Australian Journal of Crop Science
3(3):146-154 (2009)
ISSN: 1835-2707

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Heterosis in yellow maize

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Abstract

Ten new yellow maize inbred lines were top crossed to three testers i.e. Gm. 1021, S.C. 52 and Comp 21 at Gemmeiza in 2005 season. Thirty top crosses plus three checks were evaluated at Gemmeiza and Sids Agricultural Research Section, Egypt in 2006 season. Significant differences were noticed between the two locations for all the studied traits except resistance to late wilt disease. Mean squares due to crosses and their partitioning lines and testers were highly significant except 50% silking at Gemmeiza ,while lines x testers interaction were significant for plant height , ear height, resistant to late wilt disease and grain yield under two location and their combined ,while, it was significant for Gemmeiza of days to 50 % silking. At least nineteen crosses surpassed from the three checks (S.C.155, TWC. 352 and Gm.Y.Pop.) in yield potentiality. The highest mean performance were detected in the cross Gm. 3 x Gm. 1021 (15.090t/ha) followed by the cross Gm.1 x Gm. 1021 (14.640t/ha) and the cross Gm. 8 x Gm. 1021(13.731t/ha), respectively. These crosses are favorable and could be used in maize breeding programs.

Introduction

Heterosis is the phenomenon in which the cross of two checks produces hybrid that is superior in growth, size yield, or vigor of the F_1 over the better parent. The term is a contraction of stimulus of heterozygosis vigor yield and most characters of economic importance in corn are quantitative in nature and controlled by large number of genes the true heterosis differed from pseudoheterosis.In case of heterosis, there is an increase in general vigor, yield and adaptation .In case of pseudoheterosis, the F1hybrid exhibits increase in vegetative growth. It refers to the superiority of F1 over the standard commercial check variety. So, it is also called economic heterosis or superiority over checks. However, the commercial usefulness of a hybrid would primarily depend on its performance in comparison to the best commercial variety of the concerned crop species. The top crosses test with abroad and narrow base testers is the most common procedure for the evaluating process. Jenkins (1935) and Sprague (1939) suggested the method of early testing which greatly is affected by nature and number of tester needed for efficient evaluation of inbred lines of maize. Rawling and Thompson (1962) and Hallauer (1975) stated that appropriate tester should include simplicity in use, provide information that correctly classifies the relative importance of lines and maximize genetic gain. The choice of suitable tester is important to information for evaluating inbred lines. Uhr and Goodman (1995) used a public U S single cross to compare the performance of test crosses with 190 lines derived from seven tropical commercial hybrids. They found that 17 out of all the crosses yielded more than the tester. Many of the lines would combine well to produce hybrids adapted with the temperature climate.

Table 1. Mean squares of analysis of variance for the studied traits under two different locations and their combined.

S.O.V.	d.f.	50 % Silking			Plant height		
		Gm.	Sids	Comb	Gm.	Sids	Comb
Location	1	---	---	3518.51**	---	---	79994.363**
Reps/Loc.	6	---	---	22.087**	---	---	63.252
Crosses	29	7.085**	7.334**	10.789**	292.503**	813.536**	1140.903**
Lines	9	17.163**	13.001**	27.353**	702.990**	1340.190	1661.289**
Testers	2	2.158	12.100*	11.254**	2131.675**	4164.658**	6118.504**
L x T	18	2.594**	3.970	2.444	366.240**	177.862**	327.643**
Crosses x Loc.	29	---	---	3.63**	---	---	265.135**
P.vs.cr. x Loc.	1	---	---	40.98**	---	---	13407.705**
L x Loc.	9	---	---	2.79	---	---	381.890**
T x Loc.	2	---	---	3.01	---	---	177.829*
L x T x Loc.	18	---	---	4.12**	---	---	216.458**
Error	252	0.74	2.79	1.76	33.418	44.292	38.855
C.V. %		1.50	2.64	2.20	2.16	2.83	2.48
S.O.V	d.f.	Ear height			Resistance to late wilt		
		Gm.	Sids	Comb	Gm.	Sids	Comb
Location	1	---	---	4969.678**	---	---	3.197
Reps/Loc.	6	---	---	48.064	---	---	0.686
Crosses	29	290.010**	449.954**	558.293**	9.183**	5.570**	18.116**
Lines	9	277.922**	342.033**	357.406**	14.700**	6.708**	7.004**
Testers	2	1780.225**	2175.658**	3926.617**	6.700**	6.358*	5.671*
L x T	18	130.475**	312.168**	284.878**	6.700**	4.914**	2.752**
Crosses x Loc.	29	---	---	181.671**	---	---	4.592**
L x Loc.	9	---	---	262.553**	---	---	1.565
T x Loc.	2	---	---	29.267	---	---	6.054**
L x T x Loc.	18	---	---	158.164**	---	---	5.943**
Error	252	28.845	42.055	35.45	0.696	1.856	1.276
C.V. %		3.77	4.95	4.36	0.84	1.37	1.14

