COMBINING ABILITY ANALYSIS OF SOME YELLOW MAIZE (*Zea mays* L.) INBRED LINES

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Abstract

Twenty six yellow maize inbred lines derived from different hetrotic group through selection in the disease nursery field at Mallawy Agricultural Research Station were used in this study. In 2008 growing season the twenty six inbred lines were topcrossed to each of two narrow base inbred testers i.e. Gm.1002 and Gm.1021 at Mallawy Agric. Res. Stn. In 2009 season, 52 topcrosses along with two commercial check hybrids i.e. SC 162 and SC 166 were evaluated in replicated yield trials conducted at Sakha and Mallawy. Data were recorded for days to 50% silking, plant and ear height (cm), ears per 100 plants, ear length (cm), no. of rows per ear, no. of kernels per row and adjusted grain yield at 15.5% grain moisture and converted to ardab per fed. Combined analysis over the two locations showed that mean squares due to crosses and lines were significant or highly significant for all the studied traits except of lines for number of kernels/row. Mean squares due to lines x testers were significant for days to 50% silking, number of rows/ear and grain yield, indicating their differences in order of performance in crosses with each of the testers. Mean squares due to crosses x locations interactions were significant for grain yield. Mean squares due to lines x locations were significant for number of rows/ear. Testers x locations interaction were significant or highly significant for the studied traits, except days to 50% silking and number of rows/ear. Mean squares due to lines x testers x locations interaction were highly significant for all the studied traits, except days to 50% silking and no. of rows per ear. The magnitude of σ^2 GCA (average) was larger than that obtained for σ^2 SCA for plant height, ear height and ears per 100 plants. The magnitude of σ^2 SCA exceeded that of σ^2 GCA (average) for days to 50% silking, ear length, no. of rows per ear and grain yield. For grain yield, seven crosses i.e. (L-13 x Gm.1021), (L-6 x Gm.1002), (L-11 x Gm.1021), (L-2 x Gm.1021), (L-7 x Gm.1002), (L-18 x Gm.1021) and (L-7 x Gm.1021) significantly outyielded the check hybrid SC 162. One of them (L-13 x Gm.1021) also significantly outyielded the check hybrid SC 166. The best GCA effects were obtained from L-16, L-19, L-20, and L-21 for days to 50% silking, plant and ear height, which had negative and significant GCA effects. 4 inbred lines for ears per 100 plants, 11 for ear length, 5 for no. of rows per ear and 7 inbred lines for grain yield exhibited positive and significant GCA effects. The topcrosses L-1, L-9, L-12 and L-19 x Gm.1002 and L-10, L-13 and L-26 X Gm.1021) had positive and significant or highly significant SCA effects.

Key words: *Maize, Topcross, line x tester, combining ability*

INTRODUCTION

Maize (*Zea mays* L.) is one of the three most important cereal crops in the world together with wheat and rice. The topcross procedures suggested by Davis (1927) were used to evaluate the combining ability of inbred lines to determine the usefulness of the lines for hybrid development. Line x tester analysis is an extension of this method in which several testers are used (Kempthorne 1957). Line x testers analysis provides information about general and specific combining ability of parents and at the same time it is helpful in estimating various typed of gene action (Singh and Chaudhary 1985). The concepts of general combining ability (GCA) and specific combining ability (SCA) defined by Sprague and Tatum (1942) have been extensively used in breeding of several economic crop species. For maize yield, they found that GCA was relatively more important than SCA for non selected inbred lines, whereas SCA was more important than GCA for previously selected lines. Rojas and Sprague (1952) compared estimates of the variances of GCA and SCA for yield and their interaction with locations and years. They noticed that the variance of SCA includes not only the non-additive deviations due to dominance and epistasis but also a considerable portion of the genotype x environment interaction. The concepts of GCA and SCA became useful for characterization of inbred lines in crosses and often have been included in the description of an inbred line (Hallauer and Miranda Filho 1988). Jayakumar and Sundaram (2007) reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, number of grains per row and grain yield. Abd El-Maksoud et al. (2003), Almanie et al. (2006), Todkar and Navale (2006), Dar et al. (2007) and Abd El-Moula and Abd El-Aal (2009) reported similar results. The main objectives of this study were: (1) to identify the best inbred lines for general combining ability, (2) to identify the best crosses regarding the specific combining ability for grain yield and other traits and (3) to determine the different types of gene action involved in manifestation of grain yield and other studied traits.

