USEFUL HETEROSIS AND COMBINING ABILITY FOR GRAIN YIELD AND RESISTANCE TO DOWNY MILDEW DISEASE (*PRENOSCLEROSPORA SORGHI*) IN SOME NEW YELLOW INBRED LINES OF MAIZE

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ABSTRACT

Sixteen new inbred lines of yellow maize with wide genetic diversity were top-crossed with two narrow and one broad genetic testers to obtain 48 top-crosses in 2002 growing season. These crosses and two commercial check hybrids were evaluated at two locations Sakha and Nubaria Agriculture Research Station to estimate combining ability and useful heterotic effects for grain yield, its components and percentage of resistance to downy mildew disease (DMR%) in 2003 season.

The obtained results revealed that, additive genetic variance (σ^2GCA) was more important than non-additive genetic variance (σ^2SCA) in the inheritance of days to 50% silking, ear position, No. of kernels/row, 100-kernel weight, grain yield ard/fed and DMR%. Meanwhile, σ^2SCA played an effective role in the expression of plant height, ear height, ear length, ear diameter and grain yield/plant. The magnitude of the interaction of σ^2SCA by locations (σ^2SCA×Loc.) was markedly higher than those of σ^2GCA×Loc. for ear length, ear diameter, kernels/row, 100-kernel weight, grain yield ard/fed and grain yield/plant. While, σ^2GCA was more sensitive to environmental conditions than σ^2SCA for days to 50% silking, plant height, ear height, ear position and rows/ear. Inbred lines Sk-7008/7 and Sk-7008/12 exhibited good general combiners for grain yield and DMR%. Also, inbred line Skug-10 was the best combiner for earliness, ear position, grain yield and its related traits. Nine inbred lines are found desirable and inherited favorable alleles of DMR% in their top-cross progenies. Narrow genetic base was the most efficient and effective than those of broad genetic base for evaluating combining ability of most studied traits. Positive and significant heterotic effects over the commercial checks were detected via six top-crosses, i.e., Skug-10 × SC155 (27.16%), Sk-7008/12 × SC155 (19.46%), Sk-7008/7 × B-73 (17.89%), Skug-3 × SC155 (17.48%), Sk-7001/1 × SC155 (11.62%) and Sk-7001/2 × SC155 (11.54%) for grain yield and DMR% suggesting these yellow hybrids are prospective genetic materials for yielding ability with resistance to downy mildew disease in future maize breeding program.

Key words: *Maize, grain yield, downy mildew, combining ability, heterosis, additive and non-additive variances.*

INTRODUCTION

Maize is one of the most important strategic crops in Egypt and the annual national demand of maize is about 8.5 million tons which is more than the total national production by about three million tons imported annually, all of yellow grains, and totally used in the feed industry. Therefore, more efforts have been done by maize breeders to activate the national plan for increasing yellow maize production to meet the increasing demand for poultry and animal feeding. This will reduce the amounts of imported yellow maize. Development of better inbred lines and identification of heterotic patterns are essential for the success of maize hybrid development programs. Recently, downy mildew disease caused by *Prenosclerospora sorghi* became a serious pathological problems affecting maize production as a result of spread of sorghum plantation which is considered the main host plant and the spreader of this disease.

The inbred tester which had the narrowest genetic and lowest yield potentiality although it gave maximum genetic variation in the top-crosses progenies for the most studied traits indicating that inbred line is very effective tester followed by broad genetic base (Liakat and Tepora, 1986). Non-additive genetic variance play an important role in the inheritance of grain yield/plant and both of plant and ear height (Talleii and Kochaksaraei, 1999; Ashish and Singh, 2002 and Dodiya and Joshi, 2002). While, several investigators indicated that the additive genetic variance was the most effective in the inheritance of grain yield ard/fed, No. of rows/ear, No. of kernel/row and ear position

(Mostafa *et al.*, 1995; Soliman and Sadek, 1999; El-Zeir *et al.*, 2000; El-Shenawy, 2003 and Mosa *et al.*, 2004). Also, days to 50% silking controlled mainly by additive gene action (Mahmoud, 1996 and Amer *et al.*, 2002). On the other side, σ^2GCA was more affected by locations than σ^2SCA for silking date, plant height, ear height and ear position (Shehata, 1992; Soliman *et al.*, 1995; El-Zeir, 1999 and Mosa *et al.*, 2004). Meanwhile, the magnitude of the interaction of σ^2SCA with locations was markedly higher than those of σ^2GCA for grain yield (Rajas and Sprague, 1952; Nawar and El-Hosary, 1984; Sedhom, 1992; Mosa, 2001 and El-Shenawy, 2003); for ear length (Matzinger *et al.*, 1959 and El-Zeir *et al.*, 2000) and for ear diameter (Amer *et al.*, 2003). Estimates of heterotic effect relative to check hybrid was reported by Venugopal *et al.*, 2002 and Mosa, 2003. Resistance to downy mildew disease was controlled mainly by additive gene effects (Kaneko and Aday 1980; Orangel and Borges, 1987; Delean, 1994; El-Zeir and Tolba, 1999; Mahmoud, 2002 and El-Shenawy and Motawei, 2004). Useful heterotic effect for resistance to downy mildew disease over check hybrid was noticed by El-Shenawy (1995); Gabr (1997) and El-Zeir and Amer (1999).

The objectives of this study were to examine the combining abilities and heterotic patterns among yellow maize lines to identify candidates of promising hybrid combinations for yielding ability with resistance to downy mildew disease.

