J. Plant Prod. Mansoura Univ. Vol. 1 (10):1419 - 1430, 2010

COMBINING ABILITY AND HETEROSIS ESTIMATES FOR YIELD, YIELD COMPONENTS AND QUALITY TRAITS IN MAIZE UNDER TWO PLANT DENSITIES.

Sultan, M.S.; M.A. Abdel-Monaem and Soad H. Haffez
Department of Agronomy, Fac. Agric., Mansoura Univ., Egypt.

ABSTRACT

A half diallel set of crosses among six inbred lines of maize were evaluated under two plant densities (23333 and 35000 plants/fad) for grain yield and its components and quality traits at Sherenkash Village, Talkha district, El-Dakahlia Governorate.

Obtained results are as follows:

1- Highly significant variances due to general and specific combining ability for all studied yield and yield components and quality traits, except ears number per plant and protein percentage under both plant densities and oil percentage under normal plant density.
2- The GCA/SCA ratio was less one for all studied yield and yield components and quality traits under both plant densities, suggesting that non additive genetic action was more important than additive, except rows number per ear, kernels number per row and 100-kernel weight under stress plant density.
3- GCA effects showed that the lines R24, R25 and R39 were good general combiners for grain yield per plant under normal plant density.
4- SCA effects showed that the best F1 cross combinations were P1xP2, P1xP4, P1xP6, P2xP3, P3xP5 and P5xP6 for grain yield per plant. These crosses had highly significant estimates of SCA effects under normal plant density.
5- The highest value of heterotic effects relative to mid and better parents for grain yield per plant were obtained by P4xP5 followed by P5xP6. These crosses had the highest positive significant heterotic under both plant density.

Keywords: Maize, Zea mays, inbred lines, combining ability, heterosis, plant density
.

INTRODUCTION

Maize is one of the most important cereal crops. For many years, it is used as food and feed for human and different animals. Therefore, corn breeders give great and continuous efforts to improve and increase yielding ability of this crop. Many investigators use diallel analysis to study combining ability and its interactions with plant density in maize to develop and release new single crosses characterized by high yielding ability. In this connection, Nawar *et al*.(1988) found that the variances of GCA and SCA were higher under the normal plant density than under the high plant density. El Hefnawy and El Zeir (1991) showed that the mean squares of SCA were less than those of GCA for all the studied characters under all environments, except for grain yield / plant. Also, significant GCA and SCA mean squares were detected for most of the studied characters under all environments. They mentioned that SCA x densities interaction was significant for ear length, ear diameter and number of kernels/row. Khalil and Khattab (1998) noted that GCA/SCA ratios exceeded the unity for the studied characters, except ear length, ear diameter and plant height. They reported that mean squares GCA and SCA as well as their interaction with plant densities were significant for grain yield/plant, number of kernels/row, ear length, ear diameter, 100-kernel weight, plant height and days to silking. Sultan (1998) found that variance magnitude due to (GCA) was higher than that due to (SCA), indicates that additive genetic variance was the major source of variation responsible for the inheritance of grain yield and other agronomic traits. Also, the interaction of GCA by location was markedly higher and positive for grain yield and other traits. Fan *et al*. (2001) in China, found that the general combining ability (GCA) was highly significantly different for grain yield, while specific combining ability (SCA) was not significantly different. El-Shouny *et al*. (2003) observed that mean squares of most sources of variation for all traits especially genotypes and its components general and specific combining ability (GCA and SCA) were significant. The GCA / SCA ratios were larger than the unity for silking date, ear height and number of ears per plant at both densities, suggesting that additive genetic action was more important than non-additive one, also additive genetic action was more important for ear length, ear diameter and number of kernels per row only at low plant density.

Cross and Hammond (1982) found that the average heterosis for grain yield in this study was 10.7%. This heterosis can be attributed to increased kernel size and kernel number, which is consistent with the idea that heterosis may be produced by an increased effective filling period duration (EFPD). Amer (1991) observed significant useful heterosis for number of kernels /row, weight of 100-kernel and grain yield / plant. El Hefnawy and El Zeir (1991) at two locations, two season, two population densities (20 and 30 thousand plants /fed) and two nitrogen fertilizer rates, showed that highly significant heterosis over mid and better-parent was obtained over all environments, for most traits and most crosses. Saleh *et al*. (2002) in Malaysia, found that the high estimates of heterosis were shown by grain yield, ear weight and grain weight per ear, moderate for plant and ear heights, shelling percentage, ear diameter, number of kernel rows per ear, number of kernels per row and 100-grain weight. Weidong and Tollenaar (2009) studied two hybrids and its parental inbred lines grown at a low plant density (4 plants m^{-2}), and high plant density (12 plants m^{-2}). They found that increasing plant density from 4 to 12 plants m^{-2} resulted in an increase in heterosis for grain yield, but did not affect heterosis for dry matter at maturity.

The objectives of this study were to determine combining ability and their interaction with plant density and to identify superior parental lines and crosses for their use in hybrid maize breeding programe and estimates the percentage of heterosis for grain yield trait relative to mid and better parents.

MATERIALS AND METHODS

The genetic materials used in this study were six inbred lines of diverse genetic back ground. Source of these parental inbred lines are shown in Table 1. These inbred lines were obtained by Quality Tecno Seeds Company, which produced by using artificial selfing for 8 generations according to hill method.

Table (1): Names, source and grain color of the maize parental inbred lines.

