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COMBINING ABILITY FOR GRAIN YIELD AND OTHER YIELD COMPONENT TRAITS USING HALF DIALLEL CROSSES OF MAIZE INBRED LINES

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ABSTRACT

Combining ability analysis of cultivars is important to exploit the relevant type of gene action for breeding program. A Half diallel crosses were made among eight parental lines, to produce 28 F_1 hybrids. These hybrids along with the check commercial cross SC 10 were planted at two locations (Sakha and Ismailia Agric. Res. Stns.) to estimate general (GCA) and specific (SCA) combining abilities, type of gene action, and their interactions with locations. The study would show the relative magnitudes of GCA for grain yield and yield component traits (YCTs) and determine the best yielding crosses which could be used in the maize breeding programs. A randomized complete blocks design with four replications was used at each location. General (GCA) and specific (SCA) combining ability variances were estimated for all studied traits according to Griffing's (1956) Method-4, Model-I. There were differences between the two locations (Loc) were significant in the performances of all studied traits, i.e., grain yield (GY), ear length (EL), ear diameter (ED), no of ears 100 plant^{-1} (EP^{-1}), silking date (SD), plant height (PH), ear height (EH) and ear position% (Epos%) at both locations, indicating that these locations differed in their environmental conditions. Evaluation o GCA and SCA indicated that both additive and non additive gene actions were important in controlling all studied traits except for additive gene action for RE^{-1} trait. In general, the additive gene action seemed to be more important than the non additive gene action in the expression of GY, ED, EP^{-1}, SD, PH and Epos%, while, the non additive gene action was more important in the inheritance of EL, RE^{-1} and EH traits. The parental inbred lines P_1 and P_3 had the highest significant positive GCA effects (desirable) for GY, EL and EP^{-1}. The same lines had negative and significant GCA effects (desirable) for silking date toward earliness and ear position%. The inbred lines P_2 and P_5 had negative and significant GCA effects (desirable) for plant height toward shorter plants. Cross with high SCA effects usually comes from two parents possessing high GCA or from one with good GCA and other with poor GCA effects. Desirable SCA effects were obtained for GY between good and poor GCA parents in the crosses (P_1 x P_3), (P_1 x P_4), (P_1 x P_5), (P_2 x P_7), (P_3 x P_4), (P_3 x P_7) and (P_6 x P_8). Three crosses; P_1 x P_4 (35.64 ard/fed.), P_1 x P_5 (34.94 ard/ed.) and P_3 x P_7 (36.41 ard/fed.) were significantly superior than the check SC 10 (29.01 ard/fed) and the increasing percentage for grain yield relative to the check ranged from 20.44% to 25.51%. These single crosses can be recommended in maize breeding and production program for release as new commercial hybrids.

Keywords: Maize, corn, diallel crosses, GCA, SCA.

INTRODUCTION

Maize (*Zea mays* L.) has a remarkable place among cereals. It is used in human food, animal feeding and industry (Keskin *et al.,* 2005). The identification of parental inbred lines that perform superior hybrids is the most costly and time consuming phase in maize hybrid development. Plant breeders and geneticists often use diallel mating designs to obtain genetic information about a trait of interest from a fixed or randomly chosen set of parental lines (Murray *et al.,* 2003). The concept of combining ability was introduced by Sprague and Tatum (1942). Combining ability has a prime importance in plant breeding since it provides information for the selection of parents and also provides information regarding the nature and magnitude of involved gene action. The knowledge of genetic structure and mode of inheritance of different traits helps breeders to employ suitable breeding methodology for their improvement (Kiani *et al.,* 2007). Diallel analysis is has been widely used to determine combining ability, heterotic responses (Bertoia *et al.,* 2006 and Hallauer and Miranda, 1981). Conventional diallel analysis (Griffing 1956) was limited to partitioning total variation into general combining ability (GCA) of the parents and specific combining ability (SCA) of the crosses. GCA is average performance of a parent in a series of crosses and SCA designates those cases in which certain combinations perform relatively better or worse than would be expected on the basis of average performance of lines involved. The GCA includes additive and additive × additive variances, while SCA are responsible for non-additive genetic variances. Most of the literature about maize, the most extensively studied plant species, suggests that additive effects of genes with partial to complete dominance are more important than dominance effects in determining grain yield (Lamkey and Lee 1993). Breeders still contend, however, that dominance effects caused by genes with over dominant gene action are also important (Horner *et al.,* 1989). The presence of additive gene effects for traits indicates the presence of additive variation, which means that selection can be successful for traits (Gamble, 1962 and Fehr, 1991). The significant differences between the combinations of crosses and also significant effect on the general (GCA) and specific (SCA) combining ability, determine the inbreds and their hybrids which could be related. General Combining Ability (GCA) and Specific Combining Ability (SCA) mean square values were statistically significant for plant height, average ear length and weight indicating that additive and non-additive genetic effects control these traits. Vasal *et al.* (1993) were analyzed ten parents in a diallel study in eight environments. The results revealed that GCA effects were highly significant for all traits and SCA effects were significant for silking date and plant height. Genotype × environment interactions and their partitions were significant for grain yield. In other diallel study, genotypes, environment, and genotypes × environment effects were significant for grain yield in the analysis combining yield data from all environments (Mickelson *et al.,* 2001). Singh *et al.* (2002) crossed eight inbred lines in half diallel to estimate heterosis based on the per se performance, heterosis, (P_1 x P_7) was the best hybrid, yielding 14.30% more grain yield followed by (P_4 x P_7) yielded 13.07% over the superior control CM-400xCm-300. Sharief *et al.* (2009) crossed ten new yellow maize inbred lines to three testers to estimate heterosis percentage for all traits relative to the three checks SC 155, TWC 352 as marketable and Gemmeiza Yellow Population (Gem. Y. Pop.). They found that the increasing percentage of grain yield for the seven crosses relative to the three checks ranged from 16.76 to 11.19%, from 11.19 to 40.47% and from 22.02 to 54.15% for relative to the checks, respectively.