S.O.V.	d.f.	Grain yield (t/ha)		
		Gm.	Sids	Comb
Location	1	---	---	9456.032**
Reps/Loc.	6	---	---	19.823
Crosses	29	72.943**	230.295**	190.176**
Lines	9	44.742**	200.823**	179.113**
Testers	2	105.758**	761.158**	436.200**
L x T	18	83.397**	185.723**	168.371**
Crosses x Loc.	29	---	---	112.861**
L x Loc.	9	---	---	66.45**
T x Loc.	2	---	---	430.717**
L x T x Loc.	18	---	---	100.749**
Error	252	6.291	14.560	10.425
C.V.%		10.85	14.56	11.54

Many investigators reported that genetic variance among test cross progenies using inbred testers was about twice as large as when broad base testers were used (Darrah *et al.,*1972 and Horner *et al.* ,1973). Amer *ET. al.* (1998) found that heterosis as percentage from mid-parent were 259.8 ,40.6, 48.8,27.7 ,12.2, 59.1, -8.7, 55.5 ,and 61.2 for grain yield ,weight of 100 kernels , ear length ,ear diameter ,number of row / ear , number of kernels /row ,silking date , plant height and ear height , respectively. El-Zeir (1999) found that the highest heterotic values in plant height relative to mid parent for number of ears were obtained from the crosses Sd.63 x Sk.132 and Sk.132 x Sk.5073/1-2, respectively. The highest value of mid parent heterosis for number of ears/100 plants was 68.4% in the cross Sd.58 x Sk.170. However, the mid-parent heterosis for grain yield was greater in magnitude than that for the other traits. Recently Barakat and Ibrahim (2006) found seventeen crosses surpassed from the three checks SC155, SC3080 andS.C.3084 in yield potentially. Ibrahim *et al.* (2007) found that the relative increasing percentage of grain yield for the top crosses with inbred line Gm.1021 as tester , ranged from -35.9% to 2.2% and from percentage values of the relative increasing for the top crosses with inbred line Gm.1021 as tester were attained from the two crosses (Gm.385 x Gm.1021) and (Gm.382 x Gm.1021) .The relative increasing percentage of grain yield for the top crosses with inbred line Gm.1002 as tester ranged from -57% to 0.3% and from -53.7% to 9.1% relative to S.C.3084 and S.C.155, respectively. The highest percentages values of the relative increasing for the top crosses with inbred line Gm.1002 as tester were obtained from two crosses (Gm.387 x Gm.1002) and Gm.385x Gm.1002 .Singh *et al.*(2002) crossed eight diverse inbreds in half diallel to estimate heterosis based on the per se performance , heterosis , P1XP7 was the best hybrid, yielding 14.30% more grain yield per plant followed by P4XP7 yielded 13.07% over the superior control CM-400XCM-300 .The main objectives of this study were aimed to estimate heterosis percentage of all premeditated characters relative to Gm.Y.Pop inbred line and S.C.155 and T.W.C.352 as marketable checks

Materials and methods

Ten new yellow maize inbred lines, namely Gm. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 were used in this study. These inbred lines were developed at Gemmeiza Agricultural Research Station Gharbia district, Egypt. The inbred lines 1021, S.C.52 and Comp 21 were used as the testers to give 30 top crosses during the summer season, 2005. The 30 top crosses and three checks S.C.155,T.W.C.352 and Gm.Y.Pop where evaluated under two different locations i.e.Gemmeiza and Sids Agricultural Stations, Egypt during summer season ,2006.A Randomized Complete Block Design (RCBD) was used with four replications for the two locations. The plot size was 6 m long one row 80cm apart with 25cm in-between hills. One row from both thirty top crosses and the three checks were planted in the same plots. Before sowing trail received 70 kg p2O5 and 60 kg k_2O/ha. Nitrogen fertilizer was applied at the rate of 220kg N/ha in two equal doses before first and second irrigation. Number of days to 50 % silking was estimated over all plants per plot. During vegetative growth, data were collected for all crosses using five competitive plants in each plot to study plant height (cm) and ear height (cm). Resistance to late wilt calculated as percentage of wilted plants per plot which showing the symptoms of late-wilt disease at the age of 35 days after 50% silking. The scale of resistance clarifies that over 90%genotypes considered resistant. Grain yield (15.5% moisture content) was estimated in kg/plot and adjusted to ton/ha. All statistical analysis was carried out using analysis of variance technique (ANOVA) by means of "MSTAT–C" computer software package (Freed *et.al*, 1989). Useful heterosis could be measured as follows: Useful heterosis – [(F1- CC/CC] x 100 Where CC is the mean value over replications of the total commercial cultivars. Sometimes, heterosis is worked out over the standard commercial hybrid. Also, it could be measured as follows: Useful heterosis – [(F1 – SH)/SH] x100 Where, SH is the mean value over replications of the local commercial hybrid (Merdith and Bridge, 1972).

