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Line × Tester Analysis for Estimation Combining ability of some New Yellow Maize Inbred Lines for Grain Yield and Downy Mildew Resistance

Cross Mark

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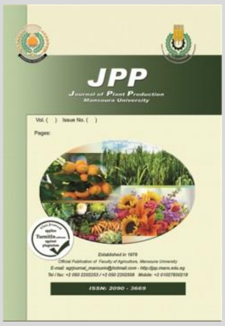

ABSTRACT

A line×tester analysis was performed at Sakha Research Station; during summer 2017, using twenty new yellow maize inbred lines and two testers; inbred line Sk-4 and single cross SC180. The resulting 40 F_1 crosses in addition to four check hybrids were evaluated in two trails during summer 2018. The first trail; for yield and other traits, was performed at Sakha and Sids Agricultural Research Stations. The second trial; for downy mildew disease resistance, was carried out under two levels of nitrogen fertilization in the disease nursery at Sakha Station. Significantly differences were detected between the two locations for the most studied traits and between the two nitrogen levels for downy mildew resistance. Significant of differences were observed among lines, testers and their interaction for all studied traits, except among testers for downy mildew resistance and line×tester interaction for plant height, ear height and downy mildew resistance. The non-additive gene effects were predominant in the inheritance of grain yield, ear length, ear diameter and downy mildew resistance. For general combining ability effects, the best general combiners were Sk5013/71 for grain yield and downy mildew resistance. While, the best tester was Sk-4 for grain yield and most traits. The desirable hybrids for specific combining ability effects were Sk5002/62×Sk-4, Sk5005/66×Sk-4 and Sk5021/74×SC180 for grain yield and Sk5004/65×SC180 for downy mildew resistance. Single cross Sk5013/71×Sk4, also three-way crosses Sk5010/69×SC180 and Sk5013/71×SC180 were superior for grain yield and high resistance to downy mildew resistance. These crosses could be use in maize breeding program.

Keywords: Maize, Combining ability, Line x tester, Resistance to downy mildew.

INTRODUCTION

Maize (*Zea mays*. L) is one of the main crops in the world and is the third most economic crop in Egypt. It is widely used as food, feed and industrial utilization. The main goal of the Egyptian national maize program is to obtain new hybrids with high yielding and diseases resistance.

General (GCA) and specific (SCA) combining abilities analysis were used by plant breeders to select good parents and hybrids, respectively (Carena *et al*., 2010). GCA associated with additive gene effects while SCA reflects the non-additive gene effects (Sprague and Tatum, 1942). Line×tester analysis is an extension of the top cross method in which several testers are used and it provides information about GCA and SCA (Kempthorne, 1957). Many investigators reported that the non-additive gene effects played an important role in the inheritance of grain yield (Mosa *et al*., 2016; Dinesh *et al*., 2016; Motawei *et al*., 2019; Mohamed, 2020 and Abdel-Moneam *et al*., 2020). While, Abd El- Mottalb *et al.* (2013); El-Gazzar *et al.* (2015); Singh *et al.* (2017) and Khalil *et al.* (2018) found that additive gene effects control in the inheritance of grain yield.

Downy mildew (DM); caused by *Prenosclerospora sorghi*, is one of the most destructive disease of maize in Egypt; especially in delta region, and causes significant yield loss (Melchers, 1931; Salama, 1976). This disease is caused by late planting date; in addition, planting sudan grass and sorghum beside maize. A variety of DM strains have been reported, and the resistance to them is polygenically controlled. El-Shenawy and Mosa (2005), Mosa *et al.* (2009) and El-Refaey *et al.* (2018) reported that additive gene effects played a major role in the expression of the inheritance of downy mildew disease. While, Turgut *et al.* (1995), Amer *et al.* (2002) and Mosa *et al.* (2017) stated that non-additive gene effects played an effective role in the inheritance of downy mildew resistance. Corn downy mildew disease needs integrated approaches to manage this disease; including crop rotation, planting superior resistance varieties, suitable cultivation techniques, and the application of fungicides when needed. Application of high levels of nitrogen increased infected plants for Philippine downy mildew, however this effect is not observed in resistant cultivars (Yamada & Aday, 1977).

