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# Combining Ability Using Half Diallel Mating Design of Yellow Maize Inbred Lines

Shalof M. S. , A.A.M. Afife, M.A.A. Abd-Elaziz, R.H.A. Alsebaey and A.S.M. Al-Deeb
Maize Research Department, Field Crops Research Institute, ARC, Egypt

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**ABSTRACT**: Combining abilities is prerequisite to developing good maize hybrids. A half diallel cross among seven new yellow maize inbred lines were made in 2022 summer growing season. The resulting, 21 $F_1$ crosses along with two yellow commercial hybrids, SC.168 and SC. 3444 were evaluated in a randomized complete block design with three replications at three locations in 2023 summer growing season. To study the combining ability to identify the most superior inbred lines and hybrids. Data recorded on days to 50% silking, plant and ear heights and grain yield. Results indicated that Both GCA and SCA mean squares were highly significant indicating the involvement of both additive and non-additive type of gene effects in the inheritance of all traits under study. However, the additive gene effects played the major role in the inheritance of all traits except for days to 50 %silking. The best inbred line for GCA effects were Gm.20 for earliness, Gm.6041 for short plant and ear heights, Gm.45 for grain yield. The best cross for SCA effects was (Gm.6041 × Gm.67) for earliness, (Gm.67 × Gm.34) for short plant height (cm), (Gm.6052 × Gm.20) for short ear height (cm) and (Gm.45× Gm.67) for high grain yield. These crosses will be evaluated to extensive testing in maize breeding program.

**Keywords**: *Zea Mays*, GCA, SCA, additive and non-additive, gene effects.

## INTRODUCTION

For increasing maize (Zea mayse L.) production must be developing hybrids to give high yields. The gen action natural is helpful for plant breeders to give new hybrids through the involvement of different quantitative characteristics. General combining ability (GCA) and specific combining ability (SCA) are the two components of combining ability which important in determining the inheritance pattern of desired traits Sprague and Tatum, (1942). Information on GCA enabled us to explore and detect the variability of breeding materials to determine desirable inbreed lines Vacaro et al. (2002) and Sharma et al. (2016). While SCA helps in determining heterotic patterns of inbred lines, indicating promising candidates for single crosses and clustering inbred lines into heterotic groups, Abrha et al. (2013). So, in breeding programs must be knowledge of gene action magnitude to select promising and efficient genotypes through combining ability analysis of both additive and non-additive gene effects, have been reported by Rojas and Sprague (1952), Moll et al. (1962), Mason and Zuber (1976). On the other hand, Gamble (1962) and Kambe et al. (2013) stated that the exploitation of hybrid vigor and selection of parents based on combining ability has been used as an important breeding approach in crop improvement. This Present study was undertaken to investigate the breeding behavior of seven maize inbred lines for days numbers to mid-silking, plant, ear height and grain yield to identify the superior hybrid yield, compared with two commercial hybrids.

## MATERIALS AND METHODS

The experimental materials, comprising of seven yellow inbred lines *viz;* Gm.6041, Gm.6052, Gm.45, Gm.56, Gm.20, Gm.67 and Gm.34 produced in maize breeding program at Gemmeiza Station. These seven inbred lines were crossed in half diallel mating design to develop 21 crosses. The 21 $F_1$ hybrids plus two yellow commercial check single crosses, SC.168 and pioneer SC. 3444 were evaluated in a randomized complete block design with three replications at three locations Gemmeiza, Nubaria and Mallawy in summer growing season. Data recorded on grain yield after 120 days from sowing (ard/fed) adjusted on 15.5% grain moisture, days to 50% silking (days number from sowing to appear 50% of silks) ,Plant height was measured in (cm) from ground surface to flag leaf and Ear height was measured in (cm) from ground surface to ear leaf. Analysis of variances was carried out for all the traits according to Snedecor and Cochran (1989) technique. Highly significant differences were noticed for crosses for all traits, hence the analyses of GCA and SCA were carried out using Griffing, (1956) technique, Method 4 model 1. Calculation of analysis of variances was carried out by using computer application of statistical analysis system (SAS 2008).

