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Inheritance of Grain Yield and Other Atributes in New Maize Inbred Lines

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Abstract

Nine yellow maize inbred lines derived from S_5 generation at Mallawy Agricultural Research Station were topcrossed with three testers, i.e., commercial inbred lines Gm1002, and Gm1021 as well as single cross 166 in 2008 season. The 27 topcrosses with three commercial hybrids SC162, SC166 and TWC352 were evaluated at Sakha, and Mallawy Research Stations during summer 2009. Number of days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows ear^{-1}, number of kernels per row^{-1}, number of ears 100 plants^{-1} and grain yield (ard fad^{-1}) were studied.

Mean square due to crosses was significant for all traits, except for number of rows ear^{-1} and number of ears 100 plants^{-1} . Mean squares due to lines and testers were significant for all of the studied traits, except for ear diameter and number of rows ear^{-1} of testers. Mean squares due to lines x testers interaction were significant for all the studied traits, except for ear height and number of rows ear^{-1}.

Significant differences were detected among locations for most studied traits. The interactions of locations (environments) with crosses were significant for all the studied traits. Inbreds x Loc. interaction were significant for ear diameter, number of rows ear^{-1}, number of kernels rows^{-1}, number of ears plant^{-1} and grain yield faddan^{-1}. Testers x Loc were significant for ear length, number of rows ear^{-1}, number of ears plant^{-1} and grain yield faddan$^{-1.}$ The interactions of L x T x Loc were significant for number of kernels row^{-1}, and number of ears 100 plant^{-1}. These interactions with locations are mainly attributed to the different ranking of genotypes from location to another

Inbred lines L1, L8 and L9 possessed significantly positive GCA effects (desirable) toward producing hybrids of high grain yield. The crosses (L2 x Gm1021), (L5 x Gm-1021), and (L7 x Gm1021) had positive and significant SCA effects for grain yield. The non-additive gene effects were more important than additive gene effects in the inheritance for days to 50%silking, plant height, ear length, ear diameter and grain yield. Furthermore, the non-additive gene action interacted more with the environmental conditions

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than the additive effects for all of the studied traits except, for silking date, ear length and no of rows per ear.

Four new single crosses i.e. (L1x Gm1002), (L1 x Gm1021), (L5 x Gm1021), and (L7 x Gm1021) out yielded the check hybrid SC162. Eight new three-way crosses i.e.,

(L1x SC166), (L2x SC166), (L3x SC166), (L4x SC166), (L5x SC166), (L6x SC166), (L8x SC166), and (L9x SC166) significantly out yielded the check TWC352. These promising yellow hybrids are prospective genetic materials for yielding ability in future maize breeding program

Key words: *Maize, top-cross,combining ability, additive, non-additive.*

Introduction

Developing high yielding maize hybrids is one of the ultimate goals of the National Maize Research Program (NMRP).

Topcross (test cross) method using broad and/or narrow testers is widely used to evaluate new improved lines for combining ability in maize hybrid breeding programmes. The choice of a tester to test the developed inbred lines is an important decision. In this respect, Lonnquist and Lindsey (1964) reported that the use of common tester parent reduced the range of traits expression among the evaluated progenies. Walejko and Russell (1977) stated that the inbred testers are effective for determining general and specific combining ability effects. Hallauer and Miranda (1981) found that the low performing testers gave a better idea of GCA of the lines than high performing testers. Ali and Tepora (1986) found that the inbred line as a narrow genetic base exhibited the highest genetic variation in the test crosses progenies for general combining ability effects for grain yield. The concept of general (GCA) and specific (SCA) combining ability was firstly defined by Sprague and Tatum (1942). They and other investigators (Hassaballa *et al* 1980, El-Morshidy and Hassaballa 1982, Mahmoud 1996, Konak *et al* 1999, Zelleke 2000 and Abd El-Moula and Abd El-Azeem2008) reported that the variance components due to SCA for grain yield and other agronomic traits were larger than that due to GCA, indicating the importance of non-additive type of gene action in the inheritance of these traits. Mathur *et al* (1998) obtained significant GCA variances for days to 50% silking. On the other hand, the environment x GCA interaction for grain yield was significant for both lines and testers (Hede *et al* 1999, Nass *et al* 2000, El-Zeir *et al* 2000, El-Morshidy *et al* 2003 and Abd El-Moula et al 2004). However, Soliman and Osman (2006) revealed that additive gene action component had the major role in the inheritance of grain yield and other traits compared with the non-additive ones. Parvez and Rather (2006) found that the non-additive component of gene effect had the major role in the inheritance of plant height, ear length, ear diameter, kernel rows ear^{-1}, 100-kernl weight and grain yield plot^{-1}. El-Hifny *et. al.* (2010), found that the grain yield character inheritance was mainly affected by non-additive gene action type.

