

Study The GCA and SCA Effects of Five Inbred Lines of Maize According to Half Diallel Mating System.

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Abstract: Half diallel crossing among five inbred lines of maize was performed to estimate the combining ability effects and some genetic parameters. The crosses differed significantly for all the studied traits. Also, GCA and SCA mean squares were significant. The ratio GCA/SCA exhibited values under one indicating that non-additive gene action mainly controls the expression of all the studied traits. Inbred line 4 contributed significantly to the good performance of the hybrids for grain yield traits. Also, inbred line 5 exhibited desirable GCA effects for five traits and it seems to be promising. The crosses 2x4, 1x4 and 3x5 own highest mean and SCA effects for grain yield.

Keywords: GCA effects; SCA effects; Maize System; Half Diallel.

I. Introduction

Maize is an important crop grown in Iraq mainly for feeding. There is an increasing requirement for maize grain as a response to extend in animal breeding. As a result, researcher's effort is focusing on raising the potential of maize genotypes. A diallel mating system is an excellent approach for detecting performance of the parents and their offspring, where they separated into components related to GCA and SCA effects [1]. The main feature of the diallel mating designs is their ability to perform a complex process in order to the exam and analyze the progenies and to take out information that could not be set up otherwise [2]. The predictable value of any defined cross is the sum of GCA s of its two parental lines, while the divergence from this expected value is called SCA. Therefore GCA values estimate the relative importance of the parents in terms of the concerned trait, whereas SCA describes the importance of the combined action of the genes of parents [3]. Wali [4], mentioned that the number of kernels per row and weight of 100 kernels is under the control of non-additive gene action. Al-Rawi [5], stated that the average degree of dominance was less than one for number of rows per ear, number of kernels per row, weight of 100 kernel and grain yield per plant. Estimate combining ability may be a useful approach for breeders in their attempts to derive new maize genotypes with high potential. The goal of the study reported here was to rate some genetic parameters to be used on maize inbred lines selection in the process of the production of the hybrid.

II. Material and Methods

Plant materials: Five maize inbred lines were used as lines in the current study i.e., P1(ZM49W3E), P2 (ZM60), P3 (ZM43WIZE), P4 (ZM19) and P5 (CDCN5) which are introduced from Yugoslavia and Italy.

Field experiment: Ten crosses were derived from crossing between the inbred lines according to half diallel mating during spring season 2016. The F1 seeds of each cross were bulked together. Ten crosses along with five parents were grown in randomized complete block design (RCBD) with four replications at the research station of Agriculture College/Al-Jadrya during fall season 2016. Inbred lines were introduced into the full diallel cross-program according to Model II , of [6]. A plot dimensions 3*3m consisted of five rows , 70 cm between rows and 25 cm within rows ,population density was 57143 plants hectore⁻¹. The recommended package of practices was followed to raise a good crop. Harvesting was performed after the grains reached maturity and plants were dried, at which grain moisture was determined. Observations were recorded on ten randomly plants for plant height, leaf area, leaves number per plant, ear height, ear length, number of rows per ear, number of kernels per row, cob weight, 100-kernel weight and grain yield per plant. while observations for the characters namely days to 50 % tasselling, days to 50 % silking, days to maturity were recorded on a plot basis.

Statistical analysis: The statistical analysis was performed out for analysis of variance using SAS software. General combining ability (GCA), specific combining ability (SCA) was estimated according to [6]. Each of the additive variation (σ^2A), dominance variation (σ^2D) was estimated using the expected variation components EMS [6]. Narrow sense ($h^2n.s$) was evaluated according to [7], Dominance degree (\bar{a}) of each trait has estimated.

III. Results and Discussion

Analysis of variance for all the studied traits is presented in Table1. Significant differences were revealed among all the genotypes indicating the existence of genetic variability among them. Many works of literature have found significant differences between crosses producing from local maize inbred lines[8-11]. Mean square due to GCA and SCA were highly significant for all the studied traits indicating that both additive and non- additive gene effects were involved in the inheritance of these traits. One can conclude the relative importance of GCA and SCA depending on the size of the mean square. The significance of GCA proposes that at least one of the five maize inbred lines differs from the others in terms of accumulation of favorable alleles. Several previous studies exhibited similar results [12-15].The C.V. values were minor, however C.V. for kernels number/row and leaf area were relatively high and that refer to some variability among the studied genotypes. Genetic components are shown in Table 2. The variance of GCA is smaller than SCA and

Table1.Mean square for the single hybrids and their parents for eight traits.

