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EVALUATION OF SOME YELLOW MAIZE TOP CROSSES UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

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ABSTRACT

The objectives of this study were to evaluate some untested inbred lines of yellow maize for combining ability using various types of testers under different environmental conditions. Ten yellow maize inbreds in S_4 generation derived from population Giza-45 (Pop-45) were top crossed to each of five testers. These testers included two broad genetic base (Pop-45 and Comp-21), one medium genetic-base (SC-10) and two inbred lines (Gm-1004 and Gm-1021). The resultant 50 top crosses were evaluated along with two checks (SC-155 and Pop 45) at Sakha, Nubaria, and Sids Agric. Res. Stations of ARC during 2001 season.

Locations significantly affected all studied traits except silking date. Significant variances were detected due to crosses, females and males. The behavior of lines differed according to testers. Differential performances of all sets of genotypes were detected under various environmental conditions. Lines contributed more than testers to the total genetic variance.

Differences among different sets of crosses under various locations were narrow for silking dates. The plants of all sets of crosses under Sids conditions were taller than under Sakha and Nubaria. Most crosses were significantly possessed shorter plants than SC-155 especially under Sakha and Sids and vice versa comparing to Pop.45. Thirty five crosses outyielded SC-155 in Nubaria compared to 0 and 2 ones in Sakha and Sids, respectively. However, all crosses significantly outyielded Pop.45 under all locations.

Variable general combining ability effects among both lines and testers concerning significance, sings and magnitudes for different traits were detected. Medium and narrow genetic base testers were better than broad genetic ones for improving test crosses performance. Moreover, unrelated testers were more efficient for improving hybrid performance.

The additive type of gene actions played the major role in the inheritance of plant height in all locations and combined over locations. In contrast, non-additive gene action was found to be more important in the inheritance of silking date, ear height and grain yield. The detected effects of environmental conditions on top cross performance should be considered in yellow maize hybrid programs.

Key words: *Zea mays, Line x testers, Combining ability, Heterosis*

INTRODUCTION

High yielding hybrids of yellow maize depends on the developing and identification of superior inbred lines with high general and specific combining ability.

The choice of suitable tester for characterizing inbred lines for combining ability is an essential step in test cross method. Choosing testers with high or low frequency of favorable alleles, broad or narrow genetic base depends on the recommended objectives. Matzinger (1953) pointed out that when the objective is to determine specific combining ability (SCA), the most appropriate tester would be narrow genetic base but if the lines are tested for general combining ability (GCA), the use of broad genetic base tester would be more efficient.

Many authors reported that the 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, Horner *et al* 1973 and Walejko and Russell 1977).

Narrow or medium genetic base testers can effectively be used to identify lines having good GCA (Attia 1992, Mahmoud 1996, AL-Naggar *et al*1997, Sultan 1998, Gado 2000). Zambezi *et al* (1986) preferred narrow than broad base testers due to sampling errors likely occurred with heterogeneous testers and inbred lines as a tester may permit quicker utilization of new lines in commercial hybrids. Also, Ameha (1977) found that the inbred testers were more effective in detecting the small differences in combining ability. Nawar and El-Hosary (1984) found that broad genetic base testers were more efficient than narrow genetic base ones.

Many workers detected the significance of both GCA and SCA, revealing the important role of both additive and non-additive components of genetic variance (El-Itriby 1979, Dubey *et al* 2001 and Sujiprihati *et al* 2001)

Significant estimates of GCA as compared to SCA effects for grain yield and days to 50% silking were detected by some authors (Zambezi *et al* 1986, Salama *et al* 1995, El-Zeir 1999 and Soliman *et al* 2001). Other scientists revealed the more important role of SCA as compared to GCA effects for grain yield and other traits (Sedhom 1994, Desai and Singh 2000 and Venugopal *et al* 2002)

The objectives of this study were to evaluate some of untested inbred lines of yellow maize for combining ability by various types of testers under different environmental conditions.

