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COMBINING ABILITY FOR YIELD AND ITS ATTRIBUTES IN NEWLY DEVELOPED YELLOW MAIZE INBRED LINES

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Abstract: Eight selected S_4 yellow inbred lines derived from the wide genetic base Population Gemmeiza Yellow maize at Mallawy Agricultural Research Station, were top-crossed with each of three commercial inbred line testers, namely, Gm-1001, Gm-1002 and Gm-1004 in 2005 season. The 24 top-crosses along with the check yellow maize SC-155 were evaluated at Sakha and Mallawy Agriculture Research Stations, ARC in 2006 growing season for grain yield (ard/fed), days to 50% silking, plant height and ear height.

The obtained results revealed that mean squares due to top-crosses, lines, testers and lines × testers were highly significant for grain yield at each location. The combined data for grain yield over the two locations showed highly significant variances for locations, crosses, lines, testers and interactions of lines x testers and location, crosses x locations and lines x locations and well as line x tester x location interaction.

Two inbred lines (L-3 and L-5) had positive GCA effects and were good combiners for grain yield. The tester line Gm1002 was a good general combiner for both grain yield and days to 50% silking.

Variance due to SCA was greater in magnitude than that due to GCA for silking date and grain yield at Sakha and over locations and for silking date and ear height at Mallawy indicating that non-additive genetic variance was the major source of genetic variation. The magnitude of δ^2GCA × Loc interaction was larger than δ^2 SCA × Loc for ear height and grain yield. Results showed also that crossing the tester Gm-1004 with either of the inbred lines L-7 and L-5 produced the best two single crosses which significantly surpassed the check single cross 155 (20.74 ard/fad.) by 3.56 and 3.05 ard/fad., respectively. However, from the combined data, the top crosses (L-8 x Gm-1002), (L-7 x Gm- 1002), (L-6 x Gm-1002), (L-4 x G-1004), (L-4 x Gm-1001), (L-3 x Gm-1001) and (L-2 x Gm-1004) produced 22.93, 22.65, 22.58, 22.26, 22.23, 22.44, and 22.35 ard/fad., respectively, relative to the commercial check SC. 155 (20.74 ard/fad.). These nine yielded top crosses have to be advanced to the other steps for evaluation and testing.

Key words: Maize, combining ability, gene action, top crosses.

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Intordaction

Successful development of maize hybrids depends upon accurate assessment of line's genotype during selection. Hallauer (1975) indicated that a suitable tester should include simplicity in use, provide information that correctly classifies the relative merit of lines, and maximize genetic gain. In general, selection experiments have indicated differences between testers in ranking the genotypes of a population (Lonnquist and Lindsey, 1964; Horner *et al*., 1969; and Mostafa *et al*., 1991).

Commonly, National Maize Breeding Program uses the top cross procedure to evaluate combining ability of inbred lines in a hybrid program and to determine the breeding values of maize genotypes.

Grain yield has received most of the emphasis in maize breeding. Dominance gene effects were reported to be more important in controlling grain yield than additive effects (Sprague and Suwantradon 1975; Mostafa *et al*., 1991; and Abd El Aziz *et al*., 1994). However, other results indicated the importance of additive gene effects for maize grain yield (Russell *et al*., 1973; Silva and Hallauer, 1975; Horner *et al*., 1976, Hallauer and Mirinda, 1981; and El-Itriby *et al*., 1990).

The magnitude of the interaction between SCA with location was found to be greater than that of GCA × Location for grain yield and plant height (Amer and El-Shenawy, 2007). Abd El-Maksoud *et al*. (2003) found that the additive genetic variance was smaller in magnitude than of non-additive genetic variance for days to 50% silking, plant height and yield and its components. Highly significant differences were reported to be present among entries and their parents, crosses and parent vs. crosses for all traits. The interactions between entries (genotypes) by location and parent × location and parent vs. crosses × location were highly significant for all studied traits (Shehata *et al*., 1997). Moreover, El-Zeir *et al*. (1993), El-Sherbieny *et al*. (1996), Tulu and Ramachandrappa (1998), Motawei (2005), Soliman and Osman (2006) and Abd El-Moula (2006), reported that the additive component of gene action had the major role in the inheritance of days to 50% silking, plant and ear height, number of ears/100 plants and grain yield (ard/fed.) as compared with the non-additive component. However, the SCA variance was reported to be greater in magnitude than that due to GCA variance for the grain yield and other traits. With the interaction of SCA with location being markedly greater than that of GCA for grain yield, days to 50% silking, plant and ear height and no. of ears/100 plant (Singh and Singh 1998, Barakat *et al*., 2003 Abd El-Moula *et al*., 2004 and Abd El-Moula 2005).

