II.8 COMBINING ABILITY ESTIMATES FOR GRAIN YIELD AND ITS COMPONONTS OF WHITE MAIZE INBRED LINES

El-REFAEY, R.A.[1], A.M. SHEHATA[2] and A.M. ABU SHOSHA[2]

1. *Agronomy Dep., Fac. Agric., Tanta Univ. Egypt.*
2. *Maize Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.*

Abstract

Six white maize (Zea mays L.) inbred lines were crossed in a half diallel mating scheme at Gemmeiza Agric. Res. Stn. in 2009 season. In 2010 season, the resulting 15 crosses along with three check hybrids.; SC 10, SC 128 and SC 129 were evaluated at Gemmeiza and Mallawy Agric. Res. Stations. General combining ability (GCA) and specific combining ability (SCA) effects were estimated according to Griffing (1956) model 1, method 4. Location mean squares were highly significant for ear diameter and 100-Kernel weight, while crosses and cross x location interaction mean squares were highly significant for all traits. Mean squares due to GCA and SCA were significant revealing that both additive and non-additive types of gene effect were involved in the inheritance of the studied traits. GCA/SCA mean square exceeded the unity for no. of rows ear^{-1} at Mallawy and combined data, no. of kernels row^{-1} at Gemmeiza and grain yield at Gemmeiza and combined data, indicated the predominance of additive (a) and (aa) gene effects in the genetic variance of these cases, while the same ratio mean squares were less than unity for the rest of the cases indicating that non-additive genes played an important role in the inheritance of these traits. 'P3' was considered as a good general combiner for 100-kernel weight at Gemmeiza. The cross; P2 x P5 had significant inter-and intra-allelic interactions for no. of kernels row^{-1}, 100-kernel weight and grain yield at both locations. The crosses; P2 x P5, P3 x P4 and P3 x P6 were superior to the three check hybrids for 100-kernel weight and grain yield.

Keywords: *Zea mays* L., GCA, SCA, diallel crosses, gene effect.

INTRODUCTION

Maize *(Zea mays* L.) is one of the three most important cereal crops in Egypt. It can play major role in decreasing the short of grain supply. It is grown in about 2.0 million feddans (one feddan = 4200 m^2) which produce about 6.7 million t of grain with an average of about 24 ard. fed.$^{-1}$ (one ardab = 140 kg). Therefore, the strategy of maize breeding programs aims to increase production through release new high-yielding hybrids.

Diallel mating design has utility as a method to crosses or parents with crosses for general combining ability (GCA) due to additive type of gene action and specific combining ability (SCA), (Griffing, 1956).

Diallel analysis has been used primarily to estimate general and specific combining ability effects from crosses of fixed set of parent. Hallauer and Miranda

(1981) stated that both GCA and SCA effects should be taken into consideration when planning for maize breeding programs to produce and release new inbred lines and crosses. Several investigators studied the general and specific combining ability and their role in the inheritance of grain yield, yield components and agronomic characteristics.

The conventional crop breeding methodology mainly depends upon the development of inbred lines from open pollinated cultivars or other heterogeneous sources and the evaluation of these lines through different techniques and the selection of the best hybrids for commercial use.

Griffing (1956) gave a complete analysis of diallel crosses for fixed and random set of parents. El-Shamarka (1995), Mostafa et al. (1996), Abd El-Aty and Katta (2002) and Ibrahim et al. (2010) reported that specific combining ability effects were much more important in the inheritance of grain yield and its components. Meanwhile, El-Hosary et al. (1999), Abd El-Moula (2005), Derera et al. (2008), Vivek et al. (2010) and Sibiya et al. (2011) reported that general combining ability was more important in determining yield and other characters. El-Hosary and Sedhom (1990), Mohamed (1993) and Sedhom (1994) concluded that the additive genetic variance was more affected by genotype x environment interaction than the non-additive one for grain yield per plant. On the contrary, Nawar et al. (2002), El-Hosary et al. (2006) and Sedhom et al. (2007) reported that the non-additive effects were more affected by the interaction with environments than the additive effects for grain yield. The present study was planned to: 1) obtain information on relative importance of general and specific combining ability for maize grain yield, and some agronomic traits and 2) to identify the best promising crosses.

MATERIALS AND METHODS

Six white maize (*Zea mays* L.) inbred lines with a wide range of diversity for several traits (Table 1) were crossed in a half diallel mating scheme in 2009 season at Gemmeiza Agric. Res. Station giving a total of 15 crosses. In 2010 season, these 15 crosses along with three commercial check hybrids; i.e., SC10, SC128 and SC129; were evaluated in a randomized complete block design experiment with four replications at two locations, i.e. Gemmeiza and Mallawy Agricultural Research Stations, representing Delta and Upper Egypt regions, respectively.

Table 1. Name and pedigree of the six white inbred lines.