Results and discussion

Analysis of variance

The analysis of variance for separate of both locations i.e. Gemmeiza and Sids and their combined analysis occupied 30 top crosses which resulted from 10 inbred lines x 3 testers are presented in Table 1.Location mean squares for all studied traits were highly significant except resistance to late wilt disease. These results would point to that the genotypes were affected by locations .These results are in the same trend with what obtained by El-Zeir (1999), and Barakt and Ibrahim (2006).

Highly significant mean squares due to the crosses were detected for all studied traits for separate location and their combination. These results are at the same trend which was obtained by Shehata *et al.*

Table 2. Mean performance of 30 top crosses yellow under two different locations and their combined

Genotypes	50% Silk days			Plant height (cm.)			Ear height (cm.)		
	Gm.	Sids	Gm.	Gm.	Sids	Comb	Gm.	Sids	Comb
Gm. 1 x Gm.1021	54.0	59.5	56.8	313.0	262.8	287.6	156.6	143.8	150.1
Gm. 2 x Gm.1021	56.5	62.5	59.5	285.0	268.0	267.5	153.3	153.8	153.5
Gm. 3 x Gm.1021	56.0	61.3	58.6	298.8	260.3	297.5	168.3	145.0	156.6
Gm. 4 x Gm.1021	55.8	60.3	58.0	303.3	275.0	289.1	166.3	157.0	161.6
Gm. 5 x Gm.1021	54.0	60.3	57.1	293.3	250.8	272.0	160.3	149.3	154.8
Gm. 6 x Gm.1021	57.3	61.6	59.5	300.5	257.3	278.9	169.8	154.0	161.9
Gm. 7 x Gm.1021	57.3	61.3	59.2	291.0	253.0	272.0	161.8	149.8	155.8
Gm. 8 x Gm.1021	55.3	61.8	58.5	322.3	290.5	306.4	163.3	155.8	159.5
Gm. 9 x Gm.1021	54.8	61.0	57.9	305.3	254.0	279.6	155.8	147.5	151.6
Gm. 10 x Gm.1021	54.3	59.8	57.0	285.3	255.5	270.4	146.8	141.0	143.9
Gm. 1 x S.C.52	55.5	61.5	58.5	291.8	250.5	271.1	146.8	133.8	140.3
Gm. 2 x S.C.52	56.0	64.8	60.4	311.8	363.0	287.4	147.0	133.8	140.4
Gm. 3 x S.C.52	56.8	62.3	59.5	296.0	236.8	266.4	146.0	120.8	133.4
Gm. 4 x S.C.52	54.3	62.3	58.3	298.5	257.8	278.1	157.3	150.8	154.0
Gm. 5 x S.C.52	54.0	61.0	57.5	275.5	239.8	257.6	148.5	127.8	138.1
Gm. 6 x S.C.52	57.0	61.5	59.1	283.3	231.0	257.1	151.0	131.0	141.0
Gm. 7 x S.C.52	57.8	63.0	60.4	294.5	250.3	272.4	158.3	141.8	150.0
Gm. 8 x S.C.52	56.0	60.5	58.3	292.0	263.8	277.9	147.0	146.5	146.8
Gm. 9 x S.C.52	56.5	62.3	59.4	296.3	250.3	273.3	134.0	137.5	135.8
Gm. 10 x S.C.52	55.0	61.3	58.1	264.0	240.3	252.1	140.3	142.5	141.4
Gm. 1 x Comp. 21	54.5	59.5	57.0	293.3	238.3	265.6	151.3	129.0	140.1
Gm. 2 x Comp. 21	57.8	61.8	59.8	280.8	249.0	264.9	141.8	140.5	141.1
Gm. 3 x Comp. 21	58.3	61.0	59.6	278.0	248.3	267.6	150.5	158.5	154.5
Gm. 4 x Comp. 21	55.0	61.5	58.3	286.5	248.5	267.5	148.8	144.0	146.1
Gm. 5 x Comp. 21	55.8	60.5	58.1	279.0	219.8	249.4	142.5	118.0	130.3
Gm. 6 x Comp. 21	57.0	62.0	59.5	281.0	239.0	260.0	150.0	128.5	139.3
Gm. 7 x Comp. 21	57.8	65.3	61.5	297.3	231.0	264.1	159.5	129.5	144.5
Gm. 8 x Comp. 21	54.3	62.5	58.4	290.0	264.8	277.4	152.0	136.5	144.3
Gm. 9 x Comp. 21	54.8	61.5	58.1	280.0	249.0	264.8	157.3	145.0	151.1
Gm. 10 x Comp. 21	54.3	59.3	56.8	279.0	241.0	260.0	147.3	142.8	145.0
L.S.D. 0.05	1.2	2.3	1.3	8.0	9.2	6.1	7.4	9.0	5.8
0.01	1.6	3.0	1.7	10.5	12.1	8.0	9.8	11.8	7.7
Checks S.C. 155	56.5	62.5	59.5	305.6	260.0	282.9	158.3	152.0	155.1
T.W.C 352	55.8	64.5	60.0	309.0	256.3	282.6	158.8	147.0	152.9
Gm.Y.Pop	58.5	64.0	61.3	299.3	261.3	280.3	153.8	151.3	152.5

