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DIALLEL ANALYSIS FOR EIGHT DIVERGENT INBRED LINES OF MAIZE

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ABSTRACT

28 F_1 crosses resulted from crossing among eight white maize inbred lines in a half diallel cross design were grown with check hybrid SC10 at two locations, i.e. Sakha and Sids Agricultural Research Station. The studied traits were days to 50% silking, plant and ear height (cm), grain yield (ard/fed), ear length and diameter (cm), no. of rows/ear and no. of kernels/row. The obtained results could be summarized as follows: Overall difference was found between locations for all traits. The variances among genotypes and their partitioning into general (GCA) and specific (SCA) combining ability were highly significant for all studied traits, indicating that both additive and non-additive gene action were important in the inheritance of all traits. The best inbred for GCA effects (g_i) was SK6005/22, for earliness, SK5058/2 for short plant and ear height, Sd7 for grain yield, SK5002/53 for ear length, Gm2 for ear diameter and no. of rows/ear and Sd63 for no. of kernels/row. The best cross for SCA effects (S_{ij}) was SK5002/53 x Gm2 for earliness, SK5058/2 x SK5001/80 for short plant and ear height, SK5001/80 x Sd7 for grain yield and ear diameter, SK5058/2 x Sd63 for ear length, no. of rows/ear and no. of kernels/row. The single cross SK5001/80 x Sd7 (35.77 ard/fed) out-yielded significantly the commercial check SC10 (32.46 ard/fed).

Keywords: ***Maize, Inbred lines, Half diallel, Combining ability, Gene action.***

INTRODUCTION

Maize is grown in more than 160 million hectares in the world and entering in 2 to 3 thousand industries, and many poor countries use white maize it in direct human foods.

The diallel cross mating design is used to determine the best genetic material for breeding programmes for the genetic improvement of various quantitative traits. Sprague and Tatum (1942) was the first to define general (GCA) and specific (SCA) combining ability. Matzinger *et al* (1959) found that the GCA variance is a function of additive genetic variance and additive x additive type of epistasis, while SCA variance is a function of non-additive variance. Nevado and Cross (1990), Tulu and Ramachandrappa (1998), Zelleke (2000), Amer (2005), Hassan (2008), Mosa *et al* (2010) and Hassan (2012) reported that both additive and non-additive genetic effects are operating in the inheritance of grain yield. However, Crossa *et al* (1990), El-Shamarka (1995), Motawei (2006) and Abo El-Haress (2015) found that the additive gene action was more important in expression of grain yield, while Katta *et al* (1975), Dawood *et al* (1994), Vicent *et al* (2001), Mosa and Amer (2004), Mosa *et al* (2010) and Hassan (2012) found that non-additive gene action seemed to play an important role in the expression of grain yield. The main objective of our study was to estimate type of gene action controlling the inheritance for studied traits, estimate combining ability effects for these inbred lines and consequently, to identify superior single cross hybrids developed from them.

MATERIALS AND METHODS

The experimental material comprised of eight inbred lines of maize are presented in Table (1).

Table 1. Inbred lines and their different sources.

No.	Inbred lines	Source
1	**SK6005/22**	**Comp-Sk-7 S_1C_1**
2	**SK5002/53**	**Syn Sk-6**
3	**SK5058/2**	**Pop. Exotic from USA**
4	**SK5001/80**	**Pop. Exotic from USA**
5	**SK6006/3**	**Sk-8 × Gm-30**
6	**Sd-7**	**A.E.D**
7	**Sd-63**	**Tepalcingo**
8	**Gm-2**	**Pop.Gm 7421**

These inbreds were developed from different genetic origin at Sakha (Sk), Sids (Sd) and Gemmeiza (Gm) Agricultural Research Stations. The half dialell mating design among these inbreds were made at Sakha Station during 2013 season. The resulting 28 F_1's plus the commercial check SC10 were evaluated in 2014 growing season at two locations, *i.e.* Sakha and Sids Agricultural Research Stations in experiments using a randomized complete block design (RCBD) with four replications. Each plot consisted of one row, 6 m length, 80 cm width and 25 cm between hills. All agronomic field operations were practiced as usual with ordinary field maize cultivation. Data were recorded on number of days to 50% silking, plant and ear height (cm), grain yield (ard/fed) adjusted at 15.5% grain moisture content, ear length and diameter (cm), no. of rows/ear and no. of kernels/row. The analysis of variance for combined data was done according to Steel and Torrie (1980). General and specific combining ability effects were estimated according to Griffing's (1956) method-4 model-1.

