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Determination of Combining Ability for Some New Yellow Maize Inbred Lines Using Line X Tester Model

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Abstract

This investigation was carried out to study the combining ability effects of 18 parents of maize (15 inbred lines and 3 testers) crossed in line x tester scheme for phonological, plant and yield characteristics. A yield trial included the 45 top crosses, 15 inbred lines, 3 testers along with the two check hybrids S.C. 168 and TWC 352. The experiment was conducted at two planting dates on 15th May and 15th June at the Agric. Res. and Experimental Station of the Fac. of Agric., Moshtohor Benha University. The randomized complete blocks design with three replications was used in this study. Significant mean squares due to crosses (C), inbred lines (L), testers (T) and line x tester (LxT) were found for most studied traits of both and across sowing dates. Variance for C, L, T and LxT with sowing dates interaction on the most studied traits was significance. δ^2_{SCA} played the major role in determining the inheritance of all traits. The magnitude of the interaction of δ^2_{SCA} x sowing date (SD) was generally higher than for δ^2_{GCA} x SD. This finding indicates that non-additive is more affected by SD than additive and additive x additive. Three crosses exhibited significant superiority over high check hybrid S.C. G 168. The best top crosses were T_3xL_2 and T_3xL_{15} at both and across sowing dates. Also, ten top crosses at combined analysis did not differ significantly than the best check hybrid for the mention trait. L2, L7, L14 and L15 were good general combiners for grain yield plant^{-1} and L9, L10 and L13 for earliness. The top-cross T1 with each of inbred lines 2, 5 and 6, T2 with each of L1 and L12 and T3 with each of L3,L4 and L12 for earliness; T1xL11, T1xL12, T1xL14, T2xL3, T2xL12 and T3xL2 for grain yield plant $^{-1}$ gave the best $\hat{S}_{ij}$ effects.

Key words: Maize, Inbred lines, Testers, Combining ability. GCA and SCA.

Introduction

Corn (*Zea mays* L.) is used as human food, poultry and livestock feeding, green fodder and silage for animal feeding. Moreover, it is also used for industrial purposes such as manufacturing starch and cooking oils. Maize is one of the most important cereal crops that plays a great role in narrowing the gap between production and consumption of grains in Egypt through increasing its cultivated area and enhancement of its productivity per unit area. In 2016 the area grown by this crop in Egypt was 0.75 Million hectares (1.76 million feddans) with an annual grain production of 6 Million metric tons and an average productivity of 8 Mg ha^{-1} (23.8 ardabs/feddan). (One feddan; fed =4200 m^2 and one ardab; ard = 140 Kg). (USDA 2018).

Evaluating inbred lines is of prime importance for hybrid production. Therefore, it is important to know nature and number of tester parents to be used for evaluating inbred lines. The top crosses test with a broad and narrow base testers is the most common procedure for the evaluating process. Nature and number of testers to be used in the line x tester model for evaluating inbred lines is still unsolved problem. In this regard, the choice of a suitable tester is an important decision. **Matzinger (1953)** showed that a narrow genetic base tester contributes more to line x tester interaction than does a heterogeneous one. **Davis (1927), Jenkins (1935) and Sprague (1939)** suggested the method of early testing that is greatly affected by the nature and number of testers needed for efficient evaluation of inbred lines. **Sprague and Tatum (1942)** was the first to partition the total combining ability effects of the lines into general (GCA) and specific (SCA) combining ability. The suitable tester should maximize information on evaluating inbred lines for combining ability. The two main genetic parameters GCA and SCA are essential in developing breeding strategies. Furthermore, the magnitude of genetic components for a certain trait would depend mainly upon the environmental fluctuations under which the breeding populations will be tested. Therefore, much effort has been devoted by corn breeders to estimate the interactions between genetic components and environments.

The objectives of this study were to (1) evaluate some inbred lines of maize., (2) provide information of suitable testers for testing of inbred lines and (3) determine GCA and SCA as well as relative superiority relative to check hybrids involved in the manifestation of grain yield and other agronomic traits.

Materials And Methods

Fifteen new inbred lines in S_7 of yellow maize were top crossed to three different testers in 2016 summer season. The female inbred lines were M 801 (L1), M 802 (L2), M 803 (L3), M 804 (L4), M 805 (L5), M 806 (L6), M 807 (L7), M 808 (L8), M 809 (L9), M 810 (L10), M 811 (L11), M 812 (L12), M 813 (L13), M 814 (L14) and M 815 (L15). The three testers were the population yellow Sahka Pop. (T1), the single cross M Y 10 (T2) and the yellow inbred line M L 212 (T3). Except for Sakha Population which was obtained from ARC, Egypt all plant materials were developed at the Department of Agronomy, Faculty of Agriculture, Benha University, Egypt by Prof. Dr. Ali El-Hosary.

