Combining Ability Analysis Using Diallel Crosses among Nine Inbred Lines of Corn under Two Nitrogen Levels

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Abstract

A half diallel cross between 9 inbred lines of maize was evaluated at two different nitrogen levels(60 and 120 kgN/fed.) for nine quantitative characters. Nitrogen level and crosses mean squares were significant for all traits under study. Significant crosses x nitrogen level mean squares were obtained for all studied traits except, No. of rows/ear. General and specific combing ability mean squares were significant for all traits, except days to 50% tasseling date. For days to tasseling and no of rows/ ear at low nitrogen rate; silking at high nitrogen level; shelling% at high nitrogen level and combined analysis and plant height, ear height, no of kernels/ row, 100 kernel weight and grain yield/ plant in both and across nitrogen levels. High ratios which largely exceeded the unity were obtained, indicating that a large part of the total genetic variability associated with these traits was a result of additive and additive by additive gene action. For remain cases, GCA/SCA ratios were less than unity. Therefore, it could be concluded that the large portion of the total genetic variability for these traits was due to non-additive gene action. The parental inbred lines No. 1, 6 and 7 gave positive and significant ($\hat{g}_i$) effects for grain yield/ plant and one or more of its components. The parental combination P_1xP_3, P_1xP_4, P_1xP_5, P_2xP_4, P_2xP_7, P_2xP_9, P_3xP_4, P_3xP_5, P_3xP_6,, P_4xP_6, P_5xP_6, P_6xP_7, P_6xP_9, P_7xP_8 and P_7xP_9 for grain yield/plant exhibited significant positive $\hat{S}_{ij}$ effects being 62.61, 20.37, 92.43, 42.37, 42.06, 17.94, 12.38, 10.57, 21.08, 53.52, 7.27, 14.95, 13.53, 42.00 and 49.83, respectively. The crosses 1x3, 2x7, 7x8, 7x9, 8x9 in low nitrogen environment, 1x3, 1x4, 1x5, 1x7, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 at low nitrogen environment and 1x3, 1x5, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 in the combined data gave the highest mean value of grain yield / plant.

Key words: Maize, Combining ability, nitrogen levels, GxE.

Introduction

Maize (*Zea mays* L.) is the most important cereal crops in the world and Egypt due to its vast grown area. It ranked 3rd cereal crop in the world, after wheat and rice. It is essential for human and animal fedding. Also, it used for industrial purposes such as manufacturing starch and cooking oils. In 2018 the corn grown area in Egypt was 1.125 Million hectares (2.76 million feddans) with an annual grain production of 7.95 Million metric tons and an average productivity of 10.08 ton ha^{-1} (24.2 ardabs/feddan). (One feddan; fed =4200 m^2 and one ardab; ard = 140 Kg). **(USDA 2018).**

Maximizing food and agricultural production, depends mainly on promoting high yielding maize hybrids to cover the mounting consumption of maize. This depends mostly on the produce new hybrid of maize across breeding programs. To carry out a successful breeding program, the breeder should have enough knowledge about the type and relative amount of genetic variance components and their interactions by environment for different attributes.

Diallel cross is a useful tool to produce promising hybrids and combining ability helps to identify the most appropriate parents and provide sufficient genetic information on the inheritance of traits. In this regard, highly general combining ability (GCA) and specific combining ability (SCA) effects leading to high heterosis were asserted by **Girma *et al* (2015), Al-Naggar *et al* (2016) and Al-Naggar *et al* (2017 a and b)**

The quantitative characters are extremely affected by the environment, and the amount of such effect increases with the increase in the number of predominant genes. Thus, expression of a specific character which controlled by several loci were display greater genotype x environment (GxE) interaction. The elimination of GxE variance from the assessments of genetic variance forms an integral part of any endeavor to determine genetic variances without partiality **(Singh 1973 and 1979 and Wani *et al* 2017).**

Diallel mating pattern utilizing combining ability analyses are greatly used in maize breeding programs to locate the combining ability types. Furthermore, the magnitude of genetic components for a certain trait would depend mainly upon the environmental flection under which the breeding populations will be tested. Thus, differences due to GCA and SCA are associated with the type of gene action implicated.

Variance for GCA contains additive part while that of SCA includes non-additive part of total variance emerging mostly from dominance and epistatic deviations **(Izhar and Chakraborty 2013).**

The main objectives of this investigation are to: 1) determine hybrid performance for the studied parental combination. 2) To estimate the amount of superiority over than the check hybrid SC 168. and 3) To establish the magnitude of both general combining ability (GCA) and specific combining ability (SCA) effects and their interaction with two nitrogen fertilizer levels.

Materials and Methods

Nine yellow inbred lines were used as parents in this study. Moshtohor P_1 (N801), P_2 (N 802), P_3 (N 803), P_4 (N 804), P_5 (N 805), P_6 (N 806), P_7 (N 807) , P_8 (N 808) and P_9 (N 809) were obtained by Prof. Dr. A.A.M. El-Hosary at the Department of Agronomy, Faculty of Agric. at Moshtohor, Benha Univ. In the first season (summer 2018) the nine parental inbred lines were sown in 1st May, 7th May and 12th May to avoid differences in flowering time and to secure enough hybrid seed. All possible combinations without reciprocals were made between the nine inbred lines by hand method giving a total of 36 crosses. In the second season (summer 2019), two adjacent experiments were conducted at the two nitrogen levels: 60 and 120 Kg N/ fed. In each experiment the 36 F_1 hybrids as well as check hybrid SC G.168 were grown in a randomized complete block design with three replications. Each plot consisted of two ridges of 5 m length and 70 cm width. Hills were spaced by 25 cm with two kernels per hill and later thinned to one plant per hill. The dry method of sowing was used. The first irrigation was given after about 21 days from sowing. The cultural practices were followed as recommended for ordinary maize field in the area. Random sample of 10 guarded plants in each plot were taken to evaluate days to 50% silking and tasseling, plant height (cm), ear height (cm), No. of kernels/row, No. of rows/ear, 100-kernel weight, grain yield/plant which was adjusted for 15.5% moisture and shelling%.