Genotypic correlations among pairs of agronomic traits provide a scope for indirect selection in a crop breeding programme. Abo El-saad *et al.* (1994) found highly significant genotypic correlation coefficients between grain yield per plant, days to 50% silking and plant height.

The main objectives of this investigation were 1) to evaluate of 9 yellow maize inbred lines during topcrosses with three testers over two locations, 2) to determine the importance gene action type. 3) identify the most superior line(s), single and three way crosses to be utilize in hybrid maize breeding program and 4) determination of the phenotypic and genotypic correlation coefficients among grain yield and other studied traits.

Materials And Methods

Nine selected yellow maize inbred lines in S_5 generation derived from different a wide genetic base populations through selection from segregating generations in the disease nursery field at Mallawy Agricultural Research Station were used for the purpose of this study. In 2008 summer season, the 9 lines were topcrossed to each of three narrow base testers, *i.e.* inbreed lines Gm-1002 and Gm- 1021, and a commercial yellow single cross 166 (SC166) at Mallawy Experimental Station. The two tester lines were developed by Maize Research Program and are being used in seed production of commercial single and three-way cross hybrids. The obtained 27 top crosses with the three commercial check hybrids, SC162, SC166 and TWC352 were evaluated in replicated yield trials conducted at Sakha and Mallawy Agric Res. Stns. in 2009 season.

The experimental design was a randomized complete block design with four replications. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. Two kernels were planted per hill and thinned later to one plant per hill to provide a population of approximately 21000 plants feddan^{-1} (Feddan = 4200 m^2). All cultural practices for maize production were applied as recommended.

Data were recorded for nine quantitative traits, i.e. number of days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows ear^{-1}, number of kernels per row^{-1}, number of ears 100 plants^{-1} and grain yield (ard fad^{-1}) adjusted to 15.5% grain moisture content. Analysis of variance was performed for the combined data over locations according to Gomez and Gomez (1984), and Kempthorne (1957). Procedure as explained by Singh and

Chaudhary (1985) was followed to obtain information about the combining ability of the lines and the testers as well as estimate types of gene effects controlling grain yield and other studied traits in the tested lines. Genotypic and phenotypic correlation coefficients were computed according to Kwon and Torrie (1964).

From the expectation of mean squares of analysis of variance, the following variance components were estimated as follows;

$$k^2_l = \frac{MS_L - MS_{L\ x\ Env.}}{rte}$$

$$k^2_t = \frac{MS_T - MS_{T\ xEnv.}}{rle}$$

$$k^2_{lt} = \frac{MS_{LT} - MS_{LT\ xEnv.}}{re}$$

$$k^2_{le} = \frac{MS_{LxEnv.} - MS_e}{rt}$$

$$k^2_{te} = \frac{MS_{TxEnv.} - MS_e}{rl}$$

$$k^2_{lte} = \frac{MS_{LTxEnv.} - MS_E}{r}$$

Where:

k^2_l = variance due to lines.

k^2_t = variance due to testers.

k^2_{lt} = variance due to line x tester interaction.

k^2_{le} = variance due to line x location interaction.

k^2_{te} = variance due to tester x location interaction.

k^2_{lte} = variance due to line x tester x location interaction.

