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COMBINING ABILITY FOR YIELD AND SOME OF ITS ATTRIBUTES IN MAIZE ACROSS TWO LOCATIONS

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ABSTRACT

Eight inbred lines of white maize were crossed in half diallel scheme in 2016 season to assess mean performance, general (GCA) and specific (SCA) combining ability and their interaction with locations. Two experiments were conducted at two locations, viz. Moshthor, (L_1) and Sohag (L_2) using RCBD with 3 replications in season 2017. Each block consisted of 28 F_1 hybrids along with the single cross SC 10. Location mean squares for all traits under study were significant with values in L_1 higher than those in L_2 for grain yield plant^{-1}. Significant hybrid mean squares were observed for all traits in both and across the studied locations, except for shelling% at L2. Significant hybrid x location mean squares occurred for all traits, except for No. of kernels row^{-1}. The crosses P_2xP_3, P_1xP_7, P_6xP_8, P_2xP_4 , P_1xP_8, P_4xP_8, and P_3xP_5 exhibited significant and positive superiority over SC 10 mean value for grain yield across the two locations and surpassed the check hybrid by 18.19, 18.13, 15.33, 14.97, 14.23, 11.88 and11.72%, respectively. GCA and SCA mean squares were significant for all studied traits, except for GCA concerning No. of rows ear^{-1} at L_1 and ear diameter at L_1 and combined across locations, SCA at L_2 for No. of rows ear^{-1} and shelling%. A large part of total variability for ear height, 100-kernel weight and ear weight plant^{-1} was non-additive gene action. On the contrary, additive and additive x additive gene action was associated with grain yield plant^{-1}. GCA×L and SCA×L interaction mean squares were significant for most studied traits. P3 and P8 expressed positive and significant $\hat{g}_i$ effects for ear and grain yields. The most desirable inter and intra-allelic interactions ($\hat{s}_{ij}$ effects) were obtained by the combinations; P_1xP_7, P_3xP_5 and P_4xP_8 for grain yield and ear weight plant^{-1}.

Key words***: Maize, locations, Combining ability, gene action.***

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in Egypt and the world. It is the third cereal crop in the world, after wheat and rice. In 2016 the area grown by this crop in Egypt was 0.75 Million hectares with an annual grain production of 6 Million metric tons and an average productivity of 8 Mg ha^{-1} (USDA 2018).

Maximizing food and agricultural production, depends mainly on promoting high yielding maize hybrids to cover the mounting consumption of maize. This depends mostly on the utilization of hybrid vigor in maize breeding programs. Diallel cross is a useful tool to produce promising hybrids (El Hosary and El-Fiki 2015) and combining ability helps to identify the most appropriate parents and provide sufficient genetic information on the inheritance of traits. In this regard, highly general combining ability (GCA) and specific combining ability (SCA) effects leading to high heterosis were asserted by Girma *et al* (2015), Al-Naggar *et al* (2016) and Al-Naggar *et al* (2017 a and b)

The quantitative characters are extremely affected by the environment, and the amount of such effect increases with the increase in the number of predominant genes. Thus, expression of a specific character which controlled by several loci were display greater genotype x environment (GxE) interaction. The elimination of GxE variance from the assessments of genetic variance forms an integral part of any endeavor to determine genetic variances without partiality (Singh 1973 and 1979 and Wani *et al* 2017).

One of the maximum important norms for distinguishing high yielding hybrids is the acquaintance of parents' kind and dimension of gene action type and their combining ability. Diallel mating pattern utilizing combining ability analyses are vastly used in maize breeding programs to locate the combining ability types. Bidhendi *et al* (2012) and Khan *et al* (2014) stated that inheritance of quantitative characters, detection of genetic diversity, selection of suitable parental lines for hybridization, classification of heterotic pattern, estimation of hybrid vigor, and evolution of hybrid all depend on gene action information on identification of maize genotypes. Thus, differences due to GCA and SCA are associated with the type of gene action implicated.

Variance for GCA contains additive part while that of SCA includes non-additive part of total variance emerging mostly from dominance and epistatic deviations (Izhar and Chakraborty 2013).

To improve new maize genotypes, breeders need knowledge concerning the type and relative magnitude of genetic variance components over their interaction with environment. Researchers (Ali *et al* 2014 and Ram *et al* 2015) calculated the superiority in maize over check hybrids. Such superiority asserts the most appropriate cross combinations for economic characters among elite inbred lines of maize. The present investigation aimed at assessing the GCA and SCA of parents and crosses, respectively across locations for some quantitative traits. Also, explore the superior hybrid combinations relative to the check hybrid.

MATERIALS AND METHODS

Diverse parental inbred lines at S_7 stage of inbreeding of white maize were used in this study i.e. M 702 (P_1), P_2 (M 703), P_3 (M 704), P_4 (M (M 733), P_5 (M 712) , P_6 (M 705), P_7 (M 722) and P_8 (M 751) Where: P_1, P_2, P_2, P_3, P_4 were developed from single cross hybrids SC 10, SC Hitech 2031, 2031, SC Pioneer 30k8, and the Synthetic var. Giza 2, respectively. P5, P6 were developed from exotic population introduce from CIMMYT and P7 and P8 were developed from the three-way crosses Giza TWC 321 and TWC 324, respectively. These parental inbred lines were developed in the Department of Agronomy, Faculty of Agriculture, Moshtohor, Benha

University, by Prof. Dr. A.A. El-Hosary and represented enormous range of variability for yield and most of its attributes.

