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COMBINING ABILITY FOR NEW MAIZE INBRED LINES FOR GRAIN YIELD AND OTHER AGRONOMIC TRAITS

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ABSTRACT: *New white 15 inbred lines of maize were mated to the two testers, inbred lines SK-13 and SC130 at Sakha Agricultural Research Station during 2012 season. The resulting 15 single crosses, 15 three way crosses and two commercial hybrid, SC10 and TWC321 were evaluated at two locations Sakha and Mallawi in 2013 season to estimate days to 50% silking (days), plant and ear heights (cm), ear length and diameter (cm) and grain yield (ard/fed). The analysis of variance revealed significant mean squares due to lines, testers and their interaction for all traits except for testers for ear diameter and lines x tester interaction for plant height and ear diameter.*

The additive gene effects were most responsible for controlling the inheritance of all traits except for days to 50% silking and grain yield. Best parental inbred lines which revealed desirable GCA effects were SK5002/3 for ear height, ear length and grain yield, SK5002/7 for days to 50% silking and plant height, SK5006/14 for plant and ear height, Sk5007/15 for ear length, ear diameter and grain yield and SK5009/16 for days to 50% silking and ear height. The best tester for GCA effects was SK13 for most traits.

The single cross SK5002/5 x SK-13 and three way cross SK5002/3 x SC130 were earliness, shorter for plant and ear heights and outyield than the commercial hybrids SC10 and TWC321, respectively. It is recommended to benefit from these crosses in maize breeding programs.

Key words: *Maize, Combining ability, Top cross.*

INTRODUCTION

The estimates of genetic components of variance help predict expected genetic from selection there by allowing comparison among breeding method for optimizing management of available genetic variability. Amongst a large array of biometrical producers for relative estimation of genetic components line x tester is an efficient procedures as it allows for inclusion of a large number of lines and provides reliable estimates of genetic components and estimates of combining ability effects. Matzinger (1953), Hallauer and Miranda (1981), Russell *et al*. (1992) and Menz *et al*. (1999) found that the suitable tester should be based on simplicity in use, ability to classify the relative merit of lines and maximizing genetic gain. However, it is difficult to identify testers having all these characteristics. The use of an inbred lines as a tester was suggested by Russell and Eberhart (1975), Darrah (1985) and Horner *et al*. (1989). While, El-Ghawas (1963), Honer *et al*. (1976), Castellanos *et al*. (1998) and Mosa (2010) used a single cross as a tester. Parvez and Rather (2006) revealed predominance of non-additive component for plant height ear length and diameter and grain yield, while Aly and Khalil (2013) found predominance of additive component for days to 50% silking, ear length and diameter and grain yield.

This study was planned to gain information on the mode of inheritance all studied traits, to identify superior inbred lines and crosses for general combining ability effects and determine the best single and three way crosses relative to commercial hybrids.

MATERIALS AND METHODS

The material for present investigation was developed at Sakha Research Station. Fifteen white maize inbred lines (Table 1), were crossed to two testers inbred lines SK13 and SC130 in a line x tester fashion.

Table (1): Pedigree and source of fifteen white maize inbred lines.

No.	Pedigree	Source
1	SK5001/1	Pop.GZ-2 x Pop. American Early (A.E)
2	SK5002/3	Pop Gz-2 x Pop. Sakha-7 (C1)
3	SK5002/4	Pop Gz-2 x Pop. Sakha-7 (C1)
4	SK5002/5	Pop Gz-2 x Pop. Sakha-7 (C1)
5	SK5002/6	Pop Gz-2 x Pop. Sakha-7 (C1)
6	SK5002/7	Pop Gz-2 x Pop. Sakha-7 (C1)
7	SK5002/8	Pop Gz-2 x Pop. Sakha-7 (C1)
8	SK5002/9	Pop Gz-2 x Pop. Sakha-7 (C1)
9	SK 5003/10	Pop Gz-2 x Local Early Seventy
10	SK5006/11	Pop Gz-2 x Texpinew (C17)
11	SK5006/13	Pop Gz-2 x Texpinew (C17)
12	SK5006/14	Pop Gz-2 x Texpinew (C17)
13	SK5007/15	Pop. A.E. x Sakha-7 (C1)
14	SK5009/16	Pop. A.E x Composite 5
15	SK5009/18	Pop. A.E x Composite 5

