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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: m*aize, 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=4200m^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 (Σg^2_i)to S.C.A. variance (ΣS^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% silk-ing	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 المراباة داخليا بمحطة البحوث الزراعية بالجميزة فى الموسم الزراعى 2010. تم تقيم هجن الجيل الأول وعددها 28 هجين مع هجينى مقارنة وهما هــ.فــ 166 و هــ.فــ 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 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 وP_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.