Combining Ability Variation of some White Maize Inbred Lines via Line X Tester Analysis under Ismailia and Mallawy Locations

Mohammed A. Emam[1] and Hany A. A. Mohamed[2]
[1]Department of Agronomy, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt
[2]Maize Research Department, Field Crop Research Institute, ARC, Egypt

Received: 20/8/2021

Abstract: Combining ability analysis was conducted using Line x tester analysis involves twelve new white inbred lines of maize were crossed two single crosses (S.C 128 and S.C 131) as testers during 2018 season. The resulted 24 hybrids with check hybrid T.W.C 324 were evaluated in two locations (Ismailia and Mallawy Research Station) during 2019 season. The combined analysis over the two locations showed highly significant due to crosses, inbred lines (L), testers (T) and line x tester interaction (L x T) for grain yield, indicating that there is a wide diversity among the studied lines in their contribution to the performance of crosses. Line and L x T were significant for all the studied traits, except ear length and no. of rows ear-^{1}. Mean squares due to crosses x location and lines x location interaction were significant for all the studied traits, except ear diameter and no. of rows ear-^{1} of Lines x Location. Mean squares due to Lines x Testers x locations interaction were significant for all the studied traits. The results also showed that $\boldsymbol{\sigma^2}$ GCA was larger than those obtained by $\boldsymbol{\sigma^2}$ SCA for all the studied traits, except ear diameters. Showing that non-additive gene effects were more important component controlling the inheritance of these studied traits. Among 12 inbred lines used for study, the inbred ISM-8 showed good general combining ability with highly significant for grain yield. The best crosses ISM-3 x SC-128 and ISM-8 x SC-131 were having good specific combiners ability with highly significant for most of studied traits. These crosses ISM-3 x SC-128 and ISM-8 x SC-131 highly significantly out yielded to the T.W.C-324, suggesting the use of this cross in maize breeding programs..

Keywords: Gene effects, genetic components, combining ability, maize and *Zea mays* L.

INTRODUCTION

Maize (*Zea mays* L.) is considered the third of the cultivated cereal crops after wheat and rice all over the world. In Egypt, it is consumed in various forms as a major staple food and source of proteins and calories. Because of the population increase in Egypt, crop breeders are adopting new breeding programs to cover all the area devoted to high-yielding maize hybrids. Successful development for improving high yielding ability and quality of maize hybrids is based mainly on accurate evaluation of inbred lines under selection. Crop breeders are looking for best inbred lines that possess higher general and specific combining ability effects to be used as parents for new hybrids. However, the combining ability helps to determine the most appropriate parents and provide ample genetic information on trait inheritance. In this respect, Girma *et al*. (2015) mentioned that extremely general combining ability (GCA) and specific combining ability (SCA) effects lead to high heterosis. The significant GCA implies that breeders can exploit the available genetic variability in the identification of elite materials with desirable traits, whereas significant SCA effects suggest that promising single cross combinations may be found. However, each of Mosa (2010), Mostafa (2018) and Mousa *et al*. (2021) reported that the tested genotypes should exhibit enough genetic diversity for an effective breeding program *via*. Top cross modeling. Top cross (L x T) method is used to evaluate new inbred lines for GCA and SCA. Top cross procedure was first suggested by Davis (1927) to test the superior inbred lines for hybrids development programs. Line x tester analysis gives information about GCA and SCA of parents and at the same time it is helpful in estimating various types of gene action through such breeding crop as reported by Barh Anupam (2015) in maize crop. Breeders need knowledge to improve new maize genotypes based on the type and relative magnitude of the components of genetic variance and their interaction with environment (Ali *et al*., 2014; Ram *et al*., 2015). Meanwhile, according to concepts of the general and specific combining ability (GCA& SCA), it has been used extensively in breeding of most economic crop species. An understanding and study of the relative importance of additive and non-additive gene actions is necessary for designing appropriate breeding programs via crosses (Ertiro *et al*., 2017; Abraha *et al*., 2018).

The concepts of general and specific combining ability (GCA& SCA), defined by Sprague and Tatum (1942), have been used extensively in breeding of most economic crop species. An understanding and study of the relative importance of additive and non-additive gene actions is necessary for designing appropriate breeding programs (Abraha *et al.,* 2018; Ertiro *et al.,* 2017).

