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Heterosis and Combining Ability for Some Important Traits of Maize Under Two Nitrogen Fertilization Levels

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Abstract

This investigation was undertaken at the Experimental Farm of the Faculty of Agriculture, Moshtohor, Benha University during the two summer growing seasons of 2018 and 2019. To estimate combining ability under two nitrogen levels and superiority% relative two check hybrids for five quantitative characters. N levels and genotypes mean squares were significant for all studied traits. Mean squares due to genotypes x N levels were significant obtained for all studied traits. SCA was higher than GCA for all studied traits revealing that the non-additive effects were controlled these traits. The overall study of GCA effects suggested that parents M65, M66 and M48 were significant for general combiner for grain yield, M70 and M57 for earliness and M50 and M70 for short plants and ear stature. However, the genotypes M65xM10, M17xM10, M37xM10 and M48xCLM550 showed high SCA effect for grain yield plant^{-1}. The maximum heterosis was recorded by the cross M48xCLM550 in combined across nitrogen levels they out-yielded SC128 and SC2031 reached 18.00 and 14.00%, respectively. 100-grain weight were correlated significantly with grain yield with r values being 0.707** in the combined analysis. Factor analysis for combined across N levels divided characters of maize into three factors accounted for 78.63% of the total variability. The first factor contributed by 39.14% included ear length, ear diameter, No. rows ear^{-1}, No. kernels row^{-1}, 100-kernel weight and shelling%. The second factor accounted for 24.83% and is mainly loaded by days to 50% tasseling and silking. The third factor accounted for 14.66% is mainly described by plant and ear heights.

Key words: Combining ability, Factor analysis, Heterosis, Maize, Nitrogen levels.

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops used in the human diet and feed component for livestock around world. In terms of total world production and the average over the last five years, maize out ranked paddy rice and wheat **(Huma *et al,* 2019)**. The cultivated area of maize in Egypt during 2020 year is about 2,614,146 fed of which, yellow maize reached 691, 756 fed. The average grain yield fed was about 2.6 ton fed^{-1} **(Bulletin of Agricultural 2020)**. Increasing maize production became one of the most important goals of the Egyptian agricultural policy to face the human and animal demands. Maximizing food and agricultural production, depends mainly on promoting high yielding maize hybrids to cover the mounting consumption of maize. This depends mostly on producing 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.

Gene action is an important to produce superior hybrids and both types of combining ability helps breeder 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 **Dagne *et al* (2010), Girma *et al* (2015), Al-Naggar *et al* (2016), Ahmed *et al* (2017), Sugiharto *et al* (2018), Elmyhun *et al* (2020) and Keimeso *et al* (2020**).

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. **Wani *et al* (2017), El-Hosary (2020) and Sedhom *et al*. (2021).** reported that the GxE interaction variance is very important to detect stable genotypes. Furthermore, the magnitude of genetic components for a certain traits 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.

Exploitation of heterosis on commercial for a particular locally requires isolation of suitable inbred and development of hybrids. To accomplish this task, one has to know the genetic diversity of the available germplasm and the combining ability of the parents. For improving the yield potential of varieties and hybrids, the decision should be made on the choice of the right parent for hybridization.

The main objectives of this investigation are to:

1) Determine hybrid performance for the studied parental combination.

2) Establish the magnitude of both general combining ability (GCA) and specific combining ability (SCA) effects and their interaction with two N levels.
3) Estimate superiority of F_1s over two check hybrids for studied traits.
4) Estimate correlation coefficients and factor analysis

Materials and Methods

Ten new developed inbred lines of maize along with two testers inbred lines were used in this study. These parental inbred lines had considerable variability regarding grain yield and some other agronomic traits. The name and origin of these parents are presented in Table (1).

-The Experimental Work

Line x tester scheme was used in this work, the selected ten new inbred lines along to two testers were planted in three planting dates during 2018 summer season. The parental 10 crosses were top crossed to the two testers giving a total of 20 top crosses.

In 2019 season, the obtained twenty top crosses along with two check hybrids (S.C. 10 and S.C 30 k 8) were grown under two nitrogen levels, i.e., 80 and 120 kg N/fed in two adjacent experiments. Each experiment was laid out in Randomized Complete Block Design with three replications. Each plot consisted of one ridge of 5 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.

Table 1. The name and origin of the studied twelve parental inbred lines.

#	Parent name	Origin	Country
Lines			
1	**M17**	**Giza 2**	**Egypt**
2	**M28**	**Giza 2**	**Egypt**
3	**M37**	**Cairo 1**	**Egypt**
4	**M47**	**Cairo 1**	**Egypt**
5	**M48**	**Pioneer 514**	**Egypt**
6	**M50**	**Pioneer (Fatah)**	**Egypt**
7	**M57**	**Giza 2**	**Egypt**
8	**M65**	**Giza 2**	**Egypt**
9	**M66**	**Pioneer 514**	**Egypt**
10	**M70**	**Cairo 1**	**Egypt**
Testers			
T1	**M10**	**Cairo 1**	**Egypt**
T2	**CLM550**	**CYMMT**	**CYMMT**

Days to 50% tasseling and silking were recorded. Random sample of 10 guarded plants in each plot was taken to evaluate plant height (cm), ear height (cm) and grain yield plant^{-1} (g) which was adjusted for 15.5% moisture.

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 **Kemptheorn (1957)**. The combined analysis of the two experiments was carried out whenever homogeneity of variance was detected **(Steel and Torrei 1987)**. Relative superiority according to **Singh *et al* (2004)** expressed as the percentage deviation of the F_1 mean performance from SC128 and SC2031 was also estimated. Simple correlation coefficient was estimated according to **Snedecor and Cochran (1980).** Correlation coefficients were used to calculate factor analysis according to **Cattell (1965)**.

Results and Discussion

Analysis of variance.

Analyses of variance for days to 50% tasseling, Days to 50% silking, plant height, ear height and grain yield plant^{-1} under the two and across nitrogen levels are presented in **Table 2**. Results indicated that significant mean squares to environment (nitrogen levels) were detected for all studied traits, revealing the different between the two studied environments. Also, mean squares due to crosses, lines and tester x lines were significant for all studied traits. This indicates the wide diversity between the parental materials used in the present study. Significant crosses x nitrogen levels mean squares were obtained for all studied traits revealing that the performance of crosses differed from one N level to another.

Table 2. Analysis of variance for days to 50% tasseling, days to 50% silking, plant height, ear height and grain yield plant^{-1} of maize genotypes under two nitrogen levels as well as combined analysis

	d.f		Days to 50% tasseling			Days to 50% silking			Plant height (cm)		
S.O.V.	**S**	**C**	**N1**	**N2**	**C**	**N1**	**N2**	**C**	**N1**	**N2**	**C**
E		**1**			267311**			294073**			7442946**
Rep	**2**		1.27	0.32		0.02	2.45		120.52	138.02*	
Rep/E		**4**			0.79			1.23			129.2*
Cross (C)	**19**	**19**	10.91**	12.14**	20.98**	14.28**	17.18**	28.31**	317.0**	323.5**	562.6**
Lines (L)	**9**	**9**	12.86**	13.82**	24.43**	18.60**	25.71**	28.31**	221.9**	309.7**	451.0**
Testers (T)	**1**	**1**	12.15**	30.82**	40.83**	5.40*	17.07**	40.74**	299.2**	1392.0**	1491.0**
L x T	**9**	**9**	8.82**	8.37**	15.33**	10.96**	8.66**	20.83**	414.1**	218.6**	571.0**
C x E		**19**			2.06**			16.72**			78.0**
L x E		**9**			2.26**			3.15**			80.6**
T x E		**1**			2.13			3.57**			200,2**
L x T x E		**9**			1.86*			2.89*			61.8*
Error	**38**	**76**	0.86	1.40	1.13	1.72	1.98	1.85	47.2	33.0	40.1
variance GCA			0.05	0.09	0.06	0.08	0.19	0.13	2.2	2.3	0.1
variance SCA			2.65	2.32	2.37	3.08	2.23	2.48	122.3	61.8	88.4
GCA x E					0.07			0.14			0.2
SCA x E					2.61			2.83			95.7

