Diallel Analysis for Yield, Downy Mildew and Agronomic Characters in Maize (*Zea mays* L.)

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Received on: 18/3/2015 *Accepted: 27/4/2015*

ABSTRACT

Half diallel cross among 9 diverse inbred lines of yellow maize were done in 2012 growing season. Thirty six F_1's and standard yellow check SC168 were evaluated in two trails, the first (grain yield) was planted at Sakha and Mallawy and the second (disease trail) was planted under artificial infection by downy mildew disease under two nitrogen rates at Sakha Station in 2013 growing season. The mean squares due to locations (Loc.) were significant for most studied traits. The mean squares due to crosses (Cr) were significant for all studied traits Crosses x location (Cr x Loc.) interactions were significantly for days to 50% silking, ear height, ear length, rows/ear and grain yield.

Both additive and non-additive effects were operating in the inheritance of most studied traits. However, the additive gene effects were the more important in inheritance of all studied traits. The best inbreds for GCA effects; were Sk6021 and GZ658 for most studied traits. The best cross showed desirable SCA for most traits was Sk5005 x GZ658. single cross Sk5001 x Sk11 (35.675 ard/fed.) was significantly outyielded, than check SC168 (31.589 ard/fed.) and showed resistance to downy mildew.

Key words: diallel cross, combining ability, downy mildew disease

INTRODUCTION

Successful hybrid maize breeding program depends on the efficiency of the procedures used to identify lines used to develop outstanding single crosses (Nawar and El-Hosary, 1985 and Halluaer, 1990). Combining ability test help in selecting the best inbreds to produce high yielding single crosses and supplying breeding program with information regarding the inheritance of yield and other desirable traits. Halluaer and Miranda (1981), stated that both general and specific combining ability effects should be considered when producing and releasing new inbred lines and crosses. Tulu and Ramachandrappa (1998), Zelleke (2000) and Abd El-Aty and Drawish (2006) found that both additive and non-additive gene effects were important in the inheritance of grain yield. However, Abd El-Aty (1987), Crossa *et al.* (1990), El-Shamarka (1995)and Motawei (2006) reported that the GCA (additive gene effects) was more important than SCA (non-additive gene effects) in the inheritance of grain yield. While, Odemah (1973), Katta *et al.* (1975), Dawood *et al.* (1994), Amer *et al.* (1998), Motawei (2005) and Mosa *et al.* (2006) found that the non-additive gene effects were the primary type of gene action operative in the crosses for grain yield.

Downy mildew *Prenosclerospora sorgi* a major disease affect maize grain yield in Egypt especially, delta region. Melchers (1931) and Salama (1976). The infection scale was suggested by Sadoma (1995). The gene disease effects were categorized as follows: highly resistance H.R. (0-5%), resistant R (5.1-10%), moderately resistance MR (10.1–20%), moderate susceptible MS (20.1-30%), susceptible S (30.1-50%) and highly susceptible HS (50.1-100%). El-Shenawy and Mosa (2005) reported that, additive gene effects were predominant in the inheritance of downy mildew disease, while, the reverse was obtained by Mosa *et al*. (2009), who found that, non-additive gene effects were the major portion of the genetic variance conditioning for downy mildew.

This study aimed to; 1) Identify the superior genotypes for grain yield and resistance to downy mildew disease, 2) Estimate the combining ability effects for nine yellow maize inbred lines, and 3) Identify type of gene action controlling the inheritance of studied maize traits.

