Assessment of Combining Ability for some New White Maize Inbred Lines (*Zea mays* L.) Using Line X Tester Model

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Abstract: This research was conducted with the aim of assessment of the combining ability for yield and yield components in some new white maize. To achieve this goal, nine new white maize inbred lines were derived from different sources crossed to three testers; Sd.34, SC.10, and SC.131 at Ismailia Agricultural Research Station during the 2021 growing season. In the 2022 growing season, 27 topcrosses in addition to two commercial check hybrids; SC.10 and TWC.321 were evaluated at three locations; Ismailia, Sakha and Sids Agricultural Research Stations. The results cleared that highly significant differences were found between the three locations for all studied traits except no. of rows ear^{-1} and no. of kernels row^{-1}. Mean squares due to crosses, their partitions and their interaction with locations were significant or highly significant for most of the studied traits. Three inbred lines; Ism.7246, Ism.7316, and Ism.8094 were possessed the best general combiners for grain yield (GY), ear length (EL), no. of rows ear $^{-1}$ (RE^{-1}) and no. of kernels row^{-1} (KR^{-1}). The results showed that significant positive GCA effects for grain yield (GY ard fed^{-1}) were highly correlated with those that had significant positive GCA effects, indicating that the line with high GCA effects for GY, generally had high GCA effects for YCTs with high GCA effects. Thus, selecting inbred lines with positive GCA effects in either all or most of the YCTs will have a greater chance to produce crosses with the ability to give higher grain yield. The histogram can show any inbred line with positive or negative GCA effects for GY and the YCTs GCA effects directly, then the inbred line Ism.7246, Ism.7316, and Ism.8094 had positive GR ratio values for all studied traits. On the other hand, the inbred line, Ism.7280 had negative GR ratio values for GY and YCTs GCA effects. The maize crosses (Ism 7246 x SC 10), (Ism 7316 x SC 10) and (Ism 7316 x SC131) increase significantly outyielded the check TWC 321. This indicates the importance of these white single- and three-way crosses as promising genetic material for high yield potential in future programs in maize breeding.

Key words: Combining ability, gene action, grain yield, Line x Tester model, Maize.

INTRODUCTION

Maize (*Zea mays* L.) is one of cereals of greatest importance in the world crops Golbashy *et al*., (2010). It 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 2022, the area grown by this crop in Egypt was 2.4 million feddans with an annual grain production of 7.5 million metric tons and an average productivity of 23.10 ardabs/feddan (Economic Affairs Sector, 2022). 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 tester 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 in breeding program, whereas line x tester mating design was used as the value of any genotype is estimated through to know its productivity, its desirable traits, its genetic components behavior and it's combining abilities, which represented by general combining ability (GCA) and specific combining ability (SCA). 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 so necessary and will be tested. So, it is necessary to focus on choosing good lines that have a GCA with genetically different to produce crosses are superior (Amoon and Abdul Hamed, 2020). The line x tester design has been used widely for preliminary evaluation of the combining ability of new inbred lines (Jenkins 1978, Hallauer and Miranda 1988, Barata and Carena 2006 and Fan *et al.,* 2008). Combining ability effects of the lines were divided into general and specific combining abilities according to Sprague and Tatum, (1942). However, the ideal tester should gather as much data as possible, while assessing the combining potential of inbred lines. Genetic variation is essential for breeders as it gives the chance to the genetic materials for effective breeding programs. The understanding of genetic variability present in each crop species for the traits under improvement is imperative for the success of plant breeding program (Sankar *et al*. 2006). It is estimated that breeders' working collections encompass only 3–5% of preserved maize variability (Curry, 2017). On the other hand, maize has one of the richest reserves of genetic resources of all major crop species (Ortiz *et al*., 2010). Generally, richness of genetic resources stored in gene banks is rarely used in plant breeding (Technow *et al*., 2014). Also, it suggested the method of early testing that is greatly affected by the nature and number of testers needed combining ability helps to determine the most appropriate parents and provide ample genetic information on trait inheritance. Therefore, this current

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study was undertaken with the following objectives: (1) to determine the combining ability effects for inbred lines and crosses. (2) to identify the best maize crosses compared with the checks. (3) to estimate the impact of yield components traits of grain yield on grain yield combining ability effects.

MATERIALS AND METHODS

Plant materials:

Nine new white maize inbred lines were developed from different genetic sources at Ismailia Agricultural Research Station. Two of the inbred lines (Ism.7246 and Ism.7253) were derived from Tep -5, and six of them (Ism.7280, Ism.7316, Ism.7385, Ism.8093, Ism.8094 and Ism.8173) were derived from Giza-2 and the final one (Ism.6036) was derived from American Early Dent. Three testers inbred lines, represent by Sd-34, SC-10 and SC-131 in a Line x Tester with two check white hybrids SC.10 and TWC.321 were considered also as plant materials.

