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Relationship between Combining Ability of Grain Yield and Yield Components for Some Newly Yellow Maize Inbred Lines Via Line X Tester Analysis

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ABSTRACT

This study was conducted to estimate general and specific combining ability effects of eleven parental lines and their crosses with two single crosses for grain yield (GY) and some of the yield components traits (YCTs) and to study the relationship between grain yield combining ability and the yield components traits (YCTs) combining ability by line x tester analysis. Therefore, eleven new yellow maize inbred lines were topcrossed with two yellow crosses as testers at Ismailia Agri. Res. Stn. during 2011 growing season. In 2012 season, the 22 crosses were evaluated in a replicate trail at two locations; Ismailia and Mallawy Agric. Res. Stns. Data were recorded on number of days to 50% silking (SD), plant height (PHT, cm), ear height (EHT, cm), number of ears 100 plants^{-1} (E100P), grain yield ard fed^{-1} (GY), grain yield plant^{-1} (YP g), ear length (EL, cm), ear diameter (ED, cm), number of rows ear^{-1} (RE) and number of kernels row^{-1} (KR). Significant differences were observed between the two locations for all of the studied traits, indicating that environmental conditions were different to both locations. Mean squares due to crosses and their partitioning into lines, testers and line x tester were significant for all of the studied traits except SD for lines; EHT and EL for testers and E100P for lines x tester interaction. Inbred line 5087 had negative and significant GCA effects for SD, PHT, and EHT toward earliness, shorter plants and lower ear placement. While, inbred lines; L5303, L5415, L5522 and L5844 had positive and significant GCA effects for grain yield (ard fed^{-1}) and grain yield plant^{-1} (g). Results showed that GCA effects of grain yield (GY) were related to GCA effects of the yield component traits (YCTs) in an inbred line. Significant positive GCA effects for grain yield (GY) were highly correlated with that had significant positive GCA effects, indicating that line with high GCA effects for grain yield (GY), generally had high GCA effects for the yield component traits (YCTs) with high GCA effects. Thus, selecting inbred lines with positive GCA effects in either all or most of the yield component traits (YCTs) will have greater chance to produce crosses with higher grain yield. The non-additive gene action played an important role in the inheritance of SD, PHT, EHT, EL, ED, RE and KR. While, the additive type of gene action played an important role in the inheritance of E100P, GY and YP. Non-additive gene action was affected more by environmental conditions than additive type of gene action. Three top crosses; L5522 x SC168 (36.81), L5844 x SC168 (36.92) and L5415 x SC168 (38.09 ard fed^{-1}) were significantly superior compared with the higher check hybrid TWC353 (33.51 ard fed^{-1} ± 3.22) for grain yield. Meanwhile, the same three top crosses were significantly superior for grain yield plants^{-1} (g) compared with higher check hybrid TWC353 (193.25 g ± 17.69). In addition, two top crosses; L5303 x SC168 (33.74) and L5323 x SC168 (33.91 ard fed-1) were not significantly different from the high yielding check hybrid. These top crosses have to be evaluated in the advanced stage for release as new commercial hybrids in maize research program.

Key words: maize, line x tester, combining ability, gain yield, yield components traits.

INTRODUCTION

Maize (*Zea mays* L.) is the world's most widely grown cereal and is the primary staple food in many developing countries (Morries *et al.* 1999). The concept of general and specific combining ability was introduced by Sprague and Tatum (1942). Estimation of combining ability and genetic variance components are important in the breeding programs for hybridization (Fehr, 1993). In any breeding program, the choice of the correct parents is the secret of the success. One of the most important criteria in breeding programs for identifying hybrids with high yield is knowledge regarding parent's genetic structure and information regarding their combining ability (Ceyhan 2003). Genetic information was obtained by different quantitative genetic methods line x tester analysis is a suitable and efficient method with eligible speed (Singh and Chaudhary, 1985). The line x tester analysis method has been widely used by plant breeders. This method was suggested by Kempthorne (1957) and is used to breed both self and cross pollinated plants, as well as estimating favorable parents, crosses and their general and specific combining ability effects. The heterozygous crosses as tester have been widely used by several breeders (El-Ghawas 1963, Horner *et al.* 1976, Mosa, 2010 and Mousa and Aly, 2012). Numerous investigators found that the non-additive genetic effects played an effective role in the inheritance of grain yield (Kara 2001, Ashish and Singh 2002, Motawei 2006 and Aly and Hassan 2011); number of days to 50% silking emergency (Dubey *et al.* 2001, El-Shenawy 2005 and Pavan *et al.* 2011); plant height (San *et al.* 2001, Mosa 2010 and Aly *et al.* 2011); and ear height, ear diameter and number of rows ear^{-1} (Aly *et al.* 2011). On the other hand, ear length (EL), ear diameter (ED), no. of rows ear^{-1} (RE) and no. of kernels row^{-1} (KR) are the most important yield components traits (YCTs) of grain yield (GY) in maize. These YCTs were significantly correlated with maize grain yield (Austin and Lee, 1988). Maize grain yield combining ability has been studied intensively and the results have been widely used in maize breeding programs (Kauffman *et al.* 1982, Fan *et al.* 2002 and Barata and Carena 2006). In Contrast, limited research, however, has been reported on maize YCTs combining ability and the relationship between combining ability of GY and combining ability of YCTs (Fan *et al.* 2008 and Mousa and Aly 2011).

The main objectives of the present study were to estimate general combining ability of lines and testers and specific combining abilities of crosses for grain yield and yield components traits, to identify the superior crosses to improve the yielding ability in maize breeding program and the relationship between GY and YCTs combining abilities.

MATERIALS AND METHODS

Experimental design

The materials for this study consisted of eleven new yellow maize inbred lines (*Zea mays* L.) in the S_5 generation derived from exotic sources at Ismailia Agric. Res. Stn. (Table1). In the 2011 growing season, the eleven inbred lines were top crossed to two yellow single crosses; SC166 and SC168 as testers. In 2012 growing season, the twenty two top crosses along with two yellow three way crosses; TWC 352 and TWC 353 were evaluated in a yield trail at two locations; Ismailia and Mallawy. A randomized complete block design with four replications was used. Plot size was one row, 6 m long and 0.8 m apart. Seeds were planted in hills evenly spaced at 0.25 m with two kernels hill^{-1}. Seedlings were thinned to one plant hill^{-1} after 21 days from planting. All cultural practices for maize production were applied as recommended. Data were recorded for number of days to 50% silking (SD), plant height (PHT, cm), ear height (EHT, cm), number of ears.100 plants^{-1} (E100P), grain yield (GY) in ardab feddan^{-1} (ard fed^{-1}). Grain yield was adjusted to 15.5% grain moisture, one ardab = 140 Kg and one feddan = 4200 m^2), yield plant-1(YP, g), ear length (EL, cm), ear diameter (ED, cm), number of rows ear^{-1} (RE) and number of kernels row^{-1} (KR).