The objectives of this investigation were to estimate general and specific combining abilities of eight newly white maize inbred lines, study the type of gene action or the inbred lines and their interactions with locations, and choose superior yielding crosses to could be used in maize breeding programs.

MATERIALS AND METHODS

The materials for this study consisted of newly eight white maize inbred lines developed at Ismailia Agriculture Research Station were isolated from different populations, i.e., Giza-2 (P_1 and P_8), TWC-321 (P_2), A.E.D. (P_3), Comp # 5 (P_5 and P_7), Laposta (P_4 and P_6). Twenty eight crosses excluding reciprocals were made among eight maize inbred lines according to Griffing,s diallel Method-4, Model-I (Griffing,s, 1956) in 2009 growing season. During the 2010 growing season, the 28 F_1's and one white check commercial hybrids SC 10 were evaluated at two locations, Sakha and Ismailia Agric. Res. Stns. A randomized complete blocks design, with four replications was used at each location. The experimental plot traits consisted of one row, 6.0 m long and 0.8 m apart. Sowing was made in hills evenly spaced at 0.25 m along the row. Two kernels hill^{-1} were planted and the seedlings were thinned to one plant hill^{-1} after 21 days from planting. All agricultural field practices were performed as usually recommended for maize cultivation.

Data were recoded for grain yield (GY) ardab/fed (one ardab = 140 kg and one feddan 4200 m^2) adjusted to 15.5% moisture, ear length (EL cm), ear diameter (ED cm), No. of rows ear^{-1} (RE^{-1}), No. of ears 100 plant^{-1} (EP^{-1}), No. of days from planting to 50% silking (SD), plant height (PH cm), ear height (EH) and ear position% (Epos%).

The GLM procedure of SAS (SAS version 6; SAS Institute, 1990) was used. Combining ability analysis was performed for traits that showed statistical differences among crosses. Griffing,s Method-4, Model-I (Griffing's 1956) was employed to determine general combining ability (GCA), specific combining ability (SCA) and their interaction effects with locations.

Useful heterosis could be measured as follows: Useful heterosis = [(F_1-CC/CC)] x 100 where CC is the mean value over replications of the total commercial cultivars. Sometimes, heterosis is worked out over the standard commercial hybrid. Also, it could be measured as follows: Useful heterosis = [(F_1-SH/SH)] x 100 where, SH is the mean value over replications of the local commercial hybrid (Merdith and Bridge, 1972).

RESULTS AND DISCUSSION

Analysis of variances.

Analysis of variance according to Griffing for grain yield and yield component traits for the resultant 28 diallel F_1's at the two locations were given in Table (1). Results revealed that the differences between the two locations were significant or highly significant for all studied traits, i.e., grain yield (GY), ear length (EL), ear diameter (ED), No. of ears 100 plant^{-1} (EP^{-1}), silking date (SD), plant height (PH), ear height (EH) and ear position% (Epos%), indicating that these two locations differed in their environmental conditions. Similar results are reported by Mickelson *et al.,* (2001) for SD and PH traits; Soengas *et al.,* (2003) for EL and RE^{-1} traits; Doerksen *et al.,* (2003) for GY and Zare *et al.,* (2011) for yield and yield component traits. Genotypes mean squares were highly significant for all studied traits except RE^{-1} trait which was only significant. Numerous researchers affirmed similar results among them Aly and Amer (2008) and Abdel-Azeem *et al.,* (2009) for GY, SD, PH, EH, EL and ED traits.

Table (1): Combined analysis of variance according to Griffing' s (1956) Method-IV Model-I for yield and yield components for resultant 28 diallel F_1' s over two locations.

