https://doi.org/10.56093/ijas.v90i3.101500

*Indian Journal of Agricultural Sciences* **90** (3): 621–4, March 2020/Article

# Evaluation of new yellow maize (*Zea mays*) inbred lines using line × tester analysis

MOHAMMAD REDA ISMAIL* and TAMER TALAT EL-MOUSLHY

*Field Crop Research Institute, Agricultural Research Center, Egypt*

Received: 24 October 2019; Accepted: 12 December 2019

ABSTRACT

This study evaluated 20 elite yellow maize (*Zea mays* L.) inbred lines which were crossed as female parents with three different testers as male parents, i.e. Gem. Pop. (Broad genetic base), Single cross 101 and Inbred line 100 represent (Narrow genetic base) at the Experiment Research Station of Moshtohor, Benha University, Egypt during 2014 summer. The resulting 60 top crosses with three commercial check hybrids i.e. SC.155, SC. Pioneer 3080 and TWC.352 were evaluated in a yield trail in two sowing dates during 2015 growing summer season. A randomized complete block design (RCBD) with three replications was used. The data were recorded on days to anthesis (AD), maturity date (MD), leaf area of upper ear (LA), ear length (EL) and grain yield per feddan (GYPF). The results showed that, sowing dates, crosses, lines, testers except for (MD) and line × testers mean squares were significant for all traits. The parental inbred lines (L-4, L-5, L-10, L-12, L-13, L-14 and L-19) possessed high GCA effects for grain yield and (L-6, L-7, L-10 and L-11) possessed high GCA effects for earliness. These lines could be utilized as promising inbred lines in a hybridization programme to develop high yielding and early maturity maize hybrids. The seven crosses (T-1×L-7, T-1×L-13, T-1×L-17, T-2×L-4, T-2×L-5, T-2×L-10 and T-2× L-12) which had out-yielded significantly the best check SC.3080 could be utilized for future breeding work as well as for direct release after confirming the stability of their performances observed in the current study.

**Key words:** Broad genetic base, Combining ability, Line × tester, Topcrosses, Zea mays

Maize (*Zea mays* L.) is the third most important staple crop worldwide. It provides over 20% of total calories in human diet in 21 countries, and over 30% in 12 countries. The importance of corn in Egypt comes after wheat and rice due to its vast grown area, total production and cash value. It is essential for human consumption as well as livestock. In addition, it is also used for industrial purposes such as manufacturing starch and cooking oils. Egypt imports around 7-8 million ton of corn every year to tackle the gap between production and consumption. Many efforts are devoted nowadays to increase the productivity through genetical improvement. Evaluating inbred lines is a prime importance for hybrid production. The topcross method of maize breeding has been used to evaluate inbred lines for general combining ability (GCA) and specific combining ability (SCA). Davis (1927), Jinkins (1935) and Sprague (1939) suggested the method of early testing. Sprague and Tatum (1942) was the first to partition the total combining ability effects of the lines into GCA and SCA. Line × tester analysis is a modification of this method in which several testers are used Kempthorne (1957), which provides good information on the general and specific combining ability effects of parents and their hybrid combinations. The design has widely been used in maize by several researchers like, Mahmoud and Abd El-Azeem (2004), El-Ghonemy (2015), Gamea (2015) and Hassan *et al.* (2016) and Ismail *et al.* (2018) who estimated general and specific combining ability of grain yield and some other characteristics. The objectives of this investigation were to provide information of suitable testers for testing inbred lines, estimate of combining ability effects of some yellow maize inbred lines, and their interactions with sowing dates and identify the most superior lines and single crosses to be used in hybrid maize breeding programs.

## MATERIALS AND METHODS

The field experiments were conducted at the Experiment Research Station of Moshtohor, Benha University, Egypt during 2014–15, summer. Twenty elite yellow maize inbred lines (L-1, L-2, L-3, ……,L-20) developed by Prof. Dr. Ali El-Hosary, Faculty of Agriculture, Benha University, Egypt were crossed as female parents with three different male parents, i.e. Gem. Pop. (T-1) represent (Broad genetic base), Single cross 101(T-2) and inbred line 100 (T-3) represent (Narrow genetic base) as testers. line × tester technique Kempthorne (1957) were used to generate 60 top crosses in 2014. The sixty top crosses along with three commercial check hybrids, i.e. Single Cross 155 (SC.155), Single

