UTILIZATION OF NARROW BASE TESTERS TO ESTIMATE COMBINING ABILITY OF MAIZE INBRED LINES

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Abstract

Seventeen yellow maize inbred lines (S_5) derived from different wide genetic base populations were topcrossed with each of three testers, two commercial yellow inbred lines i.e., Gm1002, Gm1021 and one commercial yellow single cross hybrid SC162 at Mallawy Agric. Res. Station during 2008 season. The obtained 51 topcrosses along with the three checks; (SC162, SC166 and TWC352) were evaluated for grain yield, days to 50% silking, plant height, ear position, number of ears per100 plants^{-1}, ear length and ear diameter at Sakha and Mallawy Agric. Res. Stations, ARC in 2009 growing season. Mean squares due to lines, testers, lines x testers and crosses were significant for all studied traits, except for testers ear diameter and line x testers for ear length and ear diameter. These results indicated a wide genetic diversity among each of the lines and testers in their contribution to the performance of top crosses. The interaction of crosses x location was significant for ear position, number of ears per 100 plants^{-1} and grain yield , lines x Loc. and testers x Loc. were significant for all the studied traits, except for days to 50% silking of tester x Loc. However, the lines x testers x Loc. interaction was significant for ears per 100 plants^{-1} and grain yield. These interactions with locations are mainly attributed to the different ranking of genotypes from location to another. Inbred lines L9, L10, L11, L14 and L15 possessed the best GCA effects for grain yield. Positive and significant SCA effects for grain yield were detected for crosses L7 x Gm 1002, L9 x Gm1021, L13 x Gm1002, L16 x Gm 1002, L1 x Gm 1021, L6 x SC162, L14 x SC162 and L14 x SC162. The crosses L10 x Gm1002, L9 x Gm1021, L10 x Gm1021, and L11 x Gm1021 outyielded the check hybrid SC. 162 by 18.66, 15.55, 17.79 and 15.11 % respectively. Sixteen topcrosses (between 16 inbred lines from line L 2 to L 17 with the tester yellow SC162) significantly gave better grain yield ability than the check hybrid TWC352, specially the promising three topcrosses L10 x SC162, L14 x SC162 and L15 x SC162, which yielded better than the highest check (SC166) with grain yield of 38.08, 37.40 and 36.44 (ard fed^{-1}), respectively. Those promising hybrids should be tested in advanced trials through the National Maize Breeding Program.

Key words: Maize, Top crosses, Combining ability.

INTRODUCTION

Topcross (test cross) method using broad and/or narrow genetic base testers is used to evaluate newly developed inbred lines for combining ability in maize hybrid breeding programs. Procedures for developing and improving inbred lines of maize were reported by Bauman (1981) and Hallauer and Miranda (1981).They concluded that grain yield was increased by using improved inbred lines. Topcross procedure was first suggested by Davis (1927) as an early testing to determine the inbred usefulness for hybrid development programs. The concept of general (GCA) and specific (SCA) combining ability was firstly defined by Sprague and Tatum (1942). (El-Morshidy and Hassaballa 1982, Mahmoud 1996, Konak et al 1999 and Zelleke 2000) they reported that variance component due to SCA for grain yield and other agronomic traits is larger than that due to GCA, indicating the importance of non-additive gene action type in the inheritance of those traits. Mathur et al (1998) found significant GCA variances for days to 50% silking, ear length, number of rows/ear and number of kernels/row, whereas SCA variance was significant for ear length only. Abd El-Moula and Ahmed (2006) using two sets of topcrosses and found that variances due to GCA were larger than those due to SCA for plant and ear height in set I, while the variances due to SCA were higher for silking date and grain yield. Also, the variances due to GCA x Loc. and SCA x Loc. were higher in magnitude for grain yield, silking date, ear height and number of ears per 100 plants $^{-1}$ in set I. This indicates that the non-additive gene effect was more affected by location than the additive type of gene effects. *Amer and* El-Shenawy (2007) reported that the additive genetic variance played an important role in the grain yield and silking date inheritance, while the non-additive genetic variance played an important role in the plant height inheritance. Interaction of SCA with location was higher than that of GCA x location for grain yield and plant height. Soliman et al (2007) reported that the magnitude of the dominance variance was the major source of the total genetic variance responsible for the inheritance of grain yield. On the other hand, Hede et al (1999), Nass et al (2000), El-Zeir et al (2000) and El-Morshidy et al (2003) obtained significant GCA x Environments interaction for both lines and testers for grain yield.

