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# Diallel Analysis of Grain Yield and Some Other Traits in Yellow Maize (*Zea mays* L.) Inbred Lines

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**ABSTRACT:**

Eight advanced inbred lines derived from different yellow maize populations were crossed in a half diallel mating scheme in 2010 season at Gemmeiza Agric. Res. Station. The resultant 28 crosses along with two commercial check hybrids i.e. SC 166 and SC 173 were evaluated at two locations i.e. Gemmeiza and Mallawy Agric. Res. Stations in 2011 season. Mean squares due to crosses, G.C.A. and S.C.A. were highly significant for all studied traits. The ratio of Σg2i/ ΣS2ij indicated that the non-additive gene effects played the major role in the inhertance of all the studied traits. For grain yield, one parental inbred line P3 had significant positive GCA effects and six crosses P1xP2, P1xP6, P2xP4, P3xP8, P5xP7 and P6xP7 had significant or highly significant positive SCA effects. One cross P3xP8 gave similar productivity to that of SC 166. Also two crosses P3xP5 and P5xP7 exhibited similar yield performance to that of the check hybrid SC 173, since no significant difference. These promising crosses may be released as commercial hybrids by maize research program after further testing.

***Keywords***: *maize, diallel crosses, gene effect.*

**INTRODUCTION:**

Diallel crosses in maize was developed by **Sprague and Tatum (1942)** who partitioned the variation among $F_1$ crosses resulting from inbred lines to general (G.C.A.) and specific (S.C.A.) combining ability. **Matzinger et al. (1959)** revealed that the G.C.A. variance is a function of additive variance, while S.C.A. variance is a function of the non-additive variance. **Griffing (1956)** gave a complete analysis of diallel crosses for fixed and random set of parents. **El-Shamarka (1995), Mostafa et al. (1996), Abd El-Aty and Katta (2002) and Ibrahim et al. (2010)** reported that specific combining ability effects were much more important in the inheritance of grain yield and its components. Meanwhile, **Beck et al. (1991), El-Hosary et al. (1999), Abd El-Moula (2005), Derera et al. (2008), Vivek et al. (2010) and Sibiya et al. (2011)** reported that general combining ability was more important in

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determining yield and other characters. **Gilbert (1958)** indicated that SCA was more affected by environments than GCA. **Abdel-Sattar et al. (1999)** found that the magnitude of S.C.A. x Environment was more than G.C.A. x environment for No. of ears/plants, grain yield, indicating that non-additive gene effects were much influenced by environmental conditions than additive genetic effects in these traits.

The main objectives of this study were: 1) to estimates general and specific combining abilities for some quantitative characters in a set of eight inbred lines and 2) to identify the best promising crosses.

**Matreials And Methods:**

Eight inbred lines derived from different maize populations (Table 1) were crossed in a half diallel mating scheme in 2010 season at Gemmeiza Agric. Res. Station. The resultant 28 crosses along with two commercial check hybrids i.e. SC 166 and SC 173 were evaluated in a randomized complete block design with four replications at two locations i.e. Gemmeiza and Mallawy Agric. Res. Stations in 2011 season. The experimental plot was one row, 6 m long and 0.80 m apart.

Planting was done in hills evenly spaced at 0.25 m along the row at the rate of two kernels per hill, later thinned to one plant per hill. Agricultural practices were done as recommended for maize cultivation. Data were recorded for no. of days to 50% silking, plant height, ear height, No. of ears per 100 plants, grain yield/plot and grain yield/fad adjusted to 15.5 percent grain moisture and calculated in ardab per faddan (ard $fad^{-1}$) (ardab=140kg, faddan=4200$m^2$). Bartlett test was used to test the homogeneity of error variance between the two locations. Analysis of variance was performed for the combined data over the two locations according to **Steel and Torri (1980)**. General and specific combining abilities were computed using method 4, model 1 of **Griffing (1956)**.

