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Evaluation of Some New Top Crosses of Maize under Two Nitrogen Fertilization Levels

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Abstract: This work aimed at evaluating twenty to crosses resulting from the cross between ten new inbred lines and two testers of maize under two nitrogen levels (80 and 120 kg N/ feddan). The obtained twenty top crosses along with two check hybrids (S.C. 128 and S.C. 30 k8) were evaluated under two nitrogen levels in Randomized Complete Block design with three replications. Data recorded on days to 50% silking, plant height, No. of row ear^{-1}, No. of kernel row^{-1} 100 kernel weight and grain yield plant^{-1}. General and specific combining ability and heterosis were estimated for studied traits. Significant mean squares due to nitrogen fertilization were detected for all traits. Also, significant mean squares due to crosses and their partition as well as their interaction with nitrogen levels were detected for all studied traits. The top cross M34 x M8 expressed the best mean value for number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1}. Mean squares due to SCA were more important than those of GCA for all traits revealing the important role on non-additive gene action in controlling these traits. The line M25 seemed to be the best general combiner for days to 50% silking. Parent M 30 seemed to be the best general combiner for grain yield plant^{-1}. The most desirable SCA effects for grain yield were detected for the crosses CLM 343x M8 at N1 level and M7x CIMMYT 14 at N2 level and combined data. The best heterotic effects for grain yield plant^{-1} were detected for the cross M34x M8 relative to both checks under all environments. Factor analysis divided the studied variables into three factors which accounted for 70.31 of the variance structure. The first factor included five variables and accounted for 29.74%. The second factor included four variables and accounted for 24.88% of the total variance. The third factor included only one variable and accounted for 15.69%.

Key words: Maize · Combining ability · Heterosis · Factor analysis

INTRODUCTION

Maize (*Zea mays* L.) plays an important as one of the most important cereal crops all over the world. In Egypt, it ranks the second-best cereal crop after wheat with a cultivated area of 0.99 mega ha in 2019 which produced 7.49 Gg [1]. Many efforts are currently being made by corn breeders to develop new maize hybrids with higher yield productivity to solve the problem of food shortage in Egypt.

Line x tester technique is an effective tool help breeder for screening new inbred lines of maize and studying combining ability for the sake of developing new maize hybrid with better potentiality and high response to nitrogen fertilization levels. Estimation of combining ability for important traits in maize help breeders to choose the most appropriate breeding program. If the estimates of genetic variance (G.C.A) is of major importance, the most effective breeding procedure will be the intrapopulation selection. While, hybrid program may be the appropriate choice, if specific combining ability (S.C.A) is the major component. Many researchers reported that earliness as well as grain yield and its attributed traits in maize were governed by non additive gene action. Among those are Guedes *et al*. [24], Kamara *et al*. [3], Kahriman *et al*. [4] andayani *et al*. [5], Bayoumi *et al*. [6], Noelle *et al*. [7], El Hosary [8, 9], Neveen Hamouda *et al*. [10]and Sedhom *et al*. [11]. On the contrary, the importance of additive gene action in governing the studied traits were previously reported by Sedhom *et al*. [12], El-Badawy [13], Mahesh *et al*. [14], Ahmed *et al*. [15]and Andayani *et al*. [5].

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Studying standard heterosis is of prime importance to breeders to detect the best cross combination which has better characteristics over the prevailing check hybrids. Therefore, exploitation of standard heterosis will participate in selecting superior genotypes to solve the problem of food shortage. Several investigators found desirable heterotic effects for maize grain yield and most of related traits [16, 17, 18, 7, 9 11].

Also, studying the relationship among yield and other agronomic traits as well as factor analysis help corn breeders to select the best genotypes with higher yield productivity. Factor analysis is a type of multivariate analysis that can be used to reduce a large number of correlated variables to a smaller number of main factors El-Badawy and Mehasen [19], Filipovic *et al.* [20], Seyedzavar *et al.* [21] and Youstine, Sedhom [17].

Therefore, the main objectives of this work were to evaluate combining ability and heterosis as well as study factor analysis for some important traits in maize under two different nitrogen levels.

MATERIALS AND METHODS

Line x tester analysis was used in this study where ten new maize inbred lines were used as parents and crossed to elite two testers. The name and origin of these twelve parents are presented in Table 1. This work was undertaken at the Experimental Farm of the Faculty of Agriculture, Moshtohor, Benha university during the two growing summer seasons 2018 and 2019. The obtained top crosses were evaluated for combining ability under two nitrogen levels and heterosis percentage relative two check hybrids.

In 2018 summer season, the ten new inbred lines along to two testers were planted in three planting dates to overcome differences in flowering time for the parental inbred lines. At the end of this season, twenty top crosses were obtained from line x tester analysis.

In 2019 season, the obtained twenty top crosses along with two check hybrids (S.C. 128 and S.C 30 k 8) were grown under two nitrogen levels, viz 80 and 120 kg N/ feddan in two adjacent experiments. Each experiment was laid out in Randomized Complete Block Design with three replications. Each plot consisted of one ridge of 3 m length and 70 cm width. Each hill was spaced 25 cm apart with two kernels planted per hill and later thinned to one plant per hill. The other cultural practices of maize growing were properly practiced as recommended for the area of cultivation. Data were recorded on days to 50% silking, plant height (cm), number of rows ear^{-1}, number of kernels row^{-1}, weight of 100 kernel (g) and grain yield plant^{-1}. Grain yield was adjusted to 15.5% moisture content.

Analysis of variance was carried out for all traits in each separate nitrogen level and combined analysis over both nitrogen levels was performed if the homogeneity test was not significant, according to Steel and Torrei [22].

When differences among top crosses found significant, line x tester analysis according to Kempthorne [23] was practiced for each environment and combined over both environments.

Heterosis for each trait was calculated for each individual top cross as the percent deviation of F_1 mean performance from either S.C. 128 and S.C. 30k8 average values for each experiment as well as the combined data as follows:

The check variety heterosis (heterobeltosis) =

$$\frac{F1 - Check\ varity}{Check\ variety} X100$$

Appropriate L.S.D values were computed according to the following formulae to test the significance of these heterotic effects.

L.S.D. for heterosis relative to check variety = $t\ x\sqrt{\frac{2MSe}{r}}$

where:

t: is the tabulated t value at a stated level of probability for the experimental error degree of freedom and r: is the number of replications.

Simple correlation coefficient was estimated according to Snedecor and Cochran [24]. Correlation coefficients were used to calculate factor analysis according to Cattell [26] and Walton [26].

Table 1: The name and origin of the studied ten parental inbred lines and two testers

No	Parent name	Origin	Country
Lines			
L1	M_7	Cairo 1	Egypt
L2	M15	Giza 2	Egypt
L3	CLM 343	CIMMYT	CIMMYT
L4	CLM 19	CIMMYT	CIMMYT
L5	M_{24}	Pioneer 514	Egypt
L6	M_{25}	Pioneer 514	Egypt
L7	M_{30}	Cairo 1	Egypt
L8	M_{34}	Giza 2	Egypt
L9	M_{36}	Giza 2	Egypt
L10	M_{57}	Cairo 1	Egypt
Testers			
T1	M8	Giza 1	Egypt
T2	CIMMYT 14	CIMMYT	CIMMYT

RESULTS AND DISCUSSION

Analysis of Variance and Mean Performance: Analysis of variance for days to 50% silking, plant height, number of rows ear^{-1}, number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1} under the nitrogen levels and combined analyses are presented in Table 2. Results indicated that mean squares due to nitrogen levels were highly significant for all studied traits with higher mean values of N2 (120 kg N/ feddan) being much higher than those of N1 (80 kg N/ feddan) as shown in Table 3. Such results are expected since increasing nitrogen levels leads to increase photosynthetic activities which in turn positively affects the growth and yield of maize plant. Similar results were reported by Guedes *et al*. [2], Meseka *et al*. [27], Kamara *et al*. [3], El-Naggar *et al*. [28], Kamra and Rehan [16], Omnya Turkey *et al*. [18] and Ogunniyan *et al*. [29].

Highly significant mean squares due to top crosses, lines, testers and lines x testers were detected for all studied traits indicating wide diversity among the parental materials used in this work. Moreover, mean squares due to the interaction between crosses, lines, testers and lines x tester from one side and nitrogen levels from the other side were significant for all studied traits except tester x environment for plant height, number of rows ear^{-1} and number of kernels row^{-1} and lines x environment for weight of 100 kernel. Such results revealed that the studied crosses responded differently to different nitrogen fertilization level. The variability among maize genotypes were reported by several investigators Sedhom *et al*. [12], Kamara *et al*. [3], Kahriman *et al.* [4], Noelle *et al*. [7], EL-Hosary [8] and El-Gazzar [30], Neven Hamouda *et al*. [10] and Sedhom *et al*. [11].

