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TOPCROSS ANALYSIS AND COMBINING ABILITY FOR GRAIN YIELD AND OTHER ATRIBUTES IN MAIZE (*Zea mays* L.)

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ABSTRACT

Nineteen selected S'$_3$ inbred lines families from white maize were topcrossed with each of the two the commercial inbred line testers, viz. Sd-34 and Gz-629 at Sids Agric. Res. Stn during 2008 growing season. Forty entries (38 topcrosses and two white commercial single crosses checks; SC. 10 and SC. 129) were evaluated at Sakha and Sids Agric. Res. Stn in 2009 growing season for days to 50% silking, plant and ear heights, grain yield and grain yield per plant. Obtained data revealed that, mean squares due to crosses, lines, and testers were significant for all studied traits at both locations and over locations. Line x tester interaction was significant for all of the studied traits, except days to 50% silking and plant height at Sakha, and days to 50% silking at Sids. Highly significant differences were detected among locations for all of the studied traits, indicating that the two locations differed in their environmental conditions. In addition, Location x tester interaction was significant for all studied traits, except for ear height and grain yield per plant. The four top-crosses (L-4 x Sd 34), (L-7 x Sd 34), (L-8 x Sd 34) and (L-9 x Sd 34) significantly outyielded the best check (SC. 129) by 15.1, 19.7, 12.1 and 23.8%, respectively in the combined data. The best GCA effects for grain yield were recorded for lines L-4, L-6, L-7, L-8, and L-9. However, L-10 and L-19 exhibited the highest GCA values for earliness, whereas, inbred lines 7 and 3 exhibited the highest GCA values for plant and ear height. These lines should be directly utilized in breeding program to develop high yielding hybrids. Results showed also that the cross L-9 x Sd-34 was the best positive and significant SCA effects for grain yield in ard/fed and per plant. The magnitude of σ^2_{GCA} for lines was high for all studied traits, except for silking date at Sakha, silking date, plant height and ear height at Sids and the combined data. The interaction σ^2_{GCA} x Loc for lines was higher than that of σ^2_{SCA} x Loc for only plant height and ear height, indicating that the additive type of gene action is more affected by environmental conditions than the non-additive type of gene action.
Keywords: maize, top crosses, combining ability, type of gene action.

INTRODUCTION

Topcross (test cross) method using broad and/or narrow testers is used to evaluate new improved inbred lines for combining ability. Several procedures for developing and improving maize inbred lines were reported by Bauman (1981) and Hallauer and Miranda (1981). Topcross procedure was first suggested by Davis (1927) as an early testing to determine the usefulness of the selected inbred lines for hybrid development programs. The concept of general (GCA) and specific (SCA) combining ability was 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) 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 Abd El-Aal (2009) found, in two sets of topcrosses, that variances due to GCA was larger than those of SCA for plant and ear heights in set I, while the variance due to SCA was high for silking date and grain yield. Also, the variances due to GCA x Loc and SCA x Loc were high in magnitude for grain yield, silking date, ear height and ears/100 plants in set I. This indicates that the non-additive gene effect was more affected by location than the additive gene action type. El-Sherbeiny *et al.* (2006) and Abd El-Aal (2007) reported that the additive component of gene action had the major role in determining the inheritance of grain yield, days to 50% silking, plant and ear height. They added that the non-additive gene action was more interacted with the environmental conditions than the additive component for grain yield. Amer and El-Shenawy (2007) reported that the additive genetic variances played an important role in the grain yield and silking date inheritance, while the non-additive genetic variances played an important role in the inheritance of plant height. The magnitude of the interaction between SCA with location was higher than of GCA x location for grain yield and plant height. Soliman *et al.* (2007) reported that the magnitude of dominance variances was considered the major source of the total genetic variance responsible for the grain yield inheritance. Incontrast, Hede *et al.* (1999), El-Zeir *et al.* (2000), Nass *et al.* (2002), and El-Morshidy *et al.* (2003) reported significant GCA x Environment interactions for both lines and testers for grain yield.

The main objectives of this investigation were evaluation of 38 topcrosses (19 lines x 2 testers) for grain yield and other agronomic traits, estimation of GCA effects for both lines and testers as well as SCA effects for crosses, and estimation of variance components due to GCA, SCA (σ^2GCA and σ^2SCA) and their interactions with location.

MATERIALS AND METHODS

Nineteen selected S'_3 inbred line families of white maize generation (L1 through L-19) derived from a wide genetic base population through selection from segregating generations in the disease nursery field at Sids Agric. Res. Stn., were used for the purpose of this study. In 2008 growing season, the 19 selected S'_3 line families were topcrossed to two commercial inbred line testers, *i.e.* Sd-34 and Gz-629 at Sids Exp. Stn. The two inbred line testers are being used in seed production of commercial single and three way cross hybrids. In 2009 growing season, the 38 resultant topcrosses along with two commercial check hybrids; S.C. 10 and S.C. 129 were evaluated in replicated yield trials conducted at Sakha and Sids Agric. Res. Stn. Randomized complete block design with four replications was used. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. Two kernels were planted per hill and thinned later to one plant per hill to provide a population of approximately 21000 plants/feddan (One feddan = 4200 m^2).

All cultural practices of maize production were applied as recommended. Data were recorded for number of days to 50% silking, plant height (cm), ear height (cm), grain yield adjusted at 15.5% grain moisture and converted to ardab/feddan (One ardab=140 kg) and grain yield per plant (g). Analysis of variance was performed for separate locations, and the combined data over locations according to Steel and Torrie (1980). The combining ability and types of gene effects were computed for all studied traits according to Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of variance:

Data presented in Table 1 revealed that mean squares among genotypes (crosses) were highly significant for all traits at both locations and the combined analysis over locations. Partitioning the sum of squares due to genotypes (crosses) into lines, testers and lines x testers showed that mean squares due to lines and testers were highly significant for all traits at both locations and the combined analysis, except for days to 50% silking of lines at Sids location. These results indicated that there was a wide diversity among studied inbred lines and testers in their contribution to the performance of top crosses. However, mean squares of lines x testers interaction was highly significant for all of the studied traits, except for days to 50% silking and plant height at Sakha, and days to 50% silking at Sids. This indicated that the family lines differed in order to cross performance with each of male testers. The combined analysis of variance over locations for the five studied traits is presented in Table 1. Highly significant differences were detected among locations for all of the studied traits, indicating that the two locations differed in their environmental conditions. However, interactions of Loc x genotypes and Loc x lines were not significant for all of the studied traits. However, the interaction of locations x testers was significant for days to 50% silking, plant height, and grain yield in ardab per feddan (ard/fed). Location x Lines x Testers interaction was not significant for all the studied traits, except for grain yield in ard/fed. The above mentioned results revealed that significant interactions with locations are mainly attributed to the different ranking of genotypes from location to another. The obtained results clarified that it is worthwhile to evaluate topcrosses under different environments (locations) especially for grain yield. This would help in adopting the proper which will be most appropriate to particular environment. Similar results were obtained by El-Itriby *et al.* (1990), Salama *et al.* (1995), Soliman *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), El-Sherbeiny *et al.* (2006), and Abd El-Aal (2007).