*Corresponding author e-mail: Breeder82@live.com

Cross Pioneer 3080 (SC.3080) and Three Way Cross 352 (TWC.352) were evaluated in two sowing dates, i.e. 15$^{th}$ June and 4$^{th}$ July during 2015 growing summer season. A randomized complete block design (RCBD) with three replications was used. The recommended packages of agronomic practices were followed to achieve a good growth. The data were recorded Days to Anthesis (AD); maturity date (MD) was recorded as the number of days from sowing to the day when all husks of ears turned brown; leaf area of upper ear (cm$^2$) (LA) was computed according to the formula; farther ear leaf length × farther ear leaf width × 0.75; ear length (EL) and grain yield per feddan (GYPF) was estimated and adjusted at 15.5% grain moisture and expressed in Kilogram (kg) per feddan (Feddan= 4200 m$^2$) of maize grains. 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 variance among sowing dates for all studied traits. Analysis of general combining ability and specific combining ability was carried out following the method of Kempthorne (1957).

## RESULTS AND DISCUSSION

*Significance of Mean Squares*: Combined mean squares due to Line × Tester analyses over sowing dates are presented in (Table 1). Sowing dates mean squares were highly significant for all traits, indicating that the two sowing dates are varied in climate conditions. These results are in agreement with those reported by Nawar *et al.* (1998), El-Hosary and El-Badawy (2005) and El-Hosary *et al.* (2006).

Crosses mean squares were highly significant for all the studied traits, indicating the wide diversity between the parental materials used in the present study and the crosses were sufficiently different from each other for the studied traits. Significant crosses × sowing dates mean squares were obtained for all the studied traits, revealing that the tested crosses varied from each other and ranked differently from sowing date to another. Mean squares due to lines, testers and line × tester were significant for all traits except Tester mean squares for maturity and ear length. Significant line × sowing dates were obtained for all the studied traits except for days to anthesis. Significant tester × sowing dates mean squares were detected for leaf area of upper ear, ear length and grain yield. Significant interaction lines × tester × sowing dates mean squares were obtained for all the studied traits, except for maturity and ear length. In addition, lines mean squares were much higher than those of testers mean squares for all studied traits, except for grain yield. Such results revealed that lines contributed much more to the total variation as compared to testers.

*Combining ability effects*

*General combining ability effect*: Four inbred lines, i.e. (L1, L12, L13 and L18) and the tester T-3 (L-100) expressed significant negative GCA effects (favorable) for days to anthesis trait. Moreover, both inbred lines L1 and L13 were the best combiners for this trait. For maturity date, the parental inbred lines L6, L7, L10 and L11 were considered to be the best combiners for earliness. Consequently, they could be utilized in developing new hybrids characterized by earliness in maturity. For leaf area, nine inbred lines and T-2 (SC.101) exhibited significant positive GCA effects (favorable). However, the three inbred lines L1, L2 and L16 were good combiners for this trait. Therefore, they could be of great value for developing hybrids with highest leaf area of upper ear in order to increase forage crops and grain yield. The best general combiners which had significant positive GCA effects (favorable) were L11, L12 and L20 for ear length. Significant positive GCA effects (favorable) were obtained by the tester T-1 (Gem.Pop) and

Table 1 Mean squares for days to anthesis, maturity, leaf area of upper ear, ear length and grain yield of combined analysis across two sowing dates (2015 growing season)

| SOV | d.f | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | DA (day) | MD (day) | LA (cm$^2$) | EL (cm) | GYPF (kg) |
| Sowing Dates (SD) | 1 | 2006.94** | 1941.38** | 386188** | 19.17** | 75977.37** |
| Rep/SD | 4 | 5.84 | 4.78 | 428.03 | 1.30 | 51.16 |
| Crosses (C) | 59 | 7.49** | 15.45** | 16327.0** | 5.69** | 925.39** |
| Lines (L) | 19 | 14.75** | 26.31** | 31410.8** | 7.58** | 733.38** |
| Testers (T) | 2 | 8.60** | 1.20 ns | 14599.2** | 3.36 ns | 962.21** |
| Lines × Testers | 38 | 3.80** | 10.77** | 8876.2** | 4.86** | 1019.46** |
| Crosses × SD | 59 | 3.31** | 4.91** | 4954.5** | 2.80** | 1063.07** |
| Lines × SD | 19 | 1.14 ns | 8.29** | 5771.8** | 3.88** | 1361.00** |
| Testers × SD | 2 | 1.89 ns | 0.37 ns | 8049.4** | 5.24* | 2131.00** |
| Lines × Testers × SD | 38 | 4.47** | 3.46 ns | 4382.9** | 2.12 ns | 857.90** |
| Pooled error | 236 | 1.29 | 2.91 | 1067.5 | 1.50 | 37.17 |

ns, * and ** indicate insignificant, significant at 0.05 and 0.01 probability levels, respectively. DA, days to anthesis; MD, maturity date; LA, leaf area of upper ear; El, ear length and GYPF, grain yield.