This study aimed to estimate GCA of twenty new yellow maize inbred lines and SCA of their hybrids, to identify the mode of gene effects that control the inheritance of the studied traits, and to identify the superior single and three-way crosses for high yielding ability and resistance to downy mildew disease.

MATERIALS AND METHODS

In 2017 season, twenty new yellow maize inbred lines and two testers; inbred line Sk-4 and single cross SC180 were crossed in a line×tester mating design at Sakha (Sk) Agricultural Research Station. The resulting;

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20 single cross (SC), 20 three-way cross (TWC) and the four commercial hybrids (SC168, SC3444, TWC360 and TWC368) were evaluated during 2018 season. Two trials were conducted; the first trail (for yield), planted at two locations at Sakha and Sids Agricultural Research Stations. A randomized complete block design (RCBD) with four replications was used in each location. Each plot consisted of one row of 6 m long, 0.8 m width and 0.25 m between hills. Two seeds were planted per hill and then thinned before the 1st irrigation to one plant per hill. All recommended agricultural practices were followed in each location. The data were recorded on number of days to 50% silking, plant height (cm), ear height (cm), grain yield in ton/hectare (t/ha) adjusted to 15.5% grain moisture, ear length (cm) and ear diameter (cm). The second trial was performed in a disease nursery under artificial infection by downy mildew disease at Sakha Agricultural Research Station. Annually this field was previously planted by sorghum as a source of infection in 20 June. It was alternatively planted with maize rows in a ratio of 1:2, respectively in 20 July. The resulting 40 crosses and 4 check hybrids were planted at two nitrogen fertilization levels of 143 and 286 kg N/ha in two experiments. Nitrogen fertilizer applied in two equal doses; at planting and before 1st irrigation. RCBD design with four replications was done in each experiment. Plot size was one row, 4 m length, 0.80 m apart and 0.20 m between hills. Two kernels were planted per hill and left without thinning. The percentage of resistance was taken after 40 days from planting.

Combined analysis of variance was performed across the two locations in the first trail and across the two nitrogen levels in the second trail according to Snedecor and Cochran (1967), after testing the homogeneity of error variances according to Bartllet (1937). Combining ability analysis was computed by line x tester analysis as suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Combined analysis of variance revealed significant or highly significant differences between locations (Loc) for all the studied traits, except days to 50% silking (Table l), indicating that these locations represented a wide range of differences in their environmental conditions. Highly significant differences were observed among crosses (Cr) for all studied traits, indicated the diverse performance of different cross combinations for these traits. Also, mean squares values of ear height, grain yield and ear diameter were highly significant for Cr×Loc interaction, indicate that the values of maize hybrids differ from one location to another for these traits.

Table 1. Combined analysis of variance for six traits of maize across two locations.

S.O.V	d.f	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter
Locations (Loc.)	1	135.01	150977.56**	9399.89*	90.69*	767.00**	13.21**
Rep/Loc.	6	28.26	3327.32	1379.12	8.14	2.40	0.20
Crosses (Cr)	43	23.36**	1448.00**	1256.16**	8.66**	11.41**	0.12**
Cr×Loc.	43	2.30	147.71	273.20**	2.68**	2.06	0.06**
Error	258	1.83	156.57	109.27	1.26	1.49	0.03

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

For downy mildew resistance trait, results revealed significantly differences between the two levels of nitrogen (N) (Table 2), indicated that this trait was affected by nitrogen fertilization. Highly significant differences were found among crosses (Cr), while the interaction between Cr×N was not significant.

Table 2. Combined analysis of variance for downy mildew resistance across two nitrogen levels.