Table 1. Sources of parental inbred lines used in currently study.

| Parents | Source |
|---|---|
| $P_1$ | Gm.35 (Gemmeiza yellow population) |
| $P_2$ | Gm.70 (Comp#21) |
| $P_3$ | Gm.127 (Pop.509) |
| $P_4$ | Gm.155 (Comp#45) |
| $P_5$ | Gm.190 (Pop.446)(Cimmyt) |
| $P_6$ | Gm.206 (Pop.146-66)(Cimmyt) |
| $P_7$ | Gm.220 (Pool-18-627M)(Cimmyt) |
| P8 | Gm.233 (Pop.45C8)(Cimmyt) |

## RESULTS AND DISCUSSION

**Analysis of variance:**

Analysis of variance for all studied traits over the two locations are presented in Table 2. Mean squares due to locations were significant or highly significant for all traits, indicating that the two locations differed in their environmental conditions. Mean squares due to crosses, G.C.A. and S.C.A. were highly significant for all studied traits. Mean squares for crosses x locations interaction were highly significant for all studied traits, except No. of ears per 100 plants.

Mean squares due to G.C.A. x locations and S.C.A. x locations interaction were significant or highly significant for all the studied traits, except No. of ears per 100 plants, indicating that the magnitude of all types of gene action varied from location to another. The same results were obtained by **El-Hosary (1989), Barakat et al.(2003)**,they found that the interaction between both types of combining abilities and environment was highly significant.

The magnitude of mean squares for G.C.A. x locations was higher than that of S.C.A.x locations interaction for plant and ear height, indicating that additive type of gene action was more affected by the environment than non-additive type for these traits. On the other side, magnitude of S.C.A. x locations was more than G.C.A. x locations interaction for No. of days to 50% silking, No. of ears per 100 plants, grain yield (kg/plot) and grain yield(ard/fad), indicating that non-additive type of gene action was more affected by environment for these traits. These results are in well agreement with those obtained by **Gilbert (1958)**. **Abdel-Sattar et al. (1999)** found that the magnitude of S.C.A. x Environment was more than G.C.A. x environment for no. of ears/plants, grain yield, indicating that non-additive gene effects were much influenced by environmental conditions than additive genetic effects in these traits. **Amr et al. (2003)**for silking date.

The ratio of G.C.A. variance components ($\Sigma g^2_i$)to S.C.A. variance ($\Sigma S^2_{ij}$) indicated that the major role of non-additive effects vs. additive gene effects in the inheritance for all studied traits. The same results were obtained by **Dawood et al.(1994), El-Shamarka et al. (1994), Nawar et al. (1994) and Sughroue and Hallauer (1997)** they reported that S.C.A. effects were more important than GCA revealing the predominant role of the dominance for grain yield and most traits under study. **Abd El-Sattar et al. (1999)** found low G.C.A./S.C.A. (less than unity) for grain yield, **El-Hossary et al. (2001)** and **Ibrahim et al.(2010)** for silking date.**Barakat et al. (2003)**and **Jayakumar and Sundaram(2007)** they suggested that non-additive gene effects played an important role in the inheritance of grain yield, silking date and plant height. **Dar et al.**

(2007), Abd El-Moula and Abd El-Aal (2009) reported the same results.

**Table 2. Combined analysis of variance for studied traits over two locations, 2011 season.**

| S.O.V. | df | MS | | | | | |
|---|---|---|---|---|---|---|---|
| | | Days to 50% silking | Plant height (cm) | Ear height (cm) | Ears/100 plants | Grain yield (Kg plot$^{-1}$) | Grain yield (ard fad$^{-1}$) |
| Loc. (L) | 1 | 7.87** | 537.54* | 1481.14** | 4029.02** | 147.99** | 2956.86** |
| Reps/Loc. | 6 | 11.97 | 836.02 | 169.69 | 106.38 | 0.43 | 21.66 |
| Crosses (C) | 27 | 16.13** | 621.41** | 689.33** | 119.13** | 4.08** | 181.62** |
| GCA | 7 | 14.70** | 616.88** | 861.24** | 175.39** | 2.91** | 128.56** |
| SCA | 20 | 16.63** | 622.99** | 629.16** | 99.44** | 4.48** | 200.19** |
| C x L | 27 | 2.14** | 698.83** | 644.54** | 55.43 | 1.50** | 66.66** |
| GCA x L | 7 | 2.07* | 837.56** | 821.52** | 55.05 | 0.83** | 35.67** |
| SCA x L | 20 | 2.17** | 650.27** | 582.60** | 55.57 | 1.74** | 77.51** |
| Error | 162 | 0.95 | 91.92 | 54.26 | 41.33 | 0.24 | 11.28 |
| $\Sigma g^2_i / \Sigma S^2_{ij}$ | - | 0.14 | 0.16 | 0.23 | 0.38 | 0.10 | 0.10 |
| GCAxL/ SCAxL | - | 0.95 | 1.29 | 1.41 | 0.99 | 0.48 | 0.46 |
| C.V. | - | 1.72 | 4.10 | 5.94 | 5.99 | 12.03 | 12.53 |