Pop = Population, Gz = Giza, Sk = Sakha

The tester genotypes were developed at Sakha Research Station. The inbred line tester SK-13 have good combining ability, while SC130 was high yielding hybrid. The resulting 15 single crosses and 15 three way crosses and two commercial hybrids, SC10 and TWC321 were evaluated at two diverse locations in Sakha (North Egypt) and Mallawi (South Egypt). The design used was RCBD with four replications at each location. Each hybrid was represented by one row of 6 m length with inter and intra-row spacing of 80 and 25 cm, respectively. Data was recorded on six traits including days to 50% silking, plant height (cm), ear height (cm), ear length (cm) and ear diameter (cm) and grain yield (ardab/fed.) adjusted on 15.5% grain moisture. The statistical analysis of combined data over the two locations was performed according to Steel and Torrie (1980) after Homogeneity test between two locations. The procedure of Sing and Chaudary (1999) was used for line x testers analysis.

RESULTS AND DISCUSSION

The combined analysis of variance for six traits over two locations are presented in Table 2.

Table (2): Analysis of variance for six traits in maize over two locations (Sakha and Mallawi).

S.O.V.	df	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Grain yield
Locations (Loc)	1	564.063**	46548.063**	35438.063**	422.302**	19.470**	1364.564**
Rep/Loc	6	4.737	2104.250	1129.635	3.478	0.017	32.159
Hybrid (H)	31	14.693**	1123.258**	719.780**	6.424**	0.081**	77.001**
H x Loc	31	1.869	255.385**	95.829	1.677*	0.040	6.883
Error	186	1.437	139.712	73.391	1.012	0.027	7.884

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

The differences between two locations were highly significant for six traits. The mean square due to hybrids was highly significant for all traits however, hybrids x locations interaction was non-significant for all traits except for plant height and ear length. Mean performance of inbred lines in their crosses for three growth traits over two locations are presented in Table 3.

All hybrids between 15 inbred line with two testers inbred line SK-13 and SC130 were significantly lower than the two checks SC10 and TWC321 for days to 50% silking except hybrid Sk5007/15 x SC130. The hybrids of inbred line SK5002/7 and each of two testers were the best among all the studied hybrids for earliness. This inbred line and their single and three way crosses could be utilized in the breeding programs for developing early maturing single and three-way crosses.

Means of plant height and ear height were significantly lower than the two check hybrids for all inbred lines in their crosses except top crosses between inbred lines SK5007/15 and sK5009/18 with tester SC130 for plant and ear height and SK5002/6, SK5002/8, SK5002/9 and SK5003/10 with tester SC130 for ear height. The inbred line SK5006/14 gave the best hybrids for plant and ear height with two testers. Such results indicated that these materials are prospecting in maize breeding programs towards the development of good stature for single and three-way crosses and resistance to stalk breakage.

In Table 4, the hybrids between inbred line SK5007/15 with two testers were significantly higher than the two checks SC10 and TWC321 for ear length and ear diameter. Also, the hybrids between inbred lines SK5002/3, SK5002/9 with SC130 were significantly higher than TWC321 for ear length while the hybrid between inbred line SK5002/5 with tester SK13 was significantly higher than SC10 for ear diameter.

Means of grain yield exhibited that the hybrids of inbred lines SK5002/3, SK5002/5, SK5002/6, SK5002/8 and SK5007/15 with tester inbred line SK13 (top crosses) were non-significantly higher than check SC10, also, the hybrids of inbred lines SK5002/3 and SK5007/5 with tester SC130 were non-significantly outyield than TWC321. It could be concluded that these inbred lines and crosses could be utilized by corn breeders to develop new hybrids with high yield potentiality.

The results conclusion from Table 3 and 4, exhibited that the single cross Sk5002/5 x SK13 was significantly earliness, short plant and ear heights and non significantly outyield, than check SC10, also TWC Sk5002/3 x SC130 was significantly earliness, short plant and ear height, longest ear length and diameter and non significantly outyield than check TWC321. Hence, it could be concluded that these hybrids offer good possibility for improving earliness, plant and ear heights and high grain yield.