**Table (1): The name of inbred lines and pedigree in this investigate.**

| Code | Line name | Pedigree |
|---|---|---|
| P1 | Gm. 6041 | Gm.Y. Pop. |
| P2 | Gm. 6052 | Gm 509 F. |
| P3 | Gm. 45 | Comp #45. |
| P4 | Gm. 56 | Comp #45. |
| P5 | Gm. 20 | Nub.Y. Pop. |
| P6 | Gm. 67 | Nub.Y. Pop. |
| P7 | Gm. 34 | Bank material. |

## RESULTS AND DISCUSSION

### Analysis of variances

Analysis of variances for four traits across three locations is presented in Table (2). Results showed that significant differences between the three locations (Loc) were detected for all studied traits, indicating that the three locations were differed in their environmental conditions. The mean squares of the interaction between crosses and locations (C x Loc) were highly significant for all studied traits, meaning that the crosses were affected by changing locations. These findings agreed with those reported by Aly and Amer (2008), Mousa and Aly (2012), Sultan *et al.* ( 2012), Kumar *et al.* (2017), Hammadi and Abed (2018), Rohman *et al.* (2019), Alam *et al.* (2020), Abdulla, *et al.* (2022), Suwarno *et al.* (2023) and Vishal *et al.* (2024).

**Table (2): Mean Squares of locations, crosses, and their interaction for days to 50 % silking (SK), plant height (PH), ear height (EH) and grain yield (GY).**

| SOV | d.f | SK | PH | EH | GY |
|---|---|---|---|---|---|
| Location (Loc) | 2 | 280.91** | 52633.41** | 33883.11** | 266.74** |
| Rep / Loc | 6 | 4.76 | 321.70 | 246.18 | 175.73 |
| Crosses (C) | 20 | 12.64** | 1818.22** | 854.89** | 212.95** |
| C × Loc | 40 | 23.68** | 896.15** | 427.96** | 116.41** |
| Error | 120 | 1.34 | 134.39 | 77.77 | 8.84 |

**** Highly significant different at 0.01 level of probability.**

Both GCA and SCA mean squares at (Table 3), were highly significant variances indicating the involvement of both additive and non-additive type of gene action in the inheritance of these traits. Similar findings have been reported by Moll *et al.*(1962), Mason and Zuber (1976), Saad *et al.* (2004), Sharma *et al.* (2004), Muraya *et al.* (2006), Sultan *et al.* (2012), Hammadi and Abed (2018), Rohman *et al.* (2019), Alam *et al.* (2020), Abdulla *et al.* (2022), Suwarno *et al.* (2023) and Vishal *et al.* (2024). The interactions between GCA and SCA with locations (Loc) were highly significant for all studied traits, indicating that both additive and non-additive gene effects were influenced by locations. The ratio of GCA/SCA was more than unity for all studied traits except for, days to 50% silking. These results indicated that the additive gene effects were more important and played the major role in the inheritance of all studied traits except for days to 50% silking (the non-additive gene effects was played the major role). These results agree with the finding of Hammadi and Abed (2018), Rohman *et al.* (2019), Suwarno *et al.*( 2023) and Vishal *et al.* (2024). Meanwhile, the ratio of (GCA × Loc / SCA × Loc) was more than unity for all studied traits except for grain yield indicating the additive gene effects was more affected by locations for traits (SK, PH and EH) meanwhile the reverse was obtained for grain yield, which the non-additive gene effects was more influence by locations.

**Table (3): Mean squares of GCA, SCA and their interaction with locations (Loc) for days to 50 % silking (SK), plant height (PH), ear height (EH) and grain yield (GY).**

| SOV | df | SK | PH | EH | GY |
|---|---|---|---|---|---|
| GCA | 6 | 10.04** | 4310.47** | 2035.13** | 422.13** |
| SCA | 14 | 13.76** | 750.013** | 347.08** | 123.31** |
| GCA × Loc | 12 | 32.19** | 1447.58** | 734.99** | 78.95** |
| SCA × Loc | 28 | 20.04** | 659.87** | 296.73** | 132.46** |
| Error | 120 | 1.34 | 134.39 | 77.77 | 8.84 |
| GCA / SCA | | 0.73 | 5.74 | 5.83 | 3.42 |
| GCA × Loc / SCA × Loc | | 1.61 | 2.19 | 2.45 | 0.60 |