S.O.V	d.f	Downy mildew resistance
Nitrogen (N)	1	1211.39*
Rep/N	6	134.71
Crosses (Cr)	43	136.68**
Cr x N	43	65.12
Error	258	79.25

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

Mean performance of 20 single crosses, 20 three-way crosses and four check hybrids for six different traits across two locations; in addition, downy mildew resistance trait across two nitrogen levels are presented in Table 3. For days to 50% silking, single crosses means ranged from 60.51 days for Sk5021/75×Sk-4 and Sk5023/77×Sk-4 to 67.0 days for Sk5022/76×Sk-4. The early crosses compared to the best single cross check for earliness SC168 were Sk5011/70×Sk-4, Sk5019/72×Sk-4, Sk5021/74×Sk-4, Sk5021/75×Sk-4, Sk5023/77×Sk-4 and Sk5024/78×Sk-4. While, three-way crosses means ranged from 60.3 to 66.5 days for Sk5021/74×SC180 and Sk5022/76×SC180, respectively. Ten crosses were earliness than the best check TWC368, the best crosses from them were Sk5010/69×SC180, Sk5021/74×SC180 and Sk5021/75×SC180. For plant height, single crosses means ranged from 258 cm for Sk5011/70×Sk-4 to 302.5 cm for Sk5006/67×Sk-4, while three-way crosses means ranged from 270.9 to 301.0 cm for Sk5024/78×SC180 and Sk5004/64×SC180, respectively. For ear height, single crosses means ranged from 137.8 to 182.6 cm for Sk5021/75×Sk-4 and Sk5024/79×Sk-4, respectively, while three-way crosses ranged from 143.4 to 178.0 cm for Sk5024/78×SC180 and Sk5004/64×SC180, respectively. For grain yield, single crosses means ranged from 7.91 to 11.52 t/ha for Sk5011/70×Sk-4 and Sk5001/61×Sk-4, respectively. Ten crosses were not significantly outyield than the best check SC168 (10.68 t/ha) and the best crosses from them Sk5001/61×Sk-4, Sk5004/65×Sk-4, Sk5013/71×Sk-4 and Sk5019/73×Sk-4. Meanwhile, three-way crosses ranged from 7.44 to 11.25 t/ha for Sk5008/68×SC180 and Sk5013/71×SC180, respectively, with five three-way crosses were not significantly outyielded than the best check TWC368 (10.88 t/ha) and the best crosses from them Sk5010/69×SC180, Sk5013/71×SC180 and Sk5019/73×SC180. For ear length, single crosses means ranged from 18.9 to 24.1 cm for Sk5002/62×Sk-4 and Sk5004/65×Sk-4, respectively and three-way crosses ranged from 18.7 to 23.1 cm for Sk5002/62×SC180 and Sk5004/65×SC180, respectively. This indicate that the inbred line Sk5004/65 gave the highest single cross and three way cross for ear length, while the reverse was obtained by Sk5002/62. For ear diameter, single crosses ranged from 4.55 to 5.13 cm for

Sk5024/80×Sk-4 and Sk5002/62×Sk-4, respectively. While, three-way crosses ranged from 4.63 to 4.95 cm for Sk5010/69×SC180 and Sk5023/77×SC180, respectively.

For downy mildew resistance, Sadoma (1995), who categorized the crosses based on infection percentage to highly resistant (0-5%), resistant (5.1-10%), moderately resistant (10.1–20%), moderately susceptible (20.1-30%), susceptible (30.1-50%), and highly susceptible (50.1-100%). Regarding to our results, eight single crosses and six three-way crosses were ranked as highly resistant (>95%). The best from them single crosses Sk5004/64×Sk-4, Sk5005/66×Sk-4, Sk5006/67×Sk-4, Sk5013/71×Sk-4, Sk5024/48×Sk-4 and Sk5024/80×Sk-4 and three-way crosses Sk5010/69×SC180, Sk5013/71×SC180 and Sk5024/79×SC180. From the above results the single cross Sk5013/71×Sk-4, also three-way crosses Sk5010/69×SC180 and Sk5013/71×SC180 had high grain yield and high resistance to downy mildew disease. This study suggests the use of these crosses to obtain high yielding potentially and high resistance to downy mildew disease.

Table 3. Mean performance values of 20 single crosses, 20 three-way crosses and four check hybrids of yellow maize for six different traits across two locations; in addition, downy mildew resistance trait across two nitrogen levels.