MATERIALS AND METHODS

Nine yellow maize inbred lines i.e. Sk6006,Sk6021, Sk5001,Sk5002, Sk5005, Sk11, Gm1021, Gz658 and Sk7266 were developed at Sakha (Sk), Giza (Gz) and Gimmiza (Gm) Research Stations were used in this study. All possible combinations without reciprocals were made among these inbred lines at Sakha station during 2012 growing season. The resulting 36 F_1 crosses in addition to the check SC168 were evaluated in 2013 growing season in two trails. The first (yield trail) has planted in May at two locations; Sakha and Mallawy. A randomized complete block design (RCBD) with four replications were used. The plot size was one row of six m length and 0.8 m width and 0.25 m among hills. Cultural practices were carried out according to standard recommendations for maize production in each region. Data has recorded for days to 50% silking, plant height, ear height, ear length, ear diameter, number of rows/ear, number of kernels/row and grain yield (ardab/fed.) adjusted to 15.5% grain moisture content. The second trial has planted in July (late season) in *Perenosclerospora sorghi* disease nursery under artificial infection at Sakha Station in two separate experiments represented two levels of nitrogen fertilization (80 and 120 kg nitrogen/fed). Nitrogen fertilizer applied in two equal doses, at planting and first irrigation, respectively. RCBD design with four replications was used in each experiment. Plot size was one row, four m length, 0.80 m apart and 0.20 m among hills. Two kernel were planted per hill and left without thinning. Data recorded for downy mildew score and number of infected plants after 40 days from planting. Percentage of downy mildew resistance calculated as the difference between total plants per plot and the number of infected plants divided by the total plants per plot.

Data were subjected to arc-sine transformation before analysis for downy mildew resistance percentage. Combined analysis of variance for data was performed across the two locations and across the two nitrogen levels according to Steel and Toriee (1980), after testing the homogeneity of variances according to Bartellet (1937). Diallel cross was computed according to Griffing (1956) Method-4, model-1.

RESULTS AND DISCUSSION

The combined analysis of variance from the yield trial experiments over two locations for eight studied traits presented in Table (1). Results revealed that the mean squares due to locations (Loc) were highly significant for all studied traits except for ear diameter and no. of kernels/row. The mean squares due to crosses (Cr) were highly significant for all studied traits indicating that the crosses varied from each other. Mean square due to interaction between crosses and locations (Cr x Loc) were significant ($0.01 \geq P \leq 0.05$) for days to 50% silking, ear height, ear length, no. of rows/ear and grain yield, meaning that the response of crosses to different location varied regarding magnitude or rank. These results are in agreement with those of Amer *et al*. (2002), El-Shenawy *et al*. (2003), and El-Shenawy (2006).

The analysis of variance across two nitrogen levels for downy mildew resistance are shown in Table (2).

The mean square due to nitrogen rates and Cr x N interactions were not significant, but the mean squares due to crosses were significant meaning that the downy mildew resistance were not affected by nitrogen levels and the expression of crosses did not differ under nitrogen levels, Delon (1994) reported that the downy mildew resistance had high heritability percentage and were not affected significantly by environments.

Mean performance of 36 crosses and one check hybrid SC168 for eight studied traits across locations and percentage of downy mildew resistance across two nitrogen rates are presented in Table (3). The best cross which decreased significantly compared to check SC168 were twenty seven single crosses for earliness. The earliest one from them SC Sk5001 x Sk7266 twenty three crosses equal check SC168 for plant height.

Thirty two crosses were equal to check SC168 for ear height, two single crosses Sk6021 x GZ658 and Sk5005 x GZ658 for ear length, six crosses for ear diameter where SC Sk6006 x Sk6021 and SC Sk6021 x Sk5001 was the highly significant eight single crosses for number of rows per ear, the best one from them was Sk5005 x Gz658, one cross G658 x Sk7266 for no. of kernel per row and two single crosses

Table 1: Analysis of variance across two locations for eight traits.

S.O.V.	df	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ Ear	No. of kernels/ row	Grain yield (ard/fed.)
Location (Loc)	1	208.55**	500943.6**	116725.9**	336.98**	0.166	146.86**	18.102	7590.40**
Reps/Loc	6	17.116	1325.95	1447.22	4.177	0.021	0.184	41.67	9.69
Crosses (Cr)	36	9.856**	346.183**	185.88**	7.181**	0.201**	4.650**	34.97**	123.724**
Cr x Loc	36	4.362*	252.352	128.67*	2.214*	0.059	1.641**	10.30	21.74**
Error	216	2.34	124.218	64.96	1.429	0.046	0.681	6.57	8.041

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

Table 2: Analysis of variance across two nitrogen levels from downy mildew resistance trial.

S.O.V.	df	Resistance
Nitrogen (N)	1	687.16
Reps/Nitrogen	6	174.64
Crosses (Cr)	36	482.021*
Cr x N	36	147.64
Error	216	119.250

* significant at 0.05 level of probability.