However, Al-Naggar *et al.* (1997) found that the tester with the narrowest genetic base exhibited the highest genetic variation in test crosses for most of the studied traits. Most of investigators such as El-Beially *et al*. (2007), Aly *et al*. (2011), Abd El-Zaher (2016) and Abraha *et al*. (2018) agreed with Amer *et al.* (2003) that a suitable tester should include simplicity in use, and which provide information that correctly classifies the relative merit of lines and maximum genetic gain. In addition, the variance of GCA/SCA ratio is useful in estimating that variability existed whether due to additive or non-additive or both types of gene action. El-Beially *et al*. (2007) and Ram *et al.*

*Corresponding author e-mail: m_abdelgawad55@yahoo.com

(2015) reported that the variance components due to SCA for grain yield and some other agronomic traits were larger than that due to GCA, indicating the nonadditive type of gene action played an important role in the inheritance of these traits while other results indicated the importance of additive gene effects for inheritance grain yield and some of other agronomic traits, magnitude of σ^2 GCA was larger than that obtained for σ^2 SCA for all the studied traits (Aly *et al.* 2011; El Arif *et al.* 2011; Mostafa, 2018). Jayakumar and Sundaram (2007) reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, number of grains per row and grain yield.

The objective of this study is to identify the most superior parents for crosses to use in the breeding program for yielding ability, through estimating combining ability effects of the twelve new white inbred lines.

MATERIALS AND METHODS

Plant Materials:

The plant materials of the current study consist of twelve new white inbred lines of maize, *i.e.* ISM-1, ISM-2, ISM-3, ISM-4, ISM-5, ISM-6, ISM-7, ISM-8, ISM-9, ISM-10, ISM-11 and ISM-12. In Addition, two tester's single crosses *i.e.* SC-128 and SC-131. With a commercial, check hybrids TWC-324.

Experiments Field

Ismailia and Mallawy Agricultural Research Stations were a sits for the Experiments Field. The twelve inbred lines of maize were developed at Ismailia Agricultural Research Station. In summer season 2018, the twelve inbred lines were top crossed to each of the two tester's single crosses SC-128 and SC-131. In the summer season 2019, produced 24 crosses and the commercial check hybrids TWC-324 evaluated in replicated yield trails conducted at the both Agricultural Research Stations, Ismailia and Mallawy.

Experiment Design

A randomized complete block design with four replications was used at each location. The 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 seeds were planted per hill and thinned later to one plant per hill to provide a population density of approximately 21000 plants/feddan (one feddan=4200 m^2).

Data recorded

Data were recorded for, days to 50% silking (SD), plant height (PH) cm, Ear height (EH) cm, ear length (EL) cm, ear diameter (ED) cm, number of rows / ear (NR), number of kernel / rows (NK) and grain yield (GY) ard/faddan adjusted to 15.5 % moisture.

Statistical Analysis:

Data were subjected to analysis of variance according to Steel and Torrie (1980), to determine significant differences among genotypes. A combining ability analysis of L x T was conducted based on the procedure developed by Kempthorne (1957).

RESULTS AND DISCUSSION

Analysis of Variance

The combining analysis of variance of line x tester mating design for all studied traits across two locations was presented in Table (1). Highly significant differences between the two locations (Loc) were shown due to the different environmental variations and soil conditions for the two locations, indicating that all the studied traits were affected by environmental conditions prevailed in the two locations. Aly *et al.* (2011) and Mousa *et al.* (2021) reached to the same results through their investigated on White Maize Inbred Lines via Line X Tester.

Table (1): Analysis of variance for eight traits over combined across two locations of maize

S.O.V.	D.F.	Days to 50% Silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows ear-1	No. of Kernel
Locations (Loc.)	1	1.250**	258.143**	1291.828**	23.924*	33.624**	0.555**	2.565**	22.618**
Reps/Loc.	6	0.385	60.836	72.069	4.416	4.038	0.121	0.635	3.816
Crosses (C)	23	8.831**	270.601**	152.808**	23.849**	3.173*	0.133**	0.983*	3.358*
Lines (L)	11	9.891**	291.857**	180.869**	26.377**	2.888	0.154**	0.25	4.263*
Testers (T)	1	0.260	9.065	8.760	64.059**	0.015	0.014	0.018	2.145
Lines x Testers	11	8.551**	273.122**	137.842**	17.667**	2.782	0.123*	0.548	2.563
C x Loc.	23	33.139**	617.476**	394.328**	64.463**	5.997**	0.078	1.086*	13.196**
Lines x Loc.	11	42.705**	802.580**	515.354**	79.159**	6.254**	0.037	0.744	14.718**
Testers x Loc.	1	17.010**	14.865	17.51	89.975**	2.187	0.005	0.023	22.011**
L x T x Loc	11	25.152**	487.154**	307.558**	47.450**	6.087**	0.126**	1.515**	10.865**
Pooled Error	138	0.289	28.694	38.035	5.648	1.896	0.057	0.549	1.826

