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COMBINING ABILITY OF NEWLY DEVELOPED WHITE MAIZE (*Zea mays* L.) INBRED LINES VIA TOP CROSS ANALYSIS

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ABSTRACT: Twelve newly developed white maize inbred lines were crossed with two testers *i.e.* SC 128 and SC 131 at Ismailia Agricultural Research Station during 2017 season. In 2018 summer season, the 24 top crosses and two white commercial check hybrids; TWC 321 and TWC 324 were evaluated under two locations (Loc); Ismailia and Mallawy Agricultural Research Stations. The studied traits were number of days to 50% silking (DS), plant height (PH), ear height (EH), ear length (EL), ear diameter (ED), number of rows/ear (RE), number of kernels/row (KR) and grain yield (GY). Mean square due to locations were significant for DS, EL, KR and GY traits. The crosses were significant for all studied traits, except PH trait. Mean square due to lines were highly significant for all traits except PH, EH, and KR. Mean square due to testers were highly significant for EH and GY. Also, mean square attributed to lines x testers interaction were highly significant for all traits except for DS, PH, and RE. The interactions of locations (Loc) with crosses and Loc x lines were highly significant for the studied traits except for PH. The superior inbred line Ism 6007 had desirable general combining ability (GCA) effects for grain yield and yield components. Also, the inbred line Ism 7100 showed better GCA effects for PH, EH, ED, RE and GY traits and inbred line Ism 7094 for earliness and grain yield. The tester SC 128 showed the highest GCA effect for grain yield. The best crosses for specific combining ability (SCA) effects were Ism 6040 x SC 128, Ism 7094 x SC 128, Ism 7169 x SC 128, Ism 7186 x SC 131 and Ism 7259 x SC 131 for grain yield and cross Ism 6007 x SC 131 for earliness, grain yield, and yield components. The non-additive gene effects were more important in controlling all studied traits. Moreover, non-additive gene effects were more interacted by environmental conditions than additive gene effects for all studied traits. The highest mean values and significant of crosses for grain yield (GY) were obtained from the Ism 6040 x SC 128 (37.5 ard/fad.), Ism 6007 x SC 131 (37.0 ard/fad.), Ism 7169 x SC 128 (36.7 ard/fad.), and Ism 7094 x SC 128 (35.5 ard/fad.). These three ways crosses out yielding significant than the commercial hybrids TWC 321 (33.7 ard/fad.) and TWC 324 (32.5 ard/fed). These promising hybrids should be tested in advanced trails.

Key words: Maize, line x tester, additive, non-additive, combining ability, gene action, crosses.

INTRODUCTION

Successful development of improved maize (*Zea mays* L.) hybrids is dependent on accurate evaluation of inbred lines under selection. The selection of parental genotypes is one of the important steps in the success of breeding program **Jenkins (1978)** stated that the top crossing have been widely used for the preliminary evaluation of combining ability of new inbred lines. Line x tester analysis is an extension of the top cross method in which several testers are used (**Kempthorne 1957**). In this respect, **Darrah *et al.* (1972), Horner *et al.* (1976), Al-Naggar *et al.* (1997), Amer *et al.* (2003), Mosa (2010), Mousa and Aly (2012) and Sawan *et al.* (2019)** used lines, single crosses, three way crosses and open pollinated varieties as tester to evaluate combining ability of newly selected lines. Therefore, testers could

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be used for distinguishing the new inbred lines for their combining ability. This design thus provides information about general and specific combining ability of parents and at the same time it is helpful in estimating various types of gene effects. It is very effective for identification of desired lines, so as to increase the frequency of targeted alleles in hybrids. Effect of general combining ability (GCA) and specific combining ability (SCA) are important indicators of potential value for inbred lines in hybrid combinations. Thus, information on GCA effects can aid breeders to exploit existing variability in breeding materials to choose genotypes having desirable attributes and to distinguish relatedness among the breeding materials (**Sprague and Tatum, 1942**). The SCA effects help breeders to determine heterotic patterns among populations or inbred lines to identify promising single- and three-way crosses (**Lahane *et al.,* 2014**). Many researchers were interested in maize crop such as **Sweed (2012), Wuhaib (2012), El-Hosary and Elgammaal (2013), Mousa (2014) and Mutlag *et al.* (2018)** they found a significant effect of general and specific combining abilities and that the effects of specific combining ability was more than the general combining ability in the inheritance of grain yield and yield components. Interaction due to SCA x Loc were more affected by environmental conditions than those due to GCA x Loc for grain yield as mentioned by **El-Morshidy *et al.* (2003), Mousa and Abd El-Azeem (2009), Mosa (2010) and Mostafa (2018)**.