S.O.V.	D. F	Days to tasseling	Day to Silking	Leaf area(cm^2)	Leaves number/plant	Ear length(cm)	Row s n./ ear	Kernel s number/ row	100 Kerenels weight(g m)	Grain yield/plant(gm)
Reps	3	1.31	0.99	0.0004	0.80	1.32	0.84 36	18.8	14.4	17.5
Genotypes	14	52.95*	45.95**	0.0335**	17.05**	26.42**	5.25 71	2355.1**	74.6**	10613**
Gca	4	7.96**	9.43*	0.0028*	0.61**	0.92**	0.24 92	17.78*	2.35**	221.31**
Sca	10	15.34*	12.30**	0.0106*	5.72**	8.88**	1.74 04	51.76*	25.17**	3626.19**
error ⁻	42	0.32	0.35	0.0004	0.09	0.22	0.45 70	2.11	0.62	12.25
C.V.		5.6	8.31	6.56	5.19	1.83		1.79	7.4	4.6

this refer to greater contribution of non-additive gene action as compare with additive gene action. GCA/SCA ratio is used as a measure to expose the quality of genetic variance concerned. Hence, Hence, GCA/SCA ratio is less than one for all traits indicating that these traits fundamentally governed by over dominance genes. Many previous studies found that dominance genetic variance values are bigger than corresponding additive values [16-19].

Table 2. Genetic components

Genetic components	Tasseling	Silking	Leaf area(cm^2)	Leaves number/plant	Ear length(cm)	Rows n./ ear	Grains number/ row	100 grains weight(g m)	Grain yield/plant(g m)
DUE TO GCA	1.097	1.296	0.0003	0.0746	0.0998	0.019 3	2.239	0.24	29.86
DUE TO SCA	15.02	11.94 8	0.0102	5.6349	8.6599	1.626 2	49.65	24.54	3613.93
RATIO BET GCA & SCA	0.07	0.108	0.0340	0.0132	0.0115	0.011 9	0.04	0.01	0.008

Estimates of GCA effects of five inbred lines are shown in Table 3. Highly significant negative GCA effects for tasseling and silking was found in inbred line 5 respectively. Inbred line 1 had Highly significant positive GCA effects for leaf area and leaves numbers, while inbred lines 3 and 4 had Highly significant negative GCA effects for these traits. Inbred line 2 showed positive highly significant positive GCA effects for ear length. Only inbred line 5 exhibited significant positive GCA effects for rows number per ear. Inbred lines 1 and 2 showed significant and highly significant negative GCA effects for kernels number per ear respectively, while inbred lines 4 and 5 had significant and highly significant positive GCA effects for this trait respectively. For 100 kernels weight, inbred line 1 showed significant positive GCA effect, while inbred line 5 showed highly significant negative GCA effects. Inbred line 1 had highly significant negative GCA effects for grain yield, while inbred lines 3 and 4 had significant and highly significant positive GCA effects. Inbred line 4 demonstrated to be the most hopeful in this regard, as GCA effect estimates signalize that it had a significantly high value for kernels number per row and grain yield. Inbred line 5 was also promising for tasseling, tasseling, rows per ear and kernels number per row, leaves number, and inbred line 1 for leaf area, leaves number and weight of 100 kernels.

Table 3. General combining ability of five inbred lines of maize

Inbreds	tasseling	Silking	Leaf area(cm ²)	Leaves number/plant	Ear length(cm)	Rows n/ ear	Number of kernels/ row	100 kernels weight(gm)	Grain yield/plant(gm)
1	-0.090 ^{ns}	0.35 ^{ns}	0.0255 ^{**}	0.33 ^{**}	-0.41 [*]	-0.05 ^{ns}	-1.551 ^{**}	0.657 [*]	-9.86 ^{**}
2	0.115 ^{ns}	-0.21 ^{ns}	0.0014 ^{ns}	-0.35 ^{**}	0.52 ^{**}	-0.19 ^{ns}	-1.620 ^{**}	-0.000 ^{ns}	1.15 ^{ns}
3	0.194 ^{ns}	0.30 ^{ns}	-0.0152 [*]	-0.11 ^{ns}	-0.04 ^{ns}	0.08 ^{ns}	0.066 ^{ns}	-0.250 ^{ns}	3.03 [*]
4	1.384 ^{**}	1.36 ^{**}	-0.0239 ^{**}	-0.15 ^{ns}	-0.23 ^{ns}	-0.13 ^{ns}	1.162 [*]	0.416 ^{ns}	3.95 ^{**}
5	-1.604 ^{**}	-1.80 ^{**}	0.0121 ^{ns}	0.27 ^{**}	0.16 ^{ns}	0.28 [*]	1.943 ^{**}	-0.82 ^{**}	1.71 ^{ns}
S.E.	0.19	0.20	0.0065	0.10	0.159	0.114	0.491	0.276	1.18