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

The genetic variation was observed highly significant among inbred lines for all traits except ear diameter and number of rows ear^{-1}., which indicated the presence of wide diversity among tested lines for all studied traits and among testers for grain yield. However, Line x tester interaction was highly significant for days to 50% silking, plant height, ear height, grain yield and significant for ear diameter indicating that lines differ in their performance in crosses with two testers for these investigated traits. The interaction variance of C x Loc. was significant or highly significant for traits except ear diameter, also L x Loc. was highly significant for all traits except ear diameter and number of rows ear^{-1}. Testers x Loc. was highly significant for days to 50% silking, grain yield and number of kernels/row while, L x T x Loc. was highly significant for all traits. These results are in agreement with these reported by several authors among of them Aly *et al.* (2011), Darshan and Marker (2019) and Mohamed (2020).

Mean Performance

Table (2) Presented mean performance of the 24 top-crosses and check hybrid TWC 324 for all the studied traits. For days to 50% silking, the crosses (ISM 2*SC131) and (ISM 1* SC131) were significantly earlier (56 and 56.5 days) than the check hybrid TWC 324 (61.5 days), while the latest crosses were (ISM10*SC131) and (ISM3* SC128) (61.63 and 60.75 days), respectively. For plant height, the crosses (ISM8*SC131) and (ISM3*SC128) top-crosses were significantly taller than the average of all crosses by 268 and 265.88 cm, respectively, but shorter than the check hybrid TWC-324 (275.75 cm). Regarding the ear height, crosses ranged from 107.5 to 138.13 cm, but also shorter than the check hybrid by (156 cm).

The results showed that mean performance for grain yield ranged from 32.9 ard/fed for cross ISM8*SC131 to 24.09 ard/fed for cross (ISM3* SC131). The best hybrids from them were the crosses (ISM8*SC131), (ISM6*SC128), crosses (ISM1*SC128), (ISM3*SC128), and (ISM8*SC128). These crosses significantly out yielded the check TWC 324 (28.46 ard/fed). In general, involving SC128 (1) as a tester tended to have higher average values of grain yield (28.42 ard/fed) than those of SC131 (2) as a tester (26.78 ard/fed). Also, involving inbred line (ISM 8) tended to have higher values of grain yield and most studied traits with both testers. Therefore, these top-crosses will be tested in yield trails for further evaluation.

Table (2): Mean performances for eight traits of 24 top-crosses and check variety of maize over two locations

Crosses	Days to 50% Silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows ear-1	No. of Kernel
ISM **1*SC128**	58	260.13	130.75	31.27	20.93	4.57	14.55	42.33
ISM **2* SC128**	57.75	247.31	113.75	26	19.55	4.49	14.63	41.53
ISM **3* SC128**	60.75	265.88	124.38	31.27	20.26	4.94	14.35	41.9
ISM **4* SC128**	59.25	248.81	107.5	26.56	19.83	4.54	14.2	41.75
ISM **5* SC128**	58.63	242.06	119.38	26.79	20.44	4.47	14.85	43.53
ISM **6* SC128**	58.13	254	111.88	31.38	21.91	4.52	14.7	42.68
ISM **7* SC128**	59.25	248	113.13	28.7	19.93	4.4	14.8	42.61
ISM **8* SC128**	59.63	252.69	135.75	30.89	21.48	4.54	14.5	41.6
ISM **9* SC128**	56.88	243.5	121.38	28.72	19.08	4.49	14.65	41.74
ISM **10* SC128**	59.88	255.81	130	27.15	18.78	4.43	14.5	39.84
ISM **11* SC128**	57.25	244.38	122.5	26.74	19.73	4.51	14.35	42.89
ISM **12* SC128**	59.38	236.5	114.38	25.52	19.74	4.35	14.2	42.4
Mean tester SC128	58.73	249.92	120.40	28.42	20.14	4.52	14.52	42.07
ISM **1* SC131**	56.5	242.38	123.75	26.4	19.52	4.42	14.5	40.53
ISM **2*SC131**	56	237.75	113.88	25.42	20.4	4.45	14.65	42.44
ISM **3* SC131**	56.63	246.94	112.5	24.09	20.41	4.43	14.95	42.05
ISM **4* SC131**	57.38	239.5	118.13	24.3	19.9	4.47	14.45	41.71
ISM **5* SC131**	57.25	247.31	119.38	28.91	20	4.41	14.4	41.4
ISM **6* SC131**	60	258.81	120.63	27.12	20.64	4.51	14.1	42.23
ISM **7* SC131**	59.5	251.56	113.75	27.8	20.11	4.53	14.1	42.1
ISM **8* SC131**	59.63	268	138.13	32.9	21.94	4.6	15.55	43.49
ISM **9* SC131**	60	247.63	125.63	24.55	20.34	4.41	14.15	41.44
ISM **10* SC131**	61.63	253.25	131.25	25.78	19.25	4.47	14.75	40.25
ISM **11* SC131**	58.75	243.81	117.5	27.45	21.55	4.61	15.2	42.65
ISM **12* SC131**	60.25	254.75	107.5	26.65	20.49	4.53	14.3	40.91
Mean tester SC131	58.63	249.31	120.17	26.78	20.38	4.49	14.59	41.77
TWC324(Check)	61.5	275.75	156	28.46	19.32	4.36	14.2	40.18
LSD 0.05	**0.531**	**5.292**	**6.093**	**2.348**	**1.36**	**0.236**	**0.732**	**1.335**

