

DIALLEL ANALYSIS OF YIELD AND OTHER AGRONOMIC  
CHARACTERS IN MAIZE (*Zea mays*, L.)

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ABSTRACT

An 9x9 diallel analysis of combining ability under two different levels of nitrogen for eight quantitative characters was performed. Significant mean squares due to nitrogen levels were detected for, ear height, number of rows per ear, 100-kernel weight, and grain yield per plant.

Significant general and specific combining abilities (GCA and SCA) were obtained for all traits. The magnitudes of the ratios of GCA/SCA revealed that the additive and additive X additive types of gene action were the most important expressions for all traits. The magnitude of the interaction for GCA was generally higher than for specific one for most traits. The parental inbred lines M.37, K64 and M.44 showed significant negative ( $g_i$ ) for silking and tasseling dates. The parental inbred lines M.30 and RgII expressed significant positive of ( $g_i$ ) for grain yield/plant, number of rows/ear and number of kernels/row. While, M.36 seemed to be the best combiner for grain yield, 100-kernel weight and number of rows/ear.

The highest desirable SCA effects were in crosses: RgII X M.36, RgII X M.25, RgII X M.30, K64 X M.54 and K64 X M.36 for grain yield and one or more of its components. The cross RgII X M.3 showed the highest useful heterosis for grain yield followed by RgII X M.30. The five double crosses; (RgII X K64) (M.36 X M.30), (RgII X K64) (M.54 X M.36), (RgII X K64) (M.36 X M.25), (RgII X K64) (M.36 X M.24) and (RgII X M.36) (M.24 X M.30) surpassed the respective check variety D.C. 202 by 32.35%, 24.90%, 23.50%, 10.97% and 13.51%, respectively.

### INTRODUCTION

Maize grain yield is a complex trait and is an ultimate product of the action and interaction of a number of quantitative characters, which are known to be controlled by different sets of polygenes. The study of these characters is of prime concern to maize breeder.

It is a matter of importance both theoretically and practically to investigate the constancy of the genetic components of continuous variation under differential conditions, since differences between the results of growing the same cross in different treatment, location, or season are usually obtained. The contribution of macro and micro environmental effects to the magnitude of various genetic types and heterosis were previously recorded by many investigators (Saki, 1955; Matzinger, 1963; Mather and Jinks, 1971 and Others).

General and specific combining abilities were first defined by Sprague and Tatum (1942), then many investigations were conducted on combining ability whether by using inbred lines or open-pollinated varieties. Williams *et al.*, (1963) and El-Rouby & Galal (1972), working on varietal crosses and Nawar and El-Hosary (1983 & 1985) and El-Hosary (1986), the behaviour of inbred lines, reported that GCA was more important than SCA. On the contrary, Nawar *et al.*, (1979 and 1980), reported that SCA was more important than GCA. Matzinger *et al.*, (1959) and El-Hosary (1986), suggested that the additive effects were more biased by interaction with environments than the non-additive effects.

The purpose of this investigation was (1) to estimate the GCA and SCA and their interaction with different nitrogen levels, (2) to identify superior parental lines and their prospective crosses to be used in hybrid maize breeding programs.

### MATERIALS AND METHODS

Seven inbred lines of corn i.e. Moshtohor (M) 44, 54, 37, 36, 25, 24 and 30 were obtained by El-Hosary (1986a). In addition, two inbred lines RgII and K64 were obtained from Crop Research Institute, Agricultural Center, Ministry of Agriculture, Giza. In 1986 seasons, the nine inbred lines were split planted in May 10th and 30th to avoid differences in flowering time and to secure enough hybrid seeds. All possible combinations, without reciprocals, were made.

In 1987 season, two experiments involved 36 hybrids and double cross 202 (check variety) were planted in June 27th at the Agricultural Research and Experimental Station of the Faculty of Agriculture, Moshtohor. A randomized complete block design with three replication was used. Each plot consisted of two ridges of six m. length and 70 cm. width. Hills were spaced at 30 cm. with three kernels per hill on one side of the ridge. The seedlings were thinned to one plant per hill. Two experiments each with different nitrogen levels were conducted to evaluate the 36 hybrids and D.C. 202. The first experiment received 60 kg N/fad. and the second one received 90 kg N/fad. The rest of cultural practices were followed as usual for ordinary maize field in the area. Random sample of 20 graded plants in each plot was taken to evaluate; silking date, tasseling date, plant height, ear height, number of rows per ear, number of kernels per row, 100-kernel weight and grain yield per plant. Grain yield was adjusted for 15.5% moisture.

General and specific combining ability estimates were obtained by Griffing's (1956) diallel cross analysis designated as method 4 model I for each experiment. The combined analysis of the two experiments were carried out whenever homogeneity of variance was detected. Heterosis expressed as the percentage deviation of  $F_1$  mean performance from double cross 202 for grain yield per plant.