Parent	Name	Pedigree
P_1	Gm. 80	(AED.)
P_2	Gm. 140	(Tep. # 5)
P_3	Gm. 150	(Gm.W.Pop.)
P_4	Gm. 152	(Laposta)
P_5	Gm. 165	(Gz. 2 – Ev. 60)
P_6	Gm. 210	(Tuxpino)

The experimental plot was one ridge of 6-m length and 0.80-m width. Sowing was done in hills evenly spaced by 25 cm at the rate of two kernels per hill on one side of the ridge. Seedlings were thinned to one plant per hill. Agricultural practices were applied as recommended for maize cultivation. Data were recorded for ear diameter (cm), number of rows ear^{-1}, number of kernels row^{-1}, 100–kernel weight (g) and grain yield (ard. fed.$^{-1}$) adjusted to 15.5% moisture content. Analysis of variance for randomized complete block design was performed according to the method outlined by Snedecor and Cochran (1967) for each location, and for the combined performance across locations.

The L.S.D. test at 0.05 and 0.01 level of probability according to Steel and Torrie (1980) was used for comparisons of the mean performance of genotypes. General GCA and specific SCA combining ability effects were estimated according to Griffing (1956) model I, method 4. Superiority percentage for all characteristics under study was computed for individual crosses as the percentage of increase of each cross relative to the three checks as follows:

Superiority over check $\left[(F_1 - \text{check}) \;/\; \text{check}\right] \text{x } 100$

The value of F_1-check compared with least significant difference (L.S.D) at 0.05 and 0.01 levels of probability was used to determine level of significance where:

$$\text{L.S.D}_{\substack{0.05\\0.01}} = t_{\substack{0.05\\0.01}} \sqrt{\frac{2\text{M.S error}}{r}}$$

RESULTS AND DISCUSSION

The analysis of variance for the five studied traits, in each location and their combined data are presented in Table 2. Results indicated that location mean squares were significant for ear diameter and 100–kernel weight. This result revealed overall differences between the two growing locations.

Significant differences were detected among the crosses for all traits in each location performance as well as the combined performance with one exception, i.e., at Gemmeiza for ear diameter, indicating wide diversity between the crosses used in this study. Highly significant mean squares of crosses x locations interaction were found for all traits, except for ear diameter indicating that the crosses responded differently from location to another for most traits. These results are in agreement with those reported by El-Shamarka (2000), Ogunbodede et al. (2000), Osman et al. (2012), Abd El-Mottalb and Gamea (2014), Mousa (2014) and Osman (2014).

Combining ability

Analysis of variance

Analyses of variance of combining ability, as outlined by Griffng (1956) model 1, method 4, at each location and their combined data for all traits are shown in Table 3. Mean squares associated with GCA and SCA were significant for most traits at both locations as well as the combined performance, except for mean squares associated with GCA for ear diameter, combined data and no. of rows ear^{-1} at Gemmeiza. Mean squares associated with SCA were significant for all traits, except for ear diameter at Gemmeiza and the combined analysis and no. of rows ear^{-1} at Mallawy and the combined analysis.

The GCA/SCA mean square ratio was more than unity for no. of rows ear^{-1} at Mallawy and the combined data, no. of kernels row^{-1} at Gemmeiza, grain yield at Gemmeiza and the combined analysis. These results indicated the importance of additive and additive x additive gene action in the inheritance of these traits. These results were in agreement with those reported by El-Shamarka (2000), Ogunbodede et al. (2000), Osman et al. (2012), Abd El-Mottalb and Gamea (2014), Mousa (2014) and Osman (2014).

Table 2. Mean square of white maize crosses for the five studied traits under two locations and their combined, 2010.

S.O.V.	d.f.		Ear Diameter			No. of Rows ear^{-1}			No. of Kernels row^{-1}		
	Single	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb
Loc.		1			36.7401**			0.021			2.351
Rep/Loc.		6			0.174**			1.355**			6.700**
Crosses	14	14	0.068	0.119*	0.131**	2.357**	1.092**	1.329**	30.405**	13.274**	26.927**
Crosses x Loc.		14			0.056			2.119**			16.7561**
Error	42	84	0.054	0.046	0.050	0.510	0.366	0.438	2.888	1.037	1.962

Table 2. Cont'd

S.O.V.	d.f.		100-kernel weight (g)			Grain yield		
	Single	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb
Loc.		1			1034.881**			0.120
Rep/Loc.		6			2.406			0.757
Crosses	14	14	96.952**	21.302**	71.281**	185.937**	97.617**	219.835**
Crosses x Loc.		14			46.973**			63.719**
Error	42	84	3.524	2.337	2.930	11.114	6.504	8.809

Gm.= Gemmeiza, Mal. = Mallawy, single= single analysis of variance, Comb=Combined analysis of variance.

On the other hand, the ratio of GCA/SCA mean squares was less than unity for ear diameter at Mallawy and the combined data, no. of rows ear^{-1} at Gemmeiza, 100-kernel weight at both locations and their combined analysis and grain yield (ard. fed.$^{-1}$) at Mallawy, indicating the predominance of the non-additive genetic variance in the inheritance of these traits. However, the ratio of GCA/SCA was equal one for no. of kernels row^{-1} at Mallawy, indicating that both additive and non-additive gene effects were involved in the inheritance of the trait.