The main objectives of this investigation were (1) to evaluate the obtained 24 top crosses (12 lines x 2 testers) for grain yield and its components, (2) estimates the general combining ability of lines and testers and specific combining ability of crosses for grain yield and its components, (3) identify the nature of gene action controlling the inheritance of these traits, (4) determine the line which can be used as a good tester and identify the superior crosses to improve the yielding ability in hybrid maize breeding program.

MATERIALS AND METHODS

The materials of the current study consisted of 12 new white inbred lines *i.e.* ISM 6007, ISM 6040, ISM 7093, ISM 7094, ISM 7100, ISM 7169, ISM 7186, ISM 7196, ISM 7259, ISM 7280, ISM 7304 and ISM 7385 developed at Ismailia Agriculture Research Station. In summer season 2017, the 12 inbred lines were top crossed to each of the two tester single crosses SC128 and SC131. In summer season 2018, producing 24 crosses and two commercial check hybrids *i.e.* TWC 321 and TWC 324 were evaluated in replicated yield trails conducted at Ismailia and Mallawy Agriculture Research Stations. A randomized complete block design with four replications was used at each location. Plot size was one ridge, 6 m long, 80 cm apart (4.8 m^2) and hills were spaced 25 cm along the ridge. Two grains were planted per hill and thinned later to one plant per hill to provide a population density of approximately 21000 plants/faddan (one faddan = 4200 m^2). All cultural practice were applied as recommended at the proper time. Data were recorded for eight agronomic traits; number of days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows/ ear, number of kernels/row and grain yield (ard/fad.) adjusted to 15.5% grain moisture content and converted to ardab per faddan (ardab=140 Kg). Analysis of variance was performed for the combined data across locations according to **Steel and Torrie (1980)**. Line x tester analysis was applied as described by **Kempthorne (1957)** and as explained by **Singh and Chaudhary (1985)** to obtain information about the combining ability of lines and testers as well as to estimate the types of gene action controlling grain yield and other studied traits in the tested lines.

RESULTS AND DISCUSSION

Analysis of Variance

The combined analysis of variance across two locations for 24 top-crosses for eight traits *i.e.* number of days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows/ears, number of kernels/row and grain yield are presented in Table 1. Results showed significant differences between the two locations for most traits, except for plant height, ear height, ear diameter, and number of rows/ears. These results revealed the

Table 1. Source of variation, degree of freedom, and mean squares for days to 50% silking, plant height, ear height, ear length, ear diameter, No. of rows/ear^{-1}, No. of kernels/row and grain yield of the tested crosses and the checks as combined over locations in 2018

SOV	DF	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No. of rows ear^{-1}	No. of kernels/ row	Grain yield (ard/fad.)
Locations (Loc.)	**1**	0.916*	150.104	13.188	2.349*	0.010	0.167	9.528*	21.615**
Reps/Loc.	**6**	0.157	49.951	9.335	0.173	0.012	0.009	1.681	5.380
Crosses (C)	**23**	1.706**	54.420	53.587*	3.381**	0.067**	0.501**	6.306**	28.734**
Lines (L)	**11**	3.289**	61.747	36.482	2.878*	0.059**	0.688**	5.145*	22.197**
Testers (T)	**1**	0.01	15.843	78.844	0.882	0.001	0.034	0.184	77.166**
Lines x Testers	**11**	0.277	50.599	68.395**	4.112**	0.081**	0.356	8.024**	30.868**
C x Loc.	**23**	4.379**	142.551	154.048**	5.998**	0.135**	1.490**	21.436**	53.361**
Lines x Loc.	**11**	7.435**	172.453*	107.267**	6.185**	0.110**	1.964**	23.584**	54.104**
Testers x Loc.	**1**	0.76	47.792	382.875**	3.494**	0.019	0.055	1.264	92.216**
L x T x Loc	**11**	1.652**	121.263	180.028**	6.039**	0.170**	1.147**	21.121**	49.085**
Pooled Error	**138**	0.202	88.005	22.935	0.423	0.010	0.202	2.110	2.825