Mean performance of days to 50%, plant height, number of rows ear^{-1}, number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1} under N1 and N2 nitrogen levels and combined analyses are presented in Table 3. For days to 50% silking, the top cross M30 x M8 expressed the lowest significant mean value as compared to the best check at N1, N2 and combined analyses recording 53.33, 53.67 and 53.5 day, respectively (Table 3). Regarding plant height, the best top cross was M15 x CIMMYT 14 which recoded the lowest mean value being 245.33 and 254.33 under the first nitrogen level and combined data, respectively with significant difference from the best check hybrid (S.C. 128). The top cross M34 x M8 expressed the best mean value for number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1} recording 51.07, 51.60 and 51.33; 37.00, 36.67 and 36.83; and 214.00, 225.33 and 219.67 under N1, N2 and combined analyses, respectively. Moreover, the top crosses M 30 x M 8 and M 30 x CIMMYT 14 ranked the second best for grain yield plant since they both had mean value of 214 g in the combined analysis (Table 3).

In conclusion, the top crosses M 30 x M8, M34 x M 8, M15x CIMMYT 14 and M 30 x CIMMYT 14 were considered prospective and would be used efficiently in future maize breeding program.

Combining Ability Analysis: The analyses of variance for general combining ability (GCA) and specific combining ability (SCA) for days to 50%, plant height, number of rows ear^{-1}, number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1} under N1 and N2 nitrogen levels and combined analyses are presented in Table 2. It is clear that mean squares due to SCA were much higher than those of GCA for all studied traits indicating that the total part of genetic variability associated with these traits was mainly due to non-additive gene action. Moreover, the interaction between both types of combining ability and nitrogen level cleared that SCA was more influenced than GCA for all studied traits. The importance of non-additive gene action in controlling earliness, yield and its components was previously reported by Guedes *et al*. [2], Singh *et al*. [31], Kamara *et al*. [3], Kahriman *et al*. [4] Andsysni *et al*. [5], Bayoumi *et al*. [6], Noelle *et al*. [7], El-Hosary [8, 9], Neveen Hamouda *et al*. [10] and Sedhom *et al*. [11] for grain yield plant^{-1} and other traits. On the contrary, the importance of additive gene action in governing the studied traits were previously reported by Sedhom *et al*. [12], El-Badawy [13], Mahesh *et al*. [14], Ahmed *et al*. [15] Andayani *et al*. [5] and Kamara *et al*. [3].

Estimates of GCA effects for days to 50%, plant height, number of rows ear^{-1}, number of kernels row^{-1}, weight of 100 kernel and grain yield plant^{-1} under N1 and N2 nitrogen levels and combined analyses are presented in Table 4 and Figures (1-6). The tester M8 seemed to be the best general combiner for days to 50% silking, plant height, number of kernels row^{-1} and grain yield plant^{-1}, since it expressed significant GCA effects for such traits under first, second nitrogen level and combined analyses, respectively. However, the tester exhibited positive and significant GCA effects for number of rows ear^{-1} and weight of 100 kernel under all environments.

Table 2: Analysis of variance for days to 50% tasseling, days to 50% silking, No. of rows ear^{-1}, No. of grains row^{-1}, 100 kernel weight and grain yield plant^{-1} under two nitrogen levels and combined data

	df		Days to 50% silking			Plant height (cm)			No. of rows ear^{-1}			No. of kernel row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
S.O.V	S	C	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
Environment (E)		1			298894**			7461463**			17091**			18532**			10462**			3446867**
Rep	2		1.85	5.72*		172.87	209.72		0.53	0.42		0.93	2.32		0.93	0.01		100.12	117.80	
Rep/E		4			3.78			191.29			0.48			1.62			0.47			108.96
Crosses	19	19	15.32**	10.98**	18.55**	874.21**	450.93**	1113.46**	2.09**	1.17**	2.34**	66.27**	32.38**	86.01**	17.62**	14.40**	29.37**	1195.15**	911.39**	1665.91**
Lines	9	9	11.49**	10.44**	17.26**	789.64**	634.27**	1227.05**	3.04**	0.91*	2.91**	58.45**	18.43**	64.25**	18.41**	14.41**	30.78**	746.38**	1153.79**	1460.74**
Testers	1	1	101.40**	32.27**	124.03**	1760.42**	836.27**	2511.67**	3.27**	6.27**	9.30**	406.64**	256.27**	654.27**	8.21	42.00**	43.68**	4318.02**	1738.82**	5768.53**
Lines x testers	9	9	9.59**	9.16**	8.11**	860.31**	224.79**	844.53**	1.01**	0.86*	1.01**	36.27**	21.46**	44.63**	17.87**	11.33**	26.37**	1296.94**	577.04**	1415.22**
Crosses x E		19			7.75**			211.68**			0.91**			12.64**			2.65*			440.63**
Line x E		9			4.66**			196.86**			1.04**			12.64**			2.03			439.43**
Testers x E		1			9.63**			85.01			0.24			8.64			6.53*			288.30*
Line x Testers x E		9			10.63**			240.56**			0.86**			13.10**			2.83**			458.76**
Error	38	76	1.83	1.47	1.65	123.66	71.80	97.73	0.40	0.54	0.47	6.19	5.08	5.64	1.71	1.60	1.66	86.01	88.15	87.08
C.V			2.35	2.13	2.24	3.94	2.92	3.45	4.61	5.37	5.01	5.63	4.90	5.26	3.94	3.66	3.80	4.88	4.72	4.80
variance GCA			0.13	0.04	0.12	0.31	5.12	3.04	0.02	0.01	0.02	0.68	0.25	0.47	0.01	0.07	0.03	2.30	7.56	2.84
variance SCA			2.58	2.56	1.08	245.55	50.99	124.47	0.20	0.11	0.09	10.03	5.46	6.50	5.39	3.24	4.12	403.64	162.96	221.36
GCA x E					0.05			2.39			0.02			0.46			0.03			2.43
SCA x E					4.07			172.08			0.22			8.99			4.51			345.25

*and** significant at 0.05 and 0.01 levels of probability, respectively

Table 3: Mean performance of studied top crosses for days to 50% silking, No. of rows ear^{-1}, No. of grains row^{-1}, 100 kernel weight and grain yield plant^{-1} under two nitrogen levels and combined data

	Days to 50% silking			Plant height			No. of rows ear^{-1}			No. of kernel row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
Genotype	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
M7x M8	59.33	57.00	58.17	273.33	281.67	277.50	12.40	13.20	12.80	42.40	43.73	43.07	30.67	31.33	31.00	183.67	184.67	184.17
M15x M8	56.33	56.67	56.50	266.67	269.33	268.00	13.33	13.20	13.27	44.47	45.93	45.20	34.67	35.33	35.00	202.00	204.67	203.33
CLM343x M8	58.33	55.33	56.83	290.00	301.33	295.67	13.13	12.80	12.97	47.07	48.73	47.90	34.00	34.67	34.33	199.33	197.67	198.50
CLM19x M8	58.33	57.00	57.67	290.00	292.00	291.00	14.27	13.67	13.97	46.33	46.60	46.47	27.00	28.33	27.67	202.33	185.67	194.00
M24x M8	54.00	56.00	55.00	238.00	290.67	264.33	13.53	13.53	13.53	46.80	49.07	47.93	33.67	34.67	34.17	202.67	212.00	207.33
M25x M8	53.67	55.00	54.33	291.33	300.00	295.67	13.40	13.33	13.37	47.13	47.67	47.40	28.60	30.33	29.47	201.33	206.67	204.00
M30x M8	53.33	53.67	53.50	279.33	280.67	280.00	14.00	14.67	14.33	50.33	51.33	50.83	35.00	36.00	35.50	209.33	218.67	214.00
M34x M8	56.67	57.33	57.00	284.00	285.00	284.50	14.93	13.70	14.32	51.07	51.60	51.33	37.00	36.67	36.83	214.00	225.33	219.67
M36x M8	57.67	58.00	57.83	270.00	280.00	275.00	12.53	13.07	12.80	47.40	49.07	48.23	35.00	35.67	35.33	199.33	211.33	205.33
M57x M8	55.33	56.33	55.83	284.00	284.67	284.33	12.87	12.83	12.85	45.07	46.80	45.93	32.67	34.33	33.50	171.67	195.67	183.67
M7x CIMMYT 14	59.33	59.00	59.17	290.67	294.67	292.67	14.40	14.70	14.55	47.20	47.87	47.53	36.00	36.33	36.17	210.67	212.67	211.67
M15x CIMMYT 14	60.33	60.67	60.50	245.33	263.33	254.33	14.40	13.67	14.03	30.00	43.33	36.67	34.00	35.00	34.50	184.67	205.33	195.00
CLM343x CIMMYT 14	60.00	60.33	60.17	288.67	282.67	285.67	13.27	13.83	13.55	41.47	40.53	41.00	33.33	34.33	33.83	137.33	157.33	147.33
CLM19x CIMMYT 14	57.67	59.00	58.33	294.67	304.00	299.33	15.20	14.27	14.73	41.00	43.60	42.30	32.33	33.67	33.00	191.00	187.33	189.17
M24x CIMMYT 14	59.67	57.00	58.33	302.67	310.33	306.50	12.93	13.67	13.30	39.20	40.47	39.83	35.00	35.67	35.33	177.67	184.00	180.83
M25x CIMMYT 14	58.00	55.67	56.83	298.33	306.00	302.17	14.00	14.40	14.20	40.93	44.87	42.90	32.33	36.73	34.53	179.67	187.67	183.67
M30x CIMMYT 14	58.33	57.33	57.83	283.33	287.33	285.33	14.20	13.97	14.08	46.67	47.20	46.93	35.00	35.67	35.33	213.00	215.00	214.00
M34x CIMMYT 14	61.67	54.00	57.83	278.67	292.67	285.67	14.67	14.37	14.52	43.33	43.87	43.60	31.00	36.33	33.67	157.00	209.33	183.17
M36x CIMMYT 14	56.67	58.67	57.67	305.67	304.00	304.83	13.60	12.93	13.27	46.20	46.53	46.37	33.33	35.67	34.50	171.00	208.33	189.67
M57x CIMMYT 14	57.33	55.33	56.33	287.00	295.00	291.00	12.40	14.67	13.53	40.00	40.93	40.47	33.33	34.67	34.00	194.00	167.67	180.83
SC 128	56.00	57.00	56.50	273.33	277.33	275.33	13.20	12.93	13.07	45.00	45.47	45.23	34.00	34.33	34.17	174.00	200.33	187.17
SC 2031	56.67	56.00	56.33	270.67	274.33	272.50	13.33	12.93	13.13	44.13	44.53	44.33	33.33	34.33	33.83	199.00	200.67	199.83
Over all mean	57.48	56.92	57.2	281.17	288.95	285.06	13.64	13.65	13.64	44.24	45.9	45.07	33.24	34.55	33.89	189.76	199.00	194.38
LSD 0.05	2.22	1.87	2.05	17.13	15.84	16.50	1.00	1.16	1.09	3.86	3.59	3.73	2.57	2.07	2.33	14.55	16.36	15.48
LSD 0.01	2.91	2.45	2.69	22.46	20.77	21.63	1.32	1.53	1.43	5.06	4.71	4.89	3.37	2.71	3.06	19.08	21.45	20.30