#### RESULTS AND DISCUSSION

The analysis of variance for combining ability combined over two experiments for eight characters is given in table (1).

Nitrogen levels mean squares for; ear height, number of rows per ear, 100-kernel weight and grain yield per plant were significant, with mean values by 90 kg N/fad. being higher than those by 60 kg N/fad. This indicates that presence of nitrogen led to less competition between plants for nitrogen and retarded leaf senescence, which increased period of photosynthesis and dry matter production and this in turn helped increasing grain yield. Similar results were obtained by Khalifa *et al.*, (1983) and Moursi *et al.*, (1983).

Hybrids mean squares were highly significant for all traits. With the exception of tasseling date, number of rows/ear and 100-kernel weight significant hybrids by

Table ( I ): Observed mean squares from ordinary analysis and combining ability for studied traits.

S.O.V	d.f	silking date	tasseling date	plant height	ear height	No. of row/ear	No. of kernels/row	100-kernel weight	Grain yield/plant
Fertilization	I	11.57	00.08	1218.4	2229.8	6.30	20.54	18.98	31888.0
Rep. within fertilization	4	11.56	9.81	313.0	13.1	5.02	11.39	5.43	290.7
Hybrids	35	30.54	20.70	1392.1	787.7	11.17	53.98	188.80	8515.8
GCA	8	69.14	48.83	2828.2	2611.4	34.21	124.72	460.44	16187.4
SCA	27	19.11	12.42	966.6	247.4	4.35	32.99	108.32	6242.0
Hybrids X Fertilization	35	6.46	4.19	494.5	118.0	1.55	29.19	3.79	1054.1
GCA X Fert.	8	21.89	2.12	628.7	208.9	2.94	21.18	4.95	1122.9
SCA X Fert.	27	1.88	4.80	454.7	91.1	0.43	31.56	3.44	1033.7
Error	140	3.72	2.92	339.2	45.6	0.87	12.74	3.15	485.6
GCA SCA		3.62	3.92	2.93	10.56	7.86	3.78	7.25	2.6

\* and \*\* Significant at 0.05 and 0.01 levels of probability, respectively.

nitrogen levels mean squares were detected. These interactions with nitrogen levels could be a result of different ranking of genotypes from level to the other. For the exceptional cases, insignificant interactions between hybrids and nitrogen levels were obtained revealing that the hybrids had nearly similar magnitudes at different nitrogen levels.

The variance associated with general and specific combining abilities (GCA and SCA) was significant for all traits, indicating that both additive and non-additive types of gene action were involved in determining the performance of single-cross progeny. To reveal the nature of genetic effect which had the greater role, GCA/SCA ratio was computed. High values which largely exceeded the unity were detected, revealing that the largest part of the total genetic variability associated with those traits was a result of additive and additive by additive gene action.

These results support the finding of El-Rouby *et al.*, (1973); Kassem *et al.*, (1979); Nawar & El-Hosary, (1983 & 1985) and El-Hosary, (1986) for yield and its components, Shehata & Dhwan, (1975) and Mohamed (1984), for earliness.

The magnitude of the interactions for general combining ability was generally higher than for specific ones, reaching the significant level of probability for all traits except tasseling date. Appreciable specific combining ability by nitrogen levels interactions were only reached for silking date, number of kernels per row and grain yield per plant. This finding indicates that additive and additive by additive types of gene action appeared to be more affected by environments than the non-additive genetic type. These results are in harmony with those previously reached by Matzinger *et al.*, (1959); Nawar & El-Hosary, (1983) and El-Hosary (1986) where they suggested that the additive effects were more biased by interaction with environments than the non-additive effects.

Estimation of general combining ability effects ( $g_i$ ) for individual parental inbred lines in each trait over two experiments are presented in table 2. M.37, K64 and M.44 showed significant negative ( $g_i$ ) for both of tasseling and silking dates. This finding indicates that these inbred lines are the best general combiners for earlier yield. The parental inbred line M.30 seemed to be the best combiner for dwarfness; The parental inbred lines. M.30, RgII, K64 and M.44 expressed in superiority for ear height. The parental inbred lines M.30 and RgII expressed significant positive value of ( $g_i$ ) for grain yield per plant, number

Table ( 2 ): Estimates of the relative GCA effects of parental inbred lines for the studied traits over two experiments.