The magnitude of variances due to testers was higher than that of tested inbred lines for all of the studied traits indicating that tester lines contributed much more to the total variation for these traits (Table 1). On the basis of the combined data, the variance due to Loc x tester lines was higher than that of Loc x tested lines for all of the studied traits, except for ear height. This indicated that tester lines were much more affected by the environmental conditions than the tested lines. Similar results were reported by Gado *et al.* (2000), Sadek *et al.* (2000), Soliman (2000), Soliman *et al.* (2001), El-Morshidy *et al.* (2003), El-Sherbeiny *et al.* (2006), and Abd El-Aal (2007).

Table 1. Mean squares (MS) of days to 50% silking, plant height, ear height, grain yield per plant and grain yield per feddan at Sakha (SK) and Sids (SD) and combined over locations in 2009 season.

Source	DF	Days to 50% silking	Plant height	Ear height	grain yield per plant	Grain yield per fed
			SAKHA			
Rep's	3	1.27	510.2	441.3	2157.1	25.81
Genotypes	37	5.59**	318.0**	248.5**	1410.0**	44.42**
Lines (L)	18	3.89*	452.5**	272.6**	1978.1**	54.64**
Testers (T)	1	99.53**	1765.3**	970.1**	6372.7**	268.42**
L x T	18	2.06	103.2	184.3*	566.3**	21.75*
Error	111	1.28	105.1	98.2	360.3	10.09
C.V.		1.9	4	6.8	8.5	10
			SIDS			
Rep's	3	1.59	820.3	670.3	38.1	5.11
Genotypes	37	3.27**	383.9**	118.1**	1202.7**	32.17**
Lines (L)	18	2.46	288.7**	103.3**	1620.2**	42.87**
Testers (T)	1	38.00**	4697.5**	1188.3**	2605.4**	64.52**
L x T	18	2.15	239.5**	73.4*	707.2**	19.67**
Error	111	1.13	85.8	42.6	378.7	7.53
C.V.		1.7	4.4	6.4	10.7	10.8
			COMBINED			
Loc	1	2415.95**	183015.4**	147092.0**	136795.2**	3003.98**
Rep(loc)	6	1.43	665.3	555.8	1097.6	15.46
Genotypes	37	7.19**	604.1**	294.3**	2306.2**	62.56**
Lines (L)	18	4.83**	618.9**	286.1**	3319.8**	84.56**
Testers (T)	1	130.27**	6111.1**	2152.9**	8563.8**	298.07**
L x T	18	2.72**	283.5**	198.8**	944.9	27.48**
Loc x geno	37	1.67	97.8	72.6	306.6	14.02
Loc x L	18	1.53	122.3	89.9	278.9	12.95
Loc x T	1	7.27**	351.7**	5.5	414.3	34.87**
Loc x L x T	18	1.5	59.3	58.9	328.9	13.94*
Pooled error	222	1.21	95.5	70.4	369.5	8.81
CV%		1.8	4.2	6.8	9.5	10.4

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

Mean performance:

Mean performance for the studied traits of the 38 top-cross hybrids along with the checks are presented in Table 2 and Table 3 for all characters studied. Regarding silking date, the earliest crosses were L-10 x Gz-629 (59.8 days), L-19 x Gz-629 (60.0 days), L-4 x Gz-629 (60.1 days), and L-17 x Gz-629 (60.3 days) in the combined over locations. In the contrary, the latest crosses were L-12 x Sd-34 (61.0 days) at Sakha, L-3 x Sd-34 and L-8 x Sd-34 (66.0 days) at Sids and L-6 x Gz-629 (63.1 days) in the combined data. All of the 38 topcrosses were significantly earlier than the earliest check (S.C. 129) at Sakha, Sids, and the combined analysis, respectively.

Table 2. Average performance of 38topcrosses for days to 50% silking, plant height, and ear height, at Sakha (SK), Sids (SD) and combined (Com), 2009 growing season

Crosses	Days to 50% silking			Plant height			Ear height		
	SK	SD	Com	SK	SD	Com	SK	SD	Com
L- 1 x Sd 34	59.8	65.0	62.4	270.0	218.8	244.4	140.3	107.5	123.9
L- 2 x Sd 34	59.0	65.3	62.1	249.3	213.8	231.5	140.8	101.3	121.0
L- 3 x Sd 34	59.3	66.0	62.6	253.5	217.5	235.5	149.0	106.3	127.6
L- 4 x Sd 34	59.5	64.5	62.0	259.5	213.8	236.6	144.8	101.3	123.0
L- 5 x Sd 34	58.8	65.3	62.0	251.8	210.0	230.9	138.0	96.3	117.1
L- 6 x Sd 34	59.8	64.8	62.3	255.8	208.8	232.3	142.3	102.5	122.4
L- 7 x Sd 34	60.5	65.5	63.0	263.5	225.0	244.3	151.8	111.3	131.5
L- 8 x Sd 34	60.0	66.0	63.0	256.0	212.5	234.3	148.5	103.8	126.1
L- 9 x Sd 34	60.0	65.0	62.5	262.8	218.8	240.8	147.5	110.0	128.8
L-10 x Sd 34	59.0	63.5	61.3	266.5	212.5	239.5	149.3	101.3	125.3
L-11 x Sd 34	60.0	63.8	61.9	261.0	213.8	237.4	146.3	103.8	125.0
L-12 x Sd 34	61.0	64.8	62.9	261.0	208.8	234.9	149.8	106.3	128.0
L-13 x Sd 34	59.8	64.0	61.9	251.8	190.0	220.9	139.3	91.3	115.3
L-14 x Sd 34	59.8	65.0	62.4	280.0	225.0	252.5	166.3	107.5	136.9
L-15 x Sd 34	59.0	64.0	61.5	267.5	218.8	243.1	154.8	103.8	129.3
L-16 x Sd 34	60.0	65.0	62.5	260.5	215.0	237.8	146.0	102.5	124.3
L-17 x Sd 34	58.8	65.0	61.9	274.8	217.5	246.1	158.3	107.5	132.9
L-18 x Sd 34	58.0	64.8	61.4	270.3	225.0	247.6	158.8	113.8	136.3
L-19 x Sd 34	58.8	64.8	61.8	253.8	212.5	233.1	145.8	108.8	127.3
L- 1 x Gz 629	56.8	64.3	60.5	258.0	198.8	228.4	147.0	97.5	122.3
L- 2 x Gz 629	57.5	63.3	60.4	241.5	192.5	217.0	133.0	95.0	114.0
L- 3 x Gz 629	59.5	64.5	62.0	243.3	208.8	226.0	136.3	101.3	118.8
L- 4 x Gz 629	57.0	63.3	60.1	246.5	190.0	218.3	130.3	92.5	111.4
L- 5 x Gz 629	57.0	63.8	60.4	244.8	193.8	219.3	137.5	93.8	115.6
L- 6 x Gz 629	60.0	66.3	63.1	265.5	216.3	240.9	151.0	106.3	128.6
L- 7 x Gz 629	58.5	63.3	60.9	253.0	201.3	227.1	141.8	100.0	120.9
L- 8 x Gz 629	58.0	63.5	60.8	252.0	202.5	227.3	141.0	101.3	121.1
L- 9 x Gz 629	57.3	63.3	60.3	243.0	193.8	218.4	130.0	93.8	111.9
L-10 x Gz 629	56.5	63.0	59.8	254.0	216.3	235.1	140.0	102.5	121.3
L-11 x Gz 629	59.5	63.5	61.5	257.5	201.3	229.4	151.5	100.0	125.8
L-12 x Gz 629	57.5	64.0	60.8	260.3	205.0	232.6	146.5	98.8	122.6
L-13 x Gz 629	58.5	64.8	61.6	258.0	205.0	231.5	156.5	100.0	128.3
L-14 x Gz 629	58.5	64.5	61.5	272.3	221.3	246.8	154.3	107.5	130.9
L-15 x Gz 629	57.3	63.8	60.5	257.3	205.0	231.1	141.5	96.3	118.9
L-16 x Gz 629	58.3	64.5	61.4	260.3	206.3	233.3	150.8	96.3	123.5
L-17 x Gz 629	57.3	63.3	60.3	263.5	202.5	233.0	148.5	97.5	123.0
L-18 x Gz 629	57.5	63.8	60.6	257.3	208.8	233.0	143.3	102.5	122.9
L-19 x Gz 629	57.5	62.5	60.0	251.8	197.5	224.6	140.5	97.5	119.0
Checks									
SC 10	64.0	73.0	68.5	301.5	236.3	268.9	173.0	118.8	145.9
SC 129	60.5	66.0	63.3	282.0	231.3	256.6	166.0	115.0	140.5
LSD 0.05	1.6	1.5	1.1	14.2	12.8	9.6	13.7	9.1	8.2
LSD 0.01	2.1	1.9	1.4	18.6	16.8	12.5	17.9	11.8	10.7