Gado (2000) found that the variance due to GCA (lines) was greater in magnitude than that due to SCA indicating that the additive genetic variance was the major source of variation responsible for the inheritance of the plant height, ear height, 100-grain weight and grain yield. Also, the interaction of GCA by locations was markedly higher and positive for grain yield and other traits.

The main objectives of current investigation were to (1) evaluate 24 top crosses (8 lines x 3 testers), (2) estimate GCA effects for lines as well for testers and SCA effects of crosses for grain yield and other traits and (3) estimate the variances δ^2GCA for lines and testers and δ^2SCA for top crosses and their interaction with location.

Materials and Methods

Eight S4 yellow maize inbred lines derived from Gemmeiza yellow population at Mallawy Agricultural Research Station were top-crossed with each of three tester lines namely, Gm-1001, Gm-1002, and Gm-1004. Which were developed by National Maize Research Program at Gemmeiza Agriculture Res. Station and are currently used in seed production of the commercial hybrids.

The 24 yellow top-crosses were established during 2005 summer season at Mallawy Agric. Res. Station. In 2006 season, 24 top-crosses and the commercial check hybrid SC-155 were evaluated at two locations; Sakha and Mallawy Agric. Res. Stations, using RCBD with four replications for each location. The experimental plot was one row, 6 meters long with 80 cm between rows. Planting was in hills spaced 25 cm apart. Data for days to 50% silking date, plant height and ear height and grain yield (ard/fed) were recorded. Analyses of variance were carried out separately for each location and were combined over locations according to Gomez and Gomez (1984). Combining ability analyses were carried out for each location according to Kempthorne (1957).

Results and Discussion

Analysis of variance

Mean squares for grain yield and other studied traits at Mallawy (Mal), Sakha (Sk) and when combined over locations are presented in Table (1).

Significant differences were detected between locations for all studied traits indicating that the two locations differed in their environmental conditions. These results are in agreement with those obtained by Abd El-Moula (2005), El-Sherbieny *et al.* (1996), El-Zeir *et al.* (2000), Abd El-Moula *et al.* (2004), Shehata *et al.* (1997) and Gado *et al.* (2000).

Mean squares due to crosses, lines, testers and lines x testers were significant for all studied traits at Sakha, Mallawy and over locations, except L x T for plant height at Sakha and plant height and ear height at Mallawy. Similar results were obtained by El-Sherbieny *et al*. (1996), Shehata *et al*. (2001), Abd El-Moula (2005), Soliman and Osman (2006), Amer and El-Shenawy (2007).

In addition, the interaction of crosses x loc were significant for all the studied traits, except for ear height. Significant line x loc interaction was found for days to 50% silking date and grain yield. Tester x Loc. interaction was significant for all traits, except for silking date, indicating that the genotypes effect are mainly attributed to the different ranking of genotypes from location to another. The interaction of line x tester x location was significant for silking date, plant height and grain yield. These results are in line with those obtained by Shehata *et al*. (1997), Gado (2000), Shehata *et al*. (2001), Motawei *et al*. (2005) and Amer and El-Shenawy (2007).

Table(1): Mean squares (MS) for grain yield and other traits at Sakha, Mallawy and over locations in 2006 season

Sov.	Df	Ms			
		Silking date	Plant height	Ear height	Grain yield
Sakha					
Reps	3	1.264	76.622	105.792	7.260
Crosses	23	21.759**	694.543**	225.781**	27.337**
Lines (L)	7	38.185**	454.379*	394.730**	21.606**
Testers (T)	2	46.385**	3618.948**	597.010**	75.385**
L × T	14	10.028**	396.853*	88.249	23.338**
Error	69	1.619	105.571	68.806	4.652
Mallawy					
Reps	3	82.288	705.372	521.510	85.583
Crosses	23	11.793**	165.119*	95.554*	37.710**
Lines (L)	7	18.392**	161.820*	152.368*	49.714**
Testers (T)	2	18.010*	558.323*	102.010*	126.823**
L × T	14	7.606*	110.597	66.225	18.978**
Error	69	2.093	64.495	46.989	6.953
Combined					
Location (L)	1	249.797**	954.083*	516.797	2080.801**
Rep/loc	6	41.776	390.997	313.651	46.069
Crosses (C)	23	28.081**	646.503**	248.233**	39.829**
Lines (L)	7	46.743**	557.640**	481.910**	55.264**
Testers (T)	2	60.693**	3294.188**	459.568**	49.459**
L × T	14	14.092**	312.693*	101.205*	30.734**
C × loc.	23	5.471*	213.159**	73.101	25.820**
L × loc.	7	9.833**	58.560	65.237	17.264**
T × loc.	2	3.703	883.08**	239.453**	158.828**
L × T × loc.	14	3.542*	194.756*	53.269	11.096*
Error	138	1.856	85.003	57.897	5.662