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

**Mean performance:**

Mean performance of the 28 crosses along with the Two check hybrids for all studied traits are presented in Table 3. For no. of days to 50% silking, all crosses were significantly earlier than the check hybrid SC 166 at the same time, most crosses not differ significantly than the earliest check hybrid SC 173 with few exception. The earliest crosses were $P_3xP_7$, $P_4xP_5$, $P_4xP_8$ and $P_7xP_8$, gave similar performance to that of the check hybrid SC 173.

Plant height and ear height, ranged from 220cm and 114 for cross $P_2xP_7$ to 261cm and 154 cm for cross $P_5xP_7$, respectively. Most crosses were significantly shorter and lower ear placement than the two check hybrids. Concerning No. of ears per 100 plants, two crosses i.e. $P_3xP_8$ and $P_5xP_7$ significantly surpassed the check hybrid SC 173.

Regarding grain yield, none of the crosses significantly outyielded the highest yielding check hybrid SC 166. Actually, all were significantly less yielding, except one cross $P_3xP_8$, which gave similar productivity to that of SC 166. Also two crosses $P_3xP_5$ and $P_5xP_7$ exhibited similar yield performance to that of the check hybrid SC 173. These crosses may be released as commercial hybrids by maize research program after further testing and evaluation.

**Table 3. Combined mean performance of 28 crosses and two check hybrids, for all studied traits, 2011 season.**

| Crosses | Days to 50% silking | Plant height (cm) | Ear height (cm) | Ears/100 plants | Grain yield (kg $plot^{-1}$) | Grain yield (ard $fad^{-1}$) |
|---|---|---|---|---|---|---|
| $P_1xP_2$ | 56 | 230 | 118 | 103.62 | 4.57 | 30.41 |
| $P_1xP_3$ | 57 | 230 | 120 | 105.13 | 4.21 | 28.02 |
| $P_1xP_4$ | 58 | 226 | 118 | 102.00 | 3.96 | 26.04 |
| $P_1xP_5$ | 58 | 224 | 116 | 110.62 | 3.49 | 22.94 |
| $P_1xP_6$ | 57 | 228 | 120 | 106.87 | 4.46 | 29.63 |
| $P_1xP_7$ | 57 | 231 | 119 | 112.13 | 3.05 | 20.02 |
| $P_1xP_8$ | 57 | 238 | 126 | 108.25 | 3.62 | 23.77 |
| $P_2xP_3$ | 57 | 230 | 119 | 107.63 | 4.12 | 27.16 |
| $P_2xP_4$ | 58 | 232 | 123 | 107.13 | 4.61 | 30.48 |
| $P_2xP_5$ | 57 | 227 | 118 | 105.50 | 3.61 | 23.76 |
| $P_2xP_6$ | 57 | 243 | 129 | 104.38 | 4.00 | 26.19 |
| $P_2xP_7$ | 56 | 220 | 114 | 104.13 | 2.99 | 19.65 |
| $P_2xP_8$ | 57 | 239 | 129 | 106.13 | 3.33 | 21.77 |
| $P_3xP_4$ | 56 | 234 | 123 | 106.25 | 3.77 | 24.50 |
| $P_3xP_5$ | 58 | 257 | 149 | 111.38 | 5.24 | 34.57 |
| $P_3xP_6$ | 56 | 231 | 119 | 104.50 | 3.56 | 23.41 |
| $P_3xP_7$ | 55 | 239 | 132 | 106.88 | 4.25 | 28.53 |
| $P_3xP_8$ | 56 | 241 | 129 | 113.63 | 5.86 | 38.73 |
| $P_4xP_5$ | 55 | 229 | 118 | 110.75 | 3.93 | 26.17 |
| $P_4xP_6$ | 56 | 227 | 119 | 106.38 | 3.35 | 22.23 |
| $P_4xP_7$ | 58 | 229 | 118 | 103.88 | 3.86 | 25.38 |
| $P_4xP_8$ | 55 | 231 | 116 | 107.75 | 3.70 | 24.33 |
| $P_5xP_6$ | 56 | 227 | 115 | 106.13 | 3.10 | 20.39 |
| $P_5xP_7$ | 62 | 261 | 154 | 121.00 | 5.50 | 36.10 |
| $P_5xP_8$ | 57 | 234 | 128 | 106.50 | 4.53 | 30.00 |
| $P_6xP_7$ | 56 | 235 | 126 | 105.63 | 4.60 | 30.68 |
| $P_6xP_8$ | 56 | 232 | 124 | 103.75 | 3.78 | 25.26 |
| $P_7xP_8$ | 55 | 231 | 124 | 106.13 | 4.57 | 30.38 |
| *Checks:* | | | | | | |
| SC 166 | 62 | 248 | 140 | 133.38 | 5.91 | 39.57 |
| SC 173 | 55 | 253 | 142 | 106.63 | 5.46 | 36.61 |
| LSD 0.05 | 1.00 | 9.00 | 7.00 | 6.18 | 0.48 | 3.31 |