The main objectives of this investigation were: (1) to evaluate 51 topcrosses (17 lines x 3 testers) for grain yield and other traits, 2) estimate GCA effects for both lines and testers as well as SCA effects for crosses, and 3) to identify the most superior line(s) and single crosses to be utilized in hybrid maize breeding program.

MATERIALS AND METHODS

Seventeen yellow S_5 maize inbred lines derived from different wide genetic base populations through selection in the disease nursery field at Mallawy Agric. Res. Stn., were used for the purpose of this study. In 2008 growing season, the 17 lines were topcrossed to three narrow genetic base testers, i.e. two inbred lines (Gm1002, Gm1021) and a single cross (SC162) at Mallawy Exp. Stn. The two inbred tester lines were currently used in seed production of commercial single and three way crosses.

In 2009 growing season, the resultant 51 topcrosses along with three commercial check hybrids; i.e. SC162, SC 166, and TWC 352 were evaluated in a replicated yield trial conducted at two locations, i.e. Sakha and Mallawy Agric. Res. Stns. The experimental design was a randomized complete block design with four replications. Plot size was one row, 6m long and 80cm wide. Planting was in hills spaced 25cm along the row, at the rate of two kernels per hill and later thinned to one plant per hill to provide a plant population density of approximately 22000 plants faddan^{-1} (one 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 position (%), number of ears100 plants^{-1}, ear length (cm), ear diameter (cm) and grain yield (adjusted to 15.5% moisture content) was converted to ardab feddan^{-1} (one ardab=140 kg). Analysis of variance was performed for separate locations and for the combined data over locations according to Steel and Torrie (1980). Combining ability effects were computed for all studied traits according to Kempthorne (1957) as outlined by Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Analysis of variance

Mean squares presented in Table (1) revealed that differences among topcrosses were highly significant for all studied traits across locations. Both lines and testers mean squares were significant for all traits, except for ear diameter. These results indicated the presence of wide diversity among studied testers and lines in their contribution to the performance of topcrosses. However, mean squares due to lines x testers interaction was significant for all studied traits, except for ear length and ear diameter. This indicated that the lines (L) females differed in their performance in the crosses with each of the testers (T) males. Highly significant differences were detected among locations (Loc.) for all studied traits, except for grain yield indicating that the two locations differed in their environmental conditions. In addition, the Loc. x crosses interaction was significant for all the studied traits, except number of days to 50% silking and plant height. Lines x Loc. interaction was also significant for all studied traits. Testers x Loc. interaction was significant for all the studied traits, except for days to 50% silking and ear diameter. L x T x Loc. interaction showed significance for number of ears per 100 plants^{-1} and grain yield (ard fed^{-1}).

Significant interaction of genotypes with locations may be attributed to the different ranking of genotypes from one location to another. Results clarified that it is worthwhile to evaluate topcrosses under different environments (locations) especially for grain yield. This would help in deciding which hybrid can be recommended for certain environment.

The variance magnitude due to testers was higher than that due to lines for all studied traits, except for ear diameter, indicating that testers contributed much more to the total variation than the lines for these traits (Table 1). Since testers were two inbred lines and one single cross, this magnified sum of squares of testers compared with lines. Based on the combined data, the variance due to lines x Loc. was higher than that of testers x Loc. for number of days to 50% silking, ear position and ear diameter. This indicated that the lines were more affected by the environmental conditions than the testers. However, testers x Loc. interaction was higher in its magnitude than that of lines x Loc. for plant height, number of ears per 100 plants^{-1}, ear length, and grain yield, indicating that testers were more affected by the environmental conditions than lines for such traits. Similar results were reported by El-Itriby et al (1990), Shehata et al (1997), 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) who found 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 variances due to testers and locations x testers were higher than that of 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 environment.

Mean performance

Mean performance of the 51 topcrosses along with the check hybrids for days to 50% silking, plant height (cm) and ear position (%) are presented in Table (2). For number of days to 50% silking, the earliest cross was L9 x Gm1002 (57.87 days), while the latest cross was L5 x SC162, (63.0 days). Results revealed that all top crosses involving Gm1002 and 15 crosses involving Gm1021 were significantly earlier than the earliest check SC166. Only 3 crosses i.e. L6 x SC162, L9 x SC162, and L16 x SC162 were significantly earlier than the check TWC352.

