plant per hill after emergence. Each replication contained 38 plots and each plot consisted of one ridge, with 6 m long and spacing of 30 cm between plants within ridge and 70 cm between ridges, data were recorded on plot basis for studying the following characters: days to 50% silking, plant height (cm), ear height (cm) and Grain yield (ardab/fad.) (one ardab = 140 kg. and one faddan 4200 m^2) , which was adjusted to 15.5% moisture content (estimated in kg/plot and converted to ardab/fad.).

Statistical Analysis Procedure

Analysis of variance for mean performance was performed for each location and then combined over the two locations, and were carried out whenever homogeneity of variance was detected LSD test at 5% and 1% was used according to Steel and Torrie (1980) for comparison the mean performance of the different crosses.

General combining ability (GCA) and specific combining ability (SCA) estimates were computed according to Griffings (1956) diallel cross analysis designated as Method 4 Model 1. In addition the mathematical model for a single inbred cross were tested for normality by statistical software. Then, data were analyzed using AGR 21 statically software (Agrobase, 2001).

Relative Superior to Check Hybrids

Relative superior was determined for individual crosses as the percentage deviation of F_1 means from commercial cultivar means (CV) and expressed as percentages Fehr (1991) as follows:

$$\text{Relative superior over the C.V\%} = [(F_1 - CV)/CV] \times 100$$

Where:

F_1= mean performance of F_1 hybrid and CV = mean of check or commercial variety. The significance of relative superior effect for F_1 values from the commercial variety was tested according to the following formula:

$$\text{LSD for relative superior (CV)} = t_{0.05 \text{ or } 0.01} \times (2MSe/r)^{1/2}$$

Table 1. Pedigree of the studied parental inbred lines

No.	Pedigree
P_1	Gm.500 (comp #45)
P_2	Gm.505 (SK 21)
P_3	Gm.507 (G. Y. Pop)
P_4	Gm.508 (Pool 32)
P_5	Gm.509 (Pool 33)
P_6	Gm.515 (Pool 33)
P_7	Gm.518 (Pool 35)
P_8	Gm.520 (Pool 38)
P_9	Gm.522 (Pool 40)

Where:

t = tabulated "t" value at a stated level of probability for the experimental error degree of freedom, MSe = Mean squares of the experimental error from the analysis of variance and r= Number of replications.

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance for the studied traits *i.e.* days to 50% silking, plant height, ear height and grain yield of 36 F_1 single crosses at two locations (Gemmaiza and Sids) and their combined are presented in Table 2.

Mean squares among crosses were highly significant for all studied traits at each location and combined, indicating that the crosses performance differed from location to another. These results agree with those obtained by Nawar and El-Hosary (1985), Barakat and Ibrahim (2006), Barakat and Osman (2008) and Aly and Mousa (2011).

Partition sum of squares due to crosses into its components showed that mean squares due to GCA and SCA were significant or highly significant for all studied traits at two locations (Gemmeiza and Sids) and their combined, except GCA for ear height at Gemmaiza and SCA for plant height and ear height at Sids. These results indicated that both additive and non-additive types of gene effects were involved in the inheritance of the previous traits.

The ratio of GCA/SCA was more than unity for all studied traits at two locations (Gemmaiza and Sids) and their combined, except plant height and ear height at Gemmaiza, days to 50% silking at Sids and plant height at the combined data. These results indicating that the additive genetic effects were more important and played the major role in the inheritance of these traits. These results agree with the findings of Hallauer and Miranda (1981), EI-Hosary El- Badawy (2005) and Soliman *et al.* (2005).

The interaction effect between GCA and SCA with locations (Table 2) was significant or highly significant for all studied traits. The magnitude of the interaction was lowest for GCA × locations than the SCA × locations for plant height and ear height. This indicates that non-additive genetic variance was more influenced by environment than additive and *vice versa* for days to 50% silking and grain yield. This conclusion supports the findings by EI-Hosary and El-Badawy (2005), Soliman *et al.* (2005) and Abdel-Moneam *et al*., (2014,a, b and c).

Table 2. Mean squares from analysis of variance and combining ability for days to 50% silking, plant height, ear height and grain yield of 36 maize crosses at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Location	SOV	df	Days to 50% silking	Plant height (cm)	Ear height (cm)	Grain yield (ardab/fad.)
Gemmaize	**Crosses**	**35**	2.863 **	588.507**	391.409**	22.876**
	GCA	**8**	1.705**	79.470**	39.850	6.776**
	SCA	**27**	0.422 *	167.173**	115.038**	5.406**
	Error	**105**	0.227	15.906	29.535	1.450
	GCA/SCA		4.040	0.475	0.346	1.253
Sids	**Crosses**	**35**	5.263**	178.705**	109.697**	21.010**
	GCA	**8**	0.944**	79.408**	53.429**	6.116**
	SCA	**27**	1.426**	34.385	19.719	4.997**
	Error term	**105**	0.359	29.323	19.911	1.076
	GCA/SCA		0.662	2.309	2.710	1.224
Combined	**Crosses**	**35**	5.625**	474.841**	242.825**	37.235**
	GCA	**8**	0.856**	50.206**	36.720**	5.380**
	SCA	**27**	0.658**	62.066*	28.467*	4.440**
	GCA × Loc.	**8**	1.793*	108.672**	56.559**	7.512**
	SCA × Loc.	**27**	1.19**	139.492**	106.29**	5.963**
	Error	**210**	0.147	11.307	12.362	0.631
	GCA/SCA		1.301	0.809	1.290	1.212
	GCA × Loc. / SCA x loc.		1.507	0.779	0.532	1.260
	GCA L_1 / GCA L_2		1.806	1.001	0.746	1.108
	SCA L_1 / SCA L_2		0.296	4.862	5.834	1.082