The current experiment was carried out in two succeeded seasons at Experiment and Research Station of Moshtohor, Benha University, Kalubia Governorate, Egypt. In the first summer season 2016, top crosses were constituted. The fifteen yellow inbred lines and the three testers were sown on 25th May and 3th June in order to overcome the differences in flowering time and to secure enough hybrid seeds. In the second summer season 2017, two adjacent experiments were conducted on two sowing dates i.e. 15th May and 15th June. In each experiment, included the 45 top crosses, 15 inbred lines, 3 testers along with two check cultivars single cross S.C. G.168 and T.W.C. G.352 from ARC. The experimental design was randomized complete blocks design with three replications. Each plot consisted of one ridge of 8 m long and 70 cm width. Each hill was spaced 25 cm apart with two kernels planted per hill and later thinned to one plant per hill. The plots were irrigated immediatty after sowing and the second irrigation was given after 21 days from sowing. The plants were then irrigated at intervals of 10-15 days. The plots were informally fertilized at the rate of 120 kg of nitrogen per feddan (1 feddan = 4200 m^2) given before the first and second irrigations. The other cultural practices of maize growing were properly practiced.

Data for the following traits were recorded on 15 individual guarded plants chosen at random from each plot, except for days to 50% tasseling and silking where the main plot basis was used. Data included days to 50% tasseling, days to 50% silking, plant and ear heights (cm), No. of rows ear^{-1}, No. of kernels row^{-1}, 100-kernel weight (g) and grain yield $plant^{-1}$ (g).

Analysis of variance was performed for each sowing date as well as for combined data after homogeneity test across sowing dates according to **Steel and Torrie (1980)**. Combining ability analysis of line x tester was conducted based on the procedure developed by **Kempthorne (1957)**.

Results and Discussion

Table (1) reveals that sowing date mean squares were significant for all traits, indicating over all differences between the two sowing dates, with mean values in early sowing being higher than those in late sowing for all traits (Table 1). The increase in these traits at early sowing date may be due to the prevailing favorable temperature and day length leading to greater vegetative growth, yield and its components of corn plants. Therefore, the first sowing date seemed to be non-stress environment. These results are in agreement with those obtained by **Hani *et al* (2006), Hefny and Aly (2008), Ngaboyisonga *et al* (2009), Tamilarasi and Vetriventhan (2009), EL-Badawy *et al* (2010) and Abd El-Aal (2012).** The present results confirm the earliar view of **Kang (1998)** who mentioned a prominent role of environment on phenotypic expression of agronomic traits. **Bello and Olaoye (2009)** suggested that variation in climate (rainfall, sunshine, relative humidity, etc.) could be an important factor in breeding for desirable traits including grain yield. Earliness in maize is favorable for escaping destructive injuries caused by *Sesamia cretica*, *Chilo simplex* and *Pyrausta nubilialis*. Similar results were reported by **El-Hosary and El-Badawy (2005), El-Hosary *et al* (2006), El-Hosary and Elgammaal (2013), and El-Hosary (2014)** .

Crosses mean squares were significant for all the studied traits at both sowing dates as well as the combined analysis, indicating the wide diversity among the parental materials used in the present study. Significant crosses x sowing date mean squares were obtained for all traits except number of rows / ear, number of kernels/ row and 100-kernel, revealing that the tested crosses varied from each other and ranked differently from sowing date to another.

Line mean squares were significant for all traits at early, late sowing dates and across environment, indicating the wide diversity among those inbred lines. Significant lines x sowing date mean squares were detected for all traits except number of rows/ ear, number of kernels/ row and 100-kernel weight. These finding indicate that parental inbred lines differ in their mean performance in most traits.

Significant mean squares due to testers were obtained for all traits in both sowing dates as well as the combined analysis except No of rows/ ear at early sowing date, No of kernels/ row at late sowing date as well as the combined analysis. Such results indicated a wide range of variability among parental testers. In addition, tester mean squares were much higher than those of lines for five traits of studied traits. Such results revealed that testers contributed much more to the total variation as compared to inbred lines. Also, the interaction between tester x sowing date mean squares were significant for all traits except, plant height. This indicated that the testers behaved somewhat differently from one sowing date to another.

Significant line x tester mean squares were obtained for all traits except plant height at early sowing date as well as the combined data, ear diameter and 100-kernel weight at early sowing date.

Significant interaction between line by tester x sowing date mean squares were obtained for all traits except, plant height, number of kernel/ row, 100-kernel weight.

The estimates of variances due to GCA, SCA and their interactions with sowing dates (Table 1) showed that δ^2_{SCA} played the major role in determining the inheritance of most studied traits, revealing that the largest part of the total genetic variability associated with these traits was a result of non- additive gene action. These results for most studied traits support the findings of **El-Hosary (1985), Sofi and Rather (2006) and Basbag *et al* (2007),** who reported that δ^2_{SCA} was important in the inheritance of grain yield plant^{-1} and other agronomic traits. The magnitude of the interactions for δ^2_{SCA} x sowing date (SD) was generally higher than for δ^2_{GCA} x SD. This finding indicates non-additive type of gene action to be more affected by sowing date (SD) than additive and additive x additive types of gene action. This is in agreement with the findings of several investigators who reported that δ^2_{SCA} is more sensitive to environmental changes than δ^2_{GCA} **(Gilbert 1958 and El-Hosary (2014)).**

Means of the 45 top crosses, and three testers in the combined analysis for all studied traits are presented in Table 2. Most studied top crosses recorded lower values for the measured traits at delayed sowing.