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

The variances due to testers were greater in magnitude than those of lines for all studied traits at Sakha and over locations, except for ear height and days to 50% silking date at Mallawy. In addition, the variances due to tester × locations were higher than lines × locations for plant height, ear height and grain yield (ard/fed). These results indicated that the testers contributed much more to the total variation and were more affected by the environmental conditions than the lines. Similar results were obtained by Gado *et al*. (2000), El-Morshidy *et al*. (2003), Abd El-Moula (2005) and Abd El-Moula and Ahmed (2006).

Mean Performance

Mean performance of the top-crosses for all studied traits are shown in Table 2.

The average performance of the crosses showed that the earliest and latest crosses were L-5 x Gm-1002 (57.25 days) and L-8 x Gm-1004 (66.0 days) at Sakha location, respectively. The cross L-6×Gm-1004 was the earliest (55.75 days) while the cross L-2 x Gm-1002 was the latest (61.75 days) at Mallawy. The cross L-1 x Gm-1002) was the earliest (57.25 days) while the cross L-8 x Gm-1004 was the latest (61.75 days) over both locations. Out of 24 crosses, there were10, 12 and 9 crosses significantly earlier than the check SC-155 at Sakha, Mallawy and over locations, respectively.

Plant height ranged from 185.25 (cross L-6 x Gm-1001) to 239.25 cm (cross L-7 x Gm-1004) at Sakha; from 207.75 (cross L-2 x Gm-1002) to 233.25 cm (cross L-4 x Gm-1004) at Mallawy, and from 200.875 (L-1 x Gm-1001) to 232.5 cm (L-7 x Gm-1004) over the two locations. Meanwhile, out of 24 crosses, there were 19 crosses at Sakha and 4 crosses over locations significantly shorter than the check SC-155.

The highest value for ear height was recorded for the cross L-8 x Gm-1004 (131.75 cm), while the lowest ear position (107.75 cm) was recorded for crosses L-1 x Gm-1002 and L-2 x Gm-1001 at Sakha. The shortest cross was L-1 x Gm-1004 measuring 105.75 cm, while the tallest ear placement was L-4 x Gm-1004 which gave 130.75 cm at Mallawy. Moreover, shortest cross (110.0 cm) was L-2 x Gm-1002 while the tallest ear placement (126.75 cm) was recorded for L-4 x Gm-1004 over locations. There were 18 crosses at Sakha and 11 crosses had significantly lower ear placement than the check SC-155 over locations. Similar results were obtained by Abd El-Moula *et al*. (2004).

Grain yield ranged from 11.71 (cross L-8 x Gm-1001) to 23.3 ard/fad. (crosses L-5 x Gm-1004) at Sakha, while it ranged from 19.04 for the cross L-2 x Gm-1002) to 30.69 ard/fad for the cross (L-7 x Gm-1004) at Mallawy and from 17.51 for the (cross L-4 x Gm-

1002) to 24.8 ard/fad for the (cross L-7 x Gm-1004) over locations. The best yielding crosses were L-2 x Gm-1004, L-3 x Gm-1001, L-4 x Gm-1001, L-4 x Gm-1004, L-6 x Gm-1001, L-6 x Gm-1002, L-6 x Gm-1004, L-7 x Gm-1002, L-7 x Gm-1004 and L-8 x Gm-1002 at Mallawy and (L-5 x Gm-1004 and L-7 x Gm-1004 over locations which surpassed the check SC-155 by 26.82, 21.54, 30.10, 34.96, 24.33, 29.45, 21.74, 31.03, 45.65 and 20.32% at Mallawy and by 14.67 and 19.53% over locations, respectively. Over the two locations, the two crosses (L-5 x Gm-1004) and (L-7 x Gm-1004) significantly exceeded the check SC-155. Similar results were obtained by Abd El-Moula *et al*. (2004) and Abd El-Moula and Ahmed (2006).