Table 3. Average performance of 38 top crosses for grain yield per plant and grain yield per feddan at Sakha (SK), Sids (SD) and combined (Com), 2009 growing season

Crosses	Grain yield (g/plant)			Grain yield (ard/fed)		
	SK	SD	Com	SK	SD	Com
L- 1 x Sd 34	227.8	192.6	210.2	35.60	28.25	31.92
L- 2 x Sd 34	231.2	185.5	208.3	34.01	27.81	30.91
L- 3 x Sd 34	235.1	177.4	206.2	33.10	25.39	29.25
L- 4 x Sd 34	256.7	206.8	231.8	38.92	28.11	33.51
L- 5 x Sd 34	208.7	162.1	185.4	31.56	23.01	27.28
L- 6 x Sd 34	222.3	198.3	210.3	32.48	30.38	31.43
L- 7 x Sd 34	274.2	223.3	248.8	37.68	32.03	34.86
L- 8 x Sd 34	271.9	203.2	237.5	37.25	28.05	32.65
L- 9 x Sd 34	263.1	220.2	241.6	39.40	32.71	36.05
L-10 x Sd 34	238.0	190.9	214.5	30.95	27.14	29.04
L-11 x Sd 34	230.1	197.9	214.0	28.60	24.74	26.67
L-12 x Sd 34	197.2	160.6	178.9	26.87	23.29	25.08
L-13 x Sd 34	218.5	175.8	197.2	33.13	22.15	27.64
L-14 x Sd 34	222.4	164.9	193.7	33.39	22.58	27.98
L-15 x Sd 34	220.1	178.7	199.4	30.62	25.68	28.15
L-16 x Sd 34	229.2	189.4	209.3	34.00	25.10	29.55
L-17 x Sd 34	212.8	174.8	193.8	31.82	26.26	29.04
L-18 x Sd 34	210.6	183.3	197.0	30.80	24.06	27.43
L-19 x Sd 34	212.3	146.1	179.2	29.74	20.86	25.30
L- 1 x Gz 629	222.1	176.6	199.3	33.25	23.67	28.46
L- 2 x Gz 629	199.9	168.2	184.0	29.67	23.62	26.64
L- 3 x Gz 629	219.8	176.4	198.1	33.33	25.34	29.34
L- 4 x Gz 629	223.8	184.9	204.3	31.77	27.79	29.78
L- 5 x Gz 629	215.0	183.4	199.2	33.25	27.37	30.31
L- 6 x Gz 629	222.6	194.9	208.7	31.28	27.30	29.29
L- 7 x Gz 629	238.0	191.5	214.8	35.53	28.72	32.13
L- 8 x Gz 629	236.7	210.9	223.8	33.02	28.28	30.65
L- 9 x Gz 629	217.7	169.3	193.5	29.34	24.31	26.82
L-10 x Gz 629	220.7	180.0	200.3	27.57	24.48	26.03
L-11 x Gz 629	211.0	176.6	193.8	25.72	24.54	25.13
L-12 x Gz 629	188.9	149.1	169.0	28.92	20.69	24.80
L-13 x Gz 629	204.1	181.6	192.9	26.66	25.81	26.23
L-14 x Gz 629	220.0	159.7	189.9	31.17	21.93	26.55
L-15 x Gz 629	212.1	172.8	192.4	31.16	23.51	27.34
L-16 x Gz 629	240.8	164.5	202.6	27.00	22.38	24.69
L-17 x Gz 629	218.2	178.3	198.2	33.13	24.26	28.69
L-18 x Gz 629	219.8	177.6	198.7	28.84	23.89	26.37
L-19 x Gz 629	205.3	178.4	191.8	28.83	24.95	26.89
Checks						
SC 10	269.7	177.0	223.4	26.67	24.29	25.48
SC 129	228.7	177.2	202.9	34.24	24.01	29.12
LSD 0.05	26.3	26.9	18.8	4.4	4.8	2.9
LSD 0.01	34.4	35.2	24.6	5.8	4.9	3.8

Concerning plant height, it ranged from 241.5 for cross (L-2 x Gz-629) to 280.0 cm for cross (L-14 x Sd-34) at Sakha, from 190.0 for crosses (L-13 x Sd-34 and L-4 x Gz-629) to 225.0 cm for crosses (L-7 x Sd-34, L-14 x Sd-34 and L-18 x Sd-34) at Sids, and from 217.0 for cross (L-2 x Gz-629) to 252.5 cm for cross (L-14 x Sd-34) in the combined data. All studied top-cross hybrids were moderately shorter than both check hybrids, S.C. 10 and S.C. 129.