For tasseling date eleven top crosses was significantly lower than the best earlier check variety at the combined analysis. The top crosses T_1xL_9, T_2xL_{15}, T_2xL_{13} and T_3xL_{10} gave the lowest mean values for tasseling date at the combined data.

For silking date, five crosses exhibited significantly earliness than the earlier check variety (T W 352). The top crosses T_3xL_4, T_1xL_3, T_1xL_4, T_1xL_{11}, T_1xL_{12} and T_2xL_{13} gave the lowest mean values for this trait at the combined data.

Regarding plant height three top crosses expressed significant lowest values as compared with the best check variety T.W. G 352. The top crosses T_1xL_1, T_1xL_2 and T_1xL_{13} were the best among the studied crosses since they expressed the lowest significant values of this trait.

As for ear height, four top crosses showed significant lowest values as compared to best check variety from the two check hybrids. The top crosses T_1xL_{12}, T_1xL_1, T_1xL_2, T_1xL_6, T_1xL_7, T_1xL_8, T_1xL1_2, T_1xL_{13} and T_2xL_6 at the combined analysis which had the best values for plant height showed also the most desirable values for ear height. Therefore, these top crosses are prospective in maize breeding program.

For number of rows/ ear, the top crosses T_1xL_{12}, T_2xL_{15} and T_3xL_2 exhibited significant higher than the best check hybrid.

For number of kernels/row, twenty four of the top crosses significantly surpassed the best check hybrid G 168. However, the crossesT_2xL_7, T_2xL_{10},T_3xL_1, T_3xL_2, T_3xL_4, T_3xL_5,T_3xL_7, T_3xL_9, T_3xL_{10}, T_3xL_{11}, and T_3xL_{15}, surpassed the best check hybrids.

Regarding grain yield/ plant, the highest check mean values were recorded by S.C. G 168. However, three crosses exhibited significant superiority over this check hybrid.

The best top crosses were T_3xL_2 and T_3xL_{15} at both and across sowing dates. Also, ten top crosses at combined analysis did not differ significantly than the best check hybrid.

From such results it could be concluded that the previous top crosses could be efficient and prospective in maize breeding programs since they expressed significant desirable effects for grain yield and for one or more of yield components.

The fluctuations of hybrid performance from sowing date to another were detected for most traits. These results would be due to significance of the interaction between hybrids and sowing date.

General combining ability effects for parents across sowing dates are presented in Table (3). There is no specific line recorded a desirable ($\hat{g}_i$) effects for all traits. Desirable and significant ($\hat{g}_i$) effects were obtained by L1, L2, L12 and L13 for short plant and low ear height, and L9, L10 and L13 for earliness. As expected, the tester L M 212 (T3) which had a broad genetic base, gave highly significant desirable ($\hat{g}_i$) effects for most studied traits. Moreover, H 102, (T2) was not a good combiner for most studied traits.

This observation further confirms the previous findings and experience of many maize breeders. L2, L12 and L15 were the best general combiners for No of rows ear^{-1}, L7, L13, 14 and L15 for No of kernels row^{-1}, L5, L7 and L10 for 100-kernel weight and L2, L7, L14 and L15 for high grain yield plant^{-1} in both and across sowing dates.

The superiority of inbred lines as good testers were noticed by several investigators **Al-Naggar *et al* (1997), Amer (2002), Ibrahim and Ghonemy (2010) and El-Hosary (2014).** These results indicated that these parental inbred lines possess favorable genes and that improvement in yield may be attained if they are used in a hybridization program.

Specific combining ability effects of the top crosses at combined across the two sowing dates are presented in Table (4).

The greatest inter- and intra-allelic interactions as deduced from $\hat{s}_{ij}$ effect were observed by top-crosses between T1 with each of L2, L5 and L6, T2 with each of L1 and L12 and T3 with each of L3,L4 and L12 for earliness (tassling and silking); T2xL8 for plant height; T_3xL_{11}, T_3XL_{13}, T_3xL_{14} and T_3xL_{15} for ear height; $T_3x L_2$ For number of rows/ ear; T_1xL_8, T_2xL_3, T_2xL_{10} and T_3xL_2 for number of kernels/ row; T_3xL_2 for 100-kernel weight. For grain yield/ plant, seven, four and two top crosses at early sowing date; two, three and three top crosses at late sowing date; six, two and three top crosses at the combined analysis for testers T_1, T_2 and T_3, respectively. The best $\hat{S}_{ij}$ effects were obtained from top crosses T_3xL_2 at both and across sowing date. Furthermore, the tester T_3 (Sakha Pop.) exhibited the widest range between $\hat{S}_{ij}$ effects for this trait at the combined analysis. Therefore, the immediate use of lines L_4, L_5, L_{10} and L_{12} as parents in the development of three way crosses with T_2 (S.C El-Hosary 101). Also, the immediate use of lines L_1, L_2 and L_9 as parents in development of single crosses with T_1 (L_{212}).

