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A STUDY ON COMBINING ABILITY OF NEW YELLOW MAIZE INBRED LINES USING LINE X TESTER ANALYSIS

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ABSTRACT

This study was carried out at two locations (Gemmeiza and Mallawy), in Egypt during summer of 2004. The resulting top crosses from crossing twenty inbred lines with two line testers (Gm. 1021 and Gm. 1002) and two checks (S.C. 155 and S.C. 3080) were evaluated in summer season of 2005.Mean squares due to locations were significant for all studied traits except, ear height and number of kernels/row. Variances due to crosses and their partitioning (lines, testers and line x testers) were significant for most studied traits. Additive and non-additive gene action played an important role in the inheritance of all the studied traits, while, non-additive gene action was more influenced by locations than additive gene action for most studied traits. The inbred lines Gm.(359, 362, 364, 367, 368) exhibited highly significant and desirable GCA effects for most studied characters and grain yield, while, the inbred line Gm. 370 gave significant and desirable GCA effects towards earliness and dwarfness. The highest mean performance of crosses for grain yield were obtained from the cross Gm. 363 x Gm. 1021 (36.10 ard./fed.) and the cross Gm. 364 x Gm. 1021 (33.10 ard./fed.) relative to inbred line Gm. 1021 as tester, while, the cross Gm. 364 x Gm. 1002 (32.6 ard./fed.) and the cross Gm.365 x Gm.1002(32.7 ard./fed.) relative to inbred line Gm.1002 as tester. These top crosses outyielded and earlier than the two commercial hybrids S.C.155 (27.9 ard./fed.) and S.C. 3080 (29.4 ard./fed.). Moreover, twenty top crosses gave higher values from the commercial hybrid S.C.155, while, seventeen top crosses gave higher values from the commercial hybrid S.C. 3080 relative to grain yield trait. The relative increasing percentage of grain yield (ard./fed.) for the top crosses inbred line Gm.1021 as tester , ranged from – 18.28% to 29.39% and form – 22.45% to 22.79% relative to S.C.155 and S.C.3080, respectively. The highest percentage values of the relative increasing for the top crosses with inbred line Gm.1021as tester were obtained form the crosses (Gm. 352 x 1021) , (Gm. 363 x 1021) and (Gm. 364 x 1021). The relative increasing percentage of grain yield for the top crosses with inbred line Gm.1002 as tester, ranged form – 22.22% to 17.2% and form – 25.85% to 11.22% relative to S.C. 155 and S.C. 3080, respectively. The highest percentage values of the relative increasing for the top crosses with inbred line Gm.1002 as tester were obtained form the crosses(Gm. 364 x 1002) and (Gm. 365 x 1002) . These crosses could be involved in maize breeding program to improve early maturity, disease resistance and higher grain yield.

Keywords: Maize, Zea mays L., Line x tester, Combining ability, Gene action, Top crosses.

INTRODUCTION

In recent years, maize breeder hopes to increase the national production of maize through the development of new high yielding hybrids with resistant to maize diseases especially, late wilt disease. Allison and Curnow (1966) showed that the best tester as one that capable of giving the highest grain yield of its resulting top cross. Obtaining a high yielding maize hybrid is based mainly on development of better inbred lines as reported by Jenkins (1978). Although, the line tester had the narrowest genetic and lowest yield potentiality although it gave maximum genetic variation in the top crosses for most traits. However, it could be indicated that the inbred lines considered as effective tester for evaluating inbred lines. Moreover, some investigators i.e. Mahmoud (1996), Soliman and Sadek (1999). Mosa *et al.* (2004), Amer (2004) and Ibrahim and Osman (2005) found that the estimates of additive gene type played an important role in the inheritance of grain yield, ear position, resistance to late wilt disease while, others i.e. Lonnquiest and Gardener (1961), Ibrahim (2001) and Mosa (2001) found that The estimates of non-additive gene type played an important role relative to plant height, ear height and number of rows / ear in this respect. Also, Venugopal *et al.* (2002) found that δ^2 SCA x loc. was greater than δ^2 GCA for most studied traits.

The main objectives of this study were (1) to estimate combining ability for the twenty inbred lines .(2) to determine the additive and non-additive gene action.(3) to identify the superior inbred lines, good top crosses and calculating the relative increasing percent form the crosses relative to the two checks hybrids(S.C. 155 and S.C. 3080).

MATERIALS AND METHODS

New twenty yellow inbred lines of maize derived from composite. 21 population were developed to 8^{th} generations at Gemmeiza Agricultural Research Station. These lines are ; Gm. 351, Gm. 352, Gm. 353, G. 354, Gm. 355, Gm. 356, Gm. 357, Gm. 358, G. 359, Gm. 360, Gm. 361, Gm. 362, Gm. 363, Gm. 364, Gm. 365, Gm. 366, Gm. 367, Gm. 368, Gm. 369 and Gm. 370 and crossed with two famous testers (Gm. 1021 and Gm. 1002) as good inbred lines to produce forty top crosses during 2004 season. In 2005 season, the forty top crosses plus two checks (S.C. 155 and S.C. 3080) were evaluated at Gemmeiza and Mallawy Agricultural Research Stations, Agricultural Research Center (ARC) in Egypt. These materials are fixed and distributed in a Randomized Complete Block Design with four replications, plot size was one row, 6 m length, 80 cm apart and 25 cm between hills. Recommended agricultural practices for maize production were done at the proper time and data recorded on days to 50% silking (days), plant height (cm), ear height (cm), ear position % (means the ratio between ear height and plant height), resistance to late wilt disease (%) , grain yield (ard./fed.) adjusted to 15% grain moisture content, ear length (cm), ear diameter (cm), number of rows/ear and number of kernels/row at the proper time. Statistical analysis of the combined data over two locations was performed according to Steel and Torrie (1980), while, combining ability analysis was computed using the line x tester procedure suggested by Kempthorne (1957). Combined analysis among the two locations was done based on the homogeneity test.