RESULTS AND DISCUSSION

Combined analysis for eight traits across two locations are shown in Table (2). The mean squares due to locations (Loc) were highly significant for all traits, indicating overall differences between Sakha and Sids locations. The mean squares due to crosses (Cr) were highly significant for all traits, meaning that the crosses varied significantly from each other. Also, the interaction between (Cr x Loc) mean squares were significant or highly significant for all traits, except for ear diameter, indicating that the response of crosses differed under different locations.

Table 2. Combined analysis for eight traits across two locations.

SOV	df	Days to 50% silking	Plant height	Ear height	Grain yield
Locations (Loc)	1	458.0**	165636.2**	74020.4**	4466.03**
Rep/Loc	6	9.02	2730.9	1906.2	113.64
Crosses (Cr.)	28	51.36**	3307.9**	1823.1**	172.88**
Cr. x Loc.	28	4.93**	190.1**	219.3**	66.40**
Error	168	1.38	94.1	52.7	9.24
SOV	**df**	**Ear length**	**Ear diameter**	**No. of rows/ear**	**No. of kernels/row**
Locations (Loc)	1	550.58**	10.097**	46.80**	563.59**
Rep/Loc	6	3.70	0.130	0.17	20.34
Crosses (Cr.)	28	22.89**	0.213**	10.94**	80.82**
Cr. x Loc.	28	1.95*	0.067	1.03**	16.37**
Error	168	1.18	0.048	0.54	8.25

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

Mean performances of the 28 F_1 single crosses plus the commercial check SC10 across two locations are presented in Table (3). Data showed that the 15 single crosses were earlier than the commercial check SC10. The earlier cross was SK6005/22 x SK6006/3 followed by SK6005/22 x SK5001/80. Twenty seven crosses had significantly shorter plant and lower ear height than the commercial check SC10. The shortest cross was SK5058/2 x SK5001/80, followed by SK5058/2 x SK6006/3. For grain yield, the cross SK5001/80 x Sd7 (35.77 ard/fed) significantly outyielded SC10 (32.46 ard/fed). For ear length and number of kernels/row, SC10 was the highest, meanwhile ear diameter and number of rows/ear of the crosses SK5002/53 x Gm2, SK5001/80 x Gm2 and SK6006/3 x Gm2 increased significantly than SC10.

From the above data, the inbred line Sk6005/22 gave the earliest cross, SK5058/2 gave the shortest (desirable) cross for plant and ear heights, also, Gm2 showed the best cross for ear diameter and no. of rows/ear.

Analysis of variance of combining ability (Table 4) showed that the mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all studied traits, indicating that both additive and non-additive gene effects were important in the inheritance of all studied traits. These results are in agreement with those supported by Perezvalasquez *et al* (1995), El-Shenawy (2005) and Hassan (2012).

Table 3. Mean performance of 28 single crosses and the commercial check hybrid SC10 for eight traits across two locations.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Grain yield (ard/fed)	Ear length (cm)	Ear diameter (cm)	No. of rows/ ear	No. of kernels/ row
SK6005/22 SK5002/53	62.37	249.87	133.50	27.71	21.92	4.85	13.45	42.125
x SK5058/2	62.50	228.50	125.62	24.68	18.52	4.42	13.65	38.00
x SK5001/80	62.12	242.87	129.25	26.38	20.42	4.60	13.40	40.07
x SK6006/3	61.75	243.62	125.37	23.03	19.80	4.52	14.15	39.70
x Sd-7	64.25	264.75	147.62	30.00	21.00	4.50	12.00	39.70
x Sd-63	63.37	263.62	151.25	27.56	20.22	4.62	12.65	40.72
x Gm-2	64.75	243.62	136.37	25.79	17.67	4.57	15.20	38.92
x SK5058/2	66.25	244.12	141.62	27.47	20.80	4.72	13.80	40.12
SK5002/53 SK5001/80	64.50	245.50	142.12	30.03	22.15	4.800	14.35	42.57
x SK6006/3	63.62	243.25	127.62	24.97	19.25	4.65	14.90	38.00
x Sd-7	68.50	256.50	139.12	24.72	21.00	4.57	12.50	40.62
x Sd-63	67.50	253.00	141.75	24.79	21.05	4.62	13.00	43.00
x Gm-2	65.37	216.62	117.50	25.01	18.07	4.95	15.85	39.43
x SK5001/80	70.75	185.75	102.87	12.04	16.45	4.30	12.97	30.65
x SK6006/3	63.50	220.62	116.00	22.53	17.22	4.67	14.95	34.70
SK5058/2 x Sd-7	67.50	246.62	140.37	32.55	19.02	4.50	13.10	38.65
x Sd-63	68.25	242.87	141.87	29.88	20.60	4.65	14.05	41.87
x Gm-2	70.50	214.37	117.50	26.17	17.32	4.87	15.65	34.47
x SK6006/3	63.25	239.75	125.50	21.08	18.67	4.85	15.15	38.03
x Sd-7	66.37	261.37	147.00	35.77	21.57	4.85	13.80	42.80
SK5001/80 Sd-63	66.37	251.75	143.75	29.77	21.02	4.77	14.25	43.35
x Gm-2	68.25	223.37	120.12	25.15	19.05	4.95	15.85	37.60
x Sd-7	63.25	254.50	133.87	33.42	20.50	4.60	13.45	44.32
x Sd-63	64.87	247.62	141.37	27.87	19.05	4.72	14.05	39.50
x Gm-2	65.62	237.37	131.50	24.61	17.60	4.95	16.55	35.57
SK6006/3 x Sd-63	66.50	282.75	171.62	34.67	22.30	4.62	12.50	45.20
x Gm-2	69.12	263.50	150.12	27.92	18.75	4.82	14.90	39.80
x Gm-2	68.25	250.25	147.25	28.22	18.55	4.80	14.70	40.67
Sd-7 x SC10	67.25	286.50	169.75	32.46	22.67	4.67	12.60	45.60
x								
Sd-63 x								
LSD 0.05	1.14	9.50	7.11	3.00	1.06	0.21	0.72	2.81
0.01	1.50	12.51	9.36	4.02	1.40	0.28	0.94	3.70