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

presence of clear variations between the two locations in climatic and soil conditions for these traits. The mean sum of squares for crosses (C) was significant for all the traits under study, indicating that genotypes had wide genetic diversity among themselves for all these traits providing opportunity for selection. Significant difference observed among lines (L) for all studied traits except plant height and number of kernels/rows. These results are in good agreement with those obtained by several authors among of them **(Soliman and Sadek, 1999; Amer *et al*., 2003; Mosa, 2003; Mousa and Aly, 2012; Darshan and Marker, 2019)**. Mean square due to testers (T) were highly significant for grain yield ard/fad., only. Similar results were reported by **Shehata *et al*., (1997), Habliza and Khalifa (2005) and Abd El-Moula *et al*. (2009)**. Highly significant estimates were observed between crosses x location (C x Loc) and lines x location (L x Loc) interaction for all studied traits, except for plant height was significant. Therefore, the crosses and lines differed in their order from location to another. Meanwhile, testers x location interactions (T x Loc) were highly significant for ear height, ear length and grain yield (ard/fad.). These interactions with locations indicated that the studied top-crosses had different performance from location to another. In addition, these results indicated that it would be worthwhile to evaluate test crosses under multi- environments, especially for grain yield, which was regarded as a complex polygenic trait (**Darrah and Hallauer, 1972**). The L x T interaction was highly significant for ear height, ear length, ear diameter, number of kernels/row and grain yield ard/fad., indicating genetic difference among them and also importance of specific combining ability for these traits. Many researchers found significant estimates of crosses and their partitioning into lines, testers and lines x testers (L x T) and their interactions with locations for grain yield and the other agronomic traits (**Salama *et al*., 1995; Sadek *et al*., 2002; Mousa and Aly, 2011; Aboyousef, 2019**). Mean squares due to lines x testers x location (L x T x Loc) interaction were highly significant for all traits except for plant height. These results are in good agreement with those obtained by **Mosa *et al*. (2008) and El-Gazzar *et al*. (2013)** who found that the interaction of lines x testers x locations was highly significant for grain yield. But **Shehata *et al*. (2001) and**

Mousa and Aly (2012) found that the interaction of lines x testers x locations was insignificant for grain yield and yield components.

Mean Performance

Mean performance of the 24 crosses for eight traits of maize combined over two locations are presented in Table 2. Mean values of crosses for days to 50% silking ranged from 59.38 days for Ism 7093 x SC 131 to 61.64 days for Ism 7304 x SC 131. Furthermore, all three-way crosses (TWC) were significantly earlier than the earliest check hybrid TWC-321, except two crosses *i.e.* Ism 6007 x SC-128 and Ism 7304 x SC 131 which are late or equal to the check. Regarding plant height, crosses varied from 249.50 cm for cross Ism 6007 x SC-131 to 263.88 cm for cross Ism 7169x SC-131.

The lowest ear placement as desirable trait for loading resistance was recorded by the cross Ism 6007 x SC-131(122.75 cm), while the highest ear placement was recorded by the cross Ism 6007 x SC-128 (135.5). Meanwhile, three crosses involving SC 128 and four crosses involving SC 131 had significantly lower ear height than the lower check three way cross 324. Regarding ear length, the cross Ism 7385 x SC128 recorded the lowest value (19.25 cm). in contrast, the highest value was recorded by the cross Ism 6007 x SC131 (23.35). Two crosses involving SC 128 and two crosses involving SC 131 as a tester had significantly from the best check TWC 321 in ear length. Ear diameter ranged from 4.20 cm for (Ism 7093 x SC131) to 4.81cm for (Ism 6007 x SC131), with 16 crosses increased significantly than the best check TWC 321. Only two crosses *i.e.* (Ism 7100 x SC128) and (Ism 6007 x SC131) had significantly surpassed the best check TWC 321 in number of rows per ear. Number of kernels per row varied from 39.98 for cross (Ism 7169 x SC-131) to 45.51 for cross (Ism 6007 x SC131), with four crosses Ism 7094 x SC128, Ism 7169x SC-128, Ism 7304 x SC-131 and Ism 6007 x SC131 had significantly surpassed the best check TWC 321.

Concerning grain yield ard/fad., results revealed that the crosses involved SC 128 as a tester tended to have higher values of grain yield than those included SC 131 as a tester. Grain yield crosses ranged from 28.22 ard/fad., for Ism 7186 x SC-128 to 37.50 ard/fad., for Ism 6040 x SC-128. Three crosses *i.e.* Ism 6040 x SC-128, Ism 7094 x SC-128 and Ism 7169x SC-128 out yielded significantly the best check TWC 321. Also only one cross Ism (6007 x SC131) significantly out yielded best check TWC 321. These results suggest that use of these four crosses as good as three-way crosses for maize breeding programs.