RESULTS AND DISCUSSION

Mean ($\overline{X}$), environmental error (δ^2 e) and coefficient of variability (C.V%) for the ten studied traits are shown in Table 1. Mallawy location exhibited higher and favorable mean than Gemmeiza location for most studied traits except, plant height trait. Also, all the studied traits showed higher values for coefficient of variability (C.V.%) under Mallawy location comparing to Gemmeiza location except, plant height, ear position and resistance to late wilt disease. It could be noted that 70 % of the studied characters at Mallawy location had higher environmental variances, this indicated that the genotypes differ from location to another or there was stress environment as reported by Balko and Russell (1980), El Zeir *et al*. (1993), Esmail *et al*. (1994) and Singh *and Singh.* (1998).

Table (1): Mean ($\overline{X}$), environmental error (δ^2 e) and coefficient of variability (C.V.%) for the ten studied traits at Gemmieza and Mallawy and their combined analysis.

Traits	Days to 50% silking (day)	Plant height (cm)	Ear height (cm)	Ear position (%)	Resist-ance to late wilt (%)	Ear length (cm)	Ear Diameter(cm.)	Number of rows/ear	Number of kernels/row	Grain yield (ard/ fed)
Gemmieza										
$\overline{X}$	54.71	261.18	145.60	55.84	99.26	16.63	4.78	15.65	37.50	27.50
δ^2 e	0.66	189..97	66.32	22.54	1.21	1.04	0.10	0.81	8.90	6.89
C.V. %	1.48	5.28	5.59	8.50	1.11	6.13	6.62	5.75	7.96	9.55
Mallawy										
$\overline{X}$	62.60	258.54	146.10	56.57	99.80	19.84	5.66	15.68	41.68	28.58
δ^2 e	0.94	135.82	81.10	13.52	0.93	3.43	0.20	1.13	10.86	9.44
C.V. %	1.55	4.50	6.16	6.50	0.97	9.33	9.35	6.78	9.55	10.75
Combined										
$\overline{X}$	58.66	259.86	145.85	56.21	99.53	18.23	5.22	15.66	39.59	28.04
δ^2 e	0.80	162.9	73.70	18.03	1.07	2.24	0.15	0.97	9.88	8.17
C.V. %	1.52	4.91	5.89	7.55	1.04	8.20	8.35	6.29	7.94	10.19

Mean squares of combined analysis for ten studied traits are presented in Table 2. Significant differences were found between the two locations for most traits, except ear height and number of rows/ear. This due to the two locations differences as a result for environmental variations and soil conditions.

Mean squares due to crosses were significant for all studied traits, except ear diameter. Partitioning mean squares due to lines (L) indicated significant crosses for all traits. Meanwhile, mean squares due to testers (T) were significant for some traits i.e. days to 50% silking, ear position, resistance to late wilt disease, number of rows/ear and grain yield. Mean squares due to lines x testers (L x T) were significant for all the studied traits, except ear position, ear length and ear diameter. On the other hand, mean squares due to crosses x loc. and due to lines x loc. were significant for days to 50% silking, plant height, ear height, resistance to late wilt disease and grain yield.

T2

t3

t3

Mean squares for testers x loc. were significant for resistance to late wilt disease and number of kernels/row, while, mean squares due to (L x T x loc.) were significant for days to 50% silking, resistance to late wilt disease and grain yield. These results indicated that the genotypes (crosses), their partitioning and their partitioning x locations differed form location to another, indicating that there were a fair amount of genetic variability among those items and their parts. These results were at the same order as reported by El-Zeir (1999), Amer *et al.* (2003).

Mean performance of crosses for ten traits as an average over two locations (Gemmeiza and Mallawy) are shown in Table 3. The mean values of crosses for grain yield ranged form (21.8 ard./fed.) for the cross Gm. 351 x Gm. 1002 to (36.1 ard./fed.) for the cross Gm. 363 x Gm.1021. Twenty crosses gave higher values from the commercial hybrid S.C. 155, while, seventeen crosses gave higher values from the commercial hybrid S.C. 3080. The highest mean values of crosses for grain yield were obtained from the cross Gm. 363 x Gm. 1021 (36.1 ard./fed.) followed by the cross Gm. 364 x Gm. 1021 (33.1 ard./fed.) , the cross Gm. 365 x Gm.1002(32.7 ard./fed.) and the cross Gm.364 x Gm.1002(32.6 ard./fed.).These top crosses outyielded than the commercial hybrids S.C. 155 (27.9 ard./fed.) and S.C. 3080 (29.4 ard./fed.),while, the remaining traits gave results as follows : The latest cross as compared with the two single crosses was Gm.352 x Gm.1021(61.9 days), meanwhile ,the earliest cross was Gm. 365 x Gm. 1021 (57.0 days). As for late wilt resistance, it could be noted that twelve crosses were highly of 100 %, twelve top crosses had lower ear height, ten top crosses possess the tallest ear as compared to the two single crosses which are used as checks , five top crosses gave the thinnest ear diameter than the two check crosses, thirteen top crosses gave higher of number of rows/ear and fourteen top crosses exhibited higher values for number of kernels /row than the two single crosses i.e.,S.C.155 and S.C.3080.These results are of a great interest for maize breeder to obtain the ideal genotype of maize which are early nature, resistance to late wilt and higher grain yield.

As general, the mean values for most of the top crosses including inbred line Gm.1021 as tester were higher for grain yield and most of the studied traits than those included inbred line Gm. 1002 as tester. Regarding to (Table 4) which indicated that the two testers were markedly differed in their yielding ability and for evaluating the lines. Correlation Coefficient value suggested also that the two testers were markedly differed in their yielding ability and the ranking of the lines. Similar conclusions were obtained by Rawlings and Thompson (1962), Diab *et al*., (1994) and Ibrahim *et al.,* (2007), who pointed out that a good tester should have precision in discriminating among genotypes under this study.