Table 4. Analysis of variance of combining ability for eight traits across two locations.

SOV	df	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	No. of rows/ ear	No. of kernels/ row
GCA	7	160.88**	8677.2**	4412.7**	296.48**	61.20**	0.48**	36.88**	203.44**
SCA	20	14.64**	880.4**	550.6**	126.40**	6.96**	0.13**	1.52**	30.4**
GCA x Loc	7	11.2**	405.4**	600.7**	197.38**	4.92**	0.064	1.82**	26.14**
SCA x Loc	20	2.86**	123.9	92.9*	22.82**	1.84	0.07	0.75	13.59*
Error	162	1.38	93.57	53.44	9.50	1.20	0.049	0.55	8.16

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

The interaction between GCA and locations was highly significant for all studied traits except for ear diameter. While, SCA x Loc was significant for days to 50% silking, ear height, grain yield and no. of kernels/row, indicating that both additive and non-additive effects were affected by locations for these traits.

GCA/SCA ratio (Table 5) was higher than unity for all traits, except for grain yield and ear diameter, indicating that the additive gene effects were more important than non-additive gene effects in the inheritance all traits except for grain yield and ear diameter. Also, the additive gene effects were more interacted by locations (GCA x Loc/SCA x Loc > 1) for 5 out of 8 traits.

Table 5. Estimates GCA/SCA ratio and their interaction with locations for eight traits.

Ratio	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row
GCA/SCA	2.00	1.81	1.46	0.40	1.73	0.5	6.29	1.46
GCA x Loc/ SCA x Loc	1.11	1.71	2.31	2.34	0.04	0.12	1.06	0.54

Estimates of the general combining ability effects of eight inbred lines are presented in Table (6). The inbred lines SK6005/22 and SK6006/3 had desirable significant GCA effects for days to 50% silking. Also, the inbred lines SK5058/2, SK5001/80, SK6006/3 and Gm2 had desirable significant GCA effects for plant and ear height. Positive and significant GCA effects for grain yield were obtained by inbred lines Sd7 and Sd63. Also, desirable GCA effects were shown for SK6005/22, SK5002/53, SK5001/80, Sd7 and Sd63 for ear length, Sk5002/53 and Gm 2 for ear diameter, Sk6006/3 and Gm 2 for no. of rows/ear and inbred lines Sk5002/53, Sd 7 and Sd 63 for no. of kerenels/row.

Table 6. Estimates of general combining ability effects of eight inbred lines for eight traits across two locations.