Analysis of variance was carried out for each location. Due to homogeneity of errors combined analysis of variance was done over locations according to Steel and Torrie (1980). Genotypes effects were assumed to be fixed, while location effects were considered random. The procedure of line x tester analysis according to Kempthorne (1957) was used for estimating general and specific combining ability effects and variances as described by Singh and Chaudhary (1985).

General combining ability ratio (GR).

The relationship between GCA for GY and GCA for yield components traits (YCTs) were estimated according to Fan *et al* (2008). To obtain GCA ratio (GR) for individual traits, first step, the mean absolute values of general combining ability effects (MA GCA) was calculated. Second step, the GCA/MA GCA ratio (the sign either positive or negative must be considered) was calculated for traits; Grain yield (GY), number of ear 100 plant^{-1} (E100P), yield plant^{-1} (YP), ear length (EL), ear diameter (ED), number of rows ear^{-1} (RE) and number of kernels row^{-1} (KR) of each lines and called then GY_r, E100P_r, YP_r, EL_r, ED_r, RE_r and KR_r, respectively. The GR ratio removes the variation caused by different units of different traits and the graph of GRs shows relative importance of each YCTs GCA effects to GY GCA effects of each line

Table 1: Names and sources of inbred lines used in this study

Inbred lines	Source
L_1- 5303	Exotic Spanish source
L_2- 5323	
L_3- 5415	
L_4- 5522	
L_5- 5844	
L_6- 5087	(Hungarian x Spanish)
L_7- 5090	
L_8- 5102	
L_9- 5134	
L_{10}- 5199	
L_{11}- 5222	
Testers	
T_1- SC 166	Gz-656 x Gz-639
T_2- SC 168	Gz-658 x Gz-639

Gz = Giza, SC = Single cross

RESULTS AND DISCUSSION

Analysis of variances

Analyses of variances for ten traits combined over two locations in 2012 season presented in Table (2). Results show that significant differences were detected between the two locations for all of the studied traits, indicating that the two locations differed in the environmental conditions. These findings agreed with those reported by Aly and Amer (2008), Aly *et al.* (2011) and Mousa and Aly (2012).

Table 2: Analysis of variances for ten traits of maize over two locations in 2012 season.

Sources	df	SD (day)	PHT (cm)	EHT (cm)	E100P	GY (ard fed^{-1})	YP (g)	EL (cm)	ED (cm)	RE	KR
Locations(Loc.)	1	1775.46**	1056.57*	713.84**	147.65*	208.56*	5894.34*	319.95*	51.06**	3.84*	873.09**
Reps/Loc.	6	19.73	169.83	44.78	21.73	20.46	790.49	25.14	0.54	0.62	37.84
Crosses (C)	21	59.78**	538.35**	132.09**	72.12**	154.69**	3839.13**	12.73**	0.81**	2.13**	25.61**
Lines (L)	10	18.47	255.69*	78.30*	113.58**	183.02*	3178.98*	14.18*	1.13**	2.40*	34.03**
Testers (T)	1	52.55*	1603.84*	946.11	176.2**	641.03**	19173.48**	0.15	0.16*	2.36*	29.32**
Lines x Testers	10	101.81*	714.48*	104.48**	20.26	77.81*	2965.83*	12.53**	0.54**	1.83*	16.82**
C x Loc.	21	9.09**	124.82*	28.64	14.93	33.14**	1221.98**	2.60*	0.06	0.59	3.12
Lines x Loc.	10	8.32**	65.28	18.55	18.08	43.25**	1057.99**	3.21*	0.06	0.58	5.49
Testers x Loc.	1	5.46	8.09	355.11**	2.73	7.88	782.09	2.03	0.03	0.33	2.27
L x T x Loc.	10	10.22**	196.03**	6.10	13.02	25.56*	1029.99**	2.06	0.06	0.62	0.79
Pooled error	126	1.63	77.96	38.24	12.9	10.78	325.94	1.73	0.07	0.71	5.15

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

SD = no. of days to 50% silking PHT= plant height EHT= ear height E100P = no. of ears 100 plants^{-1} GY= grain yield
YP = yield plant^{-1} EL= ear length ED= ear diameter RE = no. of rows ear^{-1} KR= no. of kernels rwos^{-1}

Significant and highly significant differences were detected among crosses, lines, testers and line x tester for all of the studied traits combined both over locations, except for SD for lines, EHT and EL for testers and E100P for line x tester. Similar results were obtained by Castellanos *et al.* (1998), Shiri *et al.* (2010), Kustanto *et al.* (2012) and Mousa and Aly (2012). Furthermore, mean squares due to crosses x location interaction were significant or highly significant for SD, PHT, GY, YP and EL traits, indicating that these crosses differed in their order from location to another for these traits. Line x location interaction was significant for SD, GY, YP and EL, indicating that differences between inbred lines were different in the two locations. Also, L x T X Loc. interaction mean squares was significant for SD, PHT, GY and YP. These results are in agreement with those obtained by Ibrahim and Mousa (2011), who reported significant interaction of (L x Loc) for GY, (T x Loc) for EHT and (L x T x Loc) for PHT and GY; Mousa and Aly (2012), who reported significant interaction of (L x Loc) for SD and GY, (T x Loc) for EHT and (L x T x Loc) for PHT trait.

Mean performances.