Estimate SCA effects of 10 crosses for all the elaborated traits are presented in Table 4. For Tasseling and tasseling traits, five crosses displayed highly significant negative effects. The crosses 3x4, 2x4 and 1x3 showed the highest desirable SCA effects for tasseling, and the crosses 3x5 and 3x4 gave the highest desirable SCA effects for tasseling. With regard to leaf area and leaves number, one cross for each trait expressed highly significant effects, which were 3x4 and 3x5 respectively. As for ear length, rows number per ear, kernels number per row and grain yield, cross 2x4 was the best one. Concerning of weight of 100 kernels, two crosses showed highly significant SCA effect and they were 3x5 and 1x4. These results are in agreement with the data of Table 2, where the same crosses gave the optimum results; therefore, these crosses could be the best set, where they showed highly significant SCA effects. Many researchers noticed positive or negative SCA effects in maize for these traits in their own studies [20-21].

Table 5 shows that the overall mean of crosses surpassed their parent lines for all traits, and the highest percentage of surpassing was for grain yield trait. Among five inbred lines, parent 5 was the best in 8 traits, included grain yield trait. Concerning the crosses, two crosses out of 10 were superior, which were 2x4 and 3x5. The cross 3x5 excelled in days to tasseling, days to silking, leaves number, ear length and weight of 100 kernels. The crosses 2x4 was dominant in ear length, rows number per ear, kernels number per row, the weight of 100 kernels and grain yield. These results presented in Table 5 coincide with the corresponding results in Table 4.

Table 4. Specific combining ability of ten crosses of maize

Crosses	Tasseling	Silking	Leaf area(cm ²)	Leaves number/plant	Ear length(cm)	Rows n./ ear	Kernels number/ row	100 Kernels weight(gm)	Grain yield/plant (gm)
1 x 2	1.10 ^{**}	-1.42	0.0227	0.055 ^{ns}	1.167 ^{**}	0.36 [*]	5.395	-1.213 ^{**}	27.48 ^{**}
1 x 3	-4.11	0.40 ^{ns}	0.0440	0.481 ^{**}	1.653 ^{**}	1.01 ^{**}	4.143	-1.013 ^{**}	3.22 [*]
1 x 4	2.90 ^{**}	2.31 ^{**}	0.0606	2.049 ^{**}	2.477 ^{**}	0.82 ^{**}	5.142	6.592 ^{**}	60.0 ^{**}
1 x 5	2.79 ^{**}	0.17 ^{ns}	0.0305	-0.318	-0.004	0.84 ^{**}	0.356	-1.802 ^{**}	-0.81 ^{ns}
2 x 3	1.92 ^{**}	1.98 ^{**}	0.0916	2.993 ^{**}	0.147 ^{ns}	0.49 ^{**}	2.101	1.446 ^{**}	26.37 ^{**}
2 x 4	-4.38	-3.82	0.0441	0.478 ^{**}	3.400 ^{**}	1.82 ^{**}	7.652	5.752 ^{**}	66.86 ^{**}
2 x 5	-0.17	-0.43	0.0576	-0.551	2.450 ^{**}	0.96 ^{**}	5.701	1.787 ^{**}	35.97 ^{**}

x									
3	-5.61	-4.89	0.1072	1.595**	1.055**	0.92**	3.457	-0.252 ^{ns}	29.88**
4	-3.21	-5.39	0.0991	3.566**	3.041**	-0.22	2.524	6.778**	59.26**
5	-1.46	-0.82	-0.018	-0.080	0.375 ⁿ	-1.03	2.675	2.971**	7.12**
S	0.49	0.52	0.016	0.26	0.411	0.29	1.26	0.691	3.056
E						5	8		