Inbreds	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	No. of rows/ ear	No. of kernels/ row
SK6005/22	-3.1146**	5.3802**	0.2708	-0.5497	0.3625*	-0.1240**	-0.7010**	0.4083
SK5002/53	-0.2813	0.7135	-0.6875	-0.6241	1.1417**	0.0552*	-0.1427	1.5125**
SK5058/2	1.5729**	-20.2865**	-10.2500**	-2.1876**	-1.2417**	-0.1156**	-0.0885	-3.0542**
SK5001/80	0.3021	-9.0365**	-6.1250**	-1.3728**	0.3250*	0.0469	0.1781	-0.2875
SK6006/3	-2.3229**	-2.9740*	-7.6875**	-1.8220**	-0.8833**	0.0219	0.7490**	-1.6625**
Sd-7	0.9479**	20.9010**	13.7292**	5.1001**	1.1250**	-0.0615*	-1.0760**	1.8833**
Sd-63	0.8854**	14.5468**	15.2500**	2.3847**	0.9000**	-0.0031	-0.5844**	2.9208**
Gm2	2.0104**	-9.2448**	-4.5000**	-0.9286*	-1.7292**	0.1802**	1.6656**	-1.7208**
LSD g_i 0.05	0.31	2.56	1.92	0.80	0.28	0.05	0.19	0.76
0.01	0.40	3.37	2.52	1.05	0.37	0.07	0.25	1.00
LSD g_i-g_j 0.05								
0.01	0.46	3.88	2.90	1.21	0.43	0.08	0.29	1.14
	0.61	5.10	3.58	1.60	0.57	0.11	0.38	1.51

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

Specific combining ability effects (S_{ij}) for all studied traits are presented in Table (7). Number of crosses which had significant desirable SCA effects were 9, 6, 6, 9, 8, 2, 3 and 3 for days to 50% silking, plant height, ear height, grain yield, ear length, ear diameter, no. of rows/ear and no. of kernels/row, respectively. The best crosses from them were SK6005/22 x SK5058/2, SK5002/53 x Gm2 and SK5058/2 x SK6006/3 for earlines, SK5002/53 x Sd7, Sk5002/53 x Gm2 and SK5058/2 x SK5001/80 for plant and ear height, SK5002/53 x SK5058/2, SK5002/53 x SK5001/80, SK5001/80 x Sd7 and SK6006/3 x Sd7 for grain yield, Sk5002/53 x SK5058/2 and SK5058/2 x Sd63 for ear length, SK6005/22 x SK5002/53 for ear diameter and SK5058/2 x Sd63 for no. of rows/ear and no. of kernels/row. Generally, the cross SK6006/3 x Sd7 had desirable values of SCA effects for grain yield and most studied traits.

Table 7. Estimates of specific combining ability effects (Sij) for 28 F_1's crosses for eight traits.