According to aforementioned results, the four three-way crosses that include lines Ism 6040, Ism 7094 and Ism 7169 had the highest values when crossed with tester SC 128 and line Ism 6007 with tester SC 131, compared with the best check cross for earliness, grain yield and most of yield components. Results indicated that these inbred lines had favorable alleles for earliness, grain yield and yield components. These results suggest using of these four crosses as good three-way crosses for maize breeding programs.

General Combining Ability (GCA) Effects

Estimates of general combining ability effects of twelve inbred lines and two testers for eight traits combined over two locations are presented in Table 3 Results reveled that three parents Ism 7093 (-1.00**), Ism 7094 (-1.00**) and Ism 7259 (-0.688**) exhibited desirable negative significance for days to 50% silking, indicating that these parents turned out to be best combiner for earliness. Desirable and significant values of general combining ability (GCA) effects were recorded to line Ism 6040 for ear length (1.132**); ear diameter (0.048*) and grain yield (2.441**); line Ism 7094 for earliness (-1.00**) and grain yield (0.895*); line Ism 7169 for ear diameter (0.122**) and grain yield (2.049**); line Ism 6007 for plant height (-4.594*), ear length (0.645**); ear diameter (0.140**); number of rows/ear (0.766**); number of kernels/row (1.033**) and grain yield (1.039*); line Ism 7100 had desirable and significant GCA effects for plant height (-4.469*); ear height (-2.927*); ear diameter (0.097**); number of rows/ear (0.481**) and grain yield (1.124**) toward shorter plants, lower ear placement and better grain yield and yield components.

According to these results, it could be concluded that line Ism 6007 and Ism 7100 have favorable alleles and could be of great value in maize breeding programs for improving grain yield and other attributes. The better tester for determining

Table 2. Days to 50% silking, plant height, ear height, ear length, ear diameter No. of kernels/ row and grain yield of the tested crosses and the checks as combined over locations in 2018

Character Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No. of rows ear^{-1}	No. of kernels/ row	Grain yield (ard/fad.)
ISM-6040 × S.C 128	60.50	254.38	127.38	22.80	4.51	14.45	43.75	37.50
ISM -7093 × S.C 128	59.63	251.63	130.88	20.08	4.45	14.05	41.70	31.78
ISM -7094 × S.C 128	59.50	256.13	128.63	21.01	4.29	13.80	44.75	35.56
ISM -7169 × S.C 128	61.38	258.38	132.00	21.65	4.63	14.45	44.68	36.72
ISM -7186 × S.C 128	60.50	256.25	125.63	21.03	4.32	14.00	41.38	28.22
ISM -7196 × S.C 128	60.50	252.75	125.13	20.73	4.41	14.05	41.08	31.13
ISM -7259 × S.C 128	59.75	255.75	123.75	21.31	4.34	13.90	43.85	31.30
ISM -7280 × S.C 128	60.38	257.75	133.00	20.65	4.37	13.95	43.08	32.32
ISM -7304 × S.C 128	61.13	254.50	133.75	20.00	4.38	14.05	41.40	31.87
ISM -7385 × S.C 128	60.75	262.00	135.00	19.25	4.43	14.10	42.15	33.81
ISM 6007 × S.C 128	61.63	252.38	135.50	19.48	4.30	14.55	41.48	28.86
ISM -7100 × S.C 128	60.50	249.63	127.38	20.09	4.58	14.90	42.73	34.72
ISM -6040 × S.C 131	60.75	254.25	129.50	21.00	4.41	13.80	41.60	31.22
ISM -7093 × S.C 131	59.38	257.13	125.00	20.15	4.20	14.05	41.00	28.83
ISM -7094 × S.C 131	59.50	256.13	128.63	20.94	4.39	14.40	43.30	30.07
ISM -7169 × S.C 131	61.25	263.88	131.63	20.20	4.44	13.95	42.23	31.22
ISM -7186 × S.C 131	60.38	253.50	125.63	21.33	4.42	13.95	42.98	29.42
ISM -7196 × S.C 131	60.25	262.13	132.25	20.65	4.52	13.95	39.98	28.71
ISM -7259 × S.C 131	59.88	255.50	130.88	20.43	4.31	13.95	41.40	32.37
ISM -7280 × S.C 131	60.88	255.75	127.13	20.73	4.34	14.35	42.33	30.85
ISM -7304 × S.C 131	61.64	258.63	131.25	20.99	4.40	14.00	44.50	30.24
ISM -7385 × S.C 131	60.88	252.38	127.00	19.98	4.26	13.80	42.78	30.90
ISM -6007 × S.C 131	60.75	249.50	122.75	23.35	4.81	15.20	45.51	37.05
ISM -7100 × S.C 131	60.38	252.50	124.63	20.64	4.44	14.40	42.46	31.37
Check TWC 321	62.00	257.75	136.37	20.96	4.27	14.15	43.06	33.76
Check TWC 324	62.88	258.75	130.75	20.51	4.14	14.02	42.85	32.53
LSD 0.05	.451	9.41	4.781	.556	.093	.467	1.430	1.650