The obtained data were statistically analyzed for analysis of variance by using computer statistical program MSTAT-C. General and specific combining ability estimates were estimated according to **Griffing's (1956)** diallel cross analysis designated as method 4 model I for each experiment. The combined analysis of the two experiments was carried out whenever homogeneity of variance was detected **(Gomez and Gomez, 1984)**. Relative superiority expressed as the percentage deviation of the F_1 mean performance from S.C. G.168.

Results and Discussion

The analysis of variance for ordinary analysis over the two experiments for all studied traits is given in Table (1). Nitrogen levels mean squares for all traits under study were significant, with mean values in high nitrogen level being higher than those in low nitrogen level for all studied traits. It coud be concluded that nitrogen fertilizer rates showed positive effect on the previous traits on maize.

The increase in these traits at high rate of nitrogen may be due to the stimulating effect of nitrogen on metabolic process in maize plant. These results are in agreement with those obtained by El-Hefnawy and El-Zeir (1991), Mohamed (1993), Rizzi *et al*. (1993), Ibrahim (2003), Medici *et al*. (2004) , Chun *et al*. (2005) and El-Hosary and El-Badawy (2005).

Crosses mean squares were significant for all traits (Table 1). This indicates wide diversity between the parental materials used in the present study. Significant crosses x nitrogen level mean squares were obtained for all traits except days to 50% tasseling. Such results indicate that, these hybrids behaved somewhat differently from low to high nitrogen rate. For the exceptional traits, insignificant interaction was obtained, reflecting that the hybrids were suspected to environmental changes by nearly similar magnitudes.

Mean performances of F_1 hybrids, S.C. G.168 are presented in Table (2). It is favorable if the single crosses were earlier in flowering than parents to develop early maturity hybrids to avoid damage by borers or other environmental adverse conditions. The parental combinations that incorporated earliness in silking and tasseling dates as well as exhibited superiority over SC 168 are plants of those F_1 hybrids 1x3, 1x7, 1x8, 2x4, 2x5,x2x8, 3x6, 3x7, 4x5, 5x9, 6x8, 6x9, 7x8 and 8x9. From the point of view for the breeder the highest plant gave high biomass is vital for high production on the same time the low ear position is important for resistance to stem lodging. The crosses 2x4 and 6x8 gave the highest plant and lowest mean values of ear height and differ significantly relative to SC 168.

The cross 2x8 gave the highest mean value of No of kernels/ row as well as No of rows/ ear and differ significantly relative to SC 168. For 100-kernel weight, the crosses 2x4, 2x7 and 5x6 had differ significantly relative to SC 168. The crosses 1x3, 2x7, 7x8, 7x9, 8x9 in low nitrogen environment, 1x3, 1x4, 1x5, 1x7, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 at low nitrogen environment and 1x3, 1x5, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 in the combined data gave the highest mean value of grain yield / plant. Also, the mention hybrids showed significant superiority over the check hybrids.

Heterosis:

Relative superiority relative to SC 168 expressed as the percentage deviation of F_1 mean performance from each of S.C. G.168 for grain yield/plant is presented in Table (2). Concerning grain yield/plant the crosses 1x3, 2x7, 7x8, 7x9, 8x9 out yielded the check hybrid in low nitrogen environment, 1x3, 1x4, 1x5, 1x7, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 out yielded the check at low nitrogen environment and 1x3, 1x5, 2x4, 2x7, 6x7, 7x8, 7x9 and 8x9 out yielded the check in the combined analysis. Hence, it could be concluded that these crosses offer possibility for improving grain yield in maize.

Many investigators reported high heterosis for yield of maize; i.e. **Nawar *et al*., (2002), Shafey *et al*., (2003),**

El-Bagoury *et al*., (2004), **Singh *et al*., (2004), El-Hosary *et al*., (2006), El-Hosary (2015)** and **EL-Hosary and EL-Fiki (2015) .**

Combining ability

The analysis of variance for combining ability at the combined analysis for all the studied traits is presented in Table (1). The mean squares of general combining ability includes the additive and additive x additive genetic portion while specific combining ability represents the non additive genetic portion of the total variance arising largely from dominance and epistatic deviations. The mean squares due to general and specific combing ability were significant for all the studied traits except for, days to 50% tasseling at high level of nitrogen experiment and days to 50% silking at low nitrogen environment.

If both general and specific combining ability mean squares are significant, one may ask which type and or types of gene action are important in determining the performance of single- cross progeny. To overcome such situation the size of mean squares can be used to assume the relative importance of general and specific combing ability mean squares which were highly significant. Hence, GCA/SCA ratio was used as measure to reveal the nature of genetic variance involved