No	Name	Source	Grain color
P1	R6	LOCALLY PRODUCT	Purple
P2	R9	LOCALLY PRODUCT	Purple
P3	R24	LOCALLY PRODUCT	Red
P4	R25	LOCALLY PRODUCT	Purple
P5	R27	LOCALLY PRODUCT	Red
P6	R39	LOCALLY PRODUCT	Dark red

In 2008 growing season, the six parental inbred lines were planted on April 30th and May 21st, and each inbred line was grown in two ridges, to overcome the differences in flowering date and to secure enough hybrid seeds. During this season, all possible cross combinations, without reciprocals, were made giving a total of 15 F1 hybrids.

In 2009 growing season, 24 entries (15 F1's along with their 6 parental inbred lines plus 3 cultivars checks; Pioneer 3062, S.C 155 and S.C 164 were grown in two experiments representing two different plant density, which were 23333 plant / fad (D1, normal) and 35000 plant / fad (D2, stress) by using distance of 60 cm between ridges and 30 or 20 cm between hills, respectively. Each experiment was designated in a Randomized Complete Blocks Design (RCBD) with three replicates. Each plot consisted of one ridge three meters long. Hills were thinned after seedling emergence to secure one plant per hill. Each experiment was hoed twice, before first and second irrigation. Phosphorus in the form of calcium super phosphate (15.5 % P2O5) at a rate of 200 kg / faddan, was added to the soil during seedbed preparation, and potassium sulphate (48 % K2O) at a level of 50 kg / fad was applied after thinning. Moreover, nitrogen in the form of Urea (46% N) at a rate of 120 kg N / fad was added in two equal split doses, before the first and the second irrigation. Other agriculture practices were applied as recommended. The studied traits were: number of ears/plant, number of rows/ear, number of kernels/row, ear diameter(cm), 100-kernel weight(g), grain yield/plant(g), shelling percentage, protein percentage, oil percentage and carotene percentage.

The estimates of general (GCA) and specific (SCA) combining ability variances and effects were estimated according to Griffing (1956) method 4 model 1 (fixed).

RESULTS AND DISCUTION

Mean squares for general (GCA) and specific (SCA) combining ability, as shown in Table (2), were significant or highly significant for all studied traits under both plant densities, except GCA for oil% under normal plant density and protein% at both densities, SCA for ears number per plant and oil% under stress density, protein% under both densities. Similar results were obtained by El Hefnawy and El-Zeir (1991), Shafey (1993), Khalil and Khattab (1998), Mathur *et al*. (1998) and Abdel-Moneam *et al*. (2009).

The relative importance of GCA/SCA for all studied traits was less than one under both plant densities, revealing that non additive gene action had a predominant role in the inheritance of these traits. Except, rows number per ear, kernels number per row and 100-kernel weight under stress plant density, showing that additive gene action had a predominant role in the inheritance of these traits and the better methods to breeding is selection under high density condition. Similar results were obtained by El Hefnawy and El-Zeir (1991), Ahmed *et a*l. (2000), El-Shenawy and Tolba (2001), Sadek et al. (2001) and Osman and Ibrahim (2007).

General combining ability effects (gi)

As shown in Table (3) R6 inbred line (P1) showed significant positive GCA effects (best general combiner) for ears number per plant and rows number per ear at normal density and for kernels number per row, 100-kernel weight and carotene% at stress density. R9 inbred line (P2) showed significant positive GCA effects (best general combiner) for rows/ear at both densities, kernels number per row, 100-kernel weight and carotene at normal density. R24 inbred line (P3) showed significant positive GCA effects (best general combiner) for kernels number per row, 100-kernel weight and shelling percentage at both densities, grain yield/plant at normal density and for carotene percentage at stress density. R25 inbred line (P4) showed significant positive GCA effects (best general combiner) for kernels number per row and shelling percentage at both densities, grain yield/plant at normal density. R27 inbred line (P5) showed significant positive GCA effects (best general combiner) for shelling percentage and carotene percentage at both densities. R39 inbred line (P6) showed significant positive GCA effects (best general combiner) for ear diameter, 100-kernel weight, shelling percentage and carotene percentage at both densities, grain yield/plant at normal density and for rows number per ear at stress density.

Specific combining ability effects (Si):

As shown in Table (4) highly significant positive estimates of SCA for grain yield/plant were recorded by crosses P1xP2, P1xP4, P1xP6, P2xP3, P3xP5 and P5xP6 at normal density. The cross combinations viz., P1xP2, P1xP4, P2xP4, P3xP5, P3xP6 and P5xP6 at both densities, and P2xP3 and P4xP6 at normal and stress density, respectively were the best specific combinations for 100-kernel weight. The best specific combinations for kernels number per row were recorded by P1xP4, P2xP4, P3xP5 and P3xP6 at both densities, and P1xP2 and P1xP6 at normal density, while at stress density were P1xP5 and P4xP6. The best specific combinations for shelling percentage were recorded by P1xP3, P1xP4, P1xP5, P2xP3, P2xP4 and P2xP6 at both densities, and P1xP6 and P2xP5 at normal density, while at stress density was P5xP6. The best specific combinations for rows number per ear were recorded by P3xP5 and P4xP6 at both densities, and P2xP6 at normal density, while at stress density were P1xP2 and P2xP3. The cross combinations viz., P4xP6 at both densities, and P1xP5 and P2xP3 at normal density were the best specific combinations for ear diameter. The cross combinations viz., P1xP4, P2xP6, P3xP4 and P3xP5 at normal density were the best specific combinations for ears number per plant. The best specific combination for oil percentage at normal density was recorded by P5xP6.