**Combining ability effects:**

**a. General combining ability effects:**

General combining ability effects for the eight parents are presented in Table 4. Parents with negative estimates for No. of days to 50% silking, plant height and ear height are considered desirable since they are of earlier maturity, short plants and lower ear placement. The parental inbred line $P_8$ possessed significant negative GCA effects for No. of days to 50% silking and are considered good combiner for earliness, while the parental inbred line $P_5$ had significant positive GCA effects. Concerning plant height, the best inbred lines were $P_1$ and $P_4$, which had negative GCA effects. For ear height both previously mentioned parental inbred lines ($P_1$ and $P_4$) exhibited significant or highly significant GCA effects. These negative effects indicate the presence of favorable genes for both traits and that such inbred lines are good combiners for shortness and lower ear placement.

**Table 4. Estimates of GCA ($\hat{g}_i$) effects of 8 inbred lines for all studied traits, combined over two locations, 2011 season.**

| Inbred lines | Days to 50% silking | Plant height (cm) | Ear height (cm) | Ears/100 plants | Grain yield (kg plot$^{-1}$) | Grain yield (ard fad$^{-1}$) |
|---|---|---|---|---|---|---|
| $P_1$ | 0.490 | -4.401 | -4.844* | -0.396 | -0.174 | -1.133 |
| $P_2$ | 0.115 | -2.026 | -2.760 | -2.083 | -0.196 | -1.369 |
| $P_3$ | -0.240 | 4.516 | 4.323* | 0.729 | 0.434** | 2.885** |
| $P_4$ | -0.385 | -4.359 | -5.094* | -1.146 | -0.204 | -1.413 |
| $P_5$ | 0.948* | 4.016 | 5.552** | 3.479* | 0.166 | 1.050 |
| $P_6$ | -0.510 | -1.734 | -2.219 | -2.229 | -0.258 | -1.639 |
| $P_7$ | 0.260 | 1.974 | 3.365 | 1.458 | 0.067 | 0.518 |
| $P_8$ | -0.677* | 2.016 | 1.677 | 0.188 | 0.165 | 1.101 |
| S.E. ($\hat{g}_i$) | 0.263 | 2.589 | 1.989 | 1.736 | 0.132 | 0.907 |
| S.E. ($\hat{g}_i$- $\hat{g}_j$) | 0.397 | 3.914 | 3.008 | 2.625 | 0.199 | 1.371 |

*;** significant at 0.05 and 0.01 levels of probability, respectively.