Mean performances of the twenty four genotypes (twenty two topcrosses + two check hybrids) for all of the studied traits combined over locations in 2012 season are shown in Table (3). Results showed that the topcrosses ranged from 55.75 day for topcross L5087 x SC168 to 60.63 day for topcross L5090 x SC168 for SD trait. Generally, eighteen out of twenty two top crosses were significantly earlier than the earliest check hybrid TWC 353 (60.13 day). As for PHT trait, topcrosses ranged from 219.38 cm for topcross L5102 x SC168 to 242.75 cm for topcross L5134 x SC166. One topcross (L5102 x SC168) was significantly shorter than the shortest check hybrid TWC 353. As for EHT trait, the 18 out 22 topcrosses had significantly lower ear placement compared with the best check hybrid TWC 353 (129.88 cm) and the topcrosses ranged from 113.38 cm for cross L5844 x SC166 to 125.75 cm for cross L5415 x SC168. Generally, the topcross L5844 x SC 166 (113.38 cm) had the lowest ear placement compared with lower check hybrid TWC 352 (121.13 cm). For E100P trait, all topcrosses did not differ significantly from the check hybrid TWC 353 (104.19%). While, three topcrosses; L5303 x SC168 (103.68%), L5415 x SC168 (106.25%) and L5844 x SC166 (105.69%) were significantly superior to the check hybrid TWC 352 (100.04 %). For GY (ard fed^{-1}) and YP (g), topcrosses ranged from (24.78 and 144.35) for topcross L54087 x SC 168 to (38.09 ard fed^{-1} and 221.00 g) for topcross L5415 x SC 168, respectively. Three topcrosses; L5522 x SC168 (36.81 and 212.59), L5844 x SC168 (36.92 and 217.41) and L5415 x SC168 (38.09 ard fed^{-1} and 221.00 g) were significantly superior to the high check hybrid TWC 353 (33.51 ard fed^{-1} and 193.25 g) in terms of GY and YP, respectively. But, the two crosses; L5303 x SC168 (33.74 and 196.71) and L5323 x SC168 (33.91 and 197.35) were not significantly different from the same check hybrid. For EL trait, the topcrosses mean values ranged from 18.01 cm for L5087 x SC168 to 20.00 cm for L5323 x SC168. Furthermore, fourteen topcrosses were significantly different compared to the longer ear check hybrid. For ED cm and RE traits, 12 and one topcrosses out 22 topcrosses were not significantly different from the check hybrid, respectively. For KR trait, the topcrosses ranged from 36.53 for topcross L5087 x SC166 to 41.45 for topcross L5222 x SC168, while ten topcrosses possessed higher number of kernels row^{-1} than the check hybrid TWC 353.

Table 3: Mean performances of twenty four genotypes (22 Top crosses and 2 Check hybrids) for all of the studied traits over two locations in 2012 season.

Crosses		SD (day)	PHT (cm)	EHT (cm)	E100P	GY (ard fed^{-1})	YP (g)	EL (cm)	ED (cm)	RE	KR
L_1xT_1	L 5303xSC 166	57.88	233.13	121.88	101.64	32.04	187.99	19.53	4.76	14.50	39.63
L_1xT_2	L 5303xSC 168	57.38	235.13	119.38	103.68	33.74	196.71	18.73	4.74	14.25	40.55
L_2xT_1	L 5323xSC 166	57.50	230.88	119.00	101.20	27.69	171.30	19.26	4.60	14.00	38.18
L_2xT_2	L 5323xSC 168	58.25	236.00	119.38	102.94	33.21	197.35	20.00	4.64	14.08	40.31
L_3xT_1	L 5415xSC 166	58.00	241.00	120.63	100.70	27.36	164.42	19.50	4.58	13.75	39.45
L_3xT_2	L 5415xSC 168	58.63	238.50	125.75	106.24	38.09	221.00	19.28	4.76	14.45	40.18
L_4xT_1	L 5522xSC 166	58.75	238.25	122.25	99.55	29.33	170.81	18.60	4.39	13.35	37.80
L_4xT_2	L 5522xSC 168	57.63	233.00	122.63	102.04	36.81	212.59	19.38	4.60	13.95	40.05
L_5xT_1	L 5844xSC 166	57.75	223.75	113.38	100.00	27.28	169.95	18.29	4.54	14.60	38.25
L_5xT_2	L 5844xSC 168	57.88	234.13	124.00	105.69	36.92	217.41	19.44	4.75	14.45	39.48
L_6xT_1	L 5087xSC166	58.38	224.13	116.25	101.73	28.91	173.70	18.05	4.46	14.00	36.53
L_6xT_2	L 5087xSC168	55.75	231.50	118.00	100.56	24.78	144.35	18.01	4.50	13.50	37.19
L_7xT_1	L 5090xSC166	57.38	234.38	121.00	100.00	26.61	162.80	19.88	4.61	14.20	40.39
L_7xT_2	L 5090xSC168	60.63	225.75	118.25	102.78	29.70	174.54	18.39	4.56	14.18	37.78
L_8xT_1	L 5102xSC166	58.63	236.63	116.50	100.00	24.97	147.61	18.18	4.41	13.40	38.26
L_8xT_2	L 5102xSC168	59.75	219.38	122.63	101.10	30.17	177.82	18.63	4.58	13.90	37.93
L_9xT_1	L 5134xSC166	57.75	242.75	118.63	101.14	24.95	149.69	18.66	4.56	13.90	37.08
L_9xT_2	L 5134xSC168	60.50	232.63	131.25	102.16	26.77	166.49	18.95	4.51	14.55	38.46
$L_{10}xT_1$	L 5199xSC166	58.63	236.13	116.88	99.90	28.91	168.46	18.84	4.73	14.25	38.28
$L_{10}xT_2$	L 5199xSC168	59.75	235.13	124.88	102.13	29.19	172.52	18.15	4.66	15.15	38.54
$L_{11}xT_1$	L 5222xSC166	57.75	233.88	119.88	102.56	27.54	163.48	19.43	4.69	14.70	41.38
$L_{11}xT_2$	L 5222xSC168	58.13	233.00	122.38	101.13	28.19	169.06	19.90	4.63	14.75	41.45
	TWC 353	60.13	232.00	129.88	104.19	33.51	193.25	17.36	4.60	15.05	36.19
	TWC 352	60.75	233.63	121.13	100.04	25.12	148.66	17.21	4.48	14.25	33.62
	LSD 0.05	1.25	8.65	6.06	3.52	3.22	17.69	1.29	0.25	0.83	3.22

SD = no. of days to 50% silking PHT= plant height EHT= ear height E100P = no. of ears 100 plants^{-1} GY= grain yield
YP = yield plant^{-1} EL= ear length ED = ear diameter RE = no. of rows ear^{-1} KR = no. of kernels rwos^{-1}