MATERIALS AND METHODS

Materials

Ten S_4 yellow maize lines derived from a wide genetic base population (Giza 45) were selected on the basis of matching in silking dates with used five testers. These testers represented different types of heterozygosity and genetic base. Two broad genetic base (Pop-45 and Comp-21), one medium genetic base (SC-10) and two narrow genetic base testers [Gemmeiza-1004 (Gem-1004) and Gemmeiza–1021 (Gem-1021)] were used.

Methods

In 2000 summer season at Sids the ten lines and the five testers were crossed according to line x tester. In the second season (2001) three yield trials were conducted at Sakha, Nubaria and Sids Experimental Stations of the Agricultural Research Center (ARC). In each trial the fifty top crosses and two checks i.e., single cross 155(SC-155) and population-45 (Pop-45) were sown in a randomized complete block design with four replications. Each experimental plot consisted of one ridge 6 m long and 80 cm apart. Grains were sown in hills distanced 25 cm. Thinning took place 21 days after sowing to one plant $hill^{-1}$.

Nitrogen fertilizer was applied at the rate of 120 kg N $feddan^{-1}$ in two equal doses before first and second irrigations. Moreover, the recommended agronomic practices for maize production were adopted.

In all the three trials, during vegetative growth, three traits were recorded i.e. days to 50% silking, plant height (cm) and ear height in cm. At maturity, ears from each plot were harvested to record grain yield kg $plot^{-1}$, which adjusted to 15.5 % grain moisture content.

Statistical analysis

Regular analysis of variance of RCBD was performed separately for obtained data in each location (Gomez and Gomez 1984). Barttlet test revealed the validity of combined analysis over the three locations for all studied traits. A factorial mating design II scheme was employed for studying genetic variance. The line x tester analysis was conducted according to Kempthorne (1957) to estimate general (GCA) and specific combining ability (SCA) of tested males and females. Various types of gene effects were calculated according to Cockerham (1956) as follows:

$\sigma^2_f = \frac{1}{4}\, \sigma^2_A$

$\sigma^2_m = ¼\, \sigma^2_A$

$\sigma^2_{mf} = ¼\, \sigma^2_D$

The weighted average of σ^2_f and σ^2_m was taken as estimate of σ^2_{gca} (Kaushik *et al* 1984).

The expected mean squares based on both parents and environments are shown in Table 1.

Table1. Combined analysis of variance for top crosses over three locations

Source of variation	Degrees of freedom	Expected mean squares
Locations (L)	L-1	
Reps/location	L(r-1)	
Crosses	(mf-1)	
Females (F)	(f-1)	$\sigma^2_e + r\sigma^2_{fml} + rm\sigma^2_{fl} + rl\sigma^2_{fm} + rml\sigma^2_f$
Males (M)	(m-1)	$\sigma^2_e + r\sigma^2_{fml} + rf\sigma^2_{ml} + rl\sigma^2_{fm} + rfl\sigma^2_m$
(M x F)	(f-1)x(m-1)	$\sigma^2_e + r\sigma^2_{fml} + rl\sigma^2_{fm}$
Crosses x locations	(mf-1)x(L-1)	
F x L	(f-1)x(L-1)	$\sigma^2_e + r\sigma^2_{fml} + rm\sigma^2_{fl}$
M x L	(L-1)x(m-1)	$\sigma^2_e + r\sigma^2_{fml} + rf\sigma^2_{ml}$
M x F x L	(f-1)x(m-1)x(L-1)	$\sigma^2_e + r\sigma^2_{fml}$
Pooled error	L(mf-1)x(r-1)	σ^2_e

