Assiut J. of Agric. Sci., 39 (4) (1-17)

SELECTION AMONG S_3 YELLOW MAIZE LINES USING COMBINING ABILITY

Magdi A. Abd El-Moula and M.E.M. Abd El-Azeem

Maize Res. Prog. Field Crops Research Institute ARC.EGYPT

Abstract: Twenty-seven yellow maize inbred lines (S_3) derived from different wide genetic base populations were topcrossed to each of two inbred line testers, **i.e.**, Gz-649 and Gm-1004 at Sids Agric. Res. Station during 2006 season. In 2007 season, the 54 topcrosses along with the two checks; SC-155 and SC-3084 were evaluated for grain yield plot^{-1}, days to 50% silking, plant and ear height and number of ears 100 plants^{-1} at Sakha and Sids Agric. Res. Stations, ARC. Mean squares due to crosses, lines, testers and lines x testers was significant for all studied traits. These results indicated wide genetic diversity among each of lines and testers in their contribution to the performance of top crosses. The interaction of crosses x Loc was significant for ear height and grain yield plot^{-1}, lines x Loc and testers x Loc were significant for plant height, ear height and grain yield plot^{-1}. Whereas the L x T x Loc interaction was significant for grain yield plot^{-1}. These interactions with locations are mainly attributed to the different ranking of genotypes from location to another. Seven crosses, i.e. L-1, 5, 6, 10 and 16 x GZ-649, L-3 and L-5 x Gm-1004 significantly outyielded the checks SC-155 and SC-3084. Inbred lines L-3, L-4, L-5, L-6, L-7, L-10, and L-16 possessed the best GCA effects for grain yield. The best general combiners of parental lines were, L-4 for high yielding ability, earliness, short plants and low ear placement, L-3 for high yield and short plants, L-5 and L-16 for high yielding ability, number of ears 100 plants^{-1} and earliness. For grain yield, positive and significant SCA effects were detected for crosses L-1 x Gz-649, L-2 x Gz-649, L-3 x Gm-1004, L-8 x Gm-1004, and L-11 x Gz-649. The topcrosses L-23 x Gz-649, L-24 x Gz-649and L-12 x Gm-1004 exhibited significant negative SCA effects toward earliness. The two crosses, L-6 x Gm-1004 and L-10 x Gm-1004 had favorable SCA effects toward short plants and low ear placement. L-16 x Gm-1004 was the only topcross that possessed favorable SCA effect toward producing more than one ear/plant. Variance magnitude due to SCA was higher than that due to GCA for all studied traits, except number of ears plant^{-1}. This indicates that non-additive genetic variance was the major source of genetic variation for the inheritance of grain yield and other traits. Also, the interaction of SCA with locations was higher than that of GCA for silking date, ears plant^{-1} and grain yield. Generally, the seven crosses produced the highest grain yield and significantly outyielded both check hybrids and should be used in hybrid maize breeding program for further studies.

Key words; Maize, Line x Tester, Combining ability, Gene action.

Introduction

Topcross (test cross) method using broad and/or narrow testers is widely used to evaluate new improved lines for combining ability in maize hybrid breeding programmes. The choice of suitable tester has been given much care among the breeders. In this respect, Lonnquist and Lindsey (1964) reported that the use of common tester parent reduced the range of traits expression among the progenies being evaluated. Russell *et al* (1973) and Walejko and Russell (1977) stated that the inbred testers are effective for determining general and specific combining ability effects. Procedures for developing and improving inbred lines of maize were reported by Bauman (1981) and Hallauer and Miranda (1981) who concluded that improved inbred lines increased grain yield and maturity. Topcross procedure was first suggested by Davis (1927) as an early testing to determine the usefulness of the lines for hybrid development programs. The concept of general (GCA) and specific (SCA) combining ability was firstly defined by Sprague and Tatum (1942). They and other investigators (Hassaballa *et al* 1980, El-Morshidy and Hassaballa 1982, Mahmoud 1996, Konak *et al* 1999 and Zelleke 2000) reported that the variance components due to SCA for grain yield and other agronomic traits was larger than that due to GCA, indicating the importance of non-additive type of gene action in the inheritance of these traits. Mathur *et al* (1998) obtained significant GCA variances for days to 50% silking. On the other hand, the environment x GCA interaction for grain yield was significant for both lines and testers (Hede *et al* 1999, Nass *et al* 2000, El-Zeir *et al* 2000, El-Morshidy *et al* 2003 and Abd El-Moula et al 2004). However, Soliman and Osman (2006) revealed that the additive component of gene action had the major role in the inheritance of grain yield and other traits compared with the non-additive ones.

The main objectives of this investigation were 1) to estimate GCA effects for lines and testers, and SCA effects of crosses for grain yield per plant and other agronomic traits, 2) to estimate the GCA variance for lines and testers and SCA variance for topcrosses and their interaction with location, and 3) identify the most superior line(s) and single crosses to be utilize in hybrid maize breeding program.