General combining ability (GCA) effects

Estimation of GCA effects for the eleven yellow maize inbred lines and the two testers over two locations in 2012 season are presented in Table (4). Results showed that the two inbred lines; L5303 and L5087 possessed negative (desirable) and significant GCA effects for SD toward earliness. Also, two inbred lines; L5087 and L5102 had negative (desirable) and significant GCA effects for PHT toward shorter plants and L5087 only has negative and significant GCA effects for EHT toward lower ear placement. On the other hand, several inbred lines possessed positive (desirable) and significant GCA effects for grain yield and yield components traits. The highest inbred lines for positive and significant GCA effects were L5303, L5415, L5522 and L5844 for GY and YP traits; L5323 and L5222 for EL; L5303 for ED; L5199 and L5222 for RE and the inbred lines L5303 and L5222 for KR trait. These results revealed that one inbred lines (L5087) had negative and significant GCA effect (desirable) for SD, PHT and EHT toward earliness, shorter plants and lower ear placement, respectively. Also, four inbred lines; L5303, L5415, L5522 and L5844 had positive and significant GCA effects (desirable) for GY and YP. These lines should be advanced in breeding program for to further testing to be used in hybrid production. Concerning the testers, the best combiner tester for favorable GCA effects was SC166, which possessed negative and significant desirable GCA values for SD, PHT and EHT toward earliness, shorter plants and lower ear placement, respectively. While, SC168 had positive and significant GCA effects (desirable) for E100P, GY, YP, EL and RE traits, indicating that it might have favorable genes and as is a good combiner for high yielding and some of the yield components. The superiority of single crosses as good testers was reported by El-Ghawas (1963), Horner *et al.* (1976), El-Shenawy and Mosa (2005), Mosa (2010) and Mousa and Aly (2012).

Table 4: General combining ability effects (GCA) for the eleven inbred lines and the two testers over two locations in 2012 season.

Lines and testers	SD (day)	PHT (cm)	EHT (cm)	E100P	GY (ard fed^{-1})	YP (g)	EL (cm)	ED (cm)	RE	KR
L 5303	-0.68*	0.99	-0.05	0.89	3.20**	15.53**	0.17	0.15*	0.20	1.13*
L 5323	-0.43	0.30	-1.48	0.30	0.76	7.51	0.68*	0.02	-0.14	0.28
L 5415	0.01	6.61**	2.52	1.77*	3.04**	15.89**	0.43	0.07	-0.08	0.85
L 5522	-0.11	2.49	1.77	-0.97	3.38**	14.88**	0.03	-0.11	-0.53*	-0.03
L 5844	-0.49	-4.20	-1.98	1.08	2.41**	16.86**	-0.09	0.04	0.35	-0.10
L 5087	-1.24**	-5.32*	-3.55*	-0.62	-2.84**	-12.79**	-0.93**	-0.13*	-0.43*	-2.10**
L 5090	0.70*	-3.07	-1.05	-0.38	-1.53	-8.15	0.18	-0.01	0.01	0.12
L 5102	0.89**	-5.14*	-1.11	-1.22	-2.12**	-14.10**	-0.56	-0.11	-0.53*	-0.87
L 5134	0.82**	4.55*	4.27**	-0.12	-3.83**	-18.73**	-0.15	-0.06	0.05	-1.19*
L 5199	0.89**	2.49	0.20	-0.75	-0.64	-6.33	-0.46	0.09	0.53*	-0.55
L 5222	-0.36	0.30	0.45	0.08	-1.83*	-10.55*	0.71*	0.05	0.55**	2.45**
S.E. (gi)	0.32	2.21	1.55	0.90	0.82	4.51	0.33	0.06	0.21	0.82
S.E. (gi-gj)	0.45	3.12	2.19	1.27	1.16	6.38	0.46	0.09	0.30	1.16*
T1- SC166	-0.27*	-3.10**	-1.92**	-1.00**	-1.91**	-10.44**	-0.33*	-0.03	-0.22*	-0.30
T2- SC168	0.27*	3.10**	1.92**	1.00**	1.91**	10.44**	0.33*	0.03	0.22*	0.30
S.E. (gi)	0.14	0.94	0.66	0.38	0.35	1.92	0.14	0.03	0.09	0.24
S.E. (gi-gj)	0.19	1.33	0.93	0.54	0.50	2.72	0.20	0.04	0.13	0.34

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

SD = no. of days to 50% silking PHT= plant height EHT= ear height E100P = no. of ears 100 plants^{-1} GY= grain yield

YP = yield plant^{-1} EL= ear length ED = ear diameter RE = no. of rows ear^{-1} KR = no. of kernels rwos^{-1}

General combining ability ratio (GR)

Tables (5 and 6), showed the mean absolute general combining ability effects (MA GCA) for grain yield (GY) and six yield component traits (YCTs). The MA GCA was calculated as the average of the absolute mean of GCA effects values for the eleven inbred lines (Table 5). While, in Table (6), the general combining ability ratio (GR) was calculated by dividing the GCA value on MA GCA for GY and the YCTs effects. Figure (1), showed the relationship between GY GCA effects and YCTs GCA effects of each inbred lines. The histogram revealed that the direction of grain yield GCA effects (i.e. positive or negative) was largely determined by the number of yield components GCA effects in the same direction. This means that, if a line had significantly positive GY GCA effects, it usually had more YCTs GCA effects with significantly positive GCA effects and if a line had significantly negative GY GCA effects, it usually had more YCTs GCA effects with significantly negative GCA effects. Similar results were obtained by Fan *et al.* (2008) and Mousa and Aly (2011). From this histogram, the inbred line 5303 had positive GR ratio values for all studied traits, and then the column of this inbred line existed in positive area for GY and all YCTs. On the other hand, the inbred lines, L5087 and L5102 had negative GR ratio values for GY and YCTs GCA effects and the columns of these inbreds existed in the negative area. This histogram can show any inbred line that had positive or negative GCA effects for GY and the YCTs GCA effects directly. This figure indicated that yield components GCA were related to GY GCA effects (Austin and Lee 1988, Fan *et al.* 2008 and Mousa and Aly 2011). From the previous results, can say that the GRs explained why selecting inbred lines with higher positive GCA effects for yield components would have better chance to get a hybrid with higher grain yield.

Specific combining ability (SCA) effects

Estimation of specific combining ability effects (SCA) of the 22 topcrosses for all of the studied traits over both locations in 2012 season are presented in Table (7). Results show that three crosses; L5087 x SC166, L5090 x SC166 and L5134 x SC166 had significantly negative SCA effects for SD (-1.85** -1.358** and -1.108**) toward earliness. Two topcrosses; L5844 x SC166 (-7.960*) and L5134 x SC166 (-6.335*) had negative and significant SCA effects for PHT toward shorter plants and topcross L5134 x SC166 (-4.392*) possess negative and significant SCA effects for EHT toward lower ear placement. Regarding, E100P, GY and YP traits, three topcrosses; (L5415 x SC168), (L5844 x SC168) and (L5087 x SC166) possessed positive and significant SCA effects toward prolificacy and high yield. For EL, two topcrosses; (L5087 x SC168) and (L5090 x SC166) had positive and significant SCA effects and the second topcross also had significant and positive SCA effects for KR trait. These results might suggest the use of these topcrosses in maize breeding program is useful to identify the best inbred lines with respect to these traits. Also, results indicated that topcross L5087 x SC166 had negative and significant (desirable) SCA effects for SD, PHT and EHT and meanwhile had positive and significant (desirable) SCA effects for E100P, GY and YP. Also, the topcross L5844 x SC168 had positive and significant SCA effects for E100P, GY, YP and EL. These topcrosses can be recommended in maize breeding and production program for release as new commercial hybrids.