Cross	Days to 50% silking	Plant height (cm)	Ear height (cm)	Grain yield (t/ha)	Ear length (cm)	Ear diameter (cm)	Downy mildew resistance(%)
Sk5001/61×Sk-4	61.6	279.9	165.0	11.52	21.2	4.90	93.9
Sk5002/62×Sk-4	61.5	277.9	165.6	10.14	18.9	5.13	96.9
Sk5003/63×Sk-4	64.5	284.9	171.3	10.56	21.5	4.83	94.5
Sk5004/64×Sk-4	62.4	296.3	177.8	10.74	22.5	4.88	98.8
Sk5004/65×Sk-4	62.8	290.1	171.8	11.04	24.1	4.85	80.6
Sk5005/66×Sk-4	63.3	284.6	165.5	10.92	20.3	5.08	100.0
Sk5006/67×Sk-4	63.9	302.5	178.0	10.86	21.2	5.00	95.8
Sk5008/68×Sk-4	61.6	272.3	150.5	9.27	23.2	4.60	93.6
Sk5010/69×Sk-4	61.5	290.3	168.0	10.98	22.2	4.83	94.8
Sk5011/70×Sk-4	61.1	258.0	143.5	7.91	20.6	4.75	92.6
Sk5013/71×Sk-4	62.4	279.9	161.5	11.46	22.5	4.83	97.6
Sk5019/72×Sk-4	61.1	273.8	158.9	10.41	20.3	4.85	94.6
Sk5019/73×Sk-4	61.6	278.1	159.4	11.08	20.9	5.03	92.8
Sk5021/74×Sk-4	61.1	263.3	142.3	9.04	20.4	4.85	96.5
Sk5021/75×Sk-4	60.5	261.1	137.8	9.85	19.8	4.80	91.3
Sk5022/76×Sk-4	67.0	295.9	181.5	10.99	22.9	4.78	84.4
Sk5023/77×Sk-4	60.5	282.0	158.9	10.44	19.9	5.00	92.5
Sk5024/78×Sk-4	60.8	269.0	141.1	9.47	19.8	4.90	98.5
Sk5024/79×Sk-4	61.6	301.6	182.6	10.88	21.7	4.78	91.9
Sk5024/80×Sk-4	63.0	290.1	166.8	9.85	21.9	4.55	98.5
Sk5001/61×SC180	62.0	279.6	167.3	10.98	20.8	4.83	93.1
Sk5002/62×SC180	61.0	275.3	159.8	8.08	18.7	4.85	94.5
Sk5003/63×SC180	64.3	291.5	174.0	9.75	21.8	4.75	93.1
Sk5004/64×SC180	62.5	301.0	178.0	10.90	21.6	4.83	95.9
Sk5004/65×SC180	63.9	298.0	173.8	9.44	23.1	4.78	92.9
Sk5005/66×SC180	64.8	276.9	164.8	8.77	21.9	4.83	95.0
Sk5006/67×SC180	64.3	300.1	171.4	9.83	22.6	4.75	94.1
Sk5008/68×SC180	61.8	282.4	161.6	7.44	22.6	4.75	88.8
Sk5010/69×SC180	60.4	297.3	171.3	11.11	21.4	4.63	98.9
Sk5011/70×SC180	61.4	277.8	159.0	8.25	21.3	4.68	92.5
Sk5013/71×SC180	64.1	291.9	165.3	11.25	22.2	4.80	97.9
Sk5019/72×SC180	61.4	277.4	161.1	10.72	21.3	4.90	96.6
Sk5019/73×SC180	61.6	283.0	162.0	11.04	21.0	4.90	92.9
Sk5021/74×SC180	60.3	278.1	153.9	10.14	21.7	4.68	90.9
Sk5021/75×SC180	60.5	275.0	150.5	10.20	21.8	4.90	85.3
Sk5022/76×SC180	66.5	291.6	174.5	9.28	21.9	4.75	85.6
Sk5023/77×SC180	61.4	285.0	159.3	10.82	21.0	4.95	96.0
Sk5024/78×SC180	61.5	270.9	143.4	9.79	20.6	4.75	92.5
Sk5024/79×SC180	63.9	296.5	180.8	10.22	22.6	4.78	99.1
Sk5024/80×SC180	65.6	296.5	176.8	8.10	22.5	4.65	91.4
Check SC168	62.6	251.6	148.6	10.68	22.5	4.88	95.3
Check SC3444	65.3	251.4	134.5	10.36	22.7	4.93	98.3
Check TWC360	64.3	258.3	145.9	9.02	23.7	4.65	96.9
Check TWC368	63.3	285.5	166.5	10.88	22.9	5.00	96.5
LSD 0.05	1.33	12.26	10.24	1.09	1.20	0.17	8.72
LSD 0.01	1.75	16.14	13.48	1.44	1.57	0.22	11.48

