Combining Abilities for Yield and Its Components through Line by Tester Analysis in Maize under Two Plant Densities

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ABSTRACT

The field experiments were carried out in two successive summer seasons of 2014 and 2015 at the experimental farm of the Faculty of Agriculture, Menoufia University, in El-Raheb, Egypt to evaluate yellow inbreed lines of maize through line x tester analysis.

Top crosses were made each of the twenty-five S_4 lines and the two testers by hand to give a total of 50 top crosses in 2014season. In the second season (2015) two adjacent experiments were conducted under two plant densities. The first experimental represented a normal plant density (ND) of 24000 plant/fad., (hills spaced 25 cm apart and one plant/ hill). The second experimental represented plant density (HD) of 30000 plants/fad. (hills spaced 20 cm a part and one plant hill). In each experiment the 50 top crosses as well as the two checks hybrids Giza 168 and Giza 176 were grown in a Randomized Complete Block Design with three replications. Performance of inbred lines varied with plant densities. Parental lines L3, L4, L5, L14 and L23 were the best in mean performance and general combining ability effects under this study. Results indicated that σ^2 SCA was more important than σ^2 GCA for all studied traits, plant height at the combined analysis. Non-additive gene action was more affected by the interaction with environments than the additive effects. The top crosses L12 x T2 and L17 x T2 showed desirable significant SCA effects for shortness and the low ear placement under low plant density. Thirteen top crosses showed significant positive SCA effects for grain yield (ard/fad) under HD, LD and combined analysis. Also, the top crosses L1 x T2 and L11 x T2 were significant under high plant density. The top crosses (L3 x T1 and L14 x T2) and (L3 x T2) showed significant number of ears per plot and 100-kernel weight relative to two check varieties for the top cross L3 x T1 gave the higher value of heterosis relative to the two checks for ear weight and grain yield.

Key words: Heterosis, combining ability, gene effect, top cross analysis, plant density, maize.

INTRODUCTION

Maize (*Zea mays*, L.) is a major cereal crop in Egypt and all over the world which grown principally during the summer season. Maize ranked the third cereal crop in the world, after wheat and rice. Maize is used as a major sours of oil, starch and carbohydrate.

Like other field crops, maize growth and grain yield is also affected by several factors. Maize genotypes differ in tolerance to high density (Maddonni *et al*., 2001). Maize grain yield is affected by variations in plant density due to its monoecious floral organization, its low tillering ability, and its short flowering period (Vega *et al*.,2001). As plant density increases, grain yield per plant decreases, while grain yield per unit area increase (Gollar and Patil, 2000).

The ultimate goal of most breeding programs is the production of improved hybrids for commercial use through the evaluation of lines for high yielding ability. Top-cross method which was suggested by Davis (1927) has become a standard procedure for evaluating general combining ability of inbred lines proposed to use in hybrid development. Combining ability was first defined by Sprague and Tatum (1942). General combining ability (GCA) is related to additive genetic effects, while specific combining ability (SCA) is related to dominance and epistatic effects (non-additive effects) of the genes. Line x tester analysis technique which was recommended by Kempthrone (1957) as one of the effective techniques available to estimate GCA and SCA effects and assists in selecting desirable parental lines and crosses. The main objectives of the present work were:

1) To evaluate twenty-five inbred lines of maize.
2) To provide information about the suitable testers for testing combining ability of inbred lines.
3) To estimate general and specific combining ability for several traits of maize.
4) To estimate percentage heterosis for all studied traits relative to (Giza 168 and Giza 176) as checks.

MATERIALS AND METHODS

This study was carried out of the experimental Farm of the Faculty of Agriculture, Menoufia University Egypt during two successive seasons of 2014 and 2015.

1. Plant materials

A total of twenty-five (*Zea mays*, L.) yellow S_4 lines derived through selection from wide genetic base Gemmeiza yellow population, Bank 365, Bank 357, Dtb cycle 2 and Population 59 E. These lines were selected on bases of yielding ability and desirable plant aspects. The plant materials were selected with a wide range of diversity for several traits. Two testers of yellow maize were used in. The two testers in represented wide heterozygosity (Giza 658 and Sids 3120). Two checks namely; Giza 168 and Giza 176 were presented in Table (1).