S.O.V.	D.F.	GY (ard/fed)	EL (cm)	ED (cm)	RE^{-1}	EP^{-1}	SD (day)	PH (cm)	EH (cm)	Epos%
Locations	1	847.09*	5.47*	2.68**	46.45**	4819.29**	53.04**	36878.79**	3528.22*	366.69*
Reps/Loc.	6	74.69	0.90	0.12	0.74	131.43	1.08	392.87	683.88	61.34
Genotypes(G)	27	166.90**	7.25**	0.12**	1.03*	703.19**	26.68**	932.47**	448.15**	26.10**
GCA	7	342.62**	5.22*	0.18**	0.62	1624.38**	44.12**	1707.83**	418.83*	27.60*
SCA	20	105.39**	7.97**	0.10**	1.18*	380.78**	20.58**	661.10**	458.41**	25.58**
G x Loc.	27	71.47**	3.77**	0.04	1.00	500.93**	10.46**	489.98*	265.42	18.81*
GCAx Loc.	7	93.46**	2.70	0.05	1.05	936.57**	12.99**	395.37	152.53	12.92
SCA x Loc.	20	182.20**	11.84**	0.10**	2.79**	995.60**	27.35**	1494.54**	871.24**	60.77**
Error	162	25.14	2.04	0.04	0.74	190.80	3.90	334.93	198.94	12.90
GCA/SCA		3.25	0.65	1.77	0.53	4.27	2.14	2.58	0.91	1.08

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

The results showed that the general combining ability (GCA) and specific combining ability (SCA) variances were significant for all studied traits except GCA for RE^{-1} trait, indicating that both additive and non-additive gene action were important in the inheritance of these traits. The present results were inconsistence with those obtained by Zare *et al.,* (2011) for all traits; Alam *et al.,* (2008) for SD; Rezaei and Roohi (2004) for EL and EH; Mousa (2004) for GY, PH, EH, EL and ED; Srdic *et al.,* (2007) for GY and Vacaro *et al.,* (2002) for PH traits.

Genotype x location interactions (G x Loc) were significant for GY, EL, EP^{-1}, SD, PH and Epos%, while they were insignificant for ED, RE^{-1} and EH. GCA x Loc interactions were only significant for GY, EP^{-1} and SD, while SCA x Loc interactions were highly significant for all studied traits. The magnitudes of SCA x Loc were larger than GCA x Loc interactions for all studied traits, indicating that the non-additive components of genetic variation are highly affected by the environment than additive components. Similar results were obtained by El-Rouby *et al.*, (1973) for EP^{-1} and GY, Zare *et al.*, (2001) for SD, PH and RE^{-1} traits; Mousa and Aly (2008) for GY, EH and Epos%, and Bello and Olaoye (2009) for SD and GY traits. The ratio of GCA/SCA was more than unity for GY, ED, SD, EP^{-1}, PH, and Epos% traits. This indicated that the additive gene action played an important role than non-additive gene action in the inheritance of these traits. Meanwhile, the GCA/SCA ratio was less than unity for EL, RE^{-1} and EH traits, indicating that the non-additive gene action played the most important role in the inheritance of these traits. These results are in agreement with those obtained by Mousa and Aly (2008) for GY, EH, and Epos% and Bello and Olaoye (2009) for GY, PH and SD traits.

Mean performances.

Mean performance of the 28 crosses and the check hybrid for yield and yield component traits over the two locations are presented in Table 2. Results showed that, three crosses; P_1 x P_4 (35.64), P_1 x P_5 (34.94) and P_3 x P_7 (36.41 ard/fed) were significantly superior than the commercial hybrid check SC 10 (29.01 ard/fed) for grain yield. Moreover, results revealed that the crosses; P_1 x P_2 (29.33), P_3 x P_4 (29.83), P_3 x P_6 (29.65), and P_6 x P_8 (33.06 ard/fed) did not differ significantly than the check. For EL trait, the crosses P_1 x P_2 (21.90), P_1 x P_5 (21.83), P_3 x P_4 (21.90), P_3 x P_8 (22.08) and P_6 x P_8 (21.85) did not differ significantly than the check (20.40 cm). The crosses ranged from 4.73 (P_5 x P_8) to 5.00 (P_1 x P_5) for ED trait and most crosses were significantly superior compared to check (4.54 cm). For the trait RE^{-1}, P_1 x P_7 (15.15) and P_7 x P_8 (14.80 cm) did not differ significantly than the check (14.80 cm). For EP^{-1} trait, results revealed that the crosses P_1 x P_8 (122.75) and P_3 x P_8 (124.14) were significantly superior compared to the check (109.0), but the crosses, P_1 x P_3 (112.66), P_3 x P_5 (111.88) and P_3 x P_6 (110.25) did not differ significantly.