MATERIALS AND METHODES

Sixteen new yellow inbred lines developed at Sakha Agriculture Research Station (12 inbred lines isolated from DMR Pop. Yellow exotic from Thailand and other four inbred lines isolated from Yugoslavic materials) i.e., Sk-7001/1, Sk-7001/2, Sk-7008/3 , Sk-7008/4, Sk-7008/5, Sk-7008/6, Sk-7008/7, Sk-7008/8, Sk-7008/9, Sk-7008/10, Sk-7008/11, Sk-7008/12, Skug-1 , Skug-3, Skug-6 and Skug-10 were used in this investigation. The 16 inbred lines were crossed to three yellow testers i.e., inbred lines B-73 and Sk-6241/2-9 as narrow genetic base and commercial single cross 155 as broad genetic base during 2002 growing season at Sakha Station. The 48 top-crosses and two commercial check hybrids (SC Pioneer3080 and TWC352) were evaluated in two experimental fields. First experiment was planted in May at two locations Sakha and Nubaria station to evaluate grain yield and other agronomical traits in 2003 season. Randomized complete block design (RCBD) with four replications was used in the two locations. Plot size was one row, 6 m. long and 80 cm. apart with 25 cm. between hills. One plant was left per hill after thinning at 21 days from planting. All agronomic field operations were practiced as usual with ordinary maize field cultivation. Days to 50% silking, and both of plant and ear height (cm.) were measured during growing season. At harvest, all plants were harvested and the following data were recorded: ear length, ear diameter, No. of rows/ear, No. of kernels/row, grain yield ard/fed, grain yield/plant (gm.) and 100-kernel weight (grain yield adjusted based on 15.5% moisture content). The second experiment was performed in July 2003 season at the nursery field of downy mildew disease to study the genetic control of resistance to downy mildew disease. The field was previously sown by Sudan grass as a source of infection with downy mildew disease. Sudan grass was sown alternatively with maize rows with a ratio of 1:2, respectively. This experiment was arranged in RCBD with four replications. The plot size was one row, 5 m. long, 20 cm. between hills. Two seeds were sown per each hill and left without thinning. The infested plants were recorded after 35 days from planting date and adjusted into percentage of resistance to downy mildew (DMR%) as follow:

$$\text{DMR\%} = 100 - \left(\frac{\text{No. of infested plants / plot}}{\text{total No. of plants / plot}} \times 100 \right)$$

Before calculating the combined analysis, test of homogeneity of error mean squares for two locations was done as outlined by Snedecor and Cochran (1967). The analysis of variance for every location and combined was carried out by Steel and Torrie (1980). Finally, line × tester analysis was made to estimate combining ability according to Kempthorne (1957). Useful heterotic effect was computed according to Meredith and Bridge (1972).

RESULTS AND DISCUSION

The combined analysis of variance for 12 studied traits are shown in Table 1. High and significant differences between the two locations were detected for all traits except for days to 50% silking. This result suggested obvious difference between the two locations in their soil and climate conditions. Mean squares due to crosses and their partitions i.e., line (L), tester (T) and L×T were found to be significant and highly significant for all traits except for that of T for the two traits of grain yield and DMR% and L×T for days to 50% silking, both of plant and ear height, ear position and ear diameter. These results reflected the presence of great diversity existed among testers and inbred lines in their respective top-crosses, and the significance of L×T interaction suggesting that inbred lines may perform differently in top-crosses depending on type of used tester. These results are in harmony with those obtained by El-Itriby *et al.*, (1990); Soliman and Sadek (1999); Mosa (2001); Amer *et al.*, (2003) and El-Shenawy (2003).

The interactions between crosses (C) and line (L) with locations (Loc.) were highly significant for all traits except of L × Loc. for rows/ear. While, T × Loc. and L × T × Loc. were insignificant of most traits except for ear length, rows/ear and 100-kernel weight. Furthermore, T × Loc. for plant height and ear diameter and L × T × Loc. for kernels/row, grain yield ard/fed and grain yield/plant exhibited significant differences. Several investigators among of them Dodiya and Joshi (2002); Ashish and Singh (2002) and Mosa *et al.*, (2004) found that significant differences among L, T and L × T and their interaction with locations.

Mean performances of 48 top-crosses for the 11 traits as an average over two locations and DMR% are given in Tale 2. Great differences were detected among top-crosses for all studied traits. The mean values for the two main traits under study ranged from 19.06 to 32.88 (SC Sk-7008/7×B-73) and from 56.21 to 100% (11 top-crosses among of them SC Sk-7008/7×B-73) for grain yield ard/fed and DMR%, respectively. The top-cross Sk-7008/7×B-73 (32.88) was significantly increased of grain yield over both check hybrids. But the five top-crosses i.e., Skug-10×SC155 (30.19),

Table1: Combined analysis of variance for 11 studied traits over two locations (Sakha and Nubaria research Stations) and percentage of resistance to downy mildew disease at Sakha in 2003 season.

S.O.V	Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield Ard/fed	Grain yield/plant cm	DMR%
Location (Loc.)	0.753	16686145**	777600.0**	10869**	1005**	35.46**	245.1**	6404.3**	1521.6**	24386.9**	1086357**	----
Rep / Loc.	83..52	9306.652	5473.832	396.05	13.787	0.664	1.63	38.831	21.472	39.966	1536.96	----
Crosses (c)	9.12**	910.523**	774.867**	68.52**	4.071**	0.195**	13.93**	43.71**	98.100**	60.647**	2444.79**	587.2**
Line (L)	21.76*	1721.251**	1764.655**	158.6**	6.239**	0.355**	12.86**	48.34**	139.451**	130.144**	5304.23**	1497.7**
Tester (T)	9.945*	2551.711**	1754.487**	192.9**	7.831**	0.594**	196.6**	278.26**	1025.7**	8.094	580.55	189.94
L x T	2.743	395.747	214.665	15.177	2.736**	0.088	2.291**	25.766**	15.578*	29.402**	1139.35**	158.47*
C x Loc.	5.67**	910.523**	336.32**	26.47**	3.617**	0.123**	1.691**	19.079**	17.033**	20.512**	873.06**	----
L x Loc.	10.2**	898.897**	763.08**	46.76**	3.349**	0.175**	1.227	16.292**	19.054**	26.853**	1212.0**	----
T x Loc.	9.784	1243.53*	349.76	38.791	21.37**	0.406**	10.39**	13.573	37.706*	8.854	590.91	----
L x T x Loc.	3.109	172.387	122.05	15.511	2.567**	0.078	1.343*	20.840**	14.645**	18.118**	722.37**	----
Error	3.325	321.292	134.78	14.06	1.173	0.066	0.801	5.672	8.396	7.408	283.09	90.99
$\bar{x}$	59.02	211.26	113.09	51.65	19.33	4.65	15.04	36.13	37.14	25.09	162.76	92.04
C.V%	3.09	8.48	10.27	7.26	5.60	5.54	5.95	6.59	7.80	10.85	10.34	10.36

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

Table 2: Mean performance of 48 top-crosses for the 11 traits over two locations and resistance to downy mildew disease in 2003 season.