A half-diallel set of crosses was carried out in 2016 season at the Experimental Farm of Faculty of Agriculture, Moshtohor, Benha University. The eight inbred lines were split planted on 11^{th} and 17^{th} June to overcome the difference in flowering time and secure enough hybrid seeds. In 2017 season, the resultant 28 crosses along with the commercial hybrid check variety (SC 10) were grown in a randomized complete block design with three replications in two different locations, i.e. Moshtohor (L_1) at the Experimental Farm of Faculty of Agriculture, Benha University and Sohag (L_2) at the Agricultural Research and Experimental Station of the Faculty Agriculture, Sohag University, respectively. The planting dates in both locations were 6/ 6/ 2017at L_1 and 1/6 / 2017 at L_2.

Meteorological data in season 2017 were obtained from the Agro-meteorological Station at L_1 and L_2. For June, July and August, the mean temperatures were 28.38, 27.54 and 29.89°C, and the maximum temperatures were 34.5, 33.24 and 36.85°C and relative humidity was 49.0, 58.0 and 59.0 %, respectively at Moshtohor (L_1). Comparable data in Sohag (L_2) were 32.4, 30.7 and 30.4°C, for mean temperature, 40.4, 37.6 and 36.9°C for maximum temperature and 50.63, 62.3 and 69.0 %, respectively for relative humidity. Soil analysis of the experimental fields shows that the L_1 soil is clay (6.80% coarse sand, 27.9% fine sand, 12.5% silt, and 52.8% clay), the pH (paste extract) is 8.00, the EC is 2.1 dSm^{-1}, calcium carbonate ($CaCo_3$) is 3.4%, the available nutrients in mg kg^{-1}were Nitrogen (N) 65.4, Phosphorous (P) 24.2, Potassium (K)850.08. However, L_2 soil is sandy clay loam (48.4% sand, 22.7% silt, and 28.9% clay), the pH is 7.8, the EC is 0.3 dSm^{-1}, $CaCo_3$ is 11.4%, the available nutrients in mg kg^{-1} were N 44.3, P 18.3 and K 495.5.

For each location, the experimental plot consisted of one ridge of five m length and the space between ridges was 75 cm and the space between hills was 25 cm. Seeds were planted on one side of the ridge. At 5-leaf stage, plants were thinned to one per hill. The cultural practices were followed for ordinary maize field in the area. In each plot, 10 guarded plants (random samples) to measure plant height (cm), ear height (cm), ear diameter (cm) and length (cm), number of kernels row^{-1}, number of rows ear^{-1}, 100-kernel weight (g), grain yield $plant^{-1}$ (g) and shelling%. Both grain yield and 100-kernel weight were adjusted to 15.5% moisture content. Data for each trait were statistically analyzed and the combined analysis across locations was made after test the homogeneity of errors. Superiority of grain yield was calculated for individual crosses as the percentage deviation of F_1 mean performance from the check variety SC 10 average value. The combining ability analysis for individual location as well as across locations was performed to determine the general and specific combining ability effects. The combining ability analysis of data for individual location was carried out for both locations separately, using Griffing's method 4, model I (1956). The combining ability analysis across locations was carried out using the method suggested by Singh (1973 and 1979), which is an extension of Griffing's method 4, model I (1956) to estimate the interactions of general and specific combining ability effects with locations, besides determining the significance of general and specific combining ability variance.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance for all genotypes for yield, yield components and some agronomic traits in each and across the two locations is presented in Table 1.

Location mean squares for all traits under study were significant except, No. of kernels/ row, with mean values in L_1 (Moshtohor) being higher than those in L_2 (Sohag) for most traits. The increase in these traits at L_1 may be due to the prevailing favorable temperature and soil leading to great vegetative growth, yield and its components of maize plants. Therefore, the first location seemed to be non-stress environments. These results agreed with those obtained by Amer (2005), El-Hosary *et al* (2006), and El Hosary (2015).

Significant cross mean squares were observed for all traits in both and across the studied locations, except for shelling% at L_2. Significant hybrid by location mean squares were detected for all traits, except for No. of kernels row^{-1}. Such results indicate that the performance of hybrids differed from one location to another. For the exceptional trait (No. of kernels row^{-1}) non-significant interaction between hybrid and location was obtained, revealing that the response of hybrids was nearly similar in magnitude at the two locations.

Hybrid performance

The mean performances of the 28 hybrids and SC 10 for all the studied traits in the combined analysis of the two locations and grain yield plant^{-1} in both locations as well as the combined across them are presented in Table 2. For plant height, the cross P3xP5 gave the highest mean followed by crosses P_2xP_5, P_4xP_6 and P_4xP_7 with a significant difference compared with SC 10 (check hybrid). The cross P3xP8 gave the lowest one for this trait. The cross P_2xP_4 gave the lowest mean value for ear height. The cross P_3xP_5 gave the highest mean for ear length, followed by crosses P_6xP_7 and P_2xP_3 with a significant difference compared with the SC 10. Regarding ear diameter, the cross P_3xP_5 gave the highest mean. All crosses surpassed the check hybrid, while, the cross P_2xP_4 gave the highest No of rows ear^{-1}. For No. of kernels row^{-1}, the cross P_5xP_6 gave the highest mean for this trait.

Table 1. Mean squares from analysis of variance and combining ability for each and across locations for the studied traits.