**** Highly significant differences at 0.01 level of probability.**

**Mean performance**

Mean performance for 21 $F_1$ and two checks (SC 168 and SC 3444) across three locations for grain yield and other agronomic traits are presented in Table 4. For days to 50% silking, crosses ranged from 59 days for (Gm 6041 x Gm 67) to 64 days for (Gm 6041 x Gm 34). Out of 21 crosses; 6 crosses were significantly earlier than the best check SC 168 and 15 crosses were significantly earlier than the check SC 3444 the best crosses from them were (Gm 6041 × Gm 67), (Gm 6041 × Gm 6052), (Gm 6052 × Gm 20), (Gm 45 × Gm 56), (Gm 45 × Gm 20) and (Gm 20 × Gm 67). For plant height, 15 crosses out of the evaluated 21new yellow single crosses were significantly shorter than the checks SC 168 and SC 3444. For ear height, 16 crosses out of the same evaluated 21 crosses were significantly lower ear placement than the check SC168 and 7 crosses than the check SC 3444. The best hybrid for short plant height and lower ear placement was the single cross (Gm 6041 × Gm 34) and (Gm 6041 × Gm 56). The highest grain yield was obtained from crosses (Gm.6052 × Gm.45) 33.09 ard/fed followed (Gm.45 × Gm.67) 32.80 ard/fed, these two crosses were significantly out yielded the check SC 168 (29.08 ard/fed) and non-significant than check SC 3444 (30.55 ard/fed). Hence it could be concluded that these two crosses may be useful for improving grain yield in maize breeding program.

**Table (4): Mean Performance of 21 crosses and two checks for days to 50 % silking (SK), plant height (PH), ear height (EH) and grain yield (GY) across three locations**

| Cross | | SK (days) | PH (cm) | EH (cm) | GY (ard/fed) |
|---|---|---|---|---|---|
| (Gm.6041 × Gm.6052) | | 60 | 226.0 | 120.4 | 29.07 |
| (Gm.6041 × Gm.45) | | 62 | 215.0 | 115.7 | 24.09 |
| (Gm.6041 × Gm.56) | | 61 | 206.8 | 111.6 | 26.16 |
| (Gm.6041 × Gm.20) | | 61 | 226.3 | 124.0 | 26.49 |
| (Gm.6041 × Gm.67) | | 59 | 228.7 | 122.2 | 19.44 |
| (Gm.6041 × Gm.34) | | 64 | 201.6 | 106.1 | 14.66 |
| (Gm.6052 × Gm.45) | | 61 | 248.7 | 142.7 | 33.09 |
| (Gm.6052 × Gm.56) | | 63 | 250.4 | 141.3 | 28.83 |
| (Gm.6052 × Gm.20) | | 60 | 245.9 | 127.6 | 25.88 |
| (Gm.6052 × Gm.67) | | 62 | 251.2 | 135.3 | 25.96 |
| (Gm.6052 × Gm.34) | | 61 | 243.1 | 131.1 | 24.81 |
| (Gm. 45 × Gm.56) | | 60 | 224.9 | 135.4 | 28.57 |
| (Gm.45 × Gm.20) | | 60 | 236.3 | 137.7 | 24.17 |
| (Gm.45 × Gm.67) | | 62 | 223.2 | 124.4 | 32.80 |
| (Gm.45 × Gm.34) | | 61 | 243.9 | 140.1 | 25.06 |
| (Gm.56 × Gm.20) | | 61 | 226.1 | 129.3 | 22.34 |
| (Gm.56 × Gm.67) | | 61 | 218.8 | 123.2 | 27.64 |
| (Gm.56 × Gm.34) | | 61 | 231.7 | 128.2 | 27.29 |
| (Gm.20 × Gm.67) | | 60 | 231.8 | 121.0 | 26.05 |
| (Gm.20 × Gm.34) | | 61 | 224.4 | 126.9 | 21.27 |
| (Gm.67 × Gm.34) | | 62 | 212.1 | 119.0 | 13.85 |
| SC.168 | | 62 | 251.3 | 142.8 | 29.08 |
| SC. 3444 | | 63 | 247.1 | 131.9 | 30.55 |
| LSD | 5% | 1.1 | 10.9 | 8.3 | 2.79 |
| | 1% | 1.4 | 14.1 | 10.7 | 3.618 |

**General combining ability (GCA) effects:**

Estimates GCA effects for seven inbred lines for traits under study are shown in Table 5. For days to 50% silking, the parental inbred line (Gm 20) showed negative and significant GCA effects (desirable). Whereas, (Gm.6041) and (Gm.34) exhibited negative and significant GCA effects (desirable) for plant height also (Gm 6041) and (Gm 67) exhibited negative and significant GCA effects (desirable) for ear height. The parental inbred lines (Gm.6052), (Gm.45) and (Gm 56) were good combiner for grain yield (positive and highly significant). From above results the desirable inbred lines for traits under study could be used for develop superior hybrids for these traits. Researchers which conformed with these results Sultan *et al.* (2012), Hammadi and Abed (2018), Rohman *et al.* (2019), Alam *et al*. (2020), Abdulla, *et al.* (2022), Suwarno *et al.* (2023) and Vishal *et al.* (2024).