Top-crosses	Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield Ard/fed	Grain yield/plant cm	DMR%
Sk-7001/1× B-73	61.3	207.4	113.3	53.4	18.4	4.66	16.9	37.2	29.96	27..98	180.36	82.01
× Sk-6241/2-9	58.3	191.4	101.5	52.0	18.9	4.51	15.2	38.5	31.66	22.78	145.78	97.22
× SC155	60.5	197.0	103.8	51.5	18.4	4.73	15.8	36.3	34.86	26.50	169.61	94.12
Sk-7001/2× B-73	60.4	206.4	112.4	52.6	17.7	5.59	18.7	33.6	29.96	22.67	148.87	97.22
× Sk-6241/2-9	59.8	198.6	114.4	57.1	19.9	4.45	14.65	40.8	35.46	24.66	157.84	79.66
× SC155	60.0	211.3	118.9	54.8	18.9	4.56	16.25	34.6	35.26	26.48	174.20	99.0
Sk-7008/3× B-73	59.9	209.8	113.1	51.8	18.7	4.78	16.4	34.3	35.08	25.98	169.41	97.83
× Sk-6241/2-9	58.6	216.3	118.4	53.9	20.6	4.45	13.1	40.4	36.65	26.64	172.71	98.15
× SC155	59.3	201.8	109.9	52.2	20.2	4.78	14.4	38.2	39.26	25.44	162.81	99.12
Sk-7008/4× B-73	59.5	215.9	115.5	51.8	19.6	4.95	16.5	37.2	37.06	24.89	161.44	98.96
× Sk-6241/2-9	59.4	207.8	109.3	51.0	20.0	4.55	12.8	39.9	37.48	26.37	168.77	100.0
× SC155	58.5	215.1	119.9	53.8	19.6	4.74	14.5	33.4	42.59	25.34	164.22	98.39
Sk-7008/5× B-73	59.0	206.4	110.0	50.8	19.9	4.68	15.2	36.5	38.31	25.07	160.42	100.0
× Sk-6241/2-9	59.0	205.6	112.5	51.8	19.7	4.38	12.9	37.5	37.86	26.38	169..96	100.0
× SC155	59.0	220.8	119.6	52.9	18.9	4.50	13.6	32.9	40.99	23.86	154.88	100.0
Sk-7008/6× B-73	58.6	216.1	114.0	50.8	19.3	4.75	15.7	34.8	37.0	24.24	156.18	99.04
× Sk-6241/2-9	59.6	226.3	124.4	53.2	19.5	4.61	13.1	34.6	40.36	25.96	166.16	97.22
× SC155	59.1	216.6	122.3	55.0	19.2	4.71	15.1	35.0	41.84	22.43	147.39	100.0
Sk-7008/7× B-73	58.9	223.5	123.1	53.5	19.2	4.76	16.1	39.0	34.78	32.88	210.41	100.0
× Sk-6241/2-9	59.9	203.5	111.5	51.6	19.4	4.41	13.5	36.3	36.96	26.96	178.33	98.30
× SC155	59.5	221.4	123.3	53.7	18.8	4.76	15.7	33.6	42.21	25.16	163.20	97.91
Sk-7008/8× B-73	60.8	209.8	114.1	52.1	18.6	4.85	16.8	33.1	37.09	26.23	170.12	98.20
× Sk-6241/2-9	59.1	219.0	118.5	52.7	20.9	4.68	14.1	39.9	37.03	26.35	168.66	99.04
× SC155	60.6	213.3	119.9	53.4	19.3	4.84	15.7	33.9	41.70	23.65	152.54	99.04
Sk-7008/9× B-73	59.8	212.5	111.4	49.8	19.2	4.88	16.7	34.4	36.13	26.08	169.27	100.0
× Sk-6241/2-9	59.0	198.5	109.1	52.8	19.2	4.48	13.7	34.6	40.44	22.94	149.82	100.0
× SC155	59.8	215.6	121.1	53.8	18.7	4.61	15.1	33.6	38.8	22.41	146.40	96.55
Sk-7008/10× B-73	60.4	215.4	120.3	52.8	19.7	4.71	16.4	34.6	35.53	26.65	175.41	97.85
× Sk-6241/2-9	59.6	209.5	118.1	53.0	19.8	4.36	13.7	37.2	38.05	24.99	162.24	99.07
× SC155	60.4	222.8	124.5	53.9	19.3	4.63	15.1	34.9	41.59	24.89	161.24	89.52

Table 2: Cont.