Table 3: Mean performance of 36 single crosses and check hybrid SC168 for eight traits across locations and percentage resistance of downy mildew across nitrogen levels.

Crosses		Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ Ear	No. of kernels/ row	Grain yield (ard/fed.)	Resistant to downy mildew. Mean	Categories
Sk6006	x Sk6021	62.87	272.37	143.12	21.425	5.375	14.750	42.775	29.789	96.87	HR
Sk6006	x Sk5001	63.75	278.62	149.50	20.325	5.125	15.100	41.200	27.090	97.12	HR
Sk6006	x Sk5002	62.37	277.25	144.62	19.775	5.050	13.900	37.825	31.022	88.75	MR
Sk6006	x Sk5005	61.75	268.12	137.50	20.300	4.900	13.950	40.825	25.370	94.87	R
Sk6006	x Sk-11	63.12	272.25	143.75	20.875	4.925	13.650	41.725	28.969	87.00	MR
Sk6006	x Gm1021	63.00	273.25	145.62	20.175	5.000	14.200	39.350	27.680	91.25	R
Sk6006	x Gz658	65.12	263.87	142.12	20.200	5.050	14.750	40.725	27.112	91.12	R
Sk6006	x Sk7266	61.75	266.62	139.37	21.350	4.850	14.400	42.42	25.470	96.00	HR
Sk6021	x Sk5001	63.12	267.75	139.37	20.400	5.275	15.600	39.95	28.212	88.37	MR
Sk6021	x Sk5002	63.00	277.50	142.00	21.200	4.925	15.150	39.975	28.729	87.00	MR
Sk6021	x Sk5005	62.75	263.12	133.50	20.188	5.000	15.000	40.075	21.356	82.50	MR
Sk6021	x Sk-11	63.25	266.12	140.250	20.275	5.100	14.500	42.250	29.811	85.50	MR
Sk6021	x Gm1021	62.50	274.50	140.00	21.400	5.350	14.900	41.625	26.485	80.25	MR
Sk6021	x Gz658	64.25	269.12	145.12	22.175	5.225	15.950	42.850	31.018	94.75	R
Sk6021	x Sk7266	62.50	269.50	137.75	21.650	5.125	15.500	42.575	28.457	94.12	R
Sk5001	x Sk5002	64.00	278.37	144.62	20.600	5.125	14.950	39.025	31.059	84.37	MR
Sk5001	x Sk5005	60.87	268.25	142.00	19.975	5.150	16.250	38.175	25.087	76.37	MS
Sk5001	x Sk-11	63.00	270.25	139.87	20.650	5.150	15.200	41.825	35.745	93.25	R
Sk5001	x Gm1021	62.50	278.37	151.250	19.125	5.250	15.600	37.625	30.936	86.87	MR
Sk5001	x Gz658	62.75	264.75	136.50	20.150	5.025	16.100	40.850	25.470	82.62	MR
Sk5001	x Sk7266	60.52	270.12	137.37	20.175	4.825	15.350	40.100	31.415	76.50	MS
Sk5002	x Sk5005	61.37	267.37	135.87	20.125	4.875	15.100	40.175	24.441	80.25	MR
Sk5002	x Sk-11	63.00	274.87	145.00	19.525	4.775	13.250	37.950	25.600	79.37	MS
Sk5002	x Gm1021	62.12	276.25	144.62	18.250	4.875	14.050	36.950	21.169	86.87	MR
Sk5002	x Gz658	64.87	270.62	148.12	19.670	4.900	14.150	38.425	27.582	93.87	R
Sk5002	x Sk7266	62.00	274.12	138.37	20.225	4.800	14.150	40.650	22.587	93.67	R
Sk5005	x Sk-11	62.37	259.37	135.50	19.575	4.925	14.900	37.350	22.585	70.75	MS
Sk5005	x Gm1021	64.00	258.62	133.62	19.650	4.800	14.050	35.600	19.175	86.87	MR
Sk5005	x Gz658	62.12	260.25	134.87	22.700	5.100	16.300	43.375	31.746	95.37	HR
Sk5005	x Sk7266	61.87	251.50	130.12	20.125	4.850	15.350	38.550	26.325	88.50	MR
Sk11	x Gm1021	63.50	269.87	137.87	18.800	4.825	13.550	36.650	22.625	82.75	MR
Sk11	x Gz658	64.12	267.87	144.37	21.725	5.185	15.150	42.050	35.675	89.87	MR
Sk11	x Sk7266	60.75	270.50	137.00	20.575	4.925	14.900	41.300	27.640	74.87	MS
Gm1021	x Gz658	63.37	264.50	143.62	21.600	5.125	14.850	43.300	33.771	96.62	HR
Gm1021	x Sk7266	61.25	267.00	136.50	20.650	4.950	14.300	41.600	21.926	86.87	MR
Gz658	x Sk7266	62.87	255.37	134.37	22.075	5.050	15.750	43.400	24.911	97.25	HR
Check SC168		64.75	261.25	137.37	20.962	4.975	14.587	41.400	31.589	91.25	R
L.S.D	0.05	1.5	10.92	7.89	1.17	0.21	0.80	2.00	2.77		
	0.01	1.97	14.37	10.397	1.542	0.276	1.06	3.30	3.65		