	d.f		Ear height (cm)			Grain yield plant^{-1} (g)		
S.O.V.	**S**	**C**	**N1**	**N2**	**C**	**N1**	**N2**	**C**
E		**1**			2003688**			3447795**
Rep	**2**		240.5**	30.0		18.3	13.8	
Rep/E		**4**			135.2*			16.0
Cross (C)	**19**	**19**	157.5**	184.6**	282.3**	1935.8**	1241.2**	2696.2**
Lines (L)	**9**	**9**	155.5**	207.1**	295.6**	1594.8**	1375.1**	2768.1**
Testers (T)	**1**	**1**	470.4**	582.8**	1050.2**	3226.6**	570.4*	541.8*
L x T	**9**	**9**	124.8**	117.8**	183.8**	2133.4**	1181.8**	2863.5**
C x E		**19**			59.7*			480.8**
L x E		**9**			67.0*			201.7
T x E		**1**			3.0			3255.2**
L x T x E		**9**			58.8*			451.6**
Error	**38**	**76**	44.8	36.3	40.5	191.6	158.2	174.9
variance GCA			0.7	1.5	1.1	4.4	1.3	1.8
variance SCA			26.6	27.1	23.8	647.2	341.2	448.1
GCA x E					29.9			1.2
SCA x E					1.1			540.3

* and ** significant at 0.05 and 0.01 levels of probability, respectively E= Environment C= combined analysis

Mean performances of F1 hybrids, SC 128 and SC 2031 are presented in **Table 3**. The crosses M57xM10, M57xCLM550 and M70xCLM550 were earlier than SC 128 and SC 2031 for both traits of flowering. 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. These results trend agree with those obtained by **Girma *et al* (2015), Al-Naggar *et al* (2016) and Ahmed *et al* (2017).**

The cross M50xCLM550 gave the lowest mean value of plant and ear heights compared with the check hybrids. However, the crosses M48xM10 and M65xM10 gave the highest value for plant height and ear height. The choice between taller plants with highest ear and shorter plants with reduced ear height depends on the breeder's objective. From the point of view for the breeder the highest plant gave high biomass is vital for high production especially for silage on the same time the low ear position is important for resistance to stem lodging on the other hand, short plant is important in produce hybrid response positively in high density. The crosses M48xCLM550, M65xM10, M66xCLM550 and M50xCLM550 gave the highest values of grain yield plant^{-1} compared with the check hybrids. Also, the mention crosses in the first N level and the combined across them had significant superiority over the check hybrid. These genotypes exhibited significant increase of traits contributing to grain yield. This enables the breeder to conduct appropriate selection of the most desirable crosses combination. The result is in agreement with the finding of (**Singh and Shahi, 2010, El Hosary and El Gamal (2013), Melkamu, 2013, Sugiharto *et al*, 2018, Elmyhun *et al*, 2020 and Keimeso *et al*, 2020**)

Combining ability analysis.

Mean squares due to both general and specific combining abilities for days to 50% tasseling, days to 50% silking, plant height, ear height and grain yield plant^{-1} are presented in **Table 2**. Results indicated that mean squares due to SCA were much higher than those of GCA for all studied traits indicating the predominance of non-additive gene action in controlling these trait. Meanwhile, the interaction between both types of combining abilities and nitrogen levels revealed that SCA x N levels mean squares were much higher than those of GCA x N levels. Such results indicated that SCA effects were more influenced by nitrogen levels than GCA.

Estimations of GCA effects (g_i) for individual parental inbred lines for each trait in both nitrogen levels as well as combined analysis are presented in **Table 4**. Results indicated that the tester M_{10} was the best general combiner for days to 50% tasseling in both and cross nitrogen levels and days to 50% silking under high N levels and combined data. This is true because it expressed the highest negative and significant GCA effects for these traits. Also, the tester CLM55O expressed the most negative and significant GCA effects for plant height in the second nitrogen level and combined data, for ear height in the first, second N levels and combined data and grain yield plant^{-1} under the first N level. Parental inbred line M50 expressed the highest negative and significant GCA effects for days to 50% tasseling in the second N level, for plant height and ear height under both environments. Parent M57 was the best general combiner for days to 50% tasseling under the first N level and combined data, days to 50% silking under the first, second N levels as well as combined data, and grain yield plant^{-1} in the second N level and combined data.

Specific combining ability (SCA) effects for days to 50% tasseling, days to 50% silking, plant height, ear height and grain yield plant^{-1} at first, second N levels and combined data are presented in **Table 5**.

For days to 50% tasseling, five, three and five top crosses expressed negative and significant SCA effects in the first, second N levels as well as combined data, respectively. However, the most desirable SCA effects for this trait were obtained for the top crosses M26xM10 and M70xCLM550 in both and across nitrogen level (**Table 5**).

Concerning days to 50% silking, three, four and five top crosses exhibited negative and significant SCA effects under N_1, N_2 and combined data, respectively. However, the best SCA effects for this trait were obtained for the top cross M17xM10 and M70xCLM550 in both and across nitogen levels. These results are in the line of (**Amiruzzaman *et al*, 2013, Mieso *et al*, 2016, Tolera *et al*, 2017, Yazachew *et al*, 2017, Gemechu *et al*, 2018, Elmyhun *et al*, 2020 and Keimeso *et al*, 2020**) who report highly significant positive and negative SCA effect for days to 50% tasseling and silking in combining ability study of early maturing maize.

For plant height, six, three and five top crosses gave negative and significant SCA effects under N_1, N_2 and combined data, respectively. However, the most desirable SCA effects for this trait were detected for the top cross M_{65} x CLM550 recording -11.60, -11.77 and -11.68 in the three respective cases.

Regarding ear height, none of the studied top crosses expressed significant desirable SCA effects in the first and second N levels. However, two crosses namely M70xM10 (-6.72) and M45xCLM550 (-5.62) expressed negative and significant SCA effects for this trait in the combined analysis. These results agreed with the finding of (**Tolera *et al*, 2017, Yazachew *et al*, 2017, Gemechu *et al*, 2018,El Hosary 2020, Elmyhun *et al*, 2020 and Keimeso *et al*, 2020**) who reported highly significant positive and negative SCA effect for plant and ear heights.

Concerning grain yield plant^{-1}, three, three and five top crosses exhibited positive and significant SCA effects under N_1, N_2 and combined data, respectively.

Table 3. Mean performance of crosses and check varieties for days to 50% tasseling and silking, plant height, ear height, grain yield^{-1} plant under two nitrogen levels and combined data.