Table 1. Mean squares from ordinary analysis of variance and combining ability for the studied traits.

SOV	d.f	Dayes to 50% shed	Dayes to 50% silk	Plant height	Ear height	Number of rows/ ear	Number of kernels/ row	100-kernel weight	Grain yield / plant
Early sowing									
Rep	2	9.70**	31.25**	982.48**	330.87**	3.73**	11.30	7.76	168.96
Crosses	44	35.15**	7.06**	453.60**	480.52**	5.49**	29.33**	38.55**	2198.47**
Lines	14	29.87**	11.07*	692.66**	864.04**	6.18**	52.16**	37.73**	2007.70**
Testers	2	20.55**	6.32**	4271.99**	2626.50**	0.33	30.84**	389.42**	10311.58**
Lines x testers	28	38.84**	5.10**	61.33	135.48**	5.50**	17.80**	13.91	1714.35**
Error	88	0.58	1.22	162.63	41.03	0.27	6.65	11.52	91.90
GCA		0.00	0.02	4.99	4.39	0.00	0.15	0.31	6.16
SCA		12.75	1.30	0.00	31.48	1.74	3.72	0.80	540.82
GCA/SCA		low	low	low	low	low	low	low	low
late sowing date									
Rep	2	0.58	8.76*	142.91	318.36**	2.64**	2.30	1.09	180.61
Crosses	44	66.22**	48.19**	692.84**	311.00**	3.84**	18.98**	47.76**	1945.20**
Lines	14	106.60**	31.29**	1140.67**	625.55**	5.19**	34.41**	46.62**	2354.32**
Testers	2	160.26*	32.19**	5000.46**	507.65*	4.08**	2.62	458.87**	6128.08**
Line x Testers x D		40.82**	57.79**	161.23**	139.68**	3.15**	12.43*	18.96**	1441.86**
Error	88	1.29	2.58	85.41	48.82	0.27	8.00	7.37	118.40
GCA		0.32	0.00	6.77	2.18	0.01	0.08	0.37	6.41
SCA		13.18	18.40	25.28	30.29	0.96	1.48	3.86	441.15
GCA/ SCA		low	low	low	low	low	low	low	low
Combined analysis									
Sowing date (D)	1	1978.79**	2582.81**	31597.39**	11446.53**	52.56**	3828.25**	333.33**	131288.20**
Rep/D	4	5.14**	20.01**	562.69**	324.62**	3.19**	6.80	4.42	174.78
Crosses	44	56.78**	27.49**	955.95**	661.83**	8.90**	43.42**	84.24**	3648.14**
Lines	14	98.17**	21.90**	1493.84**	1350.28**	11.00**	81.82**	81.97**	4075.07**
Testers	2	66.01**	32.58**	9258.10**	2657.07**	3.25**	12.76	846.34**	16055.79**
Lines x testers	28	35.42**	29.92**	93.99	175.09**	8.25**	26.41**	30.93**	2548.40**
Crosses x d	44	44.60**	27.76**	190.49*	129.69**	0.43	4.89	2.07	495.54**
Line x D	**14**	35.30**	20.46**	339.48**	139.31**	0.38	4.74	2.38	286.95**
Testers x D	2	114.80**	5.93*	14.35	477.08**	1.16*	20.70*	1.94	383.87*
Line x Testers x D	28	44.24**	32.97**	128.58	100.07**	0.40*	3.83	1.93	607.81**
Error	176	0.93	1.90	124.02	44.93	0.27	7.32	9.45	105.15
GCA		0.29	0.32	96.92	30.01	0.00	0.22	8.02	144.25

SCA	0.00	0.00	0.00	12.50	1.31	3.76	4.83	323.43
GCA/SCA	high	high	high	high	high	high	low	low
GCA xD	-0.54	0.04	89.82	20.22	-0.05	-0.266	7.56	121.20
SCA x D	14.44	10.36	1.52	18.38	0.04	-1.17	-2.51	167.55

* and ** indicate significance at 0.05 and 0.01 levels of probability, respectively.

Table 2. Mean performance of the line x tester crosses and check cultivars in combined across sowing dates.