Crosses		Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield Ard/fed	Grain yield/plant cm	DMR%
Sk-7008/11	× B-73	58.9	210.8	111.4	49.3	18.7	4.81	16.4	32.6	35.61	26.38	170.01	99.41
	× Sk-6241/2-9	57.5	199.9	111.0	52.4	18.7	4.44	13.3	35.5	37.95	24.66	159.96	100.0
	× SC155	58.1	211.6	112.5	51.4	18.5	4.79	15.1	32.2	44.23	23.57	150.83	99.14
Sk-7008/12	× B-73	58.6	230.4	125.5	53.4	18.9	4.58	16.5	36.8	31.14	25.68	172.85	100.0
	× Sk-6241/2-9	59.3	213.8	115.1	53.1	19.4	4.60	15.4	38.5	33.56	26.57	172.47	100.0
	× SC155	58.4	237.8	134.2	55.4	20.1	4.83	15.6	36.7	39.65	28.36	184.04	100.0
Skug-1	× B-73	59.0	196.1	94.0	46.1	17.9	4.56	16.2	32.4	34.63	19.14	124.07	84.55
	× Sk-6241/2-9	57.9	199.5	102.8	50.1	17.9	4.59	14.8	34.6	34.09	19.57	126.08	67.56
	× SC155	57.6	207.5	106.5	49.2	19.5	4.98	14.4	35.9	40.89	23.03	154.05	57.84
Skug-3	× B-73	58.6	205.5	102.6	48.2	19.3	4.84	16.1	36.2	33.58	23.84	154.93	84.98
	× Sk-6241/2-9	58.1	220.4	117.4	52.1	19.5	4.66	14.1	38.3	36.95	24.86	164.74	66.13
	× SC155	58.8	228.3	125.8	54.5	20.0	4.93	15.4	35.6	39.73	27.89	178.52	56.21
Skug-6	× B-73	56.6	183.6	82.8	41.6	19.9	4.36	14.2	35.9	31.79	19.31	128.12	74.57
	× Sk-6241/2-9	56.1	185.8	87.1	44.5	19.9	4.23	13.2	39.3	31.68	19.06	124.52	74.47
	× SC155	56.9	206.3	97.3	45.9	19.7	4.29	13.4	38.5	36.9	21.94	140.39	67.83
Skug-10	× B-73	58.1	220.4	109.3	47.6	20.8	4.89	16.4	39.7	36.23	28.56	188.94	86.83
	× Sk-6241/2-9	58.4	213.8	106.9	48.7	20.1	4.79	14.4	39.1	39.49	28.87	184.78	92.05
	× SC155	58.0	224.9	118.3	52.3	20.1	4.78	14.5	35.7	42.53	30.19	194.47	92.86
S.C 3080		58.9	221.0	119.4	54.3	18.6	5.10	14.8	37.2	40.65	27.89	187.56	96.88
T.W.C 352		60.5	217.8	123.3	56.5	19.3	4.94	14.7	36.6	39.41	23.74	151.93	82.35
L.S.D at	0.05	1.787	17.566	11.377	3.675	1.061	0.252	0.877	2.334	2.84	2.667	16.489	13.36
	0.01	2.352	23.123	14.976	4.837	1.397	0.331	1.155	3.072	3.738	3.511	21.705	17.67

Sk-7008/8×SC155(28.36), Skug-3×SC155(27.89), Sk-7001/1× SC155 (26.48) and Sk-7001/2×SC155(26.48) were significantly increased the same trait over only TWC 352. Furthermore, three top-crosses (SC Sk-7008/7×B-73, Sk-7008/8×SC155 and Sk-7001/2×SC155) out of the previous six top-crosses exhibited high resistance to downy mildew disease, early silking and desirable ear position. These results suggest the utilization of these yellow top- crosses in future maize breeding program as new crosses for yielding ability, earliness, good type plants and resistance to downy mildew disease.

The superiority of top-crosses over the standard check hybrids SC3080 and TWC352 for the two main traits, grain yield and DMR%,(Table3) revealed that only one SC Sk-7008/7×B-73 (17.89%) exhibited high and significant heterotic effect over commercial check hybrid 3080 for the two traits of yield and gave positive heterotic effect but insignificant for DMR%. Meanwhile, 5 TWC i.e., Skug-10×SC155 (27.16%), Sk-7008/12×SC155 (19.47%), Skug-3×SC155 (17.48%), Sk-7001/1×SC155 (11.62%) and Sk-7001/2×SC155 (11.54%) exhibited positive and significant heterotic effects over commercial check TWC352 for the two main traits except for TWC Skug-3×SC155. The conclusion indicated that these top-crosses could be used as good hybrids for yielding ability and resistance to downy mildew disease in future maize breeding program. Many investigators reported useful heterosis for grain yield of maize among of them Akhtar and Singh (1982); Venugopal *et al.*, (2002) and Mosa (2003). Heterotic effect for resistance to downy mildew disease was found in maize by Gabr (1997); El-Zeir and Amer (1999) and El-Shenawy and Motawei (2004).

General combining ability effects of 16 different inbred lines for the 12 studied traits (Table 4) demonstrated that inbred lines Sk-7008/7 and Sk-7008/12 exhibited good general combiners for the two traits of grain yield and DMR%. Moreover, inbred line Skug-10 was detected best combiner for earliness, ear position, grain yield and its component. Nine out of 12 inbred lines which isolated from a source resistant to downy mildew disease (DMR Pop. yellow) inherited desirable and favorable alleles of resistance in their progenies.

Table 3: Useful heterosis for the two traits of yield over two locations and resistance to downy mildew disease at Sakha in 2003 season.

