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Combining Ability of Yellow Inbred Maize Lines by Using Diallel Cross

Menna Tallah Saeed[1], Boshra N. Ayad[2], Mahmoud A. A. Sallam[3], Khaled A. Soliman[3]
1- Agricultural Engineer in the Egyptian Agricultural Company for seed production (EGAS)
2- Agriculture Research Center
3- Ain Shams University Faculty of agriculture, Genetic department
Corresponding Author: manasa2080_ahf@yahoo.com

Abstract

Eight parental inbred lines and their 28 crosses through the half diallel cross were used for estimation of general (GCA) and specific (SCA) combining abilities to select the best crosses for grain yield, earlier and lower ear placement. Half diallel cross mating design was carried out during the summer season of 2015 in BENI HEDER research farm of the Egyptian Agricultural Company for seed production (EGAS) Company to produce 28 yellow maize hybrids. At 2016 season, 28 hybrids (F1) and eight parents were tested in a trial using randomized complete block design with four replications, and also at 2017 season the same trial was repeated. The data was collected for ten different characters. A Griffing's method II model II was used to calculate the GCA and SCA effect and to estimate the genetic components. Inbred lines were evaluated, and then inbred 711 significantly contributed to the good performance of the hybrids for grain yield trait.

Key words: Diallel cross - SCA - GCA

Introduction

Maize (*Zea mays L.*) is one of the world's most important crops following wheat and rice, which give staple food to a large number of the populations in the world **Monday Sunday Adiaha (2017)**. Maize has a remarkable place among cereals, it's used as mankind's food, employed as animal feed and provides important-demanded fodder, Maize is also used for artificial purposes such as producing corn starch and cooking oils.

The main point of the diallel mating designs is their capability to perform a complex process in order to the test and analyze the offspring and to take out information that couldn't be set up else **B.R. Christie and V.I. Shattuck (1992).** The diallel analysis was known as making all possible combinations between favored lines is an important system to know gene action and it's constantly used by crop breeders to choose the parents with a high general combining ability (GCA) and hybrids with a high specific combining ability effects (SCA)**.** GCA values estimate the relative significance of the parents in terms of the concerned trait, whereas SCA values describe the significance of the combined action of the genes of parents **Fasahat, *et. al;* (2016)**. Combining ability analyses are extensively used in maize breeding programs to determine GCA and SCA information for maize inbred lines that allowed breeders to choose suitable parents which lead to produce good maize hybrids with good and demanded desirable traits **Keimeso, *et. al;* (2020), Hany Mohamed (2020)**, **Noëlle, *et. al;* (2017)**. Diallel mating models were developed by **Griffing (1956)** and **Gardener and Eberhart (1966)** that are the major models used in combining ability analyses. The aims of this study are to evaluate of eight parental inbred lines and their 28 crosses through the half diallel cross for estimation of GCA and SCA effects to choose the best-inbred lines for grain yield, earlier flowering and lower ear placement traits and also to determine the best crosses.

Material and methods

1. Field experiments

Eight yellow maize parental inbred lines (109, 298, 472, 711, 726, 804, 1005, and 1858) were obtained from EGAS company program. These lines were considerably differed in the expression of various agronomy traits. A half diallel crosses among the eight yellow maize inbred lines was done at 2015, 2016 and 2017 summer seasons. These lines were crossed in a half diallel cross to produce 28 crosses (all possible combinations) at 2015 summer season in the agriculture research station of (EGAS) Company 28 F1 crosses were evaluated in a randomized complete block design with four replications during two growing summer seasons to study the general and specific combining abilities in order to identify the most superior parental inbred lines that produce superior hybrids and develop high yielding new yellow single crosses. Two grains were planted per hill, then after 21 days from planting were thinned to one plant per hill. Each plot was consisted of six meters long with 30 cm between hills and 70 cm between ridges. Data for each experimental season was recorded on the following characters on plot bases: number of days to 50% pollen (D. to 50% P.), number of days to 50% silking (D. to 50% S.), plant height (cm) (PH), ear height (cm) (EH), grain yield (kg/plot) (GY), ear diameter (cm) (ED), Ear length (cm)

(EL), Number of rows (No. of R), Number of Kernels/row (No. of K/R) and 100 Kernels weight (100 KW).