Materials and Methods

Twenty-seven selected yellow maize lines in S_3 generation (L-1 through L-27) derived from different heterotic groups [Puerto Rico Group 5 #.218 (L-1, L-2,L- 3, L-4, L-5, L-6, L-7, L-8, L-9, L-10, L-11, L-12, L-13, L-14, L-15, L-16, L-17 and L-18), and Pop-59 E (L-19,L- 20, L-21, L-22, L-23, L-24, L-25, L-26,L- 27)] through selection from segregating generations in the disease nursery field at Sids Agricultural Research

Station, were used for the purpose of this study. In 2006 summer season, the 27 lines were topcrossed to each of two narrow base inbred testers, *i.e.* Giza-649 (Gz-649) and Gemmeiza 1004 (Gm 1004) at Sids Experimental Station. The two testers were developed by Maize Research Program and are being used in seed production of commercial single and three-way cross hybrids. In 2007 growing season, the 54 resultant topcrosses along with the two commercial check hybrids, SC-155 and SC Pioneer 3084 (SC-3084) were evaluated in replicated yield trials conducted at Sakha and Sids Agric Res Stns. The experimental design was a randomized complete block design with four replications. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. Two grains were planted per hill and thinned later to one plant per hill to provide a population of approximately 21000 plants/faddan (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 (cm), ear height (cm), number of ears 100 $plants^{-1}$ and grain yield $plot^{-1}$ adjusted to 15.5% grain moisture content. Analysis of variance was performed for the combined data over locations according to Steel and Torrie (1980), and Kempthorne (1957) procedure as outlined by Singh and Chaudhary (1985) was followed to obtain information about the combining ability of the lines and the testers as well as estimate types of gene effects controlling grain yield and other studied traits in the tested lines.

Results and Discussion

The combined analysis of variance for the five studied traits is presented in Table 1. Highly significant differences were detected among locations for all studied traits, indicating that the two locations differed in their environmental conditions. Mean squares among crosses were highly significant for all traits. Partitioning the sum of squares due to crosses into its components showed that mean squares due to lines and testers were highly significant for all traits, revealing that great diversity existed among testers and lines. At the same time, mean squares of the lines x testers interaction were significant for all the studied traits, indicating that the lines (females) differed in order of performance in crosses with each of the testers (males).

The interactions of locations (environments) with crosses, lines and testers were significant for ear height and grain yield per plant. In case of plant height, both lines and testers significantly interacted with locations whereas the locations x lines x testers was significant for grain yield per plant. These significant interactions with locations are mainly attributed to the different ranking of genotypes from location to another. Similar results were obtained by El-Itriby *et al* (1990), Salama *et al* (1995), Mahgoub *et al* (1996), Shehata *et al* (1997), El-Zeir (1999), Soliman and Sadek (1999), El-Zeir *et al* (2000), Soliman (2000); El-Morshidy *et al* (2003) and Abd El-Moula *et al* (2004). However, Amer and El-Shenawy (2007) obtained significant interaction between locations, lines and testers for silking date, ear height and grain yield. Also, Gado *et al* (2000), Soliman (2000), and El-Morshidy *et al* (2003) added that testers were affected much more by the environmental conditions than lines. However, Abd El-Moula and Ahmed (2006) reported that the variances due to testers and locations x testers was higher than that for lines and locations x lines for grain yield, silking date and plant height, indicating that testers contributed much more to the total variation and were more affected by environments.

Table(1): Mean squares (MS) for grain yield and other traits of 27 inbred lines topcrossed with two testers, combined over two locations, 2007 season.

SOV	DF	Days to 50% silking	Plant height	Ear height	Ears 100 plants^{-1}	Grain yield plot^{-1}
Locations (Loc)	1	645.33**	4893.79**	1800.75**	481.97**	1.176**
Rep/Loc	6	15.62	701.77	559.81	74.13	1.948
Crosses (C)	53	20.09**	1061.79**	906.62**	289.25**	1.225**
Lines (L)	26	35.62**	1803.45**	1550.30**	359.82**	1.810**
Testers (T)	1	6.26*	1850.08**	1020.59**	3160.63**	0.984*
L x T	26	5.10**	289.80**	258.54**	108.08*	0.649**
Loc x C	53	1.48	103.95	101.75*	80.99	0.668**
Loc x L	26	1.38	125.56*	138.76**	77.61	0.451**
Loc x T	1	1.12	231.15*	444.08*	13.90	10.315**
Loc x L x T	26	1.61	77.45	51.46	86.91	0.513**
Error	318	1.34	81.47	73.85	70.62	0.132
C.V%		1.87	3.64	6.26	8.06	10.42

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

Mean performance and combining abilities:

Respecting number of days to 50% silking, Table 2 shows that, in general, all the topcrosses were significantly earlier than the commercial single cross hybrid SC 3084. However, 21 out of the 54 tested topcrosses were significantly earlier than the check hybrid SC 155. For GCA effects (Table 3), the parental lines L-4 through L-16 had highly significant and negative GCA effects toward earliness with an average number of days to 50% silking ranging from 58.9 days for the topcross L-9 x Gz-649 to 61.6 days for the topcross L-7 x Gz-649.

In other words, the topcrosses involving these lines and Gz-649 as a tester were generally earlier. This indicates that these inbreds possess favorable genes for earliness. On the contrary, the parental lines L-1, L-2, L-19, L-20, L-22, L-23, L-24, L-26 and L-27 as well as the inbred tester Gm 1004 had positive and highly significant GCA effects marked by lateness in silk appearance. Respecting SCA effects (Table 4), the topcrosses L-23 x Gz-649, L-24 x Gz-649 and L-12 x Gm-1004 showed negatively significant SCA effects toward earliness (-1.067**, -1.317** and -1.183**), respectively. However, the topcrosses L-5 x Gz-649, L-23 x Gm-1004 and L-24 x Gm-1004 had positively significant SCA effects toward lateness (0.808*, 1.067** and 1.317**), respectively. Similar results were obtained by Soliman (2000) and Soliman *et al* (2001).

