COMBINING ABILITY FOR YIELD AND SOME AGRONOMIC TRAITS AMONG TEN YELLOW MAIZE (ZEA MAYS L.) INBRED LINES

EL-KOOMY, M.B.A, W.M. EL-SAYED and H.A. DARWISH

Maize Res. Sec., Field Crops Res. Institute, ARC, Egypt

(Manuscript received 19 December 2014)

Abstract

Ten advanced yellow maize inbred lines were topcrossed to two inbred lines testers at Giza Agricultural Research Station in 2013. Resulting 20 topcrosses a long with two standarad check hybrids were evaluated for grain yield and some agronomic traits at three locations, i.e., Sakha, Mallawy and Ismaelia Agricultural Research stations during 2014 growing season. Analysis of variance indicated significant mean squares due to crosses for days to 50 % silking, plant and ear heights and grain yield. The Inbred lines; GZ-656, GZ-658, GZ-661 and GZ-662 were high general combiners for grain yield. Among the crosses, four test crosses (GZ-654x078, GZ-656x078, GZ-660x021 and GZ-661x078) were found to possess positive significant SCA effects mean while better mean performance for grain yield. Negative and significant SCA effects were also observed in two crosses (GZ-654x021 and CML-121x078) for number of days to 50 % silking.

Key words: Maize, Line x Tester, Combining ability, GCA effects, SCA effects.

INTRODUCTION

Estimation of combining ability is an important attribute for maize breeders in predicting improvement in hybrid maize programs. Combining ability has been defined and categorized originally by Spargue and Tatum (1942) who reported that general combining ability (GCA) effect was mainly due to additive type of gene action, whereas specific combining ability (SCA) indicated non-additive gene effects. Hallauer and Miranda (1981) stated that estimation of combining ability variances and effects can give an indication about relative magnitude and type of genetic variance. In this context , combining ability provide a guideline for selecting elite inbred parents and desirable cross combinations to be used in formulation of a systematic breeding project for rapid development of maize hybrids. Many conclusions concerning the genetic analysis for grain yield, as well as some other agronomic traits were reported by Singh *et. al.* (1971), El-itriby *et. al.* (1990), Diab *et. al.* (1994), and El-zeir *et al.*(2000), who indicating the relative importance of GCA in controlling the inheritance of yield and some agronomic attributes in maize. On the contrary, Russell *et. al.*

(1973), El-Hosary (1985), Salama *et. al.* (1995), Sultan (1998) and Sadek *et. al.* (2002), reported that the variance component due to SCA for grain yield and some other agronomic traits was relatively higher than that of GCA, suggesting that non–additive type of gene action appeared to be more important in the inheritance of such traits. The main objectives of the current investigation were: 1) to estimate GCA and SCA effects of some new inbred lines and their interaction with locations, and 2) to identify the most promising lines and single crosses for further use in the Egyptian maize hybrids breeding program.

MATERIALS AND METHODS

Ten inbred lines named ,GZ-654 (L1) , GZ-656 (L2) , GZ-658 (L3) , GZ-659 (L4), GZ-660 (L5) , GZ-661 (L6) , GZ-662 (L7) , GZ-044 (L8) , CML-102 (L9) , and CML-121 (L10) were used in this study .In 2013 summer season the ten inbred lines were top-crossed to two inbred lines testers 021(T1) and 078(T2) at Giza Agricultural Research Station. The twenty F_1 hybrids were evaluated in Randomized Complete Block Design (RCBD) with four replications along with two yellow checks viz SC162 and SC168 at three locations i.e. Mallawy, Sakha and Ismalia Agricultural Research Stations of ARC during 2014 growing season. Plot size was one row of 6m length and 80 cm width. Planting was made in hills evenly spaced at 25 cm along the row at the rate of two kernels per hill later thinned out to one plant per hill prior to the first irrigation. The recommended agronomic practices for maize cultivation were followed. Data were recorded for number of days to 50% silking, plant height (cm), ear height (cm), and grain yield, adjusted to 15.5% grain moisture and converted to ardab per faddan (ardab fed^{-1}) where one ardab =140 Kg grains, and one feddan=4200m^2 The recorded data were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980). Bartlett test was used to test the homogeneity of error variances for all studied traits according to Bartlett (1937). Combining ability analysis was computed according to the lines x testers procedure suggested by Kempthorne (1957). Heterotic effects were calculated as percent relative to mid and better parents.