General Combining Ability (GCA) effects

Estimates of general combining ability effects (GCA) for the twelve inbred lines for eight traits combined across two locations are indicated in Table (3). The best inbred lines for general combining ability effects (GCA) were inbred lines ISM-1, ISM-2, ISM-5 and ISM-11 for earliness; inbred lines ISM-2, ISM-4, ISM-5 and ISM-11 for plant height and ear height; inbred lines ISM-1, ISM-6 and ISM-8 for grain yield (ard/fed); ISM-6 for ear length, ISM-3 and ISM-8 for ear diameter; ISM-11 for no. of rows/ear; while inbred lines ISM-5, ISM-6, ISM-8 and ISM-11 for number of kernels /row. In general, inbred line ISM-8 was positive and significant as the most superior general combiner the most studied traits. The best tester for GCA was SC-128 for grain yield. Superiority of the single cross as good tester was reported by several investigators among them, Amer *et al*. (2003), Mousa and Aly (2012), Dufera *et al*. (2018), Motawei *et al*. (2019) and Mohamed (2020). The above inbred lines can be used in maize breeding program to improve these traits. Meanwhile, the inbred lines with appropriate GCA effects for grain yield are possible to successfully contribute favorable alleles in a breeding program and could be useful as parents in constituting synthetic populations suitable to be improved for high production yield (Makumbi *et al.,* 2011). These results are in harmony with those obtained by Senthil and Bharathi (2011), Chandel and Mankotia (2014) and Shah *et al.* (2015).

Table (3): Estimates of general combining ability effects for twelve inbred lines and two testers at Mallawy and Ismailia in 2018

Inbred lines	Days to 50% Silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows ear-1	No. of Kernel
Ism **-1**	-1.427**	1.635	1.188	1.233*	0.491	-0.032	-0.011	-0.49
Ism **-2**	-1.802**	-7.083**	-5.781**	-1.888**	-0.256	-0.06	0.101	0.066
Ism **-3**	0.01	6.792**	3.719**	0.08	0.104	0.225**	0.114	0.06
Ism **-4**	-0.365	-5.458*	-5.469**	-2.169**	-0.371	-0.02	-0.211	-0.184
Ism **-5**	-0.740**	-4.927*	-1.688	0.251	-0.014	-0.088	0.089	0.547*
Ism **-6**	0.385	6.792**	0.781	1.653**	1.039**	-0.047	-0.136	0.535*
Ism- **7**	0.698**	0.167	-0.781	0.651	-0.214	-0.063	-0.086	0.441
Ism- **8**	0.948**	10.729**	8.531**	4.301**	0.673	0.338**	0.139	0.629*
Ism **-9**	-0.24	-4.052	-0.406	-0.964	-0.527	-0.087	-0.136	-0.328
Ism**- 10**	2.073**	4.917**	6.563**	-1.134	-1.217**	-0.106	0.089	-1.871**
Ism **-11**	-0.677**	-5.521**	0.406	-0.504	0.409	0.034	0.339*	0.854**
Ism **-12**	1.135**	-3.99	-7.063**	-1.512*	-0.117	-0.092	-0.286	-0.259
SE (gi)	0.244	2.272	1.366	0.597	0.356	0.069	0.167	0.279
SE (gi-gj)	0.345	3.214	1.932	0.845	0.504	0.098	0.236	0.395
SC-128	0.052	0.307	0.302	0.817**	-0.013	0.003	-0.014	0.149
SC-131	-0.052	-0.307	-0.302	-0.817**	0.013	-0.003	0.014	-0.149
SE (gi)	0.099	0.927	0.557	0.243	0.145	0.092	0.068	0.114
SE (gi-gj)	0.141	1.31	0.789	0.345	0.206	0.139	0.096	0.161