SOV	df	Plant height	Ear height	Ear length	Ear diameter	No. of rows ear^{-1}
First location Moshtohor						
Rep.	2	5.81	11.01	0.58	0.003	0.35
Cross	27	1086.61**	1244.24**	54.99**	0.28*	1.89*
Error	54	27.69	19.54	0.55	0.10	0.32
GCA	7	135.54**	260.69**	12.44**	0.04	0.14
SCA	20	441.53**	468.67**	20.39**	0.11*	0.80*
Error	54	9.23	6.51	0.18	0.03	0.11
GCA/SCA		0.31	0.56	0.61	-	-
Second location Sohag						
Rep.	2	3.77	13.68	2.28	0.01	0.35
Cross	27	407.23**	255.44**	8.04**	0.25**	1.68**
Error	54	22.54	21.73	0.88	0.06	0.65
GCA	7	65.30**	196.64**	2.45**	0.07**	0.94**
SCA	20	160.40**	46.12**	2.76**	0.09**	0.43
Error	54	7.51	7.24	0.29	0.02	0.22
GCA/SCA		0.41	4.26	0.89	0.81	-
Combined across locations						
Location	1	33889.54**	57810.63**	1048.02**	1.48**	6.11**
blocks/L.	4	4.79	12.35	1.43	0.01	0.35
Cross	27	866.88**	760.67**	33.29**	0.29**	1.70**
Cross x L	27	626.96**	739.01**	29.74**	0.25**	1.87**
Error/L.	108	25.11	20.63	0.72	0.08	0.49
GCA	7	111.40**	269.88**	4.67**	0.07	0.50**
SCA	20	351.11**	247.84**	13.35**	0.11**	0.59**
GCA xL.	7	89.44**	187.46**	10.22**	0.04	0.58**
SCA x L.	20	250.83**	266.94**	9.81**	0.10**	0.64**
Error	108	8.37	6.88	0.24	0.03	0.16
GCA/SCA		0.32	1.09	0.35	-	0.84
GCAxL./GCA		0.80	0.69	2.19	0.62	1.17
SCAxL./SCA		0.71	1.08	0.73	0.91	1.08

Table 1. Cont.

SOV	df.	No. of kernels row^{-1}	100-kernel weight	Grain yield plant^{-1}	Ear weight plant^{-1}	Shelling %
First location Moshtohor						
Rep.	2	2.68	4.74	88.94**	84.34	4.76
Cross	27	21.51**	26.65**	1467.25**	3846.38**	53.34**
Error	54	3.55	4.50	159.99	138.04	20.29
GCA	7	2.95**	11.86**	646.07**	1480.79**	21.55**
SCA	20	8.65**	7.84**	434.14**	1212.59**	16.46**
Error	54	1.18	1.50	53.33	46.01	6.76
GCA/SCA		0.34	1.51	1.49	1.22	1.31
Second location Sohag						
Rep.	2	6.44*	0.23	459.58**	17.50	18.60
Cross	27	23.05**	43.39**	343.16**	2250.28**	33.68
Error	54	3.93	6.57	122.39	169.28	23.75
GCA	7	5.84**	17.73**	116.94**	362.59**	17.70**
SCA	20	8.33**	13.32**	113.49**	885.72**	8.96
Error	54	1.31	2.19	40.80	56.43	7.92
GCA/SCA		0.70	1.33	1.03	0.41	-
Combined across locations						
Location	1	6.23	312.94**	49273.19**	3700.21**	908.31**
blocks/L.	4	4.56	2.48	274.26	50.92	11.68
Cross	27	42.61**	41.46**	1146.68**	3299.37**	39.45**
Cross x L	27	1.95	28.58**	663.74**	2797.29**	47.57*
Error/L.	108	3.74	5.53	141.19	153.66	22.02
GCA	7	7.99**	24.32**	492.73**	756.46**	6.86
SCA	20	16.38**	10.14**	343.55**	1219.96**	15.35*
GCA xL.	7	0.79	5.27*	270.29**	1086.93**	32.40**
SCA x L.	20	0.60	11.02**	204.08**	878.35**	10.07**
Error	108	1.25	1.84	47.06	51.22	7.34
GCA/SCA		0.49	2.40	1.43	0.62	0.45
GCAxL./GCA		0.10	0.21	0.55	1.44	4.72
SCAxL./SCA		0.04	1.09	0.59	0.72	0.66

*** and ** refers to significant p< 0.05 and p< 0.01, respectively.**

Table 2. Mean performance of the genotypes for all studied traits across locations, grain yield plant^{-1} at both and across locations and superiority relative to check hybrid SC10 at the combined analysis.