RESULTS

Analyses of variance:

Analyses of variance for days to 50% silking, plant and ear heights and grain yield are presented in Table. 1. Highly significant differences were found among the three locations for all studied traits. Mean squares due to crosses, lines and testers were highly significant for all traits, indicating the presence of significant differences among lines and testers for these traits. The interactions between lines and testers were highly significant for 50% silking and grain yield, indicating that the inbred lines differed in their performance in crosses with the two testers for these traits. Mean squares due to crosses x loc. and L x T x loc were highly significant for days to 50% silking and grain yield, whereas the mean squares due to Lines x Loc and Testers x Loc were significant and highly significant for all traits, except for ear height for Line x Loc. These interactions with location were indicative of different ranking of the evaluated genotypes from one location to another. Current findings are in line with the observation of Al-Naggar *et. al.* (2002), Alamine *et. al.* (2006), Abdallah *et. al.* (2009) and El-Gazzar and Khalil (2012).

Table 1. Mean squares of combined analysis of variance for grain yield and the other studied traits in 2014.

S.O.V	d.f.	Dys to 50% silking	Plant height	Ear height	Grain yield
Locations(Loc)	2	103.379**	45650.62**	54241.77**	584.79**
Rep/loc	9	4.399	1195.56**	825.84	7.89
Crosses	19	4.695**	1143.57**	439.54**	185.88**
Lines (L)	9	2.352**	2092.54**	750.68**	358.50**
Testers (T)	1	31.537**	1560.60**	614.40**	21.28*
L X T	9	4.065**	148.27	108.98	31.55**
Crosses X Loc	38	5.739**	283.30	113.43	71.42**
Line X Loc	18	7.083**	374.13**	119.05	92.85**
Tester X Loc	2	26.587**	1019.63**	603.83**	242.27**
L X T X Loc	18	2.078**	116.98	53.29	31.01**
Error	171	0.726	202.64	91.23	9.56
C.V. (%)		1.411	5.76	6.61	11.23

*, ** Indicate significance at 0.05 and 0.01 levels of probability, respectively.

Mean Performance:

Performance means across locations for days to 50% silking, plant height, ear height and grain yield of the 20 topcrosses along with two commercial check hybrids SC. 162 and SC. 168 are presented in Table.2**.** For number of days to 50% silking, all crosses were earlier than the check of SC. 162, whereas they did not differ significantly from the check hybrid SC. 168 except for the three crosses of GZ 654 (L1) , GZ 660 (L5), GZ662 (L7) with the tester 078 (T2) which were later than SC. 168. For plant height, the shortest plants were produced only when inbred line 9 was crossed with either testers, they were significantly shorter than the shorter check hybrid (SC. 168).For ear height , none of the crosses exhibited lower ear placement than the better performing check hybrid for this trait (SC 168). However, all crosses exhibited a similar performance to that of SC 168, since no significant differences, with the exception of those crosses involving the tow inbred lines L8 and L10 with both testers which were of significantly higher ear placement. Regarding grain yield, four crosses i.e. GZ661(L6) X 078(T2), GZ660(L5) X 021(T1),GZ658(L3) X 021(T1) and GZ662 (L7)X 078(T2) (31.40, 31.34,31.31 and 31.22 ard fed-^{1} respectively) significantly out yielded the highest yielding check hybrid SC. 162. The rest of the crosses exhibited similar grain productivity to that of SC. 162, with the exception of those crosses involving inbred lines L9 and L10 with both testers and the cross L5 x T2, which were of significantly lower grain productivity. Those crosses which outyielded the standard checks exhibited also better performance regarding earliness, and plant and ear heights compared to the standard check SC 162.

Table 2. Mean performance across locations of the twenty top-crosses and the tow check hybrids for the four studied traits, 2014.

