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Estimation of Gene Effects on Some Agronomic Characters in Five Hybrids and Six Populations of Maize (*Zea mays* L.)

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Abstract: Five inbred lines of maize (*Zea mays* L.); G251B, L113A, L123A, Rg5 and Rg14 were used to obtain single crosses and back crosses. The selection index revealed that the maize inbred line G251B was the best one in the combined values for all studied characters. The cross G251BxRg14 revealed the highest combined values for all characters as indicated by the selection index. The mean value of the back cross [(Rg14xL123A)xRg14] revealed the highest values for three characters; plant height (259 cm), ear length (19 cm) and grain weight per ear (112 g) comparing with all studied genotypes. The five F1 crosses gave highly significant heterotic values over mid parent (MP) and the best parent (BP) for the six studied characters. The heterotic values were ranging from 9 to 257% over MP and 8 to 173% over BP for yield components. Phenotypic correlation coefficients between all possible pairs of traits in this study were positive. Highly significant correlation coefficients were found for grain yield per ear with plant height, ear height, ear length and 100-grain weight. The results cleared that the dominant gene effect played major role in the inheritance of all studied characters. However, the additive x additive epistatic effect was more important than the two other epistatic effects especially for plant height, ear length and grain weight per ear.

Key words: Maize · heterosis · correlation · gene effect

INTRODUCTION

The plant geneticist or breeder is interested in estimation of gene effects in order to formulate the most advantageous breeding procedures for improvement of the attribute (characters). Most of the accumulated evidences refer to additive and dominance effects. Estimates of the parameters do provide an indication of the relative importance of the various types of gene effects affecting the total genetic variation of a plant attribute.

Significant positive heterosis in maize hybrids (F1's) for yield components were found by several investigators. Mohamed [1, 2] reported substantial heterosis ranging from 17.39 - 434.30% over mid parent (MP) value and 10-377.07% over the best parent (BP) for yield components. Mahmoud *et al.* [3] found that the maximum ranges for heterotic effects observed for the different characters were expressed for grain yield/plant and grain weight/ear. Mostafa [4] reported that heterosis average over MP was 33.04% for plant height, while for grain yield per plant all crosses showed positive and highly significant heterosis ranging from 112.73-159.79% over MP and 97.06-154.23% relative to BP.

Gamble [5] used population means of six inbred lines of corn and all possible F_1, F_2, P_1F_1 and P_2F_1 crosses among them to obtain estimates of the various gene effects for yield of shelled corn. He also reported that the estimation of gene effects indicate that the dominance gene effects were quite important in the inheritance of yield. Estimates of additive gene effects of low magnitude and many were non-significant. The additive x additive and additive x dominance gene effects were relatively more important than dominance x dominance effects. Shafshak *et al.* [6] and Wolf and Hallauer [7] reported that epistasis was detected more frequently for components of yield. Hassan *et al.* [8] and Awaad and Hassan [9] reported that additive, dominance and their digenic interaction types controlled the inheritance of yield and its components.

El-Hossary and Abd El-Sattar [10] estimated the gene effects in maize breeding programs for some agronomic characters. They found significant positive heterotic effects for all traits in three studied crosses. Significant dominance gene effects were obtained for all traits in all crosses, also the three digenic epistasis were much more important followed by dominance and then additive for most traits. Abd El-Aty *et al.* [11] determined

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Table 1: The origin of the five inbred lines of maize* (*Zea mays* L.)

Code no.	Inbreds	Origin
1	G251B	Hyman
2	L113A	Locally developed
3	L123A	Locally developed
4	Rg5	(San Juan×Ci 64)×(S.C. 14)
5	Rg14	(Syn-La Pasta×Ci 64)×(S.C. 14)

*Grains were kindly furnished by Maize Research Section, Ministry of Agriculture, Giza, Egypt

important genetic parameters using six population statistical model.

The present study was carried out to determine the type of gene effect, to estimate some genetic parameters and improve the genetic characters of yield components in maize by hybridization between different inbred lines.

MATERIALS AND METHODS

This work was performed, during summer seasons of 2004, 2005 and 2006 at the Experimental Station of the National Research Centre at Shalakan, El-Kalyobia, Egypt. Five inbred lines of maize (*Zea mays* L.) namely; G251B, L113A, L123A, Rg5 and Rg14 were used to obtain single crosses and back-crosses (Table 1). Five F1, one F2 of the cross Rg14×L123A and two back crosses were planted with the five parents in Randomized Complete Blocks Design with three replications. Data were taken on individual plants for the following characters: plant height (cm), ear height (cm), ear length (cm), number of rows per ear, weight of 100 kernels (g) and grain weight per ear (g).