The ratio of GCA x Loc./SCA x Loc. mean squares exceeded the unity for no. of kernels row^{-1} and grain yield (ard. fed.$^{-1}$), indicating that the additive and additive x additive gene effects were more affected by locations than the non-additive effects for these traits. However, the same ratio was less than unity for no. of rows ear^{-1} and 100-kernel weight, indicating that non-additive gene effects interacted with locations more than the additive effects for these traits.

The ratio of GCA x Loc.1/GCA xLoc.2 mean squares was more than unity for all traits, except ear diameter and no. of rows ear^{-1}, indicating that the first location (Gemmeiza) was more suitable for estimating additive and additive x additive genetic variance than the second one (Mallawy). The opposite case would be concluded for the rest of the studied traits where the ratio was less than one.

The ratio of SCA x Loc.1/SCA xLoc.2 mean squares was more than unity for no. of rows ear^{-1}, no. of kernels row^{-1}, 100-kernel weight and grain yield (ard. fed.$^{-1}$), indicating that the first location (Gemmeiza) was more favorable for estimating non-additive genetic variance than the second one (Mallawy) for these traits, the opposite would be concluded for the rest of the studied traits where the ratio was less than one.

The above-mentioned results were in the same trend with those reported by Dawood et al. (1994) where they found that SCA x location interaction mean squares were higher than GCA x location interaction, indicating that non-additive gene action was more interacted with locations than additive one for all traits. EL-Shamarka (1995) found that the ratio of GCA x N/SCA x N was more than unity for ear diameter, no. of rows ear^{-1}, no. of kernels row^{-1}, ear and grain yield (ard. fed.$^{-1}$). Mosa et al. (2006) indicated that the magnitude of GCA x location interaction was higher than that of SCA x location interaction, indicating that additive gene action appeared to be more affected by environments than non-additive one. Motawei (2006) found that mean squares due to GCA x loc. were higher than those due to SCA x Loc. for all the studied traits, indicating that the additive gene action was more affected by environments than non-additive one. Abd El-Mottalb and Gamea (2014) found that, the ratio of SCA x L/SCA was higher than that of GCA x L/GCA for most traits. Mousa (2014) reported that the magnitude of SCA x L interaction mean square was larger than GCA x L ones for all traits and Osman (2014) found that the magnitude of the interaction variance was higher for GCA x L than SCA x L for all studied traits.

Table 3. Analysis of variance for combining ability of white maize crosses for the five studied traits under two locations and their combined, 2010.

S.O.V.	d.f.		Ear diameter			No. of rows ear^{-1})			No. of kernels row^{-1}		
	single	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb
G.C.A.	5	5	0.017	0.026*	0.010	0.287	0.462**	0.261**	10.367**	3.380**	2.970**
S.C.A.	9	9	0.017	0.032**	0.020	0.757**	0.168	0.114	6.065**	3.284**	3.586**
G.C.A. x Loc.		5			0.032*			0.488**			10.777**
S.C.A. x Loc.		9			0.029*			0.812**			5.763**
Error term	42	84	0.013	0.011	0.013	0.128	0.092	0.110	0.722	0.259	0.491
G.C.A./ S.C.A			1.000	0.813	0.500	0.379	2.750	2.289	1.709	1.029	0.828
G.C.A x Loc/ S.C.A x Loc					1.103			0.601			1.870
G.C.AxLoc1/G.C.A x Loc2			0.654					0.621			
S.C.AxLoc1/S.C.A x Loc2			0.531					4.506			

Table 3. Cont'd

S.O.V.	d.f.		100–kernel weight (g.)			Grain yield		
	single	Comb	Gm.	Mal.	Comb	Gm.	Mal.	Comb
G.C.A.	5	5	17.554**	3.879**	8.059**	79.055**	22.293**	39.189**
S.C.A.	9	9	27.951**	6.129**	9.383**	28.390**	25.577**	20.974**
G.C.A. x Loc.		5			13.375**			62.158**
S.C.A. x Loc.		9			24.697**			32.993**
Error term	42	84	0.881	0.584	0.733	2.779	1.626	2.202
G.C.A./ S.C.A			0.628	0.633	0.859	2.785	0.872	1.868
G.C.A x Loc/ S.C.A x Loc					0.542			1.884
G.C.AxLoc1/G.C.A x Loc2			4.525					3.546
S.C.AxLoc1/ S.C.A x Loc2			4.560					1.109

General combining ability effects ($\hat{g}_i$)