The covariance of half-sib (H.S.) and full-sib were estimated as follows:

$$Cov\ H.S. = \frac{t\,k^2_l + l\,k^2_t}{l + t}$$

$$Cov.\ F.S. = k^2_{lt} + 2\ Cov\ H.S.$$

$$k^2\ gca = Cov\ H.S.$$

$$k^2\ sca = (Cov.\ F.S. - 2\ Cov\ H.S.)$$

$$k^2\ gca \text{ x } E = \frac{t\,k^2_{le} + l\,k^2_{te}}{l + t}$$

$$k^2\ sca \text{ x } E = k^2_{lte}$$

Results And Discosions

Analysis of variance:

Combined analysis of variance for the nine studied traits is presented in Table (1). Significant and / or highly significant differences were detected among locations for all studied traits of top crosses, except for ear length, ear diameter and number of ears 100 plants^{-1}. These results revealed the presence of markedly variations among two locations in climatic and soil conditions.

Mean squares among crosses were significant for all traits, except for number of rows ear^{-1} and number of ears 100 plants^{-1}. Partitioning the sum of squares due to crosses into its components showed that mean squares due to lines and testers were significant for all traits, except for ear diameter and number of rows ear^{-1} of testers, revealing that great diversity existed among testers and lines. At the same time, mean squares of the lines x testers interaction were significant for all the studied traits, except for ear height and number of rows ear^{-1} , indicating that the lines (females) differed in order of performance in crosses with each of the testers (males).

The interactions of locations (environments) with crosses were significant for all the studied traits. Lines x Loc. interaction were significant for ear diameter, number of rows ear^{-1}, number of kernels rows^{-1}, number of ears 100 plants^{-1} and grain yield feddan^{-1}. Testers x Loc were significant for ear length, number of rows ear^{-1}, number of ears 100 plants^{-1} and grain yield faddan$^{-1.}$ These significant interactions with locations are mainly attributed to the different ranking of genotypes from location to another. The interaction of L x T x Loc were significant for number of kernels row^{-1}, and number of ears 100 plants^{-1}, revealing that the crosses between lines and testers behaved somewhat differently from location to another.

The magnitude of the variance due to testers for days to 50 % silking, ear height, ear length, number of kernels row^{-1}, number of ears 100 plants^{-1}, and grain yield (ard feddan^{-1}) were higher than variances due to lines, indicating that the testers contributed much more to the total variation. The magnitude of the variance due to T x Loc were higher than that of L x Loc for days to 50% silking, ear length, number of ears 100 plants^{-1} and grain yield feddan^{-1}, revealing that the testers were more affected by the environmental conditions than lines. Similar results were obtained by Shehata *et al* (1997), El-Zeir *et al* (2000), El-Morshidy *et al* (2003) and Abd El-Moula *et al* (2004). However, Amer and El-Shenawy (2007) obtained significant interaction between locations, lines and testers for silking date, ear height and grain yield. Also, Gado *et al* (2000), and El-Morshidy *et al* (2003) added that testers were affected much more by the environmental conditions than lines. Abd El-Moula *et al* (2010) found that, testers x Loc. interaction was higher in its magnitude than that of lines x Loc. for plant height, number of ears per 100 plants^{-1}, ear length, and grain yield., indicating that testers were more affected by the environmental conditions than lines for such traits.

Mean performance:

Mean performance of top-crosses along with the check hybrids SC162, SC166 and TWC352 are presented in Table

(2). Respecting number of days to 50% silking, results showed that, in general, all top crosses involving Gm1002 and Gm1021 as tester were significantly earlier than the commercial check SC166. However, the crosses (L4 x SC166), (L5 x SC166) and (L6 x SC166) were significantly earlier than the check hybrid TWC352. For plant height, the crosses (L2 x Gm1002), (L6 x Gm1002), (L7 x Gm1002) and (L7 x Gm1021) were significantly shorter than the shortest check SC166 .Only one cross (L2 x SC166) was significantly shorter than the check hybrid TWC352.

For ear height, results revealed that eight crosses involving Gm1002 and five crosses involving Gm1021 as tester was significantly low ear placement than the check SC166.Only one crosses (L2 x SC166) was significantly low ear placement than the check TWC352.