Considering plant height, results revealed that the tester line Gm1002 was the shortest tester (236.21 cm) followed by Gm1021, SC162 (248.99, and 248.29 cm , respectively). Plant height ranged from 217.87 for cross L17 x Gm1002 to 268.25 cm for cross L10 x Gm1021 possessing the shortest plants. Meanwhile, 12 crosses involving Gm1002 and 4 crosses involving Gm1021 were significantly shorter than the shortest check S.C166.

Respecting ear position, results confirmed that the inbred tester Gm1002 had the lowest ear position (53.88 %) followed by SC162 (54.82%). The lowest ear placement was for the cross L9 x Gm1002 (50.07%), while the highest value was (59.86%) for the cross L10 x Gm1021. There were 4 crosses involving Gm1002 and all crosses involving SC162 exhibiting significantly lower ear placement than the lowest check S.C 166 and TWC352, respectively.

Regarding number of ears per 100 plants^{-1}(Table 3), the lowest value was 92.18 for L5 x Gm1002 while, the highest value of number of ears per 100 plants^{-1} was recorded at the cross L6 x SC162 (141.11 ears per 100 plants^{-1}). Three crosses, L6 x Gm1021, L9 x Gm1021, and L11 x Gm1021 and 7 crosses, L6 x SC162, L7 x SC162, L10 x SC162, L11 x SC162, L13 x SC162, L15 x SC162 and L16 x SC162, surpassed the highest check hybrid TWC352 for number of ears per 100 plants-^{1}.

Ear length ranged from 21.72 cm for crosses L16 x SC162 and L17 x SC162 to 17.37 cm for the cross L6 x Gm1002. All crosses involving SC162 as tester had significantly taller ears than the check TWC352.

For ear diameter, the highest value (5.10 cm) was recorded at the crosses L3 x Gm1002 and L5 x Gm1002, while the lowest value (4.57 cm) was obtained at the cross L6 x Gm1002. Crosses L3 x Gm1002, L4 x Gm1002, L5 x Gm1002, L7 x Gm1021, and L14 x Gm1021 had significantly higher ear diameter than the check hybrid SC166.

Table 1. Mean squares for days to 50% silking, plant height (cm), ear postion (%), ears per 100 plants^{-1} ear length (cm), ear diameter (cm), and grain yield (ard fed^{-1}), combined over locations in 2009 season.

S.O.V	d.f.	Mean Squar						
		Days to 50%Silking	Plant height	Ear position (%)	Number of ears per 100 plants^{-1}	Ear length (cm)	Ear diameter (cm)	Grain yield (ard fed^{-1})
Locations (Loc)	1	1906.67**	71285.41**	1755.03**	750.89**	53.39**	0.723**	13.87
Rep/L	6	20.05	2488.74	19.79	244.57	5.88	0.134	76.21
Crosses (C)	50	10.23**	1205.62**	30.35**	648.07**	7.08**	0.15**	99.36**
Line (L)	16	10.96**	1989.37**	29.30**	1008.97**	5.61**	0.325**	154.73**
Testers (T)	2	108.45**	5943.47**	242.74**	2978.94**	111.59**	0.059	511.54**
L x T	32	3.72**	517.63**	17.61**	321.94**	1.28	0.068	45.92**
C x Loc	50	1.87	252.56	15.45**	237.59**	3.64**	0.12**	29.64**
L x Loc	16	3.19*	331.83**	27.77**	257.10**	2.12*	0.227**	36.67**
T x Loc	2	1.39	619.28**	25.82*	1400.01**	52.56**	0.104	174.25**
L x T x Loc	32	1.25	190.01	8.65	155.18*	1.35	0.066	17.10*
Pooled Error	300	1.74	152.76	9.11	97.73	1.08	0.04	10.43
C.V%		2.19	2.19	5.04	5.48	5.27	4.54	10.60

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

Regarding grain yield (ard fed^{-1}), results presented in Table (3) showed that over all parental testers, the tester SC162 produced the highest grain yield (32.55 ard fed^{-1}) followed by Gm1021 as tester (30.10 ard fed^{-1}), whereas Gm1002 gave the lowest grain yield (28.72 ard fed^{-1}). Topcross L10 x SC162 produced the highest grain yield (38.08 ard fed^{-1}). On the contrary, the topcross L16 x Gm1021 produced the lowest yield (22.88 ard fed^{-1}). The highest yielding topcrosses were L7 x Gm1002, L10 x Gm1002, L9 x Gm1021, L10 x Gm1021, L11 x Gm1021, and L15 x Gm1021. Out of these crosses there topcrosses were; L10 x Gm1002, L9 x Gm1021, L10 x Gm1021, and L11 x Gm1021 outyielded the check hybrid SC 162 by 18.66, 15.55, 17.79 and 15.11 %, respectively. There were 16 top crosses involving SC162 possessed significantly higher grain yield ability than the check hybrid TWC352 and were superior to the check SC162 itself.