	Days to 50% tasseling			Days to 50% silking			Plant height (cm)		
Genotypes	**N1**	**N2**	**C**	**N1**	**N2**	**C**	**N1**	**N2**	**C**
M17x M10	53.33	54.00	53.67	56.67	56.67	56.67	276.67	299.00	276.67
M28x M10	52.00	53.00	52.50	55.00	58.33	56.67	276.67	294.00	276.67
M37x M10	53.00	53.33	53.17	56.33	57.00	56.67	273.33	296.67	273.33
M47x M10	51.33	54.67	53.00	53.67	57.67	55.67	283.33	284.00	283.33
M48x M10	53.67	54.00	53.83	56.67	57.00	56.83	295.33	297.33	295.33
M50x M10	55.33	57.33	56.33	57.00	57.67	57.33	284.00	287.67	284.00
M57x M10	52.00	53.00	52.50	53.67	53.33	53.50	293.00	295.33	293.00
M65x M10	53.67	54.67	54.17	56.67	57.00	56.83	307.67	308.00	307.67
M66x M10	51.33	53.67	52.50	58.00	58.00	58.00	281.33	288.00	281.33
M70x M10	54.00	54.33	54.17	55.67	56.00	55.83	282.67	283.33	282.67
M17xCLM550	56.67	57.00	56.83	60.33	60.33	60.33	291.00	291.67	291.00
M28xCLM550	56.33	57.33	56.83	60.00	60.00	60.00	281.33	282.00	281.33
M37xCLM550	55.67	58.67	57.17	58.33	61.00	59.67	290.00	298.67	290.00
M47xCLM550	53.00	55.33	54.17	56.00	58.33	57.17	276.67	279.33	276.67
M48xCLM550	52.00	55.67	53.83	55.00	57.33	56.17	273.67	274.67	273.67
M50xCLM550	55.00	58.33	56.67	57.00	61.33	59.17	259.67	263.33	259.67
M57xCLM550	50.00	52.33	51.17	52.33	53.00	52.67	283.33	290.00	283.33
M65xCLM550	56.00	56.33	56.17	58.00	59.00	58.50	280.00	280.00	280.00
M66xCLM550	52.67	53.67	53.17	56.00	56.00	56.00	295.33	297.33	295.33
M70xCLM550	51.33	51.67	51.50	52.33	53.00	52.67	278.33	280.00	278.33
SC 128	54.00	54.67	54.33	55.67	55.67	55.67	277.00	279.67	277.00
SC 2031	54.00	54.33	54.17	56.00	56.33	56.17	273.00	275.00	273.00
LSD 5%	1.64	2.03	1.84	2.01	2.18	2.09	10.49	8.86	10.49
LSD 1%	2.15	2.66	2.42	2.63	2.86	2.75	13.76	11.62	13.76

	Ear height (cm)			Grain yield plant^{-1} (g)		
Genotypes	**N1**	**N2**	**C**	**N1**	**N2**	**C**
M17x M10	148.00	156.67	152.33	162.67	207.33	185.00
M28x M10	141.67	152.00	146.83	170.33	200.67	185.50
M37x M10	145.00	158.33	151.67	196.33	202.67	199.50
M47x M10	154.00	155.00	154.50	193.33	202.00	197.67
M48x M10	161.33	161.67	161.50	150.33	214.67	182.50
M50x M10	142.67	143.33	143.00	161.33	205.33	183.33
M57x M10	143.33	155.00	149.17	183.33	213.33	198.33
M65x M10	160.67	161.33	161.00	223.67	235.00	229.33
M66x M10	150.00	154.33	152.17	191.00	208.00	199.50
M70x M10	140.00	140.67	140.33	154.67	168.00	161.33
M17xCLM550	146.00	155.33	150.67	150.33	152.33	151.33
M28xCLM550	142.67	143.00	142.83	186.67	192.33	189.50
M37xCLM550	142.67	143.33	143.00	161.33	189.33	175.33
M47xCLM550	137.33	145.33	141.33	189.00	195.67	192.33
M48xCLM550	146.67	142.67	144.67	239.67	240.67	240.17
M50xCLM550	132.67	133.33	133.00	207.00	210.00	208.50
M57xCLM550	150.67	155.67	153.17	185.00	186.00	185.50
M65xCLM550	147.67	149.33	148.50	197.67	200.00	198.83
M66xCLM550	136.67	159.33	148.00	226.33	228.00	227.17
M70xCLM550	147.67	148.67	148.17	190.67	201.00	195.83
SC 128	146.00	148.00	147.00	198.67	205.67	202.17
SC 2031	144.00	145.00	144.50	209.33	212.00	210.67
LSD 5%	10.69	9.28	10.01	21.55	19.79	20.69
LSD 1%	14.02	12.17	13.13	28.26	25.95	27.13

The result were comparable with the findings of several authors (**Matin *et al,* 2017, Ahmed *et al,* 2017, Kuselan *et al,* 2017, Andayani *et al,* 2018, Elmyhun *et al,* 2020 and Keimeso *et al,* 2020**).

Table 4. General combining ability effects for days to 50% tasseling and silking, plant height, ear height and grain yield plant^{-1} under both and across nitrogen levels**.**

Trait	Days to 50% tasseling			Days to 50% silking			Plant height (cm)		
	N1	N2	C	N1	N2	C	N1	N2	C
Testers									
M10	-0.45**	-0.72**	-0.58**	-0.30	-0.53*	-0.42*	2.23	4.82**	3.52**
CLM550	0.45**	0.72**	0.58**	0.30	0.53	0.42*	-2.23	-4.82**	-3.53**
L.S.D. (gi) 5%	0.33	0.42	0.27	0.47	0.50	0.34	2.46	2.06	1.60
L.S.D. (gi) 1%	0.44	0.56	0.35	0.62	0.66	0.45	3.23	2.70	2.11
L.S.D. (gi-gj) 5%	0.47	0.60	0.47	0.66	0.71	0.60	3.48	2.91	2.78
L.S.D. (gi-gj) 1%	0.62	0.79	0.61	0.87	0.94	0.78	4.57	3.82	3.65
Lines									
M_{17}	1.58**	0.58	1.08**	2.27**	1.10	1.68**	0.67	6.82**	3.74*
M_{28}	0.75*	0.25	0.50	1.27*	1.77**	1.52**	-4.17	-0.52	-2.34
M_{37}	0.92*	1.08*	1.00 **	1.10*	1.60**	1.35**	-1.50	9.15**	3.83*
M_{47}	-1.25**	0.08	-0.58	-1.40**	0.60	-0.40	-3.17	-6.85**	-5.01**
M_{48}	-0.58	-0.08	-0.33	-0.40	-0.23	-0.32	1.33	-2.52	-0.59
M_{50}	1.75**	2.92**	2.33**	0.77	2.10**	1.43**	-11.33**	-13.02**	-12.18**
M_{57}	-2.42**	-2.25	-2.33**	-3.23**	-4.23**	-3.73**	5.00	4.15	4.58*
M_{65}	1.42**	0.58	1.00**	1.10*	0.60	0.85*	10.67**	5.48*	8.07**
M_{66}	-1.42**	-1.25**	-1.33**	0.77	-0.40	0.18	5.17	4.15	4.66*
M_{70}	-0.75*	-1.92**	-1.33**	-2.23**	-2.90**	-2.57**	-2.67	-6.85**	-4.76**
L.S.D. (gi) 5%	0.74	0.95	0.60	1.05	1.12	0.77	5.50	4.60	3.58
L.S.D. (gi) 1%	0.98	1.25	0.79	1.38	1.48	1.01	7.23	6.04	4.71
L.S.D. (gi-gj) 5%	1.05	1.34	0.85	1.48	1.59	1.09	7.78	6.50	5.07
L.S.D. (gi-gj) 1%	1.38	1.76	1.12	1.95	2.09	1.43	10.22	8.55	6.66