The best specific combinations for carotene percentage were recorded by P3xP4 and P4xP5 at both densities, and P1xP2, P1xP4, P2xP3 and P5xP6 at normal density, while at stress density were P1xP3, P1xP6, P2xP4 and P2xP5.

Table (2): Mean squares of GCA and SCA for maize yield , yield components and quality traits under normal and stress plant densities.

Traits / S.V	d.f	Ears no./ plant		Rows no./ ear		Kernels no./ row		Ear diameter		100-kernel weight	
		N	S	N	S	N	S	N	S	N	S
Genotypes	14	0.246	0.013	1.39	2.14	50.2	78.1	0.405	0.177	47.8	33.6
GCA	5	0.092**	0.006*	0.537**	1.430**	27.8**	53.8**	0.090**	0.100**	26.5**	25.1**
SCA	9	0.07**	0.004	0.422**	0.317**	10.6**	10.6**	0.160**	0.036**	10.1**	3.47**
Error	28	0.002	0.002	0.022	0.021	0.020	0.048	0.008	0.008	0.013	0.018
GCA/SCA		0.299	0.556	0.323	1.19	0.656	1.27	0.136	0.808	0.655	1.81
Traits / S.V	**d.f**	**Grain yield**		**Shelling %**		**Protein %**		**Oil %**		**Carotene %**	
		N	S	N	S	N	S	N	S	N	S
Genotypes	14	1108.2	511.0	80	108.1	0.436	0.247	0.452	0.44	50482.7	18076.4
GCA	5	656.8**	134.0	28.2**	29.5**	0.0256	0.086	0.045	0.196*	6571.0**	4082.6**
SCA	9	209.7**	190.5*	25.8**	39.6**	0.212	0.080	0.209*	0.122	22525.7**	7104.8**
Error	28	0.018	74.6	0.0143	0.076	0.131	0.068	0.068	0.074	0.087	0.102
GCA/SCA		0.783	0.128	0.273	0.186	-0.324	0.380	-0.040	0.641	0.073	0.144

*and**significant at 5% and 1% probability levels, respectively.

Table (3): General combining ability (GCA) effects of inbred parents for maize yield , yield components and quality traits under normal and stress plant densities.

Traits / Parent	Ears no./ plant		Rows no./ ear		Kernels no./ row		Ear diameter		100-kernel weight	
	N	S	N	S	N	S	N	S	N	S
P1(R6)	0.218**	0.028	0.275*	0.064	-1.81**	1.21**	0.091	-0.019	-0.70**	0.56**
P2(R9)	-0.05	-0.039	0.109**	0.405**	1.01**	-0.53*	-0.084	-0.009	0.358**	-0.153
P3(R24)	0.1	0.028	-0.684**	-1.14**	2.44**	4.31**	-0.106	-0.083	0.608**	0.88**
P4(R25)	0.034	0.011	-0.1	0.205	3.03**	2.45**	-0.134	-0.054	-1.38**	-1.79**
P5(R27)	-0.084*	0.028	0.317	-0.069	-0.850**	-1.16**	-0.028	-0.143	-3.29**	-3.42**
P6(R39)	-0.217**	-0.056	0.083	0.531**	-3.82**	-6.29**	0.260**	0.308**	4.40**	3.92**
S.E(gi) 5%	0.073	NS	0.25	0.24	0.24	0.36	0.15	0.15	0.19	0.23
1%	0.11		0.39	0.38	0.37	0.57	0.23	0.23	0.29	0.35
S.E(gi-gj) 5%	0.1	NS	0.39	0.37	0.36	0.56	0.23	0.23	0.29	0.35
1%	0.18		0.60	0.59	0.57	0.88	0.36	0.35	0.46	0.55
Traits / Parent	**Grain yield**		**Shelling %**		**Protien%**		**Oil %**		**Carotene%**	
	N	S	N	S	N	S	N	S	N	S
P1(R6)	-15.1**	6.00	-3.66**	-4.01**	-0.031	0.021	0.0458	0.029	-24.3**	23.2**
P2(R9)	-5.04**	-4.37	-2.87**	-2.74**	-0.126	0.071	0.1458	-0.168	30.2**	-11.4**
P3(R24)	18.7**	7.02	3.093**	2.809**	0.052	-0.186	-0.0367	0.217	-27.2**	27.7**
P4(R25)	6.12**	1.66	0.966**	1.196**	0.092	0.238	-0.149	-0.358	-54.0**	-58.9**
P5(R27)	-11.6**	-3.12	1.086**	1.700**	-0.038	-0.054	0.066	0.117	48.0**	8.80**
P6(R39)	6.80**	-7.16	1.388**	1.047**	0.052	-0.089	-0.072	0.164	27.3**	10.7**
S.E(gi) 5%	0.22	NS	0.2	0.46	NS	NS	0.43	0.45	0.49	0.53
1%	0.35		0.3	0.7			0.68	0.71	0.77	0.83
S.E(gi-gj) 5%	0.34	NS	0.31	0.71	NS	NS	0.67	0.70	0.76	0.82
1%	0.54		0.49	1.11			1.05	1.09	1.19	1.29

*and**significant at 5% and 1% probability levels, respectively.