In respect of plant height, data presented in Table 2 indicated that the difference between the two testers was not significant. However, the inbred tester Gm 1004 induced shorter plants (246.0 cm) over all parental lines, than the inbred tester Gz-649 (250.1 cm). This finding was reflected in the combining ability effects (Table 3), where the inbred tester Gm-1004 possessed negative and significant GCA effect (desirable) towards shortness (-2.069**). This indicates that Gm-1004 had favorable dominant genes for shortness. On the contrary, the inbred tester Gz-649 had positive (undesirable) and significant GCA effect (2.069**). In this regard, Soliman *et al.* (2001) reached to similar findings. For the tested lines, the best general combiners were L-3, L-4, L-8, L-9, L-11, L-12, L-13, L-14, L-19, L-20, L-22, L-23 and L-25, since they had highly significant and negative (desirable) GCA effects with the shortest plants (Tables 2 and 3).

Plant height of the 54 topcrosses (Table 2) ranged from 229.6 to 289.0 cm for crosses L-13 x Gz 649 and L-1 x Gz 649, respectively. In general, 15 topcrosses involving the inbred tester Gz 649 and 21 crosses involving the other inbred tester Gm-1004 showed significantly shorter plants as compared to the check hybrid SC 155 (261.5 cm). For SCA effects, none of the tested topcrosses showed significantly negative SCA effect for plant height (Table 4), except L-6 x Gm-1004 and L-10 x Gm-1004 (-10.118** and -6.618*) which possessed significant negative SCA effect (desirable) toward shortness. Meanwhile, L-6 x Gz-649 exhibited highly significant positive SCA effect (10.118**) toward tallness (undesirable).

Considering ear height, the obtained results (Tables 2 and 3) reveal that the inbred tester Gm 1004 showed more favorable effect on ear placement than inbred tester Gz-649, since it exhibited lower average ear height (135.8 cm) with significant negative GCA effect (-1.537*) towards low ear placement.

The same findings were obtained by Soliman *et al* (2001) and Amer and El-Shenawy (2007). For the parental lines across the two testers, L-13, L-9, L-4, L-14 and L-8 ranked the best with an average of 122.3, 124.7, 128.2, 128.4 and 130.4 cm, respectively, and with distinct GCA effects (negatively significant) towards low ear placement (-14.974**, -12.662**, -9.162**, -8.912** and -6.912**), respectively. On the other hand, five parental lines, i.e. L-1, L-26, L-24, L-27 and L-16 exhibited the highest average for ear height (171.9, 150.8, 148.7, 147.5 and 144.9 cm), respectively, with highly significant positive GCA effects (34.587**, 13.463**, 11.400**, 10.150** and 7.588**), respectively. Average ear height for topcrosses (Table 2), ranged from 119.6 to 175.9 cm for L-13 x Gz-649 and L-1 x Gz 649, respectively. Generally, most of the studied topcrosses involving the inbred tester Gm-1004 showed lower ear placement than those involving the inbred tester Gz-649. Moreover, topcrosses involved the lines L-3, L-4, L-8, L-9, L-11, L-12, L-13, L-14, L-19, L-21, L-22 and L-23 with inbred tester Gz-649, in addition to the crosses of L-3, L-4, L-5, L-6, L-7, L-8, L-9, L-10, L-11, L-12, L-13, L-14, L-15, L-19, L-20, L-21, L-23 and L-24 with Gm 1004 manifested significantly lower ear placement than the check hybrid 'SC-155'. Regarding SCA effects (Table 4), four topcrosses, i.e. L-5 x Gm-1004, L-6 x Gm-1004, L-10 x Gm-1004 and L-18 x Gm 1004 showed negatively significant SCA effects toward low ear placement (-5.963*, -6.400*, -6.275* and -6.963*), respectively. On the other hand, the highest positive SCA effects, towards higher ear placement were shown in the topcrosses L-5 x Gx-649, L-6 x Gx-649 and L-26 x Gm 1004 (5.963*, 6.400* and 6.537*), respectively.

With respect to number of ears 100 plants^{-1}, data in Tables 2 and 3 illustrated that the inbred tester Gz-649 showed more favorable effect on number of ears per plant than the other inbred tester Gm 1004, since it manifested significantly higher average number of ears per plant (107.0 vs. 101.6 ears 100 plant^{-1}) and highly significant positive GCA effect (2.705**). These results are supported by the findings of Sadek *et al* (2000) and Soliman and Osman (2006). For the tested lines, the best general combiners over testers were L-16, L-14, L-27, L-5 and L-8 (Tables 2 and 3), since they exhibited more ears per plant (118.0, 111.1, 110.4, 109.7 and 109.4 ears 100 plants^{-1}), respectively and had highly significant positive GCA effects (13.670**, 6.777**, 6.020**, 5.344** and 4.995*), respectively. On the other hand, the tested lines L-21, L-23, L-4, L-2 and L-12 showed negative and significant GCA effects in the direction of fewer ears per 100 plants (98.8, 99.5, 99.5, 99.5 and 99.7 ears 100 plants^{-1}), respectively.

Table(2): Mean performance for grain yield and other agronomic traits of 54 yellow topcrosses and two checks in 2007 growing season, data are combined over two locations.