(1997) and Barakt and Ibrahim (2006). Lines mean squares were highly significant for all traits under the two locations of Gemmeiza, and SIDS and their combined. Mean squares due to testers were highly significant for plant height, ear height, and resistance to late wilt disease at Gemmeiza and grain yield and significant for days to 50% silking at SIDS, resistance to late wilt disease at SIDS and combined, and not significant for days to 50% silking at Gemmeiza. These results are at the same trend with results was obtained by Barakt and Ibrahim (2006). Considering the interaction lines x tester's significant and highly significant differences were obtained for all studied traits except for days to 50 % silking at Sides Respecting the interaction effect for crosses x locations highly significant mean squares were found for days to 50 % silking, plant height, and ear height, resistance of late wilt and grain yield meaning that crosses behaved differently at the two different locations. Regarding the interaction effect for lines x locations, the traits of plant height, ear height, and grain yield were significantly affected of mean squares. Pertaining to the interaction between tester x locations for the traits plant height, resistance to late

Table 2. Continue

Genotypes		Resistance of late wilt (%)			Grain yield (t/ha)		
		Gm.	Sids	Comb.	Sids	Gm.	Comb
Gm. 1 x Gm.1021		100.00	100.00	100.00	12.345	16.953	14.650
Gm. 2 x Gm.1021		100.00	100.00	100.00	6.840	9.292	8.066
Gm. 3 x Gm.1021		100.00	98.80	99.40	12.268	17.916	15.090
Gm. 4 x Gm.1021		100.00	100.00	100.00	11.988	13.467	12.728
Gm. 5 x Gm.1021		100.00	100.00	100.00	9.372	17.223	13.298
Gm. 6 x Gm.1021		100.00	100.00	100.00	8.469	16.293	12.381
Gm. 7 x Gm.1021		100.00	100.00	100.00	9.446	14.487	11.991
Gm. 8 x Gm.1021		100.00	100.00	100.00	9.752	17.649	13.731
Gm. 9 x Gm.1021		100.00	100.00	100.00	7.783	10.579	9.179
Gm. 10 x Gm.1021		100.00	100.00	100.00	9.143	14.750	11.945
Gm. 1 x S.C.52		100.00	97.925	98.96	7.417	15.876	11.645
Gm. 2 x S.C.52		100.00	100.00	100.00	10.039	14.807	12.421
Gm. 3 x S.C.52		100.00	98.88	99.44	8.246	14.537	11.392
Gm. 4 x S.C.52		100.00	100.00	100.00	8.499	14.950	11.725
Gm. 5 x S.C.52		97.50	93.88	95.69	7.800	13.224	12.061
Gm. 6 x S.C.52		100.00	100.00	100.00	7.450	12.405	9.926
Gm. 7 x S.C.52		100.00	100.00	100.00	7.883	13.501	10.692
Gm. 8 x S.C.52		100.00	100.00	100.00	8.683	14.300	11.492
Gm. 9 x S.C.52		100.00	100.00	100.00	8.463	15.820	12.141
Gm. 10 x S.C.52		100.00	100.00	100.00	9.429	11.905	10.665
Gm. 1 x Comp. 21		100.00	100.00	100.00	8.639	13.704	11.172
Gm. 2 x Comp. 21		100.00	98.750	99.38	8.769	10.739	9.752
Gm. 3 x Comp. 21		100.00	100.00	100.00	7.477	12.172	9.826
Gm. 4 x Comp. 21		100.00	98.88	99.44	10.762	14.737	12.748
Gm. 5 x Comp. 21		92.05	98.63	95.34	9.679	10.542	10.112
Gm. 6 x Comp. 21		100.00	100.00	100.00	8.799	10.052	9.426
Gm. 7 x Comp. 21		100.00	100.00	100.00	9.033	11.085	10.59
Gm. 8 x Comp. 21		100.00	100.00	100.00	10.345	13.081	11.715
Gm. 9 x Comp. 21		100.00	100.00	100.00	10.912	8.793	9.852
Gm. 10 x Comp. 21		100.00	100.00	100.00	9.972	7.517	12.901
L.S.D.	0.05	1.16	1.89	1.11	1.156	1.759	1.052
	0.01	1.52	2.48	1.45	1.516	2.309	1.379
Checks	S.C. 155	100.00	100.00	100.00	7.616	12.804	10.212
	T.W.C 352	100.00	100.00	100.00	7.750	13.734	10.745
	Gm. Y. Pop	100.00	100.00	100.00	7.230	12.348	9.789