Regarding ear length, (Table 3) the cross (L4 x Gm1002) had the lowest value 18.8, while (L9 x SC166) recorded the highest value 23.03 cm. All crosses involving SC166 as tester had significantly surpassed than the check TWC352. For ear diameter, the lowest ear diameter was recorded for crosses (L5 x Gm1002) (L2x Gm1021) and (L2 x SC166) 4.9 cm, while the highest value was 5.20 cm for cross (L3 x Gm1021). Six crosses involving Gm1002, seven crosses involving Gm1021 as tester had significantly surpassed than the check hybrid SC166. Four crosses, (L1 x SC166), (L4 x SC166), (L6 x SC166), and (L8 x SC166) had significantly high ear diameter value than the check hybrid TWC352. Number of rows ear^{-1} ranged from 14.00 (L9 x SC166) to 15.77 (L4 x Gm1002). Six crosses involving Gm1021 as tester had significantly surpassed than the check hybrid SC166.Tow crosses (L3 x SC166) and (L4 x SC166) had significantly surpassed than the check hybrid TWC352.

Number of kernels per row (Table 4) ranged from 34.46 for (L5 x Gm1002) to 43.07 for (L9 x SC166). The crosses (L3x SC166), (L4x SC166), (L7x SC166), and (L9x SC166) had significantly surpassed than the check TWC352. Respecting to number of ears 100 plants^{-1}, the lowest value was 88.59 for (L2 x Gm1002), while the highest value was 118.25

for (L1 x Gm1021). Tow crosses (L1x SC166) and (L3x SC166) surpassed than the check TWC352.

For grain yield, the lowest value had recorded for crosses (L2 x Gm1002) 22.09, while the greatest value had recorded by (L8 x SC166) 37.95 ard faddan^{-1}. Four crosses i.e. (L1x Gm1002), (L1 x Gm1021), (L5 x Gm1021), and (L7 x Gm1021) had out yielded the check hybrid SC162. Eight crosses i.e., (L1x SC166), (L2x SC166), (L3x SC166), (L4x SC166), (L5x SC166), (L6x SC166), (L8x SC166), and (L9x SC166) exhibited significantly out yielded the check TWC352.

General (ĝi) and specific (ŝij) combining ability effects:

General combining ability effects of lines and testers for all of the studied traits are shown in Table 5. Inbred lines L4, L5, and L6 had negative (desirable) and significant values of GCA effects toward earliness. Inbred lines L2, L6 and L7 exhibited negative and significant GCA effects (desirable) toward shortness and low ear placement respectively.

Regarding ear length, positive and significant GCA effects was obtained for inbred lines L1 and L9 toward longest ear, while L4 and L5 were negative and significant GCA effects toward shortest ear. Respecting ear diameter, inbred lines L3 and L6 had positive and significant GCA effects toward thickness ear and L2 and L9 had negative and significant GCA effects toward thinnest ears. Inbred lines L3 and L4 exhibited positive and significant GCA effects toward high number of rows ear^{-1}, while L1, L2 and L9 had negative and significant GCA effects (undesirable) for number of rows ear^{-1}.

Regarding number of kernels row^{-1}, L1 and L9 had positive and significant GCA effects toward high number of kernels, while negative and significant GCA effects toward low number of kernels were obtained for L5 and L6. Inbred lines L1 and L3 exhibited positive and significant GCA effects or number of ears 100 plants^{-1} toward producing hybrids of more number of ears 100 plants^{-1}.

Regarding grain yield, L1, L8 and L9 showed significantly positive GCA effects (desirable) toward producing hybrids of high grain yield, while L2 showed negative and significant GCA effects (undesirable) toward low grain yield.

Estimates of GCA effects of the three testers Gm-1002, Gm-1021 and SC166 revealed that, tester Gm-1002 was a good general combiner for days to 50%silking, plant height, and ear height. While, tester Gm-1021 had favorable alleles for number of ears 100 plants^{-1}. The tester SC166 had favorable alleles for ear length, number of kernels row^{-1} and grain yield.

Estimates of SCA effects for number of days to 50% silking, are presented in Table 6. The cross (L7 x Gm1002) showed negative values of SCA (desirable) effects across locations and was earlier in flowering compared to the check hybrids

Regarding the combined analysis across locations for plant height (Table 6) two topcrosses i.e. (L7 x Gm1021), and (L8 x SC166) exhibited significant negative SCA effects toward shortness. For ear height Table 7, three topcrosses i.e. (L2x Gm1002), (L7 x Gm1021) and (L8 x SC166) showed significant negative SCA effects toward low ear placement.