Respecting ear height, the lowest ear placement was recorded for the crosses L-9 x Gz-629 (130.0 cm) at Sakha, L-13 x Sd-34 (91.3 cm) at Sids and L-4 x Gz-629 (111.4 cm) over locations. In contrast, the highest ear placement was noticed for the crosses L-14 x Sd-34 (166.3 cm) at Sakha, L-18 x Sd-34 (113.8 cm) at Sids, and L-14 x Sd-34 (136.9 cm) over locations. All top-cross hybrids had significantly lower ear placement than the check of S.C. 129, except that for L-14 x Sd-34 at Sakha (166.3 cm).

For grain yield per plant (g), the top-cross hybrids L-7 x Sd-34 and L-8 x Sd-34 produced the highest grain yield per plant at Sakha (274.2 and 271.9 g/plant), L-7 x Sd-34 and L-9 x Sd-34 (223.2 and 220.2 g/plant) at Sids, and L-7 x Sd-34 (248.8 g/plant) over locations.

Regarding grain yield (ard/fed), the topcrosses L-11 x Gz-629, L-12 x Gz-629, and L-16 x Gz-629 produced the lowest grain yield at the two locations and the combined data (25.72, 20.69, and 24.69 ard/fed), respectively. In contrary, the topcross L-9 x Sd-34 at Sakha, Sids, and combined over locations produced the highest grain yield (39.40, 32.71 and 36.05 ard/fed), respectively. Superior crosses were (L-4 x Sd-34), (L-7 x Sd-34), (L-8 x Sd-34), (L-9 x Sd-34) at Sakha, (L-1 x Sd-34), (L-4 x Sd-34), (L-6 x Sd-34), (L-7 x Sd-34), and (L-9 x Sd-34) at Sids as well as (L-1 x Sd-34), (L-4 x Sd-34), (L-7 x Sd-34), (L-8 x Sd-34), and (L-9 x Sd-34) over the two locations.

General (g_i) and specific (s_{ij}) combining ability effects:

For general combining ability (GCA) effects (Table 3), the inbred lines L-10 at Sakha and Sids and L-10 and L-19 in the combined analysis possessed negative and significant GCA effects (desirable) toward earliness for days to 50% silking. However, L-6 at Sakha and Sids and L-3 and L-6 over locations had positive GCA effects (undesirable) toward lateness.

For plant height, Lines L-2, L-3, and L-5 at Sakha, L-4, L-5, and L-13 at Sids, and L-2, L-4, L-5, L-9, L-13 and L-19 over locations had negative and significant GCA effects toward shortness. On the other hand, L-14 and L-17 at Sakha, L-14 and L-18 at Sids, and L-14, L-17, and L-18 over locations exhibited positive and significant GCA effects toward tallness.

Respecting ear height, L-2, L-4, L-5 and L-9 at Sakha, L-4, L-5, and L-13, at Sids, and L-2, L-4, and L-5, over locations had negative and significant GCA effects toward low ear placement (desirable). It is worth noting that L-14 and L-17 at Sakha, L-18 at Sids and L-14, L-17, and L-18 over locations exhibited positive and significant GCA effects toward high ear placement (undesirable).

For grain yield per plant, Lines L-4, L-7, L-8, and L-9, at Sakha, and L-4, L-6, L-7, L-8, and L-9 at Sids, and L-4, L-7, L-8, and L-9 in the combined analysis exhibited positive and significant GCA effects for high grain yield per plant.

Regarding grain yield (ard/fed), the inbred lines L-1, L-4, L-7, L-8, and L-9 at Sakha, L-4, L-6, L-7, L-8, and L-9 at Sids, L-1, L-4, L-6, L-7, L-8, and L-9 in the combined analysis exhibited positive and significant GCA effects (desirable) toward high grain yield. It is worth noting that the three inbred lines had high or low GCA effects for other studied traits and produced significantly high grain yield when crossed with the inbred tester Sd-34 (Tables 2 and 3). Based on the combined data, the three crosses L-4 x Sd-34, L-7 x Sd-34, and L-9 x Sd-34 produced the highest grain yield (33.51, 34.86, and 36.05 ard/fed), respectively. They significantly surpassed the two check hybrids used in this study.

Concerning the tester lines, results in Table 4, revealed that the tester line Gz-629 was the good combiner for earliness, plant height, ear height at both locations and the combined data. The tester line Sd-34 was the best combiner for grain yield at both locations and the combined data.

Estimates of SCA effects for days to 50% silking (Table 5) indicated that the topcross L-6 x Sd-34 was the only cross exhibited negative and significant SCA values at Sids and the combined data. This cross flowered earlier compared with the check hybrid SC 10 (Table 2).

Regarding plant height, data in Table 5 showed that the two crosses L-6 x Sd-34 and L-13 x Sd 34 had negative and significant SCA values toward shortness at Sids location and the combined analysis. The other two crosses L-6 x Gz 629 and L-13 x Gz-629 at Sids and the combined data and L-9 x Sd-34 in the combined analysis only had positive and significant SCA value toward tallness. The two crosses L-6 x Sd-34 and L-13 x Sd 34 exhibited the shortest plants at Sids (208.8 and 190.0 cm), and the combined over both locations (232.3 and 220.9 cm), respectively.

For ear height (Table 5), the cross L-6 x Sd-34 in the combined data and L-13 x Sd-34 at Sakha, Sids and the combined data had negative and significant SCA values toward low ear placement. On the other hand, the two crosses L-9 x Sd-34 and L-6 x Gz-629 in the combined data and L-13 x Gz-629 at Sakha, Sids and the combined analysis had positive and significant SCA effects toward high ear placement.

Table 4. Estimates of general combining ability effects for days to 50% silking, plant height, ear height, grain yield per feddan and grain yield per plant at Sakha (SK), Sids (SD) and combined (Com), 2009 growing season.