Table (4): Lines rank of the two testers based on the combined data for grain yield (ard/fed).

Lines	Testers	
	Gm. 1021	**Gm. 1002**
Gm. 351	20	20
Gm. 352	3	8
Gm. 353	4	19
Gm. 354	10	15
Gm. 355	5	18
Gm. 356	8	11
Gm. 357	18	9
Gm. 358	16	14
Gm. 359	17	4
Gm. 360	19	7
Gm. 361	9	17
Gm. 362	15	13
Gm. 363	1	6
Gm. 364	2	2
Gm. 365	11	1
Gm. 366	7	3
Gm. 367	6	10
Gm. 368	13	16
Gm. 369	14	5
Gm. 370	12	12

Correlation coefficient between the two testers. r = 0.26

Estimates of variance for general (K^2 GCA) and specific (K^2 SCA) combining ability and their interaction with the two locations are given in Table 5. The results showed that K^2 GCA for plant height ,ear height ,ear position, resistance to late wilt disease and grain yield was higher than K^2 SCA, while, the other traits gave the reverse.

These results indicated the importance of both additive and non-additive gene action in the inheritance of these studied traits.On the other side, the magnitude of the interaction for K^2 SCA x loc. was markedly higher than K^2 GCA x loc. for days to 50% silking, plant height, ear height, ear position, resistance to late wilt and grain yield, while, the reverse results were obtained for other studied traits. These results indicated that the non-additive gene action was more sensitive to location differences than additive one for the remaining traits. Similar results were obtained by El-Zeir (1999), Nawar and El-Hosary (1984), Mahmoud (1996), Mosa (2001), Ibrahim (2001) and Amer (2004) for most studied traits and grain yield.

General combining ability effects for the 20 inbred lines and two testers over two locations are presented in Table 6. Variances of inbred lines gave desirable GCA effects which refer that these inbred lines could be involved in breeding program to improve these characters and develop new top crosses to be distributed and cultivated under Egyptian conditions i.e.; inbred lines Gm.(355, 357 , 359 , 361and 368) for grain yield , 7 inbred lines for days to 50% silking , 3 inbred lines for plant height , 8 inbred lines for ear height. Moreover, the inbred line Gm.370 exhibited desirable significant towards earliness and dwarfness , inbred line Gm. 364 for ear position , inbred line Gm. 365 for resistance to late wilt disease, inbred lines Gm.(363 and 367) for ear length , inbred lines Gm.(367 and 368) for ear diameter, inbred lines Gm.(354 , 355 and 356) for number of rows/ear , inbred lines Gm.(357, 362 , 363 and 367) for number of kernels/row trait on the same order. While, on the other hand, highly significant and desirable GCA effects for the testers were obtained from line tester Gm. 1021 for grain yield. This result showed that the inbred line Gm.1021 as tester had a high frequency of favorable dominant alleles, which contributed to the yield of top crosses. In this respect, superiority of crosses as good testers were noticed by Sokolov and Kostyuchenco (1978), Mosa *et al.* (2004) and Ibrahim *et al*. (2007).

Specific combining ability effects for 40 top crosses over the two locations (Gemmeiza and Mallawy) for the studied traits are shown in Table 7. The results showed that six single crosses possess desirable SCA effects and could be involved in breeding program to improve these characters. Single cross Gm.359 x Gm.1002 possess desirable SCA effects for plant and ear heights as well as number of rows/ear . Single cross Gm.351 x Gm.1002 had desirable SCA effects for earliness and grain yield. Single cross Gm.360 x Gm.1021 contained significant and desirable SCA effects for plant and ear heights. Single cross Gm.360 x Gm.1002 had positive and significant SCA effects for rows/ear and grain yield. Significant and desirable SCA effects were detected for cross Gm.365 x Gm.1002 for resistance to late wilt disease ,while, the cross Gm.369 x Gm.1002 gave negative and significant SCA effects for plant height , ear height and resistance to late wilt at the same time . These crosses are considered fruitful and promising to could be involved in breeding program of maize.

The relative increasing percentage for the top crosses relative to the two check hybrids (S.C.155 and S.C.3080) for grain yield form combined data are presented in table (8). For the top crosses with inbred line Gm. 1021 as tester, relative increasing ranged form – 18.28 to 29.39 and form – 22.45 to 22.97 to the two check hybrids (S.C.155 and S.C.3080), respectively. Out of 20 crosses under this study three crosses (18%) were significantly higher than the two check hybrids S.C.155 and S.C. 3080 . Increasing percentage of grain yield (ard/fed) for the three crosses i.e., (Gm. 352 x 1021), (Gm. 363 x 1021) and (Gm. 364 x 1021) relative to the two check S.C. 155 and S.C. 3080 ranged form 5.73% to 29.39 and form 4.76% to 22.79% respectively. For the top crosses with inbred line Gm. 1002 as tester, relative increasing ranged form – 22.22% to 17.2 and from – 25.85% to 11.22% relative to S.C.155 and S.C. 3080, respectively .Out of 20 crosses two crosses (14%) were significantly higher than two check hybrids. Increasing percentage of the two crosses (Gm.364 x 1002) and (Gm. 365 x 1002) relative to S.C.155 and S.C. 3080 ranged form 5.73% to 17.20% and form 10.88% to 11.22%, respectively.

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Table (8): Increasing percentage for crosses relative to the two check hybrids for grain yield (ard./fed.) form combined data.