Top-crosses		Grain yield ard/fed	Grain yield/plant gm.	DMR%
Sk-7001/1	× B-73	0.32	-3.84	-15.35*
	×Sk-241/2-9	-18.32**	-22.28**	0.35
	× SC155	11.62*	11.63*	14.29*
Sk-7001/2	× B-73	-18.72**	-20.63*	0.35
	× Sk-6241/2-9	-11.58*	-15.85	-17.78**
	× SC155	11.54*	14.65**	20.22**
Sk-7008/3	× B-73	-6.85	-9.68	0.98
	× Sk-6241/2-9	-4.48	-7.92	1.31
	× SC155	7.16	7.16	20.36**
Sk-7008/4	× B-73	-10.76*	-13.93	2.15
	× Sk-6241/2-9	-5.45	-10.02	3.22
	× SC155	6.73	8.08	19.48**
Sk-7008/5	× B-73	-10.11*	-14.47	3.22
	× Sk-6241/2-9	-5.41	-9.38	3.22
	× SC155	0.050	1.94	21.43**
Sk-7008/6	× B-73	-13.09**	-16.73**	2.23
	× Sk-6241/2-9	-6.92	-11.41	0.35
	× SC155	-5.52	-2.98	21.43**
Sk-7008/7	× B-73	17.89**	12.18**	3.22
	× Sk-6241/2-9	-3.34	-4.92	1.47
	× SC155	5.98	7.41	18.90**
Sk-7008/8	× B-73	-5.95	-9.30	1.36
	× Sk-6241/2-9	-5.52	-10.08	2.23
	× SC155	-0.379	0.40	20.27**
Sk-7008/9	× B-73	-6.49	-9.75	3.22
	× Sk-6241/2-9	-17.75**	-20.12*	3.22
	× SC155	-5.60	-3.63	17.24*
Sk-7008/10	× B-73	-4.45	-6.48	1.00
	× Sk-6241/2-9	-10.40*	-13.50	2.26
	× SC155	4.84	6.12	8.71
Sk-7008/11	× B-73	-5.41	-9.36	2.61
	× Sk-6241/2-9	-11.58*	-14.72	3.22
	× SC155	-0.72	-0.72	20.39**
Sk-7008/12	× B-73	-7.92	-7.84	3.22
	× Sk-6241/2-9	-4.73	-8.05	3.22
	× SC155	19.46**	21.13**	21.43**
Skug-1	× B-73	-31.37**	-33.85**	-12.73
	× Sk-6241/2-9	-29.83**	-32.78**	-30.26**
	× SC155	-2.99	1.39	-29.76**
Skug-3	× B-73	-14.52**	-17.40*	-12.28
	× Sk-6241/2-9	-10.86*	-12.17	-31.74**
	× SC155	17.48**	17.50**	-31.74**
Skug-6	× B-73	-30.76**	-31.69**	-23.03**
	× Sk-6241/2-9	-31.66**	-33.61**	-23.13**
	× SC155	-7.58	-7.59	-17.63*
Skug-10	× B-73	2.40	0.74	-10.37
	× Sk-6241/2-9	3.51	-1.48	-4.99
	× SC155	27.16**	27.99**	12.76
L.S.D at	0.05	2.667	16.489	13.36
	0.01	3.511	21.705	17.67

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

Table 4: General combining ability effects of 16 inbred lines for the 12 studied traits.

Lines	Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield ard/fed	Grain yield/plant gm	Resistance to downy mildew%
Sk-7001/1	0.976**	-12.674**	-6.912**	0.666	-0.708**	-0.023	0.859**	1.302**	-5.033**	2.500	0.6901	-0.964
Sk-7001/2	1.018**	-5.841	2.119	3.208**	-0.541*	-0.148**	1.484**	0.218	-3.575**	-2.416	-0.352	-0.047
Sk-7008/3	0.226	-2.007	0.703	1.00	0.458*	0.018	-0.349*	1.427**	-0.075	5.541	0.940	6.287*
Sk-7008/4	0.101	1.658	1.786	0.500	0.333	0.143**	-0.474**	0.718	1.757**	2.041	0.482	7.120*
Sk-7008/5	-0.023	-0.341	0.953	0.125	0.125	-0.148**	-1.140**	-0.447	1.966**	-1.125	0.065	7.953**
Sk-7008/6	0.101	8.408*	7.119**	1.333	-0.041	0.101	-0.474**	-1.281**	2.716**	-6.166	-0.893	6.703*
Sk-7008/7	0.393	4.867	6.203**	1.333	-0.208	-0.023	-0.015	0.177	0.882	21.208**	3.232**	6.703*
Sk-7008/8	1.143**	2.742	4.411	1.041	-0.291	0.101	0.526**	-0.572	1.424*	1.000	0.315	6.703*
Sk-7008/9	0.476	-2.382	0.786	0.500	-0.250	-0.023	0.109	-1.947**	1.341*	-7.708*	-1.393*	6.787*
Sk-7008/10	1.101**	4.617	7.869**	1.625*	0.333	0.018	0.067	-5.31**	1.216*	3.666	0.482	3.537
Sk-7008/11	-0.856*	-3.841	-1.463	-0.625	-0.750**	0.018	-0.099	-2.739**	1.966**	-2.500	-0.268	7.537**
Sk-7008/12	0.059	15.867**	11.953**	2.333**	0.125	-0.023	0.776**	1.218*	-2.325**	13.708**	1.732**	7.953**
Skug-1	-0.856	10.216**	-12.005**	-3.208**	-0.833**	0.101	0.067	-1.822**	-0.575	-28.041**	-4.560**	-22.047
Skug-3	-0.523	6.783	2.161	0.000	0.250	0.143**	0.109	0.552	-0.367	3.291	0.440	-22.964**
Skug-6	-2.481**	-16.049**	-24.46**	-7.666**	0.458*	-0.310**	-1.515**	1.677**	-3.658**	-31.666**	-5.018**	-19.714**
Skug-10	-0.856*	8.408*	-1.630	-2.166**	0.958**	0.059	0.067	2.052**	2.341**	26.666**	4.107**	-1.547
GCA Tester												
B-73	0.242	-0.023	-2.299*	-1.328**	-0.231*	0.031	1.270**	-0.614**	-2.544**	2.265	0.266	1.828
Sk-6241/2-9	-0.304	-4.453**	-1.971	0.234	0.260**	-0.078**	-1.205**	1.682**	-0.505*	-1.960	-0.234	-0.234
SC 155	0.062	4.476**	4.270**	1.093**	-0.028	0.046*	-0.065	-1.067**	3.049**	-0.304	-0.031	-1.594
L.S.D Line												
0.05	0.729	7.171	4.644	1.50	0.433	0.102	0.358	0.952	1.159	6.731	1.089	5.452
0.01	0.960	9.439	6.11	1.974	0.570	0.135	0.471	1.254	1.525	8.860	1.433	7.215
L.S.D Tester												
0.05	0.315	3.105	2.011	0.649	0.187	0.044	0.155	0.412	0.501	2.914	0.472	2.361
0.01	0.415	4.087	2.647	0.855	0.246	0.058	0.204	0.543	0.660	3.836	0.621	3.124

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

For GCA effects of testers (Table 4), desirable and significant GCA effects was obtained by tester line B-73 for ear height, ear position and no. of rows/ear. While, tester line Sk-6241/2-9 had good combiner for plant height, ear length, ear diameter and No. of kernels/row. Beside that tester SC155 gave good combiner for 100-kernel weight only. These results indicated that the tester lines had a high frequency of favorable alleles for vegetative and yield components traits than SC155. This result supports the finding of Ameha (1977); Ali and Tepora (1986) and Al-Naggar *et al.*,(1997).