Specific Combining Ability Effects

Specific combining ability (SCA) effects of 24 top crosses for eight traits combined over the two locations are presented in Table (4). Nine crosses showed desirable negative significant and highly significant SCA for days to 50% silking towards earliness, the cross (ISM 3 x SC 131) was the best one for earliness. Crosses (ISM 8 x SC 128), (ISM 1 x SC 131) and (ISM 3 x SC 131) showed a negative (desirable) significant and highly significant SCA for both of plant height and ear height, whereas the cross (ISM12 x SC 128) for plant height and (ISM10 x SC 128), for ear height. For grain yield, three crosses (ISM 3 x SC 128), (ISM 5 x SC 131) and (ISM 8 x SC 131) were showed Positive significant and highly significant SCA (desirable) for grain yield. The cross (ISM 3 x SC 128) was the best one for grain yield. For grain yield component, the crosses (ISM 1 x SC 128) and (ISM 11 x SC 131) showed good SCA for ear length, ISM 3 x SC 128 and ISM 8 x SC 131 for ear diameter; (ISM 6 x SC 128), (ISM 7 x SC 128), (ISM 3 x SC 131) and (ISM 11 x SC 131) for number of rows/ear and (ISM 1 x SC 128), (ISM 5 x SC 128), (ISM 2 x SC 131) and (ISM 8 x SC 131)for number of kernels. In general, the best crosses (ISM 3 x SC128) and (ISM 8 x SC131) showed positive SCA effect for the most of studied traits. Due to the most crosses possess a highly significant with positive values of SCA effects for most traits; it could be used in the maize hybrid program. In addition, highly significant SCA effects of the crosses indicate that significant deviation from what would have been predicted based on their parental performances. In this respect, Abraha *et al*. (2013) found that the crosses with highly positive and highly significant estimates of SCA effect could be selected for their SCA to use in maize improvement program. Due to the most crosses possess a highly significant with positive values of SCA effects for most traits; it could be used in the maize hybrid program. In addition, highly significant SCA effects of the crosses indicate that significant deviation from what would have been predicted based on their parental performances. In this respect, Abraha *et al*. (2013) found that the crosses with highly positive and highly significant estimates of SCA effect could be selected for their SCA to use in maize improvement program.

Table (4): Estimates of specific combining ability effects for twenty-four hybrids at Mallawy and Ismailia in 2018