Sk5001 x Sk11 and Sk11 x Gz658 (35.745 ard/fed. and 35.675 ard/fed., respectively for grain yield in addition to ten crosses were not different significantly than check SC168 (31.58 ardab/fed.).

The mean values of % downy mildew resistance ranged from 70.75%-97.25%. The mean values of 36 F_1 crosses plus check were classified according to Sadoma (1995) as follows: six single cross showed high resistance (HR) i.e. Sk6006 x Sk6021, Sk6006 x Sk5001, Sk6006 x Sk7266, Sk5005 x Gz658, Gm1021 x Gz658 and Gz658 x Sk7266, nine crosses showed resistance (R), seventeen crosses showed moderate resistance (MR) and five crosses were moderate susceptible (MS). From above results, the best crosses which had high grain yield over check and resistance to downy mildew disease were Sk5001 x Sk11, Sk5005 x GZ658 and Gm1021 x GZ658. These previous hybrids offer good possibility for high grain yield and resistance to downy mildew.

Analysis of variance for combining ability combined across two locations for eight traits and across two nitrogen levels for percentage of downy mildew resistance is presented in Table 4. Mean squares due to GCA were highly significant for all studied traits, while SCA were significant for days to 50% silking, ear diameter, no. of kernels per row and, grain yield, indicating that both additive and non-additive gene effects were involved in controlling most of studied traits.

Similar results were obtained by Desai and Singh (2001), Abd El-Aty and Darwish (2006), El-Shenawy *et al*. (2009), Mosa (2010) and Abo El-Haress (2012). The mean squares due to interaction of GCA and SCA with environments were not significant except for GCA x Loc for plant height, ear length, rows/ear and grain yield.

Data exhibited that the ratio between GCA/SCA more than unity for all studied traits meaning that the additive gene action played the important role of inheritance for these traits. While, the ratio less than unity for ear length and grain yielded indicated that the non additive gene action were predominant in the inheritance of these traits, the ratio between GCA x env/SCA x env. was more than unity for all studied traits meaning that the GCA effects were more affected by environments than SCA.

These results are in agreement with Hallauer *et al*. (1988), Mosa (2010). For days to 50% silking, plant height, ear height, ear diameter. Mosa (2010) and Abo El-Haress (2012) for downy mildew resistance.

Table 4: Analysis of variance for combining ability as combined across two locations for eight traits and across two nitrogen levels for downy mildew resistance

S.O.V	df	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ Ear	No. of kernels/ row	Grain yield (ard/fed.)	Resistant to downy mildew.
GCA	8	2.850**	147.97**	71.482**	2.195**	0.073**	2.075**	11.551**	25.356**	190.56**
SCA	27	0.653**	11.834	9.467	0.538*	0.012*	0.159	2.349**	10.371**	23.49
GCA x Env.	8	0.581	67.43	45.741**	0.476*	0.008	0.488*	1.583	5.426**	19.83
SCA x Env.	27	0.457	21.785	6.837	0.203	0.006	0.1225	1.135	2.762	18.73
Error	210	2.3	124.0	64.6	1.40	0.046	0.671	6.52	8.00	118.2
GCA/SCA ratio		4.36	12.50	7.54	4.04	6.06	13.05	4.91	2.44	8.11
GCA x env./ CA x env		1.2	3.09	6.69	2.34	2.34	3.98	1.4	1.96	1.58