Experimental locations and growing seasons:

The nine new white maize inbred lines were crossed with the three testers; Sd-34, SC-10 and SC-131 in a Line x Tester mating design according to Kempthorne, (1957) procedure during 2021 summer season. In season 2022, the 27 crosses and two check white hybrids SC.10 and TWC.321 were planted on May 15, at three locations; Ismailia, Sakha, and Sids Agricultural Research Stations.

Experimental design and its management:

Randomized Complete Block Design (RCBD) with three replications was used at each location. Plot size was one row, 6 m long and 0.8 m a part. Seeds of maize were planted in hills evenly spaced at 0.25 m along the row at the rate of two kernels hill^{-1}, then thinned to one plant hill^{-1} after 21 days from planting. All cultural practices for maize production were applied as recommended at the proper time.

Data recorded:

Data were recorded for days to 50% silking date (DTS days), plant height (PHT cm), ear height (EHT cm), ear position (Epos%), ear length (EL cm), no. of rows ear^{-1} (RE^{-1}), no. of kernels row^{-1} (KR^{-1}) and grain yield (GY ard fed^{-1}) adjusted to 15.5% moisture content.

Statistical analysis:

Combined analysis of variance was performed using SAS Statistical Package (SAS 2008, version 9.2) across three locations according to Sendecore and Cochran (1980). Line x tester analysis was performed as described by Kempthorne (1957).

General Combining Ability Ratio (GR ratio):

Relationship between general combining ability for GY and general combining ability for yield component traits (YCTs) were estimated according to Fan *et al*., (2008), Aly (2013) and Aly and Khalil (2013). To obtain GCA ratio (GR) for individual traits, first step, the mean absolute values of GCA effects (MA GCA) was calculated. Second step, calculate the GCA/MA GCA ratio (the sign either positive or negative must be considered) for grain yield and yield components traits.; ear length (EL), no. of rows ear^{-1} (RE^{-1}) and no. of kernels row^{-1} (KR^{-1}) of each line and called them GY_r, EL_r, RE_r and KR_r, respectively. The GR ratio removes the variation caused by different units of different traits and the graph of GRs show relative importance of each YCTs GCA effects to GY GCA effects of each line.

RESULTS AND DISCUSSIONS

Analysis of variances:

Analyses of variance for eight suited traits combined across three locations in 2022 season are presented in Table (1). Significant or highly significant differences were detected among three locations for all studied traits except RE^{-1} and KR^{-1} traits, indicating that the three locations differed in their environmental conditions. These results are agreement with those obtained by Aly *et al*., (2011), Mousa and Aly (2012), Abebe *et al*., (2020), Abd El-Azeem *et al*., (2021), Mosa *et al*., (2021), Mousa *et al*., (2021) and Aly *et al*., (2022). Results also detected significant and highly significant difference among maize crosses, lines, testers and line x tester for all studied traits except for grain yield (GY ard fed^{-1}) for testers. Similar results were obtained by several investigators *i.e.* Mousa and Aly (2012), Badu *et al*., (2016), Singh *et al*., (2017), Rajesh *et al*., (2018), Abu *et al*. (2021), Mousa et al., (2021), Abd El-Azeem *et al*., (2022), Aly *et al*., (2022), Nigus (2022) and El-Shenawy *et al*., (2022). Significant or to highly significant were showed between interactions of crosses, line, tester and line x tester with locations for all studied traits showed responses except Epos%, and RE^{-1} for C x Loc; RE^{-1} trait for L x Loc; Epos%, EL and KR^{-1} for T x Loc, indicating that these materials different in them behaviors from one location to another. These results are in agreement with those detected by Mousa *et al*., (2021), El- Shenawy *et al*., (2022) and Badr *et al*., (2022).

Mean performance:

Mean performance of 27 crosses and two check hybrids across three locations are presented in Table (2). Results showed that the mean values of crosses for days to 50% silking date (DTS) ranged from 63. .78 days for Ism.7316 x SC.10 to 67.22 days for Ism.6036 x SC.10. Moreover, all maize crosses were significantly earlier than the two check hybrids except Ism.6036 x SC.10. These results indicated that these crosses could be used for developing new hybrids towards earliness or high plant density in maize breeding programs. In this respect, Abd El-Azeem *et al*., (2022) and Aly *et al*., (2022) were reported the same results and suggested the same idea. Regarding PHT cm, maize crosses ranged

Table (1): Analysis of variances for nine traits of maize cross three locations during 2022 season.

SOV	df	DTS (days)	PHT (cm)	EHT (cm)	EPOS %	EL (cm)	RE^{-1} (cm)	KR^{-1} (cm)	GY (ard fed^{-1})
Locations	2	819.34**	120055.86**	42933.19**	2976.30**	294.68**	0.16	88.85	398.74**
Reps/Loc.	6	3.59	2015.38	1620.51	63.57	5.40	0.30	30.71	20.84
Crosses (C)	26	4.62**	779.28**	452.66**	39.26**	23.54**	3.69**	116.43**	94.92**
Lines (L)	8	8.63**	854.78**	395.64**	79.25**	40.25**	6.31**	223.02**	152.68**
Testers (T)	2	4.81**	2032.37**	1171.61**	23.67**	15.03**	4.94**	26.05**	5.10
Lines x	16	2.58**	584.90**	391.31**	21.21**	16.25**	2.23**	74.43**	77.26**
C x Loc.	52	2.20**	213.79**	146.07*	9.97	2.66**	0.72	7.75**	20.57**
L x Loc.	16	5.02**	399.56**	263.39**	14.76*	5.08**	0.88	21.69**	29.20**
T x Loc.	4	2.41**	448.98*	237.25*	5.93	0.72	2.60**	1.20	30.06**
L x T x Loc	32	2.54**	265.21**	194.70**	16.19**	3.86**	0.98*	7.90**	31.77**
Pooled error	156	0.45	138.24	96.08	9.12	0.48	0.60	4.48	7.62