Trait	Ear height (cm)			Grain yield plant^{-1} (g)		
	N1	N2	C	N1	N2	C
Testers						
M10	2.80*	3.12**	2.96**	-7.33**	3.08	-2.13
CLM550	-2.80*	-3.12**	-2.96**	7.33**	-3.08	2.13
L.S.D. (gi) 5%	2.40	2.16	1.61	4.95	4.50	3.35
L.S.D. (gi) 1%	3.15	2.83	2.12	6.51	5.92	4.40
L.S.D. (gi-gj) 5%	3.39	3.05	2.79	7.01	6.37	5.80
L.S.D. (gi-gj) 1%	4.45	4.01	3.67	9.21	8.37	7.62
Lines						
M_{17}	1.13	5.28*	3.21	-29.53**	-22.78**	-26.16**
M_{28}	-3.70	-3.22	-3.46	-7.53	-6.12	-6.83
M_{37}	-2.03	0.12	-0.96	-7.20	-6.62	-6.91
M_{47}	-0.20	-0.55	-0.38	5.13	-3.78	0.67
M_{48}	8.13**	1.45	4.79**	8.97	25.05**	17.01**
M_{50}	-8.20**	-12.38**	-10.29**	-1.87	5.05	1.59
M_{57}	1.13	4.62	2.88	-1.87	-2.95	-2.41
M_{65}	8.30**	4.62	6.46**	24.63**	14.88**	19.76**
M_{66}	-2.53	6.12*	1.79	22.63**	15.38**	19.01**
M_{70}	-2.03	-6.05*	-4.04*	-13.37*	-18.12**	-15.74**
L.S.D. (gi) 5%	5.36	4.82	3.60	11.08	10.06	7.48
L.S.D. (gi) 1%	7.04	6.34	4.74	14.56	13.23	9.84
L.S.D. (gi-gj) 5%	7.57	6.82	5.10	15.67	14.23	10.58
L.S.D. (gi-gj) 1%	9.95	8.96	6.70	20.59	18.71	13.91

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

Table 5. Specific combining ability effects for days to 50% tasseling and silking, plant height, ear height and grain yield plant^{-1} under both nitrogen levels as well as combined data.

Trait	Days to 50% tasseling			Days to 50% silking			Plant height (cm)		
Genotype	**N1**	**N2**	**C**	**N1**	**N2**	**C**	**N1**	**N2**	**C**
M17x M10	-1.22*	-1.05	-1.13**	-1.53*	-1.53*	-1.53**	-9.40*	1.43	-3.98
M28x M10	-1.72**	-1.72**	-1.72**	-2.20**	-0.53	-1.37*	-4.57	3.77	-0.40
M37x M10	-0.88	-2.22**	-1.55**	-0.70	-1.70*	-1.20*	-10.57**	-3.23	-6.90**
M47x M10	-0.38	0.12	-0.13	-0.87	-0.03	-0.45	1.10	0.10	0.60
M48x M10	1.28*	-0.38	0.45	1.13	0.13	0.63	8.60*	9.10*	8.85**
M50x M10	0.62	-0.05	0.28	0.30	-1.53*	-0.62	9.93*	9.93*	9.93**
M57x M10	1.45**	0.78	1.12*	0.97	0.47	0.72	2.60	0.43	1.52
M65x M10	-0.72	-0.38	-0.55	-0.37	-0.70	-0.53	11.60**	11.77**	11.68**
M66x M10	-0.22	0.45	0.12	1.30	1.30	1.30*	-9.23*	-6.90	-8.07**
M70x M10	1.78**	1.78**	1.78**	1.97**	1.80*	1.88**	-0.07	-0.57	-0.32
M17xCLM550	1.22*	1.05	1.13**	1.53	1.53*	1.53**	9.40*	-1.43	3.98
M28xCLM550	1.72**	1.72**	1.72**	2.20**	0.53	1.37*	4.57	-3.77	0.40
M37xCLM550	0.88	2.22**	1.55**	0.70	1.70*	1.20*	10.57**	3.23	6.90**
M47xCLM550	0.38	-0.12	0.13	0.87	0.03	0.45	-1.10	-0.10	-0.60
M48xCLM550	-1.28*	0.38	-0.45	-1.13	-0.13	-0.63	-8.60*	-9.10*	-8.85**
M50xCLM550	-0.62	0.05	-0.28	-0.30	1.53*	0.62	-9.93*	-9.93*	-9.93**
M57xCLM550	-1.45**	-0.78	-1.12*	-0.97	-0.47	-0.72	-2.60	-0.43	-1.52
M65xCLM550	0.72	0.38	0.55	0.37	0.70	0.53	-11.60**	-11.77**	-11.68**
M66xCLM550	0.22	-0.45	-0.12	-1.30	-1.30	-1.30*	9.23*	6.90	8.07**
M70xCLM550	-1.78**	-1.78**	-1.78**	-1.97**	-1.80*	-1.88**	0.07	0.57	0.32
L.S.D (gi) 5%	1.05	1.05	0.85	1.48	1.48	1.09	7.78	7.78	5.07
L.S.D (gi) 1%	1.38	1.38	1.12	1.95	1.95	1.43	10.22	10.22	6.66
L.S.D (gi-gj) 5%	1.49	1.49	1.48	2.10	2.10	1.88	11.00	11.00	8.78
L.S.D (gi-gj) 1%	1.95	1.95	1.94	2.76	2.76	2.48	14.46	14.46	11.54

Trait	Ear height (cm)			Grain yield plant^{-1} (g)		
Genotype	**N1**	**N2**	**C**	**N1**	**N2**	**C**
M17x M10	-1.80	-2.13	-1.97	13.50	34.83**	24.17**
M28x M10	-3.30	1.70	-0.80	-0.83	11.50	5.33
M37x M10	-1.63	4.70	1.53	24.83**	14.00	19.42**
M47x M10	5.53	2.03	3.78	9.50	10.50	10.00
M48x M10	4.53	6.70	5.62*	-37.33**	-5.67	-21.50**
M50x M10	2.20	2.20	2.20	-15.50	5.00	-5.25
M57x M10	-6.47	-3.13	-4.80	6.50	21.00**	13.75*
M65x M10	3.70	3.20	3.45	20.33*	24.83**	22.58**
M66x M10	3.87	-5.30	-0.72	-10.33	-2.67	-6.50
M70x M10	-6.63	-6.80	-6.72**	-10.67	-9.17	-9.92
M17xCLM550	1.80	2.13	1.97	-13.50	-34.83**	-24.17**
M28xCLM550	3.30	-1.70	0.80	0.83	-11.50	-5.33
M37xCLM550	1.63	-4.70	-1.53	-24.83**	-14.00	-19.42**
M47xCLM550	-5.53	-2.03	-3.78	-9.50	-10.50	-10.00
M48xCLM550	-4.53	-6.70	-5.62*	37.33**	5.67	21.50**
M50xCLM550	-2.20	-2.20	-2.20	15.50	-5.00	5.25
M57xCLM550	6.47	3.13	4.80	-6.50	-21.00**	-13.75*
M65xCLM550	-3.70	-3.20	-3.45	-20.33*	-24.83**	-22.58**
M66xCLM550	-3.87	5.30	0.72	10.33	2.67	6.50
M70xCLM550	6.63	6.80	6.72**	10.67	9.17	9.92
L.S.D (gi) 5%	7.57	7.57	5.10	15.67	15.67	10.58
L.S.D (gi) 1%	9.95	9.95	6.70	20.59	20.59	13.91
L.S.D (gi-gj) 5%	10.71	10.71	8.83	22.16	22.16	18.33
L.S.D (gi-gj) 1%	14.08	14.08	11.60	29.12	29.12	24.09

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

However, the most desirable SCA effects for this trait were obtained for the crosses M48xCLM550 in the first N level (37.33) and M17xM10 in the second N level (34.83) and combined data (24.17). These results were comparable with the finding of (**Amiruzzaman *et al*, 2013, Hailegebrial *et al*, 2015, Mieso *et al*, 2016, Matin *et al*, 2017, Tolera *et al*, 2017, Yazachew *et al*, 2017, Gemechu *et al*, 2018, Elmyhun *et al*, 2020 and Keimeso *et al*, 2020**) who reported highly significant positive SCA effect for grain yield.