MATERIALS AND METHODS

Twenty six yellow maize inbred lines derived from different hetrotic group through selection in disease nursery field at Mallawy Agricultural Research Station were used in this study. In 2008 growing season the twenty six inbred lines were topcrossed to each of the two narrow base inbred testers i.e. Gm.1002 and Gm.1021 at Mallawy Agric. Res. Stn. In 2009 season, 52 topcrosses along with two commercial check hybrids i.e. SC 162 and SC 166 were evaluated in replicated yield trials conducted at Sakha and Mallawy Agric. Res. Stns. A randomized complete block design with four replications was used in each location. Plot size was one row, 6 m long and 80cm wide, hills were spaced 25 cm along the row. All cultural practice for maize production were applied as recommended. Data were recorded for days to 50% silking, plant and ear height (cm), number of ears per 100 plants, ear length (cm), no. of rows per ear, no. of kernels per row and adjusted grain yield at 15.5% grain moisture and converted to ardab per fed (ardab = 140 kg). Analysis of variance was performed for the combined data over locations according to Steel and Torrie (1980). Procedures of Kempthorne (1957) were performed to obtain valuable information about the combining ability of lines and testers as well as their topcrosses.

RESULTS AND DISCUSSION

Analysis of variance

Combined analysis of variance over two locations for 52 topcrosses for the studied traits is presented in Table (1). Results showed highly significant differences between the two locations for all traits, except number of kernels/row and grain yield. Mean squares due to crosses and lines were significant or highly significant for all the studied traits except crosses for number of kernels/row. Mean squares due to tester were significant for days to 50% silking. Mean squares due to lines x testers were significant for days to 50% silking, number of rows/ear and grain yield, indicating that lines differed in their order of performance in crosses with each of the testers. Similar results were obtained by Castellanos et al. (1998), Soliman and Sadek (1999), Soliman (2000), Venugopal et al. (2002), Amer et al. (2003), Abd El-Moula and Abd El-Aal (2009).

Mean squares due to crosses x locations interaction were significant for grain yield. Mean squares due to lines x locations were significant for number of rows/ear. Mean squares due to testers x locations interaction were significant or highly significant for all the studied traits, except days to 50% silking and number of rows/ear. Mean squares due to lines x testers x locations interaction were highly significant for all the studied traits, except days to 50% silking and no. of rows per ear. These results are in agreement with Shehata et al. (2001) who found that the interaction of lines x testers x locations was insignificant for no. of rows per ear. Mahmoud and Abd El-Azeem (2004), Abd El-Moula and Abd El-Aal (2009) found that the interaction of lines x testers x locations was highly significant for grain yield.

Table 1. Combined mean squares for grain yield and the other studied traits, combined data of two locations in 2009 season.

S.O.V	DF	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Ear length (cm)	No. of rows/ear	No. of kernels/row	Grain yield (ard/fed)
Location (Loc)	1	6254.25**	124650.00**	74820.29**	3359.61**	67.28**	12.81**	19.00	168.6
Rep/loc.	6	17.52	73.10	162.85	153.54	1.79	1.29	15.22	55.45
Crosses	51	16.55**	544.69**	362.37**	485.26**	7.50**	4.98**	15.73	71.75**
Lines	25	26.99**	561.54*	372.70**	368.6**	8.92**	8.49**	21.15**	82.47**
Testers	1	40.00*	7693.56	64890.06	10647.45	39.32	3.43	18.83	169.33
Lines x testers	25	5.17**	241.89	106.97	195.55	4.79	1.53**	10.20	57.12**
Loc. x Crosses	51	2.29	239.45	188.68	319.65	3.39	1.29	11.54	30.04**
Loc. x Lines	25	2.55	238.08	138.88	233.84	2.96	1.99**	9.61	30.11
Loc. x testers	1	0.19	2266.44**	3583.75**	5299.59**	26.55**	0.14	68.08**	289.93**
Loc. x Lines x testers	25	2.11	159.74**	102.68**	206.01**	2.89**	0.64	11.20**	19.58**
Error	306	1.45	65.56	51.20	92.79	0.79	0.59	4.12	10.31
CV%		1.99	3.13	4.91	9.02	4.40	5.12	5.19	10.51

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

The magnitude of mean squares due to testers was higher than that of lines for all studied traits, except no. of rows per ear and no. of kernels per row, indicating that the tester contributed much more in the total variation for most the studied traits. Also the mean squares due to testers x locations were higher than that of lines x locations for all the studied traits, except days to 50% silking and no. of rows per ear, indicating that the testers were more affected by the environmental conditions than the lines. These results are in agreement with those obtained by Gado et al. (2000), El-Morshidy et al. (2003), Abd El-Moula and Ahmed (2006) and Abd El-Moula and Abd El-Aal (2009).