Estimates of general combining ability effects of the six white maize inbred lines for the five studied traits at Gemmeiza and Mallawy and the combined performance are shown in Table 4. The first inbred line (P_1) was considered as a good combiner for no. of kernels row^{-1} at Gemmeiza. The inbred line (P_2) behaved as a good combiner for grain yield (ard. fed.$^{-1}$) at Mallawy according to its significant effects ($\hat{g}_i$). The inbred line (P_3) had high significant effects ($\hat{g}_i$) in the positive direction for 100-kernel weight and grain yield (ard. fed.$^{-1}$) at the two locations and their combined data and no. of kernels row^{-1} at Mallawy. The inbred line (P_4) had significant effects ($\hat{g}_i$) in a positive value for no. of kernels row^{-1} at Gemmeiza. The inbred line (P_5) was considered as a good combiner for no. of kernels row^{-1} at both locations and their combined data, for no. of rows ear^{-1} at Mallawy and the combined analysis, and for weight of 100-kernels at Gemmeiza and the combined data, hence exhibited high significant positive effects ($\hat{g}_i$) at all mentioned cases. Inbred line (P_6) did not show any significant ($\hat{g}_i$) effects for any of the traits at either location, accordingly was considered as a poor combiner. Meanwhile, the inbred lines (P_3) and (P_5) were considered as good combiners for grain yield and some of its components. These results are in good agreement with those reported by Zellake (2000), Singh et al. (2002), Barakat et al. (2003), Singh et al. (2010), Osman et al. (2012), Abd El-Mottalb and Gamea (2014), Mousa (2014) and Osman (2014), where they came up with similar conclusions with different genetic materials.

Specific combining ability effects ($\hat{s}_{ij}$)

Estimates of specific combining ability effects ($\hat{s}_{ij}$) of the crosses for all traits at separate locations and their combined performance are presented in Table 5. Desirable significant effects ($\hat{s}_{ij}$) were detected for all traits. For ear diameter, the crosses ($P_1 \times P_6$) and ($P_3 \times P_4$) expressed desirable significant ($\hat{s}_{ij}$) at Mallawy only. For number of rows ear^{-1}, the crosses ($P_2 \times P_4$), ($P_2 \times P_5$) and ($P_3 \times P_6$) expressed desirable significant ($\hat{s}_{ij}$) at only Gemmeiza, for number of kernels row^{-1}, the crosses ($P_1 \times P_6$), ($P_2 \times P_5$) and ($P_4 \times P_5$) showed positive significant ($\hat{s}_{ij}$), at both Gemmeiza and Mallawy and their combined performance, meanwhile, the crosses ($P_1 \times P_2$) and ($P_4 \times P_6$) exhibited similar significant positive ($\hat{s}_{ij}$) for same trait but only at Gemmeiza. Regarding 100-kernel weight, only cross ($P_2 \times P_5$) showed significant ($\hat{s}_{ij}$) in the positive direction at both locations and combined performance, while three crosses; ($P_1 \times P_3$), ($P_3 \times P_4$) and ($P_4 \times P_5$) exhibited significant positive ($\hat{s}_{ij}$) at one of either locations in addition to the combined performance. Also, four crosses expressed significant desirable ($\hat{s}_{ij}$) at only one of either locations; i.e. ($P_1 \times P_2$), ($P_3 \times P_6$) and ($P_5 \times P_6$) at Gemmeiza, and ($P_3 \times P_4$) at Mallawy.

Table 4. Estimate of general combining ability effects of 6 white maize inbred lines for the five traits at two locations and their combined data, 2010.

Parents	Ear diameter			No. of rows ear^{-1}			No. of kernels row^{-1}			100–kernel weight (g)			Grain yield		
	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.
P_1	0.07	-0.11*	-0.02	-0.01	-0.15	-0.08	0.97*	-1.80**	-0.42	-2.91**	-1.65**	-2.28**	-2.19**	-3.39**	-2.79**
P_2	-0.07	-0.08	-0.07	-0.39	-0.22	-0.30*	-3.02**	0.13	-1.44**	-1.84**	0.04	-0.90*	0.76	1.71**	0.47
P_3	-0.07	0.08	0.01	0.19	-0.40**	-0.12	0.42	0.81**	0.62	2.31**	1.23**	1.77**	7.22**	3.46**	5.34**
P_4	-0.04	-0.01	-0.03	-0.25	0.05	-0.10	0.92*	0.18	0.55	-0.02	0.23	0.11	-6.26**	-0.70	-3.48**
P_5	0.06	0.06	0.06	0.28	0.56**	0.42**	1.26**	0.47*	0.86**	2.15**	-0.46	0.85*	0.72	-1.01	-0.15
P_6	0.05	0.06	0.05	0.19	0.17	0.18	-0.55	0.21	-0.17	0.30	0.60	0.45	1.27	-0.07	0.61
LSD 0.05 (gi)	-	0.10	-	-	0.28	0.30	0.78	0.47	0.64	0.87	0.71	0.78	1.54	1.18	1.35
LSD 0.01 (gi)	-	-	-	-	0.37	0.40	1.05	0.63	0.84	1.16	0.94	1.03	2.06	1.57	1.78
LSD 0.05(gi - gj)	-	0.15	-	-	0.43	0.47	1.21	0.73	0.99	1.34	1.09	1.20	2.38	1.82	2.09
LSD 0.01(gi - gj)	-	-	-	-	0.58	0.62	1.62	0.97	1.30	1.79	1.46	1.59	3.19	2.44	2.76

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

Table 5. Estimates of specific combining ability effects of 15 white maize crosses for five studied traits at two locations and their combined performance, 2010.