Table 3. General combining ability effects for twelve inbred lines and the two testers as combined over Mallawy and Ismailia in 2018

Character Line	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No. of Rows/ ear	No. of kernels/ row	Grain yield (ard/fad.)
ISM -6040	0.125	-1.219	-0.490	1.132**	0.048*	-0.044	0.215	2.441**
ISM -7093	-1.000**	-1.156	-0.990	-0.655**	-0.089**	-0.119	-1.110**	-1.614**
ISM -7094	-1.000**	0.594	-0.302	0.207	-0.073**	-0.069	0.565	0.895*
ISM -7169	0.813**	5.594*	2.885*	0.157	0.122**	0.031	0.490	2.049**
ISM -7186	-0.063	-0.656	-3.302**	0.407**	-0.043	-0.194	-0.285	-3.095
ISM -7196	-0.125	1.906	-0.240	-0.080	0.047*	-0.169	-1.935**	-1.997**
ISM -7259	-0.688**	0.094	-1.615	0.101	-0.092**	-0.244*	0.165	-0.084
ISM -7280	0.125	1.219	1.135	-0.080	-0.060**	-0.019	0.240	-0.334
ISM -7304	0.875**	1.031	3.573**	-0.274*	-0.026	-0.144	0.490	-0.861*
ISM -7385	0.313**	1.656	2.073	-1.155	-0.070	-0.219	0.002	0.437
ISM -6007	0.688**	-4.594*	0.198	0.645**	0.140**	0.706**	1.033**	1.039*
ISM -7100	-0.063	-4.469*	-2.927*	-0.405**	0.097**	0.481**	0.133	1.124**
SE (gi)	0.113	2.301	1.195	0.139	0.023	0.117	0.357	0.413
SE (gi-gj)	0.159	3.325	1.69	0.196	0.033	0.165	0.505	0.584
SC128	0.010	-0.406	0.906	-0.096	0.004	0.019	-0.044	0.897**
SC131	-0.010	0.406	-0.906	0.096	-0.004	-0.019	0.044	-0.897**
SE (gi)	0.046	0.959	0.488	0.057	0.009	0.048	0.146	0.169
SE (gi-gj)	0.065	1.357	0.69	0.08	0.014	0.067	0.206	0.238

general combining ability (GCA) effects was tester SC 128 which had positive and highly significant GCA effects and could be considered as a good combiner for grain yield, indicating that tester SC 128 had high frequency of favorable dominant alleles, which contributed to grain yield of top crosses. Superiority of single cross as good tester was noticed by several investigators among them (**El-Ghawas, 1963; Horner *et al.*, 1976; El-Shenawy and Mosa, 2005; Mousa and Aly, 2012; Dufera *et al.*, 2018; Darshan and Marker, 2019; Motawei *et al.*, 2019**).

Specific Combining Ability (SCA) Effects

Estimates of specific combining ability (SCA) effects of the 24 top crosses for the eight studied traits combined over both locations are illustrated in Table 4. Results showed that the most favorable SCA effects were recorded for the cross Ism 6007 x SC 128 (-0.427**) for days to 50% silking toward earliness, crosses Ism 7196 x SC 128 (-4.469**), Ism 7259 x SC 128 (-4.469**), and cross Ism 6007 x SC 131 (-5.469**) for ear height toward lower ear placement. Significant positive SCA effects were obtained for crosses Ism 6040 x SC 128; Ism 7169 x SC 128; Ism 7259 x SC 128; Ism 7304 x SC 131 and Ism 6007 x SC 131 for ear length; Ism 7093 x SC 128 (0.177**); Ism 7169 x SC 128 (0.094**); Ism 7385 x SC 128 (0.083*); Ism 6007 x SC 131 (0.344*) for number of rows/ear; Ism 6040 x SC 128 (1.119*); Ism 7259 x SC 128 (1.269*); Ism 7304 x SC 131 (1.506**) and Ism 6007 x SC 131(1.975**) for number of kernels/ row and crosses Ism 6040 x SC 128 (2.243**); Ism 7094 x SC 128 (1.850**); Ism 7169 x SC 128

Table 4. Specific combining ability effects for twenty-four hybrids as combined over Mallawy and Ismailia in 2018

Crosses \ Character	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No. of Rows/ ear	No. of kernels/ row	Grain yield (ard/fad.)
ISM-6040 × S.C 128	-0.135	0.469	-1.969	0.996**	0.046	0.306	1.119*	2.243**
ISM -7093 × S.C 128	0.115	-2.344	2.031	0.058	0.117**	-0.019	0.394	0.575
ISM -7094 × S.C 128	-0.010	0.406	-0.906	0.133	-0.050	-0.319	-0.231	1.850**
ISM -7169 × S.C 128	0.052	-2.344	-0.719	0.821**	0.094**	0.231	0.769	1.854**
ISM -7186 × S.C 128	0.052	1.781	-0.906	-0.054	-0.052	0.006	-0.756	-1.496*
ISM -7196 × S.C 128	0.115	-4.281	-4.469**	0.133	-0.059	0.031	0.594	0.311
ISM -7259 × S.C 128	-0.073	0.531	-4.469**	0.540**	0.013	-0.044	1.269*	-1.430*
ISM -7280 × S.C 128	-0.260	1.406	2.031	0.058	0.012	-0.219	0.419	-0.166
ISM -7304 × S.C 128	-0.260	-1.656	0.344	-0.398*	-0.011	0.006	-1.506**	-0.083
ISM -7385 × S.C 128	-0.073	5.219	3.094	-0.267	0.083*	0.131	-0.269	0.555
ISM 6007 × S.C 128	0.427**	1.844	5.469**	-1.842**	-0.257**	-0.344*	-1.975**	-4.990**
ISM -7100 × S.C 128	0.052	-1.031	0.469	-0.179	0.064	0.231	0.175	0.777
ISM -6040 × S.C 131	0.135	-0.469	1.969	-0.996**	-0.046	-0.306	-1.119*	-2.243**
ISM -7093 × S.C 131	-0.115	2.344	-2.031	-0.058	-0.117**	0.019	-0.394	-0.575
ISM -7094 × S.C 131	0.010	-0.406	0.906	-0.133	0.050	0.319	0.231	-1.850**
ISM -7169 × S.C 131	-0.052	2.344	0.719	-0.821**	-0.094**	-0.231	-0.769	-1.854**
ISM -7186 × S.C 131	-0.052	-1.781	0.906	0.054	0.052	-0.006	0.756	1.496*
ISM -7196 × S.C 131	-0.115	4.281	4.469**	-0.133	0.059	-0.031	-0.594	-0.311
ISM -7259 × S.C 131	0.073	-0.531	4.469**	-0.540**	-0.013	0.044	-1.269*	1.430*
ISM -7280 × S.C 131	0.260	-1.406	-2.031	-0.058	-0.012	0.219	-0.419	0.166
ISM -7304 × S.C 131	0.260	1.656	-0.344	0.398*	0.011	-0.006	1.506**	0.083
ISM -7385 × S.C 131	0.073	-5.219	-3.094	0.267	-0.083	-0.131	0.269	-0.555
ISM -6007 × S.C 131	-0.427**	-1.844	-5.469**	1.842**	0.257**	0.344*	1.975**	4.990**
ISM -7100 × S.C 131	-0.052	1.031	-0.469	0.179	-0.064	-0.231	-0.175	-0.777
SE (Sij)	0.159	3.325	1.69	0.196	0.033	0.165	0.505	0.584
SE (Sij-Skl)	0.225	4.702	2.39	0.278	0.047	0.234	0.715	0.826

(1.854**); Ism 7186 x SC 131(1.496*); Ism 7259 x SC 131 (1.430*) and cross Ism 6007 x SC 131 (4.990**) for grain yield. These crosses were considered as good performing hybrids for earliness, toward lower ear placement, ear length, ear diameter, number of rows/ ears, number of kernels/row and grain yield. Therefore, they could be used in maize breeding program to improve grain yield and its relevant traits.