Estimation of general (GCA) and specific combining ability (SCA) effects:

General combing ability (GCA) effects of the eight inbred lines and the three testers for the studied traits at Sakha, Mallawy and over locations are presented in Table (3).

Negative and significant GCA effects were obtained for inbred lines L-2, L-3 and L-5 at Sakha, Mallawy and over locations for silking date. Regarding to plant height, the inbreds L-1 and L-4 had negative and significant GCA effects. Negative desirable GCA effects were detected for lines L-2 and L-6 at Sakha, Mallawy and over locations for ear height. Generally, lines L-3 and L-5 manifested positive and significant GCA effects at Sakha Mallawy and over locations for grain yield/fed.

Results in Table (3), revealed that the tester line Gm1002 was a good general combiner for days to 50% silking and grain yield. Meanwhile, tester Gm1001 was good general combiner for plant and ear height at Sakha, Mallawy and over locations.

Estimates of SCA effects for the studied traits are presented in Table (4). For days to 50% silking, three crosses, namely L-1 x Gm-1002, L-4 x Gm-1001 and L-7 x Gm-1004 at Sakha, Mallawy and across locations and the cross L-8 x Gm-1002 at Sakha and L-8 x Gm-1001 at Mallawy had negative and significant SCA. Negative SCA effects were also detected for plant height for crosses L-6 x Gm-1001 at Sakha and L-6 x Gm-1004 at Mallawy. Only one cross (L-5 x Gm-1002) showed negative and significant SCA effects for plant height at Mallawy. Positive and significant SCA effects were detected for the crosses L-1 x Gm-1004 and L-8 x Gm-1002 at each station and over locations, L-3 x Gm-1001 and (L-5 x Gm-1004 at Sakha and L-4 x Gm-1001 over locations for grain yield.

Variance components

Estimates of combining ability variances δ^2 GCA for tested lines and testers as well as δ^2 SCA for each location and their interaction

with locations are presented in Table (5) and (6).

Results revealed that values of δ^2 GCA for testers was higher than δ^2 GCA for lines for plant height and grain yield at Sakha and Mallawy and plant height over locations. The magnitude of the variance due to specific combining ability (SCA) was larger than that obtained for general combing ability (GCA) for silking date and grain yield at Sakha and over locations, and silking date and ear height at Mallawy. This indicates that the non-additive genetic variance was predominant and played the major role in the in heritance of these traits. The variances due to δ^2 GCA x Loc for testers were larger in magnitude than δ^2 GCA x Loc for lines, indicating that the tested inbred lines were much more affected by the environmental conditions than testers. The magnitude of δ^2GCA × Loc was larger than δ^2 SCA × Loc for ear height and grain yield. These results indicated that the additive gene effects interacted more with the environment than non-additive. Meanwhile, the magnitude of δ^2SCA × Loc was larger than δ^2 GCA × Loc for silking date and plant height. These results indicated that the non-additive gene effects interacted more with the environment than additive

Table(5): Estimates of general (GCA) and specific combining ability (SCA) variances at Sakha and Mallawy for grain yield and other traits.

Trait	Sakha				Mallawy			
	δ^2 GCA lines	δ^2 GCA testers	δ^2 GCA	δ^2 SCA	δ^2 GCA lines	δ^2 GCA testers	δ^2 GCA	δ^2 SCA
Silking date	2.346	1.136	1.848	2.102	0.899	0.325	0.732	1.378
Plant height	4.794	100.690	87.776	72.821	4.269	13.991	13.435	11.526
Ear height	25.544	15.899	19.412	4.861	7.179	1.118	3.645	4.809
Grain yield	-0.144	1.626	1.992	4.672	2.561	3.370	3.696	3.006

Table(6): Combined estimates of general (GCA) and specific combing ability (SCA) variance for grain yield and other traits.