General (GCA) and specific (SCA) combining ability effects

Estimates of general combining ability (GCA) effects for the studied traits are shown in Table (4). Inbred lines L6, L7, L9, L14, and L16 across locations possessed significant negative GCA effects (desirable) towards earliness for days to 50% silking. In contrast; L3, L5, L10, L11, and L12 across locations had significantly positive GCA effects (undesirable) towards lateness.

For plant height, L3, L6, L7, L16, and L17 across locations had significantly negative GCA effects towards shortness. On the other hand, L10, L11 L12, and L15 across locations exhibited significantly positive GCA effects towards tallness. Respecting ear position, three inbred lines i.e. L1, L9, and L17 had significant negative GCA effects towards low ear placement (desirable). It is worthy noting that only L7 exhibited significant positive GCA effects towards high ear placement (undesirable).

As for number of number of ears per100 $plants^{-1}$, L1, L5, L8, and L14 across locations possessed significantly negative GCA effects (undesirable) toward less ears per 100 $plants^{-1}$. On the contrary, Lines L6, L10, and L11 across locations possessed desirable significant GCA effects towards producing hybrids of more ears per plant.

Table 2. Average performance of 51 topcrosses for days to 50% silking, plant height (cm), and ear position (%) combined over locations, in 2009 growing season

Line	Days to 50% silking			Plant height			Ear position		
	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162
L1	59.12	59.12	61.12	236.62	243.37	240.00	53.47	54.61	51.68
L2	59.87	59.87	61.12	241.75	250.62	252.00	55.90	57.22	55.16
L3	59.37	61.50	61.50	224.62	243.00	242.50	54.30	55.66	54.21
L4	59.75	60.87	61.50	246.37	250.75	243.62	53.90	56.97	55.86
L5	60.87	60.62	63.00	237.25	251.25	250.87	52.77	54.88	56.41
L6	59.00	59.37	59.87	230.37	235.75	238.12	54.43	55.07	53.03
L7	58.00	58.87	61.50	234.62	230.00	250.87	54.67	53.87	56.88
L8	60.75	60.50	62.00	233.00	253.62	238.62	52.90	55.65	55.27
L9	57.87	60.37	60.00	222.62	264.87	245.87	50.07	58.43	51.06
L10	60.75	59.62	62.37	263.87	268.25	268.00	55.93	59.86	56.17
L11	59.75	61.37	61.25	251.50	263.25	256.25	53.86	58.45	56.45
L12	60.25	61.00	61.37	243.37	265.12	251.87	54.57	57.72	55.66
L13	61.00	60.62	60.50	235.00	258.12	237.75	54.80	58.42	54.61
L14	58.75	58.75	60.50	240.87	248.50	245.12	54.70	55.67	56.06
L15	59.75	59.50	61.50	243.12	252.37	259.12	54.82	55.60	54.28
L16	58.37	60.00	60.25	228.75	235.75	251.00	53.92	55.86	56.15
L17	58.87	59.37	61.62	217.87	218.37	249.37	51.02	57.13	53.06
Mean	59.53	60.08	61.23	236.21	248.99	248.29	53.88	56.53	54.82
Checks:									
SC162	64.37			257.37			59.77		
SC166	62.50			254.37			56.22		
TWC352	61.75			236.37			60.07		
LSD 0.05	1.28			12.54			3.29		

Table 3. Average performance of 51 topcrosses for number of ears per 100 plants^{-1}, ear length (cm), ear diameter (cm), and grain yield (ard fed^{-1}) combined over locations in 2009 growing season.