Cross	Ear diameter			No. of rows ear^{-1}			No. of kernels row^{-1}			100–kernel weight (g)			Grain yield		
	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.
$P_1 * P_2$	-0.01	-0.12	-0.07	-0.63*	-0.18	-0.41	2.03**	-0.71	0.66	2.08**	-0.71	0.69	-0.44	2.97**	-0.26
$P_1 * P_3$	-0.21	-0.02	-0.12	0.20	-0.05	0.08	-0.41	-0.54	-0.47	7.73**	0.10	3.91**	2.86*	3.51**	0.61
$P_1 * P_4$	0.07	0.12	0.10	0.53	0.01	0.27	-2.41**	0.74	-0.83	-4.89**	1.10	-1.91**	2.78*	1.15	-0.29
$P_1 * P_5$	-0.08	-0.21*	-0.15	0.51	-0.11	0.20	-2.39**	-2.40**	-2.41**	-2.89**	-3.21**	-3.05**	-6.37**	-11.23**	-0.22
$P_1 * P_6$	0.23	0.24**	0.24	-0.61*	0.33	-0.14	3.17**	2.91**	3.04**	-2.04**	2.73**	0.35	1.17	3.60**	0.16
$P_2 * P_3$	0.08	-0.06	0.01	-0.43	0.52	0.04	1.08	0.48	0.78	-3.09**	-1.84**	-2.46**	-0.32	-3.89**	0.28
$P_2 * P_4$	-0.05	0.03	-0.01	1.11**	-0.03	0.54	-0.92	-1.80**	-1.36*	-0.09	-2.09**	-1.09	-2.26*	-0.23	-0.01
$P_2 * P_5$	0.06	0.10	0.08	0.58*	-0.55	0.02	1.75*	2.41**	2.08**	5.07**	4.60**	4.84**	8.15**	2.87**	-0.34
$P_2 * P_6$	-0.08	0.05	-0.02	-0.63*	0.24	-0.19	-3.94**	-0.38	-2.16**	-3.98**	0.04	-1.97**	-5.14**	-1.72	0.32
$P_3 * P_4$	0.11	0.18*	0.14	-0.37	-0.30	-0.33	-0.36	0.28	-0.04	1.16	1.48*	1.32*	3.40*	-0.25	0.04
$P_3 * P_5$	0.06	0.05	0.05	-0.69*	0.44	-0.13	-0.44	0.69	0.12	-8.46**	0.66	-3.90**	-6.53**	1.74	-0.59
$P_3 * P_6$	-0.03	-0.15	-0.09	1.30**	-0.62	0.34	0.12	-0.90*	-0.40	2.67**	-0.40	1.13	0.59	-1.12	-0.34
$P_4 * P_5$	-0.02	-0.06	-0.04	-0.81**	0.24	-0.28	2.06**	0.86*	1.46**	3.37**	-0.09	1.64*	-1.28	3.35**	0.78
$P_4 * P_6$	-0.11	-0.26**	-0.18	-0.47	0.08	-0.19	1.62*	-0.08	0.77	0.45	-0.40	0.02	-2.64*	-4.03**	-0.52
$P_5 * P_6$	-0.01	0.12	0.05	0.41	-0.03	0.19	-0.97	-1.56**	-1.27*	2.90**	-1.96**	0.47	6.03**	3.27**	0.38
LSD 0.05 (Sij)	-	0.17	-	0.56	-	-	1.33	0.79	1.08	1.47	1.19	1.32	2.61	1.99	-
LSD 0.01 (Sij)	-	0.22	-	0.75	-	-	1.78	1.07	1.43	1.97	1.60	1.74	3.49	2.67	-
LSD 0.05 (Sij-Sik)	-	0.27	-	0.88	-	-	2.10	1.26	1.71	2.32	1.89	2.09	4.13	3.16	-
LSD 0.01(Sij-Sik)	-	0.35	-	1.18	-	-	2.81	1.69	9.29	3.11	2.53	2.76	5.52	4.22	-
LSD 0.05 (Sij-Ski)	-	0.22	-	0.72	-	-	1.72	1.03	1.39	1.90	1.55	1.70	3.37	2.58	-
LSD 0.01(Sij- Ski)	-	0.29	-	0.79	-	-	2.30	1.38	1.84	2.54	2.07	2.25	4.51	3.45	-

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

Table 5. Estimates of specific combining ability effects of 15 white maize crosses for five studied traits at two locations and their combined performance, 2010.