Cross	Trait						
	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	No of rows ear^{-1}	No of kernels row^{-1}	100-kernel weight
P1xP2	258.2 DF	136.5 BC	15.26 HI	4.52 AG	13.02DH	37.73BF	32.64 HL
P1xP3	252.7 FH	116.2 JM	14.13 JK	4.17 GH	12.57 GI	39.92B	30.48 L
P1xP4	258.8 DF	132.2 CD	18.94 BC	4.57 AF	12.73FI	35.87DI	33.19 FL
P1xP5	241.4 K	107.3 O	13.98 JK	3.95 H	13.07CH	36.33CI	35.84 BH
P1xP6	263.0 CE	121.7 FJ	13.27 KM	4.63 AF	14.02BC	33.92IJ	33.12 FL
P1xP7	252.3 FI	123.5 EH	15.41 GI	4.59 AF	13.63BF	38.92BC	36.93 AE
P1xP8	241.6 K	116.3 JM	13.89 JK	4.80 AC	13.97BD	35.87DI	36.33 AF
P2xP3	260.8 CE	119.7 GK	19.15 B	4.83 AB	14.40B	36.1DI	36.08 AF
P2xP4	233.3 L	101.7 P	13.49 JL	4.61 AF	15.33A	34.92FJ	35.97 BG
P2xP5	270.0 B	127.7 DE	12.14 N	4.72 AE	13.15CH	39BC	31.13 JL
P2xP6	258.7 DF	143.5 A	16.20 FH	4.71 AE	13.08CH	32.43J	33.72 EL
P2xP7	260.3 CE	140.5 AB	16.33 EH	4.42 CG	13.82BE	35.82DI	32.72 GL
P2xP8	253.5 FG	110.5 MO	12.59 LN	4.71 AE	12.25H	37.92BE	35.82 BH
P3xP4	246.6 HK	113.3 LO	12.36 MN	4.32 EG	14.37B	36.33CI	32.56 HL
P3xP5	286.3 A	143.2 A	21.96 A	4.86 A	13.55BF	35.4EI	38.92 AB
P3xP6	246.0 IK	110.0 NO	15.60 GI	4.37 DG	12.23HI	39.03BC	34.12 DJ
P3xP7	263.3 CD	127.3 DF	14.07 JK	4.49 AG	13.38CG	37.63BG	32.29 IL
P3xP8	226.5 M	112.7 LO	15.93 FH	4.53 AG	12.9FI	37.3BH	36.36 AF
P4xP5	246.5 HK	112.8 LO	16.50 EG	4.59 AF	13.12CH	38.6BD	32.43 IL
P4xP6	266.0 BC	114.9 KN	14.56 IJ	4.23 FH	13.98BD	34.67HJ	32.69 GL
P4xP7	264.2 BD	108.1 O	13.70 JK	4.57 AF	12.07II	35.07FJ	37.56 AC
P4xP8	261.3 CE	110.8 MO	15.41 GI	4.58 AF	13.5BG	37.32BH	35.32 CI
P5xP6	256.4 EF	133.5 C	13.98 JK	4.38 DG	13.5BG	42.97A	30.54 L
P5xP7	244.9 JK	118.5 HL	17.34 DE	4.15 GH	12.33HI	36.98CH	31.82 JL
P5xP8	266.7 BC	122.7 EI	17.00 EF	4.69 AE	13.8BE	34.8GJ	37.07 AD
P6xP7	258.0 DF	113.0 LO	19.10 B	4.73 AD	12.97EI	39.92B	30.71 KL
P6xP8	248.6 GJ	120.3 GK	18.06 CD	4.40 CG	14.37B	32.58J	39.21 A
P7xP8	261.8 CE	117.5 IL	16.83 EF	4.45 BG	12.42HI	35.57EI	33.88 DK
Sc 10	262.6 CE	124.7 EG	16.28 EH	4.33 DG	11.671J	38.13BE	35.83 BH

Means have the same letter for each tested parameter are not significantly different by Duncan's test ($P < 0.05$)

Table 2. Cont.

Cross	Ear weight plant^{-1} (g)	Shelling%	Grain weight plant^{-1} (g)			Superiority % relative to SC10		
			Mostohor (L1)	Sohag (L2)	Combined (Comb.)	L1	L2	Comb.
P1xP2	188.5HK	84.55 A	175.0 CG	143.7 DH	159.4 C	5.68	-0.90	2.61
P1xP3	161.0M	84.22 AB	149.1 IK	122.1 IL	135.6 FG	-9.99	-15.79*	-12.69*
P1xP4	166.6LM	79.46 AE	137.0 JK	127.7 GH	132.4 G	-17.27**	-11.93	-14.78*
P1xP5	187.8HK	79.92 AE	165.2 DI	139.0 EI	150.1 CE	-16.06*	11.17	-2.06
P1xP6	171.4KM	80.21 AE	161.2 DI	113.8 J	137.5 EG	-2.66	-21.52**	-11.46*
P1xP7	249.2A	73.63 E	200.0 B	166.9 AC	183.5 A	20.77**	15.10*	18.13**
P1xP8	218.3CF	81.26 AD	179.5 BE	175.3 A	177.4 A	5.86	20.89**	14.23*
P2xP3	239.1AB	76.77 CE	196.1 BC	171.0 AC	183.6 A	18.41**	17.93**	18.19**
P2xP4	230.2AC	77.57 CE	181.4 BD	175.7 A	178.6 A	6.08	21.10**	14.97*
P2xP5	196.8FJ	78.89 AE	166.3 DI	144.2 DH	155.3 C	0.44	-0.55	-0.03
P2xP6	165.7LM	79.79 AE	147.0 IK	117.4 J	132.2 G	-11.23	-19.03**	-14.87**
P2xP7	201.0FI	77.80 BE	183.9 BD	128.9 GJ	156.4 C	11.07	-11.10	0.71
P2xP8	207.3DH	76.08 CE	177.1 CF	138.4 EI	157.8 C	6.94	-4.55	1.58
P3xP4	210.8CG	74.39 E	179.9 BE	133.8 FJ	156.9 C	8.61	-7.72	1.00
P3xP5	211.3CG	82.12 AD	173.7 CH	173.3 AB	173.5 AB	4.87	19.52**	11.72*
P3xP6	202.8FI	78.46 AE	174.0 CH	144.3 DH	159.2 C	5.07	-0.48	2.48
P3xP7	204.1EI	79.24 AE	162.9 DI	160.6 AD	161.8 BC	-3.02	12.34	4.15
P3xP8	193.4GJ	79.14 AE	153.8 GK	152.3 CF	153.1 CD	2.94	5.03	-1.45
P4xP5	192.7GK	82.66 AC	163.9 DI	154.7 BE	159.3 C	-6.58	6.69	2.58
P4xP6	186.5HL	79.76 AE	151.6 HK	145.9 DG	148.8 CF	-11.90	4.55	-4.22
P4xP7	176.7JM	79.73 AE	147.5 IK	134.2 EJ	140.9 DG	-10.92**	1.72	-9.30
P4xP8	224.9BE	77.24 CE	225.2 A	122.3 IJ	173.8 AB	33.96**	-15.66*	11.88*
P5xP6	191.8GK	78.53 AE	154.7 FK	146.5 DG	150.6 CE	-6.60	1.03	-3.03
P5xP7	165.7LM	78.99 AE	134.7 K	127.0 GJ	130.9 G	-23.31**	-7.10	-15.74**
P5xP8	201.5FI	75.60 DE	174.0 CH	130.6 GJ	152.3 CD	5.07	-9.93	-1.93
P6xP7	171.0KM	79.54 AE	147.1 IK	124.9 HJ	136.0 FG	-24.58**	1.45	-12.43*
P6xP8	225.8BD	79.31 AE	191.7 BC	166.4 AC	179.1 A	15.74*	14.76*	15.33**
P7xP8	182.6IL	81.23 AD	158 EJ	138.7 EI	148.4 CF	-4.59	-4.34	-4.48
SC 10	189.6GK	81.93 AD	165.6 DI	145.0 DH	155.3 C			