Heterosis

Standard heterosis for days to 50% tasseling, days to 50% silking, plant height, ear height and grain yield plant^{-1} relative to both checker at N_1, N_2 levels and combined analysis are presented in Table (6).

For days to 50% tasseling, seven, one and one crosses expressed negative and significant heterotic effects relative to SC 128 under first, second N levels and combined data, respectively. The respective heterotic effects relative to SC2031 were recorded in respect seven, one and two cross (Table 6). However, the best heterotic effects for days to 50% tasseling relative to SC 128 were detected for the crosses M65xCLM550 at both and across nitrogen level.

Regarding days to 50% silking, negative and significant heterotic effects were detected in two, three and three crosses relative to SC128 and in four, three and three crosses relative to SC30K8 under first, second N levels and combined analysis, respectively. Meantime, the most desirable heterotic effects relative to both checkers were detected for crosses M57xCLM550 and M70xCLM550 under all environments.

Concerning plant height, one cross M50xCLM550 expressed the most desirable heterotic effects relative to SC128 and SC30K8 recording (-6.26 and -4.88), (-5.84 and -4.24) and (-6.05 and -4.56) under first, second N level and combined data, respectively.

For ear height, the same result of plant height even obtained where the cross M50xCLM550 exhibited the negative and significant heterotic effects relative to both checkers under all environments.

Regarding grain yield plant^{-1}, three, three and three crosses expressed positive and significant heterotic effects relative to SC128 under first, second N level and combined data, respectively (Table 6). The respective crosses for heterosis relative to SC2031 were one, two and one. However, the most desirable heterotic effects for grain yield plant^{-1} relative to SC128 and SC2031 were detected for the cross M48xCLM550 recording 20.04, 17.02 and 18.80 relative to SC128 and 14.44, 13.52 and 14.00 relative to SC2031, respectively.

In conclusion, the crosses M65xCLM550, M50xCLM550 and M48xCLM550 were considered of prime importance for corn breeding towards earliness, short plant stature and grain yield plant^{-1}.

Standard heterosis in grain yield was identified with wide range of variability (negative to positive) by **Uddin *et al* (2006), Uddin *et al* (2008), Amiruzzaman *et al* (2010), Amiruzzaman *et al* (2013), Hailegebrial *et al* (2015), Mieso *et al* (2016), Matin *et al* (2017), Tolera *et al* (2017), Yazachew *et al* (2017), Gemechu *et al* (2018), Elmyhun *et al* (2020) and Keimeso *et al* (2020)**.

Correlation coefficient.

Coefficients of phenotypic correlation among the studied characters in maize over the first and second N levels as well as combined analysis of both N levels are shown in **Tables 7, 8 and 9**. Data indicate that 100-grain weight, days to 50% silking, days to 50% tasseling, ear height and plant height had the greatest influence on grain yield with r values being 0.469*, -0.200, -0.180, 0.170 and 0.057, respectively in the first N levels (Table 7).

Negative and positive correlation coefficients were detected between grain yield and each of days to 50% tasseling, days to 50% silking, plant height, ear height and 100-grain weight. 100-grain weight was found to be significant and positively correlated with grain yield in the second N level.

On combined analysis of both N levels, the results indicated that days to 50% tasseling, days to 50% silking, plant height, ear height and 100-grain weight. 100-grain weight were correlated with grain yield had the influence on grain yield with r values being -0.247, -0.229, -0.103, 0.065 and 0.707**, respectively. These results are in accordance with **Lingaiah *et al* (2014), Kinfe *et al* (2015), Kumar *et al* (2015), Sayedzavar *et al* (2015), Sedhom *et al.* (2016) and Aman *et al*. (2020).**

Table 6. Standard heterosis for days to 50% tasseling and silking, plant height, ear height, grain yield^{-1} plant under two nitrogen levels and combined data.

Trait	Days to 50% tasseling						Days to 50% silking						Plant height (cm)					
	Relative to SC128			Relative to SC2031			Relative to SC128			Relative to SC2031			Relative to SC128			Relative to SC2031		
Cross	N1	N2	C	N1	N2	C	N1	N2	C	N1	N2	C	N1	N2	C	N1	N2	C
M17x M10	-1.23	-1.22	-1.23	-1.23	-0.61	-0.92	1.80	1.80	1.80	1.19	0.59	0.89	-0.12	6.91	3.41	1.34	8.73**	5.05**
M28x M10	-1.23	-1.22	-1.23	-1.23	-0.61	-0.92	-1.20	4.79*	1.80	-1.79	3.55	0.89	-0.12	5.13	2.51	1.34	6.91**	4.14*
M37x M10	-3.70*	-3.05	-3.37	-3.70*	-2.45	-3.08	1.20	2.40	1.80	0.60	1.18	0.89	-1.32	6.08	2.40	0.12	7.88**	4.01*
M47x M10	-1.85	-2.44	-2.15	-1.85	-1.84	-1.85	-3.59	3.59	0.00	-4.17*	2.37	-0.89	2.29	1.55	1.92	3.79	3.27	3.53
M48x M10	-4.94**	0.00	-2.45	-4.94**	0.61	-2.15	1.80	2.40	2.10	1.19	1.18	1.19	6.62**	6.32**	6.47**	8.18**	8.12**	8.15**
M50x M10	-0.62	-1.22	-0.92	-0.62	-0.61	-0.62	2.40	3.59	2.99	1.79	2.37	2.08	2.53	2.86	2.69	4.03*	4.61**	4.32*
M57x M10	2.47	4.88**	3.68*	2.47	5.52**	4.00*	-3.59	-4.19*	-3.99*	-4.17*	-5.33**	-4.75*	5.78**	5.60**	5.69**	7.33**	7.39**	7.36**
M65x M10	-3.70*	-3.05*	-3.37	-3.70*	-2.45	-3.08	1.80	2.40	2.10	1.19	1.18	1.19	11.07**	10.13**	10.60**	12.70**	12.00**	12.35**
M66x M10	-0.62	0.00	-0.31	-0.62	0.61	0.00	4.19*	4.19*	4.19*	3.57	2.96	3.26	1.56	2.98	2.28	3.05	4.73**	3.89*
M70x M10	-4.94**	-1.83	-3.37	-4.94**	-1.23	-3.08	0.00	0.60	0.30	-0.60	-0.59	-0.59	2.05	1.31	1.68	3.54	3.03	3.28
M17xCLM550	0.00	-0.61	-0.31	0.00	0.00	0.00	8.38**	8.38**	8.38**	7.74**	7.10**	7.42**	5.05**	4.29*	4.67**	6.59**	6.06**	6.33**
M28xCLM550	4.94**	4.27**	4.60**	4.94**	4.91**	4.92**	7.78**	7.78**	7.78**	7.14**	6.51**	6.82**	1.56	0.83	1.20	3.05	2.55	2.80
M37xCLM550	4.32**	4.88**	4.60**	4.32**	5.52**	4.92**	4.79**	9.58**	7.19**	4.17*	8.28**	6.23**	4.69*	6.79**	5.75**	6.23**	8.61**	7.42**
M47xCLM550	3.09*	7.32**	5.21**	3.09*	7.98**	5.54**	0.60	4.79**	2.69	0.00	3.55	1.78	-0.12	-0.12	-0.12	1.34	1.58	1.46
M48xCLM550	-1.85	1.22	-0.31	-1.85	1.84	0.00	-1.20	2.99	0.90	-1.79	1.78	0.00	-1.20	-1.79	-1.50	0.24	-0.12	0.06
M50xCLM550	-3.70*	1.83	-0.92	-3.70*	2.45	-0.62	2.40	10.18**	6.29**	1.79	8.88**	5.34**	-6.26**	-5.84**	-6.05**	-4.88*	-4.24**	-4.56*
M57xCLM550	1.85	6.71**	4.29*	1.85	7.36**	4.62**	-5.99**	-4.79**	-5.39**	-6.55**	-5.92**	-6.23**	2.29	3.69	2.99	3.79	5.45**	4.62*
M65xCLM550	-7.41**	-4.27	-5.83**	-7.41**	-3.68	-5.54**	4.19*	5.99**	5.09**	3.57	4.73*	4.15*	1.08	0.12	0.60	2.56	1.82	2.19
M66xCLM550	3.70*	3.05*	3.37	3.70*	3.68	3.69*	0.60	0.60	0.60	0.00	-0.59	-0.30	6.62**	6.32**	6.47**	8.18**	8.12**	8.15**
M70xCLM550	-2.47	-1.83	-2.15	-2.47	-1.23	-1.85	-5.99**	-4.79**	-5.39**	-6.55**	-5.92**	-6.23**	0.48	0.12	0.30	1.95	1.82	1.89