Data in Table (2) showed that the mean values of days to 50% silking ranged from 58.63 for (P_3 x P_6) to 65.88 day for (P_4 x P_8). The earliest crosses for earliness were P_1 x P_3 (59.75), P_3 x P_5 (59.88), P_3 x P_6 (58.63), P_3 x P_7 (59.24) and P_6 x P_8 (60.38 day) compared to the check (62.88 day). The tallest plant (306.63 cm) was obtained for the cross P_3 x P_8, whereas the shortest plant (269.63 cm) was obtained from the cross P_5 x P_8. The heights for the crosses were: P_5 x P_8 (269.63), P_4 x P_5 (271.13), P_2 x P_5 (271.75), P_5 x P_7 (272.13), P_2 x P_4 (272.38), P_2 x P_3 (277.0), P_3 x P_5 (280.25) and P_4 x P_7 (282.88 cm). All these crosses were shorter compared to the check (304.63 cm). The trait EH trait, ranged from (156.63) for P_5 x P_8 to (184.25 cm) for P_5 x P_6 with a general mean values (169.73). The best crosses were P_5 x P_8 (156.63), P_4 x P_5 (158.25), P_3 x P_6 (160.00), P_2 x P_3 (158.50), P_2 x P_5 (161.50), P_2 x P_4 (162.25), P_2 x P_8 (164.38) and P_1 x P_2 (165.13 cm) for shorter plants compared to the check (181.50 cm). Most the crosses showed low Epos%, but did not differ than the check (59.53%), while the cross $P_1 \times P_2$ (55.64%) was the best for this trait.

Table (2): Mean performance of the 28 diallel F_1' s and the check for yield and yield components over two locations.

Crosses	GY (ard/fed)	EL (cm)	ED (cm)	RE^{-1}	EP^{-1}	SD (day)	PH (cm)	EH (cm)	Epos%
$P_1 \times P_2$	29.33	21.90	4.84	13.73	97.94	61.13	297.38	165.13	55.64
$P_1 \times P_3$	28.64	20.03	4.73	14.63	115.36	59.75	296.75	169.75	57.31
$P_1 \times P_4$	35.64	20.73	4.86	15.48	116.40	63.63	304.88	173.38	56.99
$P_1 \times P_5$	34.94	21.83	5.00	14.25	115.54	63.63	295.25	176.63	59.86
$P_1 \times P_6$	25.76	20.30	4.88	14.23	110.06	64.00	295.50	178.25	60.41
$P_1 \times P_7$	28.39	20.08	4.90	14.88	112.66	63.88	288.38	167.88	58.24
$P_1 \times P_8$	27.88	20.43	4.86	15.20	122.75	64.13	298.75	181.38	60.80
$P_2 \times P_3$	24.15	19.18	4.60	14.60	101.00	62.63	277.00	158.50	57.15
$P_2 \times P_4$	24.50	20.53	4.80	14.58	94.04	63.13	272.38	162.25	59.54
$P_2 \times P_5$	25.46	19.28	4.60	14.58	101.53	64.50	271.75	161.50	59.30
$P_2 \times P_6$	24.88	21.08	4.66	14.63	93.26	65.13	294.50	176.25	59.81
$P_2 \times P_7$	28.65	19.78	4.51	14.50	107.83	64.25	295.63	171.88	57.96
$P_2 \times P_8$	23.49	19.15	4.74	14.33	93.05	63.25	278.75	164.38	58.96
$P_3 \times P_4$	29.83	21.90	4.74	14.48	100.73	61.00	298.75	172.25	57.75
$P_3 \times P_5$	26.18	20.40	4.80	14.80	111.88	59.88	280.25	168.50	60.46
$P_3 \times P_6$	29.65	20.43	4.65	14.85	110.25	58.63	283.13	160.00	56.54
$P_3 \times P_7$	36.41	21.50	4.96	14.45	108.95	59.24	283.63	168.38	59.44
$P_3 \times P_8$	24.00	22.08	4.90	14.60	124.14	65.13	306.63	184.00	60.08
$P_4 \times P_5$	22.73	19.80	4.56	14.68	98.44	63.75	271.13	158.25	58.26
$P_4 \times P_6$	22.24	19.90	4.79	15.33	99.45	64.13	286.88	171.00	59.51
$P_4 \times P_7$	21.15	19.13	4.76	14.28	98.55	64.63	282.88	168.75	59.69
$P_4 \times P_8$	20.35	20.60	4.63	14.58	102.55	65.88	291.88	173.38	59.53
$P_5 \times P_6$	22.78	21.20	4.84	14.40	101.11	64.63	299.13	184.25	61.56
$P_5 \times P_7$	23.69	20.08	4.75	15.15	98.35	64.63	272.13	171.00	64.38
$P_5 \times P_8$	22.02	18.70	4.73	14.73	88.05	63.75	269.63	156.63	57.94
$P_6 \times P_7$	24.95	21.13	4.75	14.55	92.38	63.38	292.38	163.88	56.19
$P_6 \times P_8$	33.06	21.85	4.66	14.48	98.46	60.38	292.75	171.13	58.43
$P_7 \times P_8$	23.74	20.40	4.63	14.80	101.21	64.38	291.38	173.88	59.56
SC-10	29.01	21.78	4.54	14.80	109.00	62.88	304.63	181.50	59.53
LSD 0.05	4.91	1.40	0.19	0.84	13.54	1.94	17.94	13.82	3.52

Combining ability effects.