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
Env.: locations or nitrogen rates

Table 5: Estimates of general combining ability effects of nine inbred lines for eight traits across two locations and across two nitrogen levels for downy mildew resistance

Lines	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ Ear	No. of kernels/ row	Grain yield (ard/fed.)	Resistant to downy mildew.
Sk6006	0.2619	3.1528*	3.180**	0.0714	0.0171	-0.5841**	0.627	0.7371**	6.7776**
Sk6021	0.3333	1.4028	-0.319	0.6839**	0.1742**	0.3659**	1.375**	0.9306**	1.0596
Sk5001	-0.1667	3.7421**	2.448**	-0.3607**	0.1099**	0.7659**	-0.530	2.0960**	-6.0242**
Sk5002	0.1190	6.5813**	2.841**	-0.650**	-0.1187**	-0.5841**	-1.640**	-0.7362**	-0.4349
Sk5005	-0.6845**	-7.6687**	-5.765**	-0.1839	-0.0794**	0.3016**	-1.190**	-3.067**	-2.3938
Sk11	0.1726	0.1349	0.037	-0.2750*	-0.0579*	-0.5270**	0.194	1.0438**	-8.5760**
GM1021	0.0476	1.4385	1.394	-0.6107**	0.0028	-0.4698**	-1.394**	-2.2251**	0.4401
GZ658	1.0833**	-4.8472**	0.823	0.9107**	0.0635*	0.6016**	1.787**	2.4205**	7.1151**
Sk7266	-1.1667**	-3.9365**	-4.640**	0.4143**	-0.1115**	0.1302	1.162**	-1.2301**	2.0365
LSD g_i 0.05	0.377	2.752	1.990	0.274	0.052	0.203	0.632	0.700	2.696
0.01	0.497	3.622	2.619	0.361	0.069	0.268	0.833	0.921	3.549
LSD g_i-g_j 0.05	0.566	4.128	2.985	0.412	0.079	0.305	0.949	1.050	4.044
0.01	0.745	5.433	3.929	0.542	0.104	0.402	1.249	1.382	5.324

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

Estimates of GCA effects of nine inbred lines for eight traits combined across two locations and across two nitrogen levels for downy mildew resistance are presented in Table 6. The results showed that the inbred lines Sk5005 and Sk7266 had desirable significant values for days to 50% silking, plant height and ear height. Sk6021, GZ658 and Sk7266 for ear length, Sk6021, Sk5001 and Gz658 for ear diameter and No. of rows/ear, Sk6021 and Gz658 and Sk7266 for no. of kernels/row, Sk6006, Sk6021, Sk5001, Sk11 and Gz658 for grain yield, and Sk6006 and GZ658 for downy mildew resistance hence it could be utilize these inbreds as good donor or combiner for these traits in maize breeding programs.

Estimates of specific combining ability effects for 36 F_1's single crosses are presented in Table 7. Three crosses, Sk5001 x Sk5005, Sk5005 x GZ658 and Sk11 x Sk7266 had significant desirable values for days to 50% silking, Sk5001 x GZ658 for ear height, six crosses i.e. Sk6021 x Sk5002, Sk6021 x Gm1021, Sk5001 x Sk5002, Sk5001 x Sk11, Sk5005 x Gz658 for ear length, three cross i.e. Sk5005 x Gz658 and Gm1021 x GZ658for ear length, three crosses, i.e. Sk6006 x Sk6021,

Table 6: Estimates of SCA effects for 36 F_1s crosses for nine studied traits.