Table 2 Estimation of GCA in parents and SCA in the F1 progenies for all studied traits

| Trait lines | DA (day) | | | | MD (day) | | | | LA ($cm^2$) | | | | EL (cm) | | | | GYPF (kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GCA | SCA Combination | | | GCA | SCA Combination | | | GCA | SCA Combination | | | GCA | SCA Combination | | | GCA | SCA Combination | | |
| | | T1 | T2 | T3 | | T1 | T2 | T3 | | T1 | T2 | T3 | | T1 | T2 | T3 | | T1 | T2 | T3 |
| L-1 | -1.72** | -1.21** | 0.52 | 0.69 | -0.64 | -2.40** | 0.99 | 1.40* | 64.82** | 10.95 | -24.53 | 13.58 | 0.19 | 0.21 | -0.11 | -0.10 | 2.23 | 2.13 | -4.61 | 2.48 |
| L-2 | 0.73** | 0.68 | -0.26 | -0.42 | -0.37 | -0.17 | 0.05 | 0.13 | 46.17** | -11.58 | 49.62** | -38.04** | -0.71* | -0.70 | 0.45 | 0.24 | -15.03** | -4.29 | -5.10* | 9.40** |
| L-3 | 0.78** | 0.63 | -1.32** | 0.69 | 0.97* | -0.34 | -0.78 | 1.13 | -4.30 | 14.94 | -6.03 | -8.91 | 0.24 | 0.06 | 2.16** | -2.22** | -4.52** | -1.68 | 5.04* | -3.36ss |
| L-4 | 1.12** | -0.88 | 0.18 | 0.69 | 1.58** | -1.29 | 1.94** | -0.65 | 35.43** | 19.25 | 6.90 | -26.14 | -0.51 | -1.27* | 0.79 | 0.48 | 4.92** | -14.71** | 15.44** | -0.73 |
| L-5 | 1.51** | 0.40 | -0.04 | -0.36 | 1.30** | -0.51 | 0.55 | -0.04 | -3.65 | 22.90 | 1.98 | -24.89 | -0.69* | 0.44 | 0.68 | -1.12* | 4.82** | -4.11 | 14.81** | -10.70** |
| L-6 | 0.51 | -0.26 | -0.04 | 0.30 | -1.92** | 0.21 | -0.06 | -0.15 | 51.53** | 31.93* | -13.27 | -18.66 | 0.39 | 0.28 | -0.76 | 0.48 | 0.48 | -8.32** | -0.31 | 8.63** |
| L-7 | -0.44 | -0.82 | -0.26 | 1.08* | -1.20** | 0.16 | -0.45 | 0.29 | -18.96* | 4.92 | -0.67 | -4.25 | -0.28 | 0.13 | -0.37 | 0.24 | 0.18 | 17.42** | -11.18** | -6.24* |
| L-8 | 1.39** | -0.49 | -0.09 | 0.58 | 0.47 | -0.51 | -0.62 | 1.13 | -35.76** | 38.84* | -12.49 | -26.35* | 0.05 | -0.18 | 0.35 | -0.16 | 1.32 | 6.24* | -5.82* | -0.42 |
| L-9 | 0.56* | -0.15 | 0.41 | -0.25 | -0.14 | -0.06 | -1.67* | 1.74* | 16.24* | 2.93 | -29.98* | 27.05* | -0.65* | 0.86 | -0.98* | 0.12 | -8.43** | -6.16* | -6.50** | 12.65** |
| L-10 | -0.38 | 0.79 | 0.18 | -0.98* | -2.64** | -0.73 | 0.99 | -0.26 | -59.47** | -83.86** | 62.06** | 21.80 | -0.38 | -1.47** | 0.38 | 1.10* | 9.24** | -18.53** | 12.88** | 5.65* |
| L-11 | 0.06 | 0.01 | 0.74 | -0.75 | -1.09** | -0.12 | 0.11 | 0.01 | -44.43** | -17.41 | 11.69 | 5.72 | 1.30** | -0.73 | 0.27 | 0.47 | -1.87 | -11.02** | 1.09 | 9.94** |