Lines	Days to 50%silking		Plant height (cm)		Ear height (cm)		Grain yield (ard fed^{-1})	
	$T_{1\,(021)}$	$T_{2\,(078)}$	$T_{1\,(021)}$	$T_{2\,(078)}$	$T_{1\,(021)}$	$T_{2\,(078)}$	$T_{1\,(021)}$	$T_{2\,(078)}$
$L_{1(GZ\text{ -}654)}$	59.58	61.67	248.083	251.75	142.33	142.83	27.84	27.64
$L_{2(GZ\text{-}656)}$	60.67	60.50	240.08	250.58	141.17	145.67	28.53	30.62
$L_{3(GZ\text{-}658)}$	60.17	60.67	242.08	244.50	143.08	142.58	31.31	29.37
$L_{4(GZ\text{-}659)}$	60.00	60.42	237.058	246.08	139.75	146.83	28.33	28.64
$L_{5(GZ\text{-}660)}$	60.08	61.58	240.33	237.75	140.33	140.25	31.34	25.32
$L_{6(GZ\text{-}661)}$	60.08	60.50	243.41	249.16	142.42	148.50	30.36	31.40
$L_{7(GZ\text{-}662)}$	59.67	60.83	238.16	252.16	138.08	148.50	30.56	31.22
$L_{8(GZ\text{-}044)}$	60.25	60.42	260.00	266.75	150.58	157.33	27.68	28.44
$L_{9(CML\text{-}102)}$	59.67	60.58	232.50	233.33	135.58	135.58	20.92	20.20
$L_{10(CML\text{-}121)}$	60.25	59.50	260.08	262.00	153.83	153.38	21.46	19.53
Checks SC 162	62.42		273.33		152.52		28.22	
SC 168	60.08		245.91		141.41		27.39	
LSD 0.05	0.66		11.24		7.52		2.49	

General combining ability effects:

Estimates of general combining ability (gi) effects of the parental lines and the two testers for grain yield and other studied traits are presented in Table. 3. For days to 50% silking, both negative and positive GCA effects were observed. Both inbred line CML121(L10) and the inbred tester 021(T1) exhibited highly significant negative effects for this trait. Whereas, inbred lines GZ660 (L5) , 044 (L8) , and 078 (T2) showed significant positive and GCA effects for days to 50% silking. The negative value implies that the inbred lines are good combiners as it indicates the tendency for earliness and the reverse is true for those with positive GCA effects (Shushay *et. al.* 2013). For plant and ear heights, the inbred lines GZ660 (L5) and CML102 (L9) and 021 (T1) showed negative and significant GCA effects, whereas the inbred lines 044 (L8) and CML121 (L10) and the inbred tester 078 (T2) for plant height showed significant positive GCA effects (Table 3). The negative estimates indicate the tendency toward shorter plants and lower ear placement. In maize, short plants and low ear placement are desirable characteristics for better standability and higher plant population density. Regarding grain yield, the parental inbred lines GZ656 (L2) , GZ658 (L3) , GZ661 (L6) and GZ662 (L7) exhibited highly significant positive GCA effects. While, the inbred lines CML102 (L9) and CML121(L10) exhibited highly significant negative GCA effects for grain yield. This indicates the existence of high and low general combiners in the group of studied inbred lines. Generally, inbred lines identified for better general combining ability could be utilized in maize improvement programs for improving traits of interest as these lines have high potential to transfer desirable traits to their cross progenies. Both positive and negative GCA effects for grain yield and other agronomic traits were reported in maize by several investigators (Al-Naggar *et. al.* 2002, Amer and El-Shenawy 2007, Abdallah and Hassan 2009 and Shushey *et. al.* 2013).

Table 3. General combining ability effects (ĝi) of the parental inbred lines and the Testers for the four studied traits based on across locations performance, 2014.

Lines	Days to 50%silking	Plant height	Ear height	Grain yield
$L_{1(GZ\ -654)}$	0.22	3.433	-1.733	0.204
$L_{2(GZ-656)}$	0.179	-1.525	-0.900	2.036**
$L_{3(GZ-658)}$	0.013	-3.567	-1.483	2.803**
$L_{4(GZ-659)}$	-0.196	-5.025	-1.025	0.948
$L_{5(GZ-660)}$	0.429*	-7.817**	-4.025*	0.795
$L_{6(GZ-661)}$	-0.113	-0.567	1.142	3.342**
$L_{7(GZ-662)}$	-0.154	-1.692	-1.025	3.356**
$L_{8(GZ-044)}$	0.429*	16.517**	9.642**	0.525
$L_{9(CML-102)}$	-0.273	-13.942**	-9.317**	-6.974**
$L_{10(CML-121)}$	-0.529**	14.183**	8.725**	-7.036**
Tester $T_{1(021)}$	-0.363**	-2.550*	-1.60	0.298
$T_{2(078)}$	0.363**	2.55*	1.60	-0.298
SE gi lines ($t_{0.05,0.01}$)	0.340, 0.446	5.695,7.467	3.821, 5.010	1.237,1.622
gj testers	0.152,0.199	2.547,3.339	1.709,2.240	0.553,0.725

Specific combining ability effects:

Specific combining ability effects of the 20 crosses were estimated for the four studied traits and are presented in Table.4. For number of days to 50% silking, two crosses: ie. GZ654 (L1) X 021 (T1) and CML121 (L10) X 078 (T2) showed better SCA effects (-0.679 and -0.738, respectively) . Whereas, GZ654 (L1) X 078 (T2) and CML121 (L10) X 021 (T1) showed positive SCA effects indicating late maturity. For plant and ear heights, all testcrosses exhibited non-significant levels of SCA effects for both traits. For grain yield, significant positive estimates of SCA effects were shown for the crosses GZ654 (L1) X 078 (T2) , GZ656 (L2) X 078 (T2) , GZ660 (L5) X 021 (T1) , and GZ661 (L6) X 078 (T2) . All there crosses had acceptable performance regarding other traits since no significant SCA effects with the exception of the cross Gz 654 (L1) x 078 (T2) which showed undesirable SCA effects for earliness. Generally, inbred lines possessing significant positive GCA effects for grain yield can be utilized in developing desirable cross combinations and synthetic varieties to improve maize productivity. Furthermore, the crosses with higher desirable SCA effects could be utilized for future breeding work as well as for direct release after further testing to confirm their stability performance.

Table 4. Specific combining ability effects of 20 topcrosses for the studied traits based on across locations, performance 2014.

Lines	Days to 50%silking		Plant height		Ear height		Grain yield	
	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
$L_{1(GZ\text{ -}654)}$	-0.679**	0.679**	1.092	-1.092	1.350	-1.350	-1.197*	1.197*
$L_{2(GZ\text{-}656)}$	0.446	-0.446	-2.700	2.700	-0.650	0.650	-2.339**	2.339**
$L_{3(GZ\text{-}658)}$	0.113	-0.113	1.342	-1.342	1.850	-1.850	1.671	-1.671
$L_{4(GZ\text{-}659)}$	0.154	-0.154	-1.700	1.700	-1.942	1.942	-1.455	1.455
$L_{5(GZ\text{-}660)}$	0.388	0.388	3.842	3.842	1.642	-1.642	3.715**	-3.715**
$L_{6(GZ\text{-}661)}$	0.154	-0.154	-0.325	0.325	-1.442	1.442	-1.818*	1.818*
$L_{7(GZ\text{-}662)}$	-0.221	0.221	-4.450	4.450	-3.608	3.608	-1.629	1.629
$L_{8(GZ\text{-}044)}$	-0.221	0.221	-0.825	0.825	-1.775	1.775	-1.679	1.679
$L_{9(CML\text{-}102)}$	-0.099	0.099	2.133	-2.133	2.183	-2.183	1.065	-1.065
$L_{10(CML\text{-}121)}$	0.738**	-0.738**	1.591	-1.592	2.392	-2.392	1.666	-1.666
Sij ($t_{0.05,0.01}$)	0.482,0.632		8.054,10.561		5.404,7.086		1.750,2.294	
Sij-Skl	0.681,0.893		11.39,14.935		7.643,10.021		2.475,3.245	

*, ** Indicate significance at 0.05 and 0.01 levels of probability, respectively.

REFERENCES

1. Abdallah, T. A. E. and M. M. M. Hassan. 2009. Combining ability analysis for grain yield and some agronomic traits in maize. Egypt. J. Appl. Sci. 24(11): 164-174.
2. Abdallah, T.A.E., Afaf A.I. Gabr and A.A. EL-Khishen. 2009. Combining ability in line X tester cross of maize (*Zea mays* L.). Annals Agric. Sci. Moshtohor. 47(1): 11-20.
3. Alamine, A.M., C. Wali, P.M. Salimath and R.C. Jagadeesha. 2006. Combining ability, heterosis and *per se* performance in maize maturity components. Karnataka J. Agric. Sci., India. 19: 268-271.
4. Al-Naggar, A.M., M. S. Radwan and M. M. M. Atta. 2002. Analysis of diallel crosses among ten maize populations differing in drought tolerance. Egypt. J. Plant Breed., 6:179-198.
5. Amer, E. A. and A. A. El Shenawy. 2007. Combining ability for twenty one yellow maize inbred lines. J. Agric. Sci., Mansoura Univ. 32(9): 7053-7062.
6. Diab, M.T.; A.M. Shehata and M.I. Dawood. 1994. Using inbred lines as testers for estimating combining ability in Maize. Egypt. J. Appl. Sci.(12):208-224.
7. Bartelett M. S. 1937. Properties of sufficiency and statistical tests . Proc of the Royal Statistical Society, Series A, 160, 268-282.
8. El-Gazzar, I.A.I. and M.A.G. Khalil. 2012. Combining ability analysis of new yellow maize inbred lines using line x tester analysis. J. Agric. Res. Kafer El-Sheik Univ. 38(3): 390-398.
9. El-Hosary, A.A. 1985. Study of combining ability in some topcrosses in maize. Egypt. J. Agron. 10: 39-47.
10. El-Itriby, H. A., H.Y. El-Sherbieny; M.M. Ragheb and M.A.K. Shalaby. 1990. Estimation of combining ability of maize inbred lines in top crosses and its interaction with environments. Egypt. J. Appl. Sci. 5 : 354-370.
11. EL-Zeir, F.A.A.; E.A. Amer; A.A. Abdel Aziz and A.A. Mahmoud. 2000. Combining ability of new maize inbred lines and type of gene action using top crosses of maize. Egypt J. Appl. Sci. 15: 116-128.
12. Hallaure, A. R. and J. B. Miranda. 1981. Quantitative Genetics in Maize Breeding. Iowa State Univ.Press, Ames, USA .
13. Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons Inc., NY, USA.
14. Russell, W. A.; S. A. Eberhart and U. A. Vega. 1973. Recurrent selection for specific combining ability for yield in two maize populations. Crop Sci. 13: 257-261.