Genotype	Days to 50% tasseling days	Days to 50% silking days	Plant height (cm)	ear height (cm)	No of rows ear^{-1}	No of kernels row^{-1}	100-kernel weight (g)	grain yield (g) plant^{-1}		
								D1	D2	Comb.
L1x T1	54.67	59.87	222.63	105.33	12.14	33.12	32.75	143.00	101.53	122.27
L2xT1	56.74	60.75	230.46	112.33	10.28	29.80	34.83	119.40	95.33	107.37
L3 xT1	61.42	62.00	253.61	120.33	11.39	31.77	31.58	125.47	92.53	109.00
L4 xT1	60.53	63.00	252.18	121.83	11.69	32.77	37.08	154.93	94.33	124.63
L5 xT1	57.92	58.92	257.61	126.00	10.64	31.77	37.42	126.33	93.53	109.93
L6 xT1	58.79	61.67	237.64	107.00	12.75	36.78	34.67	174.67	117.18	145.93
L7 xT1	60.66	59.98	242.48	113.67	12.96	39.53	33.83	198.00	144.00	171.00
L8 xT1	59.61	61.28	243.81	109.00	11.19	37.59	35.25	155.33	104.30	129.82
L9 xT1	49.79	60.00	251.43	119.50	11.34	37.50	36.00	151.67	124.94	138.30
L10 xT1	57.48	60.00	251.24	133.33	10.69	36.65	38.67	158.07	124.00	141.03
L11 xT1	58.23	59.17	260.21	134.83	12.80	35.21	39.08	167.63	140.05	153.84
L12 xT1	61.60	69.44	238.41	111.67	14.81	36.38	34.00	197.87	125.53	161.70
L13 xT1	56.79	60.26	233.98	110.50	11.29	37.66	32.08	153.53	113.67	133.60
L14 xT1	57.92	60.75	255.13	132.00	12.32	38.08	38.33	191.40	154.67	173.03
L15 xT1	57.55	59.75	249.06	127.50	14.29	38.16	32.58	176.93	115.08	146.01
L1x T2	56.54	58.04	244.41	113.00	11.52	30.55	35.83	143.37	114.17	128.77
L2xT2	57.52	61.50	246.11	117.33	13.91	35.73	34.00	170.07	150.67	160.37
L3 xT2	56.64	62.75	261.93	121.33	12.57	37.78	35.58	166.00	126.00	146.00
L4 xT2	60.97	63.18	257.31	126.67	12.26	33.75	34.75	148.93	113.58	131.26
L5 xT2	56.79	59.56	264.12	135.00	11.41	34.66	40.00	150.87	89.13	120.00
L6 xT2	58.61	62.17	251.59	113.17	11.80	32.84	38.50	158.20	124.27	141.23
L7 xT2	57.16	59.45	246.91	122.83	12.45	39.42	43.00	188.17	135.03	161.60
L8 xT2	58.54	62.36	243.20	115.50	11.83	35.18	31.92	129.57	89.20	109.38
L9 xT2	51.59	60.00	263.74	124.67	11.56	34.81	40.00	148.61	134.50	141.56
L10 xT2	57.01	59.75	254.24	137.67	11.05	38.39	43.50	188.80	114.67	151.73
L11 xT2	55.52	57.70	269.88	131.33	11.96	33.72	35.58	132.27	119.77	126.02
L12 xT2	57.60	57.10	248.32	116.00	14.18	34.43	37.75	184.40	133.58	158.99
L13 xT2	50.37	58.00	248.74	131.00	11.17	39.48	35.00	148.93	126.52	137.73
L14 xT2	52.83	60.00	264.74	149.17	12.31	37.81	38.58	177.67	125.30	151.48
L15 xT2	56.63	60.25	261.71	131.00	15.11	38.39	36.00	196.30	131.80	164.05
L1x T3	58.04	61.61	251.65	118.17	12.93	34.89	42.50	183.67	165.93	174.80
L2xT3	64.12	61.75	249.59	120.33	15.98	38.56	45.92	264.87	217.33	241.10

L3 xT3	55.59	57.25	272.38	127.33	11.59	36.07	38.92	174.00	106.53	140.27
L4 xT3	55.29	56.65	267.16	138.67	12.23	32.17	41.67	148.73	111.67	130.20
L5 xT3	59.97	61.36	269.71	143.00	12.11	32.07	44.00	176.53	121.33	148.93
L6 xT3	60.15	63.86	264.60	129.17	11.32	36.53	40.33	174.93	120.92	147.93
L7 xT3	59.66	59.48	254.64	132.33	11.78	39.00	43.00	195.33	149.33	172.33
L8 xT3	60.40	60.78	268.89	125.17	12.79	34.25	34.83	169.10	131.77	150.43
L9 xT3	54.64	58.50	272.57	140.17	13.06	35.86	41.92	216.40	158.00	187.20
L10 xT3	51.15	59.25	263.24	142.33	13.34	32.43	44.17	190.47	145.67	168.07
L11 xT3	57.10	59.23	276.64	130.17	11.18	36.83	41.33	189.60	114.43	152.02
L12 xT3	60.04	59.95	258.48	118.17	11.45	37.73	39.33	157.53	114.83	136.18
L13 xT3	56.27	59.25	259.29	119.83	11.78	38.91	39.00	184.73	93.25	138.99
L14 xT3	52.53	60.50	278.40	137.17	11.43	39.15	40.42	184.60	142.00	163.30
L15 xT3	55.55	61.25	276.88	124.17	12.88	39.50	41.50	194.60	185.00	189.80
T.W. 352	60.48	62.77	237.33	126.07	14.10	28.95	31.83	174.00	95.21	122.37
SC G 168	62.50	65.40	261.55	128.50	14.25	34.51	35.67	198.00	145.55	171.78
L. S. D 5%	1.14	1.56	12.60	7.58	0.59	3.16	1.81	15.50	17.59	11.60
L. S. D 1%	1.49	2.05	16.56	9.97	0.77	4.15	2.38	20.48	23.25	15.25