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position %
EL = ear length, cm RE^{-1} = no. of rows ear^{-1} KR^{-1}= no. of kernels row^{-1} GY = grain yield ard. fed^{-1}

from 236.17 cm for Ism.7280 x Sd.34 to 274.11 cm for Ism.7246 x sd.34. Two single crosses were significant shorter than the check SC.10. While ten three-way crosses did not differ significant than the TWC.321 for this trait. For EHT, crosses ranged from 109.22 cm for Ism.7280 x Sd.34 to 137.94 cm for Ism.7385 x SC.10. Three single crosses showed significantly lower ear height with compared the check hybrids SC.10. Whereas 14 three-way crosses recorded lower ear placement compared than the check TWC.321. Regarding Epos%, crosses ranged from 44.99% for Ism.7385 x Sd.34 to 52.83% for Ism.8173 x Sd.34. The results showed that two single crosses and eleven three-way crosses were significantly had lower ear placement compared with two check hybrids; SC.10 and TWC.321, in respectively. For EL trait, cross ranged from 17.99 cm for Ism.7385 x Sd.34 to 24.71 cm for Ism.7316 x Sd.34. Five single crosses and one three-way cross were significantly higher than two check hybrids SC.10 and TWC.321, respectively. Regarding $RE^{-1}$and KR^{-1} traits, three single crosses were significant higher when compared with SC.10; Ism.7246 x Sd.34, Ism.7316 x Sd.34 and Ism.8094 x Sd.34. Most of three-way crosses did not differ significant compared with the check hybrid TWC-321 for RE^{-1} and KR^{-1} traits. For GY (ard fed^{-1}), crosses ranged from 20.12 ard fed^{-1} for cross Ism.7385 x Sd.34 to 33.65 ard fed^{-1} for Ism.7246 x Sd.34. Results cleared that two crosses; Ism.7246 x Sd.34 and Ism.7316 x Sd.34 were significant and had the highest grain yield (33.65and 34.13 ard fed^{-1}) compared with the check hybrid SC.10 (30.71 ard fed^{-1}). Two crosses; Ism.7246 x SC.10 and Ism.7316 x SC.131 had the highest grain yield (33.62 and 33.47 ard fed^{-1}) were differed significantly higher than the check hybrid TWC.321 (28.79ard fed-1). These crosses could be desirable and promising crosses for grain yield, and they may be contributed for the enhancement of maize breeding programs.

General combining ability effects:

General combining ability effects for all studied traits for nine new white inbred lines of maize and three testers combined across three locations are illustrated in Table (3). Results revealed that the inbred lines Ism.7246, Ism.7253 and Ism.7316 were exhibited highly significant and negative desirable GCA effects for DTS toward earliness. For PHT, inbred line Ism.8173 had negative and highly significant GCA effects toward shorter plants. In respect to EHT, and Epos%, the inbred lines, Ism.7253 and Ism.7280; inbred lines Ism.7246, Ism.7253 and Ism.7280 had negative and highly significant effects toward low ear height and lower ear placement, respectively. The parental inbred lines Ism.7246, Ism.7316 and Ism.8094 had positively and highly significant GCA effects toward increased EL, RE^{-1} and KR^{-1}. The best general combiners for GY were parental lines Ism.7246, Ism.7316 and Ism.8094. In addition, these lines recorded high GCA effects for one or more than one of traits contributing to GY trait especially Ism.7246 and Ism.7316 showed desirable significant value for yield and its components and desirable value toward earliness. Results showed that, Sd.34 as a tester had good combiner for EL, RE^{-1} and KR^{-1}. On the other hand, SC.131 was distinguished as a good combiner toward earliness, shorter plants, lower ear placement and long ear length.