Trait	δ^2 GCA				δ^2 GCA	δ^2 GCA x Loc.	δ^2 SCA	δ^2 SCA x Loc
	Lines	Testers	L x Loc.	T x Loc.				
Silking date	1.098	0.728	0.524	0.005	0.827	0.150	1.318	0.422
Plant height	15.881	35.831	.-11.350	21.510	30.389	12.548	14.742	27.438
Ear height	15.364	2.690	0.997	5.818	6.147	4.503	5.992	-1.157
Grain yield	0.765	-2.015	0.514	4.617	-1.257	3.498	2.455	1.359

These results are in agreement with those obtained by, Singh and Singh (1998), Barakat *et al*. (2003), Abd El-Moula *et al*. (2004), Abd El-Moula (2005), Motawei *et al*. (2005), Abd El-Moula and Ahmed (2006) and Amer and El-Shenawy (2007) who reported that the non-additive genetic variance interacted more with the environment than the additive component. On the other hand Sadek *et al.* (2000), Soliman *et al*. (2001), and El-Morshidy *et al*. (2003), reported that SCA or non additive genetic effects played an important role in the inheritance of grain yield, silking date, plant length and ear height.

Different findings were reported by Jha and Khehra (1992), Abed El-Aziz *et al*. (1994), Mostafa *et al*. (1996), San Vicente *et al*. (1998), Konak *et al*. (1999) and Abd El-Hamid (2004) who found that non additive gene action was predominant for such trait.

It could be concluded that, the promising inbred lines L-3 and L-5 were possessed best GCA effects for grain yield, should be immediately utilized in hybridization program to improve maize productivity. Moreover, The crosses L1 x Gm-1004, L2 x Gm-1004, L3 x Gm-1001, L3 x Gm-1002, L4 x Gm-1001, L4 x Gm-1004, L5 x Gm-1002, L5 x Gm-1004, L6 x Gm-1002, L7 x Gm-1002, L7 x Gm-1004 and L8 x Gm-1002 which yielded more than the best check Sc-155 in grain yield should be further tested for the possibility of regestration as commercial release.

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قدرة التآلف للمحصول ومكوناته فى سلالات جديدة من الذرة الشامية الصفراء

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هجنت 8 سلالات من الذرة الشامية مع 3 كشافات مختلفة وراثيا وهي جميزة 1001 و جميزة 1002 وجميزة 1004وذلك في محطة بحوث ملوي في موسم 2005 . تم تقييم 24 هجين قمي مع صنف المقارنة هجين فردي 155 في كل من محطة البحوث الزراعية بسخا و ملوي في موسم 2006 لصفات عدد الأيام حتي ظهور 50% من الحراير وارتفاع النبات والكوز ومحصول الحبوب بالأردب للفدان . وقد أظهرت النتائج اختلافات معنوية بين المواقع للصفات المدروسة كذلك وجدت أختلافات معنوية بين الهجن القمية ومجزئاتها ، السلالات والكشافات لكل الصفات المدروسة بسخا والتحليل المشترك في ما عدا صفه ارتفاع الكوز والتفاعل بين السلالات و الكشافات في محطة بحوث سخا، كما وجدت اختلافات معنوية بين الهجن والسلالات والكشافات والتفاعل بينهما لصفتي عدد الأيام حتى ظهور 50% من الحراير ومحصول الحبوب بمحطة بحوث ملوي. وأيضاً وجدت اختلافات معنوية بين المواقع والتفاعل بين المواقع والهجن القمية والمواقع والسلالات لكل من صفة التزهير ومحصول الحبوب.

كما كان التفاعل بين الكشافات والمواقع كان معنويا لصفة ارتفاع النبات ومحصول الحبوب وأظهرت السلالات 3 ، 5 أعلى قدرة عامة ومرغوبة لصفة محصول الحبوب

وكانت السلاله جميزه 1002 افضل كشاف لتأثير القدرة العامة علي الأئتلاف لصفة محصول الحبوب و عدد الأيام حتى ظهور 50% من الحراير ولكن السلالة جميزه 1001 افضل كشاف لتأثير القدرة العامة علي الأئتلاف لصفتي ارتفاع النبات والكوز.

كان التباين الوراثي غير المضيف هو الأكثر تحكما في توريث صفات عدد الأيام حتى ظهور 50% من الحراير ومحصول الحبوب بسخا والتحليل المشترك ، وصفة عدد الأيام حتى ظهور 50% من الحراير و ارتفاع الكوز بملوي.

كان سلوك التباين الوراثي المضيف أكثر تأثيرا بالمواقع علي صفتي ارتفاع الكوز ومحصول الحبوب ، بينما كان التباين الوراثي غير المضيف أكثر تأثيرا بالمواقع على صفتي عدد الأيام حتى ظهور 50% من الحراير و ارتفاع والكوز.