Mean Performance

Mean Performance of 36 maize crosses for days to 50% silking and plant height (cm) at two locations (Gemmaiza and Sids) and their combined are presented in Tables 3 and 4.

For days to 50% sllking, the studied 36 crosses were significantly earlier than the both checks SC 168 and SC 162. Days to 50% silking ranged from 55 days for crosses No. 11, 17 and 18 to 57.3 days for cross No. 32 at Gemmaiza location, from 57.5 days for cross No. 6 to 62.8 days for cross No. 21 at Sids location, and from 56.4 days for cross No. 6 to 59.9 days for cross No. 21 at the combined data over both locations, as shown in Table 3.

For plant height (cm), means of studied crosses varied between 208.75 cm for cross No. 13 to 265.00 cm for crosses No. 15 and No. 32 at Gemmeiza location, from 186.25 cm for

Table 3. Mean Performance of 36 maize crosses for days to 50%silking and plant height (cm) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Crosses		Days to 50% silking			Plant height (cm)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
1. P1 × P2		56.0	58.3	57.1	230.00	198.75	214.38
2. P1 × P3		55.8	59.5	57.6	235.00	213.75	224.38
3. P1 × P4		56.3	60.5	58.4	225.00	208.75	216.88
4. P1 × P5		55.3	60.0	57.6	233.75	202.50	218.13
5. P1 × P6		55.3	61.0	58.1	227.50	216.25	221.88
6. P1 × P7		55.3	57.5	56.4	241.25	203.75	222.50
7. P1 × P8		55.5	59.8	57.6	238.75	205.00	221.88
8. P1 × P9		55.5	60.0	57.8	235.00	208.75	221.88
9. P2 × P3		55.3	58.0	56.6	237.50	207.50	222.50
10. P2 × P4		55.3	58.5	56.9	212.50	210.00	211.25
11. P2 × P5		55.0	60.5	57.8	248.75	208.75	228.75
12. P2 × P6		55.8	59.3	57.5	238.75	198.75	218.75
13. P2 × P7		57.8	60.8	59.3	208.75	202.50	205.63
14. P2 × P8		57.0	61.5	59.3	236.25	198.75	217.50
15. P2 × P9		55.5	60.8	58.1	265.00	203.75	234.38
16. P3 × P4		55.5	59.8	57.6	245.00	206.25	225.63
17. P3 × P5		55.0	59.8	57.4	241.25	203.75	222.50
18. P3 × P6		55.0	58.5	56.8	218.75	198.75	208.75
19. P3 × P7		57.0	60.8	58.9	246.25	210.00	228.13
20. P3 × P8		55.8	61.5	58.6	232.50	201.25	216.88
21. P3 × P9		57.0	62.8	59.9	233.75	202.50	218.13
22. P4 × P5		55.3	60.8	58.0	232.50	203.75	218.13
23. P4 × P6		55.5	59.0	57.3	227.50	205.00	216.25
24. P4 × P7		57.0	61.0	59.0	250.00	207.50	228.75
25. P4 × P8		56.8	61.0	58.9	251.25	211.25	231.25
26. P4 × P9		56.8	59.8	58.3	240.00	212.50	226.25
27. P5 × P6		54.3	60.0	57.1	235.00	186.25	210.63
28. P5 × P7		56.0	57.8	56.9	225.00	197.50	211.25
29. P5 × P8		55.3	59.3	57.3	225.00	203.75	214.38
30. P5 × P9		54.8	59.5	57.1	236.25	195.00	215.63
31. P6 × P7		55.8	59.8	57.8	220.00	186.25	203.13
32. P6 × P8		57.3	60.3	58.8	265.00	211.25	238.13
33. P6 × P9		56.0	60.0	58.0	228.75	196.25	212.50
34. P7 × P8		56.0	58.5	57.3	246.25	201.25	223.75
35. P7 × P9		57.0	59.3	58.1	238.75	202.50	220.63
36. P8 × P9		57.3	60.5	58.9	238.75	208.75	223.75
Checks	SC 162	63.0	67.7	65.4	277.50	230.0	253.75
	SC 168	61.0	65.0	63.0	248.75	203.7	226.22
LSD	%0.05	1.3	1.6	1.0	11.1	15.16	9.46
	%0.01	1.7	2.1	1.3	14.5	19.75	12.26