Crosses	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	No. of rows/ear	No. of kernels/ row
SK6005/22 x SK5002/53	0.083	0.27	-1.42	1.96*	0.792*	0.2268**	0.193	0.661
x SK5058/2	-1.646**	-0.11	0.26	0.50	-0.224	-0.0274	0.339	1.103
x SK5001/80	-0.750*	3.02	-0.24	1.39	0.109	-0.0149	-0.178	0.411
x SK6006/3	1.500**	-2.29	-2.55	-1.52	0.692	-0.0649	0.001	1.411
x Sd-7	0.729*	-5.04	-1.71	-1.47	-0.116	-0.0065	-0.324	-2.135*
x Sd-63	-0.083	0.18	0.39	-1.20	-0.666*	0.0601	-0.165	-2.147*
x Gm-2	0.167	3.98	5.26*	0.35	-0.587	-0.1732**	0.135	0.695
SK5002/53 x SK5058/2	-0.729*	20.18**	17.22**	3.36**	1.271**	0.0935	-0.070	2.124*
x SK5001/80	-1.208**	10.31**	13.60**	5.10**	1.055**	0.0060	0.214	1.807*
x SK6006/3	0.542	2.00	0.66	0.50	-0.637*	-0.1190	0.193	-1.393
x Sd-7	2.146**	-8.63**	-9.26**	-6.67**	-0.895**	-0.1107	-0.382	-2.314**
x Sd-63	1.208**	-5.77*	-8.16**	-3.89**	-0.620	-0.1190	-0.374	-0.976
x Gm-2	-2.042**	-18.36**	-12.65**	-0.36	-0.966**	0.0226	0.226	0.090
SK5058/2 x SK5001/80	3.188**	-28.44**	-16.04**	-11.32**	-2.262**	-0.3232**	-1.215	-5.551**
x SK6006/3	-1.438**	0.37	-1.40	-0.38	-0.279	0.0768	0.189	-0.126
x Sd-7	-0.708*	2.50	1.56	2.71**	-0.487	-0.0149	0.164	0.278
x Sd-63	0.104	5.10	1.54	2.76**	1.313**	0.0768	0.622**	2.465**
x Gm-2	1.229**	0.39	-3.09	2.37	0.667*	0.1185	-0.028	-0.293
SK5001/80 x SK6006/3	-0.417	8.25**	3.97	-2.65**	-0.395	0.0893	0.122	0.432
x Sd-7	-0.563	6.00*	4.06	5.12**	0.496	0.1726**	0.597**	1.661
x Sd-63	-0.500	2.73	-0.71	1.84*	0.171	-0.0393	0.555*	1.174
x Gm-2	0.250	-1.86	-4.59*	0.53	0.826*	0.0310	-0.095	0.065
SK6006/3 x Sd-7	-1.063**	-6.94*	-7.51**	3.22**	0.636*	-0.0524	-0.324	1.561
x Sd-63	0.625	-7.46*	-1.53	0.39	-0.595	0.0143	-0.215	-1.301
x Gm-2	0.250	6.08*	8.35**	0.44	0.584	0.0560	0.035	-0.585
Sd-7 x Sd-63	-1.021**	3.79	7.31**	0.26	0.646*	-0.0024	0.060	0.853
x Gm-2	0.479	8.33**	5.56*	-3.17**	-0.274	0.0143	0.210	0.095
Sd-63 x Gm-2	-0.333	1.43	1.16	-0.16	-0.249	-0.0690	-0.482*	-0.068
LSD S_{ij} 0.05	0.68	5.68	4.25	1.78	0.63	0.12	0.43	1.68
0.01	0.90	7.47	5.59	2.34	0.83	0.16	0.56	2.21
S_{ij}-S_{ik} 0.05	1.05	8.67	6.48	2.71	0.97	0.19	0.65	2.56
0.01	1.38	11.42	8.54	3.57	1.27	0.25	0.86	3.38
S_{ij}-S_{kl} 0.05	0.93	7.76	5.80	2.43	0.86	0.17	0.58	2.29
0.01	1.23	10.21	7.64	3.20	1.14	0.23	0.77	3.02

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

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التحليل الدائرى لثمانية سلالات متباينة من الذرة الشامية

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أجريت هذه الدراسة على ٢٨ هجين فردى ناتجة من التهجين النصف دائرى لــ ٨ سلالات بيضاء من الذرة الشامية بالاضافة إلى هجين المقارنة التجارى هــ ف١٠ فى موقعين هما محطتى البحوث الزراعية بسخا وسدس. وكانت الصفات المدروسة هى تاريخ تزهير ٥٠% حريرة ، ارتفاع النبات والكوز (سم) ، ومحصول الحبوب بالأردب/فدان ، طول وقطر الكوز (سم) ، عدد الصفوف/الكوز وعدد الحبوب/الصف. ويمكن تلخيص النتائج كما يلى: كانت الاختلافات عالية المعنوية بين المواقع المختلفة لجميع الصفات و أيضا كانت الاختلافات بين التراكيب الوراثية ومجزآتها (القدرة العامة والخاصة على التآلف) عالية المعنوية لكل الصفات المدروسة مما يدل على أن كل من الفعل المضيف وغير المضيف للجين مهمين فى وراثة كل هذه الصفات. كانت أفضل السلالات فى القدرة العامة على التآلف هما: سلالة سخا ٢٢/٦٠٠٥ للتبكير, سخا ٢/٥٠٥٨ لقصر ارتفاع النبات والكوز ، سدس ٧ لمحصول الحبوب ، سخا ٥٣/٥٠٠٢ لطول الكوز وجميزة ٢ لقطر الكوز وعدد الصفوف/الكوز ، وسدس ٦٣ لصفة عدد الحبوب/الصف. كانت أفضل الهجن فى القدرة الخاصة على التآلف هى: سخا ٥٣/٥٠٠٢ × جميزة٢ للتبكير وسخا ٢/٥٠٥٨ × سخا ٨٠/٥٠٠١ لقصر النبات والكوز المنخفض ، سخا ٨٠/٥٠٠١ × سدس ٧ لمحصول الحبوب وقطر الكوز و سخا ٢/٥٠٥٨ × سدس ٦٣ لطول الكوز وعدد الصفوف/الكوز وكذلك عدد الحبوب/الصف. تفوق الهجين الفردى سخا ٨٠/٥٠٠١ × سدس ٧ (٣٥،٧٧ أردب /فدان) معنويا على هجين المقارنة هــ ف ١٠ (٣٢،٤٦ أردب /فدان)

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