RESULTS AND DISCUSSION

Analysis of variance

Combined analysis of variance over locations for studied traits is presented in Table 2. Highly significant variances were detected due to locations for all traits except silking date indicating great differences between locations effects. Moreover, highly significant mean squares of crosses were recorded revealing wide differences between tested crosses for all studied traits. Also, variances due to each of lines and testers were significant for all studied traits. However, except for grain yield, females exhibited higher magnitudes of variance than testers. With respect to the lines x testers interaction, highly significant mean squares were detected for all studied traits. This proved that the behavior of parental lines differed according to the type of parental testers. The interactions of different sets of genotypes with locations (crosses x L and components: F x L, M x L and M x F x L) were significant for grain yield regarding of all these interaction and for silking due to F x L. This demonstrated differential performances of lines, testers and crosses under various environmental conditions. These results were in agreement with those obtained by Salama *et al* (1995) and El-Zeir (1999).

Table 2. Combined analysis of variance of 50 top crosses over locations for different studied traits.

S.O.V	df	Mean square			
		Sliking date	Plant height	Ear height	Grain yield
Locations (L)	2	28.8	29478.632**	22661.7**	83.59**
Reps/location	9	17.6	2868.315	1411.3	12.35
Crosses	49	24.78**	1588.736**	930.8**	23.99**
Females (F)	9	70.84**	5446.756**	2172.3**	14.46**
Males (M)	4	20.1**	945.929**	2065.8**	184.39**
(M x F)	36	13.78**	695.653**	494.4**	14..55**
Crosses x locations	98	2.05	151.917	91.7	8.45**
F x L.	18	2.18	276.224**	99.17	6.45*
M x L	8	5.73	139.957	109.01	20.2**
M x F x L	72	1.62	122.17	87.9	7.64**
Pooled error	441	2.32	128.646	100.3	3.71
C.V%		2.6	5.05	7.9	7.11

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

Mean performance and heterosis

The performances of evaluated crosses of the ten inbred lines with different testers along to both checks under various locations for studied traits are presented in Table 3. The number of significantly surpassed (NSC) & inferior (NIC) crosses to each check was used as a measure of heterosis.

Differences among means of different sets of crosses under various environmental conditions were narrow for silking dates to detect obvious trend. However, the variations among crosses relative to both checks as NSC or NIC for silking dates reflected wider differences that varied from location to another. About 12, 4 and 6 % of the crosses silked earlier than SC-155 under Sakha, Nubaria and Sids locations, respectively. The corresponding earlier number of crosses than Pop-45 were 7, 2 and 3 in the same order. More crosses were silked later than both checks particularly under Nubaria (15) and Sids(16) locations compared to earlier ones (4 & 6) in the same locations, respectively.

In respect to plant height, the plants of all sets of crosses or checks under Sids conditions were the tallest compared to corresponding sisters sown under Sakha followed by those of Nubaria, respectively. Only one cross significantly surpassed the plant height of SC-155 under Nubaria location. Most crosses possessed shorter plants than SC-155 especially under Sakha (35 crosses) and Sids (27 crosses). Most of studied crosses (29 crosses) were significantly higher than Pop-45 check under Sakha location compared to 5 and 4 ones under Nubaria and Sids trials, respectively.

Table 3. Mean performance of crosses belonged to various testers under different locations compared to checks for studied traits of 2001 season.