Means followed by the same letter in each column are not significantly different by Duncan's test at $P < 0.05$
*** and ** refers to significant $p < 0.05$ and $p < 0.01$, respectively.**

Most hybrids exhibited high No. of kernels row^{-1} compared with the check variety SC10. For the 100-kernel weight, the cross P_6xP_8 exhibited the highest mean with no significant differences among crosses P_1xP_7, P_1xP_8, P_2xP_3, P_3xP_5, P_3xP_8, P_4xP_7 and P_5xP_8. Concerning ear weight plant^{-1}, the seven crosses P_1xP_7, P_1xP_8, P_2xP_3, P_2xP_4, P_2xP_8, P_4xP_8 and P_6xP_8 showed the heaviest ear weight plant^{-1} compared with SC 10; The hybrids P_1xP_7 ranked first for this trait. For shelling %, the cross P_1xP_2 gave the highest value with no significant differences with nineteen crosses as well as SC 10. Regarding , grain yield plant^{-1}, four crosses (P_4xP_8, P_1xP_7, P_2xP_3 and P_6xP_8), six crosses (P_1xP_7, P_1xP_8, P_2xP_3, P_2xP_4, P_3xP_5 and P_6xP_8) and seven crosses (P_1xP_7, P_1xP_8 , P_2xP_3, P_2xP_4, P_3xP_5, P_4xP_8 and P_6xP_8) at Mostohor (L1), Sohag (L1) and combined analysis, respectively had significant superiority over SC 10 (the check variety). These hybrids exhibited significant increase in two or more traits contributing to grain yield (Table 2). Fluctuation of hybrids from location to another was detected detected for most traits. These results would be due to significant interaction between hybrids and locations (Table 1).

Hybrids surpassed the check variety

The crosses P_1xP_7, P2xP3, P_4xP_8, and P_6xP_8 gave significant desirable superiority relative to SC 10 mean value for grain yield in Moshtohor location. While, The crosses P_1xP_7, P_1xP_8, P_2xP_3, P_2xP_4, P_3xP_5 and P_6xP_8 showed positive and significant superiority relative to SC 10 mean value for grain yield at Sohag. Moreover, The crosses P_2xP_3, P_1xP_7, P_6xP_8, P_2xP_4 , $P_1xP_{8,}$ $P_4xP_{8,}$ and P_3xP_5 exhibited significant and positive superiority relative to SC 10 mean value for grain yield across the two locations and surpassed the check hybrid by 18.19, 18.13, 15.33, 14.97, 14.23, 11.88 and11.72%, respectively. In the same time, all crosses except the above-mentioned hybrids and crosses P_6xP_7, P_1xP_3, P_1xP_4 and P_2xP_5 did not differ significantly relative to SC 10. These crosses revealed that a hybrid program based on these materials may be useful for testing under other different locations and years. Many investigators (Abd El-Aty and Katta 2002, Ali *et al* 2014, Saad El-Deen *et al* 2015 and Al-Naggar *et al* 2016) reported high heterosis for yield of maize.

Combining ability

The mean squares associated with general and specific combining ability were significant for all traits, except of GCA for No. of rows ear^{-1} at L_1 and ear diameter at L_1 and combined across locations as well as shelling% at the combined analysis, SCA at L_2 for No. of rows ear^{-1} and shelling%, revealing that both additive and non-additive types of gene action were involved in determining the performance of single-cross progeny. To determine the genetic effects of greatest importance, GCA/SCA ratio was computed. For ear diameter at L1 and combined analysis and No. of rows ear^{-1} at L_1, there was non-significant GCA along with significant SCA, revealing that a large part of total variability for both cases was non additive gene action. On the other hand, there was no significant SCA along with significant GCA mean squares detected for No. of rows ear^{-1} and shelling% at the L_2, indicating that the additive and additive by additive gene effects were important. For ear height at L_2, the 100-kernel weight and shelling% at L_1, high ratios which largely exceeded the unity were obtained, indicating that, large part of the total genetic variability associated with these cases was additive and additive x additive gene action. Ear height at the combined analysis, 100-kernel weight at L_2 and the combined data and grain yield plant^{-1} at L_2, had GCA/SCA ratio equal unity, indicating that additive and non-additive type of gene action have the same importance in the performance in these cases.