Lines	Silking date			Plant height (cm)			Ear height (cm)			Ears 100 plants^{-1}			Grain yield plot^{-1} (g)		
	GZ-649	Gm-1004	Mean	GZ-649	Gm-1004	Mean	GZ-649	Gm-1004	Mean	GZ-649	Gm-1004	Mean	GZ-649	Gm-1004	Mean
L- 1	66.1	66.8	66.5	289.0	279.3	284.2	175.9	167.9	171.9	101.7	98.7	100.2	5.431	4.669	5.050
L- 2	62.8	62.9	62.9	252.8	251.3	252.1	141.3	139.6	140.5	100.5	98.4	99.5	4.880	4.191	4.535
L- 3	60.8	62.4	61.6	243.8	241.3	242.6	135.5	132.8	134.2	104.2	97.1	100.7	4.972	5.566	5.269
L- 4	60.3	60.8	60.6	237.9	239.8	238.9	126.5	129.8	128.2	103.7	95.3	99.5	5.010	5.331	5.170
L- 5	61.8	60.4	61.1	259.0	242.8	250.9	145.5	130.5	138.0	117.1	102.3	109.7	5.601	5.581	5.591
L- 6	60.9	60.9	60.9	259.3	234.9	247.1	142.6	126.8	134.7	112.1	103.2	107.7	5.479	5.054	5.266
L- 7	61.6	60.4	61.0	263.9	252.3	258.1	143.9	133.0	138.5	103.8	101.2	102.5	4.984	5.321	5.152
L- 8	61.1	60.6	60.9	239.1	244.9	242.0	127.3	133.5	130.4	112.1	106.6	109.4	4.676	5.122	4.899
L- 9	58.9	59.1	59.0	240.8	236.6	238.7	124.9	124.4	124.7	103.0	101.1	102.1	4.739	4.930	4.835
L-10	61.3	60.6	61.0	254.0	236.6	245.3	139.9	124.3	132.1	101.6	100.1	100.9	5.485	5.319	5.402
L-11	61.0	61.0	61.0	241.0	245.1	243.1	128.5	133.1	130.8	105.7	98.9	102.3	5.287	4.324	4.806
L-12	61.8	59.6	60.7	245.8	238.1	242.0	133.0	128.6	130.8	101.0	98.4	99.7	4.613	4.774	4.694
L-13	60.8	61.3	61.1	229.6	235.1	232.4	119.6	125.0	122.3	105.2	105.5	105.4	4.477	4.692	4.584
L-14	61.0	60.5	60.8	237.5	241.5	239.5	128.3	128.5	128.4	113.2	109.0	111.1	4.883	5.082	4.982
L-15	60.3	60.4	60.4	243.4	244.9	244.2	134.5	131.6	133.1	109.4	102.5	106.0	4.938	4.988	4.963
L-16	61.3	60.8	61.1	263.8	248.1	256.0	150.5	139.3	144.9	129.0	107.0	118.0	5.454	5.396	5.425
L-17	61.5	61.4	61.5	258.3	254.1	256.2	144.0	138.4	141.2	103.3	102.8	103.1	4.971	5.172	5.071
L-18	61.9	61.5	61.7	264.6	248.5	256.6	150.5	133.5	142.0	112.4	100.0	106.2	5.066	4.907	4.986
L-19	63.9	65.0	64.5	242.4	237.9	240.2	133.5	132.1	132.8	108.5	102.5	105.5	4.538	3.934	4.236
L-20	62.3	63.3	62.8	243.0	232.8	237.9	142.3	127.4	134.9	101.5	100.4	101.0	4.484	4.084	4.284
L-21	62.5	61.6	62.1	248.0	252.4	250.2	134.5	144.9	139.7	101.6	96.0	98.8	4.631	4.444	4.537
L-22	62.4	63.5	63.0	236.3	236.6	236.5	131.9	133.9	132.9	110.4	105.7	108.1	4.937	4.350	4.643
L-23	62.3	64.6	63.5	240.6	243.5	242.1	134.9	134.5	134.7	99.3	99.6	99.5	4.869	5.040	4.954
L-24	61.3	64.1	62.7	261.4	257.4	259.4	148.5	148.9	148.7	102.1	98.5	100.3	5.070	4.508	4.789
L-25	61.1	62.9	62.0	245.4	247.5	246.5	139.3	138.4	138.9	100.7	102.3	101.5	4.907	5.069	4.988
L-26	63.3	63.3	63.3	254.3	262.5	258.4	145.8	155.8	150.8	114.1	102.1	108.1	4.521	4.582	4.551
L-27	62.3	63.0	62.7	258.4	255.6	257.0	145.8	149.1	147.5	112.6	108.1	110.4	4.079	4.968	4.523
Mean	61.7	62.0		250.1	246.0		138.8	135.8		107.0	101.6		4.925	4.866	
Checks															
SC-155		61.9			261.5			145.9			101.7			3.778	
SC-3084		66.0			291.4			179.0			98.8			3.171	
LSD 0.05		1.1			8.9			8.4			8.1			0.355	

Table(3): General combining ability effects ($\hat{g}_i$) of 27 inbred lines and 2 testers for grain yield and other agronomic traits combined over three locations, 2007 growing season.