Crosses		Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Rows/ Ear	No. of kernels/ row	Grain yield (ard/fed.)	Resistant to downy mildew.
Sk6006	x Sk6021	-0.460	-0.969	-0.156	0.179	0.1643*	0.1196	0.467	0.953	2.423
Sk6006	x Sk5001	0.915	2.942	3.451	0.124	-0.0214	0.0696	0.796	-2.911**	10.832**
Sk6006	x Sk5002	-0.746	-1.272	-1.817	-0.137	0.1321*	0.2196	-1.469	3.854**	-4.270
Sk6006	x Sk5005	-0.567	3.853	-0.335	-0.078	-0.0571	-0.6161*	1.081	0.502	3.876
Sk6006	x Sk-11	-0.049	0.174	0.112	0.588	-0.0536	-0.0875	0.985	0.020	-0.029
Sk6006	x Gm1021	-0.049	-0.129	0.629	0.224	-0.0393	0.4054	-0.190	2.000*	-3.045
Sk6006	x Gz658	1.040*	-3.219	-2.229	-1.273**	-0.0500	-0.1161	-1.997	-3.213**	-8.520**
Sk6006	x Sk7266	-0.085	-1.379	0.415	0.374	-0.0750	0.0054	0.328	-1.205	-1.267
Sk6021	x Sk5001	0.219	-6.193	-3.174	-0.414	-0.0286	-0.3804	-1.201	-1.982*	2.637
Sk6021	x Sk5002	-0.192	0.728	-0.942	0.675*	-0.1500*	0.5196*	-0.065	1.366	-2.502
Sk6021	x Sk5005	0.362	0.603	-0.835	-0.803*	-0.1143	-0.5196	-0.415	-3.706**	-3.668
Sk6021	x Sk-11	0.004	-4.076	0.112	-0.625	-0.0357	-0.1875	0.763	0.669	4.589
Sk6021	x Gm1021	-0.621	2.871	-1.496	0.836*	0.1536*	0.1554	1.338	0.612	-8.140*
Sk6021	x Gz658	0.094	3.781	4.201	0.090	-0.0321	0.1339	-0.619	0.499	-0.040
Sk6021	x Sk7266	0.594	3.246	2.290	0.061	0.0429	0.1554	-0.269	1.589	4.701
Sk5001	x Sk5002	1.308*	-0.737	-1.085	1.12**	0.1143	-0.080	0.888	2.531**	1.169
Sk5001	x Sk5005	-1.013*	3.388	4.897	0.290	0.1000	0.334	-0.412	-1.140	-2.322
Sk5001	x Sk-11	0.254	-2.415	-3.031	0.795*	0.0786	0.1125	0.242**	2.437**	-4.652
Sk5001	x Gm1021	-0.121	4.406	6.987**	-0.394	-0.1179	0.4554	-0.758	3.897**	3.369
Sk5001	Gz658	-0.906	-2.933	-7.192**	-0.891**	-0.1679*	-0.1161	-0.715	-6.214	-4.481
Sk5001	x Sk7266	-0.656	1.531	-0.853	-0.369	-0.1929**	-0.3946	-0.840	3.381**	-6.553*
Sk5002	x Sk5005	-0.779	-0.326	-1.621	0.468	0.0536	0.5339*	2.699**	1.046	-2.579
Sk5002	x Sk-11	-0.031	0.629	1.701	-0.041	-0.0679	-0.4875	-0.522	-1.876*	2.558
Sk5002	x Gm1021	-0.781	-0.558	-0.031	-0.980**	-0.0286	0.2554	-0.322	-3.038**	-1.745
Sk5002	x Gz658	0.933	0.103	4.040	-1.076**	-0.0643	-0.7161**	-2.029**	-1.270	1.855
Sk5002	x Sk7266	0.308	2.683	-0.246	-0.030	-0.0107	-0.244	0.821	-2.614**	5.508
Sk5005	x Sk-11	0.147	-1.879	0.808	-0.457	0.0429	0.2768	-1.572	-2.590**	-3.358
Sk5005	x Gm1021	1.897**	-3.933	-2.424	-0.046	-0.1429**	-0.6304*	-2.122**	-2.731**	2.814
Sk5005	Gz658	-1.013*	3.978	-0.603	1.483**	0.0964	0.5482*	2.471**	5.195**	4.339
Sk5005	x Sk7266	0.987*	-5.683	0.112	-0.596	0.0214	0.0696	-1.729*	3.424**	0.892
Sk11	x Gm1021	0.540	-0.487	-3.978	-0.805*	-0.1393*	-0.3018	-2.069**	-3.362**	4.483
Sk11	x Gz658	0.129	3.799	3.094	0.599	0.1000	0.2268	0.149	4.043**	1.971
Sk11	x Sk7266	-0.996*	5.513	1.183	-0.055	0.0750	0.4482	0.024	0.658	-5.563
Gm1021	x Gz658	-4.96	-0.879	0.987	0.809*	0.0393	-0.1304	2.599**	4.408**	2.430
Gm1021	x Sk7266	-3.71	-1.290	-0.674	0.356	0.0393	-0.2084	1.524	-1.786*	0.167
Gz658	x Sk7266	0.219	-4.629	-2.228	0.259	0.0786	0.1696	0.142	-3.447**	2.446
LSD S_{ij}	0.05	0.918	6.688	4.836	0.668	0.128	0.495	1.538	1.70	6.553
	0.01	1.368	8.804	6.364	0.879	0.169	0.651	2.024	2.24	8.626
LSD S_{ij}-S_{ik}	0.05	1.387	10.100	7.307	1.009	0.194	0.748	2.324	2.571	9.901
	0.01	1.826	13.300	9.619	1.329	0.256	0.984	3.059	3.384	13.033