Tester		Silking date, day			Plant height, cm			Ear height, cm			Grain yield/fed., ardab		
		Sakha	Nubaria	Sids	Sakha	Nubaria	Sids	Sakha	Nubaria	Sids	Sakha	Nubaria	Sids
Pop-45		58.8	59.5	59.4	226.2	215.4	236.6	128.6	117.3	136.3	26.1	25.5	25.6
Comp-21		58.3	58.2	58.3	222.8	209.4	235.2	124.2	112.0	133.1	26.6	25.9	24.7
SC-10		57.8	58.9	58.3	229.9	215.5	238.9	133.3	119.9	138.6	29.0	28.7	26.6
Gm-1004		58.6	58.9	57.9	220.8	207.9	234.6	121.7	108.7	131.7	27.3	28.8	27.8
Gm-1021		58.3	59.7	58.7	229.3	211.4	235.1	133.5	115.3	138.4	28.6	28.0	27
SC-155	Mean	58.8	59.5	58.0	251.8	217.5	253.5	139	121.5	148.5	28.8	24.1	26.9
	NSC	6	2	3	0	1	0	0	0	0	0	35	2
	NIC	3	4	8	35	6	27	20	8	22	7	0	6
Pop-45	Mean	59.3	58.0	58	207.8	210.5	235.8	121.3	114	132.5	15.2	12.6	14.5
	NSC	7	2	3	29	5	4	17	5	50	50	50	50
	NIC	1	11	8	1	2	6	1	3	0	0	0	0
New LSD $_{0.05}$		2.04	2.14	2.16	15.16	17.19	14.69	13.46	14.31	13.86	3.15	2.48	2.29

NSC and NIC indicate number of crosses that significantly surpassed and inferior to each check, respectively.

Regarding the ear height, none of crosses showed higher ear than SC-155, but about 50% of the crosses recorded significantly lower height of the ear than SC-155 under Sakha and Sids stations. The ear height of the crosses compared to the other check (Pop45) was clearly changed from the above mentioned to SC-155. On the other words, 17 and 50 crosses recorded significantly ear at higher position than Pop-45 under Sakha and Sids, respectively.

The performance of different crosses for grain yield varied among locations but the mean of all sets were lower under Sids (26.3 ardab/fedan) than under the other two locations (27.5 ardab/fedan). Both checks produced higher yields (28.6 and 15.2 ardab/fedan) under Sakha than Sids (26.9 and 14.5 ardab/fedan) and Nubaria (24.1&12.6 ardab/fedan) for SC-155 and Pop-45, respectively. This variation of SC-155 productivity reflected in that 35 crosses outyielded SC-155 in Nubaria compared to 0 and 2 crosses in Sakha and Sids, respectively and vice versa for significantly inferior crosses. Due to the crossing or hybrid vigor all tested crosses significantly outyielded the open pollinated check (Pop-45) under all locations for grain yield.

The heterozygosity of the tested sets of crosses reflected in variable productivity under all locations. Using single cross (SC-10) or inbreds (Gm-1004 and Gm1021) as testers, recorded higher grain yield than resulted from broad base testers (Pop-45 or Comp-21). This may be due to that narrow base testers produced pronounced heterosis (as single or three way crosses) than broad base ones when crossed with S_4 lines.

Combining ability

General combining ability effects of parental lines and testers for studied traits are presented in Table 4. Variable general combining ability effects among both lines and testers were detected concerning significance, signs and magnitudes for different traits. Four parental inbred lines and two testers exhibited the highest significant GCA effects towards earliness. However, another 3 lines and Pop-45 (as a tester) affected significantly positively the silking dates (late direction). For plant height, four lines and one tester (Comp-21) seemed to shorten the height of crosses that involved. Other three lines plus SC10 as a tester significantly affected positively the plant height of crosses included. Regarding the ear height, data revealed that 3 parental inbred lines and two testers had significantly negative GCA effects. On the other hand, other four lines and two testers appeared to be significantly increased the position of the ear on the stalk.

Table 4. General combining ability effects (gi) of combined data for 10 inbred lines and 5 testers for studied traits during 2001season.