Trait	Ear height (cm)						Grain yield plant^{-1} (g)					
	Relative to SC128			Relative to SC2031			Relative to SC128			Relative to SC2031		
Cross	N1	N2	C	N1	N2	C	N1	N2	C	N1	N2	C
M17x M10	1.37	5.86	3.63	2.78	8.05*	5.42	-18.12**	0.81	-8.49	-22.29**	-2.20	-12.18*
M28x M10	-2.97	2.70	-0.11	-1.62	4.83	1.61	-14.26**	-2.43	-8.24	-18.63**	-5.35	-11.95*
M37x M10	-0.68	6.98	3.17	0.69	9.20**	4.96	-1.17	-1.46	-1.32	-6.21	-4.40	-5.30
M47x M10	5.48	4.73	5.10	6.94	6.90*	6.92	-2.68	-1.78	-2.23	-7.64	-4.72	-6.17
M48x M10	10.50**	9.23*	9.86**	12.04**	11.49**	11.76**	-24.33**	4.38	-9.73	-28.18**	1.26	-13.37**
M50x M10	-2.28	-3.15	-2.72	-0.93	-1.15	-1.04	-18.79**	-0.16	-9.23	-22.93**	-3.14	-12.97**
M57x M10	-1.83	4.73	1.47	-0.46	6.90*	3.23	-7.72	3.73	-1.90	-12.42*	0.63	-5.85
M65x M10	10.05**	9.01*	9.52**	11.57**	11.26**	11.42**	12.58*	14.26**	13.44**	6.85	10.85*	8,86
M66x M10	2.74	4.28	3.51	4.17	6.44*	5.31	-3.86	1.13	-1.32	-8.76	-1.89	-5.30
M70x M10	-4.11	-4.95	-4.54	-2.78	-2.99	-2.88	-22.15**	-18.31**	-20.20**	-26.11**	-20.75**	-23.48**
M17xCLM550	0.00	4.95	2.49	1.39	7.13*	4.27	-24.33**	-25.93**	-25.14**	-28.18**	-28.14**	-28.16**
M28xCLM550	-2.28	-3.38	-2.83	-0.93	-1.38	-1.15	-6.04	-6.48	-6.27	-10.83*	-9.28	-10.05*
M37xCLM550	-2.28	-3.15	-2.72	-0.93	-1.15	-1.04	-18.79**	-7.94	-13.27*	-22.93**	-10.69*	-16.77**
M47xCLM550	-5.94	-1.80	-3.85	-4.63	0.23	-2.19	-4.87	-4.86	-4.86	-9.71	-7.70	-8.70
M48xCLM550	0.46	-3.60	-1.59	1.85	-1.61	0.12	20.64**	17.02**	18.80**	14.49**	13.52**	14.00**
M50xCLM550	-9.13*	-9.91**	-9.52**	-7.87*	-8.05*	-7.96*	4.19	2.11	3.13	-1.11	-0.94	-1.03
M57xCLM550	3.20	5.18	4.20	4.63	7.36*	6.00	-6.88	-9.56	-8.24	-11.62*	-12.26**	-11.95*
M65xCLM550	1.14	0.90	1.02	2.55	2.99	2.77	-0.50	-2.76	-1.65	-5.57	-5.66	-5.62
M66xCLM550	-6.39	7.66*	0.68	-5.09	9.89**	2.42	13.93*	10.86*	12.37*	8.12	7.55	7.38
M70xCLM550	1.14	0.45	0.79	2.55	2.53	2.54	-4.03	-2.27	-3.13	-8.92	-5.19	-7.04

* and ** significant at 5% and 1% level of probability, respectively

Table 7. Correlation coefficient between yield plant^{-1} and attributes characters of maize hybrids under 80 kg N fed^{-1}

characters	1	2	3	4	5	6
1- Days to 50% tasseling	1.000					
2- Days to 50% silking	0.8320**	1.000				
3- Plant height	0.0310	0.0950	1.000			
4- Ear height	-0.0234	-0.1440	0.5310*	1.000		
5- 100-grain weight	-0.2420	-0.1570	0.3430	0.1710	1.000	
6- Yield plant^{-1}	-0.2820	-0.2350	-0.1390	-0.0580	0.7080**	1.000

* and ** significant at 5% and 1% level of probability, respectively

Table 8. Correlation coefficient between yield plant^{-1} and attributes characters of maize hybrids under 120 kg N fed^{-1}

characters	1	2	3	4	5	6
1- Days to 50% tasseling	1.000					
2- Days to 50% silking	0.8440**	1.000				
3- Plant height	-0.2790	-0.1680	1.000			
4- Ear height	-0.5830**	-0.3800	0.7800**	1.000		
5- 100-grain weight	0.2390	0.1840	-0.0720	-0.0600	1.000	
6- Yield plant^{-1}	-0.1800	-0.2000	0.0570	0.1700	0.4690*	1.000

* and ** significant at 5% and 1% level of probability, respectively

Table 9. Correlation coefficient between yield plant^{-1} and attributes characters of maize hybrids under combined over both nitrogen levels

characters	1	2	3	4	5	6
1- Days to 50% tasseling	1.000					
2- Days to 50% silking	0.8540**	1.000				
3- Plant height	-0.1330	-0.0590	1.000			
4- Ear height	-0.4430*	-0.2660	0.7090**	1.000		
5- 100-grain weight	0.0430	-0.0250	0.1570	0.1180	1.000	
6- Yield plant^{-1}	-0.2470	-0.2290	-0.1030	0.0650	0.7070**	1.000

* and ** significant at 5% and 1% level of probability, respectively

-Factor analysis.

