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COMBINING ABILITY, PHENOTYPIC AND GENOTYPIC CORRELATIONS OF DIALLEL CROSSES IN YELLOW MAIZE EVALUATED UNDER TWO NITROGEN LEVELS.

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ABSTRACT

Six yellow inbred lines of maize, were setup in a half diallel crosses mating design, to produce 15 F_1 hybrids. All genotypes with the three commercial checks : SC 155, SC 162 and SC 170 were evaluated using the two nitrogen levels : 80 and 120 kg N/fed during the 2007 growing season at Sakha Agriculture Research station Kafr El- Sheikh. The aim of this study was to estimate the phenotypic and genotypic correlations, GCA, SCA and their interactions with the two nitrogen levels. The results would also identify the superior genotypes for yielding performances. The studied traits were : grain yield (Ard./fed)., ear length (cm), ear diameter (cm), number of rows / ear and weight of 100 kernels(g).

The results indicated the presence of significant differences among genotypes for most studied traits .This finding was expected due to the different origin of the parental inbred lines.

General combining ability (GCA) and specific combining ability (SCA) mean squares were significant or highly significant for most studied traits under both nitrogen levels. The interactions between GCA and SCA with nitrogen levels were not significant for all studied traits except for SCA x N which was significant for weight of 100 kernels(g).

The values of SCA mean squares were higher than those of GCA mean squares for grain yield (Ard./fed.), No. of rows / ear and weight of 100 kernels(g) traits. All means were higher under the high nitrogen level than the low nitrogen level for all studied traits.

The best general combiners for grain yield (Ard./fed.) were the inbred lines: Sk 5001/50 and Sk 7070/62.

The single hybrids Sk5001/50 x Sk 5005/ 12, Sk 5002/9 x Sk 5005/16, Sk 5001/50 x Sk5005/16 and Sk 5002/9 x Sk 5001/5 showed positive significant SCA under the two nitrogen levels for grain yield Ard./fed.

The phenotypic and genotypic correlations among the five studied traits were positive for all studied traits.

INTRODUCTION

Diallel crosses have been widely used in genetic research to investigate the inheritance of important traits among a set of genotypes (Yan and Hunt 2002). It was especially devised to determine the magnitude of combining abilities inbred lines for the purpose of identifing the lines which produce surperior hybrids. In this respect, diallel crosses analysis has been extensively used by breeders to obtained informations about genetic behavior of quantitative traits Jinks and Hayman (1953), Stuber *et al.* (1966) and Razaei *et al.* (2004).

The importance of proper nitrogen (N) management in maize (*Zea mays,* L.) is known labe a critical and important factor in maize production.

Grain yield in maize is a complex trait and depend on various yield component traits Grafius (1960). Thus, genotypic and phenotypic correlation coefficients among various traits would help to identify the traits which were associated with economic productivity. The association between two traits could be directly observed as phenotypic correlation while genotypic correlation expresses the extent to which two traits are genetically associated. Both genotypic and phenotypic correlations among pairs of agronomic traits provide scope for indirect selection.

The main objectives of this investigation were to:

1- Evaluate six yellow inbred lines of maize and their 15 F_1 hybrids under two nitrogen levels.
2- Determine the superior inbred lines which produce the best F_1 hybrids.
3- Estimate general and specific combining ability variances and their interactions with the two nitrogen levels.
4- Determine phenotypic and genotypic correlations between pairs of traits.

MATERIALS AND METHODS

Six maize inbred lines were provided by maize research program, Field Crops Research Institute (FCRI), Agricultural Research Center (ARC) to be used in this study. These inbred lines were: Sk 5002/9 (P_1) Sk 5001/6 (P_3),Sk 5001/50 (P_2), , Sk 7070/62 (P_4), Sk 5005/12 (P_5) and Sk 5005/16 (P_6).