Table 5: Mean absolute GCA effects (MA GCA) for yield traits.

lines	GY	YP	E100	EL	ED	RE	KR
L5303	3.20	15.53	0.89	0.17	0.15	0.20	1.13
L5323	0.76	7.51	0.30	0.68	0.02	0.14	0.28
L5415	3.04	15.89	1.70	0.43	0.07	0.08	0.85
L5522	3.38	14.88	0.97	0.03	0.11	0.53	0.03
L5844	2.41	16.86	1.08	-0.09	0.04	0.35	0.10
L5087	2.84	12.79	0.62	-0.93	0.12	0.43	2.10
L5090	1.53	8.15	0.38	0.18	0.01	0.01	0.12
L5102	2.12	14.10	1.22	0.56	0.11	0.53	0.87
L5134	3.83	18.73	0.12	0.15	0.06	0.05	1.19
L5199	0.64	6.33	0.75	0.46	0.09	0.53	0.55
L5222	1.83	10.55	0.08	0.71	0.05	0.55	2.45
MA GCA	2.33	12.85	0.74	0.21	0.08	0.31	0.88

GY=grain yield YP=yield plant^{-1} E100P= no. of ears 100 plants^{-1} KR = no. of kernels rwos^{-1}
EL=ear length ED=ear diameter RE=no. of rows ear^{-1}

Table 6: The GCA/MA GCA (GR ratio) for traits.

Lines	GY_r	YP_r	EP_r	EL_r	ED_r	RE_r	KR_r	Sum GR Pos.	Sum GR Neg.
L5303	1.38	1.21	1.21	0.79	1.95	0.65	1.28	8.47	0.00
L5323	0.33	0.58	0.41	3.18	0.22	-0.45	0.32	5.04	-0.45
L5415	1.31	1.24	2.31	2.03	0.88	-0.24	0.97	8.74	-0.24
L5522	1.45	1.16	-1.32	0.15	-1.43	-1.71	-0.04	2.76	-4.50
L5844	1.04	1.31	1.46	-0.44	0.55	1.14	-0.11	5.50	-0.55
L5087	-1.22	-1.00	-0.84	-4.35	-1.59	-1.39	-2.39	0.00	-12.78
L5090	-0.66	-0.63	-0.51	0.82	-0.19	0.04	0.14	1.00	-1.99
L5102	-0.91	-1.10	-1.65	-2.62	-1.43	-1.71	-0.98	0.00	-10.40
L5134	-1.65	-1.46	-0.16	-0.71	-0.85	0.16	-1.35	0.16	-6.18
L5199	-0.28	-0.49	-1.02	-2.18	1.20	1.71	-0.63	2.91	-4.60
L5222	-0.79	-0.82	0.11	3.32	0.71	1.79	2.79	8.72	-1.61

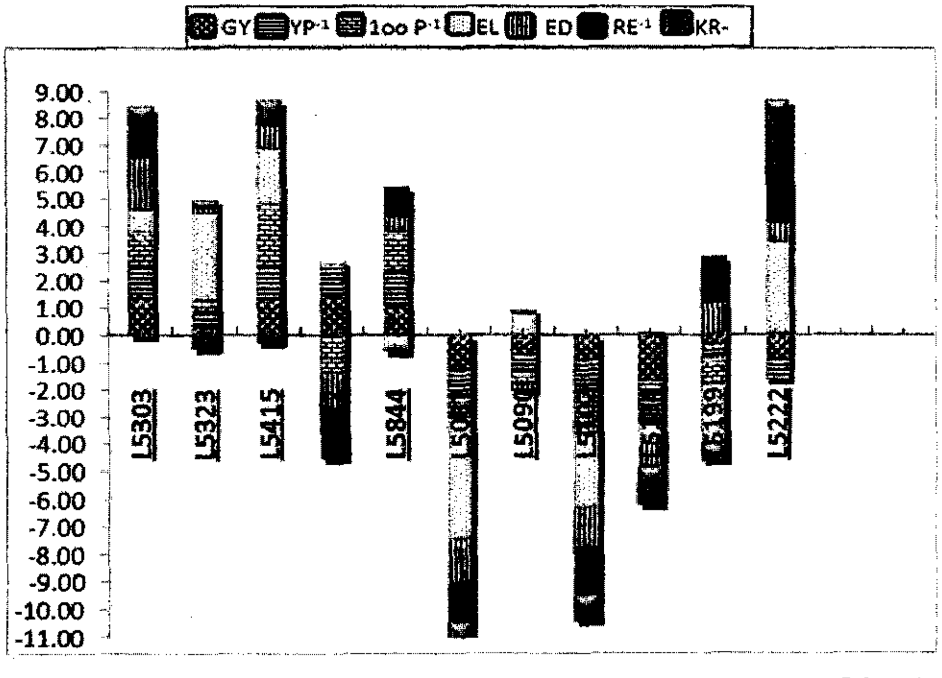

Figure 1: Impact of Yield Components GCA effects on Grain yield GCA effects

Table 7: Specific combining ability effects of the 22 topcrosses for all of studied traits over two locations in 2012 season.