Lines/ Testers	Days to 50% Silking	Plant height	Ear height	Ears 100 plants^{-1}	Grain yield plot^{-1}
L-1	4.618**	36.087**	34.587**	-4.079	0.135
L-2	0.993**	3.962	3.150	-4.867*	-0.379**
L-3	-0.257	-8.537**	-3.162	-3.661	0.354**
L-4	-1.319**	-9.224**	-9.162**	-4.792*	0.256*
L-5	-0.756**	2.837	0.712	5.364*	0.676**
L-6	-0.944**	-0.974	-2.599	3.320	0.352**
L-7	-0.819**	10.025**	1.150	-1.773	0.237*
L-8	-0.944**	-6.037**	-6.912**	4.995*	-0.015
L-9	-2.819**	-9.349**	-12.662**	-2.248	-0.079
L-10	-0.881**	-2.724	-5.224*	-3.467	0.487**
L-11	-0.819**	-4.974*	-6.474**	-2.004	-0.109
L-12	-1.131**	-6.099*	-6.474**	-4.617*	-0.221*
L-13	-0.819**	-15.662**	-14.974**	1.033	-0.329**
L-14	-1.069**	-8.537**	-8.912**	6.777**	0.068
L-15	-1.507**	-3.912	-4.224*	1.632	0.049
L-16	-0.819**	7.900**	7.588**	13.670**	0.510**
L-17	-0.381	8.150**	3.900	-1.273	0.157
L-18	-0.132	8.525**	4.712*	1.857	0.072
L-19	2.610**	-7.912**	-4.474*	1.170	-0.678**
L-20	0.931**	-10.162**	-2.474	-3.360	-0.630**
L-21	0.243	2.150	2.400	-5.542*	-0.377**
L-22	1.118**	-11.599**	-4.412*	3.758	-0.270**
L-23	1.618**	-5.974*	-2.599	-4.892*	0.040
L-24	0.868**	11.338**	11.400**	-3.998	-0.125
L-25	0.180	-1.599	1.525	-2.823	0.074
L-26	1.430**	10.338**	13.463**	3.802	-0.363**
L-27	0.806**	8.963**	10.150**	6.020**	0.109
Tester					
Gz-649	-0.120	2.069**	1.537*	2.705**	0.047*
Gm-1004	0.120	-2.069**	-1.537*	-2.705**	-0.047*
SE gca L	0.289	2.256	2.148	2.100	0.176
SE gca T	0.078	0.614	0.584	0.571	0.024

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

Regarding the topcrosses, data in Table 2 showed that the average number of ears 100 plants^{-1} ranged from 95.3 (L-4 x Gm 1004) to 129.6 (L-16 x Gz 649). Generally, most of the topcrosses involved the inbred tester Gz-649 showed more ears per plant than those involving the other inbred tester Gm 1004. The difference between the two checks; SC 155 and SC 3084 (101.7 and 98.8 ears 100 plant^{-1}), was significant. However, the topcrosses of Gz-649 with the tested lines L-3, L-4, L-5, L-6, L-7, L-8, L-9, L- 11, L-13, L-14, L-15, L-16, L-17, L-18, L-19, L-26 and L-27 exhibited significantly more ears per plant than SC 155 and SC 3084 (Table 2). Also, the topcrosses of Gm-1004 with all tested lines, except L-1, L-2, L-3, L-4, L-11, L-12, L-21 and L-24 significantly exhibited more ears per plant than that for the two checks. On the other hand, data in Table 4 showed that the best specific combinations (positively significant SCA effects) resulted from L-16 x Gz-649 (8.264** and 129.6 ears 100 plants^{-1}).

Regarding grain yield plot^{-1}, the average yield of the inbred tester Gz-649 over-all the tested lines surpassed that for the inbred tester, Gm-1004 (4.925 vs 4.866 kg plot^{-1}). This result was reflected in the combining ability effects (Table 3), since Gz-649 was the best tester line respecting GCA effect (0.047*) and produced a good yield in it's crosses with most tested lines (female lines) These results indicated that the inbred tester Gz-649 possesses a high frequency of favorable dominant alleles, which contributed to the grain yield of the testcrosses.

Grain yield of the 27 tested lines across the two testers (Table 2) ranged from 4.236 kg for L-19 to 5.591 kg plant^{-1} for L-5. The most preferable lines were L-5, L-16, L-10, L-3 and L-6. These lines produced the highest average grain yield plot^{-1} (5.591, 5.425, 5.402, 5.269 and 5.266 kg plot^{-1}), respectively and exhibited also the best significant positive GCA effects, i.e. 0.676**, 0.510**, 0.487**, 0.354** and 0.352**, respectively (Table 3). In other words, these lines in addition to the inbred tester Gz-649 had accumulated favorable alleles for grain yield and contributed to upgrading grain yield of all crosses involving these lines. On the other hand, L-19, L-20, L-2, L-21 and L-26 gave the lowest grain yield (4.236, 4.284, 4.535, 4.537 and 4.551 kg plot^{-1}), respectively. It also had a highly significant negative GCA effects, i.e. -0.678**, -0.630**, -0.379**, -0.377 and -0.363**, respectively, (Tables 2 and 3). Results reported herein are in accordance with those previously reached by Rawlings and Thempson (1962), Liakat and Teparo (1986), Zambezi *et al* (1986), El-Hosary (1988), Mahgoub *et al* (1996), Al-Naggar *et al* (1997) and Soliman *et al* (2001), who reported that the inbred tester method was more effective in selecting lines which combine well with unrelated tester, They added that the narrow base inbred testers were more effective in detecting small differences in combining ability than the wide genetic base testers.

Grain yield of the 54 topcrosses (Table 2) ranged from 3.934 to 5.601 kg plot-1 for L-19 x Gm 1004 and L-5 x Gz-649, respectively. Out of 54 topcrosses, 51 of them were superior and outyielded the commercial yellow check hybrid SC 155 (3.778 kg plot-1) with minimum of 4.191 kg $plot^{-1}$ and maximum of 5.601 kg $plot^{-1}$. Furthermore, the most seven top outyielding crosses, i.e. L-5 x Gz-649, L-5 x Gm-1004, L-3 x Gm-1004, L-10 x Gz-649, L-6 x Gz-649, L-16 x Gz-649 and L-1 x Gz-649 gave the highest grain yield $plot^{-1}$ (5.601, 5.581, 5.566, 5.485, 5.479, 5.454 and 5.431 kg $plot^{-1}$), respectively, and significantly outyielded the check hybrid SC 155 by 1.823, 1.803, 1.788, 1.707, 1.701, 1.676 and 1.653 kg $plot^{-1}$), respectively. Moreover, the previous seven topcrosses significantly surpassed the other yellow check hybrid SC 3084 (3.171 kg $plot^{-1}$) by 2.430, 2.410, 2.395, 2.314, 2.308, 2.383 and 2.260 kg $plot^{-1}$, respectively (Table 2).