Lines/	Days to 50 % silking			Plant height			Ear height			Grain yield(ard/fed)			Grain yield(g/plant)		
Testers	SK	SD	Com	SK	SD	Com	SK	SD	Com	SK	SD	Com	SK	SD	Com
L- 1	-0.44	0.30	-0.07	5.88	- 0.30	2.79	-2.11	0.76	- 0.68	2.60*	0.42	1.51*	0.80	2.82	1.81
L- 2	-0.44	-0.08	-0.26	-2.74**	- 5.92	-.33**	-.86**	-3.62	-6 .24**	0.01	0.17	0.09	- 8.62	- 4.94	- 6.78
L- 3	0.68	0.92*	.80**	- .74**	4.08	-2.83	-3.11	2.01	- 0.55	1.39	-0.17	0.61	3.27	- 4.85	- 0.79
L- 4	-0.44	-0.45	-0.45	- 5.12	- .17*	-.15**	-.24**	-.87*	- .55**	.52**	.41**	.96**	6.07**	4.11*	.09**
L- 5	-0.82	0.17	-0.32	- 9.87**	- 7.17*	-8.52**	-7.99**	-6.74**	- 7.37**	0.58	-0.35	0.11	-12.30*	- 9.00	-10.65*
L- 6	1.18**	1.17**	1.18**	2.51	3.45	2.98	0.89	2.63	1.76	0.06	3.30**	1.68*	- 1.74	14.83*	6.55
L- 7	0.81	0.05	0.43	0.13	4.08	2.11	1.01	3.88	2.45	4.78**	4.84**	4.81**	31.96**	25.66**	28.81**
L- 8	0.31	0.42	0.37	- 4.12	- 1.55	-2.83	-0.99	0.76	- 0.12	3.31**	2.63**	2.97**	30.11**	25.32**	27.71**
L- 9	-0.07	-0.20	-0.13	- 5.24	- 2.80	-4.02*	-6.99*	0.13	- 3.43	2.54*	2.97**	2.76**	16.23**	12.98*	14.61**
L-10	-0.94*	-1.08**	-1.01**	2.13	5.33	3.73**	-1.11	0.13	- 0.49	-2.56*	0.27	-1.15	5.15	3.73	4.44
L-11	1.06	-0.70	0.18	1.13	- 1.55	- 0.21	3.14	0.13	1.64	-4.67**	-0.90	-2.78**	- 3.60	5.48	0.94
L-12	0.56	0.05	0.30	2.51	- 2.17	0.17	2.39	0.76	1.57	-3.93**	-3.55**	-3.74**	-31.17**	-26.90**	-29.04**
L-13	0.43	0.05	0.24	- 3.24	-11.55**	- 7.40**	2.14	-6.12**	- 1.99	-1.93	-1.56	-1.75*	-12.85*	- 3.02	- 7.94
L-14	0.43	0.42	0.43	18.01**	14.08**	16.04**	14.51**	5.76**	10.14**	0.45	-3.28**	-1.41	- 2.97	-19.42**	-11.19**
L-15	-0.57	-0.45	-0.51	4.26	2.83	3.54	2.39	-1.74	0.32	-0.93	-0.94	-0.94	- 8.07	- 5.98	- 7.02
L-16	0.43	0.42	0.43	2.26	1.58	1.92	2.64	-2.37	0.14	-1.32	-1.80	-1.56*	10.83	- 4.82	3.01
L-17	-0.69	-0.20	-0.45	11.01**	0.95	5.98**	7.64*	0.76	4.20*	0.65	-0.28	0.19	- 8.70	- 5.22	- 6.96
L-18	-0.94*	-0.08	-0.51	5.63	7.83*	6.73**	5.26	6.38**	5.82**	-2.01	-1.56	-1.78*	- 8.98	- 1.32	- 5.15
L-19	-0.57	-0.70	-0.63*	- 5.37	- 4.05	- 4.71*	-2.61	1.38	-0.62	-2.54*	-2.63**	-2.59**	-15.40**	-19.48**	-17.44**
Tester															
Sd 34	0.81**	0.50**	0.65**	3.41**	5.56**	4.48**	2.53*	2.79*	2.66**	1.33**	0.65*	0.99**	6.48**	4.14*	5.31**
Gz-629	-0.81**	-0.50**	-0.65**	-3.41**	-5.56**	-4.48**	-2.53*	-2.79*	-2.66**	-1.33**	-0.65*	-0.99**	-6.48**	-4.14*	-5.31**
SE for															
Lines	0.40	0.38	0.27	3.63	3.27	2.24	3.63	2.31	2.10	1.12	0.97	0.74	6.71	6.88	4.81
Testers	0.13	0.12	0.09	1.18	1.06	0.79	1.18	0.75	0.68	0.36	0.31	0.24	2.18	2.23	1.56

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

Table 5. Estimates of specific combining ability for days to 50% silking, plant height and ear height at Sakha (SK), Sids (SD) and combined (Com), 2009 growing season.