crosses	SD (day)	PHT (cm)	EHT (cm)	E100P	GY (ard fed^{-1})	YP (g)	EL (cm)	ED (cm)	RE	KR
L 5303xSC 166	0.517	4.852	3.170	-0.018	1.062	6.077	0.429	0.040	0.241	-0.158
L 5303xSC 168	-0.517	-4.852	-3.170	0.018	-1.062	-6.077	-0.429	-0.040	-0.241	0.158
L 5323xSC 166	-0.108	5.665	1.733	0.132	-0.854	-2.586	-0.340	0.009	0.078	-0.764
L 5323xSC 168	0.108	-5.665	-1.733	-0.132	0.854	2.586	0.340	-0.009	-0.078	0.764
L 5415xSC 166	-0.045	-0.898	-0.642	-2.768*	-3.455**	-17.849**	0.141	-0.066	-0.234	-0.058
L 5415xSC 168	0.045	0.898	0.642	2.768*	3.456*	17.849**	-0.141	0.066	0.234	0.058
L 5522xSC 166	0.830	2.977	1.733	-0.243	-1.832	-10.450	-0.359	-0.079	-0.184	-0.820
L 5522xSC 168	-0.830	-2.977	-1.733	0.243	1.832	10.450	0.359	0.079	0.184	0.820
L 5844xSC 166	0.205	-7.960*	-3.392	-2.843*	-2.913**	-13.294*	-0.546*	-0.079	0.191	-0.308
L 5844xSC 168	-0.205	7.960*	3.392	2.843*	2.913**	13.294*	0.546*	0.079	-0.191	0.308
L 5087xSC166	1.580**	0.540	1.045	2.582*	3.972**	20.113**	0.048	0.009	0.366	-0.027
L 5087xSC168	-1.580**	-0.540	-1.045	-2.582*	-3.972**	-20.113**	-0.048	-0.009	-0.366	0.027
L 5090xSC166	-1.358**	4.040	3.295	-0.387	0.362	4.567	0.773**	0.052	0.128	1.611**
L 5090xSC168	1.358**	-4.040	-3.295	0.387	-0.362	-4.567	-0.773**	-0.052	-0.128	-1.611**
L 5102xSC166	-0.295	-3.773	-1.142	0.451	-0.688	-4.668	-0.196	-0.054	-0.134	0.473
L 5102xSC168	0.295	3.773	1.142	-0.451	0.688	4.668	0.196	0.054	0.134	-0.473
L 5134xSC166	-1.108*	-6.335*	-4.392*	0.488	0.996	2.036	-0.115	0.052	-0.209	-0.389
L 5134xSC168	1.108*	6.335*	4.392*	-0.488	-0.996	-2.036	0.115	-0.052	0.209	0.389
L 5199xSC166	-0.295	-3.523	-2.080	-0.112	1.767	8.408	0.373	0.059	-0.334	0.173
L 5199xSC168	0.295	3.523	2.080	0.112	-1.767	-8.408	-0.373	-0.059	0.334	-0.173
L 5222xSC166	0.080	2.415	0.670	1.719	1.583	7.646	-0.209	0.059	0.091	0.267
L 5222xSC168	-0.080	-2.415	-0.670	-1.719	-1.583	-7.646	0.209	-0.059	-0.091	-0.267
SE (S_{ij})	0.45	3.12	2.19	1.27	1.16	6.38	0.46	0.09	0.30	0.80
SE (S_{ij}-S_{kl})	0.64	4.41	3.09	1.80	1.64	9.03	0.66	0.13	0.42	1.13

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

SD = no. of days to 50% silking PHT= plant height EHT= ear height E100P = no. of ears 100 $plants^{-1}$ GY= grain yield

YP = yield $plant^{-1}$ EL= ear length ED = ear diameter RE = no. of rows ear^{-1} KR = no. of kernels $rwos^{-1}$

Genetic parameters

Estimation of genetic parameters for the studied traits over two locations in 2012 season is illustrated in Table (8). Results revealed that the K^2GCA_L was higher than K^2GCA_T for all of the studied traits except for PHT and EHT, indicating that most of GCA variances were due to lines. Similar results were obtained by Aly *et al.* (2011) and Mousa and Aly (2012). The non-additive gene action K^2SCA played an important role in the inheritance for SD, PHT, EHT, EL, ED, RE and KR traits and the values of K^2SCA/K^2GCA were more than unity for these traits. While, K^2GCA played an important role in the inheritance for E100P, GY and YP. The recent results supported the finding of Joshi *et al.* (1998) and Kumar *et al.* (1998) for SD; Mosa (2010) for RE; Aly *et al.* (2011) for SD, PHT, EHT, ED and RE and Mousa and Aly (2012) for SD, EL, ED and GY traits. Furthermore, the K^2GCA_L x location interaction was higher than K^2GCA_T x location interaction for SD, E100P, GY, YP, EL and KR, indicating that the K^2GCA for lines was more affected by environment than testers. The interaction of K^2SCA x location was higher than those K^2GCA x location for SD, PHT, E100P, GY, YP and EL, indicating that the non-additive type of gene action was affected more by environmental conditions than additive type of gene action. These results are of good agreement with those obtained by Lonnquist and Gardner (1961), Aly *et al.* (2011) and Mousa and Aly (2012).

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Table 8: Genetic parameters for all of the studied traits over two locations in 2012 season.

Genetic arameters	SD (day)	PHT (cm)	EHT (cm)	E100P	GY (ard fed^{-1})	YP (g)	EL (cm)	ED (cm)	RE	KR
K^2GCA_L	0.634	11.901	3.734	5.969	8.736	232.562	0.686	0.067	0.114	1.784
K^2GCA_T	0.535	18.134	6.716	1.971	7.195	208.993	-0,021	0.001	0.023	0.307
K^2 GCA	0.550	17.175	6.257	2.586	7.432	197.234	0.087	0.011	0.037	0.535
K^2SCA	11.449	64.806	12.298	0.905	6.531	191.980	1.309	0.060	0.151	2.004
K^2GCA /K^2SCA	0.048	0.265	0.509	2.858	1.138	1.027	0.067	0.188	0.245	0.267
K^2GCA_L x Loc	0.836	-1.585	-2.461	0.648	4.059	91.506	0.185	-0.001	-0.016	0.043
K^2GCA_T x Loc	0.087	-1.588	7.202	-0.231	-0.066	10.367	0.007	-0.001	-0.009	-0.065
K^2GCA x Loc	0.202	-1.588	5.715	-0.096	0.569	22.850	0.034	-0.001	-0.010	-0.049
K^2SCA x Loc	2.148	29.518	-8.035	0.030	3.695	276.013	0.083	-0.003	-0.023	-1.090

All negative estimates of variance were considered zero (Robinson *et al.* 1955)

REFERENCES

Aly, R.S.H. and E.A. Amer **(2008)**.Combining ability and type of gene action for grain yield and some other traits using line x tester analysis in newly yellow maize inbred lines (*Zea mays* L.). J. Agric. Sci. Mansoura Univ., **33(7)**: 4993-5003.

Aly, R.S.H.; E.M.R. Metwali and S.Th.M. Mousa **(2011)**. Combining ability of maize (*Zea mays* L.) inbred lines for grain yield and some agronomic traits using top cross mating design. Global Journal of Molecular Science **6(1)**: 01-08.

Aly, R.S.H and M.M.M. Hassan **(2011)**.Combining ability of grain yield and yield components in maize. Egypt. J. Plant Breed., **15(5)**: 149-161.