Cross	Ear diameter			No. of rows ear^{-1}			No. of kernels row^{-1}			100–kernel weight (g)			Grain yield		
	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.	Gm.	Mal.	Comb.
$P_1 * P_2$	-0.01	-0.12	-0.07	-0.63*	-0.18	-0.41	2.03**	-0.71	0.66	2.08**	-0.71	0.69	-0.44	2.97**	-0.26
$P_1 * P_3$	-0.21	-0.02	-0.12	0.20	-0.05	0.08	-0.41	-0.54	-0.47	7.73**	0.10	3.91**	2.86*	3.51**	0.61
$P_1 * P_4$	0.07	0.12	0.10	0.53	0.01	0.27	-2.41**	0.74	-0.83	-4.89**	1.10	-1.91**	2.78*	1.15	-0.29
$P_1 * P_5$	-0.08	-0.21*	-0.15	0.51	-0.11	0.20	-2.39**	-2.40**	-2.41**	-2.89**	-3.21**	-3.05**	-6.37**	-11.23**	-0.22
$P_1 * P_6$	0.23	0.24**	0.24	-0.61*	0.33	-0.14	3.17**	2.91**	3.04**	-2.04**	2.73**	0.35	1.17	3.60**	0.16
$P_2 * P_3$	0.08	-0.06	0.01	-0.43	0.52	0.04	1.08	0.48	0.78	-3.09**	-1.84**	-2.46**	-0.32	-3.89**	0.28
$P_2 * P_4$	-0.05	0.03	-0.01	1.11**	-0.03	0.54	-0.92	-1.80**	-1.36*	-0.09	-2.09**	-1.09	-2.26*	-0.23	-0.01
$P_2 * P_5$	0.06	0.10	0.08	0.58*	-0.55	0.02	1.75*	2.41**	2.08**	5.07**	4.60**	4.84**	8.15**	2.87**	-0.34
$P_2 * P_6$	-0.08	0.05	-0.02	-0.63*	0.24	-0.19	-3.94**	-0.38	-2.16**	-3.98**	0.04	-1.97**	-5.14**	-1.72	0.32
$P_3 * P_4$	0.11	0.18*	0.14	-0.37	-0.30	-0.33	-0.36	0.28	-0.04	1.16	1.48*	1.32*	3.40*	-0.25	0.04
$P_3 * P_5$	0.06	0.05	0.05	-0.69*	0.44	-0.13	-0.44	0.69	0.12	-8.46**	0.66	-3.90**	-6.53**	1.74	-0.59
$P_3 * P_6$	-0.03	-0.15	-0.09	1.30**	-0.62	0.34	0.12	-0.90*	-0.40	2.67**	-0.40	1.13	0.59	-1.12	-0.34
$P_4 * P_5$	-0.02	-0.06	-0.04	-0.81**	0.24	-0.28	2.06**	0.86*	1.46**	3.37**	-0.09	1.64*	-1.28	3.35**	0.78
$P_4 * P_6$	-0.11	-0.26**	-0.18	-0.47	0.08	-0.19	1.62*	-0.08	0.77	0.45	-0.40	0.02	-2.64*	-4.03**	-0.52
$P_5 * P_6$	-0.01	0.12	0.05	0.41	-0.03	0.19	-0.97	-1.56**	-1.27*	2.90**	-1.96**	0.47	6.03**	3.27**	0.38
LSD 0.05 (Sij)	-	0.17	-	0.56	-	-	1.33	0.79	1.08	1.47	1.19	1.32	2.61	1.99	-
LSD 0.01 (Sij)	-	0.22	-	0.75	-	-	1.78	1.07	1.43	1.97	1.60	1.74	3.49	2.67	-
LSD 0.05 (Sij-Sik)	-	0.27	-	0.88	-	-	2.10	1.26	1.71	2.32	1.89	2.09	4.13	3.16	-
LSD 0.01(Sij-Sik)	-	0.35	-	1.18	-	-	2.81	1.69	9.29	3.11	2.53	2.76	5.52	4.22	-
LSD 0.05 (Sij-Ski)	-	0.22	-	0.72	-	-	1.72	1.03	1.39	1.90	1.55	1.70	3.37	2.58	-
LSD 0.01(Sij- Ski)	-	0.29	-	0.79	-	-	2.30	1.38	1.84	2.54	2.07	2.25	4.51	3.45	-

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

Table 6. Superiority percentages of is white maize crosses relative to check hybrids (S.C. 10, 128 and S.C. 129) for studied traits, based on average performance across locations, 2010.