Specific combining ability effects:

Specific combining ability effects for 27 crosses for all studied traits combined across three locations are illustrated in Table (4). Results showed that, crosses Ism.7280 x SC.10, Ism.7316 x SC.10 and Ism.6036 x SC.131 had desirable negative and significant SCA effects for DTS toward earliness. The maize crosses Ism.7280 x Sd.34 and Ism.7385 x Sd.34 had negative and significant SCA effects for PHT and EHT toward shorter plants and low ear height. Cross Ism.8173 x SC.10 has negative and significant SCA effects toward

Table (2): Mean performances of 27 crosses and two check crosses for all studied traits across three locations during 2022.

cross	DTS (days)	PHT (cm)	EHT (cm)	EPOS %	EL (cm)	RE^{-1} (cm)	KR^{-1} (cm)	GY (ard fed^{-1})
Ism-7246 x Sd.34	65.11	274.11	123.89	45.31	24.08	15.11	49.44	33.65
Ism-7246 x SC.10	65.67	270.00	131.44	48.63	22.78	14.40	47.22	33.62
Ism-7246 x SC.131	64.56	256.67	118.22	46.42	21.24	14.31	46.72	28.09
Ism -7253 x Sd.34	65.11	254.44	114.94	45.36	21.12	14.31	42.89	28.63
Ism -7253 x SC.10	65.33	259.17	121.44	46.92	21.42	13.44	44.78	26.39
Ism -7253 x SC.131	64.78	248.72	115.39	46.62	22.02	12.93	45.78	29.18
Ism -7280 x Sd.34	66.44	236.17	109.22	46.26	18.42	13.02	40.11	23.28
Ism -7280 x SC.10	65.78	270.61	128.28	47.36	20.59	13.69	43.33	28.36
Ism -7280 x SC.131	66.33	251.56	113.83	45.50	19.11	13.29	43.22	26.98
Ism -7316 x Sd.34	65.89	258.72	128.89	50.01	24.71	15.60	50.33	34.13
Ism -7316 x SC.10	63.78	250.67	123.94	49.19	21.37	14.22	43.78	28.83
Ism -7316 x SC.131	64.78	247.44	125.94	51.12	22.11	13.96	45.78	33.47
Ism -7385 x Sd.34	65.56	248.33	112.00	44.99	17.99	13.64	45.22	20.12
Ism -7385 x SC.10	65.78	273.33	137.94	50.28	20.82	14.44	42.67	29.71
Ism -7385 x SC.131	65.22	258.17	123.44	47.80	21.03	13.24	37.78	29.01
Ism -809 x Sd.34	65.89	254.89	122.44	48.11	22.32	13.69	40.00	26.63
Ism -809 x SC.10	66.22	258.50	125.11	48.89	21.27	14.49	38.00	26.56
Ism -809 x SC.131	65.89	248.72	118.94	47.59	21.62	13.56	42.11	27.99
Ism -8094 x Sd.34	65.67	254.44	129.39	50.93	23.69	14.71	48.89	31.95
Ism -8094 x SC.10	66.22	257.50	133.17	51.69	20.62	14.62	40.67	29.58
Ism -8094 x SC.131	65.56	247.11	123.78	50.36	23.97	14.49	43.44	32.51
Ism -8173 x Sd.34	66.11	252.22	133.22	52.83	20.96	14.40	38.67	30.66
Ism -8173 x SC.10	66.56	244.67	117.11	48.09	19.61	13.47	42.22	24.86
Ism -8173 x SC.131	66.11	244.17	118.50	48.42	22.00	14.18	37.22	26.86
Ism -6036 x Sd.34	66.33	261.22	128.89	49.51	22.74	13.82	38.44	29.15
Ism -6036 x SC.10	67.22	252.50	124.89	49.63	20.28	13.38	43.78	28.78
Ism -6036 x SC.131	65.33	244.28	117.22	47.66	21.60	13.91	42.22	27.06
SC.10	67.11	262.1	127.4	48.61	21.37	14.04	46.78	30.71
TWC.321	67.56	246.5	136.8	51.72	22.29	14.13	45.33	28.79
LSD 0.05	0.62	10.86	9.06	2.79	0.64	0.72	1.96	2.55
0.01	0.81	14.28	11.90	3.67	0.84	0.94	2.57	3.35

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position %

EL = ear length, cm RE^{-1} = no. of rows ear^{-1} KR^{-1}= no. of kernels row^{-1} GY = grain yield ard. fed^{-1}

low ear height. Two crosses; Ism.7385 x Sd.34 and Ism.8173 x SC.10 had negative and significant SCA effects lower ear placement. In respect to GY attributes traits, ten, three and nine maize crosses had positive and significant SCA effects for EL, RE^{-1} and KR^{-1} traits, respectively toward increased for ear length, RE^{-1} a KR^{-1}. Regarding GY ard fed^{-1}, 7 out 27 maize crosses had positive and significant SCA effects: Ism-7246 x Sd-34, Ism-7246 x SC 10, Ism-7280 x SC 10, ism-7316 x sd-34, Ism-7385 x SC 10, Ism-7385 x SC 131 and Ism-8173 x Sd-34. Furthermore, most of these maize crosses showing desirable value of SCAeffects for one or more yield attributed traits especially Ism.7316 x Sd.34, Ism.7385 x SC.10 and Ism.7280 x SC.10. Two single crosses of maize; Ism.9246 x Sd.34 and 7316 x Sd.34 exhibited significant SCA effects for grain yield and had significant out yielded than the check SC.10. These crosses can be used as a new hybrid after testing their performance under different environmental conditions.