Table 4. Mean Performance of 36 maize crosses for ear height (cm) and grain yield (ardab/fad.) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Crosses		Ear height (cm)			Grain yield (ardab/fad)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
1. P1 × P2		142.50	111.25	126.88	23.28	22.08	22.68
2. P1 × P3		138.75	112.50	125.63	24.46	24.80	24.63
3. P1 × P4		143.75	117.50	130.63	22.29	20.78	21.54
4. P1 × P5		132.50	108.75	120.63	24.81	21.80	23.30
5. P1 × P6		130.00	116.25	123.13	22.75	20.38	21.56
6. P1 × P7		135.00	110.00	122.50	29.30	24.76	27.03
7. P1 × P8		142.50	115.00	128.75	21.98	21.46	21.72
8. P1 × P9		145.00	118.75	131.88	24.56	23.20	23.88
9. P2 × P3		142.50	110.00	126.25	24.45	23.40	23.93
10. P2 × P4		116.25	116.25	116.25	27.24	24.02	25.63
11. P2 × P5		132.50	113.75	123.13	25.69	25.51	25.60
12. P2 × P6		148.75	107.50	128.13	27.54	24.19	25.86
13. P2 × P7		112.50	118.75	115.63	24.58	20.87	22.73
14. P2 × P8		140.00	108.75	124.38	25.14	20.67	22.91
15. P2 × P9		150.00	112.50	131.25	25.04	21.42	23.23
16. P3 × P4		146.25	112.50	129.38	25.14	23.08	24.11
17. P3 × P5		138.75	111.25	125.00	27.49	20.02	23.76
18. P3 × P6		125.00	102.50	113.75	25.31	21.38	23.35
19. P3 × P7		123.75	117.50	120.63	21.51	18.59	20.05
20. P3 × P8		125.00	116.25	120.63	25.58	20.57	23.07
21. P3 × P9		131.25	103.75	117.50	20.49	18.18	19.33
22. P4 × P5		127.50	106.25	116.88	24.28	20.05	22.17
23. P4 × P6		142.50	113.75	128.13	23.51	23.58	23.54
24. P4 × P7		155.00	111.25	133.13	27.44	21.43	24.43
25. P4 × P8		146.25	117.50	131.88	31.13	25.64	28.39
26. P4 × P9		142.50	117.50	130.00	24.22	21.69	22.96
27. P5 × P6		138.75	98.75	118.75	22.06	17.56	19.81
28. P5 × P7		145.00	105.00	125.00	24.54	21.18	22.86
29. P5 × P8		121.25	113.75	117.50	25.55	21.88	23.71
30. P5 × P9		136.25	108.75	122.50	25.49	19.85	22.67
31. P6 × P7		128.75	102.50	115.63	21.72	19.09	20.41
32. P6 × P8		135.00	116.25	125.63	23.70	19.45	21.58
33. P6 × P9		137.50	110.00	123.75	22.14	18.96	20.55
34. P7 × P8		148.75	118.75	133.75	30.35	26.94	28.65
35. P7 × P9		133.75	117.50	125.63	24.74	23.98	24.36
36. P8 × P9		126.25	115.00	120.63	24.28	19.23	21.76
Checks	**SC 162**	161.25	127.50	144.37	27.39	18.43	22.91
	SC 168	133.75	116.25	125.00	26.64	24.96	25.80
LSD	**%0.05**	15.21	12.49	9.85	2.91	2.24	2.236
	%0.01	19.82	16.28	12.82	3.79	2.90	2.899

crosses No. 27 and No. 31 to 216.25 cm for cross No. 5 at Sids location, and from 203.13 cm for cross No. 31 to 238.13 cm for cross No. 32 at the combined data over both locations. Also, all studied 36 crosses were significantly shorter than the tallest check SC 162 (277.50, 230.0 and 253.75 cm) at both locations (Gemmaiza and Sids) and their combined data (Table 3).

With respect to ear height, means of studied crosses for this trait ranged between 112.50 cm for cross No. 13 to155.00 cm for cross No. 24 at Gemmeiza location, from 98.75 cm for cross No. 27 to 118.75 cm for crosses No. 8 and No. 34 at Sids location, and from 113.75 cm for cross No. 18 to 133.75 cm for cross No. 34 at the combined data over both locations.Also, most of the studied crosses exhibited significantly lower position in ear height than both checks SC. 162 and SC. 168 under both locations (Gemmeiza and Sids) and their combined data, as shown in Table 4.

For grain yield/fad, the result in Table 4 revealed that means of studied crosses varied between 20.49 ardab/fad., for cross No. 21 to31.13 ardab/fad., for cross No. 25 at Gemmaiza location, from 18.18 ardab/fad., for cross No. 21 to 26.94 ardab/fad., for cross No. 34 at Sids location, and from 19.33 ardab/fad., for cross No. 21 to 28.65 ardab/fad., for cross No. 34 at the combined data over both locations. It is interest to note that two crosses; ($P_4 \times P_8$) and ($P_7 \times P_8$) were significantly surpassed in grain yield/fad., over the highest check cultivar SC 162 (27.39 ardab/fad.) at Gemmeiza location and SC 168 (25.80 ardab/ fad.) at combined data over both locations. Similar results were reported by Abdel-Moneam and Ibraheem (2015b).