Data were statistically analyzed for each character on the single plant basis and F-test was used to determine the significances. Heterosis was determined as the percentage increase of F1 over the mid and better parents, according to the formula adopted by Bhatt [12]. The parameters for the various gene effects used in this study were estimated according to Gamble [5]. The phenotypic correlation between all possible pairs of the characters were calculated according to Snedecor and Cochran [13]. Classical selection index was applied as described by Singh and Chaudhary [14].

RESULTS AND DISCUSSION

The analysis of variance indicated highly significant differences among genotypes for all studied characters (Table 2).

Mean yield performance and selection index: Mean values of the six studied traits and selection index of the five maize inbred lines, five F1, one F2 and two back crosses are presented in Table 3. Mean values of the inbred lines showed that the inbred G251B gave the highest values for three characters; ear height (116 cm), 100 grain weight (25 g) and grain weight per ear (33 g). The inbred Rg5 manifested the highest mean values for ear length (13 cm) and number of rows per ear (14), while the inbred Rg14 gave the highest mean value for plant height (151 cm). Selection index revealed that the maize inbred line G251B was the best one in the combined values for all studied characters.

Mean values of the F1 crosses showed that the cross G251B×Rg14 gave the highest values for three characters; plant height (249 cm), ear height (167 cm) and grain weight per ear (90 g). This cross also revealed the highest combined values for all characters as indicated by the selection index value. This was expected because this cross contains the two parents that gave the highest mean values for most studied characters and also the highest values of selection index. Mean values of the F2 cross Rg14×L123A were less than those of its F1 cross in all studied traits. Mean values of the two back crosses revealed that the back cross 1 [(Rg14×L123A)×Rg14] revealed the highest values for three characters; plant height (259 cm), ear length (19 cm) and grain weight per ear (112 g) comparing with all studied genotypes (parents, F1, F2 and BC2 hybrids) as shown in Table 3.

Heterosis: Table 4 manifested values of heterosis in F1 over mid and better parents (MP and BP) for six characters in the five hybrids. The five crosses gave highly significant heterotic values over MP and BP for the six studied characters except number of rows per ear in which the crosses numbers 2, 3 and 4 did not showed

Table 2: Analysis of variance for the studied characters concerning replications and genotypes (5 inbred lines + F1, F2, BC1 and BC2)

		Mean squares					
SV	DF	Plant height (cm)	Ear height (cm)	Ear length (cm)	No. of rows/ear	100 grain weight (g)	Grain weight/ear (g)
Replications	2	687.0	212.0	9.2	1.3	20.2	617.0
Genotypes	9	8550.0**	4805.0**	23.6**	9.4**	134.2**	2707.0**
Errors	18	11.7	3.4	0.02	0.03	0.3	16.4

** Significant at 0.01 level

Table 3: Mean yield performance of five maize inbred lines, F1 and F2 crosses and back crosses for six agronomic characters

	Characters						
Genotypes	Plant height (cm)	Ear height (cm)	Ear length (cm)	No. of rows/ear	100 grain weight (g)	Grain weight/ear (g)	Selection index values
Inbreds							
1. G251B	147	116	11	10	25	33	737.36
2. L113A	127	70	11	10	18	20	607.73
3. L123A	143	77	10	10	17	14	707.10
4. Rg5	140	80	13	14	12	26	705.48
5. Rg14	151	85	11	12	23	32	706.59
F1 Crosses							
1.G251BxL113A	240	159	15	12	32	62	1173.59
2. G251BxRg14	249	167	16	12	27	90	1226.58
3. Rg5xL123A	236	155	17	14	25	66	1177.90
4. Rg14xL113A	244	132	17	12	33	79	1127.55
5. Rg14xL123A	240	167	18	14	29	82	1186.09
F2 Cross							
Rg14xL123A	218	156	14	13	24	28	
Back crosses							
1.[(Rg14xL123A)xRg14]	259	160	19	13	30	112	
2. [(Rg14xL123A)xL123A]	244	160	16	12	28	84	
LSD 5%	5.88	3.14	0.22	0.29	0.98	6.95	
LSD 1%	8.05	4.31	0.30	0.39	1.34	9.51	

Table 4: Expression of heterosis in F1 crosses over mid Parents (MP) and Better Parent (BP) as percentage for six characters in five hybrids