Line	Number of ears per 100 plants^{-1}			Ear length			Ear diameter			Grain yield		
	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162
L1	95.85	99.95	106.22	18.10	18.75	20.27	4.72	4.85	4.67	25.03	27.63	24.60
L2	101.45	117.97	102.76	19.05	19.05	20.17	4.87	4.75	4.75	27.02	30.78	30.66
L3	106.32	106.77	104.42	19.72	19.47	20.87	5.10	4.92	4.95	29.69	31.50	30.81
L4	103.54	108.92	105.41	19.27	19.57	20.60	5.07	5.00	4.97	30.16	29.42	34.50
L5	92.18	110.67	104.60	18.57	19.7	20.82	5.10	4.95	4.87	28.84	29.86	32.67
L6	108.98	122.08	141.11	17.37	18.82	19.17	4.57	4.65	4.70	23.83	25.17	32.67
L7	106.12	103.65	109.80	19.77	19.30	20.97	4.92	5.05	4.77	32.72	23.90	31.20
L8	99.01	100.50	99.68	19.75	20.42	21.45	4.95	4.95	4.87	28.01	31.02	30.24
L9	106.17	122.22	105.00	19.22	19.30	20.82	4.75	4.87	4.82	29.57	34.48	32.67
L10	103.31	119.07	120.98	20.22	19.72	21.10	4.97	4.85	4.97	35.41	35.15	38.08
L11	105.22	133.01	119.64	19.55	19.50	20.53	4.65	4.55	4.90	30.66	34.35	35.04
L12	104.57	105.57	103.24	19.57	20.05	20.97	4.67	4.85	4.85	27.29	30.44	31.50
L13	104.86	112.81	113.12	19.20	19.65	20.82	4.82	4.80	4.75	25.63	31.46	30.77
L14	98.90	102.30	104.58	18.45	19.60	21.20	4.92	5.07	4.77	29.70	31.95	37.40
L15	98.27	104.11	113.85	18.80	19.70	20.87	4.97	5.02	4.95	30.16	32.20	36.44
L16	101.50	101.16	112.16	19.12	19.12	21.12	4.75	4.67	4.70	29.10	22.88	32.53
L17	102.97	111.85	104.11	18.37	19.70	21.72	4.82	4.77	4.72	25.46	29.55	31.62
Mean	102.31	110.74	110.04	19.06	19.70	21.72	4.86	4.86	4.82	28.72	30.10	32.55
Checks:												
SC162	112.14			22.57			4.71			29.84		
SC166	111.56			22.15			4.82			35.02		
TWC352	98.76			17.85			4.92			22.57		
LSD0.05	9.64			1.02			0.21			3.20		

Considering ear length, inbred lines L8, L10 and L12 possessed significantly positive GCA effects (desirable), while inbred lines L1 and L6 possessed significantly negative GCA effects (undesirable). Regarding ear diameter inbred lines L3, L4, L5 and L15 possessed significantly positive GCA effects (desirable), while, inbred lines L1, L6, L11 and L16 across locations possessed significantly negative GCA effects (undesirable)

Regarding grain yield, inbred lines L9, L10, L11, L14 and L15 possessed significantly positive GCA effects (desirable) towards high grain yield. Meanwhile, inbred lines L1, L6, L16 and L17 across locations possessed significantly negative GCA effects (undesirable) towards low grain yield.

Considering the tester, results in Table (4), revealed that testers had better general combining ability effects (GCA) for the studied traits as follows: Gm1002 for earliness and plant height; Gm1021 for number of ears per100 plants^{-1}; while SC162 for number of ears per 100 plants^{-1} and grain yield.

Estimates of SCA effects for the studied traits are presented in Table (5). For number of days to 50% silking; 3 crosses had positive values of SCA (undesirable) towards late maturity. Crosses L13 x SC162 and L10 x Gm1021 possessed significant negative SCA effects across locations and were earlier in flowering compared with the check hybrids.

Regarding the combined analysis across locations for plant height (Table 5), four topcrosses possessed either significant or highly significant negative SCA effects towards shortness. These crosses were L9 x Gm1002, L7 x Gm1021, L17 x Gm1021, and L13 x SC162. On the other hand, five topcrosses possessed significant positive SCA effects towards tallness (undesirable). These crosses were L9 x Gm1021, L13 x Gm1021, L7 x SC162, L16 x SC162, and L17 x SC162.

For ear position, only one cross, L7 x Gm1021 across locations had highly significant negative SCA effect toward low ear placement.