However, data in Table 4 showed that the best specific combination (positively significant SCA effect) resulted from L-1 x Gz-649 (0.333*), L-2 x Gz-649 (0.296*), L-3 x Gm 1004 (0.344*) and L-11 x Gz-649 (0.433**) confirming it's outstanding. It is worth noting that a cross exhibiting high SCA value may come from two parents possessing good GCA or from one parent with good GCA and another with poor GCA. For example, the best Sij for grain yield $plot^{-1}$ (0.433**) was possessed between parents with poor and good GCA, L-11 x Gz-649. Similar findings were obtained by Nawar *et al* (1979), Soliman *et al* (2001) and Sadek *et al* (2002).

Estimates of variance components:

The estimates of variance components and its interaction with locations for grain yield/plant and other agronomic traits are presented in Table (5). Combined data showed that the magnitude of the variance due to specific combining ability (SCA) was larger than that obtained for general combining ability (GCA) for all the studied traits except ears 100 $plants^{-1}$. This indicates that the non-additive genetic variance was predominant and played the major role in the inheritance of grain yield and other traits. Furthermore, the non-additive gene action (dominance and epistasis) interacted more with the different environmental conditions prevailing in the two locations than additive gene effects for grain yield $plot^{-1}$, ears 100 $plants^{-1}$ and silking date. The magnitude of σ^2_{gca} for lines was higher than σ^2_{gca} for testers for all the studied traits, indicating that most of the total GCA variance was due to lines. The interaction between σ^2_{gca} for lines x Locations was larger than that of σ^2_{gca} for testers x Locations for plant and ear height, indicating that σ^2_{gca} for lines was more affected by environments.

Table(4): Specific combining ability ($\hat{s}_{ij}$) effects of 54 topcrosses (27 inbred line and 2 testers) for grain yield and other agronomic traits combined over two locations, 2007 growing seasons.

Lines	Days to 50%Silking		Plant height		Ear height		Ears/100plants		Grain yield plot^{-1}	
	Gz-649	Gm-1004	Gz-649	Gm-1004	Gz-649	Gm-1004	Gz-649	Gm-1004	Gz-649	Gm-1004
L- 1	- 0.192	0.192	2.806	- 2.806	2.463	- 2.463	- 1.236	1.236	0.333**	-0.333**
L- 2	0.058	- 0.058	- 1.319	1.319	- 0.725	0.725	- 1.674	1.674	0.296*	-0.296*
L- 3	- 0.692	0.692	- 0.819	0.819	- 0.162	0.162	0.845	- 0.845	-0.344**	0.344**
L- 4	- 0.129	0.129	- 3.007	3.007	- 3.162	3.162	1.501	- 1.501	-0.208	0.208
L- 5	0.808*	- 0.808	6.056	- 6.056	5.963*	- 5.963*	4.658	- 4.658	-0.037	0.037
L- 6	0.120	- 0.12	10.118**	-10.118**	6.400*	- 6.400*	1.739	- 1.739	0.164	-0.164
L- 7	0.745	- 0.745	3.743	3.743	3.900	- 3.900	- 1.404	1.404	-0.216	0.216
L- 8	0.370	- 0.37	- 4.944	4.944	- 4.662	4.6620	0.039	- 0.039	-0.270*	0.270*
L- 9	- 0.005	0.005	- 0.007	0.007	- 1.287	1.2870	- 1.729	1.729	-0.143	0.143
L-10	0.433	- 0.433	6.618*	- 6.618*	6.275*	- 6.275*	- 1.949	1.949	0.035	-0.035
L-11	0.120	- 0.12	- 4.131	4.131	- 3.849	3.849	0.701	- 0.701	0.433**	-0.433**
L-12	1.183**	- 1.183**	1.743	- 1.743	0.650	- 0.650	- 1.424	1.424	-0.129	0.129
L-13	- 0.129	0.129	- 4.819	4.819	- 4.225	4.225	- 2.874	2.874	-0.155	-0.155
L-14	0.370	- 0.37	- 4.069	4.069	- 1.662	1.662	- 0.617	0.617	-0.147	0.147
L-15	0.580	- 0.58	- 2.819	2.819	- 0.099	0.099	0.714	- 0.714	-0.072	0.072
L-16	0.370	- 0.37	5.743	- 5.743	4.088	- 4.088	8.264**	- 8.264**	-0.018	0.018
L-17	0.183	- 0.183	- 0.007	0.007	1.275	- 1.275	- 2.429	2.429	-0.148	0.148
L-18	0.308	- 0.308	5.993	- 5.993	6.963*	- 6.963*	3.476	- 3.476	0.031	-0.031
L-19	- 0.442	0.442	0.18	- 0.18	- 0.849	0.849	0.276	- 0.276	0.254*	-0.254*
L-20	- 0.379	0.379	3.056	- 3.056	5.900	- 5.900	- 2.154	2.154	0.152	-0.152
L-21	0.558	- 0.558	- 4.257	4.257	- 6.725*	6.725*	0.064	- 0.064	0.045	-0.045
L-22	- 0.442	0.442	- 2.257	2.257	- 2.537	2.537	- 0.348	0.348	0.245	-0.245
L-23	- 1.067**	1.067**	- 3.507	3.507	- 1.349	1.349	- 2.848	2.848	-0.133	0.133
L-24	- 1.317**	1.317**	- 0.069	0.069	- 1.725	1.725	- 0.929	0.929	0.233	-0.233
L-25	- 0.755	0.755	- 3.132	3.132	- 1.099	1.099	- 3.492	3.492	-0.129	0.129
L-26	0.120	- 0.12	- 6.194	6.194	- 6.537*	6.537*	3.270	- 3.270	-0.078	0.078
L-27	- 0.255	0.255	- 0.694	0.694	- 3.224	3.224	-0.436	0.436	0.007	-0.007
SE Sij	0.408		3.191		3.038		2.971		0.128	