The two crosses (L9 x Gm1002), and (L7 x SC166) had positive and significant SCA effects, while the crosses (L7 x Gm1021), (L9 x Gm1021), and (L1 x SC166) had negative and significant SCA effects (undesirable) for ear length. (Table 7). For ear diameter, three

crosses i.e. (L3 x Gm1021), (L7 x Gm1021), and (L4 x SC166) had positive, while the crosses (L4 x Gm1021), and (L3 x SC166) had negative and significant SCA effects.

The crosses (L1 x Gm1002) and (L7 x Gm1021) had positive, while (L1 x Gm1021) had negative and significant SCA effects for number of rows ear^{-1}. For number of kernels row^{-1} Table 8, the crosses (L1 x Gm1002), (L5 x Gm1021), and (L7 x SC166) exhibited positive, while (L5 x Gm1002), and (L1 x SC166) had negative and significant SCA effects.

Out of the 27 studied topcrosses, two crosses, (L1 x Gm1021) and (L2 x Gm1021) possessed significant positive SCA effects toward higher number of ears per 100 plants, which is desirable. On the other hand (L2 x Gm1002) possessed significant negative SCA effects toward lower number of ears per plants, which is undesirable..

Respecting grain yield, data in Table 8, showed that the crosses (L2 x Gm1021), (L5 x Gm-1021), and (L7 x Gm1021) had positive and significant SCA effects for grain yield. On the other hand the crosses (L2 x Gm1002), (L5 x Gm1021), and (L7 x SC166) showed significant negative SCA effects for grain yield. In this connection, Sprague and Tatum (1942) emphasized the importance of single and three-way cross trials for determining the most productive specific combination. Shehata *et al* (1997), reported that inbred testers were more effective to select lines that combine well with unrelated testers. Moreover, they emphasized that inbred testers were more effective in detecting small differences in combining ability more than wide genetic base testers.

Variance components

Estimates of combining ability variances for tested lines and testers (k^2_{GCA}) and of crosses (k^2_{SCA}) for grain yield and other agronomic traits of topcrosses across locations are presented in Table 9. Results revealed that estimates of k^2_{GCA} for lines (L) were higher than those of k^2_{GCA} for testers (T) for plant and ear height and, ear diameter, no of rows per ear, number of ears 100 $plants^{-1}$ and grain yield. These results indicate that most of the total variance was due to GCA of the lines. The variance interaction of k^2_{GCA} lines x Loc. was larger than that of k^2_{GCA} testers x Loc. for all studied traits, except for days to 50%silking and ear length. These results indicating that k^2_{GCA} for lines were more affected by environmental conditions than that for testers. The k^2_{SCA} variance was larger than that of k^2_{GCA} for days to 50%silking, plant height, ear length, ear diameter and grain yield. These results indicate that the non-additive gene was more important than additive gene effects in these traits inheritance.

Furthermore, the magnitude of k^2_{SCA} x Loc. interaction was greater than that of k^2_{GCA} x Loc interaction for all the studied traits except, for silking date, ear length and no of rows per ear, indicating that the non-additive gene action interacted more with the environmental conditions than the additive gene effects for this trait. These results are in agreement with the findings of several investigators who reported specific combining ability variance is more sensitive to environmental changes than general combining ability variance (Gilbert, 1958). Also, Sadek *et al* (2000 and 2002) and Parvez and Rather (2006) also found that the non-addetive genetic variation interacted more with the environment than the additive component On the other hand, El-Itrby *et al* (1990), and Soliman *et al* (2001) reported that the additive types of gene action were more affected by the environment than non-additive ones.

Genotypic correlation:

Estimates of genotypic correlation among grain yield and other studied traits are presented in Table 10. Data showed that positive and significant correlation coefficients among days to 50%silking and plant height, ear height, ear length, and number of kernels row^{-1} both at the genotypic and phenotypic levels. Correlation between number of days to 50% silking and grain yield was positive and non-significant both at the genotypic and phenotypic levels (El-Nagouli *et al*., 1983).