Mean performance

Mean performance of the 52 topcrosses for all the studied traits is presented in Table (2). For days to 50% silking, all crosses were significantly earlier than the two check hybrids. The earliest crosses were L-16 x Gm.1002, L-13 x Gm.1002, L-14 x Gm.1002, L-18 x Gm.1021 and L-14 x Gm.1021. In general, the crosses involving inbred line Gm.1002 as tester flowered earlier than those involving the inbred tester line Gm.1021 with few exceptions. Plant height, ranged from 234.3 for cross L-21 x Gm.1002 to 279.0 cm for cross L-11 x Gm.1021. Eight crosses were significantly shorter than check hybrid SC 166. For ear height, 22 crosses had significantly lower ear height than the two check hybrids. The crosses involving the inbred tester Gm. 1002 had lower ear height comparing with crosses which involving the inbred tester line Gm.1021.

Concerning no. of ears per 100 plants, seven crosses i.e. L-2, 3, 6, 11, 23, 24 and 25 x Gm.1021 significantly outyielded the check hybrid SC 162, one of them (L-6 x Gm.1021) significantly surpassed the check hybrid SC 166, with value of 132.5 ears per 100 plants. Data showed that the crosses involving the tester Gm.1021 tended to have higher no. of ears per 100 plants than those of the tester Gm.1002. For ear length, the best crosses were L-11 x Gm.1021 and L-26 x Gm.1021 with value of 21.8cm followed by L-12 x Gm.1002 and L-2 x Gm.1002 with values of 21.7 and 21.6cm, respectively. Regarding no. of rows per ear there were 12 crosses outyielded of the two check hybrids. The best crosses were L-6 x Gm.1002, L-22 x Gm.1021, L-6 x Gm.1021 and L-14 x Gm.1002 with values of 17.3, 17.1, 16.5 and 16.0 rows per ear, respectively.

Table 2. Mean grain yield and other studied traits of the crosses between 26 inbred lines and two testers (Gm.1002 and Gm.1021) evaluated in two locations during 2009 season.

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Ear length (cm)		No. of rows/ear		No. of kernels/row		Grain yield (ard/fed)	
	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021
L-1	58.6	59.7	256.1	263.8	141.6	151.6	105.9	106.5	18.2	19.2	15.1	15.0	36.3	37.5	33.57	29.52
L-2	60.9	61.1	256.8	261.6	142.4	148.6	97.7	121.9	21.6	20.6	14.4	13.4	42.4	39.9	30.55	34.79
L-3	61.9	61.1	251.9	273.3	140.4	154.5	102.5	122.0	21.1	20.3	14.1	14.6	39.8	38.9	29.71	32.73
L-4	60.5	61.1	267.4	267.5	147.4	152.6	102.4	118.3	20.6	20.7	14.2	14.3	40.2	40.6	33.27	33.03
L-5	59.9	60.9	261.4	269.0	145.6	150.6	102.3	111.4	21.0	20.9	14.5	14.5	40.8	40.1	32.03	29.67
L-6	60.1	61.8	264.1	269.8	150.3	156.1	111.0	132.5	20.6	19.8	17.3	16.5	38.0	38.5	35.46	33.09
L-7	60.0	61.8	258.4	263.4	144.4	151.8	103.2	108.5	20.9	21.1	14.6	14.2	40.0	40.2	34.27	34.67
L-8	61.3	62.0	258.5	261.0	145.3	152.3	99.6	108.0	20.5	20.6	15.6	14.3	40.2	39.1	31.00	32.14
L-9	61.8	62.3	252.6	268.8	140.9	150.5	98.9	104.9	19.3	20.1	15.5	14.2	39.3	38.2	30.41	25.04
L-10	61.9	60.6	260.1	265.4	150.3	149.3	98.9	109.4	18.1	20.9	14.9	14.3	36.0	37.9	25.20	32.89
L-11	60.6	61.6	255.3	279.0	147.3	166.0	105.6	121.3	20.7	21.8	14.10	14.3	39.3	39.7	31.46	34.91
L-12	62.6	61.3	261.3	262.8	145.0	146.8	103.2	107.1	21.7	19.6	14.6	14.4	40.0	36.2	32.95	29.58
L-13	58.3	59.3	255.4	260.9	138.8	147.5	101.7	111.0	18.1	20.2	14.6	15.0	36.4	39.0	28.67	36.53
L-14	58.3	58.5	260.6	264.6	144.6	149.1	99.8	100.6	18.8	19.6	16.0	15.9	39.0	39.8	26.91	30.61