**Table (5): GCA effects of seven inbreed lines for days to 50 % silking (SK), plant height (PH), ear height (EH) and grain yield (GY) across three locations**

| Inbred line | | SK | PH | EH | GY |
|---|---|---|---|---|---|
| Gm.6041 | | 0.089 | -14.38** | -12.19** | -2.16** |
| Gm.6052 | | -0.022 | 17.81** | 7.50** | 3.38** |
| Gm.45 | | -0.244 | 3.14 | 7.01** | 3.41** |
| Gm.56 | | -0.022 | -3.51* | 1.63 | 2.02** |
| Gm.20 | | -0.622** | 2.92 | 1.10 | -0.90* |
| Gm.67 | | -0.111 | -2.09 | -3.15** | -0.99* |
| Gm.34 | | 0.933** | -3.89* | -1.90 | -4.75** |
| LSD $g_i$ | 5% | 0.318 | 3.18 | 2.42 | 0.81 |
| | 1% | 0.412 | 4.12 | 3.14 | 1.05 |

***, ** significant and highly significant differences at 0.05 and 0.01 level of probability, respecttively.**

**Specific combining ability (SCA) effects:**

Table (6), displayed significant negative and positive SCA effects for SK, PH, EH and GY traits in combined data. For days to 50% sillking, the desirable hybrids for (SCA) effects were (Gm 6041×Gm 6052), (Gm 6041×Gm 67), (Gm 6052×Gm 34), (Gm 45×Gm 56) and (Gm 56×Gm 34). For plant heights, the desirable hybrids for (SCA) effects were **(**Gm 6041×Gm 6052), (Gm 6041×Gm 34), (Gm 45×Gm 67) and (Gm 67×Gm 34). For ear heights, results the desirable hybrids for SCA effects were (Gm 6041×Gm 6052), (Gm 6041×Gm 34), (Gm 6052×Gm 20) and (Gm 45×Gm 67). For grain yield results showed positive and significant SCA effect were detected for crosses (Gm 6041×Gm 6052), (Gm 6041 × Gm 20), (Gm 45 × Gm 67), (Gm 56 × Gm 34), (Gm 20 × Gm 67) and (Gm 20 × Gm 34) towards high grain yield. Similar results were obtained by Muraya *et al.* (2006), Sultan *et al.* (2012), Hammadi and Abed (2018), Rohman *et al.* (2019), Suwarno *et al.* (2023) and Vishal *et al.* (2024).

**Table (6): SCA effects of 21 crosses for days to 50% silking (SK), plant height (PH), ear height (EH) and grain yield (GY), across three location.**

| **Crosses** | | **SK** | **PH** | **EH** | **GY** |
|---|---|---|---|---|---|
| **(Gm.6041 × Gm.6052)** | | **-1.326**** | **-6.80*** | **-1.69** | **2.72**** |
| **(Gm.6041 × Gm.45)** | | **0.563** | **-3.14** | **-5.98*** | **-2.27**** |
| **(Gm.6041 × Gm.56)** | | **-0.437** | **-4.69** | **-4.71** | **1.18** |
| **(Gm.6041 × Gm.20)** | | **0.719*** | **8.41**** | **8.27**** | **4.437**** |
| **(Gm.6041 × Gm.67)** | | **-1.793**** | **15.77**** | **10.73**** | **-2.52**** |
| **(Gm.6041 × Gm.34)** | | **2.274**** | **-9.54**** | **-6.62**** | **-3.54**** |
| **(Gm.6052 × Gm.45)** | | **-0.215** | **-1.67** | **1.33** | **1.17** |
| **(Gm.6052 × Gm.56)** | | **2.119**** | **6.77*** | **5.38*** | **-1.69*** |
| **(Gm.6052 × Gm.20)** | | **-0.504** | **-4.22** | **-7.87**** | **-1.72*** |
| **(Gm.6052 × Gm.67)** | | **0.541** | **6.12** | **4.16** | **-1.54** |
| **(Gm.6052 × Gm.34)** | | **-0.615*** | **-0.185** | **-1.31** | **1.06** |
| **(Gm. 45 × Gm.56)** | | **-0.770*** | **-4.11** | **-0.02** | **-1.98*** |
| **(Gm.45 × Gm.20)** | | **-0.281** | **0.88** | **2.73** | **-3.45**** |
| **(Gm.45 × Gm.67)** | | **1.096**** | **-7.20*** | **-6.24**** | **5.26**** |
| **(Gm.45 × Gm.34)** | | **-0.393** | **15.25**** | **8.18**** | **1.28** |
| **(Gm.56 × Gm.20)** | | **0.496** | **-2.67** | **-0.22** | **-3.89**** |
| **(Gm.56 × Gm.67)** | | **0.096** | **-4.98** | **-2.09** | **1.49** |
| **(Gm.56 × Gm.34)** | | **-1.504**** | **9.70**** | **1.67** | **4.90**** |
| **(Gm.20 × Gm.67)** | | **-0.304** | **1.57** | **-3.78** | **2.83**** |
| **(Gm.20 × Gm.34)** | | **-0.126** | **-3.96** | **0.87** | **1.81*** |
| **(Gm.67 × Gm.34)** | | **0.363** | **-11.27**** | **-2.78** | **-5.51**** |
| **LSD $S_{IJ}$** | **5%** | **0.627** | **6.27** | **4.78** | **1.61** |
| | **1%** | **0.813** | **8.14** | **6.19** | **2.08** |