Line × tester analysis of variance combined across environments (Env.) revealed significant or highly significant mean squares for lines (L), testers (T) and line×tester (L×T) interaction for all studied traits, except, T for downy mildew resistance and L×T for plant height, ear height and downy mildew resistance, Table 4. Meanwhile, the interactions between L, T and L×T with environments (Env.) were not significant for all traits except for, L×Env. for ear height, grain yield and ear diameter and T× Env. for ear length were highly significant.

Table 4. Line×tester analysis of variance combined across environments (two locations for six traits and across two nitrogen levels for downy mildew resistance).

S.O.V	d.f	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	Downy mildew resistance
Lines (L)	19	43.24**	1886.70**	2075.70**	13.45**	18.03**	0.17**	196.38**
Testers (T)	1	16.65**	1776.61**	735.08*	25.26**	8.85*	0.44**	33.80
L x T	19	3.94**	208.57	161.66	3.99**	3.49**	0.06**	95.00
L x Env.	19	2.44	152.0	403.3**	3.66**	2.06	0.077**	43.47
T x Env.	1	1.91	96.8	290.7	0.52	16.56**	0.003	7.20
L x T x Env.	19	1.35	140.8	150.3	1.63	1.58	0.041	94.30
Error	234	1.86	164.73	112.85	1.29	1.41	0.03	81.57

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

Estimates of GCA effects of 20 inbred lines are presented in Table 5. Highly negative values of GCA effects for days to 50% silking, plant height and ear height would be desirable for the breeder, hence 10, 7 and 5 inbred lines expressed significant and negative GCA effects for days to 50% silking, plant height and ear height, respectively. Five inbred lines Sk5008/68, Sk5011/70, Sk5021/74, Sk5021/75 and Sk5024/78 were desirable for earliness and short plant and ear height and two inbred lines Sk5002/62 and Sk5019/72 were desirable for earliness and short plant height. These results suggest that these inbred lines could be considered good general combiners for improving these traits. Five inbred lines Sk5001/61, Sk5004/64, Sk5010/69, Sk5013/71 and Sk5019/73 possessed positive and significant GCA effects for grain yield. These inbred lines can be used for development of high yielding hybrids. Six inbred lines Sk5004/65, Sk5008/68, Sk5013/71, Sk5022/76, Sk5024/79 and Sk5024/80 showed positive and significant GCA effects for ear length. Additionally, four inbred lines Sk5002/62, Sk5005/66, Sk5019/73 and Sk5023/77 expressed significant and positive GCA effects for ear diameter and one inbred line Sk5013/71 had desirable GCA effects for resistance to downy mildew disease. From above results, the inbred line Sk5013/71 could be utilized in making hybrids had high yielding ability, longest ear and resistance to downy mildew disease.

The tester inbred line Sk-4 was the best general tester for earliness, short-plant type, grain yield and ear diameter (Table 5). The superiority of inbred lines as good tester was noticed by several investigators among them Darrah (1985), Al-Naggar *et al*. (1997), Abd El-Hadi *et al.* (2009) and El-Gazzar *et al*. (2015).

Table 5. General combining ability effects (GCA) of 20 inbred lines and 2 testers combined across two locations for six traits and across two nitrogen levels for downy mildew resistance.