Out of the 51 studied topcrosses (Table 6), four crosses viz. L6 x SC162, L2 x Gm1021, L9 x Gm1021, and L11 x Gm1021 possessed significant positive SCA effects towards more number of ears per100 plants^{-1}, which is desirable. On the other hand five topcrosses viz. L6 x Gm1002, L11 x Gm1002, L2 x SC162, L9 x SC162 and L17 x SC162 possessed significant negative SCA effects towards fewer number of ears per100 plants^{-1}, which is undesirable.

Table 4. Estimates of general combining ability effects for days to 50% silking, plant height (cm), ear position (%), ears per 100 plants^{-1}, ear length (cm), ear diameter (cm) and grain yield (ard fed^{-1}) combined over locations, in 2009 growing season.

Line	Days to 50%silking	Plant height (cm)	Ear position (%)	Number of ears per 100 plants^{-1}	Ear length (cm)	Ear diameter (cm)	Grain yield (ardfed^{-1})
L1	-0.473	-4.835	-1.821*	-7.024**	-0.733**	-0.098*	-4.703**
L2	0.026	3.289	1.016	-0.303	-0.349	-0.067	-0.970
L3	0.526*	-8.127**	-0.354	-1.857	0.250	0.143**	0.205
L4	0.443	2.080	0.499	-1.740	0.042	0.168**	0.902
L5	1.235**	1.822	-0.387	-5.211**	-0.283	0.126**	-0.004
L6	-0.848**	-10.085**	-0.896	16.363**	-1.316**	-0.207**	-3.234**
L7	-0.806**	-8.336**	0.066	-1.174	0.242	0.067	-1.186
L8	0.485	-3.085	-0.471	-7.966**	0.767**	0.078	-0.702
L9	-0.848**	-0.377	-1.888**	3.434	0.009	-0.032	1.775*
L10	0.651*	22.206**	2.245**	6.759**	0.575*	0.083	5.750**
L11	0.526*	12.184**	1.174	11.592**	0.084	-0.148**	2.895**
L12	0.810**	8.822**	0.908	-3.237	0.425*	-0.057	-0.714
L13	0.443	-1.210	0.866	2.567	0.117	-0.057	-1.169
L14	-0.931**	-0.002	0.399	-5.770**	-0.024	0.076	2.553**
L15	-0.014	6.706*	-0.254	-2.286	0.017	0.134**	2.478**
L16	-0.723**	-6.336*	0.233	-2.757	0.017	-0.140**	-2.290**
L17	-0.306	-16.294**	-1.337*	-1.386	0.159	-0.074	-1.583*
SE gi Lines SE (gi-gj)	0.269 0.380	2.522 3.567	0.616 0.871	2.018 2.853	0.212 0.300	0.044 0.057	0.659 0.932
Testers							
Gm1002	-0.786**	-7.622**	-1.191**	-5.388**	-0.707**	0.014	-1.736**
Gm1021	-0.184	4.164**	1.444**	3.045**	-0.314**	0.009	-0.359
SC162	0.970**	3.458*	-0.252	2.343*	1.021**	-0.023	2.093**
SE gi testers SE (gi-gj)	0.113 0.159	1.059 1.498	0.258 0.366	0.847 1.198	0.089 0.126	0.018 0.024	0.277 0.391

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

Regarding ear length, crosses L17 x Gm1002 and L17 x SC162 possessed significant positive and negative SCA effects, respectively. Crosses L14 x Gm1021, and L11 x SC162 had significant positive, while the cross L11 x Gm1021 had significantly negative SCA effects for ear diameter.

Respecting grain yield, data in Table (6) showed that, topcrosses L7 x Gm1002, L9 x Gm1021, L13 x Gm1021, L16 x Gm 1002, L1 x Gm 1021, L6 x SC162, L14 x SC162, and L16 x SC162 possessed significant positive SCA effects. In contrast, the three crosses L7 x Gm 1021, L16 x Gm 1021 and L1 x SC162 possessed significant negative SCA effects.

In this connection, Sprague and Tatum (1942) emphasized the importance of single and three-way cross trials for determining the most productive specific combination. Mahgoub et al (1996), Shehata et al (1997) and El-Zeir (1999), reported that inbred testers were more effective to select lines that combine well with unrelated testers. Moreover, they emphasized that inbred testers were more effective in detecting small differences in combining ability more than wide genetic base testers.

It could be concluded that, the promising inbred lines L9, L10, L11, L14, and L15 which possessed the best GCA effects for grain yield should be utilized in hybridization program to improve maize productivity. The best general combiners of parental lines were L9 for high yielding ability, earliness and low ear placement; L14 for high yield and earliness; L6 for high number of ears per 100 $plants^{-1}$; short plants and earliness. Moreover, the present findings suggest that the most outstanding crosses are L6 x SC162, L14 x SC162, and L16 x SC162. They had significant SCA effects and outyielded the commercial check TWC352. Accordingly, they should be further tested for the possibility of commercial release.

Table 5. Estimates of specific combining ability effects for days to 50%silkin, plant height (cm) and ear position (%), combined over Locations in 2009 season.

Line	Days to 50% silking			Plant height			Ear position		
	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162
L1	0.120	-0.482	0.363	4.247	-0.789	-3.458	1.408	-0.089	-1.318
L2	0.370	-0.233	-0.137	1.247	-1.664	0.417	0.996	-0.315	-0.681
L3	-0.630	0.892	-0.262	-4.481	2.127	2.333	0.767	-0.507	-0.260
L4	-0.172	0.350	-0.179	7.081	-0.331	-6.750	-0.487	-0.048	0.536
L5	0.162	-0.691	0.529	-1.586	0.627	0.959	-0.725	-1.248	1.973
L6	0.370	0.142	-0.512	3.247	-3.164	-0.083	1.446	-0.552	-0.893
L7	-0.672	-0.399	1.071*	3.747	-12.664**	8.917*	0.721	-2.715**	1.994
L8	-0.213	-0.066	0.279	-1.127	7.711	-6.583	-0.516	-0.402	0.919
L9	-0.755	1.142*	-0.387	-14.211**	16.252**	-2.042	-1.925	3.802**	-1.877
L10	0.620	-1.108*	0.488	5.456	-2.956	-2.500	-0.196	1.093	-0.898
L11	-0.255	0.767	-0.512	2.122	2.086	-4.208	-1.199	0.752	0.448
L12	0.162	0.308	-0.470	-2.046	7.502	-5.042	-0.221	0.293	-0.073
L13	1.078*	0.100	-1.179**	-1.002	10.336*	-9.333*	0.046	1.035	-1.081
L14	0..203	-0.399	0.196	3.664	-0.497	-3.167	0.412	-1.248	0.836
L15	0.287	-0.566	0.279	-0.794	-3.331	4.125	1.192	-0.907	-0.285
L16	-0.379	0.642	-0.262	-2.127	-6.914	9.042*	-0.196	-0.894	1.089
L17	-0.297	-0.399	0.696	-3.044	-14.331**	17.375**	-1.525	1.952	-0.427
SE.S_{ij}	0.46			4.36			1.06		
SE (S_{ij}-S_{kl})	0.65			6.17			1.50		

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

Table 6. Estimates of specific combining ability effects for number of ears per 100 plants^{-1}, ear length (cm), ear diameter (cm) and grain yield (ard fed^{-1}) combined over locations, in 2009 growing season

Line	Number of ears per 100 plants^{-1}			Ear length			Ear diameter			Grain yield (ard fed^{-1})		
	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162	Gm1002	Gm1021	SC162
L1	0.564	-3.771	3.207	-0.234	0.022	0.212	-0.039	0.090	-0.051	1.013	2.234*	-3.247*
L2	-0.557	7.533*	-6.977*	0.331	-0.080	-0.271	0.069	-0.051	-0.017	-0.733	1.654	-0.921
L3	5.872	-2.112	-3.760	0.406	-0.235	-0.171	0.094	-0.078	-0.017	0.761	1.187	-1.948
L4	2.968	-0.079	-2.889	0.185	0.072	-0.238	0.044	-0.026	-0.017	0.536	-1.584	1.048
L5	-4.911	5.142	-0.231	-0.209	-0.102	0.312	0.111	-0.034	-0.075	0.118	-0.238	0.119
L6	-9.686**	-5.020	14.707**	-0.376	0.681	-0.304	-0.081	-0.001	0.082	-1.657	-1.691	3.349**
L7	4.989	-5.920	0.932	0.466	-0.402	-0.063	-0.006	0.123	-0.117	5.188**	-5.018**	-0.170
L8	4.668	-2.279	-2.389	-0.085	0.197	-0.113	0.011	0.015	-0.026	-0.014	1.621	-1.607
L9	0.431	8.046*	-8.477**	0.148	-0.169	0.020	-0.081	0.048	0.032	-0.932	2.587*	-1.656
L10	-5.757	1.0571	4.186	0.581	-0.311	-0.371	0.025	-0.092	0.068	0.938	-0.716	-0.222
L11	-8.678**	10.675**	-1.997	0.398	-0.044	-0.364	-0.064	-0.159*	0.224**	-0.953	1.357	-0.403
L12	5.501	-1.933	-3.568	0.081	0.164	-0.346	-0.131	0.048	0.082	-0.708	1.051	-0.342
L13	-0.015	-0.500	0.515	0.015	0.072	-0.088	0.019	-0.001	-0.017	-1.917	2.527*	-0.609
L14	2.359	-2.675	0.315	-0.586	0.184	0.429	-0.14	0.140*	-0.126	-1.582	-0.704	2.287*
L15	-1.748	-4.345	6.094	-0.285	0.222	0.062	-0.022	0.032	-0.009	-1.037	-0.374	1.412
L16	1.947	-6.825	4.877	0.040	-0.352	0.312	0.027	-0.043	0.016	2.662*	-4.928**	2.266*
L17	2.051	2.492	-7.543*	-0.851*	0.081	0.771*	0.035	-0.009	-0.026	-1.682	1.035	0.647
SE.S_{ij}	3.49			0.36			0.07			1.14		
SE(S_{ij}-S_{kl})	4.94			0.52			0.10			1.61		

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

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إستخدام كشافات ضيقة القاعدة الوراثية لتقدير القدرة على التآلف في سلالات الذرة الشامية

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تم تهجين ١٧ عائلة منتخبة من الذرة الشامية الصفراء في الجيل الذاتي الخامس (S_5) مع ثلاث قواعد وراثية كشافة هي: السلالتين التجاريتين جميزة١٠٠٢ وجميزة ١٠٢١والهجين الفردي ١٦٢ وذلك بمحطة البحوث الزراعية بملوي في موسم ٢٠٠٨. وفي موسم ٢٠٠٩ تم تقييم ٥١ هجين قمي مع ثلاثة هجن للمقارنة (هـ. ف. ١٦٢ ، هـ. ف. ١٦٦ ، هـ.ث. ٣٥٢ في كل من محطتي البحوث الزراعية بسخا (محافظة كفر الشيخ) ، وملوي (محافظة المنيا) وذلك لصفات عدد الأيام من الزراعة حتى ظهور ٥٠ % من الحراير ، ارتفاع النبات وموضع الكوز، عدد الكيزان/١٠٠ نبات ، محصول الحبوب بالأردب للفدان. وقد وجدت إختلافات معنوية بين الهجن القمية , السلالات , الكشافات , السلالات × الكشافات لكل الصفات موضع الدراسة مما يدل على التباين الوراثي الكبير بين كل من السلالات والكشافات المستخدمة. كذلك وجدت إختلافات معنوية بين الجهات (البيئات) لكل الصفات ، وكذلك التفاعل بين البيئات والهجن القمية لصفات موضع الكوز، عدد الكيزان/١٠٠ نبات ، محصول الحبوب بالأردب للفدان و السلالات والكشافات والبيئات لجميع الصفات المدروسة ما عدا صفة عدد الأيام من الزراعة حتى ظهور ٥٠ % من الحراير لتباين تفاعل البيئات مع الكشافات . أما التفاعل بين البيئات والسلالات، والكشافات فقد كان معنويا لصفة عدد الكيزان/١٠٠ نبات ومحصول الحبوب. وقد أظهرت السلالات أرقام ٩ ، ١٠ ، ١١ ، ١٤ ، ١٥ أحسن التاثيرات للقدرة العامة على الإئتلاف لصفة محصول حبوب الفدان. كما أظهرت ٨ هجن قمية أحسن التاثيرات للقدرة الخاصة لصفة المحصول. كما تبين من النتائج إمكانية تكوين ثلاث هجن ثلاثية جديدة وجيدة باستخدام السلالات أرقام ١٠و ١٤و ١٥ آباء للهجين الفردي ١٦٢ والتي أعطت محصولا قدرة ٣٨,١٠و ٣٧,٤٠ و٣٦,٤٠ أردبا للفدان على الترتيب مقارنة بأفضل هجن المقارنة ١٦٦ والذي أعطى محصولا قدرة ٣٥ أردبا للفدان الأمر الذي يستوجب الإستفادة من هذه الهجن في برامج التربية.