General Combining Ability Effects ($g^\wedge_i$)

Estimation of (g^i) of four traits for both Gemmeiza and Sids location as well as the combined data are presented in Tables 5 and 6. High positive of general combining ability effects would be useful in most traits, while for days to 50% silk, plant height and ear height, high negative values would be useful from plant breeder point of view. General combining ability effects would be estimated, wherever the significant of GCA mean square for the trait in view.

For days to 50% silking, the parental inbred lines P_1 (Gm.500), P_5 (Gm.509) and P_6 (Gm. 515) at Gemmaiza location; P_1 (Gm. 500) and P_7 (Gm.518) at Sids location, and P_1 (Gm.500) and P_5 (Gm. 509) at combined data exhibited negative and significant or highly significant ($\hat{g}_i$) towards earliness, as shown in Table 5.

With respect to plant height (Table 5), parental inbred lines P_1 (Gm.500) and P_6 (Gm.515) at Gemmaiza location; P_5 (Gm. 509) and P_6 (Gm.515) at Sids location and combined data exhibited negative and significant or highly significant ($\hat{g}_i$) towards plant shortness.

Ear height results in Table 6 show that parental inbred lines P_6 (Gm.515) at Sids location and P_5 (Gm.509) at Sids location and combined data exhibited negative and highly significant ($\hat{g}_i$) towards lower ear position.

Grain yield/fad., results in Table 6 revealed that three parental inbred lines namely : P_4 (Gm. 508), P_7 (Gm.518) and P_8 (Gm. 520) at Gemmeiza location;three parental inbred lines namely : P_1 (Gm.500) and P_2 (Gm.505) and P_4 (Gm.508) at Sids location, and four parental inbred lines namely: P_2 (Gm.505), P_4 (Gm.508), P_7 (Gm.518) and P_8 (Gm.520)at combined data over both locations, showed positive significant or highly significant ($\hat{g}_i$), indicating that these inbred lines could be considered as the best combiners for increasing grain yield, as reported by Soliman and Osman (2006), Sultan *et al.* (2012 and 2013), Attia *et al.* (2013 and 2015) and Abdel-Moneam *et al*. (2014,a, b and c).

Table 5. Estimates of GCA effects of nine parental maize inbred lines for days to 50%silking and plant height (cm) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Parents		Days to 50% silking			Plant height (cm)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
P_1 (Gm.500)		-0.345 *	-0.341*	-0.343*	-2.956*	3.810*	0.427
P_2 (Gm.505)		0.048	-0.198	-0.075	-1.349	-0.298	-0.823
P_3 (Gm.507)		-0.131	0.230	0.050	0.437	1.845	1.141
P_4 (Gm.508)		0.155	0.194	0.175	-0.456	4.881*	2.212
P_5 (Gm.509)		-0.917**	-0.198	-0.558*	-1.349	-4.226*	-2.788**
P_6 (Gm.515)		-0.345**	-0.163	-0.254	-3.671**	-4.583*	-4.127**
P_7 (Gm.518)		0.655**	-0.520*	0.067	-1.528	-2.798	-2.163
P_8 (Gm.520)		0.512**	0.480*	0.496**	6.687**	1.488	4.087**
P_9 (Gm.522)		0.369*	0.516	0.442**	4.187**	-0.119	2.034
LSD (gi)	%0.05	0.268	0.338	0.270	2.246	3.049	2.373
	%0.01	0.438	0.551	0.352	3.667	4.978	3.092
LSD (gi-gj)	%0.05	0.403	0.506	0.407	3.368	4.573	3.577
	%0.01	0.657	0.827	0.528	5.500	7.468	4.637

Table 6. Estimates of GCA effects of nine parental maize inbred lines for ear height (cm) and grain yield (ardab/fad.) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Parents		Ear height (cm)			Grain yield (ardab/fad.)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
P_1 (Gm.500)		2.778	1.944	2.361	-0.741*	0.793**	0.026
P_2 (Gm.505)		-0.794	0.337	-0.228	0.622	1.208**	0.915**
P_3 (Gm.507)		-2.758	-1.448	-2.103	-0.599	-0.525	-0.562*
P_4 (Gm.508)		4.206*	2.302	3.254**	0.948*	0.939*	0.943**
P_5 (Gm.509)		-2.579	-4.306**	-3.442**	0.186	-0.836*	-0.325
P_6 (Gm.515)		-0.615	-4.127**	-2.371	-1.414**	-1.302**	-1.358**
P_7 (Gm.518)		-1.151	0.694	-0.228	0.794*	0.448	0.621*
P_8 (Gm.520)		-0.794	3.552*	1.379	1.299**	0.305	0.802**
P_9 (Gm.522)		1.706	1.052	1.379	-1.095*	-1.029**	-1.062**
LSD (gi)	%0.05	3.060	2.512	2.481	0.678	0.584	0.561
	%0.01	4.996	4.102	3.232	1.107	0.954	0.731
LSD (gi-gj)	%0.05	4.590	3.769	3.740	1.017	0.876	0.845
	%0.01	7.495	6.154	4.849	1.660	1.431	1.096

Specific combining ability effects ($s\hat{}_{ij}$)

Estimation of ($s^{\wedge}_{ij}$) of the four studied traits at the tow locations (Gemmeiza and Sids) and their combined data are presented in Tables 7 and 8.