Table (4): Specific combining ability (SCA) effects of hybrids for yield, yield components and quality traits under normal and stress plant densities.

Trait / Cross	Ears no. /plant		Rows no. / ear		kernels no. / row	
	N	S	N	S	N	S
P1 x P2	0.087	-0.047	0.030	0.509**	1.85**	-0.258
P1 x P3	0.070	0.087	-0.045	-0.017	-5.58**	-0.934**
P1 x P4	0.270**	0.036	0.072	-0.058	3.77**	1.26**
P1 x P5	-0.280**	-0.047	0.155	0.017	-0.988**	4.73**
P1 x P6	-0.147*	-0.030	-0.212	-0.450*	0.945**	-4.80**
P2 x P3	-0.197**	-0.047	0.122	0.475*	0.070	-0.458
P2 x P4	-0.330**	-0.030	0.105	-0.067	1.32**	2.63**
P2 x P5	-0.013	0.086	-0.612**	-0.592**	-0.405*	-2.69**
P2 x P6	0.453**	0.037	0.355*	-0.325	-2.84**	0.774**
P3 x P4	0.187**	0.036	-0.937**	-0.825**	-1.31**	-2.78**
P3 x P5	0.170**	-0.047	1.113**	0.484*	2.49**	1.80**
P3 x P6	-0.230**	-0.030	-0.253	-0.116	4.33**	2.37**
P4 x P5	0.036	-0.030	-0.003	0.075	-1.22**	-3.31**
P4 x P6	-0.163**	-0.013	0.763**	0.875**	-2.56**	2.19**
P5 x P6	0.087	0.037	-0.653**	0.017	0.12	-0.533*
S.E(Sij) 5%	0.106	NS	0.35	0.34	0.33	0.5
1%	0.147		0.49	0.48	0.46	0.7
S.E(Sij-Sik) 5%	0.167	NS	0.55	0.54	0.53	0.8
1%	0.23		0.77	0.75	0.74	1.13
S.E(Sij-Ski) 5%	0.136	NS	0.45	0.44	0.43	0.67
1%	0.189		0.63	0.6	0.60	0.93

***and**significant at 5% and 1% probability levels, respectively.**

Table (4): Cont.

trait / Cross	Ear diameter		100-kernel weight		Grain yield		Shelling %	
	N	S	N	S	N	S	N	S
P1 x P2	0.093	0.172	3.76**	1.61**	8.68**	-11.60	-11.1**	-13.0**
P1 x P3	-0.244*	-0.030	-2.50**	0.075	-16.01**	12.10	4.66**	4.27**
P1 x P4	-0.294*	-0.226*	1.79**	0.841**	19.3**	13.40	2.87**	5.92**
P1 x P5	0.710**	0.199	-3.30**	-2.26**	-19.6**	-2.02	1.21**	3.68**
P1 x P6	-0.265*	-0.115	0.25	-0.267	7.65**	-11.8	2.39**	-0.854*
P2 x P3	0.336**	0.116	1.48**	0.283	11.8**	9.90	0.466**	1.96**
P2 x P4	0.030	0.084	0.696**	1.52**	-7.11**	8.00	3.62**	5.46**
P2 x P5	-0.325**	-0.130	-0.353*	-0.484**	-2.23**	-9.40	3.22**	0.508
P2 x P6	-0.134	-0.241*	-5.58**	-2.93**	-11.1**	3.14	3.81**	5.09**
P3 x P4	-0.087	-0.035	-1.12**	-2.02**	-0.572**	-13.70	-0.688**	-3.52**
P3 x P5	0.037	-0.050	1.03**	1.15**	7.54**	4.86	-2.91**	-3.08**
P3 x P6	-0.041	-0.001	1.11**	0.508**	-2.80**	-13.1	-1.53**	0.374
P4 x P5	-0.255*	-0.099	-1.49**	-0.717**	-1.81**	-11.5	-1.33**	-2.18**
P4 x P6	0.606**	0.277*	0.122	0.375*	-9.77**	3.78	-4.47**	-5.68**
P5 x P6	-0.166	0.079	4.11**	2.31**	16.1**	18.00	-0.193	1.07**
S.E(Sij) 5%	0.21	0.21	0.26	0.30	0.30	20.27	0.28	0.6
1%	0.29	0.29	0.37	0.44	0.43	28.16	0.39	0.90
S.E(Sij-Sik) 5%	0.36	0.32	0.4	0.50	3.19	32.05	0.45	1.02
1%	0.46	0.45	0.58	0.70	0.69	44.54	0.6	1.4
S.E(Sij-Ski) 5%	0.27	0.27	0.34	0.41	0.40	26.17	0.36	0.83
1%	0.37	0.37	0.48	0.57	0.56	36.37	0.51	1.16

***and**significant at 5% and 1% probability levels, respectively.**

Table (4): Cont .