Cross	Ear diameter			No. of rows ear^{-1}			No. of kernels row^{-1}			100–kernel weight (g)			Grain yield (ard. fed.$^{-1}$)		
	S.C 10	S.C 128	S.C 129	S.C 10	S.C 128	S.C 129	S.C 10	S.C 128	S.C 129	S.C 10	S.C 128	S.C 129	S.C 10	S.C 128	S.C 129
$P_1 * P_2$	-4.37	-7.63	-5.74	-4.32	-11.06	-10.43	-6.30	-4.94	-2.95	-9.64	-7.13	-7.91	-3.20	1.79	0.07
$P_1 * P_3$	-3.74	-7.03	-5.12	0.76	-6.34	-5.67	-4.11	-2.72	-0.69	4.72*	7.63**	6.72**	20.35**	26.55**	24.42**
$P_1 * P_4$	-0.21	-3.61	-1.64	2.27	-4.93	-4.26	-5.11	-3.74	-1.72	-13.48	-11.08	-11.83	-14.52	-10.12	-11.63
$P_1 * P_5$	-3.33	-6.63	-4.71	5.68*	-1.76	-1.06	-8.08	-6.75	-4.80	-14.48	-12.10	-12.84	-40.33	-37.25	-38.31
$P_1 * P_6$	4.57*	1.00	3.07	1.36	-5.77	-5.11	2.38	3.86*	6.03**	-7.18	-4.60	-5.41	1.11	6.32	4.52
$P_2 * P_3$	-2.29	-5.62	-3.69	-1.14	-8.10	-7.45	-3.56	-2.17	-0.12	-7.45	-4.88	-5.68	13.34*	19.17**	17.16**
$P_2 * P_4$	-3.33	-6.63	-4.71	2.65	-4.58	-3.90	-8.79	-7.47	-5.54	-8.15	-5.60	-6.40	-14.31	-9.90	-11.42
$P_2 * P_5$	0.42	-3.01	-1.02	2.65	-4.58	-3.90	0.12	1.57	3.69*	8.05**	11.05**	10.12**	20.70**	26.92**	24.78**
$P_2 * P_6$	-1.66	-5.02	-3.07	-0.76	-7.75	-7.09	-12.43	-11.16	-9.30	-9.46	-6.95	-7.74	-7.78	-3.03	-4.67
$P_3 * P_4$	1.46	-2.01	0.00	-2.42	-9.30	-8.65	-0.78	0.65	2.76	4.21*	7.10**	6.20**	12.37*	18.15**	16.16**
$P_3 * P_5$	1.46	-2.01	0.00	3.03	-4.23	-3.55	0.36	1.81	3.94*	-6.69	-4.10	-4.91	10.18*	15.85**	13.90*
$P_3 * P_6$	-1.66	-5.02	-3.07	4.77	-2.61	-1.91	-3.33	-1.93	0.12	4.60*	7.50**	6.60**	20.11**	26.30**	24.17**
$P_4 * P_5$	-1.25	-4.62	-2.66	1.89	-5.28	-4.61	3.37*	4.87**	7.06**	2.75	5.60*	4.71*	-8.58	-3.87	-5.49
$P_4 * P_6$	-4.37	-7.63	-5.74	0.76	-6.34	-5.67	-0.71	0.72	2.83	-2.17	0.55	-0.30	-21.15	-17.09	-18.49
$P_5 * P_6$	2.49	-1.00	1.02	7.58**	0.00	0.71	-4.82	-3.45	-1.43	0.73	3.53	2.65	18.13**	24.21**	22.12**
LSD 0.05	0.22			0.66			1.39			1.70			2.95		
0.01	0.29			0.87			1.84			2.25			3.90		

*and**refer to significant at 0.05 and 0.01 level of probability, respectively.

Regarding grain yield (ard. fed.$^{-1}$), the crosses; (P_1 x P_3), (P_2x P_5) and (P_5 x P_6) exhibited high significant ($\hat{s}_{ij}$) in the positive direction at both locations, while the crosses (P_1x P_4) and (P_3 x P_4) at only Gemmeiza and the crosses (P_1 x P_2), (P_1 x P_6) and (P_4 x P_5) at only Mallawy expressed significant ($\hat{s}_{ij}$) in positive direction for the trait in view. These results were in good agreement with those reported by Barakat et al. (2003) where they obtained positive and significant ($\hat{s}_{ij}$) for grain yield, Kabdal et al. (2003) who identified five single cross hybrids as potential cross combinations based on their high ($\hat{s}_{ij}$) for no. of kernels row^{-1}, 100-kernel weight and grain yield. Singh and Roy (2007) showed hybrids with high ($\hat{s}_{ij}$) for grain yield and other traits; Osman et el. (2012) found that six crosses had significant or highly significant positive ($\hat{s}_{ij}$) for grain yield; Abd El-Mottalab and Gamea (2014) reported that five crosses showed significant positive ($\hat{s}_{ij}$) for grain yield; and Osman (2014) found that the best ($\hat{s}_{ij}$) for grain yield was obtained by the single cross P_1 x P_4.

Superiority percentage

Superiority of the crosses over the three checks (S.C 10, S.C.128 and S.C.129) relative to the average of the two locations is presented in Table 6. Results revealed that none of the 15studied crosses had significant superiority relative to any of the three check hybrids for ear diameter, with one exception of the cross (P_1 x P_6), which was superior to the check hybrid (S.C.10).