Regarding days to 50% silking, results in Table 7 appear that, three crosses ($P_1 \times P_7$, $P_2 \times P_4$ and $P_7 \times P_8$) at Gemmeiza location; six crosses ($P_1 \times P_2$, $P_1 \times P_7$, $P_2 \times P_3$, $P_2 \times P_4$, $P_5 \times P_7$ and $P_7 \times P_8$) at Sids location, and four crosses ($P_1 \times P_7$, $P_2 \times P_3$, $P_2 \times P_4$ and $P_7 \times P_8$) at combined data over both locations exhibited desirable ($s^{\wedge}_{ij}$) towards earliness, where they recorded negative significant or highly significant SCA effects for this trait.

For plant height, as given in Table 7 out of the studied 36 maize crosses, ten of them *i.e.* No. 3, 10, 13, 18, 20, 28, 29, 31, 33 and 36 at Gemmeiza location; one cross ($P_6 \times P_7$) at Sids location, and five crosses $P_2 \times P_4$, $P_2 \times P_7$, $P_3 \times P_6$, $P_5 \times P_8$ and $P_6 \times P_7$ at combined data over both locations, exhibited desirable ($s^{\wedge}_{ij}$) towards shortness, where they recorded negative significant or highly significant SCA effects for this trait.

With respect to ear height, results in Table 8 clear that, out of the studied 36 crosses, there were five crosses ($P_2 \times P_4$, $P_2 \times P_7$, $P_4 \times P_5$, $P_5 \times P_8$ and $P_8 \times P_9$) at Gemmaiza location; one cross ($P_3 \times P_9$) at Sids location, and two crosses ($P_2 \times P_4$ and $P_4 \times P_5$) at combined data over both locations, exhibited desirable ($s^{\wedge}_{ij}$) towards lower ear placement, where they showed negative significant or highly significant SCA effects for this trait.

For grain yield, out of the studied 36 maize crosses (Table 8), there were six crosses ($P_1 \times P_7$, $P_2 \times P_6$, $P_3 \times P_5$, $P_3 \times P_6$, $P_4 \times P_8$ and $P_7 \times P_8$) at Gemmeiza location; eight crosses ($P_1 \times P_3$, $P_1 \times P_7$, $P_2 \times P_5$, $P_2 \times P_6$, $P_4 \times P_6$, $P_4 \times P_8$, $P_7 \times P_8$ and $P_7 \times P_9$) at Sids location, and seven crosses ($P_1 \times P_3$, $P_1 \times P_7$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_6$, $P_4 \times P_8$ and $P_7 \times P_8$) at combined data over both locations, exhibited desirable ($s^{\wedge}_{ij}$) towards high grain yield, where they recorded positive significant or highly significant SCA effects for this trait. It is interest to note that the previous crosses shord at least one of good general combiner parent. Similar results were reported by other authors such as, Sultan *et al.* (2012 and 2013), Attia *et al.* (2013 and 2015) and Abdel-Moneam *et al.* (2014,a, b and c).

Superiority Percentages

Superiority percentages in maize grain yield for the 36 new single crosses relative to two checks SC162 and SC168 based on the combined data between the two locations (Gemmeiza and Sids) are presented in Table 9. Results indicated that six crosses namely; $P_7 \times P_8$, $P_4 \times P_8$, $P_1 \times P_7$, $P_2 \times P_6$, $P_2 \times P_4$ and $P_2 \times P_5$, showed positive and highly significant or significant superiority percentages over SC 162, which were 25.05, 23.92, 17.98, 12.88, 11.87 and 11.74%, respectively. Whereas, only two crosses namely; $P_7 \times P_8$ and $P_4 \times P_8$, showed positive significant of superiority percentages over SC 168, which were 11.05 and 10.04%, respectively. Finally, we found that the two new crosses No. 34 and 25 ($P_7 \times P_8$ and $P_4 \times P_8$) were the best crosses, where they recorded the highest percentages of superiority in grain yield over both commercial hybrids SC 162 and SC 168. These results are similar with those reported by Ibrahim *et al.* (2007), Abdel-Moneam *et al.* (2014, a, b and c) and Abdel-Moneam and Ibraheem (2015 a,b).

Table 7. Estimates of SCA effects of 36 maize single crosses for days to 50% silking and plant height (cm) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Crosses		Days to 50% silking			Plant height (cm)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
1. $P_1 \times P_2$		0.40	-1.07*	-0.33	-1.56	-8.62	-5.09
2. $P_1 \times P_3$		0.33	-0.25	0.04	1.65	4.24	2.95
3. $P_1 \times P_4$		0.54	0.79	0.67	-7.46*	-3.79	-5.63
4. $P_1 \times P_5$		0.62	0.68	0.65	2.19	-0.94	0.62
5. $P_1 \times P_6$		0.04	1.64**	0.84*	-1.74	13.17**	5.71
6. $P_1 \times P_7$		-0.96*	-1.50**	-1.23**	9.87**	-1.12	4.37
7. $P_1 \times P_8$		-0.56	-0.25	-0.41	-0.85	-4.15	-2.50
8. $P_1 \times P_9$		-0.42	-0.04	-0.23	-2.10	1.21	-0.45
9. $P_2 \times P_3$		-0.56	-1.89**	-1.23**	2.54	2.10	2.32
10. $P_2 \times P_4$		-0.85*	-1.36**	-1.10**	-21.56**	1.56	-10.00**
11. $P_2 \times P_5$		-0.03	1.04*	0.50	15.58	9.42	12.50**
12. $P_2 \times P_6$		0.15	-0.25	-0.05	7.90*	-0.22	3.84
13. $P_2 \times P_7$		1.15**	1.61**	1.38**	-24.24**	1.74	-11.25**
14. $P_2 \times P_8$		0.54	1.36**	0.95*	-4.96	-6.29	-5.63
15. $P_2 \times P_9$		-0.81	0.57	-0.12	26.29**	0.31	13.30**
16. $P_3 \times P_4$		-0.42	-0.54	-0.48	9.15**	-4.33	2.41
17. $P_3 \times P_5$		0.15	-0.14	0.00	6.29	2.28	4.29
18. $P_3 \times P_6$		-0.42	-1.43**	-0.92*	-13.88**	-2.37	-8.13*
19. $P_3 \times P_7$		0.58	1.18*	0.88*	11.47**	7.10	9.29**
20. $P_3 \times P_8$		-0.53	0.93	0.20	-10.49**	-5.94	-8.21*
21. $P_3 \times P_9$		0.87*	2.14**	1.50**	-6.74	-3.08	-4.91
22. $P_4 \times P_5$		0.12	0.89	0.50	-1.56	-0.76	-1.16
23. $P_4 \times P_6$		-0.21	-0.89	-0.55	-4.24	0.85	-1.70
24. $P_4 \times P_7$		0.29	1.46**	0.88*	16.12**	1.56	8.84**
25. $P_4 \times P_8$		0.19	0.46	0.33	9.15*	1.03	5.09
26. $P_4 \times P_9$		0.33	-0.82	-0.25	0.40	3.88	2.14
27. $P_5 \times P_6$		-0.38	0.50	0.06	4.15	-8.79	-2.32
28. $P_5 \times P_7$		0.37	-1.39**	-0.51	-7.99*	0.67	-3.66
29. $P_5 \times P_8$		-0.24	-0.89	-0.57	-16.21**	2.63	-6.79*
30. $P_5 \times P_9$		-0.60	-0.68	-0.64	-2.46	-4.51	-3.48
31. $P_6 \times P_7$		-0.46	0.57	0.06	-10.67**	-10.22*	-10.45**
32. $P_6 \times P_8$		1.19**	0.07	0.63	26.12**	10.49*	18.30**
33. $P_6 \times P_9$		0.08	-0.21	-0.07	-7.63*	-2.90	-5.27
34. $P_7 \times P_8$		-1.06*	-1.32*	-1.19**	5.22	-1.29	1.96
35. $P_7 \times P_9$		0.08	-0.61	-0.26	0.22	1.56	0.89
36. $P_8 \times P_9$		0.47	-0.36	0.06	-7.99*	3.53	-2.23
LSD (sij)	%0.05	0.82	1.03	0.76	6.84	9.29	6.69
	%0.01	1.07	1.34	0.99	8.91	12.10	8.68
LSD (sij-ski)	%0.05	1.24	1.55	1.00	10.34	14.04	8.76
	%0.01	1.61	2.03	1.29	13.47	18.29	11.36

Table 8. Estimates of SCA effects of 36 maize single crosses for ear height (cm) and grain yield (ardab/fad.) at two locations (Gemmeiza and Sids) and their combined, during 2015 season