Variance Components

Estimates of combining ability variances δ^2 GCA for lines and testers, δ^2SCA for crosses and their interactions with locations for eight traits *i.e.* number of days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows/ear, number of kernels/row and grain yield (ard/fad.) are shown in Table 5. Results revealed that values of δ^2GCA for lines (L) were higher than the corresponding values of δ^2GCA for testers for all studied traits, indicating that most of total GCA variances were due to the inbred lines. Thus the contribution of line for these traits towards δ^2GCA was greater, Similar results were obtained by **Mousa and Aly (2011) and Sawan *et al.* (2019)**. The estimates of SCA variance were of higher magnitude than GCA variance for all traits under study, indicating that the non-additive genetic action played an important role in the inheritance of these traits. **Jayakumar and Sundram (2007)** reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, plant height, ear height and grain yield and **Sawan *et al.* (2019)** for all the same traits under study except plant height, and **Motawei *et al.* (2019)** for days to 50% silking and grain yield. Besides the ratio between components of the general combining ability to the component of specific combining ability (δ^2GCA/ δ^2SCA) was less than one for all studied traits, confirming the importance of dominance gene action controlling in the inheritance of these traits. This can be exploited for development of early maturing hybrids in maize. Similar results were recorded by **El-Rouby and Galal (1972), Rajesh *et al.* (2018), Matin *et al.*, (2016), Ejigu *et al.* (2017) and Darshan and Marker (2019)** for grain yield and yield components. Results revealed that δ^2SCA x Loc interaction was higher than δ^2GCA x Loc for all of the studied traits. Therefore, non additive type of gene action was affected more by environmental conditions than additive type of gene action in all traits. These results are in agreement with the findings of **El-Zeir *et al.* (2000), Sadek *et al.* (2001), Amer and El-Shenawy (2007). Mousa and Aly (2012)**, also found that the non-additive genetic variation interacted more with the environment than the additive component. On the other hand **El-Itriby *et al.* (1990), Mousa and Aly (2011) and Darshan and Marker (2019)**, reported that the additive types of gene action were more affected by the environment than non-additive ones.

Table 5. Genetic parameters and interaction with locations for eight traits of maize over two locations

Character Genetic parameters	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No. of Rows/ ear	No. of kernels/ row	Grain yield (ard/fad.)
σ^2_{GCA}	0.081	0.215	-0.834	-0.041	-0.001	0..008	-0.097	-0.120
σ^2_{SCA}	0.176	6.377	56.968	3.958	0.076	0.246	7.002	29.503
$\sigma^2_{GCA}/\sigma^2_{SCA}$	0.460	0.336	-0.015	-0.010	-0.013	0.033	-0.014	-0.004
$\sigma^2_{GCA\times Loc}$	0.154	1.200	-1.465	-0.002	-0.002	0.019	0.018	0.241
$\sigma^2_{SCA\times Loc}$	1.349	-10.525	-40.530	5.346	0.155	0.853	17.923	44.800
$\sigma^2_{GCA\times Loc}/\sigma^2_{SCA\times Loc}$	0.1140	-0.1140	0.0361	-0.0004	-0.0129	0.0227	0.0010	0.0054
Contribution of lines	92.197	54.266	32.560	40.703	42.299	65.744	39.020	36.946
Contribution of testers	0.027	1.266	6.397	1.133	0.088	0.293	0.127	11.676
Contribution of (l*t)	7.776	44.469	61.043	58.163	57.613	33.963	60.853	51.378

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القدرة على التآلف لبعض سلالات الذرة الشامية البيضاء الجديدة باستخدام تحليل الهجن القمية