***, ** significant and highly significant differences at 0.05 and 0.01 level of probability, respectively.**

## CONCLUSION

Additive gene effects played the major role in the inheritance of most study traits. Among the evaluated inbred lines, inbreeds Gm.6052, Gm.45 and Gm.56 significantly contributed to the good performance of the hybrids for grain yield characteristics. Amongst 21 crosses only two crosses (Gm.6052×Gm.45 and Gm.45×Gm.67) positive better results over check varieties SC.168 for grain yield. Therefore, it is suggested that these single crosses may be useful for improving maize grain yield program.

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## الملخص العربي

# القدرة على الآئتلاف باستخدام التهجين التبادلي  النصف دائرى لسلالات صفراء من الذرة الشامية

محمد صلاح شلوف ، عبد الفتاح عفيفي محمد عفيفى ، محمد عبدالعزيز عبدالنبى عبد العزيز، رفيق حليم السباعي ، ايمن سالم محمد الديب

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

تقدير القدرة على الائتلاف من الاساسيات للحصول على هجن متفوقة. تم إجراء تهجين تبادلي نصف دائرى بين سبعة سلالات جديدة من الذرة الصفراء في موسم صيف 2022. تم تقييم 21 هجين الناتجة مع هجينين تجاريين هما هجين فردي 168 وهجين فردي بيونير 3444 في تصميم القطاعات الكاملة العشوائية فى ثلاثة مكررات في ثلاثة مواقع مختلفة لدراسة القدرة علي الائتلاف للتعرف علي السلالات و الهجن المتفوقة. الصفات المدروسة هى عدد الايام حتى ظهور حرائر 50% من النباتات (يوم) وارتفاع النبات (سم) وارتفاع الكوز (سم) ومحصول الحبوب (اردب/فدان). أشارت النتائج إلى أن كلا من القدرة العامة والخاصة علي الائتلاف عالية المعنوية مما يشير إلى كل من تاثيرات كلا من الفعل الوراثي المضيف و الغير مضيف مهمة ويشتركان في وراثة هذه الصفات ومع ذلك كانت تأثيرات الفعل الوراثي المضيف اكثر اهمية في وراثة جميع الصفات ما عدا صفة ظهور حريرة 50%من النباتات. وافضل السلالات في تاثيرات القدرة العامة علي الائتلاف كانت السلالة جميزة 20 لصفة التبكير و جميزة 6041 لقصر كل من ارتفاع النبات والكوز والسلالة جميزة 45 لمحصول الحبوب. افضل هجين في تأثيرات القدرة الخاصة علي الائتلاف هو (جميزة 6041 × جميزة67 ) للتبكير، (جميزة 67 × جميزة 34) لقصر ارتفاع النبات و(جميزة 6052 x جميزة 20) لقصر ارتفاع الكوز و(جميزة 45 × جميزة 67 ) لمحصول الحبوب العالي وهذة الهجن سوف يتم تقيمها في تجارب موسعة في برنامج التربية للذرة الشامية.