wilt and grain yield exhibited different significant levels. The interaction mean squares for Lines x testers x locations were highly significant for all studied trails. These results are in agreement with those obtained by Ibrahim and Osman (2005).

Mean performance

The mean performance of all 30 top crosses for all studied at Gemmeiza, SIDS and their combined data are shown in Table 2. For grain yield (t/ha) trait, are shown in Table 2. Values mean performance of grain yield ranged form 6.780t/ha for the cross Gm. 2 x Gm.1021 to 12.345t/ha for the cross Gm. 1 x Gm.1021, while, 26 top crosses gave higher grain yield combined with that from the highest marketable hybrid T.W.C. 352 (7.750 t/ha) under in Gemmeiza environment. Values of mean performance of grain yield ranged from 8.793 t/ha for the cross Gm. 9 x Gm.1021 to 17.916 t/ha for the cross Gm. 3 x Gm.1021, while, 15 top crosses gave higher from the highest commercial hybrid T.W.C. 352 (13.734 t/ha) under SIDS location. Moreover, values of mean performance for grain yield from ranged (8.066 t/ha) for the cross Gm.2 x Gm.1021) to 15.090 t/ha for the cross (Gm. 3 x Gm.1021), while, 19 top crosses (Gm.1 x Gm.1021, Gm.3 x Gm.1021, Gm.4 x Gm.1021, Gm.5 x Gm.1021, Gm.6 x Gm.1021, Gm.7 x Gm.1021, Gm.8 x Gm.1021, Gm.10 x Gm.1021, Gm.1 x S.C. 52, Gm. 2 x S.C.52, Gm.3 x S.C. 52 ,

Table 3. Percentage of heterosis for top crosses relative to three checks combined data.

Crosses	50 % Silk of days related to			Plant height related to		
	S.C. 155	T.W.C. 352	Gm. Y. Pop	S.C. 155	T.W.C. 352	Gm. Y. Pop
Gm. 1 x Gm.1021	-4.62**	-5.41**	-7.34**	1.67	1.76	2.63*
Gm. 2 x Gm.1021	0.00	-0.83	-2.85**	-5.43**	-5.35**	-4.54**
Gm. 3 x Gm.1021	-1.46	-2.28*	-4.27**	5.16**	5.26**	6.15**
Gm. 4 x Gm.1021	-2.52*	-3.33**	-5.30**	2.20*	2.29*	3.16*
Gm. 5 x Gm.1021	-3.98**	-4.78**	-6.72**	-3.84*	-3.76*	-2.94*
Gm. 6 x Gm.1021	0.00	-0.83	-2.85**	-1.41	-1.32	-0.48
Gm. 7 x Gm.1021	-0.45	-1.28	-3.29**	-3.84*	-3.76*	-2.94**
Gm. 8 x Gm.1021	-1.68	-2.50*	-4.48**	8.30**	8.40**	9.32**
Gm. 9 x Gm.1021	-2.72*	-3.53*	-5.50**	-1.14	-1.06	-0.22
Gm. 10 x Gm.1021	-4.20**	-5.00**	-6.93**	-4.41**	4.33**	-3.52**
Gm. 1 x S.C. 52	-1.68	-2.50*	-4.48**	-4.15**	-4.03**	-3.25**
Gm. 2 x S.C. 52	1.47	0.63	-1.42	1.59	1.68	2.45*
Gm. 3 x S.C. 52	0.00	-0.83	-2.85**	-5.83**	-5.74**	-4.94**
Gm. 4 x S.C. 52	-2.10	-2.91*	-4.89**	-1.67	-1.59	-0.75
Gm. 5 x S.C. 52	-3.36**	-4.16**	-6.12**	-8.92**	-8.84**	-8.07**
Gm. 6 x S.C. 52	-0.062	-1.45	-3.46***	-9.10**	-9.02**	-8.24**
Gm. 7 x S.C. 52	1.47	0.63	-1.42	-3.711*	-3.62*	-2.80*
Gm. 8 x S.C. 52	-2.10	-2.91*	-4.89**	-1.76	-1.68	-0.84
Gm. 9 x S.C. 52	-0.20	-1.03	-3.03**	-3.40*	-3.31*	-2.49*
Gm. 10 x S.C. 52	-2.30*	-3.11**	-5.09**	-10.87**	-10.79**	-10.03**
Gm. 1 x Comp 21	-4.20**	-5.00**	-6.938**	-6.05**	-5.97**	-5.17**
Gm. 2 x Comp 21	0.42	-0.41	-2.44*	-6.36**	-6.28**	-5.48**
Gm. 3 x Comp 21	-0.21	-0.61	-2.64*	-5.39**	-5.30**	-4.50**
Gm. 4 x Comp 21	-2.10	-2.91**	-4.89**	-5.43**	-5.35**	-4.54**
Gm. 5 x Comp 21	-2.30*	-3.11**	-5.09**	-11.18**	-11.76**	-11.01**
Gm. 6 x Comp 21	0.00	-0.83	-2.85**	-8.08**	-8.00**	-7.22**
Gm. 7 x Comp 21	3.36**	2.50*	0.408	-6.62**	-6.54**	-5.75**
Gm. 8 x Comp 21	-1.88	-2.70*	-4.68**	-1.94**	-1.85	-1.02
Gm. 9 x Comp 21	-2.30*	-3.11**	-5.09**	-6.40**	-6.32**	-5.53**
Gm. 10 x Comp 21	-4.62**	-5.41**	-7.34**	-8.08	-8.00**	-7.22**
L.S.D. 0.05		1.3			6.1	
0.01		1.7			8.0	