2. Field experiments

In the first summer. (2014), kernels of the twenty-five S_4 lines and two testers were split sown on 20th may and 1st June to avoid differences in flowering time and secure enough hybrid seed. All possible top crosses combination were made between the twenty-five S_4 lines and two testers by hand giving a total of 50 top crosses. In the second summer (2015), two adjacent experiments were conducted on two plant densities (24 thousand plants (normal plant density) and 30 thousand plants (high plant density)/ faddan. In each experiment the 50 top crosses as well as the two checks were growing in a Randomized Complete Block Design with three replications. The first experimental plots consisted of one ridge of 6m length and 70 cm. width. Hills were spaced at 25 cm apart with one plant/ hill. The second experiment plots consisted of one ridge of 6m length and 70 cm. width. Hills were spaced 20 cm apart with one plant /hill. The other agricultural practices for maize growing were applied.

3. Studied characters

Data were recorded for Plant height (cm), Ear height (cm), Ear length (cm), Ear diameter (cm), Number of rows / ear, Number of kernels / row, Number of ears / plot, 100- Kernel weight (g), Ear weight (g) and Grain yield (ard/fad).

4. Statistical analysis:

4.1- Analysis of variance:

An ordinary analysis of variance was performed for all traits in each experiment. Homogeneity of error variances was tested for each trait over experiments. This test revealed the validity of combined analysis of the two densities for all the studied traits. When differences among top crosses were significant, line x tester analysis according to Kempthorne, (1957) was applied. GCA and SCA effects and their standard errors (S.E) were estimated according to Singh and Chaudhary, (1985).

Table 1: The code number, name, source and origin of the studied twenty-five S4 lines and the two testers.

Code number	Name	Source	Origin
L1	2	Gm. Yellow Pop.	Egypt
L2	4	Gm. Yellow Pop.	Egypt
L3	5	Gm. Yellow Pop.	Egypt
L4	9	Gm. Yellow Pop.	Egypt
L5	10	Bank 356	Egypt
L6	11	Bank 356	Egypt
L7	13	Bank 356	Egypt
L8	14	Bank 356	Egypt
L9	15	Bank 356	Egypt
L10	16	Bank 357	Egypt
L11	17	Bank 357	Egypt
L12	18	Bank 357	Egypt
L13	19	Bank 357	Egypt
L14	20	Bank 357	Egypt
L15	22	Dtb. Cycle 2	Egypt
L16	24	Dtb. Cycle 2	Egypt
L17	25	Dtb. Cycle 2	Egypt
L18	27	Dtb. Cycle 2	Egypt
L19	30	Dtb. Cycle 2	Egypt
L20	33	Dtb. Cycle 2	Egypt
L21	35	Dtb. Cycle 2	Egypt
L22	40	Pop. 59 E	Egypt
L23	41	Pop. 59 E	Egypt
L24	44	Pop. 59 E	Egypt
L25	48	Pop. 59 E	Egypt
T1	658	Gz.	Egypt
T2	3120	Sd.	Egypt

Heterosis for studied traits was computed for individual hybrids as the percentage increase of F_1 performance relative to each of the two check hybrids Giza 168 or Giza 176. This was done for each density as well as combined data over both densities.

The check variety heterosis = $[(\overline{F1} - \overline{Check}) / \overline{Check}] \times 100$.

Appropriate L.S.D. values were computed.

RESULTS AND DISCUSSION

1- Analysis of Variance:-

Analysis of variance for the studied traits in separate two densities of plants as well as the combined analysis is presented in Table (2). Test of homogeneity revealed the validity of the combined analyses over both densities.

Crosses mean squares were significant for all the studied traits at both densities of plants as well as the combined analysis, except, ear diameter in both densities of plants as well as the combined analysis indicating the wide diversity between the parental materials used in the present study. Significant crosses x densities of plants mean squares were obtained for plant height, ear height, ear length and number of rows/ear. Lines mean squares were significant for all traits in both densities of plants and the combined analysis except, ear diameter in both densities of plants and the combined analysis. Indicating the wide diversity among those inbred lines. Significant lines x densities of plants mean squares were detected for plant height, ear height and number of rows/ear. These finding indicate that parental inbred lines in their mean performance in this traits. Insignificant mean squares due to testers were obtained for all traits in both densities of plants as well as the combined analysis. Such results indicated narrow range of variability among parental testers. In addition, tester mean squares were much higher than those of lines for most studied traits. The results are in harmony with those obtained by Al-Naggar *et al.*, 2017; Greveniotis *et al.*, 2019 and Koirala *et al.*, 2020. Such results revealed that testers contributed much more to the total variation as compared to lines. Therefore, the total GCA variance for most traits was due to inbred lines. Also, the interaction between testers x densities was insignