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GENE ACTION AND COMBINING ABILITY ESTIMATES FOR SOME WHITE PROMISING MAIZE INBRED LINES BY TOP CROSS SYSTEM

Barakat A. A. and M.M.A. Osman
Maize Res. Section, Field Crops Research Institute, ARC, Giza Egypt

ABSTRACT

Eleven white maize (*Zea mays, L.*) inbred lines isolated from different populations were topcrossed with each of three line testers, **i.e** Gm 4, Gm 21 and, Gm 22. All inbred lines and testers were developed at Gemmeiza Research Station from different genetic sources. The 33 topcrosses along with three checks, **i.e.** SC 10, SC 129 and SC 122 were evaluated at Sakha and Gemmeiza Research Stations during 2007 growing season. General (GCA) and specific (SCA) combining ability as well as other genetic parameters estimates were calculated for days to 50 % silking, plant height, ear height, number of ears/100 plants, ear length, ear diameter, number of rows/ear, kernels number per row and grain yield (ard/fad). Results indicated that ,there were highly significant differences among the evaluated 33 topcrosses for all studied traits across the two locations. Differences among inbred lines were highly significant for all traits. However, significant differences were detected among testers for silking date, ear height, ear length, ear diameter, rows/ear and grain yield. The interaction of both tested and tester inbred lines with locations was significant in case of silking date, ears/100 plants and grain yield. Significant interaction of lines x testers was detected for all traits except ear height and kernels number per row. Also, the locations interaction with lines and testers was highly significant for silking date, ears/100 plants and grain yield. The tested inbred lines and testers exhibited significant GCA effects vary greatly according to the studied traits. The variance magnitude due to GCA for tested and tester lines was higher than that due to SCA for all studied traits, except silking date, number of rows/ear. This indicates that additive genetic variance was the major source of variation responsible for the inheritance of these traits. Tester inbred line Gm 4 was the best general combiner for grain yield ability. Three single crosses i.e Gm- 304 x Gm- 4, Gm- 307 x Gm- 4 and Gm- 310 x Gm- 4 were significantly earlier and shorter than the commercial single crosses 10, 122 and 129. At the same time the grain yield ability for these three promising single crosses was equal to the best check sc 10 with no significant difference, better than the check Sc 122 and significantly higher than the commercial Sc 129. Therefore, these crosses should be released as new white earlier, shorter with high yield Potentiality relative to the three commercial check single crosses.

INTRODUCTION

Topcross selection with a broad and/or narrow base tester is among several procedures used to evaluate new improved inbreds for combining ability in maize hybrid breeding. This method was first suggested by Davis (1927), Jenkins (1935) and Sprague (1939) under the early testing scheme for new inbreds. Hallauer (1975), Bauman (1981) and Hallauer and Miranda (1981), concluded that a suitable tester should include simplicity in use, provide information that correctly classifies the relative merits of lines and maximize genetic gain. Russell *et al* (1992) and Menz *et al* (1999) concluded that improving inbred lines increased grain yield and modified maturity of their hybrids. However, Matzinger (1953) stated that the choice of a tester to test the developed inbred lines is an important decision and a narrow genetic-base tester contributes more to line x tester interaction than does a heterogeneous one.

Several investigators (Russell *et al,* 1973, Walejko and Russell, 1977, Zambezi *et al,* 1986, El-Itriby *et al* (1990), Mahgoub *et al,* 1996, Al-Naggar *et al,* 1997, Sultan (1998), Gado *et al* (2000) and Soliman, 2000) indicated that inbred testers are effective for estimating both general and specific combining ability effects. Estimation of different components of genetic variance may vary with the type of genetic materials under study. However, Zambezi *et* al (1986) added that inbred testers offer definite advantages over broad-base genetic tests

Results concerning the genetic analysis of grain yield and other agronomic traits were reported by Sultan (1998), El-Zeir (1999), Abd El-Aziz (2001), Luis Narro *et al* (2003) and Abd El-Aal (2007). They indicated that the relative importance of different components of genetic variance may vary with the type of genetic materials under study. Studies conducted with homozygous base populations indicated the importance of overdominance in grain yield performance (Vedeneev, 1988 and El-Zeir *et al*, 2000).

Several investigators (Russell *et al* (1973), Balko and Russell 1980, Diab *et al*, 1994, Ragheb *et al,* 1995, Shehata *et al*, 1997, Sultan (1998), Soliman, 2000 and Sadek *et al* 2001) reported that the variance component due to SCA for grain yield and few agronomic traits was relatively larger than that due to GCA indicating the importance of non-additive type of gene action in the inheritance of these traits in materials or lines selected previously for grain yield performance. However, El-Itriby *et al* (1990), Shehata *et al* (1997), El-Zeir (1999), Mahmoud *et* al (2001), Luis Narro *et al* (2003) and Soliman *et al* (2001 and 2005) stated that when the lines were relatively unselected, GCA or the additive type of gene action became more important.

The genotype x environment interaction is defined as the differential response of phenotype to the change in environment (Comstock and Moll 1963). The non-additive component of genetic variation significantly interacted with the environment more than the additive component. In contrast, Stuber and Moll (1977) and Soliman and Osman (2006) reported that general combining ability x environment interaction was significantly larger than the interaction of specific combining ability x environment even though the variance estimate for specific combining ability was more than that of general combining ability.

The main objectives of this investigation were to estimate general (GCA) and specific (SCA) combining ability effects and type of gene action involved in the manifestation of grain yield and other agronomic traits of eleven white inbred lines selected for a high level of grain yield and identify the most superior line(s) and single crosses for further use in the breeding program.

MATERIALS AND METHODS

The used genetic materials (Table 1) are white eleven selected tested S_5 inbred line families developed at Gemmeiza Agricultural Research Station (GARS) as well as commercial white tester inbred lines i.e Gm 4, Gm 21 and Gm 22 developed at the same (GARS) during the period from 1983 to 1998 by S.E. Sadek *et al*, National Maize Research Program (NMRP), Field Crops Research institute (FCRI), Agricultural Research Center (ARC), Ministry of Agriculture, Egypt. These tested and tester lines are adapted and resistant to late wilt disease. The tested eleven inbred lines were top crossed with of the three line testers. The 33 topcrosses were constituted during the 2006 summer season at Gemmeiza Experimental Station. The thirty-three top crosses were evaluated in a replicated yield trials conducted in 2007 growing season at Sakha and Gemmeiza Research Stations. A randomized complete block design with four replications was used in each location. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. Two kernels were planted per hill and thinned later to one plant per hill to provide a population of approximately 21,000 plants/fad (faddan=4200 m^2). All cultural practices for maize production were applied as recommended. Data were recorded for number of days to 50% silking, plant height, ear height, number of ears/100 plants, ear length (cm), ear diameter (cm), number of rows/ear, kernels number per row and adjusted grain yield at 15.5% grain moisture and converted to ardab/fad (ardab=140 kg).

Table 1: The used genetic materials

Tested inbred lines		Tester inbred lines	
S_5 tested line family	**Origin**	**Line name**	**Origin**
Gm 301, Gm 302, Gm 303	Tep# 5	Gm 2	DC 201
		Gm 21	Gm7421.Fam 1007
Gm 304, Gm 305	AED	Gm 22	Gm7421.Fam 1011
Gm 306, Gm 307	Giza-2-Ev.6		
Gm308,Gm309,Gm 310, Gm 311	Laposta		

Tep #5 = Tepal-5 subtropical white population , Laposta = Tropical thenthatic
AED = American Early Dent White maize population.

Analysis of variance was performed for separate location and combined data over locations according to Steel and Torrie (1980). The homogeneity of the experimental error of each character at the two locations was tested using Partlett Test and found to be not significant. Therefore, the combined data across the two locations were used in the current analysis. Procedures of Kempthorne (1957) were performed to obtain valuable information about lines and testers combining ability as well as their topcrosses. and to estimate the type of gene action which control grain yield and other traits as shown in Table 2.

Table 2: Combined analysis of variance for the data obtained from two locations involving 33 top-crosses (11 inbred lines, females and 3 testers, males) in 4 replications.

S.O.V	DF	MS	EMS
Locations (L)	(l - 1)		
Rep's/L	L(r-1)		
Genotypes (G)	(g-1)		
Checks	(ch-1)		
Cr vs Ch	1		
Crosses	(Cr-1)		
Lines (F)	(f-1)	M1	$\sigma^2 + r\sigma^2 fml + rm\sigma^2 fl + rl\sigma^2 fm + rml\sigma^2 f$
Testers (M)	(m-1)	M2	$\sigma^2 + r\sigma^2 fml + rf\sigma^2 ml + rl\sigma^2 fm + rfl\sigma^2 m$
F x M	(f - 1)(m - 1)	M3	$\sigma^2 + r\sigma^2 fml + rl\sigma^2 fm$
G x L	(l - 1)(g - 1)		
L x Checks	(l-1) (ch-1)		
L x Cr vs Ch	(l-1)		
L x Crosses	(l-1) (Cr-1)		
F x L	(l - 1)(f - 1)	M4	$\sigma^2 + r\sigma^2 fml + rm\sigma^2 fl$
M x L	(l - 1)(m - 1)	M5	$\sigma^2 + r\sigma^2 fml + rf\sigma^2 ml$
F x M x L	(l - 1)(f - 1)(m - 1)	M6	$\sigma^2 + r\sigma^2 fml$
Pooled error	**L(r-1)(g-1)**	**M7**	σ^2

Where:
1 -$\sigma^2 f$ = variance due to inbreds = [M1 - M3 - M4 + M6]/rml
2 - $\sigma^2 m$ = variance due to testers = [M2 - M3 - M5 + M6]/rfl
3 - $\sigma^2 fm$ = variance due to (inbreds x testers) = [M3 - M6]/rl
4- $\sigma^2 fl$ = variance due to inbreds x locations = [M4 - M6]/rm
5- $\sigma^2 ml$ = variance due to testers x locations = [M5 - M6]/rf
6- $\sigma^2 fml$ = variance due to (inbreds x testers) x locations = [m6 - M7]/r

The following covariance estimates were calculated from the mean squares of the combined analysis:

Cov HS = $[m\sigma^2 f + f\sigma^2 m]/m+f$ $\quad$ σ^2 SCA. = Cov.FS - 2Cov HS= $\sigma^2 fm$

Cov FS = $\sigma^2 fm$ + 2 Cov HS $\quad$ σ^2GCA. x L = $[m\sigma^2 fl + f\sigma^2 ml]/m+f$

σ^2 GCA. = Cov. H.S. $\quad$ σ^2SCA. x L = $\sigma^2 mfl$

Estimates of general and specific combining ability effects for inbreds, testers and (inbred x tester) crosses as well as standard errors for combining ability effects were computed as usual.

RESULTS AND DISCUSSION

1. Analysis of variance:-

Data presented in Table (3) show significant differences among genotypes for all studied traits, when the data were combined over the two locations. Also, mean significant differences were detected between checks, genotypes ***vs*** checks and crosses for all studied traits. Because of the variation due to crosses was highly significant, sum of square due to crosses was further partitioned into lines (females), testers (males) and (line x tester) interaction as shown in Table (3). Significant differences were obtained among lines with respect to all traits

3

The three testers differed significantly in all traits except plant height, number of ears/100 plants and number of kernels/row. Highly significant lines x testers interactions were obtained for all studied traits except plant and ear height, ear diameter as well as number of kernels/row.

2. Genotype x environment interaction:

Environments (locations) had highly significant effects for all studied traits except number of ears/100 plants (Table 3). The genotypes x locations interaction was highly significant for days to 50% silking, plant height, number of ears/100 plants and grain yield. The check hybrids interacted significantly with locations respecting all studied traits, except that of days to 50% silking, number of rows/ear and number of kernels/row indicated that the used checks in this trial behave differentially at the two locations. The interaction of crosses, lines, testers and lines x testers with locations was highly significant for some traits indicated that both lines and testers behaved independently according to the prevailing environment. However, the inbred lines x locations interaction was significant for 3 studied traits, ***i.***e. number of days to 50% silking, number of ears/100 plants and grain yield. This may be indicated that the studied inbred lines behaved significantly different in their respective topcrosses within the specific environments. Testers x locations interaction was also significant across the two locations for days to 50 % silking, number of ears/100 plants, number of rows/ear, number of kernels/row and grain yield, indicating that the studied three testers significantly differed from each other in inbred x tester crosses and behaved similarly in the two locations. The interaction of inbred x tester x locations was significant for only silking date, number of ears/100 plants and grain yield per faddan. This indicates that inbreds may perform similarly in their crosses at different locations depending on the type of used tester.

3. Mean performance of topcrosses:

Results in Table (4) showed that the three check hybrids SC. 10, SC. 129 and SC. 122 differed significantly in their performance. SC. 10 produced the highest grain yield as compared to other check hybrids. Topcrosses (Gm-307 x Gm-4) insignificantly out yielded SC.10 (34.62 and 33.15 ***vs*** 33.30 ard/fad, respectively), whereas it significantly surpassed SC. 122 and SC. 129 However, another eight topcrosses significantly surpassed both S.C. 122 and S.C. 129. It is worth noting that lines were differed significantly in their crosses in most of the studied traits. For days to 50 % silking, the topcrosses of tested inbred lines Gm-301, Gm-302, Gm-303, Gm-304, Gm-307, Gm-309, Gm- 310 and Gm-311 with the tester Gm-4 and Gm-21 were earlier than all of the commercial check single crosses. For plant height and ear height, all inbred lines behaved the same when topcrossed with each of the three testers. However, the inbred lines Gm-301 and Gm-302 produced the shortest plants and the lowest ear placement when topcrossed with either the inbred testers Gm-4 or Gm-22. Respecting number of ears/100 plants, Gm-307 and Gm-311 produced more ears per plant when topcrossed with either of the three testers. The four inbred lines, Gm-304, Gm-305, Gm-310 and Gm-311 exhibited better ear characteristics (ear length, ear diameter, number of rows/ear and number of kernels per row) when topcrossed with either the two inbred testers Gm-4 or Gm-21. However, the highest number of kernels per row was obtained when topcrosses six inbred lines (Gm-301, Gm-304, Gm-305, Gm-306, Gm-307, Gm-310 and Gm-311) with the line tester Gm-22 (Table 4).

Table 4: Mean performance of 36 genotypes (33 topcrosses and 3 checks) combined over two locations, 2007 growing season.

ENTRY	Days to 50% silking			Plant height cm			Ear height cm			Ears/ 100 plants		
	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22
Gm-301	58	58	58	247	251	248	131	131	137	101.0	105.8	101.5
Gm-302	58	57	58	260	259	261	142	140	153	102.3	104.7	101.0
Gm-303	58	58	58	266	257	271	139	139	149	104.0	105.0	101.6
Gm-304	58	58	59	261	263	265	145	149	150	106.8	109.3	103.6
Gm-305	60	60	60	259	264	265	149	142	150	114.5	119.5	112.4
Gm-306	60	61	58	263	261	256	149	149	145	109.3	105.0	131.3
Gm-307	58	٥٨	58	261	263	259	139	142	146	146.7	149.6	131.0
Gm-308	58	57	60	263	251	258	144	141	146	108.0	102.7	121.9
Gm-309	58	58	59	257	261	256	142	144	148	104.7	109.9	119.6
Gm-310	58	58	58	251	263	253	137	146	139	106.2	111.2	105.3
Gm-311	58	58	57	264	266	273	140	140	146	130.8	116.3	126.2
SC 10		63			281.1			185			108.9	
SC 129		60.4			301.8			173.9			106.5	
SC 122		60.9			272.8			162.3			113.1	
Average		59.1			262			145.8			112.7	
LSD 0.05		0.69			9.51			8.21			8.66	
LSD 0.01		0.91			12.42			10.72			11.3	

Table 4: Continued ..

ENTRY	Ear length cm			Ear diameter cm			Rows/ ear			Kernels/row			Grain yield ard/fad		
	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22
Gm-301	19.8	20.1	19.6	4.8	4.6	4.6	12.9	12.6	14.4	37.0	40.0	40.2	25.48	30.93	24.44
Gm-302	20.4	20.1	18.9	4.6	4.6	4.5	13.0	12.6	13.0	40.3	38.9	38	27.66	23.64	25.23
Gm-303	21.0	19.8	20.1	4.6	4.6	4.5	13.0	13.1	13.8	38.0	36.7	38.4	29.20	25.25	21.80
Gm-304	21.7	21.8	19.3	4.7	4.5	4.5	13.4	12.6	15.1	41.7	41.8	43.1	31.33	26.12	26.51
Gm-305	20.4	19.7	19.7	4.6	4.5	4.7	12.6	12.4	14.0	41.8	40.7	44.1	27.27	25.53	24.16
Gm-306	19.2	19.6	18.5	4.5	4.6	4.4	12.4	12.6	13.1	40.2	39.3	40.5	25.84	22.66	26.15
Gm-307	20.5	19.9	18.6	4.7	4.6	4.7	13.0	12.7	13.7	40.6	41.1	40.0	34.62	27.54	29.65
Gm-308	21.9	20.3	18.8	4.7	4.8	4.5	11.8	13.6	13.5	39.8	39.6	38.1	29.46	29.26	26.43
Gm-309	21.2	20.9	18.8	4.7	4.6	4.5	12.1	12.4	13.8	37.9	39.4	39.3	26.97	27.22	25.25
Gm-310	20.8	21.2	18.7	4.8	4.7	4.6	12.8	12.2	13.8	41.8	40.8	41.3	33.15	30.31	25.65
Gm-311	20.3	19.5	18.5	4.6	4.4	4.4	12.9	12.8	13.8	42.1	42.4	41.3	30.83	26.63	25.85
SC 10		22.1			4.9			13.3			60.4			33.3	
SC 129		20.9			4.7			15.4			44.7			26.57	
SC 122		21.2			4.8			14.2			44.3			30.44	
Average		20.1			4.6			13.2			40.5			27.5	
LSD 0.05		0.9			0.18			0.66			2.35			2.21	
LSD 0.01		1.2			0.23			0.86			3.07			2.88	

The behavior of the studied inbred lines respecting grain yield differed remarkably in their topcrosses with the studied three testers (Table 4). The tester line Gm-4 when topcrossed with inbred lines Gm-304, Gm-307 and Gm-310 produced high yielding crosses as compared to other crosses with the same tester. On the contrary, the highest grain yield was obtained when topcrossed Gm-301 and Gm-310 as inbred lines with the inbred tester Gm-21. These two crosses produced 30.93 and 30.31 ard/fad, respectively and significantly surpassed the check SC 129. Among topcrosses with the tester line Gm-22, the topcross (Gm-307 x Gm-22) produced the highest grain yield as compared to the check hybrid SC 129. These crosses were the highest ones as compared to other crosses and could be released as new single crosses or could be used as a good source for further breeding studies to improve it or as a base population to isolate high yielding new inbred lines in a hybrid breeding program. In this regard, Vedeneev (1988), El-Itriby *et al* (1990) and Mahmoud *et al* (2001) reported that a good tester should has precision in discriminating among genotypes under test, that is, the best tester would be the one that would give the most precise classification among entries for a given amount of testing.

4. General combining ability effects ($\hat{g}_i$):

Data presented in Table (5) showed the general combining ability effects ($\hat{g}_i$) for lines and testers for all studied traits based on the combined data in 2007 growing season. Respecting number of days to 50 % silking, eight inbred lines exhibited negative and significant estimates of $\hat{g}_i$ (toward earliness), whereas other three inbred lines, ***i.e.*** Gm-305, Gm-306 and Gm-307 possessed positive and significant values of general combining ability effect (toward lateness). Respecting plant height, four inbred lines, Gm-301, Gm-308, Gm-309 and Gm-310. had negative $\hat{g}_i$ values toward shortness, one of them (Gm-301) had significant $\hat{g}_i$ value (-11.269**), however, plant height traits for the inbred line Gm-311 had significant positive GCA effect. The same trend was observed in case of ear height, the inbred lines Gm-301, Gm-303, Gm-307, Gm-310 and Gm-311 had negative GCA effects toward low ear placement. On the other hand non of the studied inbred lines exhibited significant $\hat{g}_i$ values in case of ear height, except for Gm-301 which possessed negative significant GCA effect (-10.292**).

For number of ears/100 plants, it is worthy to note that six out of eleven studied inbred lines had significant values of $\hat{g}_i$ effect, four of them had negative values whereas the other two (Gm-307 and Gm-311) exhibited positive GCA values toward bearing more than one ear/plant (29.426** and 11.459**). Non of the three testers showed significant $\hat{g}_i$ effect indicating that the testers used in this study did not have suitable ability to discriminate inbred females in case of the number of ears/plant and most of the genetic variance are due mainly to inbred lines ***per ce***. On the other hand, the two inbred lines that have significant positive $\hat{g}_i$ values (Gm-307 and Gm-311) were also more prolific in their topcrosses than other inbred lines.

In case of the studied grain yield components, the general combining ability effects ($\hat{g}_i$) was significant and negative or positive according to the amount and direction of this effects. Three inbred lines, ***i.e.*** Gm-304, Gm-306 and Gm-311 exhibited significant values of GCA effects in case of ear length. However, Gm-304 showed positive $\hat{\mathbf{g}}_{\mathbf{i}}$ value toward longer ears and had also high average value of ear length. The inbred line tester, Gm-4 were good combiner for earliness, ear length and grain yield. Regarding ear diameter, non of the studied inbred lines possessed significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effect, except Gm-306 which showed significant negative GCA effect toward thinner ears. In addition, the topcrosses involved this inbred line produced thinner ears than other inbred lines. On the other hand, non of the testers had significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effects for ear diameter.

The two inbred lines, Gm-304 and Gm-306 possessed significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effects in case of number of rows/ear. Also, all tester lines showed highly significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effects.

Respecting number of kernels/row, four inbred lines i.e. (Gm-303, Gm-304, Gm-305 and Gm-311 exhibited highly significant $\hat{\mathbf{g}}_{\mathbf{i}}$ values, the first one had negative GCA effect, whereas the other three possessed positive values toward bigger ears with more kernels per row.

Regarding grain yield in ardab per faddan (Table 5), it is noticed that six inbred lines (females), ***i.e.*** Gm-302, Gm-303, Gm-305, Gm-306, Gm-307 and Gm-310 had highly significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effects. However, the first four lines had negative values and the other two exhibited positive $\hat{\mathbf{g}}_{\mathbf{i}}$ values. It is worthy to note that the female inbred line in the highest yielding topcrosses (Gm-307 x Gm-4), (Gm-310 x Gm-4) (Table 4) exhibited positive and significant $\hat{\mathbf{g}}_{\mathbf{i}}$ effect

The estimates of GCA effects of the three testers for all studied traits were presented in Table (5). The results showed that $\hat{\mathbf{g}}_{\mathbf{i}}$ effects of the three inbred line testers (Gm-4, Gm-21 and Gm-22) was highly significant for number of days to 50% silking and number of rows/ear. For ear length, the two tester lines Gm-4 and Gm-22 exhibited significant GCA values but in opposite direction. The male inbred lines Gm-4 and Gm-22 gave negative values of GCA effects for number of days to 50% silking where this effect was positive and significant in case of Gm-21 tester. In this respect, Hallauer and Miranda (1981), reported that inbred-line tester method was more effective in selecting lines that combined will with unrelated tester. They also pointed out that testers were more effective in detecting small differences in combining ability among the selected high yielding and low yielding groups than wide genetic base testers.

It could be concluded from the above mentioned results that the six top crosses, ***viz*** (Gm-301 x Gm-21), (Gm-304 x Gm-4), (Gm-307 x Gm-4), (Gm-307 x Gm-22) (Gm-310 x Gm-4) and (Gm-310 x Gm-21) are the best hybrids with regard to grain yield and other performance traits. Data in Tables (4 and 5) showed that inbred lines Gm-301, Gm-304, Gm-307 and Gm-310 possessed good $\hat{g}_i$ effects and produced good single crosses when topcrossed to the inbred testers Gm-4 and/or Gm-21. These promising inbreds may be utilized in hybrid maize breeding program to produce high yielding hybrids and improve the yielding ability.

Table 5. General combining ability effect ($\hat{g}_i$) for 11 lines and three testers of grain yield and other agronomic characters, combined data over two locations in 2007 growing season.

Lines/ testers	Days to 50% silking	Plant height	Ear height	Ears/ 100 plants	Ear length	Ear diameter	Rows/ ear	Kernels/ row	Grain yield
Inbred lines (Females)									
Gm-301	-1.133**	-11.269**	-10.292**	-10.203**	-0.164	0.078	0.251	-1.144	-0.264
Gm-302	-1.383**	0.064	1.667	-10.328**	-0.189	-0.022	-0.216	-1.103	-1.703**
Gm-303	-0.716**	4.731	- 1.333	- 9.458**	0.311	-0.051	0.251	-2.507**	-1.795**
Gm-304	-0.508*	2.981	4.917	- 6.437*	0.936**	-0.034	0.617**	2.006**	0.773
Gm-305	0.909**	2.856	3.667	2.476	-0.056	0.016	-0.066	2.006**	-1.558*
Gm-306	0.659**	0.148	4.375	2.242	-0.906**	-0.126*	-0.383*	-0.203	-2.329**
Gm-307	5.534**	1.398	- 0.917	29.426**	-0.314	0.091	0.051	0.389	3.393**
Gm-308	-0.633**	- 2.352	0.417	- 2.137	0.352	0.053	-0.116	-0.994	1.168
Gm-309	-0.549**	- 1.894	1.500	- 1.595	0.327	0.007	-0.333	-1.328	-0.734
Gm-310	-1.049**	- 4.394	- 2.542	- 5.445	0.244	0.091	-0.141	1.122	2.492*
Gm-311	-1.133**	7.731**	- 1.458	11.459**	-0.539*	-0.101	0.084	1.756**	0.558
Inbred tester (males)									
Gm- 4	-0.606**	- 0.500	-1.712	- 0.779	0.662**	0.058	-0.356**	-0.074	2.043**
Gm-21	1.121**	- 0.102	-1.314	- 0.353	0.280	-0.002	-0.381**	-0.123	-0.386
Gm-22	-0.515**	0.602	3.027	1.132	-0.942**	-0.056	0.737**	0.197	-1.656**
S.E. for									
Lines gi	0.205	2.802	2.417	2.550	0.277	0.052	0.193	0.693	0.650
gi-gj	0.294	3.962	3.418	3.606	0.392	0.073	0.274	0.980	0.919
Testers gi	0.109	1.463	1.262	1.331	0.145	0.027	0.101	0.362	0.339
gi-gj	0.154	2.069	1.785	1.883	0.204	0.038	0.143	0.512	0.480

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

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

Specific combining ability effects $\hat{s}_{ij}$ of the 33 single (top) crosses for all studied traits are presented in Table (6). It was noted that the highest desirable and positive SCA effects respecting grain yield were obtained from two out of 33 studied single crosses (Gm-301 x Gm-21, 4.371** and Gm-306 x Gm-22, 2.924**). Russell *et al* (1973) and Walejko and Russell (1977) reported that inbred testers are effective for improving general as well as specific combining ability.

For days to 50 % silking, 11 topcrosses exhibited negative (toward earliness) and significant $\hat{s}_{ij}$ effects, whereas another six topcrosses showed positive (toward lateness) and significant $\hat{s}_{ij}$ effect (Table 6). The topcrosses of Gm-306 and Gm-307 by either the two testers (Gm-4 or Gm-22) possessed highly significant SCA effects in an opposite direction.

T6

t6cont

Non of the studied topcrosses exhibited significant $\hat{s}_{ij}$ regarding plant and ear height. Regarding number of ears/100 plants (prolificacy), three out of 33 studied topcrosses exhibited significant $\hat{s}_{ij}$ effects, two of them (Gm-306 x Gm-22 and Gm-308 x Gm-22 had positive SCA effect (14.968** and 9.934 toward producing more than one ear per plant. The same single cross gave high grain yield and was earlier in silking date. For ear length, ear diameter, number of rows/ear and number of kernels/row, non of the studied topcrosses exhibited significant SCA effects except Gm-308 x Gm-21for rows/ear. However, these effects varied greatly in its amount and/or direction. These results are in accordance with those obtained by Hallauer and Miranda (1981), Diab *et al* (1994), El-Zeir (1999), Mahmoud *et al* (2001) and Abd El-Aal (2007). They reported that when the objective is the replacement of a line in a specific combination, specific combining ability is of prime importance and the most appropriate tester is the opposite inbred parent of a single cross on the opposite single cross parent of the double. The previous three crosses had superiority in all traits under study. Hence, it could be concluded that those crosses offer a possibility for improving maize grain yield.

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تقديرات الفعل الجيني وقدرة التآلف لسلالات مبشرة من الذرة الشامية البيضاء باستخدام التهجين القمي

عفيفي عبد المعبود بركات و محي الدين محمد أحمد عثمان

قسم بحوث الذرة الشامية بمعهد بحوث المحاصيل الحقلية بمركز البحوث الزراعية

تم إجراء التهجين القمى لأحدى عشر سلالة بيضاء من الذرة الشامية ومنتخبة في الجيل الذاتي الخامس مع ثلاث سلالات تجارية بيضاء هي جميزة ٤ ، جميزة ٢١ ، جميزة ٢٢ وذلك موسم٢٠٠٦ ، وفى صيف موسم ٢٠٠٧ تم تقييم الـ٣٣ هجينا" قمياً مقارنة بـ٣ هجن فردية بيضاء تجارية هى١٠ ، ١٢٢ ، ١٢٩ في منطقتي وسط الدلتا بمحطة البحوث الزراعية بالجميزة وشمال الدلتا بمحطة البحوث الزراعية بسخا وتم تقدير قدرات التآلف والقياسات الوراثية المختلفة لصفات التزهير وارتفاع النبات والكوز وصفات المحصول ومكوناته.