In early 2007 growing season, the parental inbred lines were crossed according to a half diallel crosses mating design to obtained 15 F_1 hybrids . In late 2007 growing season, the 15 F_1 hybrids and the three commercial checks SC 155(Ch_1), SC 162 (Ch_2)and SC 170(Ch_3) were evaluated in a Randomized Complete Blocks Design with three replications under two nitrogen levels i.e. 80 (N_1) and 120 (N_2) kg N/fed at Sakha Agriculture Research Station Kafr El- Sheikh . Each plot was one row, 6 m long and 80 cm in width. The recommended cultural practices were applied as recommended for maize cultivation. Data were recorded on: grain yield Ard./fed., ear length (cm), ear diameter (cm), number of rows / ear and weight of 100 kernels (g) .

The results were statistically analyzed and the L.S.D. values were calculated according to Steel and Torrie (1980). Combining ability was computed using Griffing's (1956) Method-4 Model 1 for each nitrogen level. The combined analysis of the two experiments (nitrogen levels) was done wherever, homogeneity of variance was not significant. Phenotypic and genotypic correlation coefficients were computed according to Steel and Torrie (1960).

RESULTS AND DISCUSSION

Analysis of variance and mean squares for the five studied traits under two nitrogen levels and their combined data are presented in Table 1.

The mean squares due to the two nitrogen levels were significant for all studied traits except for ear diameter and No. of rows/ear , indicating over all differences between the two nitrogen levels for these traits .This results supports the findings of El-Aref *et al*. (2004) and Abd El -Aty and Darwish (2006) .

The mean squares due to genotypes (G) were partitioned into crosses (C), checks(Ch) and C Vs. Ch . The differences between different crosses (C) were significant to highly significant for all studied traits under the two nitrogen levels and their combined except for number of rows/ ear. The mean squares due to checks (Ch) and C. Vs. Ch were either significant or highly significant for most studied traits under the two nitrogen levels and their combined data.

The interaction between crosses (C), checks (Ch) and C Vs. Ch with nitrogen levels were not significant for all studied traits except for C x N for weight of 100 kernels and C. Vs. Ch x N for grain yield and ear length indicating that the crosses, checks and C .Vs. Ch were not influenced by changing in levels of environments. These results agree with those results obtained by Abd El-Hadi *et al.,* (2005), El-Shenawy (2005), Motawei (2005) and Abd El-Aty and Darwish (2006).

Mean performances of 15 crosses and three checks for the five traits uder two nitrogen levels and their combined data are shown in Table 2. The mean values for all crosses and checks were higher under the high nitrogen level (120 kg N/fed.) than the low nitrogen level (80 kg N/fed.) for all studied traits. Similar results obtained by Khalil (1999), El-Absawy (2000) and El-Aref *et al.* (2004).

The crosses : SK 5001/50 x SK 7070/62 and SK 5001/50 x SK 5005/12 out yielded the three checks under the two nitrogen levels and their combined data. For ear length, the crosses : SK 5001/50 x SK 7070/62, SK 5001/50 x SK 5005/12 and SK 7070/62 x SK 5005/12 showed higher mean values over the checks : SC 155(Ch_1)and SC 170 (Ch_3) under the two nitrogen levels and their combined data. For ear diameter, the crosses : SK 5002/9 x SK 5001/50, SK 5002/9 x SK 5001/6, SK 5002/9 x SK 5005/12 and SK 5002/9 x SK 5005/16 had the highest mean values compared with the there checks under the two nitrogen levels and their combined data. With respect to no of rows/ear, this trait showed that the crosses : SK 5001/6 x SK 5005/12 and SK 7070/62 x SK 5005/12 had the highest mean values over all checks under the two nitrogen levels and their combined data. For weight of 100 kernels (g), the highest mean value was obtained from the crosses SK 5001/6 x SK 5001/50 and SK 5001/50 x SK 5005/16 compared with all the checks at the two nitrogen levels and their combined data.

Analysis of variance and mean squares for general (GCA) and specific (SCA) combining abilities of the 15 F_1 crosses for the five traits at the two nitrogen levels and their combined data are shown in Table 3.

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General combining ability (GCA) and specific combining ability (SCA) mean squares were either significant or highly significant for all studied traits at both nitrogen levels and their combined except for GCA at N_2 for No. of rows/ear.