Table 4: General combining ability effects for days to 50% tasseling, plant height, No. of rows ear-1, No. of grains row-1, 100 kernel weight and grain yield/ plant (g) under both nitrogen levels as well as combined data

	Days to 50% silking			Plant height (cm)			No. of rows ear^{-1}			No. of kernel row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
Genotypes	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
Testers																		
M8	-1.30**	-0.73**	-1.02**	-5.42**	-3.73*	-4.57**	-0.23*	-0.32*	-0.28**	2.60**	2.07**	2.34**	-0.37	-0.84**	-0.60**	8.48**	5.38**	6.93**
CIMMYT 14	1.30**	0.73**	1.02**	5.42**	3.73*	4.58**	0.23*	0.32*	0.28**	-2.60**	-2.07**	-2.34**	0.37	0.84**	0.60**	-8.48**	-5.38**	-6.93**
L.S.D. (gi) 0.05	0.48	0.43	0.33	3.98	3.03	2.50	0.23	0.26	0.17	0.89	0.81	0.60	0.47	0.45	0.33	3.32	3.36	2.36
L.S.D. (gi) 0.01	0.64	0.57	0.43	5.23	3.99	3.29	0.30	0.35	0.23	1.17	1.06	0.79	0.62	0.60	0.43	4.36	4.42	3.10
L.S.D. (gi-gj) 0.05	0.69	0.61	0.56	5.63	4.29	4.33	0.32	0.37	0.30	1.26	1.14	1.04	0.66	0.64	0.56	4.69	4.75	4.09
L.S.D (gi-gj) 0.01	0.90	0.81	0.74	7.40	5.64	5.69	0.42	0.49	0.40	1.65	1.50	1.37	0.87	0.84	0.74	6.17	6.24	5.38
Lines																		
M7	1.73**	1.03*	1.38**	-0.08	-2.10	-1.09	-0.27	0.23	-0.02	0.60	-0.19	0.20	0.14	-0.74	-0.30	7.08	-0.18	3.45
M15	0.73	1.70**	1.22**	-26.08**	-23.93**	-25.01**	0.19	-0.29	-0.05	-6.97**	-1.35	-4.16**	1.14*	0.60	0.87*	3.25	6.15	4.70
CLM343	1.57**	0.87	1.22**	7.25	1.73	4.49	-0.47	-0.41	-0.44*	0.06	-1.35	-0.65	0.47	-0.07	0.20	-21.75**	-21.35**	-21.55**
CLM19	0.40	1.03*	0.72	10.25*	7.73*	8.99**	1.06**	0.24	0.65**	-0.54	-0.89	-0.71	-3.53**	-3.57**	-3.55**	6.58	-12.35**	-2.88
M24	-0.77	-0.47	-0.62	-11.75**	10.23**	-0.76	-0.44	-0.12	-0.28	-1.20	-1.22	-1.21	1.14*	0.60	0.87*	0.08	-0.85	-0.38
M25	-1.77**	-1.63**	-1.70**	12.75**	12.73**	12.74**	0.03	0.14	0.09	-0.17	0.28	0.06	-2.73**	-1.04*	-1.88**	0.42	-1.68	-0.63
M30	-1.76**	-1.47**	-1.62**	-0.75	-6.27	-3.51	0.43	0.59*	0.51*	4.30**	3.28**	3.79**	1.80**	1.26*	1.53**	21.08**	17.98**	19.53**
M34	1.57**	-1.30**	0.13	-0.75	-1.43	-1.09	1.13**	0.31	0.72**	3.0**	1.75	2.37**	0.80	1.93**	1.37**	-4.58	18.48**	6.96
M36	-0.43	1.37**	0.47	5.75	1.73	3.74	-0.61*	-0.72*	-0.67**	2.60*	1.81*	2.20**	0.97	1.10*	1.03**	-4.92	10.98**	3.03
M57	-1.27*	-1.13*	-1.20**	3.42	-0.43	1.49	-1.04**	0.03	-0.51*	-1.67	-2.12*	-1.90**	-0.20	-0.07	-0.13	-7.25	-17.18**	-12.22**
L.S.D. (gi) 0.05	1.08	0.97	0.73	8.90	6.78	5.59	0.50	0.59	0.39	1.99	1.80	1.34	1.05	1.01	0.73	4.42	7.51	5.28
L.S.D. (gi) 0.01	1.42	1.28	0.96	11.69	8.91	7.35	0.66	0.78	0.51	2.62	2.37	1.77	1.38	1.33	0.96	9.75	9.87	6.94
L.S.D (gi-gj) 0.05	1.53	1.37	1.03	12.58	9.59	7.91	0.71	0.83	0.55	2.81	2.55	1.90	1.48	1.43	1.03	10.49	10.62	7.47
L.S.D (gi-gj) 0.01	2.01	1.80	1.35	16.54	12.60	10.40	0.94	1.10	0.72	3.70	3.35	2.50	1.95	1.88	1.35	13.79	13.96	9.81

*and** significant at 0.05 and 0.01 levels of probability, respectively

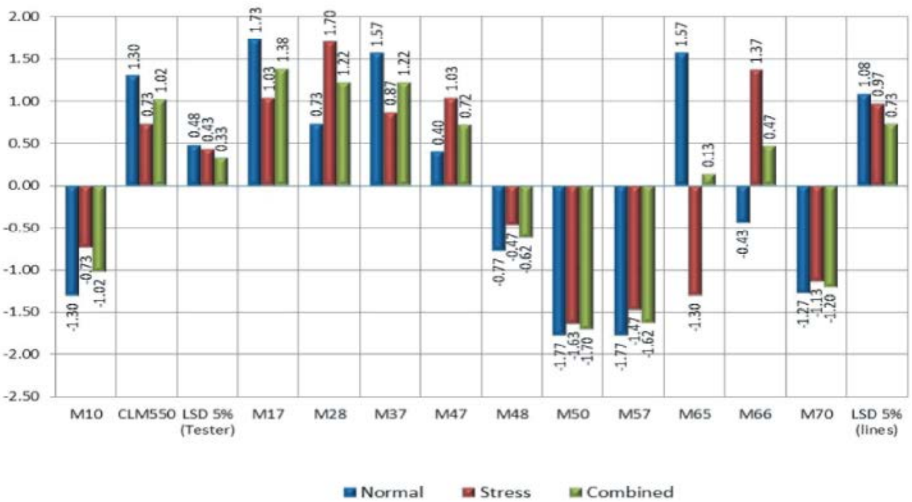

Fig. 1: GCA effects for days to 50% silking under N1 and N2 fertilization level and combined data