For days to 50% tasseling and no of rows/ ear at low nitrogen rate; days to 50% silking at high nitrogen level; shelling% at high nitrogen level and combine analysis and plant height, ear height, no of kernels/ row, 100 kernel weight and grain yield/ plant in both and across nitrogen levels, high ratios which largely exceeded the unity were obtained, indicating that a large part of the total genetic variability associated with theses traits was a result of additive and additive by additive gene action. For the remain cases, showed GCA/SCA ratios less than unity. Therefore, it could be concluded that the large portion of the total genetic variability for these traits was due to non-additive gene action. The largest heterotic magnitude expressed in the previous traits as the deviation of particular F_1 mean performance from check S.C. G168, may strengthened the conclusion about the importance of additive gene effects in the inheritance of traits. The genetic variance was previously reported to be mostly due to additive for Plant, ear height , no. of grains/row by **(Amer 2003 and Shafey *et al*., 2003)** and grain yield/ plant by **(Amer 2003; Mosa 2003; Shafey *et al*., 2003; EL-Hosary and EL-Badawy 2005 and El-Hosary *et al*., 2006).** On the other hand, the additive genetic variance was previously reported to be most prevalent for earliness and No. of rows/ear by (**Amer, 2003; Mosa, 2003**; **EL-Hosary and EL-Badawy 2005**); and 100-kernel weight by **(Dubey *et al*., 2001**; **Shafey *et al*., 2003; EL-Hosary and EL-Badawy 2005)**.

The mean squares of interaction between nitrogen levels and both types of combining ability were significant for all studied traits except days to 50%tasseling. Such results showed that the magnitude of all types of gene action varied from nitrogen level to another. It is fairly evident that the ratio for SCA x D/SCA was higher than ratio GCA x D/GCA for all studied traits except days to 50% silking. This result indicated that non-additive effects were more influenced by the environmental conditions than additive genetic effects of these traits. Such results indicated that non-additive effects are influenced by seasonal changes **(Mosa and Motawei 2005 and El-Hosary *et al*., 2006).** This result indicated that non-additive effects were more influenced by nitrogen level than additive genetic effects of this trait. This conclusion is in well agreement with those reported by **(Gilbert 1958).** This finding confirms those obtained above from the ordinary analysis of variance. Such results indicated that non-additive effects are influenced by environmental changes (**Amer 2005 and El-Hosary *et al*., 2006)**.

General combining ability effects:

Estimations of GCA effects ($\hat{g}_i$) for individual parental inbred lines for each trait in the combined analysis are presented in Table (3) General combining ability effects estimated herein differ significantly from zero. High positive values would be of interest under all traits in question except days to 50% silking, and tassling as well as plant and ear heights where high negative effects would be useful from the breeder's point of view.

The parental inbred line No. 1 gave positive and significant ($\hat{g}_i$) effects for No of rows/ ear, No of kernels/ row, grain yield/ plant. The parental inbred line no. 2 showed significant positive ($\hat{g}_i$) effects for no of kernels/ row and 100-kernel weight.

The parental inbred line No. 3 , 4 and 5 seemed to be good combiner for; plant and ear height. The parental inbred line No. 6 ranked the first for grain yield/plant and 100-kernel weight. The parental inbred line No. 7 seemed to be good combiner for all studied traits except, days to tasseling and shelling%. The parental inbred line No. 8 seemed to be good combiner for; no of rows/ ear. It seemed to be poor combiner for other traits. The parental inbred line no 9 seemed to be good combiner for no of rows/ eargrain yield/ plant and shelling%. It is worth noting that the inbred line which possessed high ($\hat{g}_i$) effects for grain yield per plant might show the same for one or more of the traits contributing grain yield. In most traits, the values of ($\hat{g}_i$) effects was mostly differed from nitrogen rate to another. This finding coincided with that reached above where significant GCA by nitrogen level mean squares were detected Table (1).

Table 1. Observed mean squares from ordinary analysis and combining ability for the studied traits in each and across nitrogen rates.

SOV	df		days to 50% tasseling			days to 50% silking			plant height		
	S.	c.	90kg N/fed.	120 kg N/fed.	C.	90kg N/fed.	120 kg N/fed.	C.	90kg N/fed.	120 kg N/fed.	C.
Nitrogen level (N)		**1**			100.04**			124.52**			30234.17**
blocks/N.	**2**	**4**	2.23	1.15	1.69	0.73	0.84	0.79	15.19	14.70	14.95
Crosses	**35**	**35**	4.00**	2.25*	4.83**	3.70**	5.79**	6.93**	6461.45**	4226.13**	9827.60**
Crosses x N		**35**			1.42			2.56**			859.99**
Error/N.	**70**	**140**	1.21	1.28	1.25	0.91	1.08	1.00	14.43	14.24	14.33
GCA	**8**	**8**	1.86**	0.31	1.39**	0.44	2.21**	1.71**	4021.16**	3108.06**	6745.70**
SCA	**27**	**27**	1.18**	0.88**	1.68**	1.47**	1.85**	2.49**	1600.53**	905.20**	2247.77**
GCA x N		**8**			0.79			0.94**			383.52**
SCA x N		**27**			0.38			0.83**			257.96**
Error	**70**	**140**	0.40	0.43	0.42	0.30	0.36	0.33	4.81	4.75	4.78
GCA/SCA			1.58	-	0.83	-	1.20	0.69	2.51	3.43	3.00
GCA x N /GCA					-			0.54			0.05
SCA x N/SCA					-			0.33			0.11
SOV	**Df**		**Ear height**			**No of rows/ ear**			**No of kernel/row**		
	S.	**c.**	**90kg N/fed.**	**120 kg N/fed.**	**C.**	**90kg N/fed.**	**120 kg N/fed.**	**C.**	**90kg N/fed.**	**120 kg N/fed.**	**C.**
Nitrogen level (N)		**1**			18446.57**			93.09**			1308.33**
blocks/N.	**2**	**4**	0.04	15.14	7.59	0.37	0.06	0.22	6.57	22.04	14.31
Crosses	**35**	**35**	3052.50**	1173.51**	3591.08**	4.28**	7.48**	9.55**	137.22**	74.02**	177.28**
Crosses x N		**35**			634.93**			2.20**			33.96**
Error/N.	**70**	**140**	24.70	24.05	24.37**	0.24	0.21	0.22	10.11	9.01	9.56
GCA	**8**	**8**	1407.28**	594.74**	1799.32**	2.10**	1.32**	2.86**	62.11**	34.12**	90.06**
SCA	**27**	**27**	902.01**	330.85**	1018.57**	1.23**	2.84**	3.28**	40.89**	21.87**	49.92**
GCA x N		**8**			202.70**			0.56**			6.16*
SCA x N		**27**			214.29**			0.79**			12.85**
Error	**70**	**140**	8.23	8.02	8.12	0.08	0.07	0.07	3.37	3.00	3.19
GCA/SCA			1.56	1.80	1.77	1.71	0.47	0.87	1.52	1.56	1.80
GCA x N /GCA					0.11			0.19			0.06
SCA x N/SCA					0.21			0.24			0.26