	Silking date	Teste-ling date	Plant height	Ear height	No. of rows	No. of kernels row	100- Kernel weight	Grain yield plant
1- M.11	0.63*	0.31	1.31	-5.89*	0.43	1.03	-1.19*	29.78
2- M.6	-1.58*	-1.34*	-4.66	-6.22*	0.85	1.28	-3.76*	4.75
3- M.14	-1.13*	-1.07*	5.67*	-2.93*	-1.88	-1.01	2.46	-6.93
4- M.54	0.94*	0.83	-2.90	4.09	-0.05	-2.54	-0.77	-11.35
5- M.37	-1.68*	-1.36*	-3.35	-1.79	-0.73	-1.09	0.70	-28.18
6- M.36	-0.63*	-0.38	11.50*	13.31*	0.89	-1.39	7.41	25.54
7- M.25	0.01	0.59*	2.22	2.83	-0.42	1.69	-2.25	-13.34
8- M.24	1.91*	1.57*	6.91*	8.35*	0.24	-0.65	-0.43	-13.77
9- M.38	0.93*	0.81*	-16.63*	-11.96*	0.38	2.88	-2.17	13.87
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( $\bar{f}_i - \bar{e}_i$ )	0.83	0.74	7.96	2.92	0.40	1.54	0.77	9.52
( $\bar{e}_i - \bar{e}_i$ )	1.10	0.98	10.53	3.86	0.53	2.04	1.01	12.59

\* and \*\* Significant differences from zero at 0.05 and 0.01 levels of probability, respectively.

of rows per ear and number of kernels per row. Whereas, M.37 seemed to be the best combiner for grain yield per plant, 100-kernel weight and number of rows per ear.

These results indicated that these parental inbred lines possess favourable genes and that improvement in yield may be attained if they are used in hybridization program.

Specific combining ability effects for the studied thirty-six parental combinations were computed for all the studied traits (table 3). The most desirable inter-and intra-allelic interactions were presented by the combinations RgII X M.54, K64 X M.36 and M.37 X M.30 for earliness, M.54 X M.36 for plant height, RgII X K64, K64 X M.30, M.54 X M.30, M.36 X M.25 and M.25 X M.24 for ear height, and RgII X M.36, RgII X M.25, RgII X M.30, K64 X M.54 and K64 X M.36 for yield and one or more of yield components.

These combinations expressed significant heterotic effect relative to Double cross 202 (table 3). In addition, these crosses might be of interest in breeding program towards synthetic varieties composed of inbred lines or hybrids involved the good combiners for the traits in view.

Heterosis expressed as the percentage deviation of  $F_1$  mean performance from Double cross 202 value for grain yield per plant in single experiment as presented in table 3. Thirteen, fifteen, and nineteen hybrids exhibited significantly heterotic effects for the first experiment, the second one and the combined, respectively. Five hybrids out-yielded the check variety in both experiments as well as the combined. The useful heterotic effects to D.C. 202 ranged from 20.59 to 67.61, 17.73 to 37.03 and 15.08 to 51.55 for exp. 1, exp. 2, and the combined, respectively. High heterotic effect was detected in the cross (RgII X M.36) followed by cross (RgII X M.30). Hence, it could be concluded that both crosses offer possibility for improving grain yield of maize.

Many investigators reported high heterosis for yield of maize (Robinson *et al.*, 1956; Hallour and Eberhart, 1966; Nawar and EL-Hosary, 1985 and EL-Hosary, 1986). Mohamed (1984) and other investigators reported good relationship between the predicted and the actual double cross yield.

Method-3 outlined by Jinkins (1934) was used to determine the prediction grain yield of double crosses. The double crosses (RgII X K64) (M.36 X M.30), (RgII X K64)

Table 3. Genetic variability coefficient for all characters studied, K 64 and K 66 relative to cross 202 for grain yield plant in each experiment and mean values over 10 experiments.