crosses	Days to 50% Silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows ear-1	No. of Kernel
ISM **1*SC128**	0.697*	8.567**	4.947*	1.617	1.214**	0.086	0.038	0.751*
ISM **2* SC128**	0.823*	4.473	2.291	-0.528	-0.411	0.035	0.001	-0.606*
ISM **3* SC128**	2.010**	9.161**	9.604**	2.771**	-0.062	0.202*	-0.286*	-0.225
ISM **4* SC128**	0.885*	4.348	-0.145	0.311	-0.025	0.049	-0.111	-0.131
ISM **5* SC128**	0.635*	-2.932	0.01	-1.878*	0.231	0.047	0.238	0.913**
ISM **6* SC128**	-0.989**	-2.713	-3.771	1.311	0.647	0.055	0.313*	0.076
ISM **7* SC128**	-0.177	-2.088	1.104	-0.369	-0.081	-0.053	0.363**	0.107
ISM **8* SC128**	-0.052	-7.963*	-4.021*	-1.822**	0.581	-0.315**	-0.162	-1.093**
ISM **9* SC128**	-1.614**	-2.3698	-3.333	1.271	-0.618	0.041	0.264	0.0005
ISM **10* SC128**	-0.927**	0.973	-3.927*	-0.129	-0.221	-0.032	-0.112	-0.356
ISM **11* SC128**	-0.802*	-0.026	0.291	-1.168	-0.895*	-0.037	-0.512**	-0.031
ISM **12* SC128**	-0.489	-9.432**	-3.052	-1.385	-0.359	-0.079	-0.036	0.594
ISM **1* SC131**	-0.697*	-8.567**	-4.947**	-1.617	-1.214**	-0.087	-0.038	-0.751*
ISM **2*SC131**	-0.822*	-4.474	-2.291	0.528	0.411	-0.035	-0.001	0.606*
ISM **3* SC131**	-2.010**	-9.161**	-9.604**	-2.771**	0.062	-0.202*	0.286*	0.224
ISM **4* SC131**	-0.885*	-4.349	0.145	-0.311	0.024	-0.049	0.111	0.131
ISM **5* SC131**	-0.635*	2.932	-0.01	1.878*	-0.231	-0.047	-0.238	-0.913
ISM **6* SC131**	0.989**	2.713	3.771	-1.311	-0.647	-0.055	-0.313*	-0.076
ISM **7* SC131**	0.177	2.088	-1.104	0.369	0.081	0.053	-0.363**	-0.107
ISM **8* SC131**	0.052	7.963*	4.021*	1.822*	-0.581	0.315**	0.161	1.093**
ISM **9* SC131**	1.614**	2.369	3.333	-1.271	0.618	-0.041	-0.263*	-0.0005
ISM **10* SC131**	0.927**	-0.974	3.927*	0.129	0.221	0.032	0.111	0.356
ISM **11* SC131**	0.802*	0.026	-0.291	1.168	0.896*	0.037	0.511**	0.031
ISM **12* SC131**	0.489	9.432**	3.052	1.385	0.359	0.079	0.036	-0.594
SE (Sij)	0.345	3.214	1.932	0.845	0.454	0.098	0.136	0.305
SE (SijSkl)	0.489	4.545	2.733	1.195	0.663	0.139	0.234	0.459

Table (5) shows the estimates of combining ability variances σ^2GCA for lines, σ^2SCA for line x tester, and their interaction's locations for all traits. These results show that, σ^2 GCA-L was higher than σ^2GCA-T for the studied traits, indicating that most of GCA variance was due to inbred line for these traits. On the other side, the results showed that σ^2SCA was larger than that obtained for σ^2GCA for all the studied traits, except for the ear diameter. The gene effects non-additive was the more important component controlling the inheritance of all studied traits. The magnitude of σ^2 SCA x Loc interaction was higher than σ^2 GCA x Loc for all traits, indicating that the additive type of gene action was more affected than the non-additive type of gene action by environment in these traits. Similar results were reported with those obtained by Mosa (2010), El-Arif *et al.* (2011), Chandel and Mankotia (2014), Ram *et al.* (2015) and Abd El-Zaher (2016).

Table (5): Genetic parameters and their interaction with locations for eight traits of maize over two locations

Parameters	Days to 50% Silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows ear^{-1}	No. of Kernel
σ^2_{GCA}	0.016	-0.142	0.843	0.349	-0.0039	-0.0002	-0.0093	0.045
σ^2_{SCA}	8.071	231.797	122.898	14.809	1.763	-0.0054	0.325	1.937
$\sigma^2_{GCA/}\ \sigma^2_{SCA}$	.0019	0.0006	.0068	0.0236	0.0022	0.0370	0.0286	0.0232
$\sigma^2_{GCA \times Loc}$	0.453	7.347	4.892	0.958	-0.005	-0.003	-0.025	0.131
$\sigma^2_{SCA \times Loc}$	25.054	473.091	246.432	38.251	3.313	0.036	0.641	8.968
$\sigma^2_{GCA \times Loc} / \sigma^2_{SCA \times Loc}$	0.018	0.016	0.019	0.025	-0.002	-0.075	-0.038	0.015
Contribution of lines	53.566	51.582	56.608	52.893	50.926	55.327	31.274	60.721
Contribution of testers	0.1282	0.146	0.249	11.678	0.024	0.473	0.199	2.777
Contribution of (l*t)	46.304	48.271	43.142	35.426	49.049	44.199	68.526	36.502

CONCLUSIONS

Generally, the results of the current study identified that inbred line Ism-8 as a good GCA effect and the best crosses ISM 3 x SC128 and ISM 8 x SC131 combinations with desirable SCA effect for the studied traits. This indicates the possibility crop breeders of developing desirable cross combinations through crossing and or recombination of inbred lines with good traits of interest. The data and information from this study may possibly be useful for breeders who would like to develop high yielding of maize crop

REFERENCES

Abd El-Zaher, I. N. (2016). Line X Tester Mating Design for Estimation Combining Ability in Maize. Assiut J. Agric. Sci., 47(4): 16-31.