*,**, significant at 0.05 and 0.01 level of probability, respectively.

Table(5): Estimates of general and specific combining ability variances and their interaction with locations for grain yield and other traits in 2007 season.

Estimates	Days to 50% silking	Plant height	Ear height	Ears 100 plants^{-1}	Grain yield plot^{-1}
$\sigma^2_{gca\ lines}$	1.907	94.603	80.735	15.734	0.073
$\sigma^2_{gca\ testers}$	0.005	7.223	3.528	14.132	0.002
Average	0.203	12.844	8.672	9.172	-0.035
SCA	0.471	26.041	23.087	4.682	0.065
$\sigma^2_{gca\ x\ Loc\ lines}$	-0.028	6.014	10.912	-1.163	-0.008
$\sigma^2_{gca\ x\ Loc\ testers}$	-0.004	1.423	3.635	-0.676	0.091
Average x Loc	-0.005	1.358	3.009	-0.469	0.084
SCA x Loc	0.067	-1.004	-5.595	4.072	0.095

The results reported herein are in agreement with those obtained by Landi *et al* (1986), Soliman (1992) Mostafa *et al* (1996), Soliman and Sadek (1999), Sadek *et al* (2000), Soliman *et al* (2001) and El-Morshidy *et al* (2003). They reported that SCA or non-additive genetic effects played an important role in the inheritance of grain yield, silking date, plant and ear height. Also Nawar and El-Hosary (1984), Mostafa et al (1996) and El Zeir et al (2000) demonstrated that variance due to dominance was more important than variance due to additive for grain yield. In addition, Sprague and Tatum (1942), Rajas and Sprague (1952), Lonnquist and Gardner (1961), Soliman and Sadek (1999), Sadek *et al* (2000), El-Morshidy *et al* (2003) and Abd El-Moula *et al* (2004) reported that the non-additive genetic variance interacted more with the environment than the additive component. On the other hand, El-Itriby *et al* (1990) and El-Zeir *et al* (2000) stated that the additive type of gene action was more affected by environments than non-additive gene effect. Abd El-Moula and Ahmed (2006) found that the additive gene effect was more important in the inheritance of plant and ear height. While the non-additive gene effects played the major role in the inheritance of grain yield and silking date. Amer and El-Shenawy (2007) reported that additive genetic variance played an important role in the inheritance for grain yield and silking date while the non-additive genetic variance was responsible for the inheritance of plant height and ear length. The magnitude of the interaction between SCA with locations was higher than that of

GCA x locations for grain yield and plant height.

It could be concluded that, the promising inbred lines L-3, L-5, L-6, L-10, and L-16 which possessed the best GCA effects for grain yield should be immediately utilized in hybridization program to improve maize productivity. The best general combiners of parental lines were, L-4 for high yielding ability, earliness, short plants and low ear placement, L-3 for high yield and short plants, L-5 and L-16 for high yielding ability, no. of ears 100 plants^{-1} and earliness. Moreover, the study suggested that the most outstanding crosses were (L-1 x Gz-649), (L-3 x Gm-1004) and (L-11 x Gz-649). It had significant SCA effects and outyielded the commercial check SC-155 and SC-3084 and should be further tested for the possibility of commercial release.

references

Abd El -Moula.M.A. and A.A.Ahmed 2006. Evaluation of new yellow maize inbred lines via line x tester analysis. Minia J. of Agric. Res. And Develop. 26(2):265-284.

Abd El -Moula.M.A., A.A.Barakat and A.A.Ahmed 2004 Combining ability and type of gene action for grain yield and other attributes in maize (*Zea mays* L.) Assiut J. Agric. Sci., 35(3):129-142

Al-Naggar, A.M., H.Y. El-Sherbieny and A.A. Mahmoud 1997. Effectiveness of inbreds, single crosses and populations as testers for combining ability in maize. Egypt. J. Plant Breed., 1: 35-46.

Amer. E.A. and A.A. El-Shenawy 2007. Combining ability for new twenty yellow maize inbred lines. J. Agric. Sci., 32 (9):7053-7062

Bauman.L.F 1981.Review of methods used by breeders to develop superior inbreds. P:199-200 In Proc Annu. Corn Sorghum Ind. Res.Conf.36th Chicago, IL 9-11 Dec. Ann. Seed Trade Assoc., Washington, D.C.

Davis, R.L.1927.Report of the plant breeding Ann. Rep.Pureto Rico Agric. Exp. Stn., P: 14-15.

El-Hosary, A. A. 1988 Evaluation of twenty new inbred lines by top crosses in corn (*Zea mays* L.). Proc. 3rd Egyptian Con. Agron., Kafr El-Shekh, (11): 48-56.