For no. of rows ear^{-1}, the crosses (P_1 x P_5) and (P_5 x P_6) were significantly superior to the check hybrid (S.C.10). Regarding no. of kernels row^{-1}, the cross (P_4 x P_5) showed superiority over the three check hybrids, while the cross (P_1 x P_6) was superior to two of the check hybrids, i.e. (S.C.128) and (S.C.129); and the crosses (P_2 x P_5) and (P_3 x P_5) were superior to only the check hybrid (S.C.129).

For 100-kernel weight, four crosses; (P_1x P_3), (P_2 x P_5), (P_3 x P_4) and (P_3 x P_6) exhibited superiority over the three check hybrids (S.C.10, S.C.128 and S.C.129), whereas the cross (P_4 x P_5) showed superiority over the two check hybrids (S.C.128 and S.C.129).

With regard to grain yield, seven crosses; i.e. (P_1 x P_3), (P_2 x P_3), (P_2 x P_5), (P_3 x P_4), (P_3 x P_5), (P_3 x P_6) and (P_5 x P_6) were significantly superior to the three check hybrids used in the study. The values of superiority percentages ranged from 10.2 to 20.7% over the check hybrid S.C.10, from 15.8 to 26.9% over the check hybrid S.C.128 and from 13.9 to 24.8% over the check hybrid S.C.129. These crosses could be used as commercial hybrids for maize production after conducting more yield trials at several locations. These results were in good agreement with those reported by EL-Kielany (1999), Rana and Kumar (2001), Hammouda (2002), Singh et al. (2002), Unay et al. (2004) , EL-Hosary and EL-Badawy (2005), who compared their crosses with check cultivars and came out with similar conclusions. Abd El-Mottalab and Gamea (2014) pointed out that four crosses had significant superiority percentages over the check hybrid SC 10 and two crosses showed higher mean values than the highest yielding check hybrid SC 128.

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٢-٨ تقدير القدرة علي التآلف لمحصول الحبوب ومكوناته في سلالات من الذرة الشامية البيضاء المرباة داخليا

رمضان علي الرفاعي[١] ، عبد الحميد مصطفي شحاته[٢] ، أحمد مصطفى أبوشوشه[٢]

١. *قسم المحاصيل – كلية الزراعة – جامعة طنطا ، مصر.*
٢. *قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية– الجيزة – مصر*

تم التهجين بين ست سلالات من الذرة الشامية البيضاء مرباة داخليا بنظام التهجين نصف الدائري بمزرعة محطة البحوث الزراعية بالجميزة حيث تم الحصول على ١٥ هجين في موسم ٢٠٠٩. وفي موسم ٢٠١٠ تم تقييم الخمسة عشر هجينا مقارنة بثلاثة هجن فردية هى: هجين فردي ١٠، هجين فردي ١٢٨ وهجين فردي ١٢٩، في موقعين هما محطة البحوث الزراعية بالجميزة بوسط الدلتا ومحطة البحوث الزراعية بملوي بمصر الوسطى باستخدام تصميم القطاعات كاملة العشوائية في أربعة مكررات. تم تقدير كل من القدرة العامة والخاصة على التآلف طبقا لنموذج جريفنج الموديل الأول الطريقة الرابعة. كان متوسط مجموع مربع الانحرافات للمواقع عالي المعنوية لصفتي قطر الكوز ووزن المائة حبه بينما كان متوسط مجموع مربع الانحرافات للهجن والتفاعل بين الهجن والمواقع عالي المعنوية لجميع الصفات المدروسة. كان متوسط مجموع مربع الانحرافات لكل من القدرة العامة والخاصة على التآلف معنويا بما يشير إلى أن كلا من الفعل الجيني المضيف وغير المضيف يؤثر في توارث الصفات تحت الدراسة. كانت نسبة مربع الانحرافات للقدرة العامة إلى متوسط مربع انحرافات القدرة الخاصة على التآلف يزيد عن الواحد الصحيح لصفات عدد الصفوف بالكوز في ملوي والتحليل المجمع، عدد الحبوب بالصف ومحصول الحبوب للفدان بالجميزة والتحليل المجمع مما يدل على أن الفعل الجيني المضيف والتفاعل بين الفعل المضيف × المضيف له دور كبير في توارث هذه الصفات في المواقع المشار إليها. بينما كانت نفس النسبة السابقة أقل من الواحد الصحيح لباقي الصفات مما يدل علي أن الفعل الجيني غير المضيف كان له التأثير الأكبر في توارث هذه الصفات. كانت السلالة رقم ٣ ذات قدرة عامة على التآلف عالية المعنوية لصفة وزن المائة حبة في موقع الجميزة وكان الهجين (٢ × ٥) ذو قدرة خاصة علي التآلف عالية المعنوية لصفات عدد الحبوب بالصف، وزن المائة حبة ومحصول الحبوب للفدان في كلا الموقعين والتحليل المجمع لهما. تفوقت الهجن الثلاثة (٢ × ٥) ، (٣ ×٤) و (٣ × ٦) علي هجين المقارنة لصفات وزن المائة حبة ومحصول الحبوب للفدان.