Table 1. Cont.

SOV			100-kernel weight			grain yield/ plant			Shelling%		
	S.	c.	90kg N/fed.	120 kg N/fed.	C.	90kg N/fed.	120 kg N/fed.	C.	90kg N/fed.	120 kg N/fed.	C.
Nitrogen level (N)		**1**			1282.76**			116192.57**			932.55**
blocks/N.	**2**	**4**	14.69	0.44	7.57	193.13*	141.28**	167.21*	107.42**	101.93**	104.67**
Crosses	**35**	**35**	110.30**	82.96**	157.58**	8594.31**	6296.11**	13305.51**	126.98**	24.62*	87.15**
Crosses x N		**35**			35.69**			1584.91**			64.46**
Error/N.	**70**	**140**	9.15	7.59	8.37	59.66	44.90	52.28	17.14	16.32	16.73
GCA	**8**	**8**	46.82**	33.82**	68.59**	4215.77**	3201.84**	7084.59**	41.72**	14.67*	32.87**
SCA	**27**	**27**	33.79**	25.83**	47.77**	2464.47**	1771.85**	3650.16**	42.51**	6.29	27.92**
GCA x N		**8**			12.05**			333.02**			23.51**
SCA x N		**27**			11.85**			586.16**			20.88**
Error	**70**	**140**	3.05	2.53	2.79	19.89	14.97	17.43	5.71	5.44	5.58
GCA/SCA			1.39	1.31	1.44	1.71	1.81	1.94	0.98	2.33	1.18
GCA x N /GCA					0.17			0.05			0.72
SCA x N/SCA					0.25			0.16			0.75

* and ** refers to significant $p< 0.05$ and $p< 0.01$, respectively.
C refer to combined across seasons.

Table 2. Mean performance of the crosses for all studied traits across environments, grain yield plant^{-1} at both and across nitrogen level and superiority relative to check hybrid SC168 at both and across environments.

cross	Days to 50% tasseling (days)	Days to 50% silking (days)	plant height (cm)	ear height (cm)	No of rows/ ear	No of kernels/ row	100-kernel weight (g)	shelling%
1x2	62.50	66.50	348.33	181.67	11.80	42.30	33.72	86.91
1x3	61.50	62.50	331.67	165.00	14.00	43.48	35.40	85.39
1x4	62.50	64.17	298.17	156.67	13.60	41.40	27.44	90.18
1x5	63.50	65.33	306.67	165.00	15.70	41.10	28.14	87.99
1x6	63.17	63.50	268.33	126.67	14.60	29.35	23.54	85.99
1x7	61.17	62.50	297.67	133.33	14.20	41.00	32.94	86.65
1x8	61.67	63.33	290.28	141.67	15.05	37.63	29.16	86.68
1x9	61.33	64.83	255.00	116.67	14.80	38.13	23.10	89.64
2x3	61.33	65.00	255.00	120.00	13.80	31.10	28.17	90.08
2x4	60.50	63.50	336.67	173.33	13.20	40.70	40.45	84.20
2x5	61.67	63.67	248.33	118.33	13.60	30.20	22.90	84.61
2x6	63.17	65.17	340.00	168.33	13.45	40.13	36.91	83.55
2x7	61.67	64.33	341.33	168.33	13.00	43.80	37.18	86.29
2x8	61.17	63.50	340.17	163.33	14.27	45.93	36.69	83.84
2x9	62.17	66.00	316.67	151.67	14.60	44.10	35.01	86.13
3x4	62.83	63.83	304.83	146.67	12.40	40.80	28.76	85.42
3x5	62.33	65.00	266.67	135.00	12.50	33.15	27.47	90.58
3x6	61.67	63.33	276.67	126.67	13.00	40.40	28.50	90.05
3x7	62.50	63.50	206.67	116.67	17.50	32.05	22.78	91.21
3x8	63.17	64.83	275.00	118.33	15.00	34.00	28.84	88.50
3x9	61.00	65.33	246.50	126.67	13.90	28.53	27.19	91.29
4x5	61.17	63.00	188.33	100.00	14.20	26.70	18.37	88.73
4x6	62.67	65.00	300.00	133.33	15.40	37.30	30.91	87.32
4x7	61.67	63.00	266.56	61.67	13.00	39.20	30.60	81.84
4x8	63.00	64.50	296.67	141.67	14.33	34.70	29.31	89.85
4x9	63.67	67.17	256.83	115.00	12.80	34.63	30.94	84.36
5x6	62.17	64.17	291.67	145.00	13.80	38.30	37.17	83.75
5x7	63.00	65.50	269.00	134.17	13.00	36.00	32.91	84.62
5x8	62.50	64.17	255.00	118.33	12.45	31.45	26.02	85.62
5x9	60.67	63.67	205.00	103.33	12.40	25.30	32.43	70.44
6x7	63.17	65.33	290.00	138.33	14.20	40.30	31.03	84.64
6x8	62.00	63.83	345.00	153.33	12.80	38.60	38.90	86.53
6x9	62.17	64.17	333.33	166.67	12.20	41.70	33.44	86.77
7x8	62.00	63.67	266.97	133.15	17.00	37.50	28.91	89.98
7x9	59.83	63.50	311.67	153.33	13.40	44.60	37.90	86.16