Results of factor analysis are presented in **Table 10 and Fig 1**. Factors were constructed using the principal factor analysis to establish the dependent relationship between yield components of maize in the first N level. The results indicated that factor analysis divided ten characters of maize into three main factors. The three factors explained 80.36% of the total variation in the dependent structure. Factor 1 accounted for 42.03% of the total variability. This factor contained six variables namely: ear length, ear diameter, No. rows ear^{-1}, No. kernels row^{-1}, 100-kernel weight and shelling%. The variables that were included into factor 1 were positively correlated with the factor. These variables were of almost equal importance and had high communality with factor 1. Factor 2 included two variables which accounted for 21.96% of the total variability in the dependent structure. The two variables were days to 50% tasseling and silking. The two variables had almost equal importance and high communality. Factor 3 included two variables which accounted for 16.37% of the total variability in the dependent structure. The two variables were plant and ear heights. The results of the present investigation indicate that, the estimated communalities, (**Table 10**) were adequate for conclusions where the two factors together accounted for 80.36% of the total communality.

The factor analysis divided the 10 variables of maize in the second N level into four factors, which explained 79.29% of the total variability in the dependence structure in **Table (11) and Fig (2).**

A summary of the composition of variables of the four factors with loadings is given in **Table (11).** The first factor included the variables ear diameter, No. rows ear^{-1}, 100-kernel weight and shelling% which accounted for 31.70% of the total variance. It had high loadings for four variables. These variables were of almost equal importance and communal with factor 1. Factor 2 consisted of days to 50% tasseling and silking which accounted for 23.12% of the total variability in the dependence structure. Factor 3 included two variables which accounted for 13.97% of the total variability in the dependent structure the two variables were plant and ear heights. Factor 4 included two variables which accounted for 10.50% of the total variability in the dependent structure the two variables were ear length and No. kernels row^{-1}. The factors 1, 2, 3 and 4 included the variables associated with maize parameters. The results indicated that the estimated whole communality was rather adequate to interpret the major portion of variations in the dependence structure in that the four factors altogether accounted for 79.29% of the total variation in the dependence structure (**Table 11**).

On the combined analysis of both N levels are shown **Table 12 and Fig 3**. The results indicated that factor analysis divided ten characters of maize into three main factors. The first factor accounted for 39.14% and is primarily related to ear length, ear diameter, No. rows ear^{-1}, No. kernels row^{-1}, 100-kernel weight and shelling%. The second factor accounted for 24.83% and is mainly loaded by days to 50% tasseling and silking. The third factor accounted for 14.66% and is mainly described by plant and ear heights. From the previous results, it can be concluded that, factor analysis is the one that can be used successfully for analysis of large amounts of multivariate data, and should be applied more frequently in field experiments. The greatest benefit of factor analysis can be delineating areas of further researches designed to test the validity of the suggested factors. Using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationships of variables and can help to determine the nature and sequence of traits to be selected in a breeding program. These results are in the line with those reported by **Sayedzavar *et al* (2015) and Sedhom *et al.* (2016).**

Table 10. Summary of factor loading for some important traits of maize hybrids under 80 kg N fed^{-1}

Variables	Loading	Percentage of total communiality	
Factor 1			**42.03**
Ear length	**0.93**	**18.68**	
Ear diameter	**0.83**	**16.73**	
No. of rows / ear	**0.75**	**15.04**	
No. of kernels/ row	**0.92**	**18.54**	
100 kernel weight	**0.87**	**17.51**	
Shelling %	**0.67**	**13.49**	
Factor 2			**21.96**
Days to 50% tasseling	**0.949**	**49.92**	
Days to 50% silking	**0.952**	**50.08**	
Factor 3			**16.37**
Plant height	**0.882**	**51.10**	
Ear height	**0.844**	**48.90**	
Cummulative variance			**80.36**

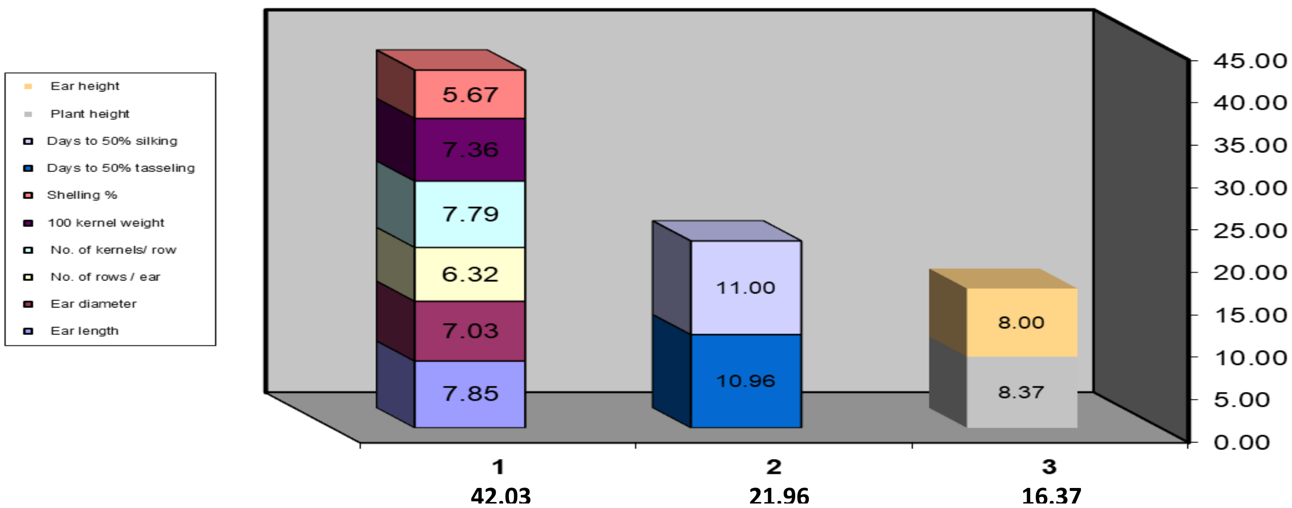

Fig. (1): Factor loading for some important characters of maize under 80 kg nitrogen level.

Table 11. Summary of factor loading for some important traits of maize hybrids under 120 kg N fed^{-1}

Variables	Loading	Percentage of total communiality
Factor 1		**31.7**
Ear diameter	0.773	28.21
No. of rows/ ear	0.321	11.72
100 kernel weight	0.906	33.07
Shelling %	0.74	27.01
Factor 2		**23.12**
Days to 50% tasseling	0.984	52.06
Days to 50% silking	0.906	47.94
Factor 3		**13.97**
Plant height	0.858	53.63
Ear height	0.742	46.38
Factor 4		**10.5**
Ear length	0.674	
No. of kernels/ row	0.911	57.48
Cummulative variance		**79.29**

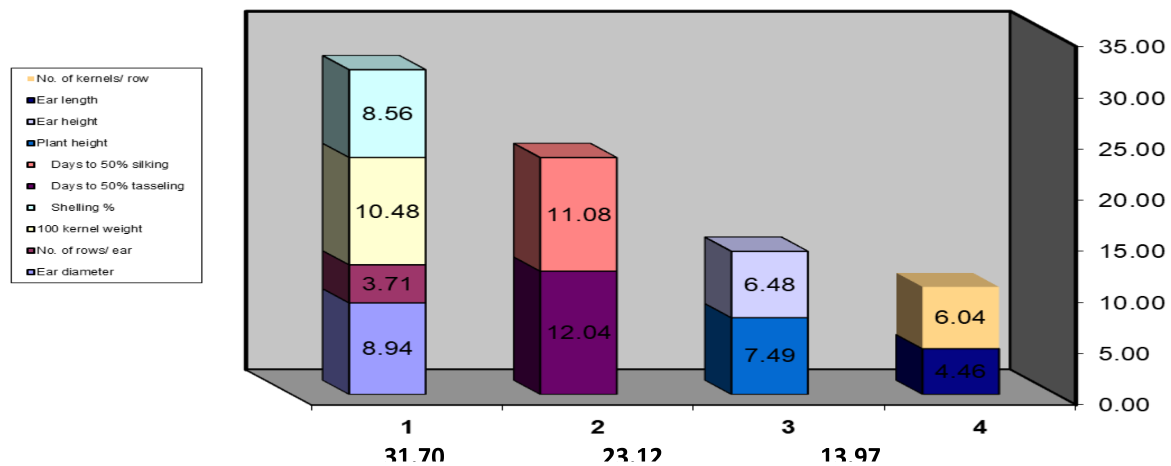

Fig. (2): Factor loading for some important characters of maize under 120 kg N/ fed.