General combining ability (GCA) effects for the eight maize parental lines based on combined data over two locations are presented in Table (3). The estimates of GCA effects were positive (desirable) for all studied traits except for SD, PH, EH and Epos% traits, which negative estimates (desirable). Results of the GCA effects revealed that the parental inbred lines P_1 and P_3 had the highest significant positive GCA effects for GY, EL and EP^{-1} traits. Furthermore, the inbred lines P_1 and P_4 were the best general combiners for ED and RE^{-1} traits, respectively. On the other hand, the inbred lines (P_1, P_3 and P_6), (P_2 and P_5) and (P_2) had negative and significant GCA effects (desirable) toward earliness, shorter plants and lower ear placement, respectively. The parental P_1, P_2 and P_3 exhibited negative and significant GCA effects for Epos% trait. The previous results, indicated that these parental inbred lines had negative and significant GCA effects (desirable case), indicating that this lines possesses favorable gene (s) for earliness, shorter plants and lower ear placement. Results revealed that the inbred lines P_1 and P_3 had a good GCA effects for grain yield, earliness and some of yield components, and these parental could be used in maize breeding programs.

Table (3): General combining ability (GCA) effects of the eight newly maize inbred lines for yield and yield components traits over two locations.

parents	GY (ard/fed)	EL (cm)	ED (cm)	RE^{-1}	EP^{-1}	SD (day)	PH (cm)	EH (cm)	Epos%
P_1	5.163**	0.324**	0.131**	-0.008	10.290**	-0.422**	9.922**	4.047**	-0.598*
P_2	-3.038**	-0.409**	-0.088**	-0.250**	-6.723**	0.224	-4.995**	-4.703**	-0.743**
P_3	1.981**	0.362**	0.016	-0.004	7.221**	-2.026**	1.464	-1.120	-0.682*
P_4	-1.763**	-0.126	-0.023	0.158*	-3.138**	0.578**	-1.432	-1.474	-0.259
P_5	-2.015**	-0.343**	-0.001	0.025	-2.348*	0.349*	-9.682**	-1.891	1.491**
P_6	0.621	0.424**	-0.009	0.004	-4.000**	-0.401**	4.484**	2.776*	-0.062
P_7	0.565	-0.209	-0.003	0.029	-1.508	0.995**	-1.828	-0.412	0.439
P_8	-1.514*	-0.022	-0.023	0.046	0.206	0.703**	2.068	2.776*	0.415
LSDgi 0.05	0.758	0.216	0.050	0.130	2.089	0.299	2.767	2.133	0.543
0.01	0.997	0.284	0.066	0.171	2.747	0.393	3.640	2.805	0.714

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

Specific combining ability (SCA) effects of 28 crosses for the studied traits over two locations are illustrated in Table (4). It is important to indicate that a high SCA cross usually obtained from two parents possessing high GCA or from one with high GCA and other with poor GCA effects. Desirable SCA effects were obtained for GY between good and poor GCA parents in the crosses (P_1 x P_3), (P_1 x P_4), (P_1 x P_5), (P_2 x P_7), (P_3 x P_4), (P_3 x P_7) and (P_6 x P_8). Similar conclusion was reported by Khristova (1978), El-Khishen 2002 and Abd El-Azeem *et al.,* (2009). The best SCA effects were obtained in the crosses (P_1 x P_2), (P_1 x P_3), (P_1 x P_5), (P_3 x P_4) , (P_3 x P_7), (P_3 x P_8) and (P_6 x P_8) for EL trait; in the crosses (P_1 x P_3), (P_1 x P_5), (P_2 x P_4), (P_2 x P7) and (P_3 x P_7) for ED trait; in the crosses (P_1 x P_4), (P_2 x P_7) and (P_3 x P_7) for RE^{-1} trait; in the crosses (P_1 x P_2), (P_1 x P_8), (P_2 x P_7) and (P_3 x P_8) for EP^{-1} trait. On the other hand, the lowest significant and negative (desirable) SCA effects were obtained from the crosses (P_1 x P_2), (P_1 x P_6), (P_3 x P_5), (P_3 x P_6), (P_3 x P_7) and (P_6 x P_8) for SD toward earliness; in the crosses (P_3 x P_6) and (P_5 x P_8) for plant and ear heights toward shorter plants and lower ear placement. The crosses (P_5 x P_8) and (P_6 x P_7) for Epos% trait, this is trait could be used as one of valuable selection criteria over plant and ear heights in the breeding programs for lower ear placement.

Table (4): Specific combining ability (SCA) effects in a 8 x8 half diallel cross for yield and yield component traits over two locations.