Cross	Silk-ling date	Plant height	SDA effects		Kernel weight	Grain yield plant	heterosis		Mean
			height	no. of kernels			00 kg. frd.	combined	
RGII x K64	0.71	-14.83	-3.25	0.25	6.01	-87.03	-35.83	-23.01	191.6
- x M.44	0.62	3.12	-2.19	0.40	0.39	-33.93	-2.83	4.30	244.5
- x M.54	-3.53	4.53	0.95	-1.97	-1.55	5.36	-2.83	-3.77	183.7
- x M.37	2.83	-1.85	5.50	-1.04	-2.52	-15.65	-12.74	-7.16	317.0
- x M.36	0.62	9.12	1.76	1.33	-0.29	58.98	67.81	37.83	219.3
- x M.25	-0.74	-1.59	3.71	1.93	6.03	31.77	21.31	17.73	243.7
- x M.24	-0.45	-1.11	0.52	0.32	5.06	21.99	6.19	23.11	273.7
- x M.30	-0.14	2.65	0.83	1.23	-0.57	24.55	25.51	32.93	195.0
K64	1.48	3.77	4.93	0.86	-5.23	-15.67	-13.74	0.61	256.5
- x M.54	2.41	13.01	3.64	0.36	4.37	60.35	14.75	29.71	131.6
- x M.50	0.52	2.76	8.88	0.96	-2.23	1.25	-16.39	-11.10	266.9
- x M.37	0.52	22.77	1.03	1.13	11.55	33.72	28.57	33.00	216.3
- x M.36	-0.27	3.95	-1.93	-0.56	-7.20	20.23	9.13	-1.71	195.3
- x M.25	0.74	5.80	-6.79	-0.72	6.78	1.54	3.49	-15.73	234.8
- x M.24	-0.12	-14.38	-9.14	-0.81	5.11	-16.34	7.87	-11.07	196.8
M.44	0.43	3.99	-2.81	0.49	2.33	12.26	-11.46	-0.93	182.5
- x M.54	0.10	16.96	6.43	0.12	-0.70	14.74	-10.49	-14.85	209.3
- x M.37	0.71	1.99	-3.62	-0.17	4.22	-12.14	9.08	-3.12	194.9
- x M.36	-1.14	-10.18	-5.88	-0.43	1.88	12.45	-11.70	-2.39	196.4
- x M.25	-1.54	-6.61	-1.20	-0.20	-4.43	14.30	-6.94	-5.73	217.6
- x M.24	0.29	-0.13	2.71	-0.63	1.57	8.09	4.00	4.03	

\* and \*\* Significant at 0.05 and 0.01 levels of probability, respectively.

Table ( 3 ): ( Cont. )

Cross	silk		plant		100-		No. of	Grain	Heterosis %		mean	
	ing	date	height	per	kennel	yield			60 kg	90 kg		plant
M.54	M.37	-2.43	-1.42	13.03	-4.12	-0.13	3.58	15.99	-8.74	-19.34	-4.31	172.3
	M.36	2.14	1.61	38.47	5.29	3.61	-2.49	-30.61	-16.42	-6.66	-11.42	136.1
	M.25	2.93	2.80	15.96	2.59	-0.36	-1.68	-26.31	-26.93	-27.48	-27.48	151.7
	M.24	-1.10	-1.35	6.43	3.57	0.05	0.74	1.51	-16.61	-12.29	-14.34	179.2
	M.30	-0.95	-0.42	-7.47	-9.12	-0.53	3.54	-23.24	-27.21	-9.37	-17.35	171.5
	M.36	0.93	1.35	-13.83	3.33	-0.14	2.29	-25.23	-7.44	-42.82	-16.73	174.3
	M.25	0.74	0.37	4.26	6.36	0.47	6.47	15.23	-20.09	-11.67	-15.68	176.1
	M.24	-0.49	-0.44	7.95	4.83	0.53	3.23	0.75	-20.09	-17.74	-13.82	169.7
	M.30	2.17	-1.93	4.52	-1.24	-0.73	-5.25	-14.93	-23.85	-11.66	-17.23	173.5
	M.25	-1.31	0.91	1.11	9.95	0.35	-1.79	-21.41	-4.13	-13.51	-7.50	193.5
	M.24	0.14	0.42	9.36	1.36	0.95	-1.40	-25.80	-3.33	-9.40	-7.37	193.
	M.30	0.79	0.51	13.62	0.93	0.20	-0.92	17.33	22.27	19.72	24.82	259.4
	M.24	0.29	0.44	0.15	-3.67	-5.34	3.41	-37.11	-32.57	-34.93	-33.79	133.5
	M.30	-0.07	-0.46	5.53	12.93	0.22	1.04	4.12	-10.24	7.37	-0.93	207.1
	M.24	2.38	2.23	5.05	2.64	0.41	0.01	9.87	-0.94	-0.94	1.60	212.5
	M.30	2.04	1.81	19.47	7.15	1.06	3.77	1.88	193.60	219.70	1.60	209.2
	M.24	2.70	2.39	25.79	9.46	1.40	4.99	23.32				
	M.30	1.96	1.65	17.79	6.52	0.20	3.45	30.86				
	M.24	2.46	2.13	23.55	8.63	1.19	4.56	21.29				
	M.30	2.46	2.13	23.55	8.63	1.19	4.56	28.17				

\* and \*\* Significant at 0.05 and 0.01 levels of probability, respectively.

(M.54 X M.36), (RgII X K64) (M.36 X M.25), (RgII X M.64) (M.36 X M.24) and (RgII X M.36) (M.24 X M.30) surpassed the respective D.C. 202 value by 32.35%, 24.90%, 23.50%, 19.97% and 13.51%, respectively.

It could be concluded that these double crosses offer a possibility for increasing grain yield of maize.

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