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Correlation coefficients had positive and significant among plant height and ear height, ear length, number of kernels row^{-1}, and grain yield both at the genotypic and phenotypic levels. Also positive and significant genotypic and phenotypic correlation had been detected among ear length, number of kernels row^{-1} and grain yield; ear diameter and number of kernels row^{-1} ; and grain yield; and among grain yield and number of ears 100 $plants^{-1}$.These results indicating that the five traits (plant height, ear height, ear length, number of kernels row^{-1} and number of ears 100 $plants^{-1}$) had related and any increase in ear length, number of kernels row^{-1} and number of ears 100 $plants^{-1}$ lead to an increase in grain yield and vice versa. Therefore, indirect selection for linked traits with grain yield would be useful and effective for improving grain yield. Similar results were obtained by El-Sherbieny *et. al.* (1994) and Muhammad and Saleem (2001). Sadek and Abdel-Azeem (2005) found positive and highly significant correlation among grain yield and plant height, ear height and ear length.

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وراثة المحصول وبعض الصفات المرتبطة في بعض سلالات الذرة الشامية الصفراء

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تم تهجين تسعة سلالات صفراء من الذرة الشامية في الجيل الذاتي الخامس مع اثنين من السلالات الكشافة المختلفة وراثيا وهى جميزة 1002 وجميزة 1021 والهجين الفردي 166 بمحطة البحوث الزراعية بملوي موسم 2008. تم تقييم الــ 27 هجين قمى الناتجة من التهجين بالاضافة الى ثلاث هجن تجارية هي هــ فــ 162 وهــ فــ 166 وهجين ثلاثي 352 وتم التقييم بمحطات البحوث الزراعية بسخا وملوي موسم 2009. تم دراسة صفات (عدد الأيام حتى ظهور 50% من الحراير ، ارتفاع النبات و الكوز ، طول الكوز ،قطر الكوز، عدد الصفوف بالكوز، عدد الحبوب بالصف، عدد الكيزان / 100نبات ، محصول الحبوب بالأردب / فدان . وكانت أهم النتائج مايلى :-

- وجدت اختلافات معنوية بين الهجن لجميع الصفات. وكانت الاختلافات الراجعة للسلالات والكشافات معنوية لجميع الصفات ما عدا صفة قطر الكوز وعدد صفوف الكوز للكشافات.

كذلك وجدت اختلافات معنوية بين الموقعين لجميع الصفات المدروسة مما يدل عل ان الموقعين مختلفتين في الظروف البيئية. وكان تباين التفاعل بين المواقع والهجن القمية معنويا لجميع الصفات المدروسة. كما كان تباين التفاعل بين السلالات والمواقع معنويا لصفات قطر الكوز، عدد الصفوف بالكوز، عدد الحبوب بالصف، عدد الكيزان لكل 100 نبات و محصول الحبوب . كما كان تباين التفاعل بين الكشافات والمواقع معنويا لصفات طول الكوز، عدد الصفوف بالكوز، عدد الكيزان لكل 100 نبات و محصول الحبوب .

- أظهرت السلالات الآتية تأثيرات مرغوبة ومعنوية للقدرة العامة على التآلف وهى سلالة 6و9و12 والسلالات 1 ، 8 و9 لصفة محصول الحبوب. كما أظهرت الهجن القمية التالية أحسن التأثيرات الموجبة والمعنوية لصفة محصول الحبوب وهي L2 x Gm1021, L5 x Gm-1021, و L7 x Gm 1021 .

- لعب التباين الوراثي الغير مضيف الدور الأهم في وراثة صفات عدد الأيام حتى ظهور 50% من الحراير، ارتفاع النبات ، طول الكوز، قطر الكوز، ومحصول الحبوب. و كان سلوك التباين الوراثي الغير إضافي أكثر تأثرا بالمواقع فى معظم الصفات المدروسة

- أظهرت الهجن القمية لفردية الآتية أحسن أداء وتفوقا وهي L1 x Gm 1021 و L1 x Gm 1002 و L5 x Gm 1021 وL7 x Gm 1021 على هجين المقارنة هــ. فــ 162 وتفوق 8 هجن ثلاثية هي L1x SC166, L2x SC166, L3x SC166, L4x SC166, L5x SC166, L6x SC166, L8x SC166, وL9x SC166 بدرجة معنوية عن هجين المقارنة هــ. ثــ 352 لصفة محصول الحبوب مما يشير إلى أهمية هذه الهجن الصفراء كمواد وراثية مثمرة للقدرة المحصولية العالية في البرامج المستقبلية لتربية الذرة الشامية.