Estimates of specific combining ability effects of the 48 top-crosses for all studied traits are given in Table 5. Desirable SCA effects were detected in SC Sk-7001/1×Sk-6241/2-9 towards earliness; SC Sk-7001/2×Sk-6241/2-9, Sk-7008/3×B-73, Sk-7008/8×Sk-6241/2-9, Skug-10×B-73 and TWC Skug-1 ×SC155 for ear length; SC Sk-7001/2×B-73, Sk-7008/12×Sk-6241/2-9, Skug-1 ×Sk-6241/2-9, Skug-6×Sk-6241/2-9 and TWC Sk-7008/7×SC155 for No. of rows/ear; SC Sk-7001/2×Sk-6241/2-9, Sk-7008/7×B-73, Sk-7008/8×Sk-6241/ 2-9, Skug-10×B-73, TWC Sk-7008/3×SC155, Skug-1×SC155 and Skug-6 ×SC155 for No. of kernels /row and SC Sk7001/2×Sk-6241/2-9 and Sk-7008/9×Sk-6241/2-9 for 100-kernel weight. Furthermore, the best desirable top-crosses for the two traits of yield were SC Sk-7001/1×B-73,. Sk-7008/6×Sk-6241/2-9, Sk-7008/7×B-73, Sk-7008/9×B-73, TWC Skug-1×SC155 and Skug-3 ×SC155.On the other side, two single crosses (Skug-1×B-73 and Skug-3×B-73) exhibited favorable SCA effects towards resistance to downy mildew disease. On the bases of these results, it could be concluded that both top-crosses are prospective genetic materials to be used for improving yielding ability or used by maize breeder as a source for new resistant inbred lines to downy mildew disease. In addition, narrow genetic base (inbred lines B-73 and Sk-6241/2-9) was the most efficient and effective than those of broad genetic base (SC155) for estimating specific combining ability of most studied traits. The same result was obtained by Liakat and Tepora (1986) and Mahmoud (1996).

Estimation of genotypic variances (σ^2GCA and σ^2SCA) and their interactions by locations of the studied traits are found in Table 6. Additive genetic variance was more important than non-additive genetic variance in the inheritance of days to 50% silking,

Table 5: Specific combining ability effects of the 48 top–crosses for 11 studied traits and resistance to downy mildew disease at Sakha in 2003 season.

Top-crosses	Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield ard/fed	Grain yield/plant gm	Resistance to downy mildew%
Sk-7001/1 × B-73	1.007	8.815	9.382*	2.411	-0.0182	-0.031	-0.312	0.447	0.252	1.943*	12.859*	-10.911*
× Sk-6241/2-9	-1.445*	-2.755	-2.695	-0.526	0.114	0.046	0.414	-0.598	-0.036	-2.807**	-17.539**	6.401
× SC155	0.437	-6.059	-6.687	-1.885	-0.096	0.078	-0.101	0.151	-0.216	0.865	4.679	4.510
Sk-7001/2 × B-73	0.0911	0.981	-0.533	-1.005	-0.934*	-0.031	0.937**	-2.093*	-1.080	-2.266*	-13.598*	3.422
× Sk-6241/2-9	0.013	-2.338	1.138	2.182	0.822*	0.078	-0.710*	2.859**	2.505*	0.359	-0.622	-12.016
× SC155	-0.104	1.356	-0.604	-1.177	0.111	-0.046	-0.226	-0.765	-1.424	1.906*	14.221*	8.594
Sk-7008/3 × B-73	0.382	0.523	1.632	0.578	0.809*	-0.0729	0.520	-2.802**	0.544	-0.182	-1.182	-2.412
× Sk-6241/2-9	-0.320	11.453	6.554	1.015	0.572	-0.088	-0.377	1.151	0.130	0.818	6.419	0.151
× SC155	-0.0625	-11.976	-8.187*	-1.593	0.236	0.161	-0.143	1.651*	-0.674	-0.635	-5.236	2.260
Sk-7008/4 × B-73	0.132	2.981	2.924	0.953	0.190	0.052	0.520	0.906	0.585	-0.974	-5.682	-1.995
× Sk-6241/2-9	0.554	-0.713	-3.653	-1.359	0.072	0.036	-0.502	1.484	-0.953	1.026	5.919	1.068
× SC155	-0.687	-2.268	0.729	0.406	-0.263	-0.088	-0.018	-2.390**	0.367	-0.052	-0.236	0.927
Sk-7008/5 × B-73	-0.242	-4.518	-1.742	0.328	0.648	-0.031	0.062	1.447	1.877	-0.307	-3.515	-1.828
× Sk-6241/2-9	0.304	-0.838	0.429	-0.359	-0.218	0.078	0.164	0.151	-0.661	1.568	10.085	0.234
× SC155	-0.062	5.356	1.312	0.031	-0.429	-0.046	-0.226	-1.598	-1.216	-1.260	-6.570	1.594
Sk-7008/6 × B-73	-0.742	-3.518	-3.908	-0.880	0.0651	-0.031	-0.229	0.656	-0.372	-0.099	-2.848	-1.578
× Sk-6241/2-9	0.783	11.036	6.138	-0.0677	0.072	-0.046	-0.252	-1.890*	1.213	1.901*	11.752*	-1.265
× SC155	0.763	-7.518	-2.229	0.947	-0.138	0.078	0.481	1.234	-0.841	-1.802	-8.903	2.843
Sk-7008/7 × B-73	0.020	7.398	6.132	1.869	0.231	-0.031	-0.312	3.322**	-0.664	4.276**	24.151**	-0.578
× Sk-6241/2-9	0.736	-8.171	-5.820	-1.567	-0.010	-0.046	-0.460	-1.723	-0.578	-1.224	-3.622	-0.266
× SC155	0.395	0.773	-0.312	-0.302	-0.221	0.0781	0.773*	-1.598	1.242	-3.052**	-20.528**	0.844
Sk-7008/8 × B-73	0.007	-4.226	-1.075	0.661	-0.893*	-0.031	0.020	-1.927*	1.044	0.443	3.984	-2.328
× Sk-6241/2-9	-0.195	9.453	2.97	-0.276	1.114**	0.0781	-0.252	2.651**	-0.994	1.193	6.835	0.484
× SC155	0.187	-5.226	-1.895	-0.385	-0.221	-0.046	0.231	-0.598	-0.049	-1.635	-10.820	1.843
Sk-7008/9 × B-73	0.007	3.648	-0.200	-1.171	0.398	0.093	0.187	0.822	0.127	1.901*	11.692*	-0.661
× Sk-6241/2-9	-0.195	-5.921	-2.778	0.515	-0.093	0.078	-0.210	-1.223	2.588*	-0.747	-3.330	1.401
× SC155	0.177	2.273	2.979	0.656	-0.304	-0.171	0.023	0.401	-2.71**	-1.427	-8.361	-0.739