D1, D2 and Comb. refer to early, late planting date and combined analysis across planting dates, respectively.

Table 3. General combining ability effects for all the studied traits.

	Days to 50% tasseling	Days to 50% silking	Plant height	Ear Height	No of rows ear^{-1}	No of kernel row^{-1}	100-kernel weight	Grain yield plant^{-1} D1	D2	Comb.
Tester										
1	0.77**	0.69**	-10.03**	-5.83**	-0.22**	-0.34	-2.72**	-9.97**	-9.44**	-9.71**
2	-0.92**	-0.31*	-0.22	0.9	0.08	-0.06	-0.6	-7.45**	-3.61*	-5.53**
3	0.16	-0.38**	10.25**	4.93**	0.13*	0.4	3.32**	17.42**	13.05**	15.23**
L.S.D. (gi) 5%	0.21	0.28	2.3	1.38	0.11	0.56	0.64	2.8	3.18	2.12
L.S.D. (gi) 1%	0.27	0.37	3.02	1.82	0.14	0.73	0.83	3.68	4.18	2.78
L.S.D. (gi-gj) 5%	0.29	0.4	3.25	1.96	0.15	0.79	0.9	3.96	4.5	3
L.S.D. (gi-gj) 1%	0.39	0.53	4.28	2.57	0.2	1.04	1.18	5.21	5.91	3.94
Line										
1	-0.80**	-0.59	-15.79**	-12.65**	-0.06	-3.01**	-0.91	-12.91**	1.73	-5.59*
2	2.25**	0.90**	-13.30**	-8.15**	1.13**	-1.16	0.32	15.19**	28.96**	22.07**
3	0.67**	0.24	7.28**	-1.81	-0.40**	-0.65	-2.57**	-14.43**	-17.13**	-15.78**
4	1.72**	0.51	3.53	4.24**	-0.2	-2.96**	-0.1	-18.72**	-18.96**	-18.84**
5	1.02**	-0.48	8.46**	9.85**	-0.87**	-3.03**	2.54**	-18.34**	-24.15**	-21.25**
6	1.97**	2.14**	-4.08	-8.37**	-0.30*	-0.47	-0.1	-0.32	-4.7	-2.51
7	1.95**	-0.79*	-7.34**	-1.87	0.14	3.46**	2.01**	24.25**	17.30**	20.77**
8	2.31**	1.04**	-3.39	-8.26**	-0.32**	-0.19	-3.93**	-18.25**	-17.06**	-17.66**
9	-5.21**	-0.93**	7.23**	3.30*	-0.27*	0.2	1.37	2.64	13.66**	8.15**
10	-2.00**	-0.76*	0.88	12.96**	-0.56**	-0.04	4.18**	9.52**	2.63	6.07*
11	-0.26	-1.73**	13.56**	7.30**	-0.28*	-0.61	0.73	-6.42*	-0.74	-3.58
12	2.53**	1.73**	-6.95**	-9.54**	1.23**	0.32	-0.91	10.35**	-0.84	4.75*
13	-2.73**	-1.26**	-8.02**	-4.37**	-0.84**	2.82**	-2.57**	-7.19*	-14.34**	-10.76**
14	-2.78**	-0.01	10.74**	14.63**	-0.23	2.49**	1.18	14.97**	15.17**	15.07**
15	-0.64**	-0.01	7.20**	2.74	1.84**	2.82**	-1.24	19.69**	18.48**	19.08**
L.S.D. 5% (gi)	0.46	0.64	5.14	3.1	0.24	1.25	1.42	6.26	7.11	4.74
L.S.D. 1% (gi)	0.61	0.84	6.76	4.07	0.32	1.64	1.87	8.23	9.34	6.23
L.S.D. 5% (gi-gj)	0.66	0.9	7.28	4.38	0.34	1.77	2.01	8.86	10.05	6.7
L.S.D. 1% (gi-gj)	0.86	1.18	9.56	5.76	0.45	2.32	2.64	11.64	13.21	8.81

* and ** indicate significance at 0.05 and 0.01 levels of probability, respectively.

D1, D2 and Comb. refer to early, late planting date and combined analysis across planting dates, respectively.