Abraha, M. T., H. Shimelis, M. Laing and K. Assefa (2018). Gene action controlling yield and yield-related traits among tef (Era-grostis tet [Zucc] Trotter) populations under drought-stressed and non-stressed conditions. Plant Breeding, 137:585-597.

Ali, A., H. Rahman, L. Shah, K. A. Shah and S. Rehman (2014). Heterosis for grain yield and its attributing components in maize variety using line x tester analysis method. Academic J. Agri. Res., 2(11): 225-230.

Al-Naggar, A. M., H. Y. El-Sherbieny and A. A. Mahmoud (1997). Effectiveness of inbreds, single crosses and populations as testers for combining ability in maize. Egypt. J. Plant Breed., 1: 35-46

Aly, R. S. H., E. M. R. Metwali and S. T. M. Mousa (2011). Combining ability of maize (Zea mays L.) inbred lines for grain yield and some agronomic traits using topcross mating design. Global J. of Mol. Sci. 6(1): 1-8.

Amer, E. A., A. A. El-Shenawy and A. A. Motawei (2003). Combining ability of new maize inbred lines via line x tester analysis. Egypt. J. Plant Breed., 7(1): 229-239. Proceed Third Pl. Breed. Conf. April 26, 2003, Giza.

Barh Anupam, N. K. Singh, S. S Verma, J. P. Jaiswal and P. S. Shukla (2015). Combining ability analysis and nature of gene action for grain yield in maize hybrids. International Journal of Environmental & Agriculture Research.Vol-1, Issue-8, December, 2-9.

Chandel, U. and B. S. Mankotia (2014). Combining ability in local and cimmyt inbred lines of maize (Zea mays L.) for grain yield and yield components using line x tester analysis. Sabrao J. Breed. Genet., 46(2): 256-264.

Darshan, S. S. and S. Marker (2019). Heterosis and combining ability for grain yield and its component characters in quality protein maize (*Zea mays* L.) hybrids. Electronic Journal of Plant Breeding, 10(1): 111-118.

Davis, R. L. (1927). Report of the plant breeder. Rep. Puerto Rico. Agric. Exp. Sta. P: 14-15.

Dufera, T., T. Bulti and A. Girum (2018). Heterosis and combining ability analysis of quality protein maize (*Zea mays* L.) inbred lines adapted to mid-altitude sub-humid agro-ecology of Ethiopia. African Journal of Plant Science, 12(3): 47-57.

El-Arif, Kh. A. O., A. S. Abo El-Hamd and I. N. Abd El-Zaher (2011). Studies on combining ability under two sowing dates in some topcrosses in maize. Minia J. of Agric. Res. & Develop., 31(1): 1-23.

El-Beially, I. E., G. I. A. Mohamed, S. H. M. Abd-El-Haleem and M. S. H. Ahmed (2007). Using line x Tester method for estimation of combining ability effects of maize. Al-

Azhar J. Agric. Sci. Sector Res., 3(12): 1-21.

Ertiro, B. T., Y. Beyene, S. Das, B. Mugo, M. Olsen, S. Oikeh and B. M. Prasanna (2017). Combining ability and testcross performance of drought-tolerant maize inbred lines under stress and non-stress environments in Kenya. Plant Breeding, 136: 197-205.

Girma, C. H., A. Sentayehu, T. Berhanu and M. Temesgen (2015). Test cross performance and combining ability of maize (*Zea mays* L.) inbred lines at Bako, 639 Western Ethiopia. Global J. of Sci. Fron. Res., 15(4): 1-12.

Jayakumar, J. T. Sundaram (2007). Combining ability studies for grain yield and other yield components in maize (*Zea mays* L.). Crop Res. (Hisar), India., 33(1/3): 179-186.

Kempthorne, O. (1957). An Introduction to Genetic Statistics. John Wiley and Sons Inc., Landon, New York.

Makumbi, D., F. J. Betrán, M., Bänziger and J. Ribaut (2011). Combining ability, heterosis and genetic diversity in tropical maize (*Zea mays* L.) under stress and non-stress conditions. Euphytica, 180: 143-162.

Mohamed, H. A. A. (2020). Combining ability of newly developed white maize (*Zea mays* L.) inbred lines via top cross analysis. Zagazig J. Agric. Res., 47(3): 657-668.

Mosa, H. E. (2010). Estimation of combining ability of maize inbred lines using top crosses mating design. J. Agric. Res. Kafer El-Sheikh Univ., 36(1): 1-16.