8x9	62.00	63.67	276.67	135.00	14.25	43.88	28.67	92.47
Check	64.50	65.67	315.00	163.33	13.25	39.90	33.62	89.35
LSD 5	1.26	1.13	4.28	5.59	0.53	3.50	3.27	4.63
LSD 1	1.70	1.52	5.75	7.50	0.72	4.69	4.39	6.21

Table 2. Cont.

cross	Grain yield/ plant (g)			Relative superiority over SC 168 H%		
	N1	N2	Comb.	N1	N2	Comb.
1x2	182.00	183.00	182.50	2.54	-7.58	-2.80
1x3	207.50	215.00	211.25	16.90	8.59	12.52
1x4	142.00	223.00	182.50	-20.00	12.63	-2.80
1x5	187.00	276.25	231.63	5.35	39.52	23.37
1x6	73.00	125.00	99.00	-58.87	-36.87	-47.27
1x7	168.00	219.00	193.50	-5.35	10.61	3.06
1x8	134.00	182.50	158.25	-24.51	-7.83	-15.71
1x9	103.00	156.25	129.63	-41.97	-21.09	-30.96
2x3	117.00	119.00	118.00	-34.08	-39.90	-37.15
2x4	178.00	214.00	196.00	0.28	8.08	4.39
2x5	39.00	117.00	78.00	-78.03	-40.91	-58.46
2x6	137.00	177.50	157.25	-22.82	-10.35	-16.25
2x7	222.00	254.00	238.00	25.07	28.28	26.76
2x8	146.00	195.00	170.50	-17.75	-1.52	-9.19
2x9	156.00	221.00	188.50	-12.11	11.62	0.40
3x4	129.00	130.00	129.50	-27.32	-34.34	-31.03
3x5	95.00	107.00	101.00	-46.48	-45.96	-46.21
3x6	136.00	159.00	147.50	-23.38	-19.70	-21.44
3x7	72.00	142.50	107.25	-59.44	-28.03	-42.88
3x8	38.00	199.00	118.50	-78.59	0.51	-36.88
3x9	62.50	140.00	101.25	-64.79	-29.29	-46.07
4x5	46.00	89.00	67.50	-74.08	-55.05	-64.05

4x6	162.00	181.00	171.50	-8.73	-8.59	-8.66
4x7	115.00	128.00	121.50	-35.21	-35.35	-35.29
4x8	93.33	185.00	139.17	-47.42	-6.57	-25.88
4x9	89.00	153.00	121.00	-49.86	-22.73	-35.55
5x6	169.00	193.00	181.00	-4.79	-2.53	-3.60
5x7	112.00	174.00	143.00	-36.90	-12.12	-23.83
5x8	75.00	136.00	105.50	-57.75	-31.31	-43.81
5x9	24.00	97.00	60.50	-86.48	-51.01	-67.78
6x7	175.00	225.00	200.00	-1.41	13.64	6.52
6x8	152.00	196.00	174.00	-14.37	-1.01	-7.32
6x9	164.00	188.00	176.00	-7.61	-5.05	-6.26
7x8	191.25	212.00	201.63	7.75	7.07	7.39
7x9	204.00	236.00	220.00	14.93	19.19	17.18
8x9	197.50	215.00	206.25	11.27	8.59	9.85
Check	177.50	198.00	187.75			
LSD 5	12.52	10.87	8.18			
LSD 1	16.59	14.39	10.98			

* and ** refers to significant $p < 0.05$ and $p < 0.01$, respectively.
N1 and N2 refer to low and high nitrogen rate, respectively.

Table 3. Estimates of general combining ability effects of nine inbred lines for all the studied traits across two nitrogen levels.

parent	Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	No of rows/ ear	No of kernels/row	100-kernel weight	Grain yield/ plant	shelling%
p1	0.12	-0.22	15.21**	12.31**	0.40**	2.07**	-1.63**	22.83**	0.93
p2	-0.33	0.49*	33.84**	20.64**	-0.46**	2.63**	3.74**	14.33**	-1.05
p3	-0.02	-0.13	-18.09**	-6.5**	0.17	-2.34**	-2.53**	-27.74**	2.79**
p4	0.22	-0.01	-5.94**	-10.31**	-0.29**	-0.63	-1.15	-14.26**	-0.15
p5	0.07*	0.0	-36.99**	-11.62**	-0.47**	-5.38**	-2.77**	-37.19**	-2.37**
p6	0.53*	0.04	22.20**	8.26**	-0.21	0.89	2.22**	11.11**	-0.62
p7	-0.21	-0.41*	-5.68**	-8.79**	0.62**	2.08**	1.34*	28.06**	-0.22
p8	0.15*	-0.39	8.02**	0.61*	0.60**	0.54	0.24	6.48**	1.50*
p9	-0.52	0.59**	-12.57	-4.6**	-0.37	0.14	0.55	-3.62*	-0.81
LSD5%(gi)	0.46	0.41	1.55	2.02	0.19	1.26	1.18	2.95	1.67
LSD1%(gi)	0.6	0.54	2.05	2.67	0.26	1.67	1.57	3.91	2.21
LSD5%(gi-gj)	0.68	0.61	2.32	3.03	0.29	1.89	1.77	4.43	2.51
LSD1%(gi-gj)	0.91	0.81	3.07	4.01	0.38	2.51	2.35	5.87	3.32

* and ** refers to significant $p < 0.05$ and $p < 0.01$, respectively.