Inbred line	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	Downy mildew resistance
Sk5001/61	-0.603	-4.175	2.234	1.169**	-0.430	0.041	-0.169
Sk5002/62	-1.166**	-7.363*	-1.203	-0.975**	-2.655**	0.166**	2.019
Sk5003/63	1.959**	4.263	8.734**	0.069	0.195	-0.034	0.144
Sk5004/64	0.022	14.700**	13.984**	0.725*	0.595	0.028	3.644
Sk5004/65	0.897*	10.138**	8.859**	0.163	2.145**	-0.009	-6.919**
Sk5005/66	1.584**	-3.175	1.234	-0.243	-0.368	0.128**	3.831
Sk5006/67	1.647**	17.388**	10.797**	0.263	0.470	0.053	1.269
Sk5008/68	-0.728*	-6.613*	-7.828**	-1.750**	1.445**	-0.147**	-2.481
Sk5010/69	-1.478**	9.825**	5.734*	0.957**	0.345	-0.097	3.144
Sk5011/70	-1.166**	-16.050**	-12.641**	-2.025**	-0.530	-0.109*	-1.106
Sk5013/71	0.834*	1.950	-0.516	1.257**	0.883**	-0.009	4.100*
Sk5019/72	-1.166**	-8.363*	-3.891	0.475	-0.655*	0.053	1.956
Sk5019/73	-0.791*	-3.363	-3.203	0.969**	-0.493	0.141**	-0.856
Sk5021/74	-1.728**	-13.238**	-15.828**	-0.481	-0.443	-0.059	0.019
Sk5021/75	-1.916**	-15.863**	-19.766**	-0.062	-0.618*	0.028	-5.419*
Sk5022/76	4.334**	9.825**	14.109**	0.050	0.933**	-0.059	-8.669**
Sk5023/77	-1.478**	-0.425	-4.828	0.532	-0.980	0.153**	0.581
Sk5024/78	-1.291**	-13.988**	-21.641**	-0.443	-1.230**	0.003	1.831
Sk5024/79	0.334	15.138**	17.797**	0.457	0.658*	-0.047	1.831
Sk5024/80	1.897**	9.388**	7.859**	-1.106**	0.733*	-0.222**	1.269
LSD g_i (L) 0.05	0.668	6.289	5.205	0.557	0.582	0.085	4.100
0.01	0.880	8.278	6.852	0.733	0.766	0.112	5.825
LSD g_i-g_j (L) 0.05	0.945	8.894	7.361	0.787	0.823	0.120	6.259
0.01	1.244	11.707	9.690	1.036	1.083	0.158	8.238
Tester Sk-4	-0.228*	-2.356*	-1.516	0.281**	-0.166	0.037**	0.325
Tester SC180	0.228*	2.356*	1.516	-0.281**	0.166	-0.037**	-0.325
LSD g_i (T) 0.05	0.211	1.989	1.646	0.176	0.184	0.027	1.399
0.01	0.278	2.618	2.167	0.232	0.242	0.035	1.842
LSD g_i-g_j (T) 0.05	0.299	2.813	2.328	0.249	0.260	0.038	1.979
0.01	0.393	3.702	3.064	0.328	0.343	0.050	2.605

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

The estimated specific combining ability effects (SCA) of the 40 crosses for all traits are presented in Table 6. The hybrids that presented desirable and significant SCA effects were Sk5024/80×Sk-4 for earliness; Sk5002/62×Sk-4, Sk5005/66×Sk-4 and Sk5021/74×SC180 for grain yield; Sk5021/75×SC180 for ear length; Sk5008/68×SC180 for ear diameter and Sk5004/65×SC180 for downy mildew resistance. These SCA effects values provide important information about the non-additive gene effects, which also can be related to hybrid vigor, helping in the selection of the best hybrid combinations (Reif *et al*., 2007).

Table 6. Specific combining ability effects (SCA) of 40 crosses combined across two locations for six traits and across two nitrogen levels for downy mildew resistance.