Crosses	GY (ard/fed)	EL (cm)	ED (cm)	RE^{-1}	EP^{-1}	SD (day)	PH (cm)	EH (cm)	Epos%
P_1 x P_2	1.973	1.51**	0.041	-0.649*	9.770*	-1.914**	4.260	8.950*	1.999
P_1 x P_3	3.972**	1.136**	0.146**	0.005	6.290	-1.039	-2.830	-1.900	-0.385
P_1 x P_4	3.011*	0.051	0.001	0.693**	5.110	0.232	8.190	1.070	-1.132
P_1 x P_5	3.563*	1.368**	0.116*	-0.399	3.460	0.461	6.820	4.740	-0.007
P_1 x P_6	-5.248**	-0.924*	-0.001	-0.403	-0.370	-1.586**	-7.100	1.700	2.095*
P_1 x P_7	-2.566	-0.515	-0.175**	-0.222	-0.260	0.065	-7.910	-5.490	-0.580
P_1 x P_8	-2.000	-0.353	-0.001	-0.530*	8.110*	0.607	-1.430	4.820	2.009*
P_2 x P_3	-5.396**	-1.253**	-0.082	0.222	-5.640	1.360*	-7.660	-5.400	-0.399
P_2 x P_4	-0.364	-0.585	0.157**	-0.035	-3.688	-0.914	-9.390	-1.300	-1.565
P_2 x P_5	-1.987	-0.449	-0.066	0.168	4.460	3.690**	-1.760	-1.630	-0.422
P_2 x P_6	-0.935	-0.585	0.005	0.239	-4.150	2.365**	6.820	-8.450*	1.643
P_2 x P_7	5.048**	-0.082	0.151**	0.089	10.920**	-0.205	14.260**	7.260	-0.707
P_2 x P_8	0.813	-0.895*	0.095	0.103	-6.570	-0.914	-6.510	-3.430	0.320
P_3 x P_4	5.379**	1.189**	0.009	0.295	7.500	-0.789	10.730*	5.120	-0.282
P_3 x P_5	0.982	-0.095	0.003	0.147	2.860	-1.685**	0.280	1.780	0.680
P_3 x P_6	1.821	-0.836*	-0.111*	0.218	2.890	-2.185**	-11.010*	-11.380**	-1.693
P_3 x P_7	3.640*	0.872*	0.195**	0.207	-4.952	-1.295*	-4.200	0.180	0.614
P_3x P_8	-1.693	1.260**	-0.153**	-0.074	12.570**	4.211**	14.900**	12.620**	1.072
P_4 x P_5	-1.7	-0.207	-0.168**	-0.171	-7.220	-0.414	-5.950	-7.110	-1.943
P_4 x P_6	-1.848	-0.874*	0.036	0.530*	-5.450	0.711	-4.370	2.030	0.859
P_4 x P_7	-2.879	-1.015*	0.035	-0.545*	-0.940	-0.185	-2.060	0.910	0.534
P_4 x P_8	-1.6	0.272	-0.082	-0.261	-6.340	1.357*	3.050	2.350	0.399
P_5x P_6	0.942	0.643	0.093	-0.291	3.320	1.440*	15.870**	13.640**	1.159
P_5x P_7	-0.089	0.151	-0.151**	0.464	-7.930	1.344*	-4.560	3.570	3.472**
P_5 x P_8	-2.71	-1.445**	-0.005	0.022	-13.950**	-0.539	-10.950*	-13.990**	-3.939**
P_6 x P_7	-1.462	0.435	-0.007	-0.116	-6.260	-0.455	1.530	-8.220*	-3.164**
P_6 x P_8	3.872**	0.972*	0.039	0.207	-1.880	-3.164**	-1.990	-4.150	-0.899
P_7 x P_8	-2.539	0.255	-0.103	0.093	-1.620	-0.560	2.940	1.780	0.262
LSD S_{ij} 0.05	2.93	0.83	0.11	0.50	8.090	1.16	10.72	8.26	2.10
0.01	3.86	1.10	0.14	0.66	10.64	1.52	14.10	10.86	2.76

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

Useful heterosis relative to the check.

Useful heterosis relative to the commercial check for grain yield and yield component traits over to locations are presented in Table (5). Results revealed that the crosses (P_1 x P_4), (P_1 x P_5), and (P_3 x P_7) exhibited significant superiority effects relative to the commercial check and the increasing percentage for grain yield were 22.85%, 20.44%, and 25.51% , respectively. For ED trait, eighteen crosses had significant and superiority effects relative to the check and increasing percentage ranged from 4.13% in the cross (P_1 x P_3) to 10.19% in the cross (P_1 x P_5). The crosses (P_1 x P_8) and (P_3 x P_8) exhibited significant and superior effects relative to the check and increasing percentage were 12.61% and 13.89% for the two crosses, respectively for EP^{-1} trait. On the other hand, four crosses; (P_1 x P_3), (P_3 x P_5), (P_3 x P_6), (P_3 x P_7) and (P_6 x P_8) showed negative and highly significant relative to the check for silking date toward earliness, and percentage of useful heterosis ranged from -6.76% to -3.98%. Results revealed that 12, 11 and 2 single crosses were desirable negative and significant useful heterosis for plant height toward shorter plants, ear height toward lower ear placement and ear position% toward ear low position, respectively. The vales of useful heterosis ranged from (-11.49% to -5.83%) for plant height; from (-13.70% to -7.23%) for ear height, and from (-6.53% to -5.61%) or ear position%. These results are generally analogous to the findings of Revilla *et al.,* (2006), Guimaraes *et al.,* (2007) and Ojo *et al.,* (2007) as they observed a different ratio of values for grain yield and the yield component traits in their F_1,s and Sharief *et al.* (2009) for GY, PH, and EH traits.