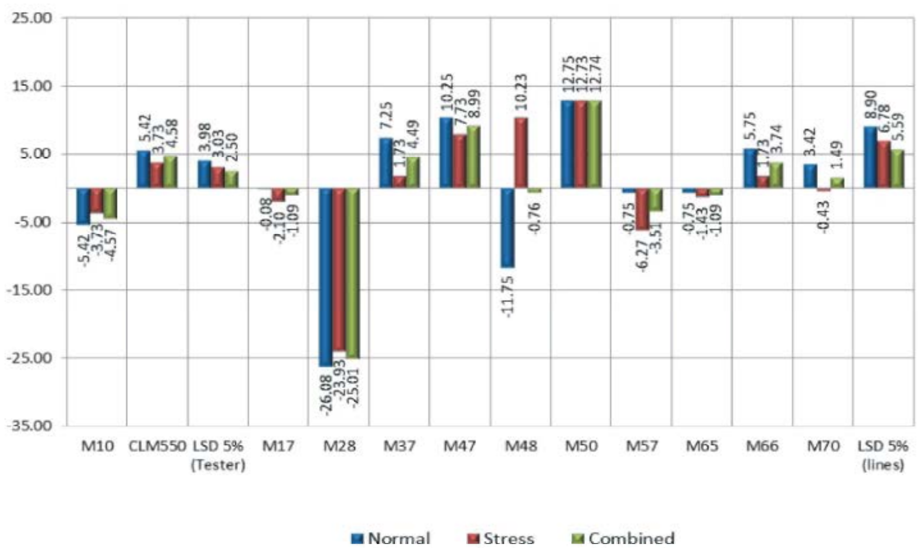

Fig. 2: GCA effects for plant height under N1 and N2 fertilization level and combined data

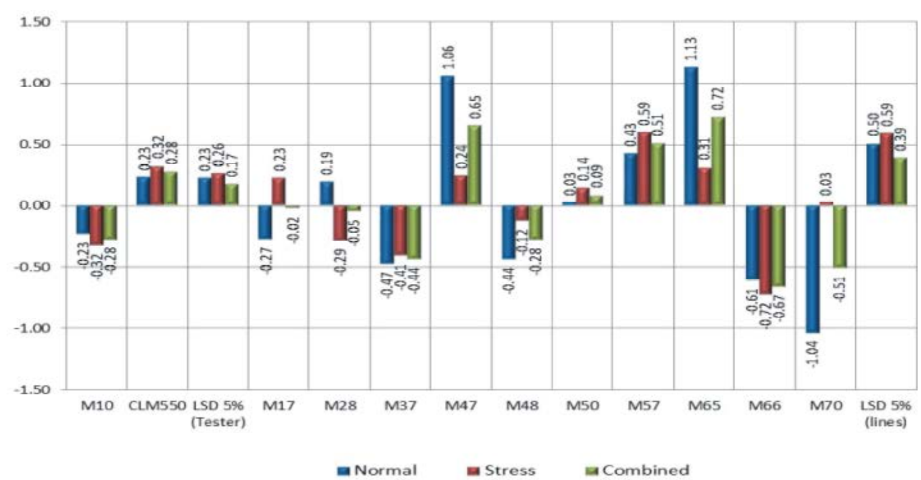

Fig. 3: GCA effects for No. rows ear^{-1} under N1 and N2 fertilization level and combined data

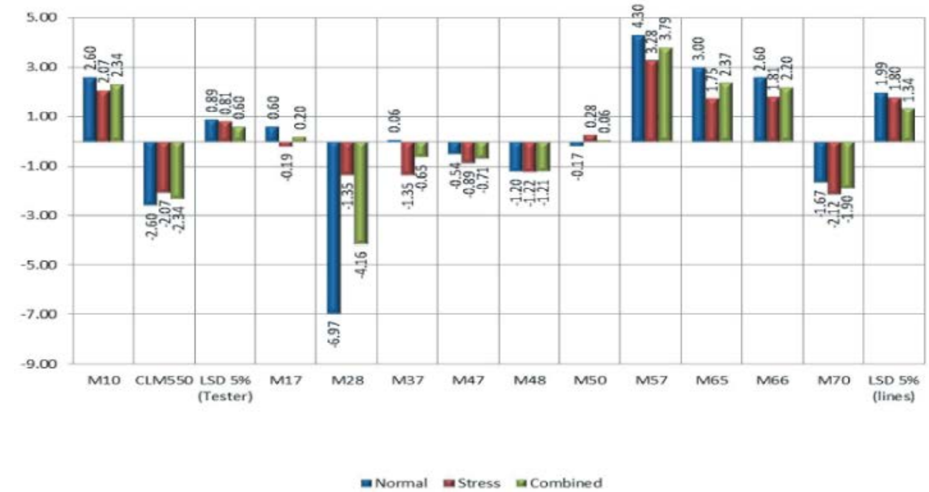

Fig. 4: GCA effects for No. of kernels row^{-1} under N1 and N2 fertilization level and combined data

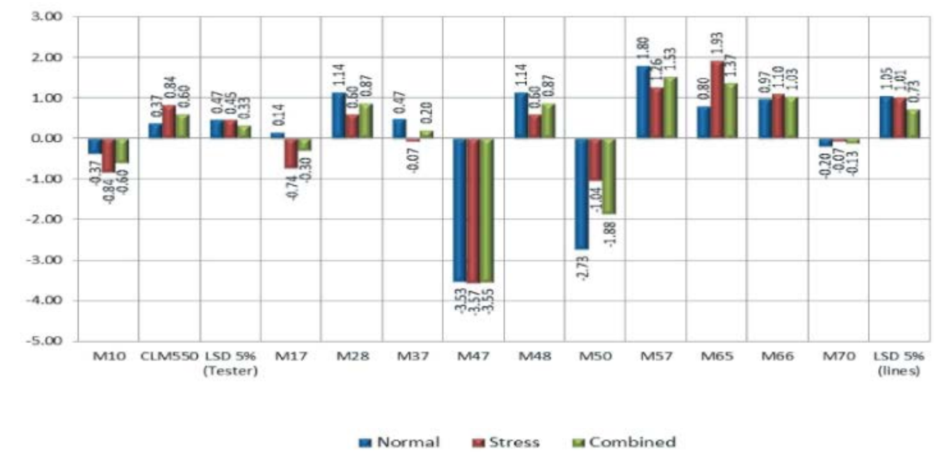

Fig. 5: GCA effects for 100 kernel weight under N1 and N2 fertilization level and combined data

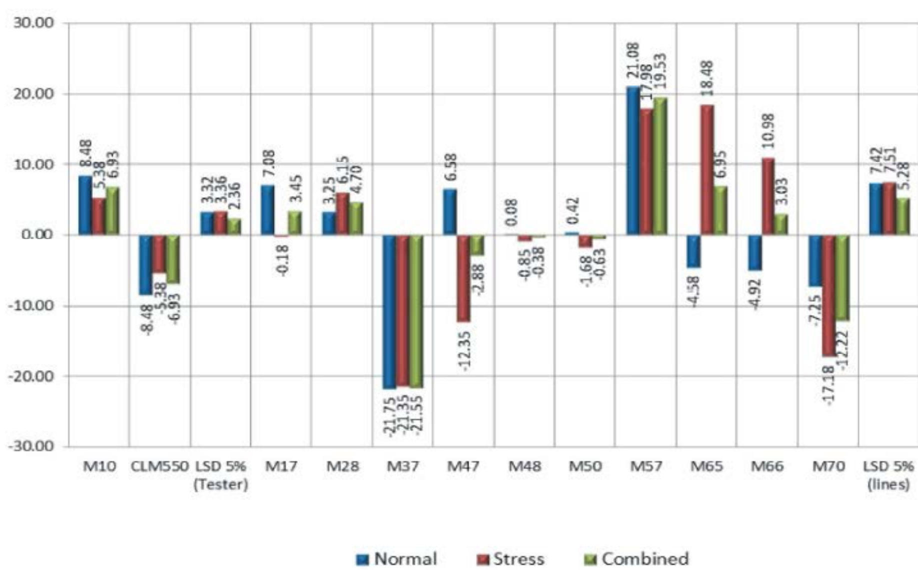

Fig. 6: GCA effects for grain yield plant^{-1} under N1 and N2 fertilization level and combined data

The line M25 seemed to be the best general combiner for days to 50% silking since it expressed negative and significant GCA effects being -1.77, -1.63 and 1.70 under N1, N2 and combined data, respectively (Table 4). Parent M 15 expressed the highest negative and significant GCA effects for plant height under both nitrogen levels and combined data. Parent M 30 seemed to be the best general combiner for number of rows ear^{-1} under second nitrogen level, number of kernels row^{-1} under all environments, as well as 100 kernel weight and grain yield plant^{-1} under N1 and combined data. Moreover, parent M 34 expressed the highest positive and significant GCA effects for number of rows ear under N1 and combined data and 100 kernel weight and grain yield plant under the second nitrogen level.