Crosses	Ear height related to			Resistance to late wilt disease related to		
	S.C. 155	T.W.C. 352	Gm. Y. Pop	S.C. 155	T.W.C. 352	Gm. Y. Pop
Gm. 1 x Gm.1021	-3.22	-1.79	-1.55	0.00	0.00	0.00
Gm. 2 x Gm.1021	-1.05	0.40	0.65	0.00	0.00	0.00
Gm. 3 x Gm.1021	0.96	2.45	2.70	0.60	0.60	0.60
Gm. 4 x Gm.1021	4.19	5.72*	5.98**	0.00	0.00	0.00
Gm. 5 x Gm.1021	-0.24	1.22	1.47	0.00	0.00	0.00
Gm. 6 x Gm.1021	4.35*	5.88*	6.15*	0.00	0.00	0.00
Gm. 7 x Gm.1021	0.39	1.87	2.13	0.00	0.00	0.00
Gm. 8 x Gm.1021	2.81	4.33*	4.59*	0.00	0.00	0.00
Gm. 9 x Gm.1021	-2.25	-0.18	-0.57	0.00	0.00	0.00
Gm. 10 x Gm.1021	-7.25**	-5.88*	-5.65*	0.00	0.00	0.00
Gm. 1 x S.C. 52	-9.59**	-8.26**	-8.03**	-1.04	-1.04	-1.04
Gm. 2 x S.C. 52	-9.50**	-8.17**	-7.94**	0.00	0.00	0.00
Gm. 3 x S.C. 52	-14.02**	-12.75**	-12.53**	-0.57	-0.57	-0.57
Gm. 4 x S.C. 52	-0.72	0.73	0.98	0.00	0.00	0.00
Gm. 5 x S.C. 52	-10.95**	-9.64**	-9.42**	-4.32**	-4.32**	-4.32**
Gm. 6 x S.C. 52	-9.10**	-7.77**	-7.54**	0.00	0.00	0.00
Gm. 7 x S.C. 52	-3.30	-1.88	-1.63	0.00	0.00	0.00
Gm. 8 x S.C. 52	-5.40*	-4.00*	-3.77	0.00	0.00	0.00