Table 4. Estimates of specific combining ability effects of all parental combinations for all studied traits across two nitrogen levels.

crosses	Days to 50% tasseling	Days to 50% silking	Plant height	Ear height	No of rows/ ear	No of kernels/row	100-kernel weight	Grain yield/ plant	Shelling %
P1xP2	0.65	1.95**	13.08**	11.15**	-2.01**	0.12	1.00	-8.21*	0.41
P1xP3	-0.66	-1.43**	48.34**	21.63**	-0.44	6.26**	8.96**	62.61**	-4.95*
P1xP4	0.10	0.12	2.69	17.11**	-0.38	2.48	-0.39	20.37**	2.79
P1xP5	1.24*	1.24*	42.25**	26.75**	1.90**	6.93**	1.94	92.43**	2.82
P1xP6	0.46	-0.60	-55.28**	-31.46**	0.54*	-11.09**	-7.66**	-88.50**	-0.93
P1xP7	-0.80	-1.14*	1.93	-7.75**	-0.69**	-0.64	2.62	-10.94**	-0.67
P1xP8	-0.66	-0.33	-19.16**	-8.82**	0.18	-2.48	-0.05	-24.61**	-2.37
P1xP9	-0.33	0.19	-33.85**	-28.61**	0.90**	-1.57	-6.42**	-43.14**	2.90
P2xP3	-0.38	0.36	-46.95**	-31.70**	0.23	-6.67**	-3.64*	-22.14**	1.71
P2xP4	-1.45*	-1.26*	22.56**	25.44**	0.08	1.22	7.26**	42.37**	-1.22
P2xP5	-0.14	-1.14*	-34.72**	-28.25**	0.66**	-4.53**	-8.67**	-52.69**	1.41
P2xP6	0.91	0.36	-2.24	1.87	0.25	-0.87	0.34	-21.75**	-1.40
P2xP7	0.15	-0.02	26.97**	18.92**	-1.03**	1.61	1.49	42.06**	0.94
P2xP8	-0.71	-0.88	12.11**	4.51	0.26	5.28**	2.11	-3.86	-3.23
P2xP9	0.96	0.64	9.19**	-1.94	1.56**	3.85*	0.11	24.23**	1.37
P3xP4	0.58	-0.31	42.66**	25.92**	-1.35**	6.29**	1.84	17.94**	-3.85
P3xP5	0.22	0.81	35.55**	15.56**	-1.06**	3.39*	2.18	12.38**	3.54
P3xP6	-0.90	-0.86	-13.64**	-12.66**	-0.82**	4.37**	-1.79	10.57**	1.26
P3xP7	0.67	-0.24	-55.77**	-5.61**	2.84**	-5.18**	-6.64**	-46.62**	2.02
P3xP8	0.98	1.07*	-1.13	-13.34**	0.36	-1.69	0.53	-13.79**	-2.42
P3xP9	-0.52	0.60	-9.05**	0.20	0.24	-6.76**	-1.43	-20.94**	2.69
P4xP5	-1.18*	-1.31*	-54.94**	-15.63**	1.09**	-4.77**	-8.30**	-34.61**	4.63*
P4xP6	-0.14	0.69	-2.46	-2.18	2.03**	-0.44	-0.77	21.08**	1.47
P4xP7	-0.40	-0.86	-8.03**	-56.80**	-1.20**	0.27	-0.20	-45.86**	-4.41*
P4xP8	0.58	0.62	8.38**	13.80**	0.15	-2.69	-0.38	-6.61	1.88
P4xP9	1.91**	2.31**	-10.87**	-7.66**	-0.41	-2.36	0.94	-14.68**	-1.29
P5xP6	-0.49	-0.19	20.26**	10.80**	0.61*	5.31**	7.12**	53.52**	0.12
P5xP7	1.08	1.60**	25.47**	17.01**	-1.02**	1.81	3.74*	-1.43	0.59
P5xP8	0.22	0.24	-2.23	-8.22**	-1.55**	-1.20	-2.05	-17.34**	-0.12
P5xP9	-0.95	-1.24*	-31.64**	-18.01**	-0.63**	-6.94**	4.05**	-52.25**	-12.99**
P6xP7	0.79	1.43**	-12.72**	1.30	-0.08	-0.15	-3.14*	7.27*	-1.13
P6xP8	-0.73	-0.10	28.58**	6.89**	-1.46**	-0.31	5.84**	2.85	-0.97
P6xP9	0.10	-0.74	37.50**	25.44**	-1.09**	3.19*	0.06	14.95**	1.59
P7xP8	0.01	0.19	-21.57**	3.76	1.91**	-2.61	-3.27*	13.53**	2.08
P7xP9	-1.49**	-0.95	43.71**	29.16**	-0.72**	4.89**	5.41**	42.00**	0.58
P8xP9	0.32	-0.81	-4.99**	1.42	0.15	5.71**	-2.72	49.83**	5.16*
LSD5%(sij)	1.11	0.99	3.76	4.90	0.47	3.07	2.87	7.18	4.06
LSD1%(sij)	1.47	1.31	4.98	6.49	0.62	4.07	3.81	9.51	5.38
LSD5%(sij-sik)	1.68	1.50	5.68	7.41	0.71	4.64	4.34	10.85	6.14
LSD1%(sij-sik)	2.22	1.99	7.53	9.82	0.94	6.15	5.75	14.38	8.13
LSD5%(sij-ski)	1.53	1.37	5.19	6.77	0.65	4.24	3.96	9.91	5.61
LSD1%(sij-ski)	2.03	1.81	6.87	8.96	0.86	5.61	5.25	13.13	7.43

* and ** refers to significant $p < 0.05$ and $p < 0.01$, respectively.