Specific combining ability effects for the studied traits under the two nitrogen levels and combined data are presented in Table 5. It is notable that three, two and one crosses expressed negative and significant SCA effects for days to 50% silking under N1, N2 levels and combined analyses, respectively. However, the most desirable SCA effects for this trait were obtained for the crosses M 34 x CIMMYT 14 under N2 level and M 36 x CIMMYT 14 under N1 and combined data. For plant height, two crosses namely, M 24 x M 8 and M 15 x CIMMYT 14 expressed desirable SCA under 80 kg N/ feddan, while the cross CLM 343x CIMMYT 14 gave the best SCA effects under 120 kg N/ feddan. None of he studied crosses exhibited desirable SCA effects for plant height under combined data (Table 5). Regarding number of rows ear^{-1}, The top cross M7x CIMMYT 14 was the only among all studied crosses that expressed desirable SCA effects under N1 and combined data being 0.77 and 0.64, respectively. For number of kernels row^{-1}, one top cross (M7x CIMMYT 14) expressed the most desirable SCA effects recording .64, 5.00 and 4.84, respectively. For 100 kernel weight, four, three and four crosses exhibited desirable SCA effects under both nitrogen levels and combined over them. However, the best SCA effects were detected for the crosses M 34 x M8, M 25 x CIMMYT 14 and M7 x CIMMYT 14 at N1, N2 levels and combined data, respectively. Regarding grain yield plant^{-1}, four, two and four crosses expressed positive and significant SCA effects at Ni and N2 levels and combined analyses, respectively. Meanwhile, the most desirable SCA effects for this trait were detected for the crosses CLM343x M8 at N1 level (22.52 g) and M7x CIMMYT 14 at N2 level (22.48 g) and combined data (22.23 g) (Table 5).

In general, the top crosses CLM343x M8, M7x CIMMYT 14 and M36x CIMMYT 14 are of prime importance regarding earliness and yield potentiality in maize breeding programs.

Heterosis: Standard heterosis values for days to 50% silking, plant height, number of rows ear-1, number of kernels row-1, 100 kernel weight and grain yield plant-1 relative to S.C. 128 and S.C 30 k8 under N1 and N2 levels and combined analyses are presented in Table 6 and 7. For days to 50% silking, two, two and one crosses expressed negative and significant heterotic effects relative to S.C 128 at N1, N2 levels and combined data, respectively. The respective heterotic values relative to S.C. 30 k 8 were three, two and one (Table 6). However, the best heterotic effects for days to 50% silking were detected for the cross M 30 x M 8 relative to S.C 128 and S.C 30 k8 recording -5.31 and -5.03, respectively in the combined analysis.

Earliness if found is favourable trait for corn breeders because it enables plants to escape destructive injuries caused by *Sesamia cretica ledi chilo simplex* and *Pyrausta nubilialis*. Similar results were obtained by Panda *et al*. [32], Youstina Sedhom *et al*. [17], Patil *et al*. [33] and El-Hosary [9].

Regarding plant height, negative and significant heterotic effects were detected for two and one crosses relative to each of S.C 128 and S.C 30 k8 under the first N level and combined data, respectively (Table 6). However, the most desirable heterotic effects relative to S.C 128 were recorded for the crosses M 24 x M 8 under the first N level and M15x CIMMYT 14 in the combined data. The same trend was obtained for heterotic effects relative to S.C. 20 k8.

For number of rows ear^{-1}, six crosses expressed positive and significant heterotic effects relative to S.C. 128 for each nitrogen level and combined data. Desirable heterotic effects relative to S.C. 30 k8 were obtained for five, six and four crosses under first, second N levels and combined analyses, respectively. Moreover, the most desirable heterotic effects were detected for the crosses M7x CIMMYT 14 (11.35) and CLM19x CIMMYT 14 (12.18) relative to S.C 128 and S.C 30 k8, respectively in the combined analysis.

Regarding number of kernels row^{-1}, the most desirable heterotic effects relative to both checks were detected for the cross M 34 x M 8 under both nitrogen levels as well as combined data (Table 7). This particular

Table 5: Specific combining ability effects for days to 50% tasseling, plant height, No. of rows ear^{-1}, No. of grains row^{-1}, 100 kernel weight and grain yield plant^{-1} (g) under both nitrogen levels as well as combined data

	Days to 50% silking			Plant height (cm)			No. of rows ear^{-1}			No. of kernel row^{-1}			100 kernel weight			Grain yield (g) plant^{-1}		
Genotypes	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
M7x M8	1.30	0.30	0.80	-3.25	-1.08	-2.17	-0.77*	-0.52	-0.64*	-5.00**	-4.67**	-4.84**	-2.30**	-2.13**	-2.21**	-21.98**	-22.48*	-22.23**
M15x M8	-0.70	-0.70	-0.70	16.08*	8.42	12.25	-0.30	0.00	-0.15	4.63	-1.30	1.66	0.70	0.54	0.62	0.18	-8.82	-4.32
CLM343x M8	0.47	-1.20	-0.37	6.08	14.75*	10.42	0.17	-0.28	-0.06	0.20	1.50	0.85	0.70	0.54	0.62	22.52**	11.68*	17.10**
CLM19x M8	1.63*	0.30	0.97	3.08	-0.58	1.25	-0.23	-0.07	-0.15	0.06	-1.10	-0.52	-2.30**	-2.30**	-2.30**	-2.82	-9.32	-6.07
M24x M8	-1.53*	0.80	-0.37	-26.92**	-4.42	-15.67	0.53	0.17	0.35	1.20	1.70	1.45	-0.30	-0.13	-0.21	4.02	5.52	4.77
M25x M8	-0.87	0.97	0.05	1.92	2.42	2.17	-0.07	-0.30	-0.18	0.50	-1.20	-0.35	-1.50*	-2.83**	-2.16**	2.35	1.02	1.68
M30x M8	-1.20	-0.53	-0.87	3.42	2.08	2.75	0.13	0.58	0.36	-0.77	-0.54	-0.65	0.37	0.54	0.45	-10.32	-6.65	-8.48*
M34x M8	-1.20	2.97**	0.88	8.08	1.58	4.83	0.37	-0.10	0.13	1.26	1.26	1.26	3.37**	0.54	1.95**	20.02**	-0.48	9.77*
M36x M8	1.80*	0.97	1.38**	-12.42	-6.58	-9.50	-0.30	0.30	0.00	-2.00	-1.34	-1.67	1.20	0.37	0.79	5.68	-6.98	-0.65
M57x M8	0.30	1.80*	1.05*	3.92	0.25	2.08	0.47	-0.68	-0.11	-0.07	0.33	0.13	0.04	0.20	0.12	-19.65**	5.52	-7.07
M7x CIMMYT 14	-1.30	-0.30	-0.80	3.25	1.08	2.17	0.77*	0.52	0.64*	5.00**	4.67**	4.84**	2.31**	2.13**	2.21**	21.98**	22.48**	22.23**
M15x CIMMYT 14	0.70	0.70	0.70	-16.08*	-8.42	-12.25	0.30	0.00	0.15	-4.63**	1.30	-1.66	-0.70	-0.54	-0.62	-0.18	8.82	4.32
CLM343x CIMMYT 14	-0.47	1.20	0.37	-6.08	-14.75*	-10.42	-0.17	0.28	0.06	-0.20	-1.50	-0.85	-0.70	-0.54	-0.62	-22.52**	-11.68*	-17.10**
CLM19x CIMMYT 14	-1.63*	-0.30	-0.97	-3.08	0.58	-1.25	0.23	0.07	0.15	-0.06	1.10	0.52	2.30**	2.30**	2.30**	2.82	9.32	6.07
M24x CIMMYT 14	1.53*	-0.80	0.37	26.92**	4.42	15.67	-0.53	-0.17	-0.35	-1.20	-1.70	-1.45	0.30	0.13	0.21	-4.02	-5.52	-4.77
M25x CIMMYT 14	0.87	-0.97	-0.05	-1.92	-2.42	-2.17	0.07	0.30	0.18	-0.50	1.20	0.35	1.50*	2.83**	2.16**	-2.35	-1.02	-1.68
M30x CIMMYT 14	1.20	0.53	0.87	-3.42	-2.08	-2.75	-0.13	-0.58	-0.36	0.77	0.54	0.65	-0.37	-0.54	-0.45	10.32	6.65	8.48*
M34x CIMMYT 14	1.20	-2.97**	-0.88	-8.08	-1.58	-4.83	-0.37	0.10	-0.13	-1.26	-1.26	-1.26	-3.37**	-0.54	-1.95**	-20.02**	0.48	-9.77*
M36x CIMMYT 14	-1.80*	-0.97	-1.38**	12.42	6.58	9.50	0.30	-0.30	0.00	2.00	1.34	1.67	-1.20	-0.37	-0.79	-5.68	6.98	0.65
M57x CIMMYT 14	-0.30	-1.80*	-1.05*	-3.92	-0.25	-2.08	-0.47	0.68	0.11	0.07	-0.33	-0.13	-0.04	-0.20	-0.12	19.65**	-5.52	7.07
L.S.D (gi) 0.05	1.53	1.53	1.03	12.58	12.58	7.91	0.71	0.71	0.55	2.81	2.81	1.90	1.48	1.48	1.03	10.49	10.49	7.47
0.01	2.01	2.01	1.35	16.54	16.54	10.40	0.94	0.94	0.72	3.70	3.70	2.50	1.95	1.95	1.35	13.79	13.79	9.81
L.S.D (gi-gj)0.05	2.17	2.17	1.78	17.80	17.80	13.70	1.01	1.01	0.95	3.98	3.98	3.29	2.09	2.09	1.78	14.84	14.84	12.93
0.01	2.85	2.85	2.34	23.39	23.39	18.01	1.33	1.33	1.25	5.23	5.23	4.32	2.75	2.75	2.35	19.51	19.51	17.00