| L-12 | -0.99** | 1.07* | -0.54 | 0.53 | -0.42 | 2.21** | -0.56 | -1.65* | 18.94* | 14.07 | 55.57** | -69.63** | 0.61* | 0.44 | -0.14 | -0.29 | 5.01** | -12.57** | 28.11** | -15.54** |
| L-13 | -1.55** | -0.38 | 0.35 | 0.02 | -0.20 | 0.99 | -0.12 | -0.87 | -57.51** | 18.83 | -12.39 | -6.44 | -0.18 | 0.28 | -0.74 | 0.46 | 11.94** | 18.87** | -9.84** | -9.04** |
| L-14 | -0.22 | 0.63 | 0.68 | -1.31** | 0.02 | 1.77* | -1.17 | -0.60 | 25.67** | 4.61 | 26.57* | -31.18* | 0.30 | 1.03* | -0.62 | -0.40 | 4.40** | 2.93 | 2.52 | -5.45* |
| L-15 | -0.27 | 0.01 | -0.26 | 0.25 | 0.47 | -1.01 | 2.72** | -1.71* | 5.65 | -40.81** | -29.15* | 69.97** | 0.06 | -1.01* | 0.66 | 0.35 | -1.54 | -4.67 | -6.26* | 10.93** |
| L-16 | -0.49 | 0.24 | 0.46 | -0.70 | 0.80* | 1.16 | -0.95 | -0.21 | 60.28** | -9.76 | -39.30** | 49.06** | -1.41** | 0.64 | -0.56 | -0.09 | -7.06** | 9.72** | -16.24** | 6.51** |
| L-17 | 0.78** | 0.29 | 0.35 | -0.64 | 1.80** | 0.99 | 1.05 | -2.04** | -24.45** | 7.98 | -33.39* | 25.41 | -0.26 | 0.75 | -0.48 | -0.28 | 1.56 | 19.26** | -25.00** | 5.75* |
| L-18 | -0.72** | -0.38 | 0.35 | 0.02 | -0.59 | 0.71 | -1.39* | 0.68 | -68.98** | -41.24** | -13.86 | 55.11** | 0.43 | -0.16 | -0.83 | 0.99* | -7.18** | 6.99** | 1.31 | -8.30** |
| L-19 | -0.27 | -0.49 | -1.26** | 1.75** | -0.14 | 0.10 | -1.01 | 0.90 | 28.75** | -21.29 | 21.58 | -0.29 | 0.36 | 0.75 | -0.36 | -0.39 | 2.95* | 7.41** | -0.71 | -6.70** |
| L-20 | -0.38 | 0.29 | -0.15 | -0.14 | 1.97** | -1.18 | 0.38 | 0.79 | -35.97** | 33.81* | -20.90 | -12.90 | 1.14** | -0.35 | 0.20 | 0.14 | -3.41* | -4.92* | 10.37** | -5.46* |
| SE gi | 0.26 | | | | 0.40 | | | | 7.70 | | | | 0.28 | | | | 1.43 | | | |
| SE gi-gj | 0.37 | | | | 0.56 | | | | 10.89 | | | | 0.40 | | | | 2.03 | | | |
| T-1 | 0.10 | | | | -0.10 | | | | -12.69** | | | | 0.17 | | | | 3.19** | | | |
| T-2 | 0.21* | | | | 0.01 | | | | 7.32* | | | | -0.16 | | | | -0.97 | | | |
| T-3 | -0.30** | | | | 0.10 | | | | 5.36 | | | | -0.01 | | | | -2.22** | | | |
| SE gi | 0.10 | | | | 0.15 | | | | 2.98 | | | | 0.11 | | | | 0.55 | | | |
| SE gi-gj | 0.14 | | | | 0.22 | | | | 4.21 | | | | 0.15 | | | | 0.78 | | | |
| SE SCA | | | 0.46 | | | | 0.69 | | | | 13.33 | | | | 0.5 | | | | 2.48 | |