The interaction between GCA or SCA with nitrogen levels were not significant for all studied traits except for SCA x N for weight of 100 kernels (g) at combined data. These results indicated that the additive and non-additive effects would contribute to the inheritance of all studied traits. These results are in common agreement with those obtained by Abd El-Hadi *et al.* (2005), El-Shenawy (2005) and Katta *et al.* (2007).

The values of SCA mean squares were higher than those of GCA mean squares for grain yield (Ard./fed.), No. of rows/ear and weight of 100 kernels (g). Similar results were obtained by Nigussie and Zellelke (2001), Soliman *et al.* (2005), Mosa (2006), Motawei (2006) and Katta *et al.* (2007). These results generally indicated the presence of superior hybrids would be associatal with significant SCA.

Estimates of GCA effects (g_i) were calculated for each parental line at the two nitrogen levels and combined data as appeared in Table 4. The parental inbred line SK 5001/50 expressed highly significant positive GCA effect for grain yield Ard./fed., ear length, ear diameter and weight of 100 kernels at both nitrogen levels and their combined data. For No. of rows/ear, the inbred line SK 5005/12 showed significant positive GCA effects under N_1 level and the combined data.

Specific combining ability effects (S_{ij}) of the 15 crosses for the five traits at both nitrogen levels and combined data are presented in Table 5. The most desirable specific combining ability effects at both nitrogen levels and their combined were obtained for grain yield (Ard./fed.) in the crosses SK 5001/50 x SK 5005/12 , SK 5002/9 x SK 5005/16 and SK 5001/6 x SK 7070/62, for ear length in the crosses SK 5001/50 x SK 5005/16 and SK 7070/62 x SK 5005/12, for ear diameter in the crosses SK 5001/6 x SK 5005/12 and SK 7070/62 x SK 5005/16, for No. of rows/ear in the cross SK 7070/62 x SK 5005/12 and SK 7070/62 x SK 5005/12 and for weight of 100 kernels in the crosses SK 5002/9 x SK 5005/12 and SK 7070/62 x SK 5005/12. Those significant effects would contribute the superiority of their hybrids.

The phenotypic and genotypic correlations between each pair of the five studied traits were calculated for the F_1 hybrids from the combined data and the results are presented in Table 6. Correlation coefficients were highly significant for most traits. Phenotypic and genotypic correlations between grain yield and other studied traits had positive values. These results agree with similar results obtained by El-Hadidi *et al.* (1981), Burak and Mago (1990), Galal (1992) and Mosa and El-Shenawy (2005).

In general these results indicated that selection for one trait would also lead to the selection at the other traits .

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Table 6: Phenotypic and genotypic correlations among five studied traits for F_1 hybrids from the combined data over the two nitrogen levels.

Traits	Grain yield (Ard. / fed.)	Ear length (cm)	Ear diameter (cm)	Number of rows / ear	Weight of 100 kernels (g)
Grain yield (Ard./Fed.)	-	-	-	-	-
	-	-	-	-	-
Ear length (cm)	0.826**	-	-	-	-
	0.868**	-	-	-	-
Ear diameter (cm)	0.559**	0.410**	-	-	-
	0.638**	0.420**	-	-	-
Number of rows / ear	0.223	0.197	0.408**	-	-
	0.204	0.060	0.426**	-	-
Weight of 100 kernels (g)	0.471**	0.345**	0.582**	0.21	-
	0.517**	0.394**	0.640**	0.211	-

Where: Phenotypic correlations above and genotypic correlations below.
*** and ** Significant at 5% and 1% levels of probability, respectively.**

REFERENCES

Abd El-Aty, M.S.M. and I.H.I. Darwish (2006). Combining ability and heterosis and their interaction with three nitrogen levels in some yellow maize inbred lines. J. Agric. Res. Tanta Univ., 32 (4): 808-830.

Abd El-Hadi, A.H.; Kawther S. Kash; A.A. El-Shenawy and I.A. El-Gazzar (2005). Combining ability and heterosis in maize (*Zea mays,* L.). Egypt. J. Gent. & Cytol., 34 (1): 123-134.

Burak, R. and J.L. Mago (1990). Yield and yield components of full sib and half sib families derived from a perennial teosinte introgessed population. Maize Genet. Cooper. News letter No. 64 and 76, India. [C.F. Plant Breed. Abst., 61 (3): 2360].