*and** significant at 0.05 and 0.01 levels of probability, respectively

Table 6: Standard heterosis for days to 50% tasseling, plant height and No. of rows ear^{-1}, relative to S.C. 128 and S.C. 30 k 8 under both nitrogen levels as well as combined data

	Days to 50% silking						Plant height (cm)						No. of rows ear^{-1}					
	Relative to S.C. 128			Relative to S.C. 30 K 8			Relative to S.C. 128			Relative to S.C. 30 K 8			Relative to S.C. 128			Relative to S.C. 30 K 8		
Genotypes	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
M7x M8	5.95**	0.00	2.95	4.71*	1.79	3.25	0.00	1.56	0.79	0.99	2.67	1.83	-6.06	2.06	-2.04	-7.00	2.06	-2.54
M15x M8	0.60	-0.58	0.00	-0.59	1.19	0.30	-2.44	-2.88	-2.66	-1.48	-1.82	-1.65	1.01	2.06	1.53	0.00	2.06	1.02
CLM343x M8	4.17*	-2.92	0.59	2.94	-1.19	0.89	6.10	8.65**	7.38*	7.14*	9.84**	8.50**	-0.51	-1.03	-0.77	-1.50	-1.03	-1.27
CLM19x M8	4.17*	0.00	2.06	2.94	1.79	2.37	6.10	5.29	5.69	7.14*	6.44*	6.79*	8.08*	5.67	6.89	7.00	5.67	6.35
M24x M8	-3.57	-1.75	-2.65	-4.71*	0.00	-2.37	-12.93**	4.81	-4.00	-12.07**	5.95*	-3.00	2.53	4.64	3.57	1.50	4.64	3.05
M25x M8	-4.17*	-3.51	-3.83	-5.29**	-1.79	-3.55	6.59*	8.17**	7.38*	7.64*	9.36**	8.50**	1.52	3.09	2.30	0.50	3.09	1.78
M30x M8	-4.76*	-5.85**	-5.31**	-5.88**	-4.17*	-5.03**	2.20	1.20	1.69	3.20	2.31	2.75	6.06	13.40**	9.69*	5.00	13.40**	9.14*
M34x M8	1.19	0.58	0.88	0.00	2.38	1.18	3.90	2.76	3.33	4.93	3.89	4.40	13.13**	5.93	9.57*	12.00**	5.93	9.01*
M36x M8	2.98	1.75	2.36	1.76	3.57*	2.66	-1.22	0.96	-0.12	-0.25	2.07	0.92	-5.05	1.03	-2.04	-6.00	1.03	-2.54
M57x M8	-1.19	-1.17	-1.18	-2.35	0.60	-0.89	3.90	2.64	3.27	4.93	3.77	4.34	-2.53	-0.77	-1.66	-3.50	-0.77	-2.16
M7x CIMMYT 14	5.95**	3.51	4.72*	4.71*	5.36**	5.03**	6.34*	6.25*	6.30*	7.39*	7.41*	7.40*	9.09*	13.66**	11.35**	8.00*	13.66**	10.79
M15x CIMMYT 14	7.74**	6.43**	7.08**	6.47**	8.33**	7.40**	-10.24**	-5.05	-7.63*	-9.36**	-4.01	-6.67*	9.09*	5.67	7.40	8.00*	5.67	6.85
CLM343x CIMMYT 14	7.14**	5.85**	6.49**	5.88**	7.74**	6.80**	5.61	1.92	3.75	6.65*	3.04	4.83	0.51	6.96	3.70	-0.50	6.96	3.17
CLM19x CIMMYT 14	2.98	3.51	3.24	1.76	5.36**	3.55	7.80*	9.62**	8.72**	8.87**	10.81**	9.85**	15.15**	10.31**	12.76**	14.00**	10.31*	12.18**
M24x CIMMYT 14	6.55**	0.00	3.24	5.29**	1.79	3.55	10.73**	11.90**	11.32**	11.82**	13.12**	12.48**	-2.02	5.67	1.79	-3.00	5.67	1.27
M25x CIMMYT 14	3.57	-2.34	0.59	2.35	-0.60	0.89	9.15**	10.34**	9.75**	10.22**	11.54**	10.89**	6.06	11.34**	8.67*	5.00	11.34*	8.12
M30x CIMMYT 14	4.17*	0.58	2.36	2.94	2.38	2.66	3.66	3.61	3.63	4.68	4.74	4.71	7.58	7.99	7.78	6.50	7.99	7.23
M34x CIMMYT 14	10.12**	-5.26**	2.36	8.82**	-3.57*	2.66	1.95	5.53	3.75	2.96	6.68*	4.83	11.11**	11.08**	11.10**	10.00**	11.08*	10.53*
M36x CIMMYT 14	1.19	2.92	2.06	0.00	4.76**	2.37	11.83**	9.62**	10.71**	12.93**	10.81**	11.87**	3.03	0.00	1.53	2.00	0.00	1.02
M57x CIMMYT 14	2.38	-2.92	-0.29	1.18	-1.19	0.00	5.00	6.37*	5.69	6.03	7.53*	6.79*	-6.06	13.40**	3.57	-7.00	13.40**	3.05

*and** significant at 0.05 and 0.01 levels of probability, respectively

Table 7: Standard heterosis for No. of kernels row^{-1}, 100 kernel weight and grain yield plant^{-1}, relative to S.C. 128 and S.C. 30 k 8 under both nitrogen levels as well as combined data

	No. of kernel row^{-1}						100 kernel weight						Grain yield (g) plant^{-1}					
	Relative to S.C. 128			Relative to S.C. 30 K 8			Relative to S.C. 128			Relative to S.C. 30 K 8			Relative to S.C. 128			Relative to S.C. 30 K 8		
Genotypes	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.	N1	N2	Comb.
M7x M8	-5.78	-3.81	-4.79	-3.93	-1.80	-2.86	-9.80**	-8.74**	-9.27**	-8.00**	-8.74**	-8.37**	5.56	-7.82	-1.60	-7.71*	-7.97	-7.84*
M15x M8	-1.19	1.03	-0.07	0.76	3.14	1.95	1.96	2.91	2.44	4.00	2.91	3.45	16.09**	2.16	8.64*	1.51	1.99	1.75
CLM343x M8	4.59	7.18	5.90	6.65	9.43*	8.05	0.00	0.97	0.49	2.00	0.97	1.48	14.56**	-1.33	6.06	0.17	-1.50	-0.67
CLM19x M8	2.96	2.49	2.73	4.98	4.64	4.81	-20.59**	-17.48**	-19.02**	-19.00**	-17.48**	-18.23**	16.28**	-7.32*	3.65	1.68	-7.48	-2.92
M24x M8	4.00	7.92	5.97	6.04	10.18*	8.12	-0.98	0.97	0.00	1.00	0.97	0.99	16.48**	5.82	10.77*	1.84	5.65	3.75
M25x M8	4.74	4.84	4.79	6.80	7.04	6.92	-15.88**	-11.65**	-13.76**	-14.20**	-11.65**	-12.91**	15.71**	3.16	8.99*	1.17	2.99	2.09
M30x M8	11.85**	12.90**	12.38**	14.05**	15.27**	14.66**	2.94	4.85	3.90	5.00	4.85	4.93	20.31**	9.15*	14.34**	5.19	8.97*	7.09
M34x M8	13.48**	13.49**	13.49**	15.71**	15.87**	15.79**	8.82**	6.80*	7.80**	11.00**	6.80*	8.87**	22.99**	12.48**	17.36**	7.54*	12.29**	9.92*
M36x M8	5.33	7.92	6.63	7.40	10.18*	8.80*	2.94	3.88	3.41	5.00	3.88	4.43	14.56**	5.49	9.71*	0.17	5.32	2.75
M57x M8	0.15	2.93	1.55	2.11	5.09	3.61	-3.92	0.00	-1.95	-2.00	0.00	-0.99	-1.34	-2.33	-1.87	-13.74**	-2.49	-8.09*
M7x CIMMYT 14	4.89	5.28	5.08	6.95	7.49	7.22	5.88*	5.83*	5.85*	8.00**	5.83	6.90*	21.07**	6.16	13.09**	5.86	5.98	5.92
M15x CIMMYT 14	-33.33**	-4.69	-18.94**	-32.02**	-2.69	-17.29**	0.00	1.94	0.98	2.00	1.94	1.97	6.13	2.50	4.19	-7.20	2.33	-2.42
CLM343xCIMMYT 14	-7.85	-10.85*	-9.36*	-6.04	-8.98*	-7.52	-1.96	0.00	-0.98	0.00	0.00	0.00	-21.07**	-21.46**	-21.28**	-30.99**	-21.59**	-26.27**
CLM19x CIMMYT 14	-8.89*	-4.11	-6.48	-7.10	-2.10	-4.59	-4.90	-1.94	-3.41	-3.00	-1.94	-2.46	9.77*	-6.49	1.07	-4.02	-6.64	-5.34
M24x CIMMYT 14	-12.89**	-11.00*	-11.9**	-11.18*	-9.13*	-10.15*	2.94	3.88	3.41	5.00	3.88	4.43	2.11	-8.15*	-3.38	-10.72**	-8.31*	-9.51*
M25x CIMMYT 14	-9.04*	-1.32	-5.16	-7.25	0.75	-3.23	-4.90	6.99**	1.07	-3.00	6.99*	2.07	3.26	-6.32	-1.87	-9.72**	-6.48	-8.09*
M30x CIMMYT 14	3.70	3.81	3.76	5.74	5.99	5.86	2.94	3.88	3.41	5.00	3.88	4.43	22.41**	7.32*	14.34**	7.04	7.14	7.09
M34x CIMMYT 14	-3.70	-3.52	-3.61	-1.81	-1.50	-1.65	-8.82**	5.83*	-1.46	-7.00**	5.83	-0.49	-9.77*	4.49	-2.14	-21.11**	4.32	-8.34*
M36x CIMMYT 14	2.67	2.35	2.51	4.68	4.49	4.59	-1.96	3.88	0.98	0.00	3.88	1.97	-1.72	3.99	1.34	-14.07**	3.82	-5.09
M57x CIMMYT 14	-11.11*	-9.97*	-10.54*	-9.37*	-8.08*	-8.72*	-1.96	0.97	-0.49	0.00	0.97	0.49	11.49**	-16.31**	-3.38	-2.51	-16.45**	-9.51*