* and ** indicate insignificant, significant at 0.05 and 0.01 probability levels, respectively.

seven inbred lines (L4, L5, L10, L12, L13, L14, and L19) for grain yield. Hence, it could be concluded that these inbred lines would be of great values in breeding programs for improving grain yield.

*Specific combining ability effects*: Significant negative SCA effects (favorable) for days to anthesis were recorded by T1×L1, T2×L3, T2×L19, T3×L10 and T3×L14 (Table 2). Accordingly, the immediate use of L-3 and L-19 as a parent of three way cross with (SC.101) could be recommended. Regarding to maturity date, the top crosses T1×L1, T2×L9, T2×L18, T3×L12, T3×L15 and T3×L17 exhibited significant negative SCA effects (favorable). Eleven top crosses gave significant positive SCA effects (favorable) for Leaf area of upper ear. However, the crosses T3×L15 followed by T2×L10 and T2×L12 gave the highest significant positive SCA effects (favorable). For ear length, the top crosses T1×L14, T2×L3, T3×L10 and T3×L18 expressed significant positive SCA effects (favorable). Regarding to grain yield, 21 crosses showed positive significant SCA effects (favorable). The best SCA effects were obtained from the two crosses T2×L12 and T1×L17. These two crosses significantly out-yielded the best check hybrid SC.3080 (3410 Kg/fad). According to that these crosses are recommended for release after further evaluation.

It is concluded that the parental lines (L-4, L-5, L-10, L-12, L-13, L-14, and L-19) possess high GCA effects for grain yield and (L-6, L-7, L-10 and L-11) possess high GCA effects for earliness. They can be utilized as promising inbred lines in a hybridization programs to develop high yielding and early maturity maize hybrids. Most crosses that selected based on desirable SCA effects also had high mean performance for grain yield, viz. the seven crosses (T-1×L-7, T-1×L-13, T-1×L-17, T-2×L-4, T-2×L-5, T-2×L-10 and T-2×L-12) which had out-yielded significantly the best check SC. 3080. These crosses could be utilized for future breeding work as well as for direct release after confirming the stability of their performances across different environments. Hence, the information from this study may possibly be useful for researchers who would like to develop high yielding hybrids of maize.

## ACKNOWLEDGEMENTS

I sincerely thank Prof. (Dr) Ali Abd El-Maksoud El-Hosary, Faculty of Agriculture, Benha University, Egypt for providing the inbred lines used in this study and for valuable suggestions and revisions of the manuscript.

## REFERENCES

Davis R L. 1927. Report of the plant breeding. Annual Report, Puerto Rico agricultural experiment station, pp 14–15.

El-Ghonemy M A M. 2015. Combining ability of new yellow maize inbred lines using top cross method. *Egypt Journal of Plant Breeding* **19**(3): 903–15.

El-Hosary A A and El-Badawy M El M. 2005. Heterosis and combining ability in yellow corn (*Zea mays* L.) under two nitrogen levels. The 11th Conf. Agronomy, Agronomy Department, Faculty Agriculture, Assiut University, 89–99.

El-Hosary A A, El-Badawy M El M and Abdel-Tawab Y M. 2006. Genetic distance of inbred lines and prediction of maize single cross performance using RABD and SSR markers. *Egypt Journal Genetics and Cytology* **35**: 209–24.

Gamea H A A. 2015. Estimate of combining ability of new yellow maize inbred lines using top crosses. *Egypt Journal Agricultural Research* **93**(2): 287–98.

Hassan M A A, El-Shenawy A A, Abo El-Haress S M and Khalil M A G. 2016. Combining ability of new yellow maize inbred lines for earliness and grain yield. *Egypt Journal of Plant Breeding* **20**(2): 353–62.

Ismail M R, Abd El-Latif MS and Abd-Elaziz M A A. 2018. Combining ability analysis for some top crosses of white maize. *Egypt Journal of Plant Breeding* **22**(5): 1003–13.

Jenkins M T. 1935. The effect of inbreeding and selection within inbred lines of maize upon the hybrids made after successive generations of selfing. *Iowa State Journal of Science* **3**: 429–50.

Kempthorne O. 1957. *An Introduction to Genetic Statistics*. John Wiley and Sons Inc., NY, USA.

Mahmoud A A and Abd El-Azeem M E. 2004. Estimates of general and specific combining ability of some yellow maize inbred lines using top-crosses. *Annals of Agricultural Science* Moshtohor, Zagazig University **42**: 427–37.

Nawar A A, El-Shamarka S A, El-Absawy E A, Ibrahim M E and Shehata M A. 1998. Estimation of genetic variation in maize population and their interaction with growing season. *Minufiya Journal Agricultural Research* **23**(6): 1509–30.

Sprague G F. 1939. An estimation of the number of top crossed plants required for adequate representation of corn variety. *Journal of American Society of Agronomy* **38**: 11–16.

Sprague G F and Tatum L A. 1942. General versus specific combining ability in single crosses of corn. *Journal of American Society of Agronomy* **34**: 923–32.

Steel R G and Torrie J. 1980. *Principles and Procedures of Statistics.* Mc Graw-Hill Book Company, New York, USA.