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

Sk6006 x Sk5002 and Sk6021 x Gm1021 for ear diameter, Sk6021 x Sk5002, Sk5002 x Sk5005 and Sk5005 x Gz658 for number of rows/ear, Sk5001 x Gm1021, Sk5002 x Sk5005, Sk5005 x Gz658 and Gm1021 x Gz658 for no. of kernels/row, Sk6006 x Sk5002, Sk6006 x Gm1021, Sk5001 x Sk5002, Sk5001 x Sk11, Sk5001 x Gm1021, Sk5001 x Sk7266, Sk5005 x Gz658, Sk5005 x Sk7266, Sk11 x Gz658 and Gm1021 x Gz658 for grain yield and cross Sk6006 x Sk5001 for downy mildew disease. Hence these crosses could be used in maize breeding program.

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الملخص العربى

التحليل الدائرى لصفة المحصول والبياض الزغبى وبعض الصفات الخضرية الأخرى فى الذرة الشامية

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تم عمل التهجين الدائرى بين تسعة سلالات صفراء فى إتجاه واحد فى موسم ٢٠١٢ وتم تقييم ٣٦ هجين فردى الناتجة بالاضافة إلى هجين المقارنة هـ. ف١٦٨ فى تجربتين الاولى للمحصول حيث تم التقييم فى موقعين هما سخا وملوى والثانية للمرض وتم تقييمهم فى حقل العدوى الصناعية بالبياض الزغبى تحت معدلين نتروجين فى محطة بحوث سخا موسم ٢٠١٣.

أظهر التباين الراجع إلى المواقع معنوية فى معظم الصفات المدروسة وكذلك أظهر التباين الراجع للهجن معنوية عالية فى كل الصفات المدروسة أيضا تباين التفاعل بين الهجن والمواقع كان معنويا فى صفة تاريخ ظهور ٥٠% من حرائر النورات المؤنثة وإرتفاع الكوز وطول الكوز وعدد السطور/كوز ومحصول الحبوب.

وكان كلا من الفعل الوراثى المضيف والغير مضيف لهما أثر فى وراثة معظم الصفات حيث كان الفعل الوراثى المضيف الأكثر تحكما فى وراثة كل الصفات تحت الدراسة وكذلك كان الفعل الوراثى المضيف الأكثر تأثراً بالمواقع لكل الصفات المدروسة وكانت أفضل السلالات فى القدرة العامة على الائتلاف سلالة سخا ٦٠٢١ وسلالة جـ٦٥٨ فى معظم الصفات المدروسة.

أظهر هـ. ف سخا ٥٠٠٥ × جـ. ٦٥٨ معنوية مرغوبة فى معظم الصفات للقدرة الخاصة على الأئتلاف.

أعطى الهجين سخا ٥٠٠٥ × سخا ١١ (٣٥,٧٥٤ اردب/فدان) متفوقا عن هجين المقارنة هـ. ف ١٦٨ (٣١,٥٨٩ أردب/فدان) كما أظهر نفس الهجين مقاومة لمرض البياض الزغبى.