Genetic parameters:

Genetic parameters and contribution of L, T and L x T for all studied traits of maize across three locations are illustrated in Table (5). Results revealed that K2 GCA_L were higher than those K^2 GCAT for DTS, Epos%, EL, RE^{-1}, $KR^{-1}$and GY, indicating that most of the total GCA variance was due to

Table (3): General combining ability effects for all studied traits for nine inbred lines and three testers across three locations during season 2022.

Inbred lines	DTS (days)	PHT (cm)	EHT (cm)	EPOS %	EL (cm)	RE^{-1} (cm)	KR^{-1} (cm)	GY (ard fed^{-1})
Ism-7246	-0.564**	12.173**	1.500	-1.562**	1.237**	0.595**	4.658**	3.049
Ism -7253	-0.601**	-0.642	-5.759**	-2.051**	0.059	-0.449**	1.344**	-0.675
Ism -7280	0.510**	-1.975	-5.907**	-1.981**	-2.089**	-0.679**	-0.916*	-2.537**
Ism -7316	-0.860**	-2.475	3.241	1.756**	1.267**	0.580**	3.492**	3.400**
Ism -7385	-0.156	5.191*	1.444	-0.662	-1.515**	-0.235	-1.249**	-2.462**
Ism -809	0.325**	-0.716	-0.852	-0.155	0.274*	-0.101	-3.101**	-1.684**
Ism -8094	0.140	-1.735	5.759**	2.642**	1.296**	0.595**	1.195**	2.605**
Ism -8173	0.584**	-7.735**	-0.074	1.430**	-0.607**	0.002	-3.767**	-1.282*
Ism -6036	0.621**	-2.086	0.648	0.582	0.078	-0.309*	-1.656**	-0.414
SE gi (L)	0.129	2.263	1.886	0.581	0.133	0.149	0.407	0.531
LSD 0.05	0.252	4.435	3.697	1.139	0.260	0.149	0.407	1.041
LSD 0.01	0.332	5.829	4.859	1.497	0.342	0.293	0.798	1.369
Sd 34	0.115	0.198	-0.475	-0.205	0.319**	0.244**	0.640**	-0.052
S.C 10	0.165*	4.907**	4.019**	0.613	-0.490**	0.005	-0.200	-0.221
S.C 131	-0.280**	-5.105**	-3.543**	-0.408	0.172*	-0.249**	-0.440	0.273
S.E. gi (T)	0.074	1.306	1.089	0.335	0.077	0.086	0.235	0.307
LSD 0.05	0.146	2.561	2.135	0.658	0.150	0.169	0.461	0.601
LSD 0.01	0.191	3.365	2.806	0.864	0.198	0.222	0.606	0.790

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position %

EL = ear length, cm RE^{-1} = no. of rows ear^{-1} KR^{-1}= no. of kernels row^{-1} GY = grain yield ard. fed^{-1}

the inbred lines for these traits. These results are in agreement with finding reported by Aly and Hassan (2011), Mousa and Aly (2012) and Aly and Khalil (2013). The results showed that the highest contribution for GY and its attributes traits were due to contribution of lines, indicating that the lines were played more important role toward improving most of these traits. On the other hand, contribution of tester and line x tester was low for most of the investigated traits. These results are accord in with that obtained by Camdzija *et al.,* (2012), Mousa and Aly (2012) and Aly and Khalil (2013). Non-additive genetic effects K2 SCA played a major role in all studied traits except DTS. Similar results were reported by Aly and Hassan (2011) for KR^{-1}, Aly (2013) for DTS and Aly and Khalil (2013) for KR^{-1} trait, which confirming our results. σ^2SCA x Loc interaction was higher than that of $\sigma^2$2GCA x Loc for all studied traits, indicating that non-additive variance was more affected by environmental conditions than the additive component for these traits. In this connection, Mousa and Aly (2012) and Aly and Khalil (2013) reached the same results, where σ^2 GCA L x Loc was higher than σ^2 SCA T x Loc for all studied traits except RE^{-1} trait.

General Combining Ability Ratio (GR ratio):

Results in Tables (6 and 7) showed that the mean absolute GCA effects (MA GCA) for grain yield (GY) trait and four yield components traits (YCTs); EL, ED, RE-1 and KR-1. The MA GCA was calculated as the average of the absolute mean of GCA effects values of nine inbred lines under this investigation (Table 6). While the general combining ability ratio (GR ratio) by dividing GCA values on MA GCA for GY and YCTs effects was calculated and illustrated in Table (7). In the same trend, Figure (1), showed the relationship between GY GCA effects and YCTs GCA effects for each inbred line. The histogram revealed that the direction of grain yield GCA effects (i.e. positive or negative) was largely determined by the number of yield components GCA effects in the same direction. This means that, if a line had significantly positive GY GCA effects, it usually had more YCTs GCA effects with significantly positive GCA effects and if a line had significantly negative GY GCA effects, it usually had more YCTs GCA effects with significantly negative GCA effects. Similar results were obtained Fan *et al.,*(2008), Mousa and Aly (2012) and Aly (2013). Therefore, according to this histogram, the inbred line Ism.7246, Ism.7316 and Ism.8094 had positive GR ratio.