Table 5: Cont.

Top-crosses		Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield ard/fed	Grain yield/plant cm	DMR%
Sk-7001/1	× B-73	0.007	-0.476	1.591	0.953	0.440	0.052	0.104	-0.343	-0.372	1.026	6.817	0.589
	× Sk-6241/2-9	-0.195	-1.921	-0.861	-0.484	-0.177	-0.088	-0.169	-0.015	0.338	-0.224	-2.080	3.651
	× SC155	0.187	2.398	-0.729	-0.468	-0.263	0.036	0.065	0.359	0.033	-0.802	-4.736	-4.239
Sk-7001/2	× B-73	0.466	3.356	2.049	-0.421	0.273	0.052	0.145	-0.135	-0.997	1.276	7.4[illegible]	-1.9[illegible]
	× Sk-6241/2-9	-0.361	-3.088	1.346	1.140	-0.218	-0.088	-0.502	0.317	-0.911	0.026	[illegible].710	[illegible].651
	× SC155	-0.104	-0.268	-3.395	-0.718	-0.054	0.036	0.356	-0.182	1.908	-1.302	-9.195	1.260
Sk-7008/3	× B-73	-0.700	3.273	2.757	0.744	-0.351	-0.031	-0.604	0.0312	-1.080	-1.349	-5.848	-1.828
	× Sk-6241/2-9	0.471	-9.421	-7.945	-0.942	-0.218	-0.046	0.747*	-0.515	-0.619	0.0260	-2.122	0.234
	× SC155	0.229	6.148	5.187	0.197	0.570	0.078	-0.143	0.484	1.700	1.323	7.971	1.594
Sk-7008/4	× B-73	0.591	-4.893	-4.783	-1.088	-0.393	-0.156	-0.145	-1.302	0.669	-1.682	-12.973*	12.922**
	×Sk-6241/2-9	0.013	2.911	3.638	1.348	-0.760*	-0.046	0.830**	-1.348	-1.869	-0.807	-6.747	-2.266
	× SC155	-0.604	1.981	1.145	-0.260	1.153**	0.203	-0.684*	2.651**	1.200	2.489**	19.721**	-10.656*
Sk-7008/5	× B-73	-0.117	-12.158	10.325*	-2.046	0.023	0.052	-0.312	0.197	-0.664	-1.807	-13.432*	14.089**
	× Sk-6241/2-9	-0.070	6.786	4.096	0.265	-0.343	0.036	0.039	-0.098	0.671	-0.557	0.669	-2.599
	× SC155	0.187	5.731	6.229	1.781	0.320	-0.088	0.273	-0.098	-0.007	2.365*	12.763*	-11.489*
Sk-7008/6	× B-73	-0.15	-1.559	-3.992	-1.130	0.315	0.135	-0.687*	-1.302	0.877	-1.099	-5.223	0.588
	× Sk-6241/2-9	-0.111	-5.005	0.054	0.182	-0.177	-0.005	0.789*	-0.348	-1.411	-0.849	-4.622	2.401
	× SC155	0.270	6.565	3.937	0.947	-0.138	-0.130	-0.101	1.651*	0.533	1.948*	9.840	-2.989
Sk-7008/7	× B-73	-0.283	0.731	0.091	-0.755	0.815*	0.010	0.104	2.072*	-0.747	-1.099	-2.682	-5.578
	× Sk-6241/2-9	-0.513	-1.463	-2.611	-1.067	-0.552	0.119	0.455	-0.723	0.588	0.0260	-2.705	1.734
	× SC155	-0.229	0.731	2.520	1.822	-0.263	-0.130	0.559	-1.348	0.158	1.073	5.388	3.844
LSD for S_{ij}	0.05	1.264	12.421	8.045	2.598	0.751	0.178	0.620	1.65	2.008	1.886	11.659	9.443
	0.01	1.663	16.35	10.59	3.420	0.988	0.234	0.816	2.172	2.643	2.483	15.348	12.496

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

Table 6: Genotypic variance (σ^2GCA and σ^2SCA) and their interactions by locations for the 11 studied traits over two locations and resistance to downy mildew disease in 2003 season.

Genotypic variance	Days to 50% silking	Plant height	Ear height	Ear position	Ear length	Ear diameter	No. of rows/ear	No. of kernels/row	100 kernels weight	Grain yield ard/fed	Grain yield/plant gm.	DMR%
σ^2 GCA	0.0815	8.814	9.754	1.653	-0.0723	-0.089	0.0022	1.2895	1.789	6.494	0.526	44.153
σ^2 SCA	-0.046	27.920	11.576	-0.042	0.02115	0.021	0.0013	0.1185	0.6158	0.1166	1.411	16.872
σ^2 GCA× Loc.	0.1815	23.660	11.431	0.720	0.2577	0.251	0.00559	0.1177	-0.158	0.3614	-0.007	-
σ^2 SCA × Loc.	-0.054	-37.183	-3.183	0.363	0.3485	0.349	0.003	0.1355	3.792	1.5624	2.678	-

ear position, No. of kernels/row, 100-kernel weight, grain yield ard/fed and DMR%. Similar results were observed by Ali and Tepora (1986); Mostafa *et al.*, (1995); El-Zeir *et al.*, (2000) and El-Shenawy (2003) for grain yield ard/fed; Mahmoud (1996) and Amer *et al.*, (2002) for days to 50% silking.