Lines	S.C. 155		S.C. 3080	
	Gm. 1021	Gm. 1002	Gm. 1021	Gm. 1002
Gm. 351	-18.28**	-21.86**	-22.45**	-25.85**
Gm. 352	15.77**	-0.72	9.86**	-5.78**
Gm. 353	13.98**	-22.22**	8.16**	-19.39**
Gm. 354	6.09**	-9.68**	0.68	-14.29**
Gm. 355	13.26**	-13.62**	7.48**	-18.03**
Gm. 356	10.39**	-6.09**	4.76**	-10.88**
Gm. 357	-10.04**	-4.30**	-14.63**	-9.18**
Gm. 358	-8.24**	-9.32**	-12.93**	-13.95**
Gm. 359	-8.60**	7.98**	-13.27**	2.38
Gm. 360	-0.15	1.43	-19.05**	-3.74**
Gm. 361	7.89**	-13.26**	2.38	-17.69**
Gm. 362	-4.30**	-6.81**	-9.18**	-11.56**
Gm. 363	29.39**	5.73**	22.79**	0.34
Gm. 364	18.64**	16.85**	12.59**	10.88**
Gm. 365	5.73**	17.20**	0.34	11.22**
Gm. 366	11.11**	8.24**	5.44**	2.72
Gm. 367	11.47**	-5.38**	5.78**	-10.20**
Gm. 368	1.79	-11.11**	-3.40**	-15.65**
Gm. 369	-0.36	7.17**	-5.44*	1.70
Gm. 370	2.51	-6.45**	-2.72	-11.22**
Mean	4.90**	-3.32*	-1.14	-7.91**

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

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دراسة القدرة على التآلف لسلالات جديدة من الذرة الصفراء باستخدام تحليل السلالة × الكشاف

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تم تهجين عشرين سلالة جديدة من الذرة الشامية الصفراء مع كشافين من السلالات التجارية المعروفة وهما سلالة جميزه ١٠٢١ ، وسلالة جميزه ١٠٠٢ ، وذلك بمحطة البحوث الزراعية بالجميزه خلال الموسم الصيفى ٢٠٠٤م وذلك للحصول على عدد ٤٠ هجين قمى.

تم تقييم الأربعين هجين قمى مع الهجينين التجاريين (هـ٠ ف ١٥٥ ـ هـ٠ ف ٣٠٨٠) كهجن قياسية للمقارنة وذلك بمحطتي البحوث الزراعية بالجميزه (بحرى) ـ ملوى (قبلى) فى موسم ٢٠٠٥م الصيفى.

أخذت القراءات على الصفات التالية: عدد الأيام حتى ٥٠% من ظهورالحريرة(النورة المؤنثة) ـ ارتفاع النبات (سم) ـ ارتفاع الكوز (سم) ـ موقع الكوز% (النسبة بين ارتفاع الكوز الي ارتفاع النبات) ـ نسبة المقاومة لمرض الذبول المتأخر ـ طول الكوز (سم) ـ قطر الكوز (سم) ـ عدد السطور/كوزـ عدد الحبوب/للسطر ـ محصول الحبوب (أردب/فدان). واستخدمت طريقة تحليل السلالة × الكشاف المقترحة بواسطة العالم كمبثورن (١٩٥٧) ويمكن تلخيص النتائج المتحصل عليها علي الوجة التالي:-

1. أظهرت النتائج اختلافات معنوية بين المواقع لكل الصفات المدروسة ماعدا صفتى ارتفاع الكوز وعدد الحبوب/ للسطر.
2. أظهرت الهجن القمية الناتجة فروقا معنوية وكذلك مكوناتها (السلالات ـ الكشافات ـ تفاعل السلالات مع الكشافات) لمعظم الصفات المدروسة.
3. كان للفعل الجيني المضيف والفعل الجيني الغير مضيف أهمية فى وراثة هذه الصفات المختلفة وكان الفعل الجيني الغير مضيف أكثر تأثرا بالمواقع من الفعل الجيني المضيف.
4. أظهرت السلالات جميزة (٣٧٠ ـ ٣٦٧ ـ٣٦٤ ٣ ـ٢ ٣٦ ـ ٣٦٩) تأثيرات معنوية وجيدة لتأثير القدرة العامة على التآلف لصفة المحصول والسلالة جميزه ٣٧٠ أيضاً أظهرت تأثيرات معنوية وجيدة لتأثير القدرة العامة على التآلف لصفة التبكير وقصر النبات.وكذلك أعطت السلالة جميزة ١٠٢١ ككشاف تأثيرات معنوية وجيدة للقدرة العامة على التآلف لصفة المحصول.
5. أعطى٢٠ هجين قمي متوسطات محصولية أعلى من الهجين التجارى هـف ١٥٥ وكذلك أعطى ١٧ هجين قمي متوسطات محصولية أعلى من الهجين التجارى هـف ٣٠٨٠
6. حصلنا على أعلى قيم للمحصول من الهجين جميزه ١٠٢١ × جميزه ٣٦٣ بمحصول (٣٦,١ أردب/فدان) والهجين جميزه١٠٢١ × جميزه ٣٦٤بمحصول (٣٣,١ أردب/فدان) بالنسبة للسلالة جميزة ١٠٢١ ككشاف- بينماأعطت الهجن جميزه ١٠٠٢ × جميزه ٣٦٥ بمحصول (٣٢,٧ إردب/فدان) ثم الهجين جميزه ١٠٠٢× جميزه ٣٦٤ بمحصول (٣٢,٦إردب/فدان) بالنسبة للسلالة جميزة ١٠٠٢ ككشاف وكانت هذة الهجن أعلى قيما من الهجينين التجاريين المستخدمين كأصناف قياسية للمقارنة وهما هجين فردى ١٥٥ (٢٧,٩ اردب/فدان) وهجين فردى٣٠٨٠ (٢٩,٤ اردب/فدان) وذلك بالنسبة لصفة محصول الحبوب/فدان و بعض الصفات الأخرى مما يدل على تفوق السلالة الكشاف جميزة ١٠٢١ عن السلالة الكشاف جميزة ١٠٠٢ بالنسبة لصفة المحصول وبعض الصفات الاخرى.
7. تراوحت قيم النسبة المئوية للزيادة المحصولية للهجن القمية مع السلالة جميزة ١٠٢١ ككشاف من -١٨,٢٨% إلى ٢٩,٣٩ %ومن -٢٢,٤٥% إلى ٢٢,٧٩ %وذلك لصنفى المقارنة وهما هجين فردى١٥٥ وهجين فردى٣٠٨٠ على التوالى.واعلى قيم للنسبة المئوية للزيادة المحصولية كانت للسلالات المشتركة مع السلالة جميزة ١٠٢١ ككشاف وكانت من الهجن جميزة ١٠٢١ × جميزة ٣٦٣ وجميزة ١٠٢١× جميزة٣٦٤.
8. تراوحت قيم النسبة المئوية للزيادة المحصولية للهجن القمية مع السلالة جميزة ١٠٠٢ ككشاف من -٢٢,٢٢% إلى ١٧,٢ % ومن -٢٥,٨٥% إلى ١١,٢٢ وذلك بالنسبة لصنفى المقارنة وهما هجين فردى١٥٥ وهجين فردى٣٠٨٠ على التوالى.واعلى قيم للنسبة المئوية للزيادة المحصولية كانت للسلالات المشتركة مع السلالة جميزة١٠٠٢ ككشاف وكانت من الهجن جميزة١٠٠٢ × جميزة٣٦٤ وجميزة ١٠٠٢× جميزة٣٦٥.
9. لذا وعلى ضوء هذه النتائج نوصى بإمكانية استخدام هذه الهجن فى برنامج تربية محصول الذرة الشامية حيث تعتبر هذه الهجن جيدة ومبشرة ومتفوقة على الهجن الفردية التجارية والمستخدمةكأصناف قياسية فى هذة الدراسة.