The interaction between lines, tester and lines x testers with locations was not significant for all traits except for lines x locations for plant height and ear length and testers x locations for plant height and ear height.

The additive gene effects (K^2GCA) seemed to have played an important role than non-additive gene effects (K^2SCA) in the expression of all studied traits except for days to 50% silking and grain yield (Table 6). This result supports the findings of Nawar and El-Hosary (1984) for ear diameter, Dodiya and Joshi (2002), Mosa (2004) for days to 50% silking and Parvez and Rather (2006) for grain yield, Mosa (2010) for plant and ear height and Aly and Khalil (2013) for ear length.

Estimates of general combining ability effects (GCA) for 15 inbred lines for six traits over two locations are presented in Table 7. The desirable GCA effects were obtained by inbred lines, SK5002/7, SK5006/11, SK5006/13 and SK5009/16 for earliness, SK5002/7 and SK5006/14 for plant height, SK5002/3, SK5002/4, SK5006/14 and SK5009/16 for ear height, SK5002/3, SK5002/8, SK5002/9, SK5006/11 and SK5007/15 for ear length, SK5006/11 and SK5007/15 for ear diameter, SK5002/3, SK5002/5, SK5002/6, SK5003/10 and SK5007/15 for grain yield.

Table (3): Mean performance of top crosses and two testers Sk13 and SC130 for three agronomic traits over two locations.

Inbred line	Days to 50% silking		Plant height (cm)		Ear height (cm)	
	SK13	SC130	SK13	SC130	SK13	SC130
SK5001/1	59.75	59.12	244.125	258.250	133.125	142.500
SK5002/3	60.00	60.75	247.125	269.250	124.625	145.375
SK5002/4	59.75	59.75	245.375	265.375	134.000	141.125
SK5002/5	58.75	59.00	244.250	262.000	137.000	148.375
SK5002/6	58.87	59.87	258.250	262.000	141.000	149.125
SK5002/7	57.00	57.37	241.750	259.000	130.750	147.125
SK5002/8	59.50	60.12	257.00	255.125	143.875	149.250
SK5002/9	61.12	60.00	255.625	266.625	145.375	150.375
SK5003/10	58.25	60.25	241.625	262.500	136.625	152.000
SK5006/11	57.50	59.75	257.625	261.500	139.250	148.000
SK5006/13	58.87	58.37	254.25	260.625	140.250	136.500
SK5006/14	59.62	58.87	239.750	255.500	133.375	140.750
SK5007/15	60.62	61.75	258.750	273.500	142.750	156.750
SK5009/16	57.87	59.25	248.625	260.875	124.125	142.625
SK5009/18	60.37	60.12	252.750	268.500	142.875	157.375
Check SC10	63.12	-	297.250	-	168.125	-
Check TWC321	-	62.37	-	279.250	-	157.125
LSD 0.05	1.13		11.58		8.39	
LSD 0.01	1.49		15.24		11.05	

Table (4): Mean performance of top crosses and two testers Sk13 and SC130 for yielding traits over two locations.

Inbred line	Ear length (cm)		Ear diameter (cm)		Grain yield (ard/fed)	
	SK13	SC130	SK13	SC130	SK13	SC130
SK5001/1	21.97	22.12	4.650	4.575	31.47	36.57
SK5002/3	22.95	22.47	4.625	4.600	36.47	39.27
SK5002/4	20.55	21.17	4.725	4.675	28.89	31.52
SK5002/5	21.50	20.40	4.920	4.725	37.22	35.57
SK5002/6	22.02	21.22	4.675	4.675	35.92	33.77
SK5002/7	21.05	19.87	4.725	4.725	28.97	32.33
SK5002/8	22.77	21.90	4.750	4.725	35.97	33.14
SK5002/9	22.97	22.89	4.750	4.550	28.46	29.68
SK5003/10	22.60	20.95	4.825	4.700	33.66	35.72
SK5006/11	22.60	22.27	4.850	4.850	29.68	33.39
SK5006/13	22.10	20.65	4.750	4.625	28.45	30.32
SK5006/14	20.85	20.75	4.750	4.750	33.01	30.75
SK5007/15	23.49	22.62	4.920	5.025	36.10	38.39
SK5009/16	20.87	21.62	4.700	4.825	31.67	35.35
SK6009/18	21.82	21.45	4.750	4.700	31.68	33.27
Check SC10	22.50	-	4.750	-	35.21	-
Check TWC321	-	21.30	-	4.825	-	37.84
LSD 0.05	0.98		0.16		2.75	
0.01	1.29		0.21		3.62	