Table 3. Continue

Gm. 9 x S.C. 52	-12.49**	-11.20**	-10.98**	0.00	0.00	0.00
Gm. 10 x S.C. 52	-8.86**	-7.52**	-7.29**	0.00	0.00	0.00
Gm. 1 x Comp 21	-9.66**	-8.33**	-8.11**	0.00	0.00	0.00
Gm. 2 x Comp 21	-9.02**	-8.33**	-7.45**	0.63	0.63	0.63
Gm. 3 x Comp 21	-0.40	1.05	1.31	0.00	0.00	0.00
Gm. 4 x Comp 21	-5.80*	-4.41*	-4.17*	-0.57	-0.57	-0.57
Gm. 5 x Comp 21	-16.03**	-14.80**	-14.59**	0.00	0.00	0.00
Gm. 6 x Comp 21	-10.23**	-8.91**	-8.68**	0.00	0.00	0.00
Gm. 7 x Comp 21	-6.85*	-5.48*	-5.24**	0.00	0.00	0.00
Gm. 8 x Comp 21	-7.01**	-5.64*	-5.40**	0.00	0.00	0.00
Gm. 9 x Comp 21	-2.57	-1.14	-0.89	0.00	0.00	0.00
Gm. 10 x Comp 21	-6.53*	-5.15*	-4.91*	0.00	0.00	0.00
L.S.D. 0.05		5.80			1.11	
0.01		7.70			1.45	

Gm.4 x S.C. 52 , Gm.5 x S.C. 52, Gm.8 x S.C. 52, Gm.9 x S.C. 52, Gm.1 x Comp21, Gm.4 x Comp21, Gm.8 x Comp 21and Gm.10 x Comp21) under combined data surpassed from the check T.W.C. 352 10.742 t/ha for grain yield trait.

3- Percentage of heterosis for top crosses relative to checks.

The relative increasing percentage for the top crosses relative the three checks (S.C155, T.W.C.352 and Gm.Y.Pop.) for studied traits under this stagy relative to combined data are presented in Table 3. For days to 50% Silking, 12 top crosses (Gm.1 x Gm. 1021, Gm.3 x Gm. 1021, Gm.5 x Gm. 1021, Gm.9 x Gm. 1021, Gm.10 x Gm. 1021, Gm.5 x S.C.52, Gm.10 x S.C.52, Gm.1 x Comp.21, Gm.5 x Comp.21, Gm.7 x Comp.21 , Gm.9 x Comp.21 and Gm.10 x Comp.21 exhibited significant and superiority effects relative to the earliest check S.C. 155, while 11 top crosses showed significantly superior relative to the check T.W.C. 352 and 27 top crosses exhibited significant superiority effects which the earliest check Gm .Y.Pop. the parented lines Gm.1, Gm.5 and Gm.10 contributed positively for the crosses which are involved herein. In view of plant height, 16 top crosses exhibited highly significant superiority effects relative to the best check (Gm.Y.Pop) for this trait. The tester Comp 21 was of with inbred lines Gm. 2, Gm. 5, Gm. 7 and Gm. 10 gave the best top crosses for this trait. Regarding ear height, the top crosses Gm.10 x Gm. 1021, Gm.1 x S.C.52, Gm. 2 x S.C 52, Gm. 3 x S.C 52, Gm. 1 xComp21, Gm. 2 x Comp21, Gm. 4 x Comp 21, Gm. 5 x Comp 21, Gm. 6 x Comp21, Gm.7 x Comp 21, Gm.8 x Comp 21and Gm.10 x Comp 21 showed negative and highly significant relative to the check S.C.155.14 and 12 top crosses exhibited superiority relative to the checks T.W.C 352 and Gm.Y.Pop, respectively. The top cross Gm 5 x Comp21 gave heights superiority effects towards ear low position.

For the resistant to late wilt disease, there were no crosses superior relative to the checks but all crosses remained resistance. This may be due to that all parental lines were derived from Gm.Y.Pop, which was adapted under the Egyptian environment, conditions also for the resistance to late wilt disease. The relative increasing percentage for the top crosses for the three checks (S.C.155, T.W.C 352 and Gm.Y.Pop) for grain yield relative to combined data are presented in Table 3. For the top crosses with inbred line Gm1021 as tester, relative increasing ranged from -21.01% to 47.67%, from -24.90% to 40.47 % and from -17.59% to 54.15% relative to S.C155, T.W.C 352 and Gm.Y.Pop, respectively. Out of the ten crosses under study seven crosses were exhibited significant superiority effects relative to the three checks (S.C.155, T.W.C. 352 and (Gm.Y.Pop.), Increasing percentage of grain yield (t/ha) for the seven crosses (Gm.1 x Gm.1021, Gm.3 x Gm.1021, Gm.4 x Gm.1021,Gm.5x Gm.1021, Gm. 6 x Gm. 1021, Gm. 8 x Gm. 1021 and Gm.10 x Gm.1021) relative to the three checks S.C.155, T.W.C. 352 and Gm.Y.Pop ranged from 16.76% to 11.19% ,from 11.19 to 40.47 and from 22.02 to 54.15%, respectively. For the top crosses with S.C. 52 as a tester, relative increasing ranged from -2.80 % to 21.36%, from -7.59% to 15.63% and from 1.39 % to 23.21% relative to S.C 155, T.W.C 352 and Gm. Y pop, respectively. Out of the ten crosses under study three crosses were exhibited significant superiority effects for the three checks (S.C 155, T.W.C. 352 and Gm.Y.Pop.). Increasing percentage of grain yield (t/ha) for the three crosses (Gm.2 x S.C. 52, Gm.5 x S.C. 52 and Gm.9 x S.C. 52) relative to three check S.C. 155, T.W.C.352 and Gm. Y. Pop. Ranged from