Table (2): Analysis of variance for the ten studied traits of the combined data under two locations (Gemmeiza and Mallawy) during summer season of 2005.

S.O.V.	D.F	Mean squares									
		Days to 50% silking (day)	Plant height (cm.)	Ear height (cm.)	Ear position (%)	Resistance to late wilt (%)	Ear length (cm.)	Ear diameter (cm.)	Number of Rows/ear	Number of kernels/ row	Grain yield (ard./fed.)
Locations	1	4984.90**	559.15*	21.01	41.00*	23.11**	385.00**	70.31**	0.02	1399.50**	91.42**
Reps/locations	6	2.065	513.44	149.90	64.15	3.22	2.91	0.33	0.76	12.02	42.63
Crosses (Cr)	39	8.53**	678.75**	597.11**	43.04*	7.51**	5.43**	0.20	4.13**	42.35**	85.76**
Lines (L)	19	12.38**	877.82**	849.23**	68.00**	8.03**	7.30**	0.42*	2.85**	58.00**	96.39**
Testers (T)	1	6.33*	6.90	115.20	44.25*	12.01**	0.20	0.01	2.28*	16.20	409.51**
L x T	19	4.79**	515.04*	370.35**	18.02	6.75**	3.83	0.39	5.50**	28.08*	58.09**
Cr x Loc.	39	1.95*	518.38*	299.71**	34.44	6.93**	2.26	0.11	1.16	16.14	50.07**
L x loc.	19	2.23*	607.63**	421.81**	38.06	7.73**	2.68	0.04	1.50	23.54	37.77**
T x loc.	1	1.13	226.14**	130.05	7.51	6.06**	0.31	0.04	0.16	33.36**	3.21
L x T x loc.	19	1.71	444.52*	186.54	32.23	6.18**	1.94	0.03	0.88	7.84	64.83**
Error	234	0.80	16.209	73.70	18.03	1.07	2.24	0.19	0.97	9.88	8.17

***, ** refer to 0.05 and 0.01 level of significantly, respectively**

Table (3): Mean performance of 40 top crosses of maize for the ten studied traits of maize under the two different locations.

Top crosses	Days to 50% Silking (day)	Plant height (cm)	Ear height (cm)	Ear Position (%)	Resistance to late wilt (%)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/row	Grain yield (ard./fed.)
Gm. 351 x Gm. 1021	60.5	257.4	148.9	56.70	96.60	19.0	4.9	15.4	38.1	22.8
Gm. 351 x Gm. 1002	59.6	255.1	141.0	55.30	94.00	18.0	5.0	15.8	39.2	21.8
Gm. 352 x Gm. 1021	61.9	269.4	158.4	58.90	99.80	17.5	4.9	15.7	37.9	32.3
Gm. 352 x Gm. 1002	59.3	260.4	143.4	55.25	100.00	18.0	5.1	16.3	38.6	27.7
Gm. 353 x Gm. 1021	58.1	259.4	146.4	56.40	100.00	19.1	5.2	15.8	39.5	31.8
Gm. 353 x Gm. 1002	58.9	254.9	131.5	51.60	100.00	18.1	5.4	16.3	37.7	23.7
Gm. 354 x Gm. 1021	58.9	270.9	155.3	57.30	100.00	18.8	5.5	15.0	40.1	29.6
Gm. 354 x Gm. 1002	57.5	251.8	137.1	54.40	99.80	17.5	5.3	15.4	37.6	25.2
Gm. 355 x Gm. 1021	57.1	264.5	144.4	54.60	99.80	19.6	5.3	15.2	42.0	31.6
Gm. 355 x Gm. 1002	57.3	249.3	132.9	53.30	93.00	19.2	5.2	14.9	37.3	24.1
Gm. 356 x Gm. 1021	58.3	260.5	143.0	54.90	99.80	19.9	5.3	15.2	40.7	30.8
Gm. 356 x Gm. 1002	57.4	251.1	135.3	53.80	99.80	18.5	5.1	15.4	41.1	26.2
Gm. 357 x Gm. 1021	60.3	266.8	154.0	57.80	98.40	20.7	5.2	16.0	46.3	25.1
Gm. 357 x Gm. 1002	58.6	255.1	137.6	53.90	100.00	19.0	5.1	14.7	39.1	26.7
Gm. 358 x Gm. 1021	59.0	263.4	155.0	58.90	94.80	18.7	4.9	15.1	40.7	25.6
Gm. 358 x Gm. 1002	58.3	252.3	136.3	54.00	99.80	19.7	5.0	15.6	40.3	25.3
Gm. 359 x Gm. 1021	59.8	274.1	155.5	56.80	98.10	19.8	5.2	14.9	42.4	25.5
Gm. 359 x Gm. 1002	58.6	267.3	150.6	56.30	99.90	18.6	5.1	16.6	40.6	30.1
Gm. 360 x Gm. 1021	59.0	264.0	156.5	59.20	97.30	18.0	5.1	17.4	39.1	23.8
Gm. 360 x Gm. 1002	57.6	252.8	144.3	57.10	99.80	17.8	5.3	16.1	37.4	28.3
Gm. 361 x Gm. 1021	58.5	253.1	143.1	56.50	99.50	19.8	5.2	15.4	40.6	30.1
Gm. 361 x Gm. 1002	58.0	249.5	132.1	52.90	99.90	18.8	5.2	15.6	38.1	24.2
Gm. 362 x Gm. 1021	59.8	262.3	161.5	61.70	99.90	18.7	5.4	16.1	39.0	26.7