Trait / Cross	Protein %		Oil %		Carotene%	
	N	S	N	S	N	S
P1 x P2	-0.302	0.267	0.249	-0.170	126.4**	-81.4**
P1 x P3	0.041	-0.256	0.032	0.186	-3.93**	90.8**
P1 x P4	-0.060	-0.031	0.114	0.191	44.7**	-19.1**
P1 x P5	0.541	0.422	-0.561	-0.495	-116.2**	-105.3**
P1 x P6	-0.220	-0.403	0.167	0.288	-51.0**	115.1**
P2 x P3	-0.495	-0.086	0.422	0.183	143.7**	-10.7**
P2 x P4	0.406	0.0095	-0.326	-0.502	-54.9**	4.94**
P2 x P5	-0.005	-0.338	-0.041	0.423	-88.5**	132.5**
P2 x P6	0.396	0.147	-0.304	0.066	-126.7**	-45.3**
P3 x P4	-0.262	-0.003	0.247	0.123	54.7**	9.41**
P3 x P5	0.418	0.0995	-0.449	-0.142	-109.7**	-35.8**
P3 x P6	0.298	0.245	-0.251	-0.350	-84.8**	-53.7**
P4 x P5	-0.282	-0.086	0.314	0.203	3.67**	14.7**
P4 x P6	0.198	0.110	-0.349	-0.015	-48.2**	-9.97**
P5 x P6	-0.672	-0.098	0.737*	0.011	310.7**	-6.09**
S.E(Sij) 5%	NS	NS	0.6	NS	0.69	0.75
1%			0.85		0.96	1.04
S.E(Sij-Sik) 5%	NS	NS	0.97	NS	1.10	1.19
1%			1.34		1.52	1.65
S.E(Sij-Ski) 5%	NS	NS	0.79	NS	0.90	0.97
1%			1.10		1.25	1.35

***and**significant at 5% and 1% probability levels, respectively.**

Heterosis studies:

Results given in Table (5) revealed that the cross combinations viz., P4xP5, P5xP6, P4xP6 and P1xP4 at both densities recorded the highest positive significant heterosis over mid and better-parents for grain yield/plant. These crosses had positive and significant heterosis over mid and better-parent for ear diameter, kernels number per row and 100-kernel weight. The highest significant positive heterosis over mid and better-parent for protein percentage were recorded by P3xP6 and P1xP5 at normal density and P2xP4 and P3xP4 at stress density. For oil percentage, the highest positive significant heterosis over mid and better-parent were recorded by P5xP6 and P4xP5 at normal density and P1xP6 at stress density. For carotene percentage, the highest positive significant heterosis over mid and better-parents was recorded by P5xP6 at normal density and P1xP6 at stress density. The results agree with those obtained by Amer (1991), El Hefnawy and El Zeir (1991), Saleh et al. (2002) and Weidong and Tollenaar (2009), found that significant useful heterosis for number of kernels /row, weight of 100-kernels and grain yield / plant.

Table (5): Percentage of heterosis over mid (M.P) and better-parent (B.P) for F1 crosses of studied maize traits under normal and stress plant densities.

Trait / Cross	Ears no. /plant				Rows no. / ear			
	N		S		N		S	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1xP2	23.1**	0.00	-3.24**	-6.93**	11.9**	9.47**	5.09**	1.70**
P1xP3	44.4**	23.8**	12.5**	5.91**	14.0**	7.48**	1.01*	-7.63**
P1xP4	55.6**	33.4**	13.3**	13.3**	25.5**	13.1**	2.63**	2.63**
P1xP5	-5.3**	-21.7**	0.047	-5.83**	17.4**	17.1**	6.96**	1.05**
P1xP6	20.0**	20.0**	0.00	0.00	3.45**	-4.11**	4.86**	2.10**
P2xP3	-20.0**	-25.0**	-9.09**	-11.7**	11.4**	2.82**	4.30**	-7.39**
P2xP4	-33.3**	-37.5**	-3.24**	-6.28**	21.3**	7.17**	1.78**	-1.48**
P2xP5	-23.4**	-25**	3.00**	0.00	7.47**	4.86**	1.07**	-7.39**
P2xP6	17.9**	-4.2**	-3.24**	-6.28**	4.22**	-1.37**	4.96**	-0.983**
P3xP4	19.1**	19.1**	6.24**	0.00	15.4**	9.97**	-4.75**	-12.9**
P3xP5	4.5**	0.00	-5.83**	-5.83**	24.6**	17.7**	10.9**	7.10**
P3xP6	-16. 7**	-28.6**	-6.24**	-11.7**	1.43**	-11.0**	7.26**	0.558*
P4xP5	-9.1**	-13.0**	0.047	-5.83**	25.6**	13.4**	8.63**	2.63**
P4xP6	-16. 7**	-28.6**	0.00	0.00	18.7**	0.00	16.8**	13.7**
P5xP6	-10.5**	-26.1**	0.047	-5.83**	0.741**	-6.85**	14.0**	10.6**
LSD 1%	**0.143**	**0.117**	**0.156**	**0.128**	**0.503**	**0.411**	**0.761**	**0.622**
LSD 5%	**0.191**	**0.156**	**0.209**	**0.171**	**0.672**	**0.549**	**1.02**	**0.831**

***and**significant at 5% and 1% probability levels, respectively.**

Table (5): Cont.