15. Sadek, S.E.; M.S.M. Soliman; A.A. Barakat and K.I. Kkalifa. 2002. Topcrosses analysis for selecting maize lines in the early self generations. Minufiya J. Agric. Res., 27: 197-213.
16. Salama, F.A., Sh.F. Aboel-Saad and M.M. Ragheb. 1995. Evaluation of maize (*Zea mays* L.) top crosses for grain yield and other agronomic traits under different environmental conditions. J. Agric. Sci. Mansoura Univ. 20(1): 127-140.
17. Shushey, W. Abrha, H. Z. Zeleke and D. W. Gissa. 2013. Line × tester analysis of maize inbred lines for grain yield and yield related traits. Asian J. Pl. Sci. Res. 3(5): 12-19.
18. Singh, B.; S. Ramaniam and N.L. Dhawan. 1971. Genetics of yield and yield components in maize composites. Indian Jour. Genet. And Plant Breed., 31: 322-332.
19. Sprague, G.F. and L.A. Tatum. 1942. General versus specific combining ability in single crosses of corn. J. Amer. Soc. Agron. 34 : 923-932.
20. Steel, R.G. and J. Torrie. 1980. Principles and Procedures of Statistics. Mc Graw-Hill Book Company, New York, USA.
21. Sultan, M. A. 1998. Estimates of combining ability of yellow maize inbred lines in top crosses. J. Agric. Sci. Mansoura Univ., 23 (12): 5837 -5851.

القدرة على التالف لصفة المحصول وبعض الصفات الزراعية لعشرة سلالات من الذرة الشامية الصفراء

محمود بيومى عبدالجواد الكومى ، وائل محمد النبوى السيد ، هانى عبدالعاطى درويش

قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية–جيزة

تم إجراء التهجين القمي لعشرة سلالات من الذرة الشامية الصفراء مع سلالاتين كشافتين في محطة البحوث الزراعية بالجيزة عام 2013 . وفي موسم 2014 تم تقييم ال20 هجين القمي مع هجيني المقارنة (الهجين الفردى الاصفر جيزة 162 وجيزة 168) وذلك بالنسبة لصفة المحصول وبعض الصفات الزراعية في ثلاث محطات بحثية وهي سخا وملوي والإسماعيلية . وقد دلت النتائج على وجود فروق المعنوية بين الهجن بالنسبة لعدد الأيام حتى ظهور 50% من النورة المؤنثة وارتفاع النبات وارتفاع الكوز ومحصول الحبوب . كما اظهرت السلالات جيزة656 وجيزة 658و جيزة 661 وجيزة 662 تأثيرات عالية المعنوية وموجبة للقدرة العامة على الائتلاف لصفة المحصول. اظهرت اربعة هجن فردية (جيزة654x078 وجيزة656x078 وجيزة660x021 وجيزة661x078) أعلى معنوية موجبة للقدرة الخاصة على الائتلاف وأيضا أفضل أداء لصفة المحصول. كما اظهر هجينين (جيزة 654 x021و 078 xCML121) تفوقا معنويا سالبا للقدرة الخاصة على الائتلاف لصفة عدد الأيام حتى ظهور 50% من النورة المؤنثة.