Table (5): Line x tester analysis for six traits over two locations

S.O.V.	df	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Grain yield
Lines (L)	14	15.579**	384.527**	464.607**	10.643**	0.134**	124.224**
Testers (T)	1	11.267**	10010.417**	6678.150**	16.017**	0.096	117.824**
L x T	14	4.026**	197.943	156.293*	2.002*	0.035	24.275**
L x Loc	14	2.015	341.193**	95.381	2.728**	0.046	5.815
T x Loc	1	0.001	843.749*	442.816*	0.01	0.01	0.59
L x T x Loc	14	1.222	149.063	63.992	0.84	0.046	4.811
Error	174	1.347	139.712	73.391	1.012	0.027	7.884

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

Table (6): Estimate of variance for general combining ability (K^2GCA) and specific combining ability (K^2SCA) over two locations

Genetic components	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Grain yield
K^2GCA	0.181	67.72	48.56	0.175	0.580	1.73
K^2SCA	0.350	6.11	11.53	0.145	0.001	2.43

Table (7): Estimates of general combining ability effects for fifteen inbred lines over two locations.

Trait / Inbred line	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Grain yield
SK5001/1	0.029	-5.062	-4.062	0.300	-0.122**	0.783
SK5002/3	0.966**	1.937	-6.875**	0.962**	-0.122**	4.735**
SK5002/4	0.341	-0.875	-4.312*	-0.887**	-0.035	-3.031**
SK5002/5	-0.533	-3.125	0.812	-0.800**	0.077	3.163**
SK5002/6	-0.033	3.875	3.187	-0.125	-0.060	1.609*
SK5002/7	-2.220**	-5.587*	-2.937	-1.287**	-0.010	-2.584**
SK5002/8	0.404	-0.187	4.687*	0.587*	0.002	1.322
SK5002/9	1.154**	4.875	6.000**	1.175**	-0.085*	-4.164**
SK5003/10	-0.158	-4.187	2.437	0.025	0.027	1.456*
SK5006/11	-0.783**	3.312	1.750	0.687**	0.115**	-1.609*
SK5006/13	-0.783**	1.187	-3.500	-0.375	-0.047	-3.848**
SK5006/14	-0.158	-8.625**	-4.812*	-0.950**	0.015	-1.356
SK5007/15	1.779**	9.875**	7.875**	1.300**	0.227**	4.010**
SK5009/16	-0.845**	-1.500	-8.500**	-0.500*	0.027	0.274
SK6009/18	0.841**	4.375	8.250**	-0.112	-0.010	-0.760
LSD 0.05	0.56	5.79	4.19	0.49	0.08	1.37
0.01	0.74	7.62	5.52	0.64	0.10	1.81

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

Generally, inbred line SK5007/15 showed desirable general combining ability for grain yield, ear length and diameter, SK5002/3 had good GCA effects for ear height, ear length and grain yield as well as SK5002/7 for days to 50% silking and plant height, SK5006/14 for plant and ear heights and SK5009/16 for days to 50% silking and ear height. These inbred lines could be utilized in making hybrids that had high yielding ability, earliness and suitable for plant and ear height.

The testers inbred line SK13 was the best general combiner for all traits except for grain yield (Table 8). The superiority of inbred line as good tester was noticed by several investigators among them Russell and Eberhart (1975), Darrah (1985), Al-Naggar *et al*. (1997) and Mosa (2010). While, the superiority of single cross as good tester was reported by Horner *et al*. (1976), Mosa (2001) and Aly and Khalil (2013).

The best crosses identified on the basis of specific combining ability effects for six traits over two locations are shown in Table 9. The results revealed that the hybrid of the inbred line SK5003/10 with tester SK13 had good SCA effect for days to 50% silking and ear length, while the hybrids of the inbred line SK5006/11 with testers SK13 and SC130 had good SCA effects for days to 50% silking and plant height, respectively as well as SK5002/8 with Sk13 and SC130 for grain yield and plant height, respectively, SK5009/16 with Sk13 and SC130 for ear height and ear length and ear diameter, respectively. These crosses which recording superior for SCA effects can serve as a source of improved lines with desirable alleles for a trait.