Crosses	Days to 50% silking			Plant height			Ear height		
	SK	SD	Com	SK	SD	Com	SK	SD	Com
L- 1 x Sd 34	0.69	-0.13	0.28	2.59	4.44	3.52	-5.90	2.20	-1.85
L- 2 x Sd 34	-0.06	0.50	0.22	0.47	5.07	2.77	1.35	0.33	0.84
L- 3 x Sd 34	-0.93	0.25	-0.34	1.72	-1.18	0.27	3.85	-0.30	1.78
L- 4 x Sd 34	0.44	0.13	0.28	3.09	6.32	4.70	4.72	1.58	3.15
L- 5 x Sd 34	0.07	0.25	0.16	0.09	2.57	1.33	-2.28	-1.55	-1.91
L- 6 x Sd 34	-0.93	-1.25*	-1.09**	-8.28	-9.31*	-8.80**	-6.90	-4.67	-5.79*
L- 7 x Sd 34	0.19	0.63	0.41	1.84	6.32	4.08	2.47	2.83	2.65
L- 8 x Sd 34	0.19	0.75	0.47	-1.41	-0.56	-0.98	1.22	-1.55	-0.16
L- 9 x Sd 34	0.57	0.38	0.47	6.47	6.94	6.70*	6.22	5.33	5.78*
L-10 x Sd 34	0.44	-0.25	0.10	2.84	-7.43	-2.30	2.10	-3.42	-0.66
L-11 x Sd 34	-0.56	-0.38	-0.47	-1.66	0.69	-0.48	-5.15	-0.92	-3.04
L-12 x Sd 34	0.94	-0.13	0.41	-3.03	-3.68	-3.36	-0.90	0.95	0.03
L-13 x Sd 34	-0.18	-0.88	-0.53	-6.53	-13.06**	-9.80**	-11.15*	-7.17*	-9.16**
L-14 x Sd 34	-0.18	-0.25	-0.22	0.47	-3.68	-1.61	3.47	-2.80	0.34
L-15 x Sd 34	0.07	-0.38	-0.15	1.72	1.32	1.52	4.10	0.95	2.53
L-16 x Sd 34	0.07	-0.25	-0.09	-3.28	-1.18	-2.23	- 4.90	0.33	-2.29
L-17 x Sd 34	-0.06	0.38	0.16	2.22	1.94	2.08	2.35	2.20	2.28
L-18 x Sd 34	-0.56	0.00	-0.28	3.09	2.57	2.83	5.22	2.83	4.03
L-19 x Sd 34	-0.18	0.63	0.22	-2.41	1.94	-0.23	0.10	2.83	1.46
L- 1 x Gz 629	-0.69	0.13	-0.28	-2.59	-4.44	-3.52	5.90	-2.20	1.85
L- 2 x Gz 629	0.06	-0.50	-0.22	-0.47	-5.07	-2.77	- 1.35	-0.33	-0.84
L- 3 x Gz 629	0.93	-0.25	0.34	-1.72	1.18	-0.27	- 3.85	0.30	-1.78
L- 4 x Gz 629	-0.44	-0.13	-0.28	-3.09	-6.32	-4.70	- 4.72	-1.58	-3.15
L- 5 x Gz 629	-0.07	-0.25	-0.16	-0.09	-2.57	-1.33	2.28	1.55	1.91
L- 6 x Gz 629	0.93	1.25*	1.09**	8.28	9.31*	8.80**	6.90	4.67	5.79*
L- 7 x Gz 629	-0.19	-0.63	-0.41	-1.84	-6.32	-4.08	- 2.47	-2.83	-2.65
L- 8 x Gz 629	-0.19	-0.75	-0.47	1.41	0.56	0.98	- 1.22	1.55	0.16
L- 9 x Gz 629	-0.57	-0.38	-0.47	-6.47	-6.94	-6.70	- 6.22	-5.33	-5.78*
L-10 x Gz 629	-0.44	0.25	-0.10	-2.84	7.43	2.30	- 2.10	3.42	0.66
L-11 x Gz 629	0.56	0.38	0.47	1.66	-0.69	0.48	5.15	0.92	3.04
L-12 x Gz 629	-0.94	0.13	-0.41	3.03	3.68	3.36	0.90	-0.95	-0.03
L-13 x Gz 629	0.18	0.88	0.53	6.53	13.06**	9.80**	11.15*	7.17*	9.16**
L-14 x Gz 629	0.18	0.25	0.22	-0.47	3.68	1.61	- 3.47	2.80	-0.34
L-15 x Gz 629	-0.07	0.38	0.15	-1.72	-1.32	-1.52	- 4.10	-0.95	-2.53
L-16 x Gz 629	-0.07	0.25	0.09	3.28	1.18	2.23	4.90	-0.33	2.29
L-17 x Gz 629	0.06	-0.38	-0.16	-2.22	-1.94	-2.08	- 2.35	-2.20	-2.28
L-18 x Gz 629	0.56	0.00	0.28	-3.09	-2.57	-2.83	- 5.22	-2.83	-4.03
L-19 x Gz 629	0.18	-0.63	-0.22	2.41	-1.94	0.23	- 0.10	-2.83	-1.46
SE. for									
S_{ij}	0.57	0.53	0.39	5.13	4.63	3.45	4.95	3.26	2.97
$S_{ij} - S_{kl}$	0.80	0.75	0.55	7.25	6.55	4.89	7.01	4.61	4.20

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

Table 6. Estimates of specific combining ability for grain yield per plant and grain yield per feddan at Sakha (SK), Sids (SD) and combined (Com), 2009 growing season.

Crosses	Grain yield per plant			Grain yield (ard/fed)		
	SK	SD	Com.	SK	SD	Com.
L- 1 x Sd-34	-3.61	3.87	0.13	-0.15	1.64	0.74
L- 2 x Sd-34	9.15	4.51	6.83	0.84	1.44	1.14
L- 3 x Sd-34	1.19	-3.65	-1.23	-1.45	-0.63	-1.04
L- 4 x Sd-34	9.99	6.81	8.4	2.25	-0.49	0.88
L- 5 x Sd-34	-9.61	-14.75	-12.18	-2.17	-2.83*	-2.50*
L- 6 x Sd-34	-6.63	-2.42	-4.52	-0.73	0.89	0.08
L- 7 x Sd-34	11.63	11.76	11.69	-0.25	1	0.38
L- 8 x Sd-34	11.1	-7.98	1.56	0.78	-0.77	0.01
L- 9 x Sd-34	16.23	21.28*	18.75**	3.70*	3.55**	3.63**
L-10 x Sd-34	2.19	1.31	1.75	0.36	0.68	0.52
L-11 x Sd-34	3.09	6.51	4.8	0.11	-0.55	-0.22
L-12 x Sd-34	-2.33	1.62	-0.35	-2.35	0.65	-0.85
L-13 x Sd-34	0.74	-7.04	-3.15	1.91	-2.48	-0.29
L-14 x Sd-34	-5.25	-1.54	-3.4	-0.22	-0.33	-0.27
L-15 x Sd-34	-2.45	-1.18	-1.81	-1.6	0.43	-0.58
L-16 x Sd-34	-12.25	8.33	-1.96	2.17	0.71	1.44
L-17 x Sd-34	-9.16	-5.87	-7.51	-1.98	0.35	-0.82
L-18 x Sd-34	-11.04	-1.29	-6.16	-0.35	-0.57	-0.46
L-19 x Sd-34	-2.96	-20.30*	-11.63	-0.87	-2.7	-1.78
L- 1 x Gz-629	3.61	-3.87	-0.13	0.15	-1.64	-0.74
L- 2 x Gz-629	-9.15	-4.51	-6.83	-0.84	-1.44	-1.14
L- 3 x Gz-629	-1.19	3.65	1.23	1.45	0.63	1.04
L- 4 x Gz-629	-9.99	-6.81	-8.4	-2.25	0.49	-0.88
L- 5 x Gz-629	9.61	14.75	12.18	2.17	2.83*	2.50*
L- 6 x Gz-629	6.63	2.42	4.52	0.73	-0.89	-0.08
L- 7 x Gz-629	-11.63	-11.76	-11.69	0.25	-1	-0.38
L- 8 x Gz-629	-11.1	7.98	-1.56	-0.78	0.77	-0.01
L- 9 x Gz-629	-16.23	-21.28*	-18.75**	-3.70*	-3.55**	-3.63**
L-10 x Gz-629	-2.19	-1.31	-1.75	-0.36	-0.68	-0.52
L-11 x Gz-629	-3.09	-6.51	-4.8	-0.11	0.55	0.22
L-12 x Gz-629	2.33	-1.62	0.35	2.35	-0.65	0.85
L-13 x Gz-629	-0.74	7.04	3.15	-1.91	2.48	0.29
L-14 x Gz-629	5.25	1.54	3.4	0.22	0.33	0.27
L-15 x Gz-629	2.45	1.18	1.81	1.6	-0.43	0.58
L-16 x Gz-629	12.25	-8.33	1.96	-2.17	-0.71	-1.44
L-17 x Gz-629	9.16	5.87	7.51	1.98	-0.35	0.82
L-18 x Gz-629	11.04	1.29	6.16	0.35	0.57	0.46
L-19 x Gz-629	2.96	20.30*	11.63	0.87	2.7	1.78
SE. for						
S_{ij}	9.49	9.73	6.8	1.59	1.37	1.05
$S_{ij} - S_{kl}$	13.42	13.76	9.61	2.25	1.94	1.48

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

Respecting grain yield, data in Table 6 show that the topcross L-9 x Sd-34 possessed positive and significant SCA effect (desirable) at Sakha, Sids and the combined data, (3.70*, 3.55**, and 3.63**), respectively, and L-5 x Gz 629 at Sids and the combined analysis (2.83* and 2.50*). However, topcross L-9 x Gz-629 exhibited negative and significant SCA effect (undesirable) at Sakha, Sids, and the combined analysis, (-3.70*, -3.55**, and -3.63**), respectively.