Regarding No. of ears per 100 plants, one parental inbred lines i.e. $P_5$ exhibited significant positive GCA effect, implying that this inbred line may be posses favorable genes for prolificacy. Regarding grain yield, only one parental inbred line $P_3$ had significant positive GCA effects and is considered good combiner for grain yield. These result indicated that this parental inbred line posses favorable genes and that improvement in yield may be attained if it is used in hybridization program.

**b. Specific combining ability effects:**

Specific combining ability effects of 28 crosses for all studied traits are presented in Table 5. For No. of days to 50% silking, plant height and ear height, negative SCA effects are desirable, while for other traits positive are desirable. For No. of days to 50% silking, four crosses

$P_1xP_2$, $P_2xP_7$, $P_3xP_7$ and $P_4xP_5$ had significant or highly significant negative SCA effects.

For plant height, one cross ($P_2xP_7$) possessed significant negative SCA effects. Respecting ear height, three crosses $P_1xP_5$, $P_2xP_7$ and $P_5xP_6$ had significant or highly significant negative SCA effects. For no. of ears per 100 plants, only one cross ($P_5xP_7$) exhibited significant positive SCA effects. For grain yield, seven crosses $P_1xP_2$, $P_1xP_6$, $P_2xP_4$, $P_3xP_5$, $P_3xP_8$, $P_5xP_7$ and $P_6xP_7$ had significant or highly significant positive SCA effects.

**Table 5. Estimates of SCA ($\hat{s}_{ij}$) effects of 28 crosses for all studied traits combined over two locations, 2011 season.**

| Crosses | Days to 50% silking | Plant height (cm) | Ear height (cm) | Ears/100 plants | Grain yield (kg plot$^{-1}$) | Grain yield (ard fad$^{-1}$) |
|---|---|---|---|---|---|---|
| $P_1xP_2$ | -1.631** | 2.941 | 1.524 | -1.181 | 0.878** | 6.106** |
| $P_1xP_3$ | 0.473 | -3.726 | -2.935 | -2.494 | -0.109 | -5.531** |
| $P_1xP_4$ | 0.744 | 1.399 | 4.482 | -3.744 | 0.286 | 1.784 |
| $P_1xP_5$ | -0.464 | -9.101 | -8.664* | 0.256 | -0.561 | -3.781 |
| $P_1xP_6$ | 0.494 | 1.149 | 3.732 | 2.214 | 0.839** | 5.599** |
| $P_1xP_7$ | -0.402 | 0.316 | -3.351 | 3.777 | -0.903** | -6.172** |
| $P_1xP_8$ | 0.786 | 7.024 | 5.211 | 1.173 | -0.429 | -3.006 |
| $P_2xP_3$ | 0.348 | -5.851 | -6.268 | 1.693 | -0.175 | -1.154 |
| $P_2xP_4$ | 1.369* | 4.899 | 6.773 | 3.068 | 0.955** | 6.462** |
| $P_2xP_5$ | -0.464 | -8.476 | -8.247 | -3.181 | -0.415 | -2.724 |
| $P_2xP_6$ | 0.869 | 13.774* | 10.149* | 1.401 | 0.399 | 2.393 |
| $P_2xP_7$ | -1.277* | -13.185* | -10.685* | -2.536 | -0.940** | -6.306** |
| $P_2xP_8$ | 0.786 | 5.899 | 6.753 | 0.735 | -0.701* | -4.777* |
| $P_3xP_4$ | 0.223 | 0.107 | 0.315 | -0.619 | -0.520 | -3.773 |
| $P_3xP_5$ | 0.140 | 14.607* | 15.795** | -0.119 | 0.586* | 3.830 |
| $P_3xP_6$ | 0.098 | -4.893 | -6.935 | -1.286 | -0.677* | -4.637* |
| $P_3xP_7$ | -1.923** | -1.101 | 0.482 | -2.598 | -0.312 | -1.677 |
| $P_3xP_8$ | 0.640 | 0.857 | -0.455 | 5.423 | 1.208** | 7.943** |
| $P_4xP_5$ | -2.339** | -3.643 | -5.664 | 1.131 | -0.091 | -0.270 |
| $P_4xP_6$ | -0.131 | -0.643 | 2.607 | 2.464 | -0.242 | -1.518 |
| $P_4xP_7$ | 1.223* | -1.976 | -4.101 | -3.723 | -0.065 | -0.525 |
| $P_4xP_8$ | -1.089 | -0.142 | -4.414 | 1.423 | -0.323 | -2.160 |
| $P_5xP_6$ | -0.714 | -9.142 | -11.539** | -2.411 | -0.867** | -5.825** |
| $P_5xP_7$ | 4.139** | 21.274** | 21.378** | 8.777* | 1.205** | 7.724** |
| $P_5xP_8$ | -0.298 | -5.518 | -3.059 | -4.452 | 0.144 | 1.045 |
| $P_6xP_7$ | -0.777 | 1.274 | 1.149 | -0.890 | 0.731* | 4.995* |
| $P_6xP_8$ | 0.161 | -1.518 | 0.836 | -1.494 | -0.183 | -1.007 |
| $P_7xP_8$ | -0.985 | -6.601 | -4.872 | -2.806 | 0.284 | 1.961 |
| **S.E. for ($\hat{s}_{ij}$)** | **0.582** | **5.731** | **4.403** | **3.842** | **0.291** | **2.008** |
| **S.E. for ($\hat{s}_{ij}$-$\hat{s}_{ik}$)** | **0.889** | **8.753** | **6.726** | **5.869** | **0.446** | **3.066** |