El-Absawy, E.A. (2000). Evaluation of some new inbred lines and their crosses of maize to general and specific combining abilities under two nitrogen levels. Proc. 9th Conf. Agron. Minufiya Univ., 1-2 Sept. 2000: 223-237.

El-Aref, Kh.A.O.; A.S. Abo El-Hamed and A.M. Abo El-Wahb (2004). Response of some maize hybrid to nitrogen and potassium fertilization levels. J. Agric. Sci. Mansoura Univ., 29 (11): 6063-6070.

El-Hadidi, M.S.; A.M. El-Adl; Z.A. Kosba and M.A. Salaby (1981). Genotypic and phenotypic correlations between economic traits of corn (Zea mays, L.) J. Agric. Sci. Mansoura Univ., 6: 238-245.

El-Shenawy, A.A. (2005). Estimation of genetic and environment parameters for new white inbred lines of maize (*Zea mays,* L.). J. Agric. Res. Tanta Univ., 31 (4-A): 647-662.

Galal, A.R. (1992). Evaluation of inbred lines for the possibility of producing hybrids in *Zea mays*, L. M. Sc. Thesis, Fac. Agric., Mansoura Univ., Egypt.

Grafius, J.E. (1960). Does over dominance exist for yield in corn? Agron. J., 52: 361-365.

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

Jinks, J.L. and B.L. Hayman (1953). The analysis of diallel crosses. Maize Genet. Coop. News letter, 27: 48-54.

Katta, Y.S.; M.S.M. Abd El-Aty; M.A. El-Hity and M.M. Kamara (2007). Estimate of heterosis and combining ability of some white inbred lines of maize (*Zea mays*, L.). J. Agric. Sci. Mansoura Univ., 32 (9): 7077-7088.

Khalil, A.N.M. (1999). Genetic effects estimated from generation mean in two maize crosses. Minufiya, J. Agric. Res. ,24 (6) : 1911-1924.

Mosa, H.E. (2006). Diallel analysis of nine white inbred lines for different characters under different locations. J. Agric. Sci. Mansoura. Univ., 31 (4): 2073-2080.

Mosa, H.E. and A.A. El-Shenawy (2005). Genetic variability, genotypic and phenotypic correlations between economic traits of maize under different dates of planting. J. Agric. Sci. Mansoura Univ., 30 (10): 5973-5981.

Motawei, A.A. (2005). Combining ability and heterotic effect of nine maize inbred lines via diallel cross analysis. J. Agric. Sci Minufiya. Univ., 30 (1): 197-214.

Motawei, A.A. (2006). Gene action and heterosis in diallel crosses among ten inbred lines of yellow maize across various environments. Egypt. J. Plant Breed., 10 (1): 407-418.

Nigussie, M. and H. Zellelke (2001). Heterosis and combining ability in a diallel among eight elite maize populations. J. African Crop Sci., 9 (3): 471-479.

Razaei, A.; B. Yazdisamadi; A. Zali; A. Tallei; H. Zeinali and A. Rezaei (2004). Estimate of heterosis and combining ability in maize (*Zea mays,* L.) using diallel crossing method. Pp. 395-397. Inst. Genetic variation for Plant Breeding (2004). EuCARPia and Boku, Vienna, Austria.

Soliman, M.S.M.; Fatma A.E. Noval and M.E.M. Abd El-Azeem (2005). Combining ability for yield and other attributes in diallel cross of some yellow maize inbred lines. J. Agric Sci. Minufiya. Univ., 30 (6): 1767-1781.

Steel, R.G.D and J.H. Torrie (1980). Principles and Procedures of Statistics. A Biometrical Approach. 2nd Ed. Me Graw Hill, N.4. USA.

Steel, R.G.D. and J.H. Torrie (1960). Principles and Procedures of Statistics. Mc. Grow Hill Book Company, Inc., New York.

Stuber, C.W.; R.H. Moli and W.D. Hanson (1966). Genetic variance and inter relationship of six traits in hybrid population of *Zea mays,* L. Crop Sci. 6: 455-458.