Specific combining ability:

Estimation of SCA effects in 36 crosses for the studied traits over the two nitrogen level are presented in table (4). The most desirable inter and intra allelic interactions were presented by P_2xP_4, and P_4xP_5 for days to 50% tasseling and silking; P_1xP_6, P_1xP_8, P_1xP_9, P_2xP_3, P_2xP_5, P_3xP_6, P_3xP_7, P_4xP_5, P_4xP_7, P_4xP_9 and P_5xP_9 for plant and ear heights; P_1xP_5, P_1xP_6 and P_1xP_9 for no of rows/ ear, P_1xP_3, P_1xP_5, P_2xP_8, P_2xP_9, P_3xP_4, P_3xP_5, P_3xP_6, P_5xP_6, P_6xP_9, P_7xP_9 and P_8xP_9 for No of kernels/ row; P_1xP_3, P_2xP_4, P_5xP_6, P_5xP_7, P_5xP_9, P_6xP_8, and P_7xP_9 for 100-kernel weight. The parental combination P_1xP_3, P_1xP_4, P_1xP_5, P_2xP_4, P_2xP_7, P_2xP_9, P_3xP_4, P_3xP_5, P_3xP_6, , P_4xP_6, P_5xP_6, P_6xP_7, , P_6xP_9, P_7xP_8 and P_7xP_9 for grain yield/plant exhibited significant positive $\hat{S}_{ij}$ effects being **62.61, 20.37, 92.43, 42.37, 42.06, 17.94, 12.38, 10.57, 21.08, 53.52, 7.27, 14.95, 13.53, 42.00 and 49.83**, respectively. These crosses may be prime importance in breeding programmes either towards hybrid maize production or synthetic varieties composed of hybrids which involved the good combiners for the traits in view.

Reference

Al-Naggar, A.M.M., M.M.M. Atta, M.A. Ahmed and A.S.M. Younis (2016). Mean performance, heterobeltiosis and combining ability of corn (*Zea mays* L.) agronomic and yield traits under elevated plant density. J Appl. Life Sci. Int. 7(3):1-20.

Al-Naggar, A.M.M., R. Shabana, M. S. Hassanein , T. A. Elewa, A.S.M. Younis and A.M.A. Metwally (2017a). The effect of increasing plant density on performance and heterobeltiosis in maize testcrosses among 23 inbreds and three testers. J. Archives of Cur. Res. Int. 8(4): 1-14.

Al-Naggar, A.M.M., R. Shabana, M. S. Hassanein , T. A. Elewa, A.S.M. Younis and A.M.A. Metwally (2017 b). Estimation of genetic parameters controlling inheritance of maize quantitative traits under different plant densities using Line × Tester analysis. Asian J of Adv. Agric. Res. 2(2): 1-12.

Amer, E.A. (2003). Diallel analysis for yield and its components of maize under two different locations. Minufiya J. Agric. Res.28 (5): 1363-1373.

Amer, E.A. (2005): Estimates of combining ability using diallel crosses among eight new maize inbred lines. j. Aric. Res. Tanta Univ., 31(2) 67-73.

Badr, M. M., Bassal, S. A. A., Ibrahim, E. M. (2003). Effect of preceding winter crops, nitrogen and phosphorus fertilizer levels on growth and yield of maize, Zea mays L. *Mansoura University Journal of Agricultural Sciences, Egypt*.

Chun, L., Chen, F., Zhang, F., & Mi, G. (2005). Root growth, nitrogen uptake and yield formation of hybrid maize with different N efficiency. *Plant Nutrition and Fertitizer Science*, *11*(5), 615-619.

Dubey, R.B.; V.N. Joshi and N.K. Pandiya (2001). Heterosais and combining ability for quality, yield and maturity traits in conventional and non-conventional hybrids of maize (*Zea mays L.*). Indian J. of Gen. and Plant Breed. 61(4): 353- 355.

El-Bagoury, O.H.; K.A. El-Shouny; H.Y. El-Sherbieny and S.A. Al-Ahmad (2004). Estimation of heterosis and its interaction with plant densities in some yellow maize crosses. Arab Universities J. Agric.Sci. 12(1): 201-219.

EL-Hosary, A. A. A and I. A. I. EL-Fiki (2015). Diallel cross analysis for earliness, yield, its components and resistance to late wilt in maize. Inter. J Agric. Sci. Res. 5(6):, 199-210.

EL-Hosary, A.A. and M.EL.M. EL-Badawy (2005). Heterosis and combining ability in yellow corn (*Zea mays L.*) under two nitrogen levels. The 11th Conf. Agron., Agron. Dept., Fac. Agric., Assiut Univ., 89-99.

EL-Hosary, A.A.; M.EL.M. EL-Badawy and Y.M. Abdel-tawab (2006). Genetic distance of inbred lines and prediction of maize single-cross performance using RAPD and SSR markers. Egypt. J. Genet. Cytol. 35: 209-224.

El-Hosary, A.A.A. (2015). Genetic analysis of water stress tolerance attributes in F_1 maize diallel crosses. Egypt. J. Plant Breed. 19 (6): 1765-1781

Gilbert, N.E.G. (1958). Diallel cross in plant breeding heredity, 12: 477-492.