Table 5: Useful heterosis relative to check for yield and yield component traits over two locations.

crosses	GY (ard/fed)	EL (cm)	ED (cm)	RE^{-1}	EP^{-1}	SD (day)	PH (cm)	EH (cm)	Epos%
P_1 x P_2	1.10	0.57	6.61**	-7.26**	-10.15	-2.78	-2.38	-9.02*	-6.53*
P_1 x P_3	-1.28	-8.04*	4.13*	-1.18	5.84	-4.97**	-2.59	-6.47	-3.72
P_1 x P_4	22.85**	-4.82	7.16**	4.56	6.79	1.19	0.08	-4.47	-4.26
P_1 x P_5	20.44*	0.23	10.19**	-3.72	6.00	1.19	-3.08	-2.68	0.57
P_1 x P_6	-11.20	-6.77*	7.44**	-3.89	0.98	1.79	-3.00	-1.79	1.49
P_1 x P_7	-2.14	-7.81*	7.99**	0.51	3.36	1.59	-5.33	-7.50*	-2.16
P_1 x P_8	-3.90	-6.20*	7.16**	2.70	12.61*	1.99	-1.93	-0.07	2.14
P_2 x P_3	-16.75	-11.94**	1.38	-1.35	-7.34	-0.40	-9.07**	-12.67**	-3.99
P_2 x P_4	-15.55	-5.74	5.79	-1.52	-13.73*	0.40	-10.59**	-10.61**	0.02
P_2 x P_5	-12.24	-11.48**	1.38	-1.52	-6.86	2.58	-10.79**	-11.02**	-0.38
P_2 x P_6	-14.24	-3.21	2.75	-1.18	-14.44*	3.58*	-3.32	-2.89	0.48
P_2 x P_7	-1.24	-9.18**	-0.55	-2.03	-1.08	2.19	-2.95	-5.30	-2.62
P_2 x P_8	-19.03*	-12.06**	4.41*	-3.21	-14.63*	0.60	-8.49**	-9.43*	-0.94
P_3 x P_4	2.83	0.57	4.41*	-2:20	-7.59	-2.98	-1.93	-5.10	-2.98
P_3 x P_5	-9.76	-6.31*	5.79**	0.00	2.64	-4.77**	-8.00**	-7.16*	1.58
P_3 x P_6	2.21	-6.20*	2.48	0.34	1.15	-6.76**	-7.06*	-11.85**	-5.02
P_3 x P_7	25.51**	-1.26	9.37**	-2.36	-0.05	-5.79**	-6.89*	-7.23*	-0.15
P_3x P_8	-17.27*	1:38	7.99**	-1.35	13.89*	3.58	0.66	1.38	0.92
P_4 x P_5	-21.65*	-9.07**	0.50	-0.84	-9.69	1.39	-11.00**	-12.81**	-2.12
P_4 x P_6	-23.34**	-8.61**	5.56**	3.55	-8.76	1.99	-5.83*	-5.79	-0.02
P_4 x P_7	-27.09**	-12.17**	4.90*	-3.55	-9.59	2.78	-7.14*	-7.02	0.27
P_4 x P_8	-29.85**	-5.40	2.04	-1.52	-5.92	4.77**	-4.18	-4.47	0.00
P_5x P_6	-21.48*	-2.64	6.67**	-2.70	-7.24	2.78	-1.80	1.52	3.42
P_5x P_7	-18.34*	-7.81*	4.68*	2.36	-9.77	2.78	-10.67**	-5.79	8.15**
P_5 x P_8	-24.10**	-14.12**	4.24*	-0.51	-19.22**	1.39	-11.49**	-13.70**	-2.67
P_6 x P_7	-14.00	-2.99	4.68*	-1.69	-15.25*	0.80	-4.02	-9.71*	-5.61*
P_6 x P_8	13.96	0.34	2.70	-2.20	-9.67	-3.98*	-3.90	-5.71	-1.85
P_7 x P_8	-18.17*	-6.31*	2.04	0.00	-7.14	2.39	-4.35	-4.20	0.06
LSD 0.05	4.91	1.40	0.19	0.84	13.54	1.94	17.94	13.82	3.52
0.01	6.46	1.84	0.24	1.11	17.81	2.55	23.59	18.18	4.63

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

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القدرة على التآلف لصفة محصول الحبوب وصفات المحصول الأخرى باستخدام تهجين نصف دورى بين عدد من سلالات الذرة الشامية