Yan, W. and L.A. Hunt (2002). Biplot analysis of diallel data. Crop Sci., 42: 21-30.

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القدرة على التألف والارتباط المظهرى والوراثى فى التهجين النصف دوري للذرة الصفراء تحت مستويان من التسميد النتروجينى

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تم تكوين 15 هجين ناتجه من التهجين النصف دورى لـ 6 سلالات من الذرة الشامية الصفراء. قيمت كل هذه التراكيب الوراثية مع بعض الهجن الاختبارية وهى هجين فردى 155، هجين فردى 162، هجين فردى 170 تحت معدلين من التسميد الآزوتى 80، 120 كجم/ فدان خلال موسم نمو 2007 بمحطة البحوث والتجارب الزراعية بسخا كفرالشيخ . حيث كان الهدف من هذه الدراسة تقدير الارتباط المظهرى والوراثى والقدرة العامة على الإئتلاف والقدرة الخاصة على الائتلاف وتفاعلهم مع معدلات التسميد النتروجينى. وقد تم دراسة كل الصفات التالية:-

محصول الحبوب بالأردب/ الفدان، طول الكوز، قطر الكوز، عدد السطور/ كوز ووزن 100 حبه.

اشارت النتائج إلى وجود فروق عالية المعنوية بين التراكيب الوراثية فى معظم الصفات المدروسةويرجع ذلك إلى إستخدام مصادر مختلفة المنشأ من سلالات الآباء .

كما كانت تباينات القدرة العامة والخاصة على الائتلاف معنوية أو عالية معنوية فى معظم الصفات المدروسة تحت كلا المستويان من التسميد الآزوتى.

أظهر التفاعل بين كل من القدرة العامة والخاصة على الائتلاف مع التسميد النتروجينى فروقاً غير معنوية لكل الصفات المدروسة ما عدا تفاعل القدرة الخاصة على الائتلاف مع التسميد كانت معنوية فقط لصفة وزن الـ100 حبة.

كانت قيم تباين القدرة الخاصة على الائتلاف أكثر أهمية من قيم تباين القدرة العامة على الائتلاف فى الصفات المدروسةهى محصول الحبوب بالأردب للفدان وعدد السطور/ كوز ووزن الـ 100 حبة.

كانت قيم متوسطات الهجن الفردية الناتجة تحت المستوى العالى للتسميد الآزوتى أعلى منها تحت المستوى المنخفض من التسميد الآزوتى لجميع الصفات المدروسة.

كانت السلالات سخا 5001/50 وسخا 7070/62 أفضل السلالات للقدرة العامة على الائتلاف لصفة محصول الحبوب للفدان.

أعطت الهجن الفردية التالية سخا 5001/50 × سخا 5005/12، وسخا 5002/9 × سخا 5005/16، وسخا 5001/50 × سخا 7070/62، وسخا 5001/6 × سخا 5005/12 فروقاً معنوياً وموجبة للقدرة الخاصة على الائتلاف تحت المستويان من التسميد وتفاعلهم المشترك لصفة محصول الحبوب للفدان.كما أظهرت قيم الارتباط المظهرى والوراثى بين الخمس الصفات محل الدراسة ارتباطاً موجبا.

قام بتحكيم البحث

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Table 1: Analysis of variance for five studied traits under two nitrogen levels and their combined data.