El-Itriby,H.A, H.Y.El-Sherbieny, M.M. Ragheb and M.A.K. Shalaby 1990. Estimation of combining ability of maize inbred lines in top crosses and its interaction with environments. Egypt. J. Appl. Sci., 5(8):354-370.

El-Morshidy,M.A and E.A.Hassaballa 1982. Relative values of five testers in evaluating combining ability of

Shehata, A.M., F.A.El-Zeir and E.A.Amer.1997.Influence of tester lines on evaluating combining ability of some new maize inbred lines. J. Agric. Sci. Mansoura Univ., 25(5): 2491-2502.

Singh,I.S. and Chaudhary 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers. New Delhi, 3rd Ed., P.39-68.

Soliman, F.H.S. 2000. Comparative combining ability of newly developed inbred lines of yellow maize (Zea mays L.). Egypt.J.Appl.Sci., 15:87-102.

Soliman, F.H.S. and S.E.Sadek. 1999. Combining ability of new maize inbred lines and its utilization in the Egyptian hybrids program. Bull. Fac. Agric., Cairo Univ., 50(1):1-20.

Soliman,M.S.M. 1992. Breeding studies on some maize hybrids. M.Sc. Thesis, Fac. Agric. Zagazig Univ., Egypt.

Soliman, M.S.M, A.A.Mahmoud, F.A. El-Zeir, Afaf A.I. Gaber and F.H.Soliman 2001. Utilization of narrow base tester for evaluating combining ability of newly developed maize inbred lines (Zea mays L.). Egypt. J. Plant Breed., 5:61-76.

Soliman, M.S.M. and M.M.A. Osman 2006. Type of gene action for grain yield using test cross analysis in new developed maize inbred lines. J. Agric. Sci. Mansoura Univ., 31(5):2615-2630.

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

Steel, R. G. D. and J. H. Torrei 1980. Principles and Procedures of Statistics. A Biometrical Approach. 2nd Ed, McGrow Hill Book Company, New York, U.S.A.

Walejko, R.N. and W.A. Russell 1977. Evaluation of recurrent selection for specific combining ability in two open pollinated varieties. Crop Sci., 13:647-651.

Zambezi, B. T., E.S. Horner and F.G. Martin 1986. Inbred lines as testers for general combining ability in maize. Crop Sci., 26:908-910.

Zelleke, H.2000. Combining ability for grain yield and other agronomic characters in inbred lines of maize (*Zea mays* L.). Indian J. Genet & Pl Br 60(1): 63-70.

الانتخاب بين سلالات الجيل الذاتي الثالث في الذرة الشامية باستخدام القدرة على التآلف

مجدي احمد عبد المولى ، محمد المهدي محمد عبد العظيم

قسم بحوث الذرة الشامية-معهد بحوث المحاصيل الحقلية-مركز البحوث الزراعية

تم تهجين 27 سلالة من الذرة الشامية صفراء الحبوب(الجيل الذاتى الثالث) مع إثنين من الكشافات المختلفة "جيزة-649 ، جميزة-1004" وذلك بمحطة البحوث الزراعية بسدس في موسم 2006 ، وفي موسم 2007 تم تقييم الـ 54 هجين قمي مع إثنين من الهجن الفردية التجارية للمقارنة (هـ. ف.155 ، هـ. ف. 3084) وذلك في كل من محطة البحوث الزراعية بسخا (محافظة كفر الشيخ) ، وسدس (محافظة بنى سويف) وذلك لصفات عدد الأيام من الزراعة حتى ظهور 50 % من الحراير- ارتفاع النبات - إرتفاع الكوز - عدد الكيزان 100 نبات[-1] ومحصول الحبوب للقطعة بالكيلوجرام. وقد وجدت إختلافات معنوية بين الهجن القمية ، السلالات ، الكشافات ، السلالات × الكشافات لكل الصفات موضع الدراسة مما يدل على التنوع الوراثى الكبير بين كل من السلالات والكشافات موضع الدراسة. كذلك وجدت إختلافات معنوية بين الجهات (البيئات) لكل الصفات ، وكذلك التفاعل بين البيئات والهجن القمية لصفة ارتفاع النبات ومحصول حبوب القطعة ، والتفاعل بين كل من السلالات والكشافات والبيئات لصفات إرتفاع النبات ، إرتفاع الكوز ، ومحصول حبوب القطعة. أما التفاعل بين البيئات والسلالات ، والكشافات فقد كان معنويا لصفة محصول حبوب القطعة فقط. وقد تفوقت الهجن القمية للسلالات أرقام 1 ، 5 ، 6 ، 10 ، 16 مع الكشاف جيزة-649 ، والهجن القمية للسلالات أرقام 3 ، 5 ، مع الكشاف جميزة-1004 معنويا على هجينى المقارنة هـ. ف.155 ، هـ. ف. 3084. وقد أظهرت السلالات رقم 3 ، 4 ، 5 ، 6 ، 10 ، 16 أحسن قدرة عامة على الإئتلاف لصفة محصول حبوب القطعة وغيرها من الصفات موضع الدراسة. كما أظهرت 5 هجين قمية احسن التقديرات للقدرة الخاصة لصفة المحصول. وكان تباين القدرة الخاصة على التآلف عاليا لجميع الصفات تحت الدراسة عدا صفة عدد الكيزان لكل 100 نبات. كما كان تباين التفاعل للقدرة الخاصة على التآلف مع البيئات عالياً للصفة مجصول الحبوب مما يدل على ان الفعل الجيني غير المضيف اكثر تأثراً بالبيئات عن الفعل المضيف.