The other cases showed GCA/SCA ratios less than unity. Therefore, it could be concluded that the large portion of the total genetic variability associated with these cases is due to non-additive gene action. These results agree with the findings of other investigators (Derera *et al* 2007, Abd El-Mottalb and Gamea 2014 and Saad El-Deen *et al*2015 and Wani *et al*2017), who mentioned that, additive and non-additive gene action were important in maize traits inheritance. The ratio of SCA to GCA effects also suggests a preponderance of SCA component in the expression of all the studied traits except ear height. Abd El-Aty and Katta (2002), El-Morshidy *et al* (2002), Singh and Kumar (2008), Ibrahim *et al* (2010) and Wani *et al* (2017) reported that, specific combining ability effects were more important in the inheritance of grain yield and yield components. On the other hand, El Shouny *et al* (2003), Al-Naggar *et al* (2011) and EL-Hosary and Elgammaal (2013) concluded that additive gene effects illustrats the major role in the inheritance of grain yield and other agronomic characters.

Significant interaction mean square between locations and both types of combining ability were exhibited for all traits except No. of kernels for both combining abilities by location, ear diameter for GCAxL and shelling % for SCAxL. Such results showed that the magnitude of all types of gene action varied from one location to another. For the exceptional cases, No. of kernels row^{-1}, the additive and non-additive types of gene action were stable from one location to another. For ear diameter, the additive and additive by additive gene action did not vary from one location to another. However, the shelling%, non-additive gene action was stable from one location to another. The ratios for SCAxL/SCA were higher than ratios of GCAxL/GCA for all traits, except for plant height, ear length, ear height and shelling%. Such results indicate that non additive effects were much more affected by location than additive genetic effects in these traits. This conclusion in agreement with that reported by Gilbert (1958). For the exceptional traits the ratio of GCAxL/GCA was higher than ratio of SCAxL/SCA revealing that additive and additive x additive types of gene action were more influenced by location (Table 1).

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

Estimates of general combining ability effects ($\hat{g}_i$) for individual inbred lines across two locations are presented in Table 3. High values would be of interest for all traits, except for ear height, where high negative ones would be useful from the breeder point of view. The parental inbred line P_1 behaved as the appropriate combiner for No. of rows ear^{-1}, Meanwhile, it was on the average in the rest of traits, P_8 and P_3 that seemed to be suitable combiner for grain and ear yields $plant^{-1}$. P_2 seemed to be suitable combiner for ear diameter and ear weight, it expressed either a significant negative or non-significant positive for No. of kernels/ row, 100-kernel weight, grain and ear yields $plant^{-1}$. The parental inbred line P_4 expressed effective combiner for ear height, while, it gave significant undesirable or non-significant positive $\hat{g}_i$ effects for plant height, ear length and No. of kernels row^{-1}. While, it gave undesirable $\hat{g}_i$ effects for other traits.

Table 3. Estimates of general combining ability effects of eight inbred lines for all the studied traits across two locations.

Parent	Traits									
	Plant height	Ear height	Ear length	Ear diameter	No of row ear^{-1}	No of kernels row^{-1}	100-kernel weight	Grain yield $plant^{-1}$	Ear weight $plant^{-1}$	Shelling %
P_1	-3.17**	1.62	-0.73**	-0.07	0.31*	0.05	0.38	-0.64	-6.01*	1.54
P_2	1.28	5.98**	-0.69**	0.15	-0.18	-0.88*	0.58	4.32	6.89*	-0.43
P_3	-0.78	-0.22	0.65**	-0.01	0.05	0.92*	3.62*	5.78*	6.83*	0.05
P_4	-1.75	-8.38**	-0.72**	-0.03	0.16	-0.58	-3.07	-2.38	1.00	-0.54
P_5	4.22**	3.61**	0.60**	-0.05	-0.10	1.31**	1.34	-3.38	-4.83	0.45
P_6	1.65	2.15*	0.25	-0.03	-0.17	0.04	-2.00	-5.98*	-10.84**	0.26
P_7	3.02**	0.78	0.58**	-0.04	-0.25	0.11	-3.24	-8.33**	-5.03	-0.64
P_8	-4.47**	-5.53**	0.07	0.09	0.18	-0.98*	2.39	10.62**	12.00**	-0.69
LSD5%($\hat{g}_i$)	2.20	1.99	0.37	ns	0.31	0.85	3.49	5.21	5.44	ns
LSD1%($\hat{g}_i$)	2.91	2.64	0.49	ns	0.41	1.12	4.63	6.91	7.21	ns
LSD5%($\hat{g}_i$ - $\hat{g}j$)	3.32	3.01	0.56	ns	0.46	1.28	5.28	7.88	8.22	ns
LSD1%($\hat{g}_i$ - $\hat{g}j$)	4.41	3.99	0.75	ns	0.61	1.70	7.00	10.45	10.90	ns

*** and ** refers to significant $p< 0.05$ and $p< 0.01$, respectively.**

The parental lines P_6 and P_7 gave undesirable $\hat{g}_i$ effects for all traits, except P_7 for ear length. The parental line P_8 seemed a suitable combiner for grain and ear yields $plant^{-1}$, plant and ear heights. However, it gave non-significant $\hat{g}_i$ effects for other traits.