Statistical analysis procedures

Analysis of variance for mean performance was used for each season and their combined over the two seasons. The L.S.D test at 5% was used for comparing the mean performance of the different crosses. General (GCA) and specific (SCA) combining abilities were estimated according to **Griffing (1956).**

Result and discussion

1. Mean performance

Results of all studied trait mean performances for all lines and their twenty eight showed in table (1) hybrids are combined togeather (2016 and 2017 seasons). Lines 109, 472, 1005 and 1858 were the earliest ones, while for hybrids all of them were early (Pollen, Silking). For plant height, lines such as 472, 109 and 298 were the tallest plants while lines 726, 711 and 804 were the shortest plants, Hybrid 726x1858 gave the tallest plant height while hybrid 109x711, 429x711, 472x1858, 804x1005 and 1005x1858 gave the shortest plant height. Lines 109, 298 and 726 showed the highest values for ear height trait, while line 1858 gave the lowest value for the same trait. Hybrids 109x726, 298x1005 and 711x804 showed the highest values for ear height trait, while hybrids 109x711 and 1005x1858 gave the lowest values for the same trait. For grain yield trait, lines 1858, 804 and 711 were recorded the highest values of this trait, while hybrids 472x726 and 711x1005 were recorded the highest values of the same trait.

Table 1. Mean performance for all studied trait of eight parental lines and their 28 hybrids

	Entry	D. 50% P.	D. 50% S.	PH	EH	EL
1	109	59	58	155	78	19
2	298	60	60	156	78	16
3	472	58	58	217	69	17
4	711	61	61	141	71	16
5	726	60	59	135	76	18
6	804	60	61	149	69	16
7	1005	59	59	145	68	18
8	1858	59	59	148	73	17
9	109x298	55	55	200	97	23
10	109x472	55	54	202	100	23
11	109x711	55	55	193	96	23
12	109x726	56	55	204	107	21
13	109x804	54	54	198	100	21
14	109x1005	54	54	207	105	24
15	109x1858	54	54	200	104	22
16	298x472	55	55	198	99	23
17	298x711	54	54	201	104	23
18	298x726	55	55	202	105	23
19	298x804	55	54	197	103	21
20	298x1005	55	55	205	109	22
21	298x1858	54	54	206	105	22
22	472x711	55	54	193	100	20
23	472x726	54	55	197	97	23
24	472x804	54	55	200	97	21
25	472x1005	54	54	196	101	21
26	472x1858	54	54	193	98	21
27	711x726	55	55	197	100	22
28	711x804	56	55	198	99	22
29	711x1005	55	55	208	108	22
30	711x1858	54	54	197	99	21
31	726x804	55	55	196	101	22
32	726x1005	56	56	205	106	23
33	726x1858	55	55	247	101	21
34	804x1005	54	54	192	100	21
35	804x1858	55	55	188	104	22
36	1005x1858	55	54	188	96	21

Table (1) continue:

	Entry	ED	No. R	No. of K/R	W. of 100 K.	GY
1	109	4	13	32	27	1.6
2	298	4	14	28	29	1.4
3	472	4	14	34	27	1.7
4	711	4	14	31	28	1.9
5	726	4	15	34	35	1.5
6	804	4	15	31	30	2
7	1005	4	15	34	26	1.6
8	1858	4	16	33	27	2.5
9	109x298	5	17	46	35	4.7
10	109x472	5	17	45	36	3.6
11	109x711	4	15	47	35	4.3
12	109x726	4	15	44	35	4
13	109x804	5	16	45	34	4.1
14	109x1005	5	16	46	40	4.2
15	109x1858	5	17	46	33	4.2
16	298x472	5	16	47	34	3.5
17	298x711	5	16	47	36	5.1
18	298x726	5	16	47	35	4.2
19	298x804	5	16	43	38	4
20	298x1005	5	17	44	34	3.7
21	298x1858	5	15	45	35	4.1
22	472x711	5	17	42	32	3.6
23	472x726	5	15	47	34	4.8
24	472x804	5	15	43	33	3.6
25	472x1005	5	16	43	36	3.9
26	472x1858	5	16	46	35	4.4
27	711x726	5	16	45	34	3.4
28	711x804	5	15	48	37	4.1
29	711x1005	5	17	46	33	4.8
30	711x1858	5	16	46	33	4.4
31	726x804	5	16	47	32	4.4
32	726x1005	5	16	45	35	4.3
33	726x1858	5	16	46	35	3.7
34	804x1005	5	16	45	37	4
35	804x1858	5	18	44	36	3.7
36	1005x1858	5	17	41	34	3.3