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يعتبر تقدير القدرة على الإئتلاف للتراكيب الوراثية من العوامل الهامة لمعرفة نوع الفعل الجينى فى برامج التربية. وعلى ذلك فلقد تم عمل تهجين نصف دورى بين ثمانية سلالات أبوية نتج عنها ٢٨ هجين. تم زراعة الهجن الناتجة مع الهجين الفردى١٠ كمقارنة فى موقعين هما (محطتى البحوث الزراعية بسخا والإسماعيلية) لحساب كلا من القدرة العامة والخاصة على التآلف ومعرفة اهمية الفعل الجينى المؤثر على صفة محصول الحبوب وبعض الصفات المحصولية والتعرف على ايا من التراكيب الوراثية عالية المحصول ويمكن إستخدامها فى برنامج تربية الذرة الشامية. تم تنفيذ التجربة فى تصميم القطاعات الكاملة العشوائية ذات لأربع مكررات وتم تقدير القدرة العامة والخاصة على التآلف بإستخدام النموذج الرابع والموديل الأول لجريفنج ١٩٥٦

وتتلخص أهم النتائج المتحصل عليها فيما يلى :

١ – كان التباين الراجع للمواقع معنويا لجميع الصفات المدروسة وهى : محصول الحبوب (أردب/فدان) ، طول الكوز (سم) ، قطر الكوز (سم) ، عدد السطور بالكوز ،عدد الكيزان/١٠٠ نبات ، عدد الأيام حتى ظهور ٥٠% من نورات الحراير المؤنثة ، إرتفاع النبات (سم) ، إرتفاع الكوز (سم) والنسبة المئوية لموقع الكوز على النبات وإتضح من معنوية هذا التباين إختلاف كلاً من سخا والإسماعيلية كمواقع بيئية.

٢ – تبين من حساب تأثير الفعل الجينى المضيف والفعل الجينى غير المضيف أن لهما دوراً مهما فى وراثة جميع الصفات المدروسة فيما عدا صفة عدد السطور بالكوز بالنسبة للفعل الجينى المضيف. علاوة على ذلك فلقد تبين أن الفعل الجينى المضيف كان أكثر أهمية فى وراثة صفات محصول الحبوب ، قطر الكوز ، عدد الكيزان/١٠٠ نبات ، عدد الأيام حتى ظهور ٥٠% من نورات الحراير المؤنثة ، إرتفاع النبات ، والنسبة المئوية لموقع الكوز على النبات بينما الفعل الجينى غير المضيف كان أكثر أهمية فى وراثة صفات طول الكوز ، عدد السطور بالكوز و إرتفاع الكوز.

٣ – أظهرت النتائج أن أفضل السلالات (١ و ٣) والتى تمتلك قدرة إئتلاف عامة موجبة (مرغوبة) ومعنوية لصفة المحصول وطول الكوز وعدد الكيزان لكل ١٠٠ نبات وكذلك إمتلاكها قدرة إئتلاف سالبة ومعنوية (مرغوبة) لصفة التبكير والنسبة المئوية لأفضلية موقع

الكوز على النبات. بينما إمتلكت السلالات (٢ ، ٥) قدرة إئتلاف سالبة ومعنوية تجاة قصر النبات. وبذلك يوصى بإستخدام هذه السلالات فى برامج تربية الذرة الشامية لتحسين مثل هذه الصفات.

٤ – أظهرت النتائج إنه غالبا ما تأتى الهجن العالية القدرة الخاصة على التآلف بين ابوين إما كلاهما يمتلك قدرة عامة على التآلف عالية أو على الأقل أحدهما يمتلك القدرة العامة على التآلف العالية الموجبة والمعنوية وتأكيداً لذلك فإن الهجن (١ X ٣) ، (١ X ٤) ، (١ X ٥) ، (٢ X ٧) ، (٣ X ٤) ، (٣ X ٧) و (٦ X ٨) إمتلكت قدرة خاصة على التآلف موجبة ومعنوية لصفة محصول الحبوب. على الجانب الآخر إمتلكت الهجن (١ X ٢) ، (١ X ٦) ، (٣ X ٥) ، (٣ X ٦) ، (٣ X ٧) و (٦ X ٨) قدرة إئتلاف خاصة سالبة ومعنوية تجاة التبكير فى حين إمتلكت الهجن (٣ X ٦) و (٥ X ٨) قدرة إئتلاف عامة سالبة ومرغوبة لصفات إرتفاع النبات فى إتجاة قصر النبات وصفة إرتفاع الكوز ناحية أفضلية موقع الكوز على النبات.

٥ – أظهرت النتائج المتحصل عليها تفوق ثلاثة هجن فردية وهى ١ X ٤ (٣٥,٦٤ أرد/فدان) ، ١ X ٥ (٣٤,٩٤ أرد/فدان)، ٣ X ٧ (٣٦,٤١ أردب/فدان) تفوقا معنويا لصفة محصول الحبوب على هجين المقارنه هجين فردى١٠ (٢٩,٠١ أردب/فدان) وكانت نسبة الزيادة (قوة الهجين المفيدة) مقارنة هجين المقارنة تترلوح ين ٢٠,٤٤% إلى ٢٥,٥١% زيادة موجبة ومعنوية لصفة محصول الحبوب. ويوصى بإستخدام هذه الهجن فى برامج التربية وإنتاج الذرة الشامية لإمتلاكها لصفات المحصول العالى وبعض مكونات المحصول إلى جانب الأفضلية فى صفة التبكير.

قام بتحكيم البحث

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