Table 4. Specific combining ability effects for all the studied traits.

top Crosses	Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	No of rows ear^{-1}	No of kernels row^{-1}	100-kernel weight	Grain yield $plant^{-1}$		
								D1	D2	Comb.
T1xL1	-2.52**	-0.66	-6.9	-1.01	0.16	0.61	-1.56	-3.7	-16.24**	-9.97*
T1xL2	-3.49**	-1.28*	-1.56	1.49	-2.89**	-4.56**	-0.69	-55.40**	-49.67**	-52.54**
T1xL3	2.77**	0.64	1	3.16	-0.24	-3.10**	-1.06	-19.72**	-6.38	-13.05**
T1xL4	0.84*	1.36*	3.32	-1.4	-0.15	0.21	1.97	14.04*	-2.75	5.64
T1xL5	-1.07**	-1.72**	3.82	-2.84	-0.53*	-0.72	-0.33	-14.94**	1.64	-6.65
T1xL6	-1.16**	-1.59**	-3.61	-3.62	1.01**	1.74	-0.44	15.37**	5.83	10.60*
T1xL7	0.73	-0.35	4.5	-3.45	0.78**	0.56	-3.39**	14.14*	10.65	12.40**
T1xL8	-0.68	-0.89	1.88	-1.73	-0.52*	2.26*	3.97**	13.97*	5.32	9.65*
T1xL9	-2.99**	-0.19	-1.12	-2.79	-0.43*	1.79	-0.58	-10.59	-4.77	-7.68
T1xL10	1.50**	-0.36	5.03	1.38	-0.78**	1.17	-0.72	-11.07*	5.33	-2.87
T1xL11	0.51	-0.22	1.33	8.55**	1.04**	0.3	3.14*	14.44**	24.74**	19.59**
T1xL12	1.09**	6.58**	0.03	2.21	1.55**	0.54	-0.31	27.91**	10.32	19.11**
T1xL13	1.55**	0.4	-3.33	-4.12	0.09	-0.68	-0.56	1.11	11.96	6.53
T1xL14	2.73**	-0.36	-0.93	-1.62	0.52*	0.07	1.94	16.82**	23.45**	20.13**
T1xL15	0.21	-1.36*	-3.46	5.77*	0.41	-0.18	-1.39	-2.37	-19.44**	-10.91**
T2xL1	1.05*	-1.49**	5.07	-0.06	-0.76**	-2.24*	-0.59	-5.87	-9.44	-7.65
T2xL2	-1.02*	0.48	4.28	-0.23	0.44*	1.1	-3.65**	-7.27	-0.17	-3.72
T2xL3	-0.32	2.39**	-0.49	-2.56	0.64**	2.64*	0.82	18.29**	21.25**	19.77**
T2xL4	2.96**	2.55**	-1.35	-3.29	0.12	0.92	-2.48*	5.51	10.66	8.09
T2xL5	-0.52	-0.08	0.53	-0.56	-0.06	1.89	0.13	7.07	-8.59	-0.76
T2xL6	0.35	-0.09	0.54	-4.17	-0.24	-2.48*	1.27	-3.62	7.08	1.73
T2xL7	-1.08**	0.12	-0.88	-1.01	-0.03	0.16	3.66*	1.78	-4.15	-1.18
T2xL8	-0.05	1.20*	-8.54*	-1.95	-0.19	-0.43	-1.48	-14.32**	-15.62*	-14.97**
T2xL9	0.51	0.81	1.38	-4.34	-0.51*	-1.18	1.29	-16.17**	-1.04	-8.60*
T2xL10	2.72**	0.39	-1.78	-1.01	-0.73**	2.63*	1.99	17.13**	-9.84	3.65