Crosses		Ear height (cm)			Grain yield (ardab/fad.)		
		Gm	Sd.	Com.	Gm	Sd.	Com.
1. $P_1 \times P_2$		4.20	-3.08	0.56	-1.43	-1.63	-1.53
2. $P_1 \times P_3$		2.41	-0.04	1.18	0.97	2.82**	1.90*
3. $P_1 \times P_4$		0.45	1.21	0.83	-2.74*	-2.67**	-2.70**
4. $P_1 \times P_5$		-4.02	-0.94	-2.48	0.54	0.13	0.33
5. $P_1 \times P_6$		-8.48	6.38	-1.05	0.07	-0.82	-0.37
6. $P_1 \times P_7$		-2.95	-4.69	-3.82	4.42**	1.80*	3.11**
7. $P_1 \times P_8$		4.20	-2.54	0.83	-3.40**	-1.36	-2.38**
8. $P_1 \times P_9$		4.20	3.71	3.95	1.57	1.72	1.64*
9. $P_2 \times P_3$		9.73*	-0.94	4.40	-0.40	1.00	0.30
10. $P_2 \times P_4$		-23.48**	1.56	-10.96**	0.85	0.16	0.50
11. $P_2 \times P_5$		-0.45	5.67	2.61	0.05	3.43**	1.74*
12. $P_2 \times P_6$		13.84**	-0.76	6.54	3.50**	2.57**	3.04**
13. $P_2 \times P_7$		-21.88**	5.67	-8.10	-1.66	-2.50**	-2.08**
14. $P_2 \times P_8$		5.27	-7.19	-0.96	-1.61	-2.55**	-2.08**
15. $P_2 \times P_9$		12.77**	-0.94	5.92	0.69	-0.47	0.11
16. $P_3 \times P_4$		8.48	-0.40	4.04	-0.04	0.96	0.46
17. $P_3 \times P_5$		7.77	4.96	6.36	3.08*	-0.33	1.37
18. $P_3 \times P_6$		-7.95	-3.97	-5.96	2.49*	1.50	2.00*
19. $P_3 \times P_7$		-8.66	6.21	-1.23	-3.52**	-3.04**	-3.28**
20. $P_3 \times P_8$		-7.77	2.10	-2.83	0.05	-0.93	-0.44
21. $P_3 \times P_9$		-4.02	-7.90**	-5.96	-2.65*	-1.98*	-2.31**
22. $P_4 \times P_5$		-10.45**	-3.79	-7.12*	-1.68	-1.76	-1.72
23. $P_4 \times P_6$		2.59	3.53	3.06	-0.86	2.23**	0.69
24. $P_4 \times P_7$		15.63**	-3.79	5.92	0.87	-1.67	-0.40
25. $P_4 \times P_8$		6.52	-0.40	3.06	4.05**	2.69**	3.37**
26. $P_4 \times P_9$		0.27	2.10	1.18	-0.46	0.07	-0.20
27. $P_5 \times P_6$		5.62	-4.87	0.38	-1.53	-2.02*	-1.78
28. $P_5 \times P_7$		12.41**	-3.44	4.49	-1.26	-0.14	-0.70
29. $P_5 \times P_8$		-11.70*	2.46	-4.62	-0.76	0.69	-0.03
30. $P_5 \times P_9$		0.80	-0.04	0.38	1.57	0.00	0.79
31. $P_6 \times P_7$		-5.80	-6.12	-5.96	-2.49*	-1.77	-2.13**
32. $P_6 \times P_8$		0.09	4.78	2.43	-1.01	-1.27	-1.14
33. $P_6 \times P_9$		0.09	1.03	0.56	-0.18	-0.43	-0.30
34. $P_7 \times P_8$		14.38**	2.46	8.42**	3.43**	4.47**	3.95**
35. $P_7 \times P_9$		-3.13	3.71	0.29	0.21	2.85**	1.53
36. $P_8 \times P_9$		-10.98**	-1.65	-6.32	-0.75	-1.76	-1.25
LSD (sij)	%0.05	9.32	7.65	7.00	2.06	1.78	1.58
	%0.01	12.14	9.97	9.07	2.69	2.32	2.05
LSD (sij-ski)	%0.05	14.09	11.57	9.16	3.12	2.69	2.07
	%0.01	18.36	15.07	11.88	4.07	3.50	2.68

Table 9. Superiority percentages of the 36 maize single crosses relative to two check hybrids (SC 162 and SC 168) for grain yield based on the combined data between the two locations (Gemmeiza and Sids), during 2015 season

Crosses		Grain yield (ardab/fad.)	
		SC 162	SC168
1. $P_1 \times P_2$		-1.00	-12.09**
2. $P_1 \times P_3$		7.51	-4.53
3. $P_1 \times P_4$		-5.98	-16.51**
4. $P_1 \times P_5$		1.70	-9.69*
5. $P_1 \times P_6$		-5.89	-16.43**
6. $P_1 \times P_7$		17.98**	4.77
7. $P_1 \times P_8$		-5.19	-15.81**
8. $P_1 \times P_9$		4.23	-7.44
9. $P_2 \times P_3$		4.45	-7.25
10. $P_2 \times P_4$		11.87*	-0.66
11. $P_2 \times P_5$		11.74*	-0.78
12. $P_2 \times P_6$		12.88**	0.23
13. $P_2 \times P_7$		-0.79	-11.90**
14. $P_2 \times P_8$		0.00	-11.20*
15. $P_2 \times P_9$		1.40	-9.96*
16. $P_3 \times P_4$		5.24	-6.55
17. $P_3 \times P_5$		3.71	-7.91
18. $P_3 \times P_6$		1.92	-9.50*
19. $P_3 \times P_7$		-12.48*	-22.29**
20. $P_3 \times P_8$		0.70	-10.58*
21. $P_3 \times P_9$		-15.63**	-25.08**
22. $P_4 \times P_5$		-3.23	-14.07**
23. $P_4 \times P_6$		2.75	-8.76*
24. $P_4 \times P_7$		6.63	-5.31
25. $P_4 \times P_8$		23.92**	10.04*
26. $P_4 \times P_9$		0.22	-11.01*
27. $P_5 \times P_6$		-13.53**	-23.22**
28. $P_5 \times P_7$		-0.22	-11.40**
29. $P_5 \times P_8$		3.49	-8.10
30. $P_5 \times P_9$		-1.05	-12.13**
31. $P_6 \times P_7$		-10.91*	-20.89**
32. $P_6 \times P_8$		-5.81	-16.36**
33. $P_6 \times P_9$		-10.30*	-20.35**
34. $P_7 \times P_8$		25.05**	11.05*
35. $P_7 \times P_9$		6.33	-5.58
36. $P_8 \times P_9$		-5.02	-15.66**
LSD	%0.05	2.236	
	%0.01	2.899	