Ashish, S. and I.S. Singh **(2002)**. Evaluation and classification of exotic inbreds over locations based on line x tester analysis in maize (*Zea mays* L.). Crop Improvement, **29:** 184-189.

Austin D.F. and M. Lee **(1998)**. Detection of quantitative trait loci for grain yield and yield components in maize across generations in stress and non-stress environments. Crop Sci. **38:** 1296-1308.

Barata C. and M. Carena **(2006)**. Classification of North Dakota maize inbred lines into heterotic groups based on molecular and testcross data. Euphytica **151:** 339-349.

Castellanos, J.S.; A.R. Hallauer and H.S. Cordovac **(1998)**. Relative performance of testers to identify elite lines of corn (*Zea mays* L.).Maydica **43(3):** 217-226.

Ceyhan, E. **(2003)**. Determination of some agricultural characters and their heredity through line x tester method in Pea parents and crosses. Selcuk Univ., Graduate School Nat. Applied Sci., Pp.130.

Dubey, R.B.; V.N. Joshi and N.K. Pandiya **(2001)**. Heterosis and combining ability for quality, yield and maturity traits in conventional and non-conventional hybrids of maize (*Zea mays* L.). Indian J. Genetics and Plant Breeding, **61(4):** 353-355.

El-Ghawas, M.T. **(1963)**. The relative efficiency of certain open pollinated varieties, single and double crosses as testers in evaluating the combining ability of maize inbred lines topcrosses. Alex. J. Agric. Res. **11**: 115-130.

El-Shenawy, A.A. **(2005)**. Combining ability of prolific and non-prolific maize inbred lines in their diallel crosses for yield and other traits. J. Agric. Res. Tanta Univ., **31(1):** 16-31.

El-Shenawy, A.A. and H.E. Mosa **(2005)**. Evaluation of new single and three way crosses for resistance to downy mildew disease and grain yield under different environments. Alex. J. Agric. Res. **50**: 35-43.

Fan, X.M.; H.M. Chen; J. Tan; C.X. Xu; Y.D. Zhang; L.M. Luo; Y.X. Huang and M.S. Kang **(2008)**. Combining abilities for grain yield components in maize. Maydica, **53**: 39-46.

Fan X.M.; J. Tan, J.Y. Yang, F. Liu, B.H. Huangh and Y.X. Huangh **(2002)**. Study on combining ability for yield and genetic relationship between exotic tropical, subtropical maize inbreeds and domestic temperate maize inbreeds. (In Chinese, with English abstract.) Sci. Agric. Sinica **35**: 743-749.

Fehr, W.R. **(1993)**. Principles of Cultivar Development. MacMillan Publication Co. New York, Pp.342.

Horner, E.S.; M.C. Lutrick; W.H. Chapman and F.G. Martin **(1976)**. Effect of recurrent selection for combining ability with a single cross tester in maize. Crop Sci. **16**: 5-8.

Ibrahim, Kh.A.M. and S.Th.M. Mousa **(2011)**. Genotypic correlation and combining ability of some yellow maize inbred lines via line by tester analysis. Egypt. J. Plant Breed. **15(1):** 161-177.

Joshi, V.N.; N.K. Pandiya and R.B. Dubey **(1998)**. Heterosis and combining ability for quality and yield in early maturing single cross hybrids of maize. Indian J. Genetics and Plant Breed., **58:** 519-524.

Kara, S.M. **(2001)**. Evaluation of yield and yield components in inbred maize lines. I. Heterosis and line x tester analysis of combining ability. Turkish J. Agric. and Forestry, **25(6):** 383-391.

Kauffman, K.D.; C.W. Crum, M.F. Lindsey **(1982)**. Exotic germplasms in a corn breeding program.Illinois Corn Breed. School **18:** 6-39.

Kempthorne, O. **(1957)**. An Introduction to Genetic Statistical. John Wiley and Sons Inc., New York, U.S.A.

Kumar, A.; A.G. Gangashetti and N. Kumar **(1998)**. Gene effects in some metric traits in maize, Annals Agric. Biology Res., **3**: 139-143.

Kustanto, H.; Sugiharto A.N.; Basuki N. and A. Kasno **(2012)**. Study on heterosis and genetic distance of S_6 inbred lines of maize. J. Agric. Food Tech., **2(8):** 118-125.

Lonnquist, J.H. and C.O. Gardner **(1961)**. Heterosis in intervarietal crosses in maize and its implication in breeding procedure. Crop Sci. **1:** 179-183.

Morries, M.L.; J. Rispoulos and D. Beck **(1999).** Genetic changes in farmers recycle maize seed: A review of the evidence, CIMMYT Econ., Working paper No. 99-07, Mexico, D.F., CIMMYT. Pp.1.

Mosa, H.E. **(2010).** Estimation of combining ability of maize inbred lines using top cross mating design. J. Agric. Res. Kafer El-Sheikh Univ. **36(1)**: 1-15.

Motawei, A.A. **(2006).** Additive and non-additive genetic variances of important quantitative traits in new maize inbred lines via line x tester analysis. J. Agric. Sci., Mansoura Univ., **31**: 6855-6865.

Mousa, S.Th.M. and R.S.H. Aly **(2011).** Combining ability for grain yield and some related traits of newly yellow maize (*Zea mays* L.) inbred lines. J. Agric. Chem. and Biotech., Mansoura Univ. **2(12):** 331-341.

Mousa, S.Th.M. and R.S.H. Aly **(2012).** Estimation of combining ability effects of new white maize inbred lines (*Zea mays* L.) via line x tester analysis. Fourth Field Crops Conference "Field Crops Facing Future Challenges". Egy. J. Agric. Res., **90(4):** 77-90.

Pavan, P.; G. Prakash and N.M. Karjina **(2011).** General and specific combining ability studies in single cross hybrids of maize (*Zea mays* L.). Current Biotica **5(2):** 196-208.

Prasad, G.S.V. and M.V.S. Sastery **(1987).** Line x tester analysis for combining ability and heterosis in brown plant hopper-resistant varieties. Indian Agric., **31**: 257-265.

Robinson, J.O.; R.E. Comstock and P.H. Harvey **(1955).** Genetic variance in open pollinated varieties of corn. Genetics, **40**: 45 – 60.

San, V.F.; A. Bejarano, J. Cross and C. Marin **(2001).** Heterosis and combining ability of tropical yellow endosperm maize populations. Agronomia tropical, **51(3)**: 301-318.