Specific combining ability effect:

Estimation of SCA effect for all studied traits of the combined data over the two seasons (2016 and 2017) are presented in table (2). For days to 50% pollen, there was no significant SCA values. Regarding days to 50% silking, results showed that there were three crosses (no 5, 9, and 22) exhibited desirable earliness where they recorded highly negative SCA effects for these traits. For plant height, out of the studied 28 crosses, only one cross number 25 was highly significant for this trait. With respect to ear height out of the studied 28 crosses, crosses number 4, 12, 21and 27 were significant for this trait. Regarding ear diameter, out of the studied 28 crosses, there were three crosses (no. 1, 2, and 5) exhibited desirable increasing for this trait, where they showed highly significant SCA effect for these trait.

Table 2. Estimation of SCA effects of the 28 hybrids for all studied traits

	Entry	D. to50% P.	D. to50% S.	PH	EH	ED
1	**109X298**	-0.535	-0.178	8.381	-1.017	0.390**
2	**109X472**	-0.222	-0.528	1.479	6.836	0.435**
3	**109X711**	-1.222	-0.515	7.256	0.407	-0.365
4	**109X726**	-0.310	-0.203	13.414	9.996*	-0.050
5	**109X804**	-1.747	-1.815	12.419	5.768	0.420**
6	**109X1005**	-1.472	-1.490	19.047	8.331	0.313*
7	**109X1858**	-1.197	-0.865	9.454	8.191	0.285
8	**298X472**	-0.985	-0.378	-3.328	4.587	0.190
9	**298X711**	-1.860	-1.865	14.005	7.446	0.315*
10	**298X726**	-1.072	-1.553	10.719	6.272	0.230*
11	**298X804**	-1.260	-1.665	10.062	6.907	0.200
12	**298X1005**	-0.860	-0.715	16.591	11.244*	0.168
13	**298X1858**	-1.335	-1.340	15.072	7.742	0.165
14	**472X711**	-1.047	-1.840	-2.635	8.073	0.260*
15	**472X726**	-1.135	-0.528	-3.908	3.449	0.225*
16	**472X804**	-1.072	-0.765	4.722	5.722	-0.030
17	**472X1005**	-0.797	-1.190	-1.674	7.809	0.163
18	**472X1858**	-0.897	-0.815	-7.368	5.219	0.185
19	**711X726**	-1.260	-1.515	10.450	4.108	0.175
20	**711X804**	-0.697	-1.503	16.730	5.856	0.270*
21	**711X1005**	-1.297	-1.303	23.934	13.781*	0.288*
22	**711X1858**	-1.522	-1.553	11.215	5.316	0.185
23	**726X804**	-1.660	-1.440	10.257	5.869	0.110
24	**726X1005**	-0.385	-0.240	16.123	8.682	0.178
25	**726X1858**	-0.985	-1.115	55.692**	5.054	0.125
26	**804X1005**	-1.822	-1.478	8.641	6.142	0.223*
27	**804X1858**	-1.047	-0.978	2.372	10.927*	0.345*
28	**1005X1858**	-0.772	-1.028	0.101	0.327	0.138

For ear length seven crosses (no. 1, 6, 8, 9, 15, 20 and 27) were significant for SCA effects that help to increase yield. With respect to No. of rows/ear, three crosses (no. 2, 14 and 27) were significant. For No. of kernels/row three crosses (no. 8, 9, and 20) were highly significant and 12 crosses such as (1, 3, 6, 7, 10, 13, 15, 18, 21, 22, 23 and 25) were significant that help for increasing yield. For 100 kernels weight only one cross (no. 6) was highly significant. A lot of papers showed positive or negative SCA effects in maize for these traits in their own studies **Assefa, *et. al;* (2017) and Murtadha, *et. al;* (2018)**, With respect to grain yield, out of the studied 28 crosses, 13 crosses 1, 3, 5, 6, 7, 9, 10, 15, 18, 21, 22, 23 and 24 were exhibited desirable high grain yield that recorded highly significant SCA effects for this traits, noticed that inbred lines 109, 472, 726, 298 and 711 were good to produce high yielding crosses **Aldulaimy and Hammadi ,(2021) as well as Begum, *et. al;* (2018)** showed highly significant SCA effects for grain yield trait in their studies.