Table 3. Continue

Crosses	Grain yield (t/ha) related to		
	S.C. 155	T.W.C. 352	Gm. Y. Pop
Gm. 1 x Gm.1021	43.45**	36.38**	49.65**
Gm. 2 x Gm.1021	-21.01**	-24.90**	-17.59**
Gm. 3 x Gm.1021	47.76**	40.47**	54.15**
Gm. 4 x Gm.1021	24.63**	18.48**	30.02**
Gm. 5 x Gm.1021	30.21**	23.79**	35.84**
Gm. 6 x Gm.1021	21.23**	15.26**	26.48**
Gm. 7 x Gm.1021	17.42**	11.63*	22.49**
Gm. 8 x Gm.1021	34.15**	27.54**	39.95**
Gm. 9 x Gm.1021	10.11*-	-1.45	-6.22
Gm. 10 x Gm.1021	16.96*	11.19*	22.02**
Gm. 1 x S.C. 52	14.02**	8.40	18.95**
Gm. 2 x S.C. 52	21.63**	15.63**	26.88**
Gm. 3 x S.C. 52	11.54*	6.04	16.37**
Gm. 4 x S.C. 52	14.81**	9.15	19.77**
Gm. 5 x S.C. 52	18.10**	12.28*	23.21**
Gm. 6 x S.C. 52	-2.80	-7.59	1.39
Gm. 7 x S.C. 52	4.69	-0.46	9.22
Gm. 8 x S.C. 52	12.52*	6.97	17.39**
Gm. 9 x S.C. 52	18.89**	13.02**	24.02**
Gm. 10 x S.C. 52	4.43	-0.71	8.95
Gm. 1 x Comp 21	9.39	4.00	14.12**
Gm. 2 x Comp 21	-4.50	-9.21	-0.37
Gm. 3 x Comp 21	-3.78	-8.52	0.37
Gm. 4 x Comp 21	24.82**	18.67**	30.22**
Gm. 5 x Comp 21	-0.97	-5.86	3.30
Gm. 6 x Comp 21	-7.69	-12.25*	-3.17
Gm. 7 x Comp 21	-1.50	-6.35	2.75
Gm. 8 x Comp 21	14.71**	9.21	19.67**
Gm. 9 x Comp 21	-3.52	-8.28	0.64
Gm. 10 x Comp 21	26.32**	20.09**	31.79**
L.S.D. 0.05		3.16	
0.01		4.14	

18.10 - 21.63 %, from 12.28 -15.63 % and from 23.21 - 26.88 %, respectively. For the top crosses with Comp.21 as tester, relative in creasing ranged from -7.69 % to 26.32 %, from -12.25 % to 20.09 % and from -3.17 % to 31.79 % relative to S.C. 155, T.W.C 352 and Gm.Y.Pop., respectively .Out of the ten crosses under study two crosses exhibited significant superiority effects of the three checks (S.C 155, T.W.C. 352 and Gm.Y.Pop.). Rising percentage of grain yield (t/ha) for the two crosses (Gm. 4 x Comp. 21 and Gm. 10 x Comp. 21) relative to the three checks S.C 155, T.W.C.352 and Gm.Y.Pop, ranged from 24.82 %, to 26.32% ,from 18.67% to 20.09% and from 30.22% to 31.79%, respectively. Five top crosses (Gm.1 x S.C. 52, Gm.3 x S.C.52, Gm.4 x S.C.52, Gm.8 x S.C.52 and Gm.8 x Comp.21) and six top crosses (Gm.1 x S.C.52, Gm.3 x S.C.52, Gm.4 x S.C.52, Gm.8 x S.C.52, Gm.1 x Comp.21 and Gm.8 x Comp.21) exhibited significant advantage effects for the check S.C. 155 and Gm.Y.Pop, respectively.

Conclusion

It can be concluded that nineteen crosses surpass three checks (S.C.155, TWC. 352 and Gm.Y.Pop.) in yield potential. The highest mean performance were detected in the cross Gm. 3 x Gm. 1021 (15.090t/ha) followed by the cross Gm.1 x Gm.1021 (14.640t/ha) and the cross Gm. 8 x Gm. 1021(13.731t/ha), respectively. These crosses are constructive and may possibly be use in maize breeding programs.

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