S.V.	d. f		Grain yield Ard./ fed.			Ear length (cm)			Ear diameter (cm)			No. of rows / ear			Weight of 100 kernels (g)		
	Single	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.
Nitrogen levels (N)	-	1	-	-	702.**	-	-	33.1*	-	-	0.623	-	-	4.81	-	-	191**
Rep/ N	2	4	-	-	15.6	-	-	3.83	-	-	0.164	-	-	0.960	-	-	4.78
Genotypes (G)	17	17	136.**	158.**	274.**	15.5**	10.1**	24.2**	0.179**	0.21**	0.354**	2.06*	1.95*	3.39**	61.8**	47.4**	87.2**
Crosses (C)	14	14	149.**	183.**	319.**	13.0**	10.1**	22.7**	0.208**	0.248**	0.419**	1.36	2.18*	2.94**	71.5**	54.4**	101**
Check s(Ch)	2	2	16.8	47.2*	54.9**	31.8**	10.7*	39.2**	0.013	0.04	0.023	1.01	0.498	1.23	8.76	21.5	24.5
C. vs. Ch.	1	1	184.**	36.8	82.9**	17.4**	7.99	15.7**	0.105	0.018	0.106	14.0**	1.69	14.0**	31.4	1.29	10.1
G x N	-	17	-	-	20.7*	-	-	1.42	-	-	0.035	-	-	0.625	-	-	22.1
C x N	-	14	-	-	13.9	-	-	0.559	-	-	0.037	-	-	0.60	-	-	24.3*
Ch x N	-	2	-	-	9.21	-	-	3.33	-	-	0.03	-	-	0.275	-	-	5.79
C. vs. Ch. X N	-	1	-	-	138.5**	-	-	9.71*	-	-	0.017	-	-	1.67	-	-	22.5
Error	34	68	8.466	9.522	8.99	1.158	2.361	1.75	0.069	0.06	0.064	0.878	0.844	0.861	8.30	18.352	13.3

*** , ** Significant at 5% and 1% levels of probability, respectively.**

Table 2: Mean performance of 15 crosses resulted form six inbred lines of maize evaluated at the two nitrogen levels and their combined data for all the studied traits.

Crosses	Grain yield Ard./ fed.			Ear length (cm)			Ear diameter (cm)			No. of rows / ear			Weight of 100 kernels (g)		
	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.
Sk 5002/9 x Sk 5001/6	31.25	33.43	32.34	19.13	19.26	19.2	5.0	5.2	5.10	14.66	15.73	15.2	38.93	40.49	39.71
x Sk 5001/50	29.05	33.85	31.45	19.0	21.13	20.06	5.06	5.46	5.26	15.33	15.6	15.46	39.86	38.99	39.43
x Sk 7070/62	23.74	28.12	25.93	18.73	20.40	19.56	4.53	4.96	4.75	14.26	14.4	14.33	30.59	33.17	31.88
x Sk 5005/12	24.06	26.55	25.30	17.93	18.46	18.2	5.0	5.13	5.06	15.2	15.46	15.33	33.41	43.43	38.42
x Sk 5005/16	25.93	29.99	27.96	18.13	18.66	18.4	5.0	5.0	5.0	14.53	15.93	15.23	41.72	39.67	40.69
Sk 5001/6 x Sk 5001/50	20.0	27.18	23.59	17.6	17.8	17.7	4.86	4.93	4.9	13.73	14.0	13.86	40.49	43.61	42.05
x Sk 7070/62	27.49	36.03	31.76	18.66	19.6	19.13	4.6	4.66	4.63	14.26	14.53	14.40	30.92	36.74	33.83
x Sk 5005/12	17.34	27.65	22.49	17.86	19.26	18.56	4.93	4.93	4.93	15.6	15.13	15.36	30.16	33.92	32.04
x Sk 5005/16	21.87	26.24	24.05	15.73	18.86	17.3	4.53	5.0	4.76	14.36	15.6	14.98	37.65	38.03	37.84
Sk 5001/50 x Sk 7070/62	35.62	40.1	37.86	20.93	22.46	21.7	4.66	4.8	4.73	14.13	14.13	14.13	38.15	41.51	39.83
x Sk 5005/12	34.40	39.37	36.88	20.66	21.53	21.1	4.66	5.0	4.83	15.86	15.6	15.73	39.56	39.24	39.40
x Sk 5005/16	28.74	36.55	32.64	20.86	20.46	20.66	4.93	4.96	4.95	14.8	15.43	15.11	39.48	45.0	42.24
Sk 7070/62 x Sk 5005/12	19.21	34.68	26.94	21.13	21.93	21.53	4.66	4.8	4.73	15.46	15.86	15.66	40.85	38.01	39.43
x Sk 5005/16	19.68	20.93	20.31	15.93	17.60	16.76	4.8	4.86	4.83	13.6	14.53	14.06	34.0	45.04	39.52
Sk 5005/12 x Sk 5005/16	8.62	9.68	9.15	13.86	15.8	14.83	4.06	4.13	4.10	14.4	13.33	13.86	25.89	30.90	28.39
SC. 155 (Ch.1)	26.87	27.81	27.34	16.46	18.73	17.6	4.8	4.8	4.8	12.93	14.26	13.6	36.29	36.04	36.17
SC. 162 (Ch.2)	29.85	35.47	32.66	22.93	22.26	22.6	4.86	5.0	4.93	13.06	13.73	13.4	39.65	38.86	39.25
SC. 170 (Ch.3)	31.56	33.43	32.49	20.40	21.66	21.03	4.93	5.0	4.96	14.0	14.53	14.26	38.55	41.40	39.97
L.S.D. 0.05	4.82	5.11	3.46	1.78	2.54	1.53	0.435	0.406	0.292	1.55	1.52	1.07	4.77	7.10	4.21
L.S.D. 0.01	6.48	6.8	4.60	2.39	3.42	2.03	0.585	0.546	0.388	2.08	2.047	1.40	6.42	9.54	5.60