*and** significant at 0.05 and 0.01 levels of probability, respectively

cross exhibited the best heterotic effects for 100 kernel weight under N1 level and combined data relative to both checks. The best heterotic effects for 100 kernel weight under N2 level were detected for the cross M25x CIMMYT 14 relative to both checks.

For grain yield plant^{-1}, twelve, three and two crosses expressed positive and significant heterotic effects relative to S.C. 128 under N1, N2 and combined data, respectively. The respective crosses relative to S.C. 30 k8 were one, two and one (Table 7). However, the most desirable heterotic effects for grain yield plant^{-1} were detected for the cross M34 x M8 relative to both checks under N1, N2 and combined data. This cross (M34x M8) had heterotic values of 17.36 and 9.92 relative to S.C 128 and S.C 30 k8, respectively. Similar results were reported by several investigators. Among them are Kamara and Reham [17], Kahriman *et al*. [4], Youstina Sedhom *et al*. [18], Omnya Turkey *et al*. [19], El-Hosary [8, 9] and Sedhom *et al*. [11].

In conclusion, the single crosses M30x M8, M7x CIMMYT 14, CLM19x CIMMYT 14 and M 34 x M 8 are promising and could be used possibility for improving grain yield of maize.

Correlation and Factor Analysis: Correlation coefficient values between grain yield plant^{-1} and days to 50% tasseling, days to 50% silking, plant height, ear height, ear length, ear diameter, number of rows^{-1}, number of kernels row^{-1}, 100 grain weight and shelling % in the combined data over both nitrogen levels are presented in Table 8. Positive and highly significant correlation coefficient values were registered between day to 50% tasseling and days to 50% silking, while negative and significant correlation values were detected between days to 50% tasseling and each of number of kernels row^{-1} and grain yield plant^{-1}. Also, negative and significant correlation values were obtained between days to 50% silking and number of grains row^{-1}. Positive and significant correlations were found between ear length and each of number of grain row-1 and grain yield plant^{-1} and between ear diameter and number of rows ear^{-1}. Meantime, positive and significant correlation values were detected between number of grains row^{-1} and each of shelling % and grain yield plant^{-1} and also between shelling % and grain yield plant^{-1}. The correlation coefficient values between maize grain yield and other agronomic traits were previously reported by El-Badawy and Mehasen [19], Filipovic *et al.* [20], Seyedzavar *et al.* [21] and Youstine, Sedhom [17].

The factor analysis technique divided the studied variables into three factors (Table 9 and Fig. 7). The three factors accounted for 70.31 of the variance structure. The first factor included five variables, i.e, days to 50% tasseling, days to 50% silking, ear length, number of kernels row-1 and shelling % and accounted for 29.74%. The second factor included four variables, i.e., plant height, ear height, ear diameter and number of rows ear-1 and accounted for 24.88% of the total variance. The third factor included only one variable (100 kernel weight) and accounted for 15.69%.

Table 8: Correlation matrix between grain yield/ plant and other important agronomic characters in maize hybrids combined over both nitrogen levels

Trait	1	2	3	4	5	6	7	8	9	10	11
1- Days to 50% tasseling	1.0000										
2- Days to 50% silking	0.9150	*1.0000									
3- Plant height	0.1030	0.0080	1.0000								
4- Ear height	0.2640	0.1510	0.3220	1.0000							
5- Ear length	-0.4020	-0.3600	-0.4210	0.0590	1.0000						
6- Ear diameter	0.0720	0.0320	0.2380	0.3660	0.0680	1.0000					
7- No. of rows/ ear	0.2290	0.1710	0.1680	0.1870	0.0880	0.6390	**1.0000				
8- No. of grains/ row	-0.5770	**-0.5850	**0.0420	0.1070	0.7250	**0.1880	0.0180	1.0000			
9- 100 grain weight	0.1200	0.1050	-0.1130	0.3570	0.3730	0.3940	0.1580	0.1160	1.0000		
10- Shelling %	-0.3060	-0.2820	0.1810	0.3160	0.4160	0.3900	0.0820	0.4960	*0.1300	1.0000	
11- Grain yield/ plant	-0.4450	*-0.4150	-0.2330	-0.0530	0.7350	**0.4100	0.2160	0.6870	**0.2490	0.4600	*1.0000

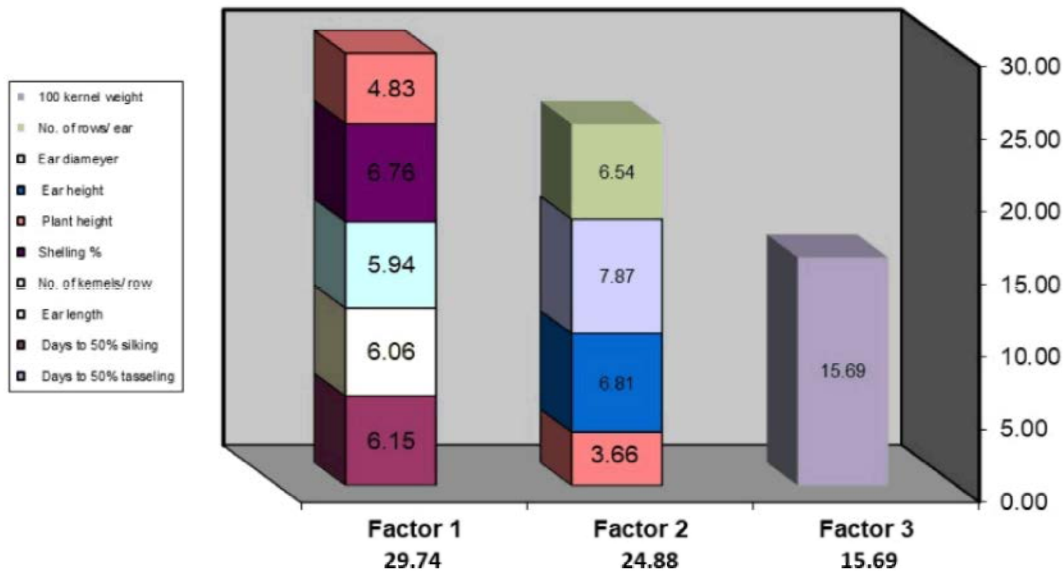

Fig. 7: Factor loading for some important characters of maize combined over two nitrogen levels

Table 9: Summary of factor loading for some important traits of maize

Variables	Loading	Percentage of total communality
Factor 1		29.74
Days to 50% tasseling	0.799	20.68
Days to 50% silking	0.788	20.39
Ear length	0.772	19.98
No. of kernels/ row	0.878	22.72
Shelling %	0.627	16.23
Factor 2		24.88
Plant height	0.375	14.72
Ear height	0.697	27.35
Ear diameter	0.806	31.63
No. of rows/ ear	0.670	26.30
Factor 3		15.69
100 kernel weight	0.552	100.00
Cummulative variance		70.31

In general, the most important yield traits particularly number of grains row^{-1} and shelling % would lead to maximizing total maize grain yield. These results agree with those obtained by El-Badawy and Mehasen [19], Beiragi *et al.* [34], Khodarahmpour [35], Filipovic *et al.* [20], Seyedzavar *et al.* [21] and Youstina Sedhom [17].