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تم في هذه الدراسة اختبار اثني عشر سلالة جديدة مبشرة من الذرة الشامية عن طريق تهجينهم مع اثنين من الكشافات البيضاء وهما هجين فردى ١٢٨وهجين فردى ١٣١ بمحطة البحوث الزراعية بالإسماعيلية خلال الموسم الصيفي ٢٠١٧، تم تقييم ال ٢٤ هجين قمي مقارنة باثنين من الهجن التجارية هما هجين ثلاثي ٣٢١ وهجين ثلاثي ٣٢٤ وذلك في محطتي البحوث الزراعية بالإسماعيلية وملوى خلال الموسم الصيفي ٢٠١٨ تم عمل التحليل الوراثي للقدرة على التآلف باستخدام تحليل السلالة في الكشاف طبقا لما اقترحه Kempthorne 1957، وذلك لصفات عدد الأيام حتى ظهور ٥٠ % حرايرو ارتفاع النبات وارتفاع الكوز وطول الكوز وقطر الكوز وعدد السطور/الكوز وعدد الحبوب/السطر ومحصول الحبوب أردب/فدان، ويمكن تلخيص أهم النتائج للتحليل المشترك للموقعين فيما يلي: كانت قمة التباين الراجع للمواقع معنوية لصفات عدد الأيام حتى ظهور حرايرر ٥٠% من النباتات وطول الكوز وعدد الحبوب/السطر ومحصول الحبوب أردب/فدان، كذلك وجدت اختلافات معنوية بين الهجن القمية لجميع الصفات تحت الدراسة فيما عدا صفة ارتفاع النبات، كما كانت قيمة التباين الراجع للسلالات عالية المعنوية لكل الصفات تحت الدراسة عدا صفة ارتفاع النبات وارتفاع الكوز وعدد الحبوب/السطر، كان تباين التفاعل بين السلالات في الكشافات عالي المعنوية لكل الصفات تحت الدراسة ما عدا صفة عدد الأيام حتى ظهور حرايرر ٥٠% من النباتات وارتفاع النبات وعدد السطور/الكوز كما كانت قيمة التباين الراجع للكشافات عالي المعنوية لصفتي ارتفاع الكوز ومحصول الحبوب أردب/فدان، كان تباين تفاعل الهجن القمية في المواقع وكذلك التفاعل بين السلالات في المواقع عالي المعنوية لكل الصفات تحت الدراسة ما عدا ارتفاع النبات، كان تفاعل الكشافات في المواقع معنويا لصفات ارتفاع الكوز وطول الكوز ومحصول الحبوب أردب /فدان، كما كان تباين التفاعل للسلالات والكشافات مع المواقع عالي المعنوية لجميع الصفات تحت الدراسة ماعدا صفة ارتفاع النبات، كانت أفضل السلالات في القدرة العامة على التآلف سلالة اسماعيلية ٦٠٠٧ لصفة المحصول ومكوناته، بينما أظهرت السلالة اسماعيلية ٧١٠٠ قدرة ائتلافية مرغوبة لصفات ارتفاع النبات وارتفاع الكوز وقطر الكوز وعدد سطور الكوز ومحصول الحبوب وكذلك السلالة إسماعيلية ٧٠٩٤ لصفتي التبكير ومحصول الحبوب، بينما اظهر الكشاف هجين فردى ١٢٨ قدرة عامة على الائتلاف مرغوبة لصفة محصول الحبوب، أفضل الهجن في القدرة الخاصة على الائتلاف هي اسماعيلية ٦٠٤٠ × هـ. ف ١٢٨ واسماعيلية ٧٠٩٤ × هـ. ف ١٢٨ واسماعيلية ٧١٦٩ × هـ. ف١٢٨ واسماعيلية ٧١٨٦ × هـ. ف ١٣١ واسماعيلية٧٢٥٩ × هـ. ف١٣١ لمحصول الحبوب والهجين اسماعيلية ٦٠٠٧ × هـ. ف١٣١ لصفات التبكير والمحصول ومكوناته، كان الفعل الجيني غير الضيف أكثر اهمية في وراثة جميع الصفات تحت الدراسة، علاوة على ذلك كان الفعل الجيني غير المضيف أكثر تأثرا بالمواقع مقارنة بالفعل الجيني المضيف لكل الصفات المدروسة، دلت النتائج على تفوق الهجن اسماعيلية ٦٠٤٠ × هـ. ف ١٢٨ (٣٧,٥ اردب/فدان) الهجين واسماعيلية ٧٠٩٤ × هـ. ف ١٢٨ (٣٥,٥ أردب /فدان) الهجين اسماعيلية ٧١٦٩ × هـ. ف١٢٨ (٣٦,٧ اردب/فدان) والهجين اسماعيلية ٦٠٠٧ × هـ. ف١٣١ (٣٧,٠ أردب/فدان) أعلى حيث زادت معنويا عن محصول هجن المقارنة هـ.ث ٣٢١ (٣٣,٧ أردب/فدان) و هـ. ث ٣٢٤ (٣٢,٥ أردب/فدان) مما يشير إلى أهمية هذه الهجن البيضاء كمواد وراثية مبشرة للقدرة المحصولية العالية في البرامج المستقبلية لتربية الذرة الشامية.

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