T2xL11	-0.51	-0.69	1.19	-1.67	-0.1	-1.47	-2.48*	-23.45**	-1.38	-12.42**
T2xL12	-1.22**	-4.75**	0.15	-0.17	0.62**	-1.68	1.32	11.91*	12.54*	12.23**
T2xL13	-3.18**	-0.86	1.63	9.66**	-0.33	0.86	0.24	-6.02	18.98**	6.48
T2xL14	-0.68	-0.11	-1.13	8.83**	0.21	-0.48	0.07	0.56	-11.75	-5.6
T2xL15	0.98*	0.14	-0.61	2.55	0.93**	-0.23	-0.09	14.47**	-8.55	2.96
T3xL1	1.47**	2.15**	1.83	1.07	0.60**	1.64	2.15	9.57	25.67**	17.62**
T3xL2	4.51**	0.8	-2.72	-1.26	2.45**	3.46**	4.34**	62.67**	49.84**	56.26**
T3xL3	-2.45**	-3.03**	-0.51	-0.6	-0.39	0.46	0.23	1.43	-14.87*	-6.72
T3xL4	-3.80**	-3.91**	-1.97	4.68	0.03	-1.13	0.51	-19.55**	-7.91	-13.73**
T3xL5	1.59**	1.80**	-4.35	3.4	0.59**	-1.17	0.21	7.87	6.95	7.41
T3xL6	0.81*	1.68**	3.07	7.79**	-0.77**	0.74	-0.82	-11.75*	-12.92*	-12.34**
T3xL7	0.34	0.23	-3.62	4.46	-0.75**	-0.72	-0.27	-15.92**	-6.5	-11.21**
T3xL8	0.73	-0.31	6.67	3.68	0.72**	-1.83	-2.49*	0.35	10.3	5.32
T3xL9	2.48**	-0.62	-0.26	7.13**	0.94**	-0.6	-0.71	26.76**	5.81	16.28**
T3xL10	-4.22**	-0.03	-3.25	-0.37	1.51**	-3.80**	-1.27	-6.06	4.51	-0.78
T3xL11	0	0.91	-2.52	-6.87*	-0.93**	1.17	-0.66	9.01	-23.36**	-7.17
T3xL12	0.14	-1.83**	-0.18	-2.04	-2.16**	1.15	-1.02	-39.82**	-22.86**	-31.34**
T3xL13	1.63**	0.46	1.7	-5.54*	0.23	-0.18	0.32	4.91	-30.94**	-13.01**
T3xL14	-2.05**	0.47	2.06	-7.21**	-0.72**	0.4	-2.02	-17.37**	-11.7	-14.54**
T3xL15	-1.18**	1.22*	4.07	-8.32**	-1.35**	0.41	1.48	-12.10*	27.99**	7.95
L.S.D. (Sij) 5%	0.21	1.1	8.41	5.36	0.42	2.17	2.46	10.85	12.31	8.21
1%	0.27	1.45	11.71	7.05	0.55	2.85	3.23	14.26	16.18	10.78
L.S.D. (Sij-Ski)5%	0.29	1.56	12.6	7.58	0.59	3.06	3.48	15.34	17.41	11.6
1%	0.39	2.05	16.56	9.97	0.77	4.03	4.57	20.16	22.89	15.25

* and ** indicate significance at 0.05 and 0.01 levels of probability, respectively.

D1, D2 and Comb. refer to early, late planting date and combined analysis across planting dates, respectively.

From the present study, it could be concluded that testers of broad genetic base are more efficient than those of narrow genetic base for evaluation of $\hat{g}_i$ effects for inbred lines of maize

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تقدير القدرة على التآلف لبعض السلالات الصفراء الجديدة من الذرة الشامية باستخدام نموذج السلالة x الكشاف

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تم تقييم 45 هجين قمى ناتجين من تهجين 15 سلالة x 3 كشافات مع اثنين من الهجن التجارية للمقارنة (هجين فردى 168 و هجين ثلاثى 352) فى تصميم القطاعات الكاملة العشوائية تحت ميعادى زراعة (15 مايو و 15 يونيه) موسم 2017 فى مزرعة كلية الزراعة – جامعة بنها لصفات عدد الايام حتى ظهور 50% من الحراير, ارتفاع كلا من النبات و الكوز, المحصول و مكوناته. و كانت اهم النتائج:

- كان التباين الراجع الى الكشافات و السلالات و التفاعل بين السلالات x الكشافات معنوى فى كلا الميعادين و التحليل المشترك لمعظم الصفات تحت الدراسة.
- كان التباين الراجع الى التفاعل بين الهجن القمية و السلالات و الكشافات و السلالات x الكشافات مع ميعادى الزراعة معنويا لمعظم الصفات تحت الدراسة.
- أظهر التباين الراجع للفعل الوراثى غير المضيف دورا اكثر اهمية فى وراثة الصفات محل الدراسة بالمقارنة بالتباين الراجع للفعل المضيف و مع ذلك كان التفاعل بين التأثير غير المضيف x ميعادى الزراعة اعلى من التفاعل بين التأثير المضيف x ميعادى الزراعة لجميع هذه الصفات.
- اظهرت 3 هجن زيادة معنوية عن الهجين الفردى 168. و اظهرت الهجن T_3xL_2 و T_3xL_{15} فى كلا معادى الزراعة و التحليل التجميعى زيادة معنوية عن افضل صنف المقارنة (هـ ف 168) . و ايضا يوجد 10 هجن قمية لم تظهر معنوية عن افضل صنف مقارنة لصفة محصول الحبوب / نبات
- اظهرت السلالات2, 7, 14 و 15 قدره عامة على التآلف لصفة محصول حبوب النبات الفردى و السلالات 9, 10 و 13 لصفة التبكير فى التزهير.
- و اظهرت الهجن القمية بين الكشاف رقم 1 و السلالات 2 ,5 و 6 و الكشاف رقم 2 و كل من السلالات 1 و 12 و الكشاف رقم 3 x السلالات 3, 4 و 12 للتبكير فى التزهير , و الهجن القمية T1xL11 , T1xL12, T1xL14, T2xL3, T2xL12 و T3xL2 لصفة المحصول افضل الهجن فى القدرة الخاصة على التآلف.