Topcrosses did not exhibit significant SCA effect for grain yield per plant at Sakha, whereas at Sids, L-9 x Sd-34 and L-19 x Gz-629 had significant positive SCA effect, and L-19 x Sd-34 and L-9 x Gz-629 had significant negative SCA effect at Sids (Table 6). For the combined data, topcrosses L-9 x Sd-34 and L-9 x Gz-629 exhibited significant negative and positive SCA effects, respectively.

Finally, the combined data revealed that L-9 with Sd-34 was considered to be the best combiner in case of grain yield and other agronomic traits. Also, topcross involved the same tester (Sd 34), i.e. L-9 x Sd-34 had favorable SCA effects and produced also high grain yield.

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), El-Zeir (1999), El-Sherbeiny *et al.* (2006), Abd El-Aal (2007) and Abd El-Moula and Abd El-Aal (2009), reported that inbred tester method was more effective to select lines that combined well with unrelated tester. Moreover, they emphasized that inbred testers were more effective in detecting small differences in combining ability more than the wide genetic base testers.

Variance components:

The estimates of combining ability variances for lines and testers (σ^2_{gca}) and for crosses (σ^2_{sca}) for grain yield and other agronomic traits in the two locations and the combined data are presented in (Table 7). Results revealed that values of σ^2_{GCA} for lines were higher than that of σ^2_{gca} for testers for all studied traits, except for days to 50% silking at Sakha, Sids and the combined over locations, and plant and ear height at Sids and the combined analysis. This indicated that most of the total variance was due to GCA of the lines. Higher GCA variance of all studied traits indicated that the largest part of the total genetic variability associated with these traits was due to the additive gene action. The variance of σ^2_{gca} (lines) x Loc interaction was larger than σ^2_{gca} (testers) x Loc for plant and ear height, whereas σ^2_{gca} (testers) x Loc for grain yield was higher than that of σ^2_{gca} (lines) x Loc, indicating that σ^2_{gca} for both lines and testers were more affected by environmental conditions.

Data in Table 7 indicated that variances due to SCA (σ^2_{sca}) was relatively larger for all studied traits except for plant height at Sakha which was small and negative (-0.487). Moreover, values of SCA variance component (σ^2_{sca}) were higher than that of GCA variance for grain yield per plant and per feddan at Sids and the combined data as well as ear height at Sakha and the combined analysis indicating that the non-additive gene effects were more important. In contrast, variance component due to SCA (σ^2_{sca}) was lower than that for GCA for days to 50% silking at Sakha, Sids, and the combined data and grain yield at both locations and the combined analysis indicating that additive variance played an important role in the inheritance of these traits.

Table 7. Estimates of general (σ^2_{gca}) and specific (σ^2_{sca}) combining ability variance components at Sakha, Sids and combined for grain yield and other plant traits.

Estimates	Days to 50% silking	Plant height	Ear height	Grain yield	Yield/ plant
Sakha					
σ^2_{gca} (lines)	0.23	43.67	11.04	4.11	176.46
σ^2_{gca} (testers)	1.28	21.87	10.34	3.25	76.40
σ^2_{sca}	0.20	-0.49	21.54	2.91	51.52
Sids					
σ^2_{gca} (lines)	0.04	6.14	3.74	2.90	114.12
σ^2_{gca} (testers)	0.47	58.66	14.67	0.59	24.98
σ^2_{sca}	0.26	38.44	7.68	3.03	82.13
Combined					
σ^2_{gca} (lines)	0.13	20.96	5.46	3.57	148.43
σ^2_{gca} (testers)	0.84	38.34	12.86	1.78	50.12
σ^2_{sca}	0.19	23.50	16.04	2.33	71.93
σ^2_{gca} x Loc (lines)	0.04	7.87	3.87	-0.12	-6.27
σ^2_{gca} x Loc (testers)	0.08	3.85	-0.70	0.28	1.13
σ^2_{sca} x Loc	0.08	-9.05	-2.86	1.28	-10.21

Furthermore, the magnitude of σ^2_{sca} x Loc interaction was higher than that of σ^2_{gca} x Loc interaction for days to 50% silking and grain yield indicating that the additive gene action was more affected by the environmental conditions than the non-additive component for these traits. This result was in agreement with the findings of several investigators who reported that specific combining ability to be more sensitive to environmental changes than general combining ability (Gado *et al.*, 2000). Also, Sadek *et al.* (2000) found that the non-additive genetic variation interacted more with the environment than the additive component. On the other hand, El-Itrby *et al.* (1990), Soliman *et al.* (2001) and Abd El-Moula and Abd El-Aal (2009) reported that the additive type of gene action was more affected by environment than the non-additive.

REFERENCES

Abd El-Aal, A.M.M. 2007. Commercial inbred lines as testers for combining ability in new developed maize lines. Minufiya J. Agric. Res., 32 (1): 219 - 235.

Abd El-Moula. M.A. and A.M.M. Abd El-Aal 2009. Evaluation of some new yellow maize inbred lines via top cross analysis. Egypt. J. Appl. Sci., (12A): 148-166.

Amer, E.A and A.A. El-Shenawy 2007. Combining ability for new twenty one yellow maize inbred lines. J. Agric. Sci. Mansoura Univ., 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. Stat. p: 14-15.

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

El-Itriby, .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 maize inbred lines. Assiut J. Agric. Sci., 13 (1):95-102.

El-Morshidy, M.A, E.A. Hassaballa, Sh.F. Abou-Elsaad and M.A. Abd El-Moula 2003.Combining ability and type of gene action in maize under favorable and water stress environments. Proc. Plant Breed. Conf., April 26, 2003: 55-57.

El-Sherbieny, H.Y., T.A.E. Abdallah and A.M.M. Abd El-Aal 2006. Comparative performance and combining ability of new yellow maize inbred lines in top crosses with three inbred testers. Proceedings of First Field Crops Conference, 22-24, August 2006.

El-Zeir, F.A.A. (1999). Evaluation of some new inbred lines for combining ability using top crosses in maize (*Zea mays* L). Minufiya Agric. Res., 24(5):1609-1620.