Table (3): Count.

Top crosses		**Days to 50% Silking (day)**	**Plant height (cm)**	**Ear height (cm)**	**Ear position (%)**	**Resistance to late wilt (%)**	**Ear length (cm)**	**Ear diameter (cm)**	**Number of rows/ear**	**Number of kernels/ row**	**Grain yield (ard./fed.)**
Gm. 362 x Gm. 1002		58.5	254.1	142.0	55.90	100.00	17.3	5.1	16.1	33.0	26.0
Gm. 363 x Gm. 1021		59.6	268.3	153.5	57.20	99.90	17.9	5.3	16.4	38.9	36.1
Gm. 363 x Gm. 1002		59.6	270.5	149.3	55.30	100.00	18.6	5.3	16.3	39.9	29.5
Gm. 364 x Gm. 1021		59.3	276.4	160.4	58.00	99.50	19.7	5.4	16.6	44.0	33.1
Gm. 364 x Gm. 1002		58.6	260.3	146.6	56.60	99.90	18.7	5.2	15.7	38.8	32.6
Gm. 365 x Gm. 1021		57.0	245.3	131.3	53.70	99.90	17.9	5.3	16.7	37.4	29.5
Gm. 365 x Gm. 1002		58.0	268.1	148.6	55.40	99.50	18.7	5.3	16.7	40.6	32.7
Gm. 366 x Gm. 1021		59.0	267.1	161.1	60.30	99.00	18.8	5.2	15.6	38.1	31.0
Gm. 366 x Gm. 1002		57.4	259.0	144.6	55.90	100.00	18.8	5.2	15.2	41.6	30.2
Gm. 367 x Gm. 1021		59.1	256.6	152.3	57.90	99.90	19.1	5.0	15.0	41.6	31.1
Gm. 367 x Gm. 1002		57.3	263.1	137.0	52.10	100.00	18.7	5.0	14.7	38.0	26.4
Gm. 368 x Gm. 1021		59.5	267.6	151.5	56.60	99.40	18.6	5.2	16.3	38.8	28.4
Gm. 368 x Gm. 1002		58.5	255.5	139.5	54.70	100.00	18.9	5.4	16.8	38.7	24.8
Gm. 369 x Gm. 1021		58.5	269.0	150.3	55.90	99.40	20.2	4.8	14.0	43.4	27.8
Gm. 369 x Gm. 1002		57.5	267.5	146.1	54.70	98.90	20.1	4.8	16.7	41.1	29.9
Gm. 370 x Gm. 1021		58.3	240.6	141.4	60.30	100.00	18.6	5.2	14.9	38.1	28.6
Gm. 370 x Gm. 1002		58.3	233.4	136.0	60.20	100.00	17.8	5.1	15.0	37.3	26.1
$\overline{X}$ (crosses)		58.6	259.9	145.8	56.20	99.50	18.8	5.2	15.6	39.6	28.1
Checks	S.C. 155	59.3	258.6	148.6	57.50	100.00	18.9	5.1	15.3	38.4	27.9
	S.C. 3080	59.4	266.3	146.3	55.00	100.00	18.2	5.4	15.0	39.3	29.4
L.S.D. sij-sik	0.05	0.97	14.32	10.09	4.41	0.69	1.47	0.09	0.98	5.30	3.69
	0.01	1.27	18.85	13.28	5.81	0.91	1.93	0.12	1.28	6.97	4.85

Table (5): Variance estimates of general (K^2 GCA) and specific (K^2 SCA) combining ability and their interaction with locations.

Variance	Day to50% silking (day)	Plant height (cm.)	Ear height (c m.)	Ear position (%)	Resistance to late wilt (%)	Ear length (c m.)	Ear diameter (c m.)	Number of rows/ear	Number of kernels/row	Grain yield (ard./fed.)
K^2 GCA	0.022	-11.261@	0.255	0.540	0.029	0.004	- 0.002@	- 0.033@	- 0.204@	2.719
K^2 SCA	0.320	-11.570@	- 6.433@	- 2.505@	- 0.123@	0.144	0.044	0.500	0.568	2.540
K^2GCA/K^2 SCA	0.163	0.973	- 0.040	- 0.216	- 0.236	0.028	- 0.045	- 0.066	- 0.359	1.070
K^2 GCA x loc.	0.001	- 0.628@	2.032	- 0.215@	0.016	-0.009@	0.001	- 0.001@	- 0.112@	-1.008@
K^2 SCA x loc.	0.185	4.000	20.138	2.993	1.068	-0.075@	- 0.075@	-0.028@	- 0.743@	12.670
K^2 GCA x loc. / K^2 SCA x loc.	0.005	-0.157	0.101	- 0.072	0.015	0.120	- 0.013	0.036	0.151	0.080

@ **Variance estimate preceded by negative sign is considered zero.**

Table (6): Estimates of general combining ability effects for lines and testers from the combined data relative to the ten studied traits.