Table 2. Continued

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Ear length (cm)		No. of rows/ear		No. of kernels/row		Grain yield (ard/fed)	
	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021
L-15	58.8	59.6	247.8	263.4	136.9	147.9	98.3	104.4	18.2	20.1	15.9	16.4	38.0	41.7	27.96	31.18
L-16	57.3	59.1	244.9	257.9	135.1	144.8	100.3	111.1	20.1	19.4	15.0	15.6	39.8	40.3	23.55	27.61
L-17	59.5	61.1	250.5	263.0	135.6	149.3	103.9	106.0	20.0	21.3	15.5	15.2	39.7	40.5	32.36	30.30
L-18	60.1	58.4	253.0	263.0	141.9	148.5	99.8	109.9	20.4	21.2	15.2	14.8	38.1	41.1	30.70	34.35
L-19	58.6	59.4	243.9	259.3	133.5	146.4	102.1	103.3	19.5	20.4	14.9	15.0	37.6	38.6	30.41	25.07
L-20	58.9	59.8	252.1	244.1	140.1	138.5	101.7	105.1	20.5	20.9	15.1	15.0	40.5	41.3	31.79	29.18
L-21	59.4	59.4	234.3	252.5	124.6	140.1	99.9	107.0	19.5	20.3	14.3	15.4	38.3	38.9	28.11	32.10
L-22	62.6	62.8	254.0	251.9	140.3	142.8	101.0	109.6	18.3	19.4	16.2	17.1	37.9	39.3	27.32	28.66
L-23	58.8	59.6	249.6	264.4	143.3	152.6	103.0	121.8	18.6	20.1	15.1	14.6	38.4	38.6	29.83	33.21
L-24	58.6	62.1	264.5	266.8	143.9	151.9	100.7	120.9	19.6	20.9	14.7	14.1	38.2	38.8	27.86	31.44
L-25	61.1	62.6	259.4	262.1	147.5	147.8	102.0	120.2	20.0	20.6	14.7	14.3	38.4	37.7	28.64	28.96
L-26	62.5	61.9	250.0	268.4	139.8	154.1	99.1	104.8	19.7	21.8	15.1	14.3	39.6	41.0	24.24	30.06
Check hybrids:																
SC 162	66.4		270.8		151.9		108.3		24.1		14.0		44.2		30.60	
SC 166	64.4		258.8		150.5		119.4		22.3		14.8		42.2		33.18	
LSD 0.05	1.2		7.93		7.01		9.4		0.9		0.7		-		3.15	

It may be noticed that the inbred lines no. 6, 14, 15 and 22 exhibited a similar performance with the two testers, indicating that these inbred lines were considered as good combiners for high number of rows per ear. For no. of kernels per row, mean performance ranged from 36.2 for cross L-12 x Gm.1021 to 42.4cm for cross L-2 x Gm.1002.

Concerning grain yield, results showed that the crosses involving Gm.1021 as a tester tended to have higher values of grain yield than those of Gm.1002 as a tester. There were seven crosses outyielded the check hybrid SC 162 i.e. L-13 x Gm.1021 (36.53 ard/fed), L-6 x Gm.1002 (35.46), L-11 x Gm.1021 (34.91), L-2 x Gm.1021 (34.79), L-7 x Gm.1002 (34.67), L-18 x Gm.1021 (34.35) and L-7 x Gm.1021 (34.27). One of them (L-13 x Gm.1021) outyielded the check hybrid SC 166.

General and specific combining ability effects

General combining ability effects are presented in Table (3). For days to 50% silking there were 10 inbred lines i.e. L-1, L-13, L-14, L-15, L-16, L-18, L-19, L-20, L-21 and L-23 exhibited negative and highly significant GCA effects. These inbred lines are considered the best inbred lines for earliness. Concerning plant height, the inbred lines no. 16, 19, 20, 21 and 22 manifested negative and highly significant GCA effects. Regarding ear height, five inbred lines (L-16, L-19, L-20, L-21 and L-22) had negative and significant or highly significant GCA effects. For ears per 100 plants, data illustrated that the tester inbred line Gm.1021 showed more favorable effect than inbred line Gm.1002 for ears per 100 plants. Four inbred lines i.e. L-3, L-6, L-11 and L-23 possessed positive and significant or highly significant GCA effects.