Genotypes		Silking date, day	Plant height, cm	Ear height, cm	Grain yield/fed, ardab
Lines	L1	-0.75**	-15.54**	-10.8**	0.64**
	L2	0.70**	3.83**	1.91	-0.10
	L3	-0.69**	2.29	1.08	0.11
	L4	0.23	-7.41**	-2.41	-0.23
	L5	-1.75**	7.86**	3.33*	-0.098
	L6	1.02**	-11.43**	-7.37**	0.86**
	L7	1.6**	9.49**	6.6**	-0.17
	L8	0.43	9.84**	6.34**	0.27
	L9	0.58	-7.24**	-4.49**	-0.72**
	L10	-1.37**	8.31**	5.11**	-0.56*
Testers	Pop-45	0.58**	1.47	1.21	-1.41**
	Comp-21	-0.38**	-2.13*	-3.06**	-1.34**
	Sc10	-0.30*	3.5**	4.43**	1.011**
	Gm-1004	-0.17	-3.49**	-5.48**	0.94**
	Gm-1021	0.27	0.65	2.9**	0.8**
S.E. for lines					
g_i		0.197	1.46	1.46	0.25
g_i- g_j		0.278	2.07	2.07	0.35
S.E. for tester					
g_i		0.139	1.04	1.04	0.18
g_i- g_j		0.197	1.46	1.46	0.25

For grain yield only 2 inbreds (L1 and L6) in addition to the two medium and narrow base testers (Gm-1004, Gm-1021 and SC-10) were significantly positively affected the yield potential of crosses. On the contrary, the undesirable effects were recorded by both lines L9 & L10 and testers Pop-45 &Comp-21.

It could be concluded that the evaluated lines and testers differed widely in their combining ability effects for various traits. Some of tested material (L1 and L6) possessed desirable combining ability effects particularly for grain yield. Likewise, the medium (SC 10) and narrow base testers (Gm-1004 & Gm-1021) exhibited similar gi effects on hybrid performance for grain yield. On the other hands, the broad base testers (Pop-45 and Comp.-21) possessed undesirable gi effects on yield performance of top crosses. Moreover, Pop-45 affected significantly negatively the silking dates of crosses that an opposite to Comp-21. This means that unrelated testers would be better than related ones for improving hybrid performance.

The other lines or testers may be affected desirably one or two of studied traits and may affected negatively the other traits. Such contradicting GCA effects should be avoided when included these material in hybrid release program.

Genetic variance components

Estimates of genetic variance due to GCA (σ^2_A) and SCA (σ^2_D) under different locations for investigated traits are presented in Table 5. The results show that the additive type of gene actions played the major role in the inheritance of plant height in all locations and combined over locations. These results were agreement with those obtained by (Salama *et al* 1995, El-Zeir 1999 and Soliman *et al* 2001). In contrast, non-additive gene action was found to be more important in the inheritance of silking date, ear height and grain yield, which are harmony with those obtained by (Sedhom 1994, Sujiprihati *et al* 2001 and Venugopal *et al* 2002).

Table 5. Estimates of genetic variance components and their ratios under various locations and combined over locations for studied traits.

Parameters	Silking date				Plant height			
	Sa	Nu	Si	Comb	Sa	Nu	Si	Comb
σ^2_A	2.6	3.0	3.92	4.39	387	158.4	243.6	385
σ^2_D	3.72	2.28	4.08	6.08	347.4	106.88	99.8	286.8
σ^2_A/σ^2_D	0.7	1.32	0.96	0.72	1.12	1.48	2.44	1.25

Parameters	Ear height				Grain yield			
	Sa	Nu	Si	Comb	Sa	Nu	Si	Comb
σ^2_A	127.48	92.08	103	158	1.68	3.72	2.88	3.12
σ^2_D	152.44	104.2	112.6	203.2	2.24	6.8	3.72	3.44
σ^2_A/σ^2_D	0.84	0.88	0.92	0.78	0.76	0.55	0.77	0.90

The obtained results of the present investigation demonstrated that variable environmental conditions affected differently the estimates of yellow maize line x tester procedure. Such effects should be considered in recommending hybrids for variable locations. Moreover, medium or narrow genetic base testers may be of great value for analyzing the combining ability of yellow maize inbreds.

In addition single cross or inbred testers may consider an easier and/or rapid method for developing maize hybrid.