Genotypes	Days to 50% Silking (day)	Plant height (cm)	Ear height (cm)	Ear Position (%)	Resistance to late wilt(%)	Ear length (cm)	Ear diameter	Number of rows/ear	Number of kernels / row	Grain yield (ard./fed.)
Inbred lines:										
Gm. 351	0.853	-0.609	-1.306	0.472	0.038	0.700	-0.034	0.147	-0.256	-1.619
Gm. 352	0.166	-7.547*	-9.244**	-2.153	0.413	-0.425	0.028	-0.103	-1.069	-5.119
Gm. 353	2.166	5.953	14.131	3.909	0.350	-0.613	-0.097	0.022	-1.006	1.444
Gm. 354	0.228	-2.609	-3.119	-0.653	0.475	-1.113	0.091	0.584*	-3.819	-1.244
Gm. 355	0.228	3.953	4.131	0.659	0.413	-0.300	0.153	0.522*	-0.319	5.756**
Gm. 356	0.603	2.828	-5.431*	-2.841*	0.475	-0.550	0.153	0.522*	-0.756	-1.431
Gm. 357	0.416	13.766	12.006	1.534	0.225	0.388	0.216	-0.041	2.494**	3.194**
Gm. 358	-0.584*	-3.859	-3.931	-0.716	0.350	-0.863	0.028	-0.041	-1.381	0.944
Gm. 359	-1.584**	-4.984	-7.994**	-2.028	0.350	0.013	0.153	0.397	0.181	2.444**
Gm. 360	-1.022**	-1.172	-5.056*	-1.903	0.225	0.138	0.153	0.147	-0.569	0.256
Gm. 361	-0.022	3.953	6.256	1.347	-0.150	0.513	0.153	-0.228	-0.131	2.756**
Gm. 362	-1.272**	-4.797	-5.859*	-1.278	0.350	-0.175	0.028	-0.353	1.744*	0.069
Gm. 363	1.041	5.328	7.319**	1.659	-0.400	1.263**	-0.15	-0.103	4.431**	0.006
Gm. 364	-0.709**	-0.734	-8.494**	-3.091**	0.475	0.013	0.091	-0.978	-0.944	-1.431
Gm. 365	0.603	5.641	7.444	1.597	2.463**	0.050	-0.159	-0.103	0.181	-1.056
Gm. 366	-0.272	-5.984	-7.931**	-1.966	0.350	0.450	0.091	0.209	0.056	-2.931
Gm. 367	0.478	11.703	7.069	0.159	-0.775*	1.263**	-0.347**	-0.853	3.306**	-1.431
Gm. 368	-0.5784*	7.516	2.569	-0.653	-0.150	0.638	-0.284**	-0.291	1.306	2.806**
Gm. 369	-0.022	-7.547*	3.131	3.597	-0.900**	-0.333	0.091	0.022	-1.131	-1.806
Gm. 370	-0.709**	-16.797**	-5.681*	2.347	0.350	-0.925	-0.034	0.522	-2.319	-0.869
Testers:										
Gm 1021	0.141	0.147	-0.600	-0.372	-0.194	-0.025	-0.003	-0.084	0.225	1.131**
Gm. 1002	-0.141	-0.147	0.600	0.372	0.194	0.025	0.003	0.084	-0.225	- 1.131
L.S.D. gi lines 0.05	0.481	7.161	5.044	2.206	0.667	0.733	0.215	0.487	1.611	1.843
L.S.D. gi lines 0.01	0.633	9.426	6.640	2.904	0.891	0.965	0.284	0.641	2.121	2.426
L.S.D. gi testers 0.05	0.152	2.265	1.595	0.697	0.214	0.232	0.068	0.154	0.509	0.583
L.S.D. gi testers 0.01	0.200	2.981	2.100	0.918	0.282	0.305	0.090	0.203	0.671	0.767

Table (7): Estimates of the specific combining ability effects for 40 top crosses of combined analysis for the ten studied traits.