Trait / Cross	kernels no. / row				Ear diameter			
	N		S		N		S	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1xP2	52.9**	41.2**	66.5**	58.3**	34.3**	17.6**	15.7**	9.64**
P1xP3	30.8**	18.3**	85.4**	76.9**	21.6**	6.09**	10.1**	7.06**
P1xP4	64.4**	56.2**	84.4**	78.3**	31.4**	24.3**	18.8**	10.7**
P1xP5	41.4**	23.3**	96.4**	77.7**	74.9**	67.3**	26.9**	18.9**
P1xP6	25.8**	19.3**	34.0**	12.5**	24.1**	3.02**	12.7**	3.64**
P2xP3	81.9**	77.8**	89.2**	88.6**	18.5**	18.0**	8.94**	6.06**
P2xP4	80.3**	75.0**	92.4**	89.0**	18.5**	9.10**	19.6**	5.97**
P2xP5	71.2**	60.8**	60.0**	51.8**	11.6**	1.69**	8.78**	-3.07**
P2xP6	32.6**	28.9**	63.9**	43.9**	8.50**	1.90**	3.63**	0.392**
P3xP4	79.0**	69.9**	89.0**	86.3**	13.5**	4.12**	16.6**	5.80**
P3xP5	96.7**	88.8**	107.8**	96.6**	22.1**	10.9**	12.3**	2.52**
P3xP6	74.0**	65.5**	99.4**	74.2**	10.0**	3.73**	11.3**	5.04**
P4xP5	71.2**	56.4**	69.0**	57.8**	22.9**	21.5**	24.2**	23.4**
P4xP6	38.4**	38.1**	84.9**	59.5**	37.8**	19.9**	31.8**	13.6**
P5xP6	46.0**	33.6**	62.5**	49.3**	19.0**	2.50**	21.8**	5.59**
LSD1%	**0.486**	**0.397**	**0.805**	**0.658**	**0.278**	**0.227**	**0.278**	**0.227**
LSD5%	**0.650**	**0.531**	**1.08**	**0.879**	**0.372**	**0.304**	**0.372**	**0.304**

***and**significant at 5% and 1% probability levels, respectively.**

Table (5): Cont.

Trait / Cross	100-kernel weight				Grain yield			
	N		S		N		S	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1xP2	51.9**	50.4**	37.1**	30.5**	74.3**	73.8**	63.1**	62.7**
P1xP3	5.23**	-4.57**	26.2**	14.1**	52.5**	36.1**	155.5**	132.6**
P1xP4	52.2**	31.1**	49.1**	29.0**	205.3**	115.1**	230.9**	124.6**
P1xP5	-2.31**	-11.0**	8.92**	-1.50**	58.2**	10.6**	163.7**	84.3**
P1xP6	27.5**	7.44**	26.9**	5.73**	136.9**	94.9**	94.19**	56.7**
P2xP3	31.3**	20.1**	17.7**	11.5**	113.4**	91.1**	128.8**	108.8**
P2xP4	50.2**	28.3**	40.1**	16.3**	161.2**	83.7**	185.7**	94.2**
P2xP5	22.8**	10.8**	9.99**	-4.86**	129.5**	60.2**	113.9**	49.8**
P2xP6	3.24**	-12.3**	5.03**	-8.74**	116.4**	77.5**	106.29**	66.8**
P3xP4	24.5**	-1.14**	14.4**	-9.03**	186.5**	89.3**	193.39**	110.5**
P3xP5	19.9**	0.00	19.7**	-1.04**	167.2**	75.4**	228.5**	143.9**
P3xP6	26.3**	16.4**	21**	10.5**	148.3**	87.0**	117.6**	90.4**
P4xP5	24.1**	16.6**	21.2**	15.4**	353.2**	347.1**	315.9**	295.0**
P4xP6	39.2**	4.13**	32.4**	-1.58**	283.05**	213.1**	268.6**	191.4**
P5xP6	44.1**	12.7**	29.6**	-0.288*	316.3**	237.6**	291.0**	222.4**
LSD1%	**0.383**	**0.313**	**0.465**	**0.380**	**0.461**	**0.376**	**25.6**	**20.9**
LSD5%	**0.512**	**0.418**	**0.622**	**0.508**	**0.616**	**0.503**	**34.2**	**27.9**

***and**significant at 5% and 1% probability levels, respectively.**

Table (5): Cont.

Trait / Cross	Shelling%				Protein %			
	N		S		N		S	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1xP2	-22**	-22.4**	-24.3**	-24.5**	-3.80**	-8.27**	4.90**	2.85**
P1xP3	3.76**	3.08**	4.87**	4.44**	7.13**	4.88**	-3.57**	-8.86**
P1xP4	12.87**	-0.223	22.9**	4.49**	2.04**	-3.71**	6.25**	0.901**
P1xP5	1.07*	-2.06**	14**	2.30**	13.3**	10.7**	6.56**	3.30**
P1xP6	-1.55**	-2.78**	-5.02**	-5.76**	4.05**	2.83**	-7.67**	-9.61**
P2xP3	-0.822	-0.935*	3.72**	3.47**	-7.42**	-9.87**	2.03**	-1.72**
P2xP4	14.2**	0.508	24.4**	5.87**	2.69**	1.57**	9.93**	6.41**
P2xP5	3.94**	0.177	11.5**	0.221	-1.62*	-4.04**	-2.47**	-3.59**
P2xP6	0.510	-0.198	4.21**	3.22**	6.90**	3.11**	3.60**	3.44**
P3xP4	16.3**	2.23**	19.6**	2.01**	-1.80*	-5.42**	9.73**	9.18**
P3xP5	3.61**	-0.248	14.6**	3.21**	10.4**	10.12**	4.24**	1.55**
P3xP6	1.13*	0.528	5.51**	4.27**	11.2**	10.12**	4.96**	1.25**
P4xP5	17.7**	7.08**	35.7**	27.6**	-3.62**	-6.99**	7.65**	5.39**
P4xP6	8.21**	-5.38**	12.1**	-5.29**	5.98**	1.14	9.14**	5.80**
P5xP6	4.19**	-0.253	16.4**	3.76**	-5.51**	-6.60**	-1.05*	-2.04**
LSD 1%	**0.917**	**0.749**	**1.20**	**0.977**	**1.42**	**1.16**	**0.784**	**0.641**
LSD 5%	**1.23**	**1.00**	**1.60**	**1.31**	**1.89**	**1.54**	**1.05**	**0.857**

***and**significant at 5% and 1% probability levels, respectively.**

Table (5): Cont.