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تقييم بعض الهجن القمية للذرة الصفراء تحت ظروف بيئية متبا ينة

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اجريت هذه الدراسة بهدف تقييم القدرة على التآلف لمجموعة من سلالات الذرة الصفراء المستنبطة بالتربية الذاتية من العشيرة ٤٥ باستخدام طرز مختلفة من المختبرات تحت ظروف بيئية متباينة. ولقد تم اجراء الهجن القمية بين عشرة سلالات منتخبة وخمس طرز من المختبرات: اثنين منها ذات قاعدة وراثية عريضة (عشيرة ٤٥ و الصنف التركيبى ٢١) ومختبر واحد ذو قاعدة وراثية متوسطة (هجين فردى ١٠) و اثنين ذو قاعدة وراثية ضيقة (سلالة جميزة-٤٠٠١او سلالة جميزة-٢١٠١). فى موسم ٢٠٠٠ تم عمل جميع الهجن القمية بنظام (السلالة فى المختبر). فى الموسم الثانى ٢٠٠١ تم تقييم الخمسون هجينا قمياً الناتجة بالاضافة الى صنفي مقارنة هما هجين فردى د٥١

والصنف جيزة ٤٥ في ثلاث محطات تابعة لمركز البحوث الزراعية بسخا و النوبارية و سدس. وسجلت صفات : عدد الأيام من الزراعة حتى ظهور ٥٠% من الحرائر ، طول النبات (سم) ارتفاع الكوز(سم) و محصول الحبوب بالأردب للفدان.

اظهرت المواقع تأثيراً معنوياً على اداء كل الصفات فيما عدا موعد ظهور الحرایر. كانت تباينات الهجن والامهات والاباء معنوية لكل الصفات. اختلف اداء الهجن باختلاف الظروف البيئية السائدة من موقع لاخر. كان تأثير التباين الراجع للامهات اكبر من نظيره الراجع للمختبرات.

كان التباين في موعد ظهور الحرایر للهجن القمية ضيقاً في حين ان نباتات كل الهجن القمية كانت الاطول في سدس عنها في سخا والنوبارية. ولقد كانت نباتات معظم الهجن القمية الاقصر طولاً عن تلك الخاصة بالهجين الفردى ١٥٥ وخاصة في سخا وسدس وعلى العكس فلقد كانت نباتات العشيرة المفتوحة جيزة ٤٥ هي الاقصر عن نباتات الهجن القمية. ولقد تفوق ٣٥ هجيناً قمياً على الهجين الفردى ١٥٥ في محصول الحبوب في النوبارية مقارنة بعدم تفوق اى هجين قمى في سخا وتفوق هجينين قميين فقط على هجين المقارنة الفردى ١٥٥ في سدس. الا ان كل الهجن القمية قد تفوقت على صنف المقارنة المفتوح جيزة ٤٥ في كل المواقع.

اظهرت كل السلالات والمختبرات تأثيرات متباينة للقدرة العامة على التآلف من حيث المعنوية والاتجاه والقيمة والتي اختلفت من صفة لاخرى. كانت المختبرات المتوسطة وضيقة القاعدة الوراثية هي الافضل من حيث تحسين اداء الهجن القمية. بل الاكثر من ذلك فان المختبرات غير ذات العلاقة بالسلالات كانت الاحسن في تحسين اداء الهجن.

كانت طرز الفعل الجينى المضيف هي الاكثر اهمية في توارث ارتفاع النباتات في كل المواقع. بعكس طرز الفعل الجينى غير المضيف فلقد كانت الاكثر اهمية في توارث صفات موعد ظهور الحرایر وارتفاع الكوز وغلة الحبوب.

التأثيرات المتحصل عليها في هذه الدراسة من الظروف البيئية المتباينة على اداء والقدرة العامة على التآلف والتفوق الهجينى للسلالات والهجن القمية بالاضافة الى طبيعة فعل الجين الخاصة بتوارث الصفات المختلفة يجب وضعها في الحسبان في برامج استنباط هجن الذرة الصفراء.

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