ودلت النتائج المتحصل عليها على وجود فروق معنوية بين الهجن القمية والكشافات لجميع الصفات المدروسة وكذا وجود فروق معنوية بين السلالات الكشافة وبعضها لمعظم الصفات المدروسة وكان التفاعل بين الكشافات والبيئة معنويا" لصفات التزهير وعدد كيزان الـ١٠٠ نبات وعدد صفوف الكوز وحبوب الصف ومحصول حبوب الفدان ، وكان للقدرة العامة على التآلف التأثير الأكبر مقارنة بالقدرة الخاصة وذلك بالنسبة للسلالات المختبرة والكشافة على السواء لكل الصفات المدروسة تقريبا" مما يدل على أن الفعل المضيف للجين كان هو السائد في تحديد سلوك الصفات المدروسة .

كما أوضحت النتائج المتحصل عليها أن السلالة الكشافة جميزة ٤ هي أفضل الكشافات المستخدمة من حيث القدرة العامة على التآلف. وأن الهجن القمية الثلاث الداخلة فبها وهى (جميزة ٣٠٤×جميزة ٤) ، (جميزة ٣٠٧×جميزة ٤) ، (جميزة ٣١٠×جميزة ٤) أعطت محصول قدرة ٣, ٣١، ٦, ٣٤، ٢, ٣٣ إردب للفدان على الترتيب وذلك مقارنة بإنتاجية الهجن التجارية هف ١٢٩بإنتاجية ٦, ٢٦ إردب للفدان، هف ١٢٢بإنتاجية ٤, ٣٠ إردب للفدان، هف ١٠بإنتاجية٣, ٣٣ إردب للفدان. ذلك بالإضافة إلى أن هذه الهجن الثلاثة تتميز بالتبكير في النضج وقصر ارتفاع النباتات بدرجة معنوية عالية حيث يمكن استغلال ذلك في رفع إنتاجية الوحدة المساحية.

Table 3. Analysis of variance for , grain yield and some agronomic traits of 36 genotypes (33 top crosses, and three checks) combined data over two locations in 2007 season.

S.O.V.	DF	Days to 50% silking	Plant height	Ear height	Ears/ 100 plants	Ear length	Ear diameter	Rows/ ear	Kernels/ row	Grain yield
Locations (Loc)	1	2424.24**	8174.1**	1790.0**	159.1	166.23**	5.308**	5.067**	96.95**	477.10**
Rep's/Loc	6	2.13	1728.4	1043.9	219.4	7.41	0.298	0.168	23.96	12.41
Genotypes (G)	35	95.29**	772.2**	851.3**	1218.1**	8.25**	0.112**	5.089**	34.68**	72.27**
Checks (Ch)	2	15.54**	1782.0**	1035.3**	88.3	3.26**	0.049	8.487**	1.28	91.14**
Cr ***vs*** Ch	1	136.67**	14144.5**	20353.8**	277.6**	41.73**	0.870**	140.543**	443.33**	183.48**
Crosses (Cr)	32	98.98**	291.2**	230.4**	1318.1**	7.51**	0.092**	4.016**	24.00**	67.61**
Lines (L)	10	93.45**	615.8**	429.8**	3328.2**	6.09**	0.134**	2.059**	57.94**	82.96**
Tester (T)	2	83.15**	27.4	608.0**	88.6	61.83**	0.284**	35.875**	2.60	310.88**
L x T	20	103.33**	155.2	92.9	435.9**	2.79**	0.051	1.809**	9.17	35.61**
Loc x G	35	87.37**	887.3**	94.2	303.8**	1.06	0.047	0.397	6.62	54.52**
Loc x Ch	2	0.13	4343.4**	256.3**	326.0**	2.37**	0.180**	0.927	7.05	64.55**
Loc x Cr ***vs*** Ch	1	1.06	19100.0**	522.0**	9.1	0.46	0.032	0.000	2.18	5.63
Loc x Cr	32	95.52**	102.2	70.7	311.7**	1.00	0.039	0.376	6.73	55.42**
LOC x L	10	93.39**	122.7	85.3	437.9**	1.10	0.054	0.441	4.31	122.83**
LOC x T	2	77.52**	165.2	11.0	352.5**	0.59	0.007	1.144**	25.72**	60.64**
LOC x L x T	20	98.39**	85.6	69.3	244.4**	0.99	0.034	0.267	6.05	21.20**
Pooled Error	210	0.52	94.2	70.1	78.0	0.92	0.032	0.449	5.76	5.07
C.V.		1.22	3.71	5.74	7.84	4.78	3.91	5.09	5.92	8.20

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

Table 6: Specific combining ability effect ($\hat{s}_{ij}$) for 33 topcrosses (11 lines topcrossed to three testers) of grain yield and other agronomic and yield characters, combined data over two locations in 2006 season.

ENTRY	Days to 50% silking			Plant height cm			Ear height cm			Ears/ 100 plants		
	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22	Gm-4	Gm-21	Gm-22
Gm-301	0.564	- 1.163**	0.599	-1.208	2.269	-1.061	0.087	-0.561	0.473	- 0.975	3.399	- 2.424
Gm-302	0.689	- 1.413**	0.724	0.458	-1.189	0.731	-1.246	-4.144	5.390	0.363	2.386	- 2.749
Gm-303	0.398	- 1.079**	0.682	1.917	-7.856	5.939	-1.496	-2.144	3.640	1.292	1.816	- 3.107
Gm-304	0.564	- 1.288**	0.724	-1.583	0.519	1.064	-1.121	1.981	-0.860	0.971	3.120	- 4.091
Gm-305	0.273	- 1.330**	1.057**	-3.083	1.519	1.564	3.504	-3.769	0.265	- 0.154	4.357	- 4.203
Gm-306	1.398**	- 0.205	- 1.193**	3.750	0.727	-4.477	3.045	2.273	-5.318	- 5.121	- 9.847*	14.968**
Gm-307	- 5.852**	12.296**	- 6.443**	0.625	1.977	-2.602	-1.663	0.939	0.723	5.033	7.570	-12.603**
Gm-308	0.314	- 2.038**	1.724**	6.375	-6.648	0.273	2.379	-1.769	-0.610	- 2.092	- 7.843	9.934*
Gm-309	0.356	- 1.621**	1.265**	-0.083	2.644	-2.561	-0.830	0.773	0.057	- 5.883	- 1.197	7.080
Gm-310	0.731	- 1.496**	0.765*	-3.958	7.394	-3.436	-2.163	6.814	-4.652	- 0.596	4.003	- 3.407
Gm-311	0.564	- 0.663	0.099	-3.208	-1.356	4.564	-0.496	-0.394	0.890	7.163	- 7.764	0.601
SE for												
S_{ij}		0.361			4.853			4.186			4.416	
S_{ij}-S_{kl}		0.509			6.863			5.920			6.245	

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

Table 6: Continued . . . .

ENTRY	Ear length			Ear diameter			Rows/ ear			Kernls/row			Grain yield		
	Gm-4	**Gm-21**	**Gm-22**	**Gm-4**	**Gm-21**	**Gm-22**	**Gm-4**	**Gm-21**	**Gm-22**	**Gm-4**	**Gm-21**	**Gm-22**	**Gm-4**	**Gm-21**	**Gm-22**
Gm-301	-0.704	-0.022	0.726	0.063	-0.039	-0.023	-0.044	-0.319	0.363	-2.001	1.073	0.928	-3.518**	4.371**	-0.853
Gm-302	-0.054	0.028	0.026	0.000	0.061	-0.061	0.473	0.148	-0.620	1.332	-0.019	-1.313	0.106	-1.487	1.381
Gm-303	0.046	-0.772	0.726	-0.033	0.027	0.006	0.056	0.181	-0.237	0.361	-0.877	0.516	1.745	0.218	-1.963
Gm-304	0.071	0.603	-0.674	0.038	-0.039	0.002	0.039	-0.686*	0.646*	-0.426	-0.277	0.703	1.300	-1.478	0.178
Gm-305	-0.212	-0.530	0.742	-0.025	-0.114	0.139	-0.027	-0.252	0.280	-0.351	-1.327	1.678	-0.426	0.264	0.162
Gm-306	-0.562	0.220	0.342	-0.058	0.090	-0.032	0.089	0.264	-0.354	0.282	-0.569	0.287	-1.085	-1.838	2.924**
Gm-307	0.171	-0.022	-0.149	-0.075	-0.039	0.114	0.206	-0.019	-0.187	0.116	0.614	-0.730	1.976	-2.682	0.705
Gm-308	0.855	-0.289	-0.566	-0.012	0.123	-0.111	-0.827*	1.048**	-0.220	0.724	0.523	-1.247	-0.969	1.268	-0.298
Gm-309	0.255	0.311	-0.566	-0.004	0.031	-0.028	-0.311	0.014	0.296	-0.918	0.656	0.262	-1.550	1.127	0.424
Gm-310	-0.062	0.695	-0.633	0.013	-0.027	0.014	0.273	-0.377	0.105	0.607	-0.369	-0.238	1.403	0.995	-2.398*
Gm-311	0.196	-0.222	0.026	0.092	-0.073	-0.019	0.073	-0.002	-0.070	0.274	0.573	-0.847	1.019	-0.757	-0.261
SE for															
S_{ij}		0.480			0.089			0.335			1.200			1.126	
S_{ij}-S_{kl}		0.678			0.126			0.474			1.697			1.592	

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