Table 12. Summary of factor loading for some important traits of maize hybrids under combined over both nitrogen levels

Variables	Loading	Percentage of total communiality
Factor 1		**39.14**
Ear length	0.88	18.54
Ear diameter	0.81	16.98
No. of rows / ear	0.67	14.11
No. of kernels/ row	0.80	16.77
100 kernel weight	0.93	19.63
Shelling %	0.66	13.98
Factor 2		**24.83**
Days to 50% tasseling	0.934	49.60
Days to 50% silking	0.949	50.40
Factor 3		**14.66**
Plant height	0.93	51.52
Ear height	0.875	48.48
Cummulative variance		**78.63**

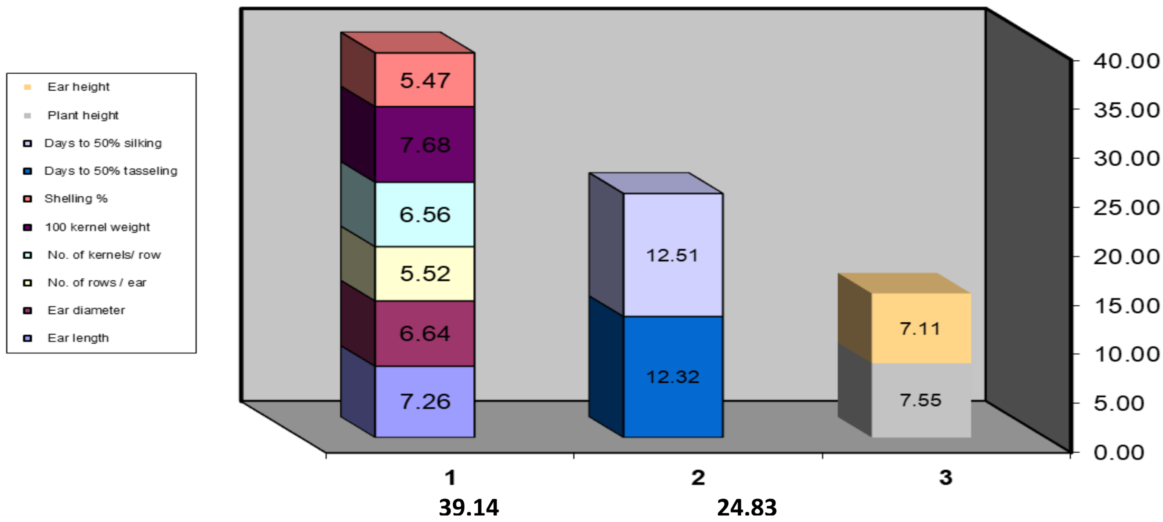

Fig. (3): Factor loading for some important characters of maize combined over both nitrogen levels.

Conclusion

From the study, it can be concluded that better performing inbred lines with desirable GCA, cross combinations with desirable SCA effects and crosses with noticeable level of heterosis above the standard check for grain yield and other grain yield related traits were successfully identified. These genotypes constitute a source of valuable genetic materials that could be successively used for future breeding work in the development of maize hybrids with desirable traits' composition for highland sub-humid agro-ecology of Egypt.

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قوة الهجين والقدرة على الإئتلاف لبعض الصفات الهامة فى الذرة الشامية تحت مستويين مختلفين من التسميد النتروجينى

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يهدف البحث لدراسة قوة الهجين و القدرة على التآلف وتفاعلها مع معدلين من التسميد النيتروجيني للهجن الناتجة بنظام التهجين القمى لعشرة سلالات مع كشافين. صممت التجربة فى قطاعات كاملة العشوائية ذات ثلاث مكررات فى مزرعة مركز البحوث الزراعية – كلية الزراعة بمشتهر– جامعة بنها خلال موسمين زراعين 2018 و2019م. تم تقييم ال 20 هجين فردى (10 سلالات x 2 كشاف) من الذرة الشامية البيضاء بالأضافة الى هجينين تجاريين هما (فردى 128 وفردى 2031) كمقارنة. دونت النتائج لعينة من 10 نباتات أختيرت عشوائيا من كل قطعة تجريبية وأجرى التحليل المعتاد للتباين لكل تجربة على حده كما أجرى التحليل المشترك فى حالة تجانس التباينات فى التجربتين. وقد قدرت قوة الهجين لكل من الصفات المدروسة فى صورة تباينات ومقارنة بهجن المقارنة كنسبة مئوية للانحراف قيمة الجيل الاول من قيمة تلك الأصناف المقارنة كما قدرت القدرة على التألف بتطبيق ما أقترحه **كمبثورن 1957** لتحليل السلالهx الكشاف.

__ويمكن تلخيص النتائج المتحصل عليها كالاتى:–__

- كانت متوسطات التباين لكل من مستويات التسميد الأزوتي والهجن معنوية فى كل الصفات تحت الدراسة. كما كان متوسط التباين للتفاعل بين الهجن و مستويات التسميد الأزوتي معنوي لكل الصفات تحت الدراسة.
- كانت التباينات للقدرة العامة والخاصة علي التآلف معنوية لبعض الصفات تحت الدراسة. أظهرت السلالات الأبوية أرقام M48 & M66 & M65 قدرة جيدة عامة على التآلف لصفة محصول الحبوب للنبات و أرقام M57 & M70 قدرة جيدة عامة على التآلف لصفة التبكير وأرقام M70 & M50 قدرة جيدة عامة على التآلف لصفة طول النبات وإرتفاع الكوز.
- أظهرت التراكيب الوراثية M48xCLM550 & M37xM10 & M17xM10 & M65xM10 معنوية للقدرة الخاصة علي التآلف لصفة محصول الحبوب للنبات.
- كان التباين الراجع لقوة الهجين عالي وموجب المعنوية بقيم (**18.80 & **14.00%) مقارنة بالهجن (SC30k8 & SC128) علي الترتيب وذلك لصفة محصول حبوب النبات فى التحليل الضام لمستويات التسميد الأزوتي.
- أظهر تحليل معامل الارتباط وجود تلازم معنوى جدا بين محصول النبات ووزن 100 حبة.
- تم تقسيم تحليل العامل المتغيرات العشر إلى ثلاث عوامل يشتمل الأول منها طول و قطر وعدد سطور الكوز ، عدد حبوب السطر ، وزن ال100 حبة والنسبة المئوية للتصافي ويسهم هذا العامل بحوالى 39.14% من التباين الكلى والانتخاب لهذه الصفات يعطى محصول عالى من الحبوب. ويحتوى العامل الثانى على صفتي طرد 50% للنورات المؤنثة والمذكرة ويسهم هذا العامل بحوالي 24.83% من التباين الكلى. بينما يحتوي العامل الثالث على صفتي إرتفاع النبات والكوز ويسهم هذا العامل ب 14.66% من التباين الكلى.