Table (2): continue

	Entry	EL	No. of R.	No. of K/R	100 KW	GY
1	**109X298**	1.909*	1.186	4.119*	0.594	1.093**
2	**109X472**	1.616*	1.233*	2.259	2.969	0.126
3	**109X711**	1.594	-0.427	4.005*	1.732	0.603**
4	**109X726**	-0.976	0.293	0.276	0.794	0.433*
5	**109X804**	-0.214	0.433	2.915	-0.218	0.548**
6	**109X1005**	1.944*	0.103	4.664*	6.594**	0.710**
7	**109X1858**	0.799	1.056	3.051*	0.344	0.590**
8	**298X472**	2.011*	0.208	5.271**	1.219	0.096
9	**298X711**	1.939*	0.448	4.842**	2.482	1.323**
10	**298X726**	1.619*	0.218	4.089*	0.294	0.641**
11	**298X804**	0.656	0.608	1.577	3.032	0.481*
12	**298X1005**	0.714	0.928	2.851	0.469	0.167
13	**298X1858**	1.344	-0.719	3.339*	1.719	0.447*
14	**472X711**	-0.229	1.746*	-0.293	-0.143	0.018
15	**472X726**	1.851*	-0.084	3.729*	0.794	1.361**
16	**472X804**	0.339	-0.519	0.842	-0.218	0.126
17	**472X1005**	-0.004	0.226	1.441	3.469	0.500*
18	**472X1858**	0.976	0.178*	3.379*	2.219	0.892**
19	**711X726**	1.229	0.156	1.600	0.057	-0.237
20	**711X804**	2.116*	-0.204	6.376**	3.544	0.403*
21	**711X1005**	1.149	0.816	3.537*	0.357	1.102**
22	**711X1858**	0.454	-0.132	3.800*	0.982	0.620**
23	**726X804**	1.571	0.066	4.410*	-2.393	0.846**
24	**726X1005**	1.179	0.211	2.234	0.669	0.832**
25	**726X1858**	0.484	0.488	3.146*	1.294	0.087
26	**804X1005**	0.916	0.126*	2.422	2.782	0.497*
27	**804X1858**	2.446*	1.278*	2.560	2.782	0.027
28	**1005X1858**	0.404	0.448	-0.991	1.469	-0.274

General combining ability effect

The higher values of GCA effect in inbred lines could be useful for obtaining good crosses with a high yield. High positive values of general combining ability could be useful in grain yield, ear length, ear diameter, number of rows/ ear, number of kernels/ row and 100 kernel weight. While traits such as (days to 50% silking, plant height and ear height) could be more useful for the breeder when gave negative values and many authors showed positive and negative values of GCA in their studies **Mousa, et. al; (2021), Abdulazeez et. al; (2021) and Darshan and Marker (2019)** The result showed the GCA values in table (3)

Table (3) Estimation of GCA of the parental inbred lines in F1's generation for all studied traits

No.	parents	GCA				
		D. to 50% P.	D. to 50% S.	PH	EH	ED
1	**109**	-0.209	-0.366	0.102	1.002	-0.093
2	**298**	0.053	0.234	0.734	2.075	0.002
3	**472**	-0.509	-0.416	9.924*	-2.440	0.057
4	**711**	0.491	0.322	-4.435	-0.886	-0.068
5	**726**	0.328	0.259	0.314	1.450	0.042
6	**804**	0.016	0.122	-4.566	-1.422	-0.003
7	**1005**	-0.009	-0.078	-2.270	0.478	-0.045
8	**1858**	-0.159	-0.078	0.199	-0.257	0.107*

For days to 50 % pollen and silking parent 3 (472) showed negative values for pollen and silking towards earliness. Therefore, this line gave the best GCA values with the combined data over the two seasons for this traits. Regarding to plant height, results in table (3) showed that parent 3 (472) was significant for this trait. With respect to ear height, results in table (3) showed that all parental inbred lines were not significant for this trait. For ear diameter, results in table (3) indicated that parental inbred line parent 8 (1858) exhibited positive and significant towards increasing ear diameter with the combined data over the two seasons and this could be considered as the best general combiner for this trait and useful for grain yield.