REFERENCES

1. FAOSTAT, 2020. Food & Agriculture Organization of the United Nations Statistics Division. Rome. Italy. http://www.fao.org/faostat/en/#data.
2. Guedes, F.L., J.C. Souza, E.F. Costa, M.C. Reis, G.A. Cardoso and H.J. Ematne, 2011. Evaluation of maize top cros under two nitrogen levels. Ciênc. agrotec., Lavras, 35(6): 1115-1121.
3. Kamara, M.M., I.S. El-Degwy and H. Koyama, 2014. Estimation combining ability of some maize inbred lines using line × tester mating design under two nitrogen levels. Australian J. Crop Sci. AJCS, 8(9): 1336-1342.

4. Kahriman, F., C.O. Egesel, G.E. Orhun and B. Alaca, 2016. Comparison of graphical analyses for maize genetic experiments: Application of biplots and polar plot to line × tester design. Chilean J. of Agric. Res. 76(3): 286-293. http://dx.doi.org/10.4067/S0718-58392016000300004.
5. Andayani, N.N., M. Aqil, R. Efendi and M. Azrai, 2018. Line × tester analysis across equatorial environments to study combining ability of Indonesian maize inbred. Asian J. Agri. & Biol., 6(2): 213-220.
6. Bayoumi, R.A., S.M. Shoker, G.Y. Hamam and A.A.A. El-Hosary, 2018. Determination of Combining Ability for Some New Yellow Maize Inbred Lines Using Line X Tester Model. Annals of Agric. Sci., Moshtohor, 56(2): 305-316.
7. Noelle, M.A.H., K. Richard, G. Vernon, Y.A. Martin, M.N. Laouali, T.N. Lilane and N. Godswill, 2017. Combining Ability and Gene Action of Tropical Maize (*Zea mays* L.) Inbred Lines under Low and High Nitrogen Conditions. Journal of Agricultural Science, 9(4): 222-235.
8. El-Hosary, A.A.A., 2020a. Estimation of genetic variability using line X tester technic in yellow maize and stability analysis for superior hybrids using different stability procedures. J. Plant Production, Mansoura Univ., 11(9): 847-854. https://doi.org/10.21608/jpp.2020.118047.
9. El-Hosary, A.A.A., 2020b. Estimation of genetic variability using line x Tester Technic in Yellow Maize and Stability Analysis for Superior hybrids using different stability procedures. J. of Plant Production, Mansoura Univ., 11(9): 847-854. https://doi.org/10.21608/jpp.2020.118047.
10. Neveen Hamouda, M., A.A. El-Hosary, S.A. Sehom, G.Y. Hamam, T.A.E. Saafan and A.A.A. El-Hosary, 2021. Genetical analysis for substantial traits in new yellow maize crosses using line X tester model. Annals of Agric. Sci., Moshtohor, 59(1): 17-30.
11. Sedhom, S.A., M.E. El-Badawy, A.A.A. El-Hosary, M.S. Abd El-Latif, A.M.S. Rady, M.M.A. Moustafa, S.A. Mahmoud, O.A.M. BAdr, S.A. Abo-MArzoka, K.A. Baiumy and M.M. El-Nahas, 2021. Molecular markers and GGE biplot analysis for selecting higher-yield and drought-tolerant maize hybrids. Agronomy Journal, 113(5): 3871-3885. https://doi.org/10.1002/agj2.20778.
12. Sedhom, S.A., M.H. Tag El-Din, M.E. El-Badawy and M.A. El-Bakey, 2012. Breeding for grain yield, yield components and quality traits in yellow maize (*Zea mays*, L.). Proc. 13th Int. Conf. Agron. Fac. of Agric. Benha Univ., Egypt, 9- 10 September, 332-351.
13. El-Badawy, M.El.M., 2013. Heterosis and combining ability in maize using diallel crosses among seven new inbred lines. Asian J. Crop Sci., 5(1): 1-13.
14. Mahesh, N., M.C. Wali, M.V.C. Gowda, B.N. Motagi and N.F. Uppinal, 2013. Genetic analysis of grain yield, starch, protein and oil content in single cross hybrids of maize. Karnataka J. Agric. Sci., 26(2): 185- 189.
15. Ahmed, S., S. Begum, M.A. Islam, M. Ratna and M.R. Karim, 2017. Combining ability estimates in maize (*Zea mays* L.) Through line × tester analysis. Bangladesh J. Agril. Res., 42(3): 425-436.
16. Kamara, M.M. and M.R. Rehan, 2015. Combining ability in maize under two nitrogen levels and assessing genetic diversity using RAPD marker. J. Plant Production, Mansoura Univ., 6(12): 2051-2067.
17. Youstina, Sedhom, A.S., M.M.A. Ali, H.A. Awaad and H.A. Rabie, 2016. Heterosis and factor analysis for some important traits in new maize hybrids. Zagazig J. Field Crop Sci., 43(3): 711-728.
18. Omnya Turkey, H., S.A. Sedhom, M.EL.M. El-Badawy and A.A.A. El-Hosary, 2018. Combining ability analysis using diallel crosses among seven inbred lines of corn under two sowing dates. Annals of Agric. Sci. Moshtohor, 56(2): 293-304.
19. El-Badawy, M.El.M. and S.A.S. Mehasen, 2011. Multivariate analysis for yield and its components in maize under zinc and nitrogen fertilization levels. Aust. J. Basic App. Sci., 5(2): 3008-3015.
20. Filipovic, M., M. Babic, N. Delic, G. Bekavac and V. Babic, 2014. Determination relevant breeding criteria by the path and factor analysis in maize. Genetika, 46(1): 49-58.
21. Sayedzavar, J., M. Norouzi and S. Aharizad, 2015. Relationships of morphological characters and yield components in corn hybrids under water deficit stress. Biological Forum- An Int. J., 7(1): 1512-1519.
22. Steel, R.G.D., J.H. Torrie and D.A. Dicky, 1997. Principles and Procedures of Statistics, A Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York, pp: 352-358.

23. Kempthorne, O., 1957. An Introduction to Genetics Statistics, 1st eds, pp: 457-71. John wiley and sons, New York.
24. Snedocor, G.W. and W.G. Cochran, 1967. Statistical methods. 6th Edition, Iowa State Univ., Press. Ames, Iowa, USA.
25. Cattell, E.B., 1965. Factor analysis: An introduction to essentials. I. The purpose and the underlying models. Biometrics, 21: 190-215.
26. Walton, P.D., 1972. Factor analysis of yield in spring wheat (*Triticum aestivum*, L.). Crop Sci., 12: 731-733.
27. Meseka, S.K., A. Menkir, A.E.S. Ibrahim and S.O. Ajala, 2013. Genetic analysis of maize inbred lines for tolerance to drought and low nitrogen. JONARES, 1: 29-36.
28. El-Naggar, A.M.M., R. Shabana, M.M. M. Attal and T.H. Al-Khalil, 2015. Regression of Grain Yield of Maize Inbred Lines and Their Diallel Crosses on Elevated Levels of Soil-Nitrogen. International Journal of Plant & Soil Sci., 4(6): 499-512. https://www.semanticscholar.org/paper/Genetic-analysis-of-maize-inbred-lines-for-to-and-Meseka-Menkir/556f2bd568615fd9102430ec27cf15b7d38b5d76.
29. Ogunniyan, D.J., D.K. Ojo, S.A. Olakojo and O.A. Talabi, 2019. Diallel analysis of maize inbred lines for agronomic traits in nitrogen stress and optimal conditions. Ghana J. Agric. Sci., 54(1): 10-23.
30. El-Gazzar, I.A.I., 2021. Combining ability of new yellow maize inbred lines and superiority of their hybrids to check cultivars. J. Plant Production, Mansoura Univ., 12(5): 585-589. DOI: 10.21608/JPP.2021.178934.
31. Singh, P.K., N. Singh, A.K. Singh, J.P. Shahi and M. Rao, 2013. Heterosis relation to combining ability in quality protein maize (*Zea mays* L.). Biolife Journal, 1(2): 65-69.
32. Panda, S., M.C. Wali, R.M. Kachapur and S.I. Harlapur, 2017. Combining ability and heterosis analysis of single cross hybrids of maize (*Zea mays* L.). Int. J. Curr. Microbiol. App. Sci., 6(10): 2608-2618.
33. Patil, M.S., B.N. Motagi and R.M. Kachapur, 2020. Heterosis and Combining Ability Studies in Maize (*Zea mays* L.) for Drought Tolerance, TLB Disease Resistance and Productivity in Northern Dry Tract of Karnataka. Int. J. Curr. Microbiol. App. Sci., 9(10): 1054-1064. https://doi.org/10.20546/ijcmas.2020.910.126.
34. Beiragi, M.A., B.A. Sar, H.S. Geive, M.N. Alhossini, A. Rahmani and A.B. Gharibdoosti, 2012. Application of the multivariate analysis method for some traits in maize. African J. Agric. Res., 7(10): 1524-1533.
35. Khodarahmpour, Z., 2013. Study of Some Quantitative Traits in Maize (*Zea mays* L.) Inbred Lines under The Drought Stress Using Multivariate Analysis. Intl. J. Agri. Crop Sci., 5(14): 1547-1552.