		Plant height		Ear height		Ear length		No. of rows/ear		100 grain weight		Grain weight/ear	
Cr. No	Crosses	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1	G251B×L113A	66**	63**	65**	37**	43**	36**	20**	20**	52**	28**	164**	88**
2	G251B×Rg14	67**	77**	66**	44**	46**	46**	9**	0.0	13**	8**	177**	173**
3	Rg5XL123A	67**	65**	98**	94**	133**	31**	17**	0.0	72**	32**	230**	154**
4	Rg14XL113A	76**	62**	71**	56**	55**	55**	9**	0.0	61**	44**	204**	147**
5	Rg14XL123A	63**	59**	106**	97**	71**	64**	27**	17**	45**	26**	257**	156**
	LSD 0.05	5.1	5.9	2.7	5.5	0.2	0.2	0.3	0.3	0.8	0.9	6.0	6.9
	LSD 0.01	6.9	8.1	3.7	7.5	0.3	0.3	0.4	0.4	1.1	1.3	8.2	9.5

any heterotic values over BP. The heterotic values were ranging from 9-257% over MP and 8-173% over BP for yield components. The cross 2 (G251B×Rg14) manifested the highest heterotic values for plant height and grain weight per ear over BP (77% and 173%, respectively). The cross 3 (Rg5×L123A) revealed the highest values of heterosis for ear length and 100 grain weight over MP (133 and 72%, respectively). The cross 4 (Rg14×L113A) showed the highest heterotic values for plant height over MP (76%) and 100 grain weight over BP (44%).

Generally, The cross 5 (Rg14×L123A) was the best cross, which showed the highest significant heterotic values for ear height over MP (106%) and BP (97%), ear length over BP (64%), number of rows per ear over MP (27%) and grain weight per ear over MP (257%).

These results are in agreement with those of Mohamed [2] who reported substantial heterosis ranging from 17.4-434.3% over the mid parent and 10-377.1% over the better parent for yield components. These results also coincided with those of Dornescu [15] who found that hybrids were superior to their parents by 222% for grain weight per ear and Mahmoud *et al.* [3] who observed that the maximum ranges of heterosis effects for different characters were expressed for grain weight per ear.

Phenotypic correlation coefficients: Phenotypic correlation coefficients between all possible pairs of traits in this study were positive as shown in Table 5. Highly significant correlation coefficients were found

Table 5: Phenotypic correlation between all possible pairs of the studied characters

Characters	Plant height	Ear height	Ear length	No. of rows/ear	100 grain weight	Grain weight/ear
Plant height	1.00	0.93**	0.93**	0.52	0.83**	0.94**
Ear height		1.00	0.87**	0.49	0.80**	0.91**
Ear length			1.00	0.73*	0.69*	0.92**
No. of rows/ear				1.00	0.15	0.58
100 grain weight					1.00	0.81**
Grain weight/ear						1.00

Table 6: Estimation of gene effects for six studied characters of maize crosses

	Characters					
Gene effect	Plant height (cm)	Ear height (cm)	Ear length (cm)	No. of rows/ear	100 grain weight (g)	Grain weight/ear (g)
Mean	218.4**	155.7**	13.8**	12.9**	24.1**	27.8**
Additive effect	14.6	-0.5	3.0	1.2	2.6	27.7
Dominance effect	220.5**	101.5**	21.1**	2.2	28.6**	337.2**
AdditivexAdditive	131.3*	16.9	15.4**	-0.5	19.5	279.6**
Additive x Dominant	12.1	-3.0	2.2	0.1	-0.2	12.0
Dominantx Dominant	-365.0**	-156.5**	-29.1**	-2.8	-38.4**	-475.2**

*, **: Significant at 0.05 and 0.01 levels, respectively

for grain yield per ear with plant height, ear height, ear length and 100-grain weight, while it was not significant with number of rows per ear. Weight of 100 grains was highly significant correlated with plant height and ear height and significant with ear length. Number of rows per ear was significantly correlated only with ear length. Ear length was highly significant correlated with plant height and ear height. Ear height was highly significant correlated with plant height. These results suggest that selection for high plant, high ear on plant, long ear and heavier 100-grain weight lead to achieve higher grain yield per ear.

Gene effects: Estimates of the six components, i.e. mean (m), additive (a), dominance (d), additive x additive (aa), additive x dominance (ad) and dominance x dominance (dd) from generation means are presented in Table 6. The results showed that dominance gene effect (d) was positive and highly significant for all studied characters except number of rows per ear. The additive x additive (aa) epistatic effect was highly significant for ear length and grain weight per ear and was significant for plant height. The dominance x dominance (dd) epistatic effect was highly significant but negative for all studied characters except number of rows per ear. Regarding the epistatic effect of genes, additive x dominance (ad) was not significant for all studied characters.

It is clear that the dominant gene effect played major role in the inheritance of all studied characters, except number of rows per ear. However, the additive x additive epistatic effect was more important than the two other epistatic effects especially for plant height, ear length and grain weight per ear. Similar results were found by Gamble [5].

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