Top crosses	Days to 50% Silking (day)	Plant height (cm)	Ear height (cm)	Ear Position (%)	Resistance to late wilt (%)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/ row	Grain yield (ard./fed.)
Gm. 351 x Gm. 1021	0.859*	1.978	1.975	0.559	0.256	-0.538	-0.309*	-0.228	-1.538	-2.656
Gm. 351 x Gm. 1002	-0.859*	-1.978	-1.975	-0.559	-0.256	0.538	0.309	0.228	1.538	2.656*
Gm. 352 x Gm. 1021	0.672*	2.666	5.038	1.684	0.256	-0.413	0.003	0.397	0.275	-0.056
Gm. 352 x Gm. 1002	-0.672*	-2.666	-5.038	-1.684	-0.256	0.413	-0.003	-0.397	-0.275	0.056
Gm. 353 x Gm. 1021	0.922*	3.416	-0.963	-1.128	0.194	-0.600	-0.247	0.022	-0.788	4.006**
Gm. 353 x Gm. 1002	-0.922**	-3.416	-0.963	1.128	-0.194	0.600	0.247	-0.022	0.788	-4.006
Gm. 354 x Gm. 1021	0.234	2.978	1.288	0.059	0.194	0.400	0.066	0.084	2.650**	2.069
Gm. 354 x Gm. 1002	-0.234	-2.978	-1.288	-0.059	-0.194	-0.400	-0.066	-0.084	-2.650	-2.069
Gm. 355 x Gm. 1021	-0.898**	-4.584	-2.963	-0.128	0.256	0.463	-0.122	-0.228	0.025	-1.056
Gm. 355 x Gm. 1002	0.898**	4.584	2.963	0.128	-0.256	-0.463	0.122	0.228	-0.025	1.056
Gm. 356 x Gm. 1021	-0.516	-7.959	-8.275*	-1.378	0.194	-0.163	0.003	0.147	-1.413	-1.744
Gm. 356 x Gm. 1002	0.516	7.959	8.275	1.378	-0.194	0.163	-0.003	-0.147	1.413	1.744
Gm. 357 x Gm. 1021	-0.328	-2.897	-1.963	-0.003	0.444	-0.475	0.066	-0.791	-2.163	-0.619
Gm. 357 x Gm. 1002	0.328	2.897	1.963	0.003	-0.444	0.475	-0.066	0.791*	2.163	0.619
Gm. 358 x Gm. 1021	-0.703*	-4.397	-4.150	-0.628	0.194	-0.600	0.003	-0.166	-0.788	-2.694
Gm. 358 x Gm. 1002	0.703*	4.397	4.150	0.628	-0.194	0.600	-0.003	0.166	0.788	2.694*
Gm. 359 x Gm. 1021	-0.078	9.478	7.163	0.809	0.194	0.900	0.128	-0.728	2.025	2.256
Gm. 359 x Gm. 1002	0.078	-9.478*	-7.163*	-0.809	-0.194	-0.900	-0.128	0.728*	-2.025	-2.256
Gm. 360 x Gm. 1021	-0.516	-9.584*	-7.275*	-0.690	0.444	0.275	-0.003	-0.728	-1.850	-3.056
Gm. 360 x Gm. 1002	0.516	9.584	7.275	0.690	-0.444	-0.275	0.003	0.728*	1.850	3.056*
Gm. 361 x Gm. 1021	-0.516	-3.459	-8.463*	-2.441	0.569	0.525	-0.003	-0.103	-1.088	0.944
Gm. 361 x Gm. 1002	0.516	3.459	8.463	2.441	-0.569	-0.525	0.003	0.103	1.088	-0.944
Gm. 362 x Gm. 1021	-0.141	-4.084	-4.088	-0.691	0.069	-0.163	-0.003	0.147	-0.413	-0.744

Table (7):Count.

Top crosses		Days to 50% silking	Plant height (cm)	Ear height (cm)	Ear position (%)	Resistance to late wilt (%)	Ear length (cm)	Ear diameter (cm)	Number of rows/ear	Number of kernels/row	Grain yield (ard./fed.)
Gm. 362 x Gm. 1002		0.141	4.084	4.088	0.691	-0.069	0.163	0.003	-0.147	0.413	0.744
Gm. 363 x Gm. 1021		0.422	1.416	1.475	0.372	-0.556	0.775	-0.066	0.647	2.295**	-1.681
Gm. 363 x Gm. 1002		-0.422	-1.416	-1.475	-0.372	0.556	-0.775	0.066	-0.647	-2.295	1.681
Gm. 364 x Gm. 1021		0.547	-4.147	0.913	1.247	0.194	0.275	0.128	0.022	0.400	1.256
Gm. 364 x Gm. 1002		-0.547	4.147	-0.913	-1.247	-0.194	-0.275	-0.128	-0.022	-0.400	-1.256
Gm. 365 x Gm. 1021		-0.391	-2.272	2.350	1.434	-2.119	-0.038	-0.184	-0.478	0.650	-0.244
Gm. 365 x Gm. 1002		0.391	2.272	-2.350	-1.434	2.119**	0.038	0.184	0.478	-0.650	0.244
Gm. 366 x Gm. 1021		-0.266	-1.772	-1.025	0.122	0.069	0.463	-0.184	-0.666	0.650	1.381
Gm. 366 x Gm. 1002		0.266	1.772	1.025	-0.122	-0.069	-0.463	0.184	0.666	-0.650	-1.381
Gm. 367 x Gm. 1021		0.484	2.416	3.225	0.872	-0.431	-0.100	0.253	0.897*	-0.725	-0.119
Gm. 367 x Gm. 1002		-0.484	-2.416	-3.225	-0.872	0.431	0.100	-0.253	-0.897	0.725	0.119
Gm. 368 x Gm. 1021		0.422	-0.272	2.850	1.184	0.694	-0.725	0.316	-0.416	-0.475	1.256
Gm. 368 x Gm. 1002		-0.422	0.272	-2.850	-1.184	-0.694	0.725	-0.316*	0.416	0.475	-1.256
Gm. 369 x Gm. 1021		0.234	11.541	8.163	-0.191	-1.181	-0.350	-0.059	0.897*	0.338	-1.244
Gm. 369 x Gm. 1002		-0.234	-11.541*	-8.163*	0.191	1.181*	0.350	0.059	-0.897	-0.338	1.244
Gm. 370 x Gm. 1021		-0.453	9.541	4.725	-1.066	0.069	0.088	0.066	1.272**	-0.225	2.444
Gm. 370 x Gm. 1002		0.453	-9.541	-4.725	1.066	-0.069	-0.088	-0.066	-1.272	0.225	-2.444
L.S.D.Sij	0.05	0.681	10.128	7.134	3.119	0.957	1.037	0305	0.688	2.279	2.607
	0.01	0.896	13.331	9.391	4.106	1.260	1.365	0.401	0.906	2.999	3.431
L.S.D. sij-sik	0.05	0.962	14.322	10.089	4.411	1.353	1.467	0.431	0.973	3.222	3.686
	0.01	1.267	18.852	13.280	5.807	1.781	1.931	0.567	1.281	4.242	4.852