Trait / Cross	Oil %				Carotene %			
	N		S		N		S	
	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.	M.P.	B.P.
P1xP2	2.87**	-2.08**	-9.77**	-12.6**	35.8**	-1.83**	-25.5**	-34.7**
P1xP3	-9.71**	-12.5**	6.04**	-3.84**	-54.4**	-56.3**	34.8**	-7.40**
P1xP4	-4.17**	-13.3**	-10.5**	-18.3**	-29.2**	-50**	-46.0**	-62.7**
P1xP5	-18.9**	-25.3**	-14.6**	-20.2**	-55.6**	-67.04**	-49.3**	-63.6**
P1xP6	-8.10**	-9.90**	15.3**	11.00**	-52.5**	-54.1**	113.2**	84.2**
P2xP3	8.86**	6.86**	-2.93**	-9.32**	50.5**	11.9**	-28.0**	-46.2**
P2xP4	-9.12**	-13.8**	-39.4**	-43.1**	-13.9**	-17.0**	-54.6**	-65.8**
P2xP5	4.02**	0.576	4.70**	0.877*	22.3**	17.5**	31.3**	3.40**
P2xP6	-13.7**	-16.3**	-1.52**	-2.09**	-42.2**	-57.3**	-22.5**	-23.8**
P3xP4	0.700	-6.19**	-15.6**	-16.2**	-21.5**	-43.0**	-53.6**	-54**
P3xP5	-15.2**	-19.5**	-7.50**	-10.4**	-51.4**	-62.8**	-43.7**	-47.6**
P3xP6	-18.8**	-19.8**	-9.29**	-14.8**	-61.8**	-62.1**	-36.7**	-52.1**
P4xP5	11.8**	9.57**	-13.4**	-15.6**	31.9**	22.3**	-54.3**	-57.1**
P4xP6	-19.1**	-25.5**	-15.7**	-20.3**	-43.3**	-59.0**	-52.3**	-63.7**
P5xP6	16.9**	9.76**	1.71**	-1.46**	143.2**	84.9**	-18.6**	-35.0**
LSD 1%	0.821	0.670	0.838	0.684	0.915	0.747	0.962	0.786
LSD 5%	1.10	0.895	1.12	0.914	1.22	0.998	1.29	1.05

***and**significant at 5% and 1% probability levels, respectively.**

REFERENCES

Abdel-Moneam, M. A.; A.N.E. Attia; M.I. El-Emery and Eman A. Fayed (2009). Combining ability and heterosis for some agronomic traits in crosses of maize. Pakistan J. Biol. Sci, 12 (5): 433-438.

Ahmed, M.A.; M.H. El-Sheikh and Sh.A. EL-Shamarka (2000). Diallel analysis of yielding ability and earliness in maize. J. Agric. Sci. Mansoura Univ., 25 (7): 3717-3726.

Amer, E.E. (1991). Genetic studies on some crosses of maize. Ph.D Thesis, Fac. of Agric., Al-Azhar Univ., Egypt.

Cross, H.Z. and J.J. Hammond (1982). Plant density effects on combining abilities of early maize synthetics. Crop Sci., 22: 814-817.

El Hefnawy, N.N., and F.A.El Zeir (1991). Studies on genetic behavior of some parental lines of maize and their single crosses under different environmental factors. Annals of Agric. Sci. Moshtohor, 29(1): 97-116.

El-Shenawy, A.A. and S.A.E Tolba (2001). General and specific combining ability and reciprocal crosses effects in complete diallel set of maize inbreds. J. Agric. Sci. Mansoura Univ.,26(3): 1271-1279.

El-Shouny,K.A.; Olfat. H.El Bagoury.; H.Y.El Sherbieny and S.A.Al Ahmad (2003). Combining ability estimates for yield and its components in yellow maize (*Zea Mays* L.) under two plant densities. Proceed. Third Pl. Breed. Conf. April 26, 2003 (Giza), Egypt. J. Plant Breed. 7(1):399-417.

Fan, X; T. Jing; H. Bihua and L. Feng (2001). Analyses of combining ability and heteroic groups of yellow grain quality protein maize inbreds. Seventh Eastern and Southern Africa Regional Maize Conference, pp. 143-148.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing system. Australian J. Biol. Sci., 9: 463-493.

Khalil, A.N.M., and A.B.Khattab (1998). Influence of plant densities on the estimates of general and specific combining ability effects in maize. Minufiya. J. Agric. Res., 2(3): 521-543.

Mathur, R.K.; S.K. Bhatnagar and V. Singh (1998). Combining ability for yield, phonological and ear characters in white seeded maize. Indian. J. of Genet. & Plant Breed. 58(2): 177-182.