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

Appreciation of specific combining ability (SCA) effects for 28 F_1 crosses for all studied attributes across the two locations are given in Table 4. The most desirable inter and intra-allelic interactions were presented by the combinations; P_2xP_4 , P_3xP_8 and P_5xP_7 for short plant height, P_1xP_5, P_2xP_4, P_2xP_8 and P_3xP_6 for ear height; P_1xP_4, P_2xP_3 and P_3xP_5 for ear length; P_3xP_5 and P_6xP_7 for ear diameter; P_2xP_7 for No. of rows ear^{-1}; P_5xP_6 , P_1xP_3 , P_2xP_8 , P_6xP_7 for No of kernels row^{-1}; P_3xP_5 , P_1xP_2 , P_1xP_7 and P_1xP_8 for 100-kernel weight and P_1xP_7, P_3xP_5 and P_4xP_8 for grain yield and ear weight plant^{-1}.

Table 4. Estimates of specific combining ability effects for all studied traits across two locations.

Parental combination	Trait				
	Plant height	Ear height	Ear length	Ear diameter	No. of rows ear^{-1}
P_1xP_2	4.74	8.39**	1.07*	-0.08	-0.42
P_1xP_3	1.39	-5.86**	-1.40**	-0.27	-0.10
P_1xP_4	8.34**	18.37**	4.79**	0.15	-0.05
P_1xP_5	-14.92**	-18.48**	-1.50**	-0.45**	-0.45
P_1xP_6	9.25**	-2.64	-1.85**	0.21	0.57
P_1xP_7	-2.79	0.63	-0.05	0.18	0.27
P_1xP_8	-6.01*	-0.42	-1.06*	0.26	0.17
P_2xP_3	4.92*	-6.67**	3.57**	0.18	-0.77*
P_2xP_4	-21.49**	-16.63**	-0.71	-0.02	0.05
P_2xP_5	9.30**	-2.62	-3.39**	0.10	0.13
P_2xP_6	0.36	14.82**	1.03*	0.07	0.12
P_2xP_7	0.80	13.21**	0.83*	-0.20	0.94**
P_2xP_8	1.36	-10.49**	-2.40**	-0.04	-0.05
P_3xP_4	-6.17*	1.43	-3.18**	-0.16	0.85*
P_3xP_5	27.59**	19.19**	5.09**	0.41**	0.30
P_3xP_6	-10.14**	-12.43**	-0.91*	-0.11	-0.95**
P_3xP_7	5.93*	6.34**	-2.78**	0.02	0.29
P_3xP_8	-23.52**	-2.00	-0.41	-0.06	0.37
P_4xP_5	-11.36**	-3.02	1.01*	0.15	-0.25
P_4xP_6	10.77**	0.47	-0.58	-0.23	-0.32
P_4xP_7	7.58**	-4.88*	-1.77**	0.12	-0.15
P_4xP_8	12.33**	4.25	0.45	0.00	-0.14
P_5xP_6	-4.64	7.37**	-2.48**	-0.05	0.46
P_5xP_7	-17.57**	-6.43**	0.55	-0.28*	-0.62
P_5xP_8	11.61**	3.98	0.72	0.13	0.42
P_6xP_7	-1.90	-10.58**	2.67**	0.28*	0.08
P_6xP_8	-3.71	2.97	2.13**	-0.17	0.04
P_7xP_8	7.94**	1.71	0.56	-0.11	-0.81*
LSD5%(sij)	4.86	4.41	0.82	0.28	0.68
LSD1%(sij)	6.45	5.85	1.09	0.37	0.90
LSD5%(sij-sik)	7.43	6.73	1.26	0.42	1.03
LSD1%(sij-sik)	9.85	8.93	1.67	0.56	1.37
LSD5%(sij-skl)	6.64	6.02	1.12	0.38	0.93
LSD1%(sij-skl)	8.81	7.99	1.49	0.50	1.23

Table 4. Cont.