Resistance to downy mildew disease is controlled mainly by additive genetic effects (Kaneko and Aday, 1980; Orangel and Borges, 1987; Delean, 1994; Mahmoud, 2002 and El-Shenawy and Motawei, 2004). Meanwhile, σ^2SCA played an effective role in the expression of plant height, ear height , ear length, ear diameter and grain yield/plant. This result is in harmony with that obtained by Talleii and Kochaksaraei (1999); Ashish and Singh (2002) and Dodiya and Joshi (2002) for grain yield/plant, plant and ear height.

Additive genetic variance was more sensitive to environmental differences than non-additive type of gene action for days to 50% silking, plant height, ear height , ear position and rows/ear traits. This result is in agreement with that obtained by Shehata (1992); Soliman *et al.*, (1995) and El-Zeir (1999) for silking date, plant height and ear height and Amer *et al.*, (2002) for rows/ear trait. On the other hand, the magnitude of the interaction of σ^2SCA by locations was markedly higher than those σ^2GCA×Loc. in the inheritance of ear length, ear diameter, kernels/row, 100-grain weight, grain yield ard/fed and grain yield/plant, indicating that non-additive genetic variance of these traits is more affected by environmental conditions than additive genetic variance. The same results were obtained by Rajas and Sprague (1952); Nawar and El-Hosary (1984); Sedhom (1992) and Mosa (2001) for grain yield ; Matzinger *et al.*, (1959); El-Zeir *et al.*, (2000) and Mosa (2001) for ear length and Amer *et al.*, (2003) for ear diameter.

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الملخص العربي

قوة الهجين والقدرة على التآلف لمحصول الحبوب ومقاومة مرض البياض الزغبى في بعض سلالات الذرة الصفراء الجديدة

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هجنت ١٦ سلالة صفراء جديدة متباعدة وراثياً قميا مع اثنان من الكشافات ذات القاعدة الو راثية الضيقة وكشاف ذو قاعدة وراثية واسعة للحصول على ٤٨ هجين قمى . تم تقييم هذه الهجن القمية مع اثنان من هجن المقارنة التجارية في محطتي بحوث سخا والنوبارية في موسم ٢٠٠٣ وذلك لقياس القدرة على التآلف وقوة الهجين للمحصول ومكوناته بالاضافه إلى مقاومة مرض البياض الزغبى وكانت أهم النتائج ما يلي :-

- كان التباين الوراثى المضيف أكثر أهمية عن التباين الوراثى الغير مضيف في وراثة صفات ظهور ٥٠% حريرة، موقع الكوز ، عدد الحبوب بالسطر ، وزن ١٠٠ حبه ، محصول الحبوب بالأردب / فدان ومقاومة مرض البياض الزغبى. بينما لعب التباين الوراثى الغير مضيف دوراً مؤثراً في وراثة صفات ارتفاع النبات ، ارتفاع الكوز ، طول الكوز ، قطر الكوز ، محصول الحبوب / النبات.
- كان تفاعل التباين الوراثى الغير مضيف أعلى في تأثره بالمواقع عن التباين الوراثى المضيف لصفات طول الكوز، قطر الكوز ، عدد

الحبـــوب بالســـطر ، وزن ١٠٠ حبـــه ، ومحصـــول الحبـــوب بالأردب / فدان ، ومحصول الحبوب / النبات . بينما كـــان التبـــاين الوراثى المضيف أكثر حساسية بالمواقع عن التباين الـــوراثى الغيـــر مضيف لصفات ظهوره ٥٠% حريرة ، ارتفاع النبات ، ارتفاع الكوز ، موقع الكوز ، وعدد السطور بالكوز.

- أظهرت السلالتان سخا - ٧٠٠٨ /٧ وسخا - ١٢/٧٠٠٨ قدرة تـــآلف جيدة لصفات محصـــول الحبـــوب بـــالأردب / فـــدان ، محصـــول الحبوب/ النبات ومقاومة مرض البياض الزغبى. وقد وجدت الســـلالة سخا - ١٠ ذات قدرة تآلف مرغوبة لصفات التبكير ، موقع الكـــوز ، صفتي محصول الحبوب والصفات المرتبطة به.
- وجدت ٩ سلالات جيده في توريث الآليلات المرغوبة لمرض البياض الزغبى في النسل الناتج منها ، وقد كانت القاعدة الو راثيـــة الضـــيقة أكثر فعالية وتأثيراً عن القاعدة الو راثية الواسعة فـــي تقيـــيم معظـــم الصفات المدروسة.
- أظهرت ستة هجن قمية هي سخا - ١٠ × هـ.ف ١٥٥ (٢٧,١٦%) ، سخا - ١٢/٧٠٠٨ × هـــ. ف ١٥٥ (١٩,٤٦%) ، سخا - ٧/٧٠٠٨ × ب-٧٣ (١٧,٨٩%) ، ســـــخا - ٣ × هـ.ف ١٥٥ (١٧,٤٨%) ، وسخا ١/٧٠٠١ × هـــ.ف ١٥٥ (١١,٦٢%) ، وسخا - ٢/٧٠٠٢ × هـــ.ف ١٥٥ (١١,٥٤%) تأثيرات موجبه ومعنوية لقوة الهجين مقارنة بهجين المقارنة لصفتي محصول الحبوب ومقاومة مـــرض البيـــاض الزغبى مما يشير على أهمية هذه الهجين الصفراء كواد وراثية مثمرة للقدرة المحصولية العالية مع مقاومة مرض البيـــاض الزغبـــى فـــي البرامج المستقبلية لتربية الذرة الشامية.