Table 3: Analysis of variance and mean squares for general (GCA) and specific (SCA) combining ability of six inbred lines and their F_1 crosses for all studied traits in the two nitrogen levels and their combined data.

S.V.	d. f		Grain yield Ard./ fed.			Ear length (cm)			Ear diameter (cm)			No. of rows / ear			Weight of 100 kernels (g)		
	Single	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.
GCA	5	5	140**	155**	303**	20.03**	14.6**	34.16**	0.222*	0.456**	0.636**	2.19**	1.05	2.32*	70.5**	44.9*	98.6**
SCA	9	9	166**	190**	328**	9.243**	7.68**	16.36**	0.200**	0.132*	0.298**	0.906	2.81**	3.29**	72.1**	59.8**	103**
GCA x N	-	5	-	-	3.50	-	-	0.537	-	-	0.042	-	-	0.918	-	-	16.8
SCA x N	-	9	-	-	17.64	-	-	0.563	-	-	0.034	-	-	0.423	-	-	28.5*
Error	34	68	8.46	9.52	8.99	1.15	2.36	1.75	0.069	0.06	0.064	0.878	0.844	0.861	8.3	18.3	13.3

*** , ** Significant at 5% and 1% levels of probability, respectively.**

Table 4: Estimates of general combining ability effects (gi) of parental inbred lines for all studied traits under the two nitrogen levels and their combined data.

Lines	Grain yield Ard./ fed.			Ear length (cm)			Ear diameter (cm)			No. of rows / ear			Weight of 100 kernels (g)		
	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.
Sk 5002/9	2.80**	0.444	1.62**	0.166	0.083	0.125	0.138	0.277**	0.208**	0.111	0.444	0.277	0.888	-0.055	0.416
Sk 5001/6	-1.02	0.027	-0.500	-0.750*	-0.750	-0.750**	0.055	0.027	0.041	-0.222	0.027	-0.097	-0.527	-0.888	-0.708
Sk 5001/50	6.47**	6.86**	6.66**	1.83**	1.41**	1.62**	0.14*	0.111	0.125**	0.027	-0.055	-0.013	4.30**	3.19**	3.75**
Sk 7070/62	0.888	2.52**	1.70**	0.833**	1.08*	0.958**	-0.027	0.027	0.00	-0.305	-0.472	-0.388*	-1.527	-0.388	-0.958
Sk 5005/12	-4.77**	-3.22**	-4.0**	-0.166	-0.333	-0.250	-0.194**	-0.222**	-0.208**	0.777**	0.111	0.44*	-2.69**	-2.63*	-2.66**
Sk 5005/16	-4.36**	-6.63**	-5.5**	-1.91**	-1.50**	-1.70**	-0.111	-0.222**	-0.166**	-0.388	-0.055	-0.222	-0.444	0.777	0.166
L.S.D.(g_i) 0.05	1.55	1.65	1.11	0.575	0.821	0.494	0.140	0.131	0.094	0.501	0.491	0.345	1.54	2.29	1.36
L.S.D.(g_i) 0.01	2.09	2.22	1.48	0.774	1.10	0.657	0.188	0.176	0.125	0.674	0.660	0.450	2.07	3.08	1.80

*** , ** Significant at 5% and 1% levels of probability, respectively.**

Table 5: Estimates of specific combining ability effects (S_{ij}) under the two nitrogen levels and their combined data for all studied traits.