Table (3): continue

No	parents	GCA				
		EL	No. of R	No. of K/R	100 KW	GY
1	**109**	0.638*	-0.281	0.459	-0.059	0.038
2	**298**	-0.058	-0.056	-0.579	0.441	0.005
3	**472**	-0.090	-0.103	0.181	-0.684	-0.127
4	**711**	-0.193	-0.093	0.235	-0.697	0.145*
5	**726**	0.452	-0.213	0.889	0.866	-0.035
6	**804**	-0.460	-0.003	-0.625	0.628	-0.012
7	**1005**	0.108	0.177	-0.374	0.066	-0.073
8	**1858**	-0.398	0.574*	-0.186	-0.559	0.059

With respect to ear length, results in Table (2) showed that the parental inbred line parent 1 (109) exhibited positive and significant value with the combined data over the two seasons (2016 and 2017). This result showed that this line was the best general combiner for this trait and helps to increase grain yield. For number of rows per ear, results in Table (2) showed that parental inbred line parent 8 (1858) exhibited positive and significant value toward increasing number of rows per ear and this line could be considered as the best general combiner for this trait. For number of kernels/ rows and 100 kernels weight, results in Table (3) showed that all of these lines were not significant for these traits. For grain yield results in Table (3) showed that parental inbred line parent 4 (711) exhibited positive and significant value toward increasing grain yield and this line could be considered as the best general combiner for this trait. This result support to perform DNA fingerprint for this parent. . A lot of researchers have found significant differences among crosses produced from local maize inbred lines **Wuhaib, *et. al;* (2016) and Amegbor, *et. al;* (2020)**.

Conclusion

We conclude that the genetic variability in the studied genotypes could considerably raise the favorable alleles of the studied traits when used in a plant hybridization program depending on exploiting mainly the non-additive effects. Among the evaluated inbred lines, inbred 711 significantly contributed to the good performance of the hybrids for grain yield trait. Probably, there was a high genetic diversity between this line and the other inbreds, which mean that inbred 711 owns favorable genes that do not exist in the other lines.

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الملخص العربى

تم عمل التهجين المتكرر النصفى لثمانى سلالات من الذرة الصفراء فى الموسم الصيفى عام 2015 بالمزرعة البحثية للشركة الزراعية المصرية (ايجاسيد) ببنى حدير بمحافظة بنى سويف لانتاج 28 هجين ذرة صفراء و تم تقييمهم فى عامى 2016 و 2017 و عمل تجربة القطاعات كامة العشوائية بأربعة مكررات و تم تجميع البيانات لدراسة عشر صفات مختلفة و استخدمت طريقة جريفنج الثانية النموذج الثانى لحساب قدرة التآلف العامة و الخاصة و تقييم الهجن لاختيار افضل السلالات لكل صفة .

فى الموسم الصيفى 2016 اظهرت النتائج عدم وجود معنوية فى قدرة التآلف العامة لجميع الصفات ما عدا قطر الكوز و طول الكوز فقد كانت نتائجهم معنوية اما فى قدرة التآلف الخاصة فقد كانت جميع الصفات عالية المعنوية ما عدا صفة وزن الـ 100 حبة فقد كانت غير معنوية.

فى الموسم الصيفى 2017 اظهرت النتائج عدم وجود معنوية فى قدرة التآلف العامة لجميع الصفات ما عدا صفة قطر الكوز و المحصول فقد كانت نتائجهم معنوية اما قدرة التآلف الخاصة فقد كانت جميع الصفات عالية المعنوية .

قدرة التآلف العامة الموجبة و العالية تكون مفيدة فى رفع محصول الهجن و تكون متأثرة بطول الكوز و قطر الكوز و عدد الصفوف فى الكوز و عدد الحبوب فى الصف و وزن الـ 100 حبة و لكن التزهير و ارتفاع النبات و ارتفاع الكوز تكون القيم السالبة مهمة فى برامج التربية لانها تؤدى الى التبكير فى النضج و تقليل نسبة النباتات المائلة و المكسورة فى الحقل مما يكون له تأثيرفى زيادة المحصول .