Parental combination	Trait				
	No. of kernels row^{-1}	100-kernel weight	Grain yield plant^{-1}	Ear weight plant^{-1}	Shelling %
P_1xP_2	0.11	8.57*	10.72	-10.22	4.29
P_1xP_3	3.48**	-8.11*	-15.88**	-37.59**	3.48
P_1xP_4	1.93*	-6.77	-16.34**	-26.35**	-0.69
P_1xP_5	-1.49	-7.13	-14.55*	3.23	-1.21
P_1xP_6	-2.65**	-3.33	0.95	-7.18	-0.74
P_1xP_7	-1.72	8.07*	29.36**	63.40**	-6.41**
P_1xP_8	0.34	8.70*	5.74	14.71*	1.27
P_2xP_3	-0.41	-3.39	-6.70	28.10**	-2.00
P_2xP_4	-0.08	-4.09	-2.34	24.96**	-0.61
P_2xP_5	0.12	0.78	3.45	-2.94	-0.28
P_2xP_6	-3.20**	-1.27	-8.44	-31.16**	0.81
P_2xP_7	0.14	-0.16	9.84	0.53	-0.27
P_2xP_8	3.31**	-0.44	-6.52	-9.26	-1.94
P_3xP_4	-0.47	2.64	7.31	4.89	-4.27
P_3xP_5	-3.28**	9.62*	16.04**	13.45*	2.47
P_3xP_6	-0.38	5.59	11.50	8.76	-1.00
P_3xP_7	0.16	-3.18	-0.11	4.82	0.69
P_3xP_8	0.91	-3.18	-12.16*	-22.43**	0.63
P_4xP_5	-0.59	4.57	4.79	-0.56	3.60
P_4xP_6	-1.26	2.79	-2.13	-0.35	0.88
P_4xP_7	-0.93	3.75	-6.65	-16.07**	1.76
P_4xP_8	1.41	-2.89	15.36**	13.48*	-0.68
P_5xP_6	8.14**	-0.37	4.75	11.16	-1.32
P_5xP_7	-0.91	-1.88	-9.73	-21.20**	0.04
P_5xP_8	-1.98*	-5.59	-4.76	-3.12	-3.30
P_6xP_7	3.29**	-6.70	-15.84**	-9.67	0.77
P_6xP_8	-3.95**	3.30	9.20	28.45**	0.60
P_7xP_8	-0.04	0.10	-6.86	-21.82**	3.42
LSD5%(sij)	1.88	7.73	11.53	12.03	4.55
LSD1%(sij)	2.49	10.25	15.30	15.96	6.04
LSD5%(sij-sik)	2.87	11.81	17.62	18.38	6.96
LSD1%(sij-sik)	3.80	15.66	23.36	24.37	9.23
LSD5%(sij-skl)	2.56	10.56	15.76	16.44	6.22
LSD1%(sij-skl)	3.40	14.01	20.90	21.80	8.25

*** and ** refears to significant $p< 0.05$ and $p< 0.01$, respectively.**

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القدرة على التآلف للمحصول وبعض مكوناته فى الذره الشاميه عبر موقعين للزراعة

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٣. قسم المحاصيل– كلية الزراعه – جامعة طنطا

تم اجراء التحليل الوراثى لثمانية سلالات ابويه من الذره الشاميه من خلال التزاوج النصف دائرى الذى اجرى خلال موسم ٢٠١٦ بمزرعة التجارب الزراعيه بكلية الزراعه بمشتهر جامعة بنها ، حيث تم تقييم الهجن (بدون الهجن العكسيه) وصنف تجارى للمقارنة باستعمال تصميم القطاعات الكاملة العشوائيه (RCBD) وذلك باستعمال ثلاث مكررات واجرى التقييم بموقعين ، الاول مشتهر (L1) والثانى سوهاج (L2) وذلك خلال الموسم الزراعى ٢٠١٧. اقيمت التجربتين بهدف قياس متوسط اداء الهجن و مقدار التفوق عن صنف المقارنة (هجين فردى ١٠) و تقدير القدرة على التآلف و تفاعلهم مع المواقع المختلفة. وكانت الإختلافات عالية المعنويه بين الموقعين لكل الصفات تحت الدراسة مما يشير الى اختلاف الموقعين فى ظروفهما البئيه. و كان متوسط صفة

محصول حبوب/ نبات اعلى فى الموقع الاول عن الثانى. كان تباين الهجن عالى المعنوية فى كل الصفات المدروسة عدا نسبة التفريط% فى موقع مشتهر وكان التفاعل بين الهجن والمواقع معنويا عدا صفة عدد الحبوب /سطر ، مما يشير الى اختلاف سلوك التراكيب الوراثيه فى هذين الموقعين المختلفين فى ظروفهما البيئية. اظهرت الهجن P_2xP_3 P_1xP_7 , , P_6xP_8, P_2xP_4, P_1xP_8, , P_4xP_8 و P_3xP_5 تفوقاً موجبا عالى المعنوية عن صنف المقارنة هجين فردى ١٠ فى التحليل المجمع و كانت نسبة التفوق ١٨.١٩ , ١٨.١٣ , ١٥.٣٣ ,١٤.٩٧, ١٤.٢٣ , ١١.٨٨ و ١١.٧٢% على الترتيب. اظهر تباين القدره العامه والخاصه على الائتلاف اختلافات معنويه لكل الصفات التى تم دراستها عدا القدرة العامة على التآلف لصفة عدد السطور / كوز فى الموقع الاول و قطر الكوز فى كلا من الموقع الاول و التحليل المجمع و القدرة الخاصة على التآلف لصفة عدد السطور بالكوز و نسبة التفريط % ، بالنسبة لصفات ارتفاع الكوز و وزن ال ١٠٠ حبة و محصول الكيزان/ نبات فأن الجزء غير المضيف هو الذى يتحكم فى اظهار تلك الصفات. اما الجزء المضيف فأنه يتحكم فى اظهار صفة محصول الحبوب/ نبات. كان التفاعل الراجع للقدره العامه على الائتلاف مع البيئه (GCA × L) و التفاعل الراجع للقدره الخاصه على الائتلاف مع البيئه(SCA × L) معنويا لمعظم الصفات المدروسة. كل من الابوين P_3 و P_8 كانوا لهم قدرة عامة عالية على التآلف لصفة محصول الحبوب/ نبات. اوضحت النتائج ان الهجن (P_1xP_7) , (P_3xP_5) و P_4xP_8 كانوا احسن الاتحادات المرغوبه فى قدرتها الخاصة على التآلف لمحصول حبوب النبات.

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