Crosses	Grain yield Ard./ fed.			Ear length (cm)			Ear diameter (cm)			No. of rows / ear			Weight of 100 kernels (g)		
	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.	N_1	N_2	Comb.
Sk 5002/9 x Sk 5001/6	5.00**	3.15*	4.07**	1.51**	0.467	0.992*	-0.016	-0.283*	0.160*	0.001	0.15	0.075	2.43	2.1	2.29
x Sk 5001/50	-4.83**	-3.35*	-4.09**	-1.40**	0.300	-0.550	-0.100	0.300**	0.100	0.416	0.233	0.325	-1.68	-3.31	-2.5*
x Sk 7070/62	-4.58**	-5.02**	-4.8**	-0.733	-0.700	-0.717	-0.266*	0.050	-0.108	-0.250	-0.683	-0.467	-5.18**	-5.4**	-5.29**
x Sk 5005/12	1.41	-0.93	0.242	-0.733	-0.950	-0.842*	0.233	-0.033	0.100	-0.333	-0.267	-0.300	-1.01	6.85**	2.91*
x Sk 5005/16	3.00*	6.15**	4.57**	1.35**	0.883	1.11**	0.150	-0.033	0.058	0.166	0.567	0.367	5.4**	-0.238	2.58*
Sk 5001/6 x Sk 5001/50	-9.66**	-9.93**	-9.8**	-1.81**	-2.53**	-2.17**	-0.016	-0.116	-0.066	-0.916*	-1.01*	-0.967**	0.733	2.18	1.45
x Sk 7070/62	2.91*	3.4*	3.15**	-0.150	-0.200	-0.175	-0.183	-0.033	-0.108	0.083	0.067	0.075	-3.1*	-1.23	-2.16
x Sk 5005/12	-1.41	0.82	-0.3	0.517	0.550	0.533	0.316*	0.216	0.266**	0.333	0.150	0.242	-2.6*	-1.98	-2.29
x Sk 5005/16	3.16*	2.57	2.86**	-0.067	1.71*	0.825	-0.100	0.216	0.058	0.50	0.650	0.58*	2.48	-1.06	0.708
Sk 5001/50 xSk 7070/62	4.08**	0.9	2.49*	-0.067	0.633	0.283	0.066	-0.450**	-0.191*	-0.166	-0.517	-0.342	-0.6	-0.65	-0.625
x Sk 5005/12	8.41**	5.65**	7.03**	0.600	0.717	0.658	-0.100	0.133	0.016	0.416	0.567	0.492	1.9	-0.4	0.750
x Sk 5005/16	2.00	6.73**	4.36**	2.68**	0.883	1.78**	0.150	0.133	0.141	0.250	0.733	0.492	-0.35	2.18	0.917
Sk 7070/62 xSk 5005/12	-1.33	5.32**	1.99*	2.26**	1.71*	1.99**	0.066	0.216	0.141	0.416	1.31**	0.867**	9.06**	1.85	5.45**
x Sk 5005/16	-1.08	-4.6**	-2.84**	-1.31*	-1.45*	-1.38**	0.316*	0.216	0.266**	-0.083	-0.183	-0.133	-0.183	5.43**	2.62*
Sk 5005/12 xSk 5005/16	-7.08**	-10.85**	-8.96**	-2.65**	-2.03**	-2.34**	-0.516**	-0.533**	--0.525**	-0.833	-1.76**	-1.30**	-7.35**	-6.31**	-6.83**
L.S.D. (S_{ij}) 0.05	2.64	2.80	1.89	0.976	1.39	0.838	0.238	0.222	0.160	0.850	0.834	0.586	2.60	3.88	2.30
L.S.D. (S_{ij}) 0.01	3.55	3.76	2.52	1.31	1.87	1.11	0.320	0.299	0.212	1.14	1.12	0.780	3.51	5.23	3.07

*** , ** Significant at 5% and 1% levels of probability, respectively.**