Shiri, M.; R.T. Aliyev and R. Choukan **(2010).** Water stress effects on combining ability and gene action of yield and genetic properties of drought tolerance indices in maize. Res. J. Env. Sci., **4(1)**: 75-84.

Singh, R.K. and D.B. Chaudhary **(1985).** Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publisher, Baharate, Ram Road, Daryagani, New Delhi, India.

Sprague, G.F. and L.A. Tatum **(1942).** General vs. specific combining ability in single crosses of corn. J. Amer. Soc. Agron. **34:** 923 – 932.

Steel, R.G.D. and J.H. Torrie **(1980).** Principle and Procedures of Statistic.A biometric Approach. 2^{nd} Ed. McGraw Hill, N.Y, USA.

الملخص العربى

العلاقة بين القدرة الإئتلافية لمحصول الحبوب ومكوناته فى سلالات جديدة صفراء من الذرة الشامية بإستخدام تحليل السلالة فى الكشاف

رزق صلاح حسانين على

قسم بحوث الذرة الشامية- معهد بحوث المحاصيل الحقلية – محطة البحوث الزراعية بالإسماعيلية
مركز البحوث الزراعية – مصر

إستخدمت فى هذه الدراسة إحدى عشر سلالة صفراء جديدة من الذرة الشامية تم الحصول عليها من التلقيح الذاتى المستمر والإنتخاب لمصادر مختلفة بمحطة البحوث الزراعية بالإسماعيلية وذلك بغرض قياس تاثيرات القدرة العامة والخاصة على التآلف لهذه السلالات وهجنها على الترتيب لصفة محصول الحبوب وبعض صفات مكونات المحصول الأخرى إلى جانب دراسة العلاقة بين القدرة العامة على الإئتلاف لصفة محصول الحبوب والقدرة العامة على الإئتلاف لمكونات المحصول. تم التهجين القمى بين هذه السلالات الصفراء مع إثنين من الكشافات الصفراء وهما هـــ ف ١٦٦، هـــ ف ١٦٨ بمحطة البحوث الزراعية بالإسماعيلية موسم ٢٠١١.

ثم تقييم الهجن القمية الناتجة (٢٢ هجين) مع إثنين من الهجن الثلاثية التجارية الصفراء كهجن مقارنة وهما ٣٥٢، ٣٥٣ فى محطتى البحوث الزراعية بالإسماعيلية وملوى موسم ٢٠١٢ وتم أخذ البيانات على عدد الأيام حتى ظهور ٥٠% من حراير النورات المؤنثة، إرتفاع النبات، إرتفاع الكوز، عدد الكيزان لكل ١٠٠ نبات، محصول الحبوب أردب فدان$^{-١}$، محصول النبات الفردى بالجرام، طول الكوز، قطر الكوز، عدد السطور بالكوز وعدد الحبوب بالسطر وقد تلخصت أهم النتائج فى الأتى:

وجود إختلافات معنوية بين موقعى الدراسة لجميع الصفات مشيراً إلى إختلاف الظروف الجوية بين موقعى الدراسة. وجود إختلافات معنوية وعالية المعنوية بين الهجن ومشتقاتها من السلالات، الكشافات، السلالات فى الكشافات لجميع الصفات المدروسة فيما عدا صفة التزهير بالنسبة للسلالات، صفتى إرتفاع وطول الكوز بالنسبة للكشافات، وصفة عدد الكيزان لكل ١٠٠ نبات بالنسبة للتفاعل بين السلالات فى الكشافات. أظهرت السلالة ٥٠٨٧ أفضل السلالات إمتلاكاً للقدرة العامة على التآلف لصفات التزهير، إرتفاع النبات وإرتفاع الكوز ناحية التبكير، قصر النبات وأفضلية لموقع الكوز على النبات على الترتيب. بينما إمتلكت السلالات ٥٣٠٣، ٥٤١٥، ٥٥٢٢ و ٥٨٤٤ أفضل قدرة عامة على التآلف لصفتى محصول الحبوب ومحصول النبات الفردى. وجد إرتباط قوى بين قدرة الإئتلاف العامة لصفة محصول الحبوب وقدرة الإئتلاف العامة لصفات مكونات المحصول حيث أن السلالة التى تمتلك قدرة عامة على التآلف عالية وموجبة غالباً ما تمتلك قدرة إئتلاف عامة عالية وموجبة لمكونات المحصول. بمعنى لو وجدت سلالة ذات قدرة إئتلاف عامة للمحصول فإنه غالباً ما تمتلك قدرة إئتلاف عامة موجبة وعالية لأغلبية مكونات المحصول. لذلك فإن إختيار السلالات ذات قدرة إئتلاف عامة موجبة فى كل أو معظم صفات مكونات المحصول تعطى الفرصة الأكبر للحصول على هجن عالية المحصول. كان التباين الغير مضيف أكثر أهمية ويلعب الدور الأكبر فى وراثة صفات التزهير، إرتفاع النبات، إرتفاع الكوز، طول الكوز، قطر الكوز، عدد السطور بالكوز وعدد الحبوب بالسطر بينما الفعل الجينى المضيف يبدو أنه يلعب الدور الأهم فى وراثة صفات عدد الكيزان لكل ١٠٠ نبات، محصول النبات الفردى ومحصول الحبوب. أظهرت النتائج وجود ثلاثة هجن قمية وهم السلالة٥٥٢٢ x هـ ف ١٦٨ (٣٦,٨١ أردب فدان$^{-١}$)، السلالة٥٨٤٤ x هـ ف ١٦٨ (٣٦,٩٢ أردب فدان$^{-١}$)، السلالة٥٤١٥ x هـ ف ١٦٨ (٣٨,٠٩ أردب فدان$^{-١}$) تفوقت تفوقاً معنوياً عن أفضل وأعلى هجن المقارنة هـ ث ٣٥٣ (٣٣،٥١ ±٣،٢٢ أردب فدان$^{-١}$) فى محصول الحبوب. بالإضافة إلى ذلك يوجد هجينين قميين وهما السلالة٥٣٠٣ x هـ ف ١٦٨ (٣٣,٧٤ أردب فدان$^{-١}$)، السلالة٥٣٢٣ x هـ ف ١٦٨ (٣٣,٩١ أردب فدان$^{-١}$) كانت لا تختلف معنوياً عن أفضل هجن المقارنة أيضاً. لذا فإنه يوصى بإستخدام هذة الهجن كهجن مبشرة وإعادة تقييمها فى المراحل المختلفة المتقدمة لبرنامج تربية الذرة الشامية تمهيداً لإطلاقها كهجن تجارية جديدة لبرنامج الذرة الشامية.