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

Generally, the previous results indicated that the inbred line $P_8$ possessed favorable alleles for earliness, $P_1$ and $P_4$ for shortness and low ear position, $P_5$ for prolificacy and $P_3$ for grain yield. Moreover the promising cross $P_3xP_8$ (38.37 ard $fad^{-1}$) that had yielded as much as the highest yielding check hybrid may be released as a commercial hybrid by maize research program after further testing and evaluation.

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# تحليل الهجن الدائرية لصفة المحصول و صفات أخرى فى سلالات الذرة الشامية الصفراء

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تم إجراء جميع الهجن الممكنة (ماعدا العكسية) بين 8 سلالات من الذرة الشامية الصفراء المرباة داخليا بمحطة البحوث الزراعية بالجميزة فى الموسم الزراعى 2010. تم تقيم هجن الجيل الأول وعددها 28 هجين مع هجينى مقارنة وهما هـ.فـ 166 و هـ.فـ 173 فى الموسم الزراعى 2011 بمحطتى البحوث الزراعية بالجميزة وملوى. أظهرت النتائج وجود اختلافات عالية المعنوية بالنسبة للهجن والقدرة العامة والخاصة على التالف لكل الصفات محل الدراسة. أظهرت النسبة بين تباين القدرة العامة والخاصة أهمية نسبية لفعل لفعل الجين غير المضيف بالنسبة لجميع الصفات محل الدراسة. أظهرت النتائج أيضا أن السلالة الأبوية $P_3$ كانت أفضل السلالات من حيث تأثيرات القدرة العامة على التالف أما بالنسبة للقدرة الخاصة على التالف فان الهجن $P_1xP_2$ و $P_1xP_6$ و $P_2xP_4$ و $P_3xP_8$ و $P_5xP_7$ و$P_6xP_7$ أظهرت قدرة خاصة عالية المعنوية. بالنسبة لمحصول الحبوب كان هناك هجين واحد فقط ($P_3xP_8$) والذى أعطى محصول حبوب لا يختلف معنويا عن محصول الحبوب للهجين الفردى 166 أيضا كان هناك هجينين ($P_3xP_5$ & $P_5xP_7$) أعطوا محصول حبوب لايختلف معنويا عن الهجين الفردى 173. تعتبر هذه الهجن مبشرة ويمكن إدخالها فى مراحل التقييم المختلفة لإطلاقها كهجن تجارية.