Table 5. Mean performance for the single crosses and their inbred lines

Genotypes	Days to tasseling	Day to Silking	Leaf area (cm ²)	Leaves number/plant	Ear length (cm)	Rows number/ear	Kernels number / row	100 grains weight (g m)	Grain yield/plant (g m)
1	60.9	66.9	0.5	12.5	13.1	13.1	24.3	24.1	70.0
2	63.4	68.3	0.4	10.8	14.1	12.5	21.2	20.2	58.6
3	68.3	71.5	0.3	8.4	13.6	13.8	28.9	20.1	81.4
4	69.4	73.2	0.4	10.6	12.5	13.2	27.8	17.4	60.7
5	60.2	66.5	0.5	12.2	14.0	15.0	33.2	17.6	87.3
1x2	63.5	65.6	0.6	13.0	17.9	14.8	37.1	23.5	153.5
1x3	58.4	68.0	0.6	13.6	17.8	15.8	37.6	23.5	131.1
1x4	66.6	70.9	0.6	15.2	18.4	15.4	39.7	31.7	188.8
1x5	63.5	65.6	0.6	13.2	16.3	15.8	35.6	22.1	125.7
2x3	64.6	69.0	0.6	15.5	17.2	15.1	35.4	25.3	165.2
2x4	59.5	64.2	0.5	12.9	20.3	16.2	42.1	30.2	206.7
2x5	60.7	64.4	0.6	12.3	19.7	15.8	40.9	25.0	173.5
3x4	58.3	63.7	0.6	14.3	17.4	15.6	39.6	24.0	171.6
3x5	57.8	60.0	0.6	16.7	19.8	14.9	39.4	29.8	198.7
4x5	60.7	65.6	0.5	13.0	16.9	13.8	40.7	26.6	147.5
Mean	62.4	66.9	0.5	12.9	16.6	14.7	34.9	24.1	134.7
LSD	1.6	1.7	0.05	0.9	1.3	0.96	4.1	2.2	9.9
Mean of Parents	64.4	69.3	0.4	10.9	13.4	13.5	27.1	19.9	71.6
Mean of Crosses	61.3	65.7	0.6	14.0	18.2	15.3	38.8	26.2	166.2
Percentage of crosses superiority	-4%	-5%	50%	28%	35%	13%	43%	31%	132%

Results presented in Table 6 shows the values of variance of additive, non-additive, heritability in broad sense and the degree of dominance. The extent of VA was less than that of VD causing the ratio of GCA/SCA (Table 2) less than one for all traits; these outcomes suggest that the dominance genetic variance was more worthy than the additive genetic variance in the inheritance of studied traits. Results also exhibited that the degree of dominance (\bar{a}) was greater than one, for all traits, point out the control of over dominance genes on the traits. These results reflected on the values of heritability, therefore the $h^2_{b.s}$ recorded for diallel crosses ranged (1.62-17.4). These results are emphasizing that the

non-additive genetic variation was the major component of genetic variation in the inheritance of these traits and the hybridization would be more effective for improving these traits. These results were proved with by [22,23].

Table 6. Genetic parameters

Genetic	Tassel g	Silkin g	Leaf area(cm ²)	Leaves number/pla nt	Ear length(c m)	Rows number/ea r	Grains numbe r/ row	100 grains weight(g m)	Grain yield/plant(g m)
VA	2.194	2.592	0.0006	0.1492	0.1996	0.0386	4.478	0.48	59.72
VD	15.02	11.94	0.0102	5.6349	8.6599	1.6262	49.65	24.54	3613.93
H narrow %	12.5	17.4	5.3	2.5	2.19	1.8	7.9	1.8	1.62
\bar{A}	3.7	3.0	5.8	8.6	9.3	9.1	4.7	10.1	11.0

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 inbred lines evaluated, inbred line 4 contributed significantly to the good performance of the hybrids for grain yield traits. Probably, there is a high genetic diversity between this line and other inbreds, which mean inbred line 4 owns favorable genes that do not exist in other lines. Also, inbred line 5 demonstrated a prospect to participate in the development of genetic materials with a good performance for most traits and exhibited desirable GCA effects for five traits. Hence, we can conclude that inbred line 5 could be a good source for favorable genes. Some inbred lines showed negative GCA effects but their SCA effect tends to be positive. This could be an indication of good complementarity among genes, i.e. inbred lines 2,3 and 4 for the weight of 100 kernels and inbred lines 3 and 4 in leaf area and leaves number.

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