Cross	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	Downy mildew resistance
Sk5001/61×Sk-4	0.041	2.481	0.391	-0.012	0.354	0.001	0.05
Sk5002/62×Sk-4	0.478	3.669	4.453	0.757*	0.254	0.101	0.863
Sk5003/63×Sk-4	0.353	-0.956	0.141	0.125	0.054	0.001	0.363
Sk5004/64×Sk-4	0.166	-0.019	1.391	-0.368	0.654	-0.012	1.113
Sk5004/65×Sk-4	-0.334	-1.581	0.516	0.519	0.679	0.001	-6.450*
Sk5005/66×Sk-4	-0.522	6.231	1.891	0.800*	-0.609	0.088	2.175
Sk5006/67×Sk-4	0.041	3.544	4.828	0.244	-0.546	0.088	0.488
Sk5008/68×Sk-4	0.166	-2.706	-4.047	0.632	0.429	-0.112*	2.113
Sk5010/69×Sk-4	0.791	-1.144	-0.109	-0.35	0.554	0.063	-2.388
Sk5011/70×Sk-4	0.103	-7.519	-6.234	-0.456	-0.196	0.001	-0.263
Sk5013/71×Sk-4	-0.647	-3.644	-0.359	-0.2	0.316	-0.024	-0.45
Sk5019/72×Sk-4	0.103	0.544	0.391	-0.443	-0.346	-0.062	-1.325
Sk5019/73×Sk-4	0.228	-0.081	0.203	-0.25	0.091	0.026	-0.388
Sk5021/74×Sk-4	0.666	-5.081	-4.297	-0.825*	-0.484	0.051	2.488
Sk5021/75×Sk-4	0.228	-4.581	-4.859	-0.456	-0.834*	-0.087	2.675
Sk5022/76×Sk-4	0.478	4.481	5.016	0.582	0.641	-0.024	-0.95
Sk5023/77×Sk-4	-0.209	0.856	1.328	-0.487	-0.396	-0.012	-2.075
Sk5024/78×Sk-4	-0.147	1.419	0.391	-0.45	-0.221	0.038	2.675
Sk5024/79×Sk-4	-0.897	4.919	2.453	0.038	-0.284	-0.037	-3.95
Sk5024/80×Sk-4	-1.084*	-0.831	-3.484	0.6	-0.109	-0.087	3.238
Sk5001/61×SC180	-0.041	-2.481	-0.391	0.012	-0.354	-0.001	-0.05
Sk5002/62×SC180	-0.478	-3.669	-4.453	-0.757*	-0.254	-0.101	-0.863
Sk5003/63×SC180	-0.353	0.956	-0.141	-0.125	-0.054	-0.001	-0.363
Sk5004/64×SC180	-0.166	0.019	-1.391	0.368	-0.654	0.012	-1.113
Sk5004/65×SC180	0.334	1.581	-0.516	-0.519	-0.679	-0.001	6.450*
Sk5005/66×SC180	0.522	-6.231	-1.891	-0.800*	0.609	-0.088	-2.175
Sk5006/67×SC180	-0.041	-3.544	-4.828	-0.244	0.546	-0.088	-0.488
Sk5008/68×SC180	-0.166	2.706	4.047	-0.632	-0.429	0.112*	-2.113
Sk5010/69×SC180	-0.791	1.144	0.109	0.350	-0.554	-0.063	2.388
Sk5011/70×SC180	-0.103	7.519	6.234	0.456	0.196	-0.001	0.263
Sk5013/71×SC180	0.647	3.644	0.359	0.200	-0.316	0.024	0.45
Sk5019/72×SC180	-0.103	-0.544	-0.391	0.443	0.346	0.062	1.325
Sk5019/73×SC180	-0.228	0.081	-0.203	0.25	-0.091	-0.026	0.388
Sk5021/74×SC180	-0.666	5.081	4.297	0.825*	0.484	-0.051	-2.488
Sk5021/75×SC180	-0.228	4.581	4.859	0.456	0.834*	0.087	-2.675
Sk5022/76×SC180	-0.478	-4.481	-5.016	-0.582	-0.641	0.024	0.95
Sk5023/77×SC180	0.209	-0.856	-1.328	0.487	0.396	0.012	2.075
Sk5024/78×SC180	0.147	-1.419	-0.391	0.450	0.221	-0.038	-2.675
Sk5024/79×SC180	0.897	-4.919	-2.453	-0.038	0.284	0.037	3.95
Sk5024/80×SC180	1.084*	0.831	3.484	-0.600	0.109	0.087	-3.238
LSD S_{ij} 0.05	0.945	8.894	7.361	0.755	0.823	0.110	6.259
0.01	1.244	11.707	9.690	1.036	1.083	0.158	8.238
LSD S_{ij-kl} 0.05	1.337	12.578	10.411	1.113	1.164	0.170	8.851
0.01	1.759	16.557	13.704	1.465	1.532	0.223	11.651