Table (4): Specific combining ability effects for 27 crosses for all studied traits combined across three locations during 2022.

Crosses	DTS (days)	PHT (cm)	EHT (cm)	EPOS %	EL (cm)	RE^{-1} (cm)	KR^{-1} (cm)	GY ($ardfed^{-1}$)
Ism-7246 x Sd.34	-0.12	6.99	-0.15	-1.27	1.06**	0.26	1.01	1.92*
Ism-7246 x SC.10	0.39	-1.83	2.91	1.23	0.57*	-0.21	-0.37	2.05*
Ism-7246 x SC.131	-0.28	-5.15	-2.75	0.04	-1.63**	-0.05	-0.63	-3.97**
Ism -7253 x Sd.34	-0.08	0.14	-1.84	-0.74	-0.72**	0.50	-2.23**	0.61
Ism -7253 x SC.10	0.09	0.15	0.17	0.01	0.39	-0.12	0.50	-1.45
Ism -7253 x SC.131	-0.02	-0.28	1.67	0.73	0.33	-0.38	1.74*	0.84
Ism -7280 x Sd.34	0.14	-16.81**	-7.41*	0.09	-1.27**	-0.56*	-2.75**	-2.87**
Ism -7280 x SC.10	-0.57**	12.93**	7.15*	0.37	1.70**	0.35	1.31*	2.38**
Ism -7280 x SC.131	0.43*	3.88	0.27	-0.46	-0.43	0.20	1.44*	0.50
Ism -7316 x Sd.34	0.96**	6.25	3.10	0.11	1.66**	0.76**	3.06**	2.04*
Ism -7316 x SC.10	-1.20**	-6.52	-6.33	-1.53	-0.87**	-0.38	-2.65**	-3.09**
Ism -7316 x SC.131	0.24	0.27	3.23	1.42	-0.79**	-0.39	-0.41	1.05
Ism -7385 x Sd.34	-0.08	-11.81**	-11.99**	-2.49*	-2.28**	-0.38	2.69**	-6.10**
Ism -7385 x SC.10	0.09	8.48*	9.46**	1.98*	1.36**	0.66*	0.98	3.65**
Ism -7385 x SC.131	-0.02	3.33	2.52	0.52	0.91**	-0.28	-3.67**	2.46**
Ism -809 x Sd.34	-0.23	0.65	0.75	0.12	0.27	-0.47	-0.68	-0.38
Ism -809 x SC.10	0.06	-0.44	-1.07	0.08	0.02	0.57*	-1.84**	-0.28
Ism -809 x SC.131	0.17	-0.21	0.32	-0.20	-0.29	-0.11	2.51**	0.66
Ism -8094 x Sd.34	-0.26	1.23	1.09	0.15	0.61**	-0.14	3.92**	0.66
Ism -8094 x SC.10	0.24	-0.43	0.37	0.08	-1.65**	0.01	-3.47**	-1.55
Ism -8094 x SC.131	0.02	-0.80	-1.46	-0.23	1.04**	0.13	-0.45	0.89
Ism -8173 x Sd.34	-0.26	5.01	10.75**	3.26**	-0.22	0.14	-1.34	3.26**
Ism -8173 x SC.10	0.13	-7.26	-9.85**	-2.31*	-0.75**	-0.55*	3.05**	-2.38**
Ism -8173 x SC.131	0.13	2.25	-0.90	-0.95	0.97**	0.41	-1.71*	-0.88
Ism -6036 x Sd.34	-0.08	8.36*	5.70	0.78	0.89**	-0.13	-3.68**	0.87
Ism -6036 x SC.10	0.76**	-5.07	-2.80	0.09	-0.77**	-0.33	2.50**	0.67
Ism -6036 x SC.131	-0.68**	-3.28	-2.90	-0.87	-0.11	0.46	1.18	-1.55
SE Sij	0.22	3.92	3.27	1.01	0.23	0.26	0.71	0.92
LSD 0.05	0.44	7.68	6.40	1.97	0.45	0.51	1.38	1.80
0.01	0.57	10.10	8.42	2.59	0.59	0.67	1.82	2.37

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position %
EL = ear length, cm RE^{-1} = no. of rows ear^{-1} KR^{-1}= no. of kernels row^{-1} GY = grain yield ard. fed^{-1}

values for all studied traits, and then the column of this inbred line existed in positive area for GY and all YCTs. On the other hand, the inbred line, Ism.7280 has negative GR ratio values for GY and YCTs GCA effects and the columns of these inbred existed in the negative area. This histogram can show any inbred line that had positive or negative GCA effects for GY and the YCTs GCA effects directly. This figure indicated that yield components GCA were related to GY GCA effects (Austin and Lee 1998; Fan *et al*. 2008; Mousa and Aly 2012 and Aly 2013). Regarding the previous results, it can say that the GRs explained why selecting inbred lines with higher positive GCA effects for yield components would have better chance to get a hybrid with higher grain yield.