Girma, C.H., A. Sentayehu, T. Berhanu and M. Temesgen (2015). Test cross performance and combining ability of maize (*Zea mays* L.) inbred lines at Bako, Western Ethiopia. Global J. of Sci. Fron. Res. 15(4)1:1-12.

Gomez, K.N. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research. John.Wiley and Sons. Inc., new york, 2nd ed.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Aus. J. of Biol. Sci. 9: 463-493.

Izhar, T. and M. Chakraborty (2013). Combining ability and heterosis for grain yield and its components in maize inbreds over environments (Zea mays L.). African J. of Agric. Res. 8(25): 3276-3280.

Medici, L. O., Pereira, M. B., Lea, P. J., Azevedo, R. A. (2004). Diallel analysis of maize lines with contrasting responses to applied nitrogen. *The Journal of Agricultural Science*, *142*(5), 535-541.

Mosa, H.E. (2003). Combining ability of eight yellow maize (*Zea mays L.*) inbred lines for different characters in diallel crosses. J. Agric. Res. Tanta Univ., 31(4-A) 604-614.

Mosa, H.E. and A.A. Motawei (2005). Combining ability of resistance to late wilt diseases and grain yield and their relationships under artificial and natural infections in maize. J. Agric. Sci. Mansoura Univ., 30(2): 731-742.

Nawar, A.A.; S.A. El-Shamarka and E.A. El-Absawy (2002). Diallel analysis of some agronomic traits of maize. J. Agric. Sci. Mansoura Univ., 27 (11): 7203-7213.

Rizzi, E., Balconi, C., Nembrini, L., Stefanini, F. M., Coppolino, F.,Motto, M. (1993). Genetic variation and relationship among N-related traits in maize. *Maydica*.

Shafey, S.A.; yassien, H.E.; El-Beially, I.E.M.A. and Gad-Alla, O.A.M. (2003). Estimation of combining ability and heterosis effects for groth, earliness and yield in maize (*Zea mays L*.). J. Agric. Sci. Mansoura Univ., 28 (1): 55-67.

Singh A.K.; Shahi, J.P. and Singh, J.K. (2004). Heterosis in maize. J. Applied Biology 14(1): 1-5.

Singh, D. (1973). Diallel analysis over different environments-I. Indian J Genetics and Plant Breed. 33: 127-136.

Singh, D. (1979). Diallel analysis for combining ability over environments. Indian J Genetics and Plant Breed., 39: 383-386.

USDA-FAS, (2018). United States Department of Agriculture, Foreign Agricultural Service. Circular Series January 2018 WAP 1-18

Wani, M.M.A., S.A. Wani, Z.A. Dar, A.A. Lone, I. Abedi and A. Gazal (2017). Combining ability analysis in early maturing maize inbred lines under temperate conditions, Int. J. Pure App. Biosci. 5(2): 456-466.

تحليل القدرة على التالف باستخدام التهجين التبادلى بين تسعه سلالات من الذرة الشامية تحت مستوين تسميد

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أجرى تقييم الهجن الناتجة من التهجين النصف دائرى لتسعة سلالات من الذرة الصفراء وذلك تحت مستويين تسميد نيتروجيني 60 و 120 كجم / فدان لتسعة صفات كمية . كانت متوسطات التباين لكل من مستويات التسميد والهجن معنوية فى كل الصفات تحت الدراسة . كما كان متوسط التباين للتفاعل بين الهجن ومستويات التسميد معنوي لكل الصفات تحت الدراسة ما عدا صفة عدد الصفوف للكوز . و كانت التباينات للقدرة العامة والخاصة معنوية لكل الصفات تحت الدراسة عدا عدد الايام حتي تزهير 50 % من النورات المذكرة . وكانت النسبة بين القدرة العامة والقدرة الخاصة أكبر من الوحدة لكل من صفة موعد تزهير النوره المذكرة و المؤنثة وعدد صفوف الكوز تحت معدل التسميد المنخفض، ارتفاع النبات و عدد الحبوب / صف و وزن 100 حبة ومحصول حبوب / نبات في كلا مستويين التسميد و التحليل التجميعي. و هذا يدل على ان التأثير المضيف هو الذى يتحكم فى توريث تلك الصفات.. اما باقى الحالات فنجد ان النسبة اقل من الوحده و هذا يدل على ان الجزء الغير مضيف يلعب الدور الاكبر فى توريث تلك الصفات. أظهرت السلالة الأبوية رقم 1 و 6 و 7 قدرة جيدة عامة على التالف لمحصول الحبوب للنبات ومكوناته. . أظهرت الهجن P_6 , X P_6 ,P_5 X P_3 ,P_4 X P_3 ,P_9 X P_2 ,P_7 X P_2,P_4 X P_2,P_5 X P_1,P_4 X P_1 ,P_3 X P_1 P_6 X P_7 , P_5 X P_6 , P_7 X P_9 , P_7 X P_8 , P_6 X P_9 ,P_4 X P_3 قدرة خاصة على التآلف لصفة متوسط محصول النبات . اظهرت الهجن P_8 X P_9 , P_7 X P_9 , P_7 X P_8 , P_6 X P_7 , P_2 X P_7 , P_2 X P_4 , P_1 X P_7 , P_1 X P_5 ,P_1 X P_4 ,P_1 X P_3 تحت مستوى التسميد المنخفض , والهجن P_7 X P_8 , P_6 X P_7 , P_2 X P_7, P_2 X P_4 , P_1 X P_5 , P_1 x P_3 P_7 X P_9 تحت مستوى التسميد العالي زيادة معنوية عن صنف المقارنة هجين فردى 168 بصفة وزن حبوب / نبات.