Mostafa, A. K. (2018). Combining ability and type of gen action of some new yellow maize inbred lines. Alex. J. Agric. Sci., 63(1): 63-71.

Motawei, A. A., H. E. Mosa, M. A. G. Khalil, M. M. B. Darwish and H. A. A. Mohamed (2019). Combining ability and heterotic grouping of two sets of new maize inbred lines. Egypt. J. Plant Breed., 23(4): 667- 679.

Mousa, S. Th. M., H. A. A. Mohamed, R. S. H. Aly and H. A. Darwish (2021). Combining Ability of White Maize Inbred Lines Via Line X tester analysis. J. of Plant Production, Mansoura Univ., 12(2): 109-113.

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. Egypt J. Agric. Res., 90(4): 77-90.

Ram, L., R. Singh and S. K. Singh (2015). Study of combining ability using Qpm donors as testers for yield and yield traits in maize (*Zea mays* L.). Sabrao J. of Bree. And Gene., 47(2): 99-112.

Senthil, P. K. and P. Bharathi (2011). Studies on line x tester analysis in maize (*Zea mays* L.). Crop Res., 41(1, 2 & 3): 168-170.

Shah, L., H. U. Rahman, A. Ali, N. A. Bazai and M. Tahir (2015). Combining ability esti mates from line x tester mating design in maize (*Zea maize* L.). Acad. Res. J. Agri. Sci. Res, 3(4): 71-75.

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

Steel, R. G. and J. H. Torrie (1980). Principles and procedures of statistics. McGraw-Hill Book Company, New York, Toronto, London.

تباين القدرة الائتلافية لبعض سلالات الذرة الشامية البيضاء باستخدام تحليل السلالة x الكشاف بموقعي الإسماعيلية وملوى

محمد عبد الجواد إمام[1]، هاني عبد الله عبد المجيد محمد[2]
[1]جامعة قناة السويس، كلية الزراعة، قسم المحاصيل
[2]مركز البحوث الزراعية، معهد بحوث المحاصيل الحقلية، قسم بحوث الذرة

تم إجراء تحليل القدرة العامة على الائتلاف باستخدام تحليل السلالة X الكشاف متضمناً اثني عشر سلالة بيضاء جديدة من الذرة مع كشافين (S.C 128 وS.C 131) خلال موسم 2018 بمحطة البحوث الزراعية بالإسماعيلية. وقد نتج عن هذا التهجين 24 هجيناً، تم تقييمها مع الهجين المحلىTWC 324 كهجين مقارنة في موقعين (الإسماعيلية ومحطة أبحاث ملوي) خلال موسم 2019. أظهر تحليل التباين المشترك للموقعين وجود اختلافات عالية المعنوية لصفه محصول الحبوب بين الهجن، السلالات، الكشافات والتفاعل بين السلالات والكشافات، مما يشير إلى وجود تنوع كبير بين السلالات المدروسة في مدى مساهمتها في أداء الهجن الناتجة. وقد أظهرت السلالات والتفاعل بين السلالات والكشافات وجود اختلافات معنوية لكل الصفات المدرسة ما عدا صفتي طول الكوز، عدد الصفوف في الكوز، كما وجدت اختلافات معنوية للتفاعل بين كل من الهجن والمواقع، والسلالات والمواقع لكل الصفات المدروسة باستثناء صفة قطر الكوز وصفة عدد الحبوب في الكوز، وكان التفاعل بين السلالات X المواقع X الكشافات فكان معنوياً لكل الصفات المدرسة. أظهرت النتائج أن تباين القدرة العامة على الائتلاف كان أكبر من تباين القدرة الخاصة على الائتلاف لجميع الصفات المدروسة باستثناء صفه قطر الكوز، مما يشير إلى أن التأثيرات غير مضيفه هي التي تلعب الدور الأكبر في وراثة تلك الصفات. أظهرت النتائج أن السلالة ISM-8 كانت الأفضل في القدرة العامة على الائتلاف لصفه محصول الحبوب من بين الـ 12 سلاله، كما كانت الهجن ISM-3 x SC-128 و ISM-8 x SC-131 الأفضل في القدرة الخاصة على الائتلاف لأغلب الصفات المدروسة. أظهر الهجينين ISM-3 x SC-128 و ISM-8 x SC-131 اختلافات معنوية عالية لصفة محصول الحبوب مقارنةً بالهجين المحلىTWC 324 ، مما يعزز أمكانية استخدام هذه الهجن في برامج التربية لمحصول الذرة الشامية.