Table (5): Genetic parameters and contributions of line, tester and line x tester for all studied traits of maize combined across three locations.

Genetic parameters	DTS (days)	PHT (cm)	EHT (cm)	EPOS %	EL (cm)	RE^{-1} (cm)	KR^{-1} (cm)	GY (ard fed^{-1})
k^2 lines	0.13	16.86	4.89	2.39	1.30	0.20	7.46	4.57
k^2 testers	0.030	19.55	11.54	0.22	0.18	0.03	0.31	-0.31
k^2 average	0.06	18.88	9.88	0.76	0.46	0.07	2.09	0.91
k^2 SCA	0.01	53.28	32.77	0.84	2.06	0.21	11.09	7.58
$\sigma^2 GCA_L$ x Loc	0.51	29.04	18.59	0.63	0.51	0.03	1.91	2.40
$\sigma^2 GCA_T$ x Loc	0.07	11.51	5.23	-0.12	0.01	0.07	-0.12	0.83
σ^2 GCA x Loc	0.18	15.89	8.57	0.07	0.13	0.06	0.39	1.22
σ^2 SCA x Loc	0.70	42.32	32.87	2.36	1.13	0.13	1.14	8.05
Contribution of lines	57.53	33.75	26.89	62.11	52.62	52.57	58.9	49.49
Contribution of tester	8.01	20.06	19.91	4.64	4.91	10.29	1.72	1.41
Contribution of (L x T)	34.46	46.19	53.19	33.25	42.47	37.14	39.34	49.09

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

k^2 = *kappa square and* σ^2 = *Sigma square*

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position %

EL = ear length, cm RE^{-1} = no. of rows ear^{-1} KR^{-1}= no. of kernels row^{-1} GY = grain yield ard. fed^{-1}

Table (6): Mean absolute GCA effects (MA GCA) for yield traits

	GY	EL	RE^{-1}	KR^{-1}
Ism-7246	3.048	1.237	0.595	4.658
Ism -7253	0.675	0.059	0.449	1.344
Ism -7280	2.537	2.089	0.679	0.916
Ism -7316	3.400	1.267	0.580	3.492
Ism -7385	2.462	1.515	0.235	1.249
Ism -809	1.684	0.274	0.101	3.101
Ism -8094	2.605	1.296	0.595	1.195
Ism -8173	1.282	0.607	0.002	3.767
Ism -6036	0.414	0.078	0.309	1.656
MA GCA	2.01	0.94	0.39	2.38

Table (7): GCA/MA GCA (GR ratio) for GY and yield attributed traits

	GY_r	EL_r	RE_r	KR_r	Sum GR Pos.	Sum GR Neg.
Ism-7246	1.51	1.32	1.51	1.96	6.31	0.00
Ism -7253	-0.34	0.06	-1.14	0.57	0.63	-1.48
Ism -7280	-1.26	-2.23	-1.72	-0.39	0.00	-5.60
Ism -7316	1.69	1.35	1.47	1.47	5.99	0.00
Ism -7385	-1.22	-1.62	-0.60	-0.53	0.00	-3.96
Ism -809	-0.84	0.29	-0.26	-1.31	0.29	-2.40
Ism -8094	1.30	1.39	1.51	0.50	4.69	0.00
Ism -8173	-0.64	-0.65	0.01	-1.59	0.01	-2.87
Ism -6036	-0.21	0.08	-0.78	-0.70	0.08	-1.69