Nawar, A.A.; A.A. El Hosary ; H.A. Dawwam and F.A. Hendawy (1988). Influence of plant densities on the expression of heterosis and combining ability in maize (*Zea mays* L.). Minufiya J. Agric. Res 13(1): 55-69.

Osman,M.M.A. and M.H.A.Ibrahim (2007). A study on combining ability of new lines using line x tester analysis. J.Agric.Sci .Mansoura Univ., 32(2): 815-830.

Sadek, S.E.; M.S.M. Soliman and A.A. Barakat (2001). Evaluation of new developed maize lines using commercial inbred tester. Egypt. J. Appl. Sci., 16: 406-425.

Saleh, G.B.; D. Abdullah and A.R. Anuar (2002). Performance, heterosis and heritability in selection tropical maize single, double and three-way cross hybrids. The J. of Agric. Sci., 138: 21-28.

Shafey, S.A. (1993). Diallel analysis for some agronomic characters and yield in yellow maize (*Zea mays* L.). Egypt. J. Appl. Sci., 8(7): 602-616.

Sultan, M.A. (1998). Estimates of combining ability of yellow maize inbred lines in top crosses. J. Agric. Sci. Mansoura Univ., 23(12): 5837- 5851.

Weidong, L and M. Tollenaar (2009). Response of yield heterosis to increasing plant density in maize. Crop Sci., 49: 1807-1816.

تقدير القدرة على الائتلاف وقوة الهجين لصفة المحصول ومكوناته وصفات جودة الحبوب فى الذرة الشامية تحت كثافتين نباتيتين.

محمود سليمان سلطان، مأمون أحمد عبد المنعم و سعاد حسن حافظ
قسم المحاصيل - كلية الزراعه- جامعة المنصورة - مصر

يهدف هذا البحث إلى تقييم بعض سلالات الذرة الشامية والهجن الفردية الناتجة منها تحت كثافتين للزراعة (٢٣٣٣٣ و ٣٥٠٠٠ ألف نبات بالفدان)، وتقدير القدرة العامة والخاصة على الائتلاف لهذه السلالات وتقدير قوة الهجين تحت هاتين الكثافتين.

وقد أستخدم فى هذه الدراسة ست سلالات نقية من الذرة الشامية وهى: R6 ،R9 ، R24 ، R25 ،R27 ، R39. وقد أجريت جميع التهجينات المتبادلة الممكنة بين هذه السلالات فى صيف ٢٠٠٨ دون الهجن العكسية وذلك فى مزرعة قسم المحاصيل – كلية الزراعة- جامعة المنصورة حيث تم الحصول على الحبوب الهجينية لخمسة عشر هجينا فرديا وتم تقييم السلالات النقية والهجن الفردية الناتجة منها فى عام٢٠٠٩ تحت مستويين من الكثافة النباتية (٢٣٣٣٣ و ٣٥٠٠٠ ألف نبات بالفدان)، فى تصميم القطاعات الكاملة العشوائية لكل كثافة فى ثلاث مكررات.

أخذت البيانات على صفات: عدد كيزان النبات الواحد ، عدد صفوف الكوز ، عدد حبوب الصف ، قطر الكوز ، وزن ١٠٠ حبة ، محصول حبوب النبات ، ونسبة التفريط ، والنسبة المئوية للبروتين ، والنسبة المئوية للزيت ، والنسبة المئوية للكاروتين.

وقد تم تحليل النتائج وراثيا تبعا للطريقة الرابعة الموديل الاول للعالم جريفينج (١٩٥٦)

ويمكن تلخيص نتائج البحث فيما يلى:

١-كان التباين الراجع لكل من القدرة العامة والخاصة على التألف معنويا لكل الصفات المحصولية ماعدا عدد الكيزان/نبات تحت الكثافتين النباتيتين.

٢-كان التباين الراجع لكل من القدرة العامة والخاصة على التألف معنويا لكل صفات جودة الحبوب ماعدا النسبة المئوية للبروتين تحت الكثافتين النباتيتين والنسبة المئوية للزيت تحت الكثافة المنخفضة (العادية).

٣-أظهرت النسبة ما بين القدرة العامة والخاصة على الائتلاف أهمية التأثير الغير مضيف فى وراثة كل الصفات المحصولية ماعدا عدد صفوف الكوز ، وعدد حبوب الصف ، ووزن ١٠٠حبة تحت الكثافتين النباتيتين، كما أظهرت هذه النسبة أهمية التأثير الغير مضيف فى كل صفات جودة الحبوب تحت الكثافتين النباتيتين.

٤-أظهرت السلالات R39 , R25 , R24 أفضل قدرة عامة على الائتلاف لصفة محصول الحبوب/نبات تحت الكثافة المنخفضة.

٥-أظهرت الهجن P1xP2, P1xP4, P1xP6, P2xP3, P3xP5 and P5xP6 أفضل قدرة خاصة على الائتلاف لصفة محصول الحبوب/نبات تحت الكثافة المنخفضة.

٦-أظهر الهجين P4xP5 يلية P5xP6 أعلى قيم لقوة الهجين بالنسبة لمتوسط الاباء وأفضل الاباء لصفة محصول النبات الفردى تحت الكثافتين النباتيتين.

قام بتحكيم البحث

أ.د / محمد حسين عبد الفتاح غنيمة	**كلية الزراعة – جامعة المنصورة**
أ.د / علي عبد المقصود محمد الحصري	**كلية زراعة مشتهر – جامعة بنها**