Table (8): Estimate of general combining ability effects for two testers over two locations

Tester	Days to 50% silking	Plant height	Ear height	Ear length	Ear diameter	Grain yield
SK13	-0.216*	-6.458**	-5.275**	0.258**	0.020	-0.700**
SC130	0.216*	6.458**	5.275**	-0.258**	-0.020	0.700**
LSD 0.05	0.20	2.11	1.53	0.179	0.029	0.502
0.01	0.27	2.78	2.01	0.236	0.038	0.661

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

Table (9): Best crosses identified on the basis of specific combining ability effects for six traits over two locations.

Trait	SCA effects
Days to 50% silking	SK5003/10 x SK13 SK5006/11 x SK13
Plant height	SK5002/8 x SC130 SK5006/11 x SC130
Ear height	SK 5006/13 x SC130 SK5009/16 x SK13
Ear length	SK5003/10 x SK13 SK5009/16 x SC130
Ear diameter	SK5009/16 x SC130
Grain yield	SK5001/1 x SC130 SK5002/8 x SK13

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القدرة على الائتلاف لسلالات جديدة من الذرة الشامية لصفة المحصول وصفات خضرية أخرى

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الملخص العربى

تم التهجين بين ١٥ سلالة من الذرة مع إثنين من الكشافات سلالة سخا ١٣ ، هجين فردى ١٣٠ بمحطة بحوث سخا خلال موسم ٢٠١٢. الهجن الناتجة (١٥ هجين فردى + ١٥ هجين ثلاثى) بالإضافة لهجينين تجاريين م ف١٠ ، و م ث ٣٢١ قيمت فى موقعين مختلفين فى سخا وملوى موسم ٢٠١٣ وأخذت النتائج على صفات تاريخ ظهور حريرة ٥٠% من النورات المؤنثة وارتفاع النبات وارتفاع الكوز وطول وقطر الكوز ومحصول الحبوب. تحليل السلالة فى الكشاف أظهر معنوية تباينات السلالات والكشافات والتفاعل بينها لجميع الصفات ماعدا تباين الكشافات لصفة قطر الكوز وتباين التفاعل بين السلالات والكشافات لصفتى ارتفاع النبات وقطر الكوز.

تأثيرات الفعل الجينى المضيف هى المتحكمة الأكثر فى وراثة جميع الصفات ماعدا صفتى تاريخ ظهور حريرة ٥٠% من النورات المؤنثة ومحصول الحبوب حيث تأثيرات الفعل الجينى غير المضيف هو الأكثر تحكما فى وراثتهما.

أفضل السلالات التى أظهرت قدرة عامة مرغوبة هى سلالة سخا ٣/٥٠٠٢ لصفات ارتفاع الكوز وطول الكوز ومحصول الحبوب وسخا ٧/٥٠٠٢ لصفتى تاريخ ظهور حريرة ٥٠% من النورات المؤنثة وإرتفاع النبات ، وسخا ١٤/٥٠٠٦ لصفتى ارتفاع النبات والكوز وسخا ٥٠٠٧/ ١٥ لصفة طول وقطر الكوز ومحصول الحبوب وسخا ١٦/٥٠٠٩ لصفتى تاريخ ظهور حريرة ٥٠% من النورات المؤنثة وارتفاع الكوز.

أفضل كشاف للقدرة العامة على الائتلاف هو السلالة سخا ١٣ لمعظم الصفات. الهجين الفردى سخا ٥/٥٠٠٢ × سخا ١٣ والهجين الثلاثى سخا٣/٥٠٠٢ × هجين فردى ١٣٠ كانت مبكرة وأقصر فى ارتفاع النبات والكوز وأعلى فى المحصول بالمقارنة بالهجن التجارية هجين فردى ١٠ وهجين ثلاثى ٣٢١ على التوالى ولذلك توصى هذه الدراسة بإستخدام هذه الهجن فى برنامج التربية للهجن عالية المحصول.