El-Zeir, F.A, E.A. Amer, A.A. Abdel Aziz and A.A. Mahmoud 2000. Combining ability of new maize inbred lines and type of gene action using top crosses of maize. Egypt. J. Appl. Sci., 15(2): 116-128.

Gado, H.E., M.S.M. Soliman and M.A.K. Shalaby.2000. Combining ability analysis of white maize (*Zea mays* L.) inbred lines. J. Agric. Sci. Mansoura Univ.25:3719-3729

Hallauer, A.R. and J.E. Miranda. 1981. Quantitative Genetics in Maize Breeding. 2nd Ed., Iowa State Univ., Press, Ames. USA.

Hassaballa, E.S., M.A.El-Morshidy, M.Khalfa and E.M. Shalaby. (1980). Combining ability analysis in maize. 1- Flowering. Res. Bull. Fac. Agric., Ain Shams Univ., 1291, 8pp.

Hede, A.R., G.Srinvasan, G. Stolen and S.K. Vasal.(1999). Identification of heterotic pattern in tropical inbred maize lines using broad-base synthetic testers. Maydica, 44(4):325-331.

Kempthorne, O. 1957. An Introduction to Genetic Statistics .John Wiley and Sons Inc., NY, USA.

Konak, G., A. Unay, E. Serter and H. Basal (1999). Estimation of combining ability effects, heterosis and heterobeltiosis by line x tester method in maize. Turkish J. of Field Crops. 4(1): 1-9 [C.F.Plant Bread. Abst., 69(11): 10711].

Mahgoub, G.M.A., H.Y. El-Sherbieny and M.A.N. Mostafa 1996. Combining ability between newly developed inbred lines of maize. J. Agric. Mansoura Univ., 21(5): 1619-1627.

Mahmoud, A.A.1996. Evaluation of combining ability of new-developed inbred lines of maize. Ph.D. Thesis, Fac. Agric., Cairo Univ.

Mathur, R.K., Chunilal, S.K. Bhatnagar and V. Singh. (1998). Combining ability for yield, phonological and ear characters in white seeded maize. Indian J. Genet. & Plant Bread., 58 (2):177-182.

Nass, L.L., M.Lima, R.Vencovesky and P.B.Gallo.2002.Combining ability of maize inbred lines evaluated in three environments in Brazil. Scientia Agricola, 57(1): 129-134.

Sadek, E.S., H.E.Gado and M.S.M.Soliman.2000. Combining ability and type of gene action for maize grain yield and other attributes. J. Agric. Sci. Mansoura Univ., 25(5): 2491-2502.

Salama, F.A, Sh.F.Aboel-Saad and M.M.Ragheb (1995). Evaluation of maize top crosses for grain yield and other agronomic traits under different environmental conditions. J. Agric. Mansoura Univ., 20(1): 127-140

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.

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, .S.M, A.A.El-Shenawy, F.A. El-Zeir and E.A.Amer (1995). Estimates of combining ability and type of gene action in top crosses of yellow maize> Egypt. J. Appl. Sci., 10(8):312-329

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, F.H.S., SH.A.Shafay, A.I. El-Agmy and M.A. Mostafa (2007). Inheritance of grain yield and oil content in new maize high oil single crosses. Conf of Egypt. J. Plant. Breed., 11(2): 507-530

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.

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

Steel,R.G. and J.H.Torrie.1980. Principal and Procedures of Statistics. Mc.Grow Hill Book Inc., New York, USA.

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

تحليل الهجن القمية والقدرة على التآلف لمحصول الحبوب وبعض الصفات الأخرى في الذرة الشامية

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تم إختبار ١٩ سلالة بيضاء الحبوب ومنتخبة من الذرة الشامية فى الجيل الذاتى الثالث مع إثنين من السلالات التجارية البضاء وهما سدس-٣٤ وجيزة ٦٢٩ وذلك بمحطة البحوث الزراعية بسدس في موسم ٢٠٠٨ . وفي موسم ٢٠٠٩ تم تقييم ٣٨ هجين قمي مع أثنين من هجن المقارنة بيضاء الحبوب (هـ. ف. ١٠ ، هـ. ف. ١٢٩) في كل من محطة البحوث الزراعية بسخا (محافظة كفر الشيخ) ، وسدس (محافظة بنى سويف) وذلك لصفات عدد الأيام حتى ظهور ٥٠ % حريرة ، إرتفاع كل من النبات والكوز، ، محصول الحبوب بالأردب للفدان ، ومحصول الحبوب للنبات الواحد. وقد وجدت اختلافات معنوية بين الهجن القمية ، السلالات ، الكشافات، لكل الصفات موضع الدراسة في كلا الجهتين والتحليل التجميعي ، أما التفاعل بين السلالات × الكشافات فقد كان معنويا لجميع الصفات موضع الدراسة فيما عدا عدد الأيام حتى ظهور ٥٠ % حريرة وارتفاع النبات فى سخا ، و عدد الأيام حتى ظهور ٥٠ % حريرة فقط فى سدس. كذلك وجدت اختلافات معنوية بين المناطق لجميع الصفات المدروسة مما يدل على ان المنطقتين مختلفتين في الظروف البيئية. وكان التفاعل بين المناطق والكشافات معنويا لجميع الصفات موضع الدراسة ماعد ارتفاع النبات ومحصول حبوب النبات. ، وكانت الهجن **(L-4 x Sd-34), (L-7 x Sd-34), (L-8 x Sd-34), (L-9 x Sd-34)** اعلى معنويا عن هجين المقارنة هـ.ف. ١٢٩ بنحو ١٥,١ ، ١٩,٧ ، ١٢,١ ، ٢٣,٨% وذلك فى التحليل التجميعي ، كما أظهرت السلالات رقم ٤، ٦، ٧، ٨ ، ٩ أحسن قدرة عامة ومرغوبة لصفة المحصول كما أظهر الهجين القمى **(L-9 x Sd-34)** أحسن التقديرات للقدرة الخاصة على التآلف لصفة المحصول الأمر الذى يستوجب الإهتمام بتلك الهجن المتفوقة معنويا وسلالاتها فى دعم برامج استنباط الهجن وترقية المواد الناجحة معنويا للمراحل المتقدمة من التقييم ، كما نود الإشارة بأن تباين القدرة العامة على التآلف كان عاليا لجميع الصفات موضع الدراسة عدا صفة التزهير فى سخا ، وصفة التزهير وإرتفاع النبات والكوز فى سدس والتحليل التجميعي. وكان التباين الراجع لتفاعل للقدرة العا مة على التآلف مع المناطق عاليا لصفة ارتفاع النبات وارتفاع الكوز مما يدل على ان الفعل الجيني المضيف كان اكثر تأثرا بالمناطق عن الفعل غير المضيف لهذه الصفات.

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