*** Significant at the 0.05 level of probability.**

The results in Table 7 showed that K^2GCA\$K^2$SCA ratio were higher than unity for silking date, plant height and ear height, which indicated the majority of additive gene effects in controlling the inheritance of these traits. While, grain yield, ear length, ear diameter and downy mildew resistance showed that non-additive gene effects were the most important controlling these traits. This finding is agreement with those of, Turgut *et al.* (1995); Amer *et al.* (2002) and Mosa *et al.* (2017) who reported the preponderance of non-additive gene effects in controlling the inheritance of downy mildew and grain yield. Whereas, El-Shenawy and Mosa (2005); Mosa *et al.* (2009) and El-Refaey *et al.* (2018) who found that grain yield and downy mildew resistance were mainly controlled by additive gene effects

Table 7. Estimates of additive gene effects (K^2GCA) and non-additive gene effects (K^2SCA) for six traits and downy mildew resistance.

Genetic component	Days to 50% silking	Plant height	Ear height	Grain yield	Ear length	Ear diameter	Downy mildew resistance
K^2 GCA	0.32	18.94	14.69	0.21	0.14	0.003	0.381
K^2 SCA	0.26	5.48	6.10	0.34	0.26	0.004	1.679
K^2GCA/ K^2SCA	1.23	3.46	2.41	0.61	0.53	0.83	0.23

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تحليل السلالة ×الكشاف لتقدير القدرة على التآلف لبعض السلالات الجديدة من الذرة الشامية الصفراء لمحصول الحبوب والمقاومة لمرض البياض الزغبى

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تم التهجين بنظام السلالة × الكشاف فى محطة البحوث الزراعية بسخا خلال موسم الزراعه 2017 بين 20 سلالة ذرة صفراء جديدة و 2 من الكشافات وهما سلاله سخا-4 والهجين الفردى 180. تم تقييم الـ 40 هجين الناتجة بالاضافة الى اربعة هجن للمقارنه فى تجربتين. التجربة الاولى لمحصول الحبوب وبعض الصفات الأخرى وتم التقييم فى محطتى بحوث سخا وسدس. التجربة الثانيه لتقييم صفة مقاومة مرض البياض الزغبى تحت مستويين من التسميد النيتروجينى فى محطة بحوث سخا. أظهرت النتائج فروق معنوية بين الموقعين لمعظم الصفات تحت الدراسة وكذلك بين مستويي التسميد النيتروجينى لصفة المقاومة لمرض البياض الزغبى. وجد أن هناك معنوية للتباين الراجع للسلالات والكشافات وكذلك التفاعل بينهما لمعظم الصفات تحت الدراسة ماعدا صفة المقاومة لمرض البياض الزغبى بين الكشافات وكذلك تباين تفاعل السلالة ×الكشاف لصفات ارتفاع النبات وارتفاع الكوز والمقاومة لمرض البياض الزغبى. كانت تأثيرات الفعل الجينى الغير المضيف هى الأكثر أهمية فى وراثة صفات محصول الحبوب وطول الكوز وقطر الكوز وكذلك لصفة المقاومة لمرض البياض الزغبى . أفضل السلالات فى القدرة العامة على الأئتلاف كانت السلالة Sk5013/71 لصفة محصول الحبوب والمقاومة لمرض البياض الزغبى. أظهرالكشاف Sk-4 أفضل قدرة عامه على التآلف لصفه المحصول العالى ومعظم الصفات تحت الدراسة. وكانت أفضل الهجن للقدرة الخاصة على الائتلاف الهجن Sk5002/62×Sk-4و Sk5005/66×Sk-4 وSk5021/74×SC180 لصفة المحصول و الهجين Sk5004/65×SC180 لصفة المقاومة لمرض البياض الزغبى. أظهر الهجين الفردى Sk5013/71×Sk-4 و ايضا الهجينان الثلاثيان Sk5010/69×SC180 و Sk5013/71×SC180 تفوقاً فى المحصول ومقاومة عالية لمرض البياض الزغبى وتوصى الدراسة باستخدام هذه الهجن فى برنامج تربية الذرة الشامية.