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القدرة على التآلف والتفوق لمحصول الحبوب وبعض الصفات المرتبطة في الهجن الدائرية لتسع سلالات جديدة من الذرة الشامية الصفراء تحت موقعيين

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أجريت هذه الدراســة خلال الموسمين الزراعيين ٢٠١٤، ٢٠١٥ بمحطتي البحوث الزراعية بالجميزة وسدس، في موسم ٢٠١٤ تم إجراء التهجين النصف دائرى في محطة البحوث الزراعية بالجميزة بين ٩ سلالات جديدة من الذرة الشامية الصفراء (جميزة ٥٠٠، ٥٠٥، ٥٠٧ ، ٥٠٨ ، ٥٠٩ ، ٥٠١٥ ، ٥١٨ ، ٥٢٠ ، ٥٢٢)، وفي موسم ٢٠١٥ تم تقييم الــ ٣٦ هجين فردي المنتجة من الموسم الأول بالإضافة إلى هجيني المقارنة وهما هــف ١٦٢، هــف ١٦٨ في موقعي الجميزة وسدس وذلك فى تصميم القطاعات كاملة العشوائية فى أربعة مكررات. وذلك لدراسة القدرة على التآلف لتحديد أكثر السلالات تميزا والتى تنتج هجن متفوقة لتحسين إنتاجية الهجن الفردية الصفراء من الذرة الشامية، وكانت الصفات محل الدراسة هي عدد الإيام من الزراعـة حتى ظهور ٥٠% من النورات المؤنثة، ارتفاع النبات، ارتفاع الكوز ومحصول الحبوب أردب/فدان، وكانت أهم النتائج المتحصل عليها ما يلي: أظهرت النتائج أن التباين الراجع للهجن كان عالى المعنوية لكل الصفات المدروسة فى كلا الموقعين (الجميزة وسدس) والتحليل التجميعى بينهما، وكان تباين القدرة العامة والخاصة على التآلف معنوياً أو عالى المعنوية لكل الصفات المدروسة فى كلا الموقعين (الجميزة وسدس) والتحليل التجميعى بينهما، عدا تباين القدرة العامة على التآلف لصفة ارتفاع الكوز فى موقع الجميزة والقدرة الخاصة على التآلف لصفتى إرتفاع النبات وإرتفاع الكوز فى موقع سدس وكانت النسبة بين تباين القدرة العامة والقدرة الخاصة على التآلف أكبر من الوحدة لكل الصفات المدروسة فى كلا الموقعين والتحليل التجميعى بينهما، عدا صفتى إرتفاع النبات وارتفاع الكوز فى موقع الجميزة، وصفة عدد الأيام حتى ٥٠% حريرة فى موقع سدس. تشير هذه النتائج إلى أن تأثيرات الفعل الجينى المضيف كانت أكثر أهمية وتلعب دوراً رئيسياً فى وراثة هذه الصفات. بالنسبة لتأثير القدرة العامة على التآلف، كانت السلالتان جميزة ٥٠٠ و ٥٠٩ أفضل الآباء لصفات التبكير، وكانت الأربع سلالات (جميزة ٥٠٥ ، ٥٠٨ ، ٥١٨ ، ٥٢٠) هى الأفضل قدرة على التالف لصفة محصول الحبوب، أما بالنسبة للقدرة الخاصة على التآلف كانت الأربعة هجن : ($P_1 \times P_7$; $P_2 \times P_3$; $P_2 \times P_4$; $P_7 \times P_8$) الأفضل فى صفة التبكير، فى حين كانت السبعة هجن: ($P_1 \times P_3$; $P_1 \times P_7$; $P_2 \times P_5$; $P_2 \times P_6$; $P_3 \times P_6$; $P_4 \times P_8$; $P_7 \times P_8$) هى الأفضل فى تحسين صفة محصول الحبوب .بالنسبة للتفوق النسبى فى كمية المحصول، سجل هجينين (Gm. 518 × Gm. 520) و (Gm. 508 × Gm. 520) أعلى نسبة تفوق في محصول الحبوب على الهجينين التجاريين فردى ١٦٢ و فردى ١٦٨ .

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