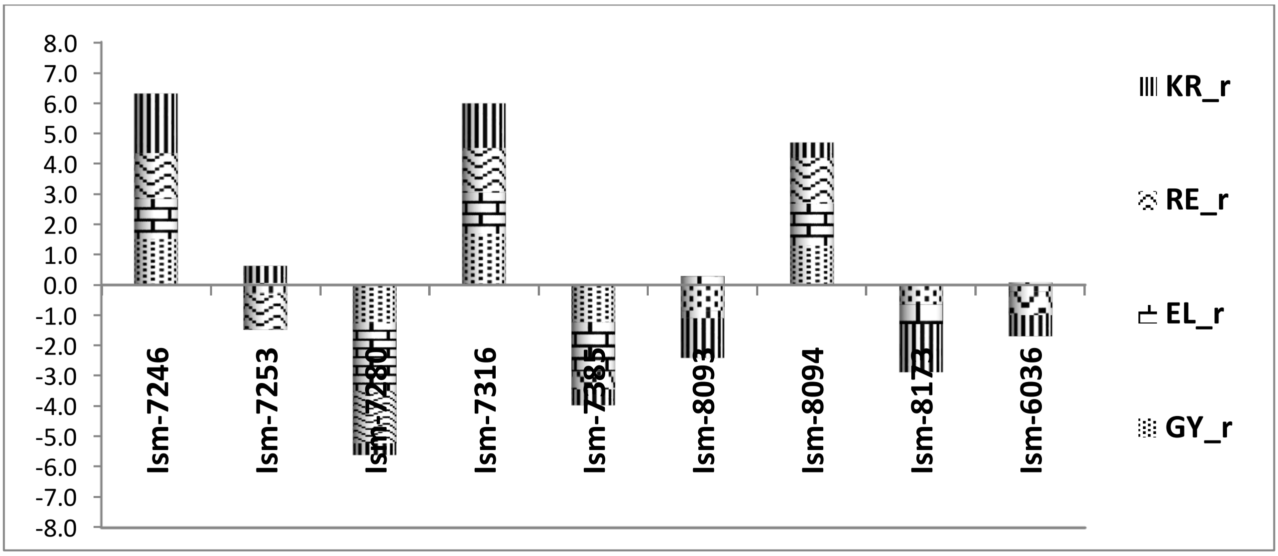

Figure (1): Impact of Yield Components GCA effects on Grain yield GCA effects.

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تقييم القدرة الائتلافية لبعض سلالات الذرة البيضاء الجديدة باستخدام نظام تزاوج السلالة في الكشاف

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أجري هذا البحث بهدف تقييم القدرة الائتلافية لصفة المحصول ومكوناته في بعض سلالات الذرة البيضاء الجديدة باستخدام نظام التزاوج السلالة في الكشاف. ولتحقيق هذا الهدف تم استخدام تسع سلالات بيضاء جديدة من الذرة الشامية وتهجينهم مع ثلاث كشافات (سلالة سدس-34، هجين فردى 10، وهجين فردى 131) وذلك في المزرعة البحثية بمحطة البحوث الزراعية بالإسماعيلية خلال الموسم 2021. تم تقييم الـــــ 27 هجين الناتجة مع اثنين من هجن التجارية المقارنة (هجين فردى 10 وهجين ثلاثي 321) في تجارب محصوليه بنظام القطاعات كاملة العشوائية ذات ثلاث مكررات في ثلاث محطات بحثية وهي: الإسماعيلية، سخا وسدس، وكانت موعد الزراعة في 2022/5/15 في الثلاثة محطات. أظهرت النتائج وجود اختلافات معنوية بين مواقع الدراسة الثلاثة لكل الصفات المدروسة، عدا صفتي عدد السطور بالكوز وعدد الحبوب بالسطر. كانت مربعات القيم للهجن ومجزأتها وكذلك تفاعلها مع المواقع معنوية او عالية المعنوية لمعظم الصفات المدروسة. امتلكت ثلاث سلالات (اسماعيلية 7246، اسماعيلية 7316، اسماعيلية 8094) أفضل قدرة ائتلافية عامة لصفات محصول الحبوب اردب/فدان، طول الكوز، عدد السطور بالكوز وعدد الحبوب بالسطر. اظهرت السلالة سدس 34 أفضل قدرة ائتلافية لصفات طول الكوز، عدد السطر بالكوز، عدد الحبوب بالسطر، بينما اظهر الهجين 131 أفضل قدرة ائتلافية لصفات عدد الأيام حتى ظهور 50 % من الحراير، ارتفاع النبات، ارتفاع الكوز وطول الكوز ناحية التبكير، قصر النبات، أفضلية لموقع الكوز على النبات وزيادة طول الكوز على الترتيب. أكدت النتائج وجد ارتباط قوى بين القدرة العامة على الائتلاف لصفة محصول الحبوب وبين القدرة العامة على الائتلاف لصفات مكونات المحصول. أظهرت السلالات إسماعيلية 7246، إسماعيلية 7316، إسماعيلية 8094 قدرة عامة على التألف موجبة لكل من محصول الحبوب ولصفات مكونات المحصول، بينما اظهرت السلالة 7280 قدرة ائتلافية سالبة لكل من محصول الحبوب ولصفات مكونات المحصول. كما أظهرت الهجن القمية (إسماعيلية 7246 × سدس34)، (إسماعيلية 7316 × سدس34) ، (إسماعيلية 8173 × سدس34) ، (إسماعيلية 7246 × هـ. ف 10)، (إسماعيلية 7280 × هـ. ف 10)، (إسماعيلية 7385 × هـ. ف 10)، و(إسماعيلية 7385 × هــ. ف 131) تأثيرات موجبة ومعنوية لمعظم صفات المحصول ومكوناته. كذلك تفوقا الهجينين القميين (إسماعيلية 7246 × سدس34) و (إسماعيلية 7316 × سدس34) تفوقاً معنويا على هجين المقارنة هـ. ف 10 وكذلك أظهرت الهجن القمية (إسماعيلية 7246 × هــ. ف 10)، (إسماعيلية 7316 × هــ. ف 10) و (إسماعيلية 7316 × هــ. ف 131) تفوقا معنوياً على هجين المقارنة هــ. ث 321، مما يشير إلى أهمية استخدام هذه الهجن الفردية والثلاثية البيضاء كمادة وراثية واعدة للقدرة المحصولية العالية في البرامج المستقبلية في تربية الذرة الشامية.

الكلمات المفتاحية: الذرة الشامية، القدرة على التآلف - التفاعل الجيني، نظام تهجين السلالة في الكشاف، ومحصول الحبوب في الذرة.