Regarding ear length, data showed that the tester inbred line Gm.1021 was more favorable effect inbred line than inbred line Gm.1002. 11 inbred lines possessed positive and significant or highly significant GCA effects. For no. of rows per ear, the tester inbred lines Gm.1002 showed more favorable effect inbred line than inbred line Gm.1021 and considered good combiners for this trait. Five inbred lines (L-6, L-14, L-15, L-17 and L-22) exhibited positive and significant or highly significant GCA effects for no. of rows per ear. Regarding grain yield, there were seven inbred lines (L-2, L-4, L-6, L-7, L-11, L-13 and L-18) had positive and significant or highly significant GCA effects, indicating that they have favorable genes and are best combiners for grain yield. The tester inbred line Gm.1021 had positive and highly significant GCA effects and could be considered as good combiners for grain yield.

Specific combining ability effects of 52 topcrosses for all the studied traits are presented in Table (4). Results showed that, four crosses (L-10, L-12 and L-18 x Gm.1021 and L-24 x Gm.1002) for days to 50% silking, three crosses (L-3 and L-11 x Gm.1002 and L-20 x Gm.1021) for plant height had negative (desirable) and significant or highly significant SCA effects. One cross (L-2 x Gm.1021) for ears/100 plant, nine crosses (L-2, L-3, L-6, L-12 and L-16 x Gm.1002 and L-10, L-13, L-15 and L-26 x Gm.1021) for ear length and three crosses (L-9 x Gm.1002, L-21 x Gm.1021

Table 3. General combining ability effects ($\hat{g}_i$) for grain yield and the other studied traits, combined data over two locations in 2009 season.

Inbred line	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Ear length (cm)	No. of rows/ear	Grain yield (ard/fed)
L-1	-1.22**	0.88	0.89	-0.57	-1.46**	0.08	0.98
L-2	0.59*	0.13	-0.23	3.06	0.94**	-1.07**	2.10**
L-3	1.09**	3.51	1.70	5.49*	0.56*	-0.62**	0.65
L-4	0.40	8.38**	4.27*	3.55	0.52*	-0.74**	2.58**
L-5	-0.04	6.13**	2.39	0.10	0.78**	-0.48*	0.28
L-6	0.53	7.88**	7.45**	14.98**	0.03	1.95**	3.70**
L-7	0.46	1.82	2.33	-0.93	0.87**	-0.55**	3.90**
L-8	1.21**	0.69	3.02	-2.94	0.42	-0.02	1.00
L-9	1.59**	1.63	-0.05	-4.89*	-0.47*	-0.09	-2.84**
L-10	0.84**	3.69	4.02*	-2.64	-0.64**	-0.35	-1.53
L-11	0.71*	8.07**	10.89**	6.69**	1.09**	-0.77**	2.61**
L-12	1.53**	2.94	0.14	-1.60	0.52*	-0.45*	0.70
L-13	-1.66**	-0.93	-2.61	-0.41	-0.97**	-0.13	2.03*
L-14	-2.04**	3.57	1.14	-6.54**	-0.94**	0.96**	-1.81
L-15	-1.22**	-3.49	-3.36	-5.43*	-0.99**	1.17**	-1.00
L-16	-2.22**	-7.68**	-5.80**	-1.07	-0.36	0.36	-4.94**

Table 3. continued

Inbred line	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Ear length (cm)	No. of rows/ear	Grain yield (ard/fed)
L-17	-0.10	-2.31	-3.30	-1.84	0.53*	0.37*	0.76
L-18	-1.16**	-1.06	-0.55	-1.91	0.66**	0.06	1.95*
L-19	-1.41**	-7.49**	-5.80**	-4.07	-0.16	-0.04	-2.83**
L-20	-1.10**	-10.93**	-6.42**	-3.37	0.57**	0.11	-0.09
L-21	-1.04**	-15.68**	-13.36**	-3.32	-0.28	-0.08	-0.47
L-22	2.28**	-6.12**	-4.23*	-1.50	-1.26**	1.67**	-2.58**
L-23	-1.22**	-2.06	2.20	5.61*	-0.82**	-0.14	0.95
L-24	-0.04	6.57**	2.14	4.01	0.09	-0.53**	-0.92
L-25	1.46**	1.69	1.89	4.35	0.18	-0.43*	-1.77
L-26	1.78**	0.13	1.20	-4.80*	0.58**	-0.26	-3.42**
SE (g_i)	0.30	2.02	1.79	2.41	0.22	0.19	0.80
SE(g_i-g_j)	0.43	2.86	2.53	3.41	0.31	0.27	1.14
Testers							
Gm.1002	-0.31**	-4.30**	-3.95**	-5.06**	-0.31**	0.09*	-0.64**
Gm.1021	0.31**	4.30**	3.95**	5.06**	0.31**	-0.09*	0.64**
SE (g_i)	0.08	0.56	0.50	0.67	0.06	0.05	0.22
SE(g_i-g_j)	0.12	0.79	0.70	0.94	0.09	0.08	0.31

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

Table 4. Specific combining ability effects ($\hat{S}_{ij}$) of 52 topcrosses (26 inbred lines with two testers) for grain yield and the other studied traits, combined data over two locations in 2009 season.

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Ear length (cm)		No. of rows/ear		Grain yield (ard/fed)	
	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021
L-1	-0.25	0.25	0.49	-0.49	-1.05	1.05	4.77	-4.77	-0.17	0.17	-0.03	0.03	2.66*	-2.66*
L-2	0.19	-0.19	1.86	-1.86	0.82	-0.82	-7.04*	7.04*	0.78*	-0.78*	0.45	-0.45	-1.48	1.48
L-3	0.69	-0.69	-6.39*	6.39*	-3.11	3.11	-4.71	4.71	0.72*	-0.72*	-0.30	0.30	-0.87	0.87
L-4	-0.002	0.002	4.24	-4.24	1.32	-1.32	-2.89	2.89	0.28	-0.28	-0.13	0.13	0.75	-0.75
L-5	-0.19	0.19	0.49	-0.49	1.45	-1.45	0.49	-0.49	0.34	-0.34	-0.09	0.09	1.82	-1.82
L-6	-0.50	0.50	1.49	-1.49	1.01	-1.01	-5.72	5.72	0.72*	-0.72*	0.33	-0.33	1.83	-1.83
L-7	-0.56	0.56	1.80	-1.80	0.26	0.26	2.42	-2.42	0.21	-0.21	0.13	-0.13	0.43	-0.43
L-8	-0.06	0.06	3.05	-3.05	0.45	-0.45	0.86	-0.86	0.23	-0.23	0.52	-0.52	0.06	-0.06
L-9	0.06	-0.06	-3.76	3.76	-0.86	0.86	2.06	-2.06	-0.08	0.08	0.55*	-0.55*	3.32**	-3.32**
L-10	0.94*	-0.94*	1.67	-1.67	4.45	-4.45	-0.17	0.17	-1.11*	1.11*	0.23	-0.23	-3.21**	3.21**
L-11	-0.19	0.19	-7.57**	7.57**	-5.43	5.43	-2.78	2.78	-0.24	0.24	-0.18	0.18	-1.09	1.09
L-12	1.00*	-1.00*	3.55	-3.55	3.07	-3.07	3.12	-3.12	1.33**	-1.33**	0.01	-0.01	2.32*	-2.32*
L-13	-0.19	0.19	1.55	-1.55	-0.43	0.43	0.42	-0.42	-0.73*	0.73*	-0.29	0.29	-3.29**	3.29**
L-14	0.19	-0.19	2.30	-2.30	1.70	-1.70	4.67	-4.67	-0.06	0.06	-0.03	0.03	-1.21	1.21

Table 4. continued

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Ear length (cm)		No. of rows/ear		Grain yield (ard/fed)	
	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002	Gm. 1021
L-15	-0.13	0.13	-3.51	3.51	-1.55	1.55	2.01	-2.01	-0.63*	0.63*	-0.32	0.32	-0.97	0.97
L-16	-0.63	0.63	-2.20	2.20	-0.86	0.86	-0.32	0.32	0.66*	-0.66*	-0.40	0.40	-1.44	1.44
L-17	-0.50	0.50	-1.95	1.95	-2.86	2.86	4.01	-4.01	-0.36	0.36	0.08	-0.08	1.67	-1.67
L-18	1.19**	-1.19**	-0.70	0.70	0.63	-0.63	-0.04	0.04	-0.08	0.08	0.12	-0.12	-1.19	1.19
L-19	-0.06	0.06	-3.39	3.39	-2.49	2.49	4.43	-4.43	-0.14	0.14	-0.13	0.13	3.31**	-3.31**
L-20	-0.13	0.13	8.30**	-8.30**	4.76	-4.76	3.37	-3.37	0.13	-0.13	-0.09	0.09	1.94	-1.94
L-21	0.31	-0.13	-4.82	4.82	-3.80	3.80	1.48	-1.48	-0.09	0.09	-0.65*	0.65*	-1.35	1.35
L-22	0.25	-0.25	5.36	-5.36	2.70	-2.70	0.76	-0.76	-0.24	0.24	-0.57*	0.57*	-0.03	0.03
L-23	-0.13	0.13	-3.07	3.07	-0.74	0.74	-4.32	4.32	-0.43	0.43	0.17	-0.17	-1.05	1.05
L-24	-1.44**	1.44**	3.18	-3.18	-0.05	0.05	-5.07	5.07	-0.32	0.32	0.21	-0.21	-1.15	1.15
L-25	-0.44	0.44	2.93	-2.93	3.82	-3.8	-4.02	4.02	0.02	-0.02	0.11	-0.11	0.48	-0.48
L-26	0.62	-0.62	-4.89	4.89	-3.24	3.24	2.22	-2.22	-0.76*	0.76*	0.27	-0.27	-2.27*	2.27*
SE (S_{ij})	0.43		5.61		4.96		3.41		0.31		0.27		1.14	
SE (S_{ij}-S_{kl})	0.60		7.36		6.50		4.82		0.44		0.38		1.61	

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

and L-22 x Gm.1021) for no. of rows per ear had positive and significant or highly significant SCA effects .

For grain yield, seven crosses (L-1, L-9, L-12 and L-19 x Gm.1002 and L-10, L-13 and L-26 X Gm.1021) had positive and significant or highly significant SCA effects with values of 2.66*, 3.23**, 2.32*, 3.31**, 3.21**, 3.29** and 2.27*, respectively.

Variance components

Estimates of combining ability variances σ^2GCA for lines, σ^2SCA for line x tester and their interactions with environments are presented in Table (5). The results showed that, σ^2 GCA-L was higher than σ^2 GCA-T for days to 50% silking, ear length, no. of rows per ear and grain yield, indicating that most of GCA variance was due to lines for these traits, while σ^2 GCA-T was higher than σ^2 GCA-L for plant height, ear height and ears per 100 plants, indicating that most of GCA variance was due to testers. The magnitude of σ^2 GCA (average) was larger than that obtained for σ^2 SCA for plant height, ear height and ears per 100 plants, indicating that the additive type of gene action played an important role in the inheritance of these traits.

The magnitude of σ^2 SCA exceeded that of σ^2 GCA (average) for days to 50% silking, ear length, no. of rows per ear and grain yield, indicating that the non-additive type of gene action played an important role in the inheritance of these traits. Jayakumar and Sundaram (2007) reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, number of grains per row and grain yield. Abd El-Maksoud et al. (2003), Almanie et al. (2006), Todkar and Navale (2006), Dar et al. (2007) and Abd El-Moula and Abd El-Aal (2009) reported similar results.

Furthermore, the magnitude of σ^2 SCA x E interaction was higher than σ^2 GCA (average) x E for days to 50% silking, plant height, ear length and no. of kernels per row, indicating that the non-additive type of gene action was more affected by environment than the additive type of gene action in these traits. These results are in a good agreement with those obtained by Sadek et al. (2000), Soliman et al. (2001), Abd El-Moula et al. (2004) and Amer and El-Shenawy (2007). They found that the magnitude of σ^2 SCA x E interaction was higher than that of σ^2GCA x E interaction.

On the other side, the magnitude of σ^2 GCA (average) x E interaction was higher than σ^2 SCA x E for ear height, ears per 100 plants and grain yield, indicating that the additive type of gene action was more affected by environment than non-additive ones. These results are in agreement with those obtained by El-Itriby et al. (1990), El-Zeir et al (2000) and Soliman et al. (2001).

Table 5. Genetic parameters for grain yield and the other studied traits of 52 topcrosses and two testers over the two locations.

Parameter	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Ear length (cm)	No. of rows/ear	Grain yield (ard/fed)
$\sigma^2_{GCA\text{-}L}$	1.36	19.98	16.81	10.82	0.26	0.43	1.48
$\sigma^2_{GCA\text{-}T}$	0.17	35.83	311.46	50.25	0.17	0.01	0.54
$\sigma^2_{GCA\ (average)}$	0.26	24.94	264.69	24.12	0.07	0.04	0.00
σ^2_{SCA}	0.46	22.04	6.97	12.85	0.50	0.12	5.85
$\sigma^2_{GCA}/\sigma^2_{SCA}$	0.56	1.13	37.97	1.88	0.14	0.33	0.00
$\sigma^2_{GCA\text{-}L\ x\ E}$	0.05	9.79	4.53	3.48	0.01	0.17	1.32
$\sigma^2_{GCA\text{-}T\ x\ E}$	0.00	20.26	33.47	48.98	0.23	0.00	2.60
$\sigma^2_{GCA\ (average)\ x\ E}$	0.00	19.51	31.40	45.73	0.21	0.01	2.51
$\sigma^2_{SCA\ x\ E}$	0.16	23.55	12.87	28.31	0.53	0.01	2.32
$\sigma^2_{GCA\ x\ E}/\sigma^2_{SCA\ x\ E}$	0.00	0.83	2.44	1.62	0.40	1.00	1.08

All negative estimates of variance were considered zero.

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تحليل القدرة على التآلف فى بعض سلالات الذرة الشامية الصفراء

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تم إجراء التهجين بين ٢٦ سلالة من الذرة الشامية الصفراء مرباة تربية داخلية بمحطة البحوث الزراعية بملوى مع كشافين عبارة عن السلالة النقية جميزة ١٠٠٢ و جميزة ١٠٢١ فى موسم ٢٠٠٨ . تم تقييم ٥٢ هجين قمى مع هجينين مقارنة وهما الهجين الفردى ١٦٢ والهجين الفردى ١٦٦ فى محطتى البحوث الزراعية بسخا وملوى فى الموسم الزراعى ٢٠٠٩. تم اخذ القراءات على صفات عدد الايام حتى ظهور ٥٠% من الحراير و ارتفاع النبات والكوز وعدد الكيزان لكل ١٠٠ نبات وطول الكوز وعدد الصفوف بالكوز وعدد الحبوب فى الصف ومحصول الحبوب (اردب/فدان). اظهر التحليل المشترك اختلافات معنوية او عالية المعنوية ناتجة من الهجن والسلالات لكل الصفات محل الدراسة ما عدا صفة عدد الصفوف بالكوز للهجن . كما اظهر تباين تفاعل السلالات مع الكشافات اختلافات معنوية لصفات عدد الايام حتى ظهور ٥٠% من الحراير , عدد الصفوف بالكوز ومحصول الحبوب . كان تباين التفاعل بين السلالات x المواقع معنويا لصفة عدد الصفوف فى الكوز وكان تباين تفاعل الكشافات x المواقع معنويا او عالى المعنوية بالنسبة لكل الصفات محل الدراسة ماعدا صفة عدد الأيام حتى ظهور ٥٠% من الحراير وعدد الصفوف بالكوز. اظهر التفاعل المشترك بين السلالات والكشافات والمواقع اختلافات عالية المعنوية فى كل الصفات المدروسة ماعدا عدد الأيام حتى ظهور ٥٠% من الحراير وعدد الصفوف فى الكوز .كان تباين القدرة العامة على التآلف اكبر من تباين القدرة الخاصة على التآلف فى صفات ارتفاع النبات والكوز وعدد الكيزان لكل ١٠٠ نبات. بينما كان تباين القدرة الخاصة على التآلف اكبر من تباين القدرة العامة على التآلف فى صفات عدد الأيام حتى ظهور ٥٠ % من الحراير وطول الكوز وعدد الصفوف فى الكوز و المحصول. تفوقت ٧ هجن قمية معنويا على هجين المقارنة ١٦٢ وهى (السلالة-١٣ x جميزة ١٠٢١) و (السلالة-٦ x جميزة ١٠٠٢) و (السلالة-١١ x جميزة ١٠٢١) و (السلالة-٢ x جميزة ١٠٢١) و (السلالة-٧ x جميزة ١٠٠٢) و (السلالة-١٨ x جميزة ١٠٢١) و(السلالة-٧ x جميزة ١٠٢١). أظهرت السلالات ١٦ و ١٩و ٢٠ و ٢١ و ٢٢ أفضل قدرة عامة على التآلف حيث كانت سالبة ومعنوية فى صفات عدد الأيام حتى ظهور ٥٠% من الحراير وارتفاع النبات والكوز. أظهرت ٤ سلالات بالنسبة لصفة عدد الكيزان لكل ١٠٠ نبات و ١١ سلاله بالنسبة لطول الكوز و ٥ سلالات بالنسبة لعدد الصفوف فى الكوز و٧ سلالات فى محصول الحبوب قدرة عامة موجبة ومعنوية. أما بالنسبة للقدرة الخاصة على التآلف فقد أظهرت الهجن القمية (السلالة- ١ و ٩ و ١٢ و ١٩ x جميزة ١٠٠٢) والهجن (السلالة-١٠ و ١٣ و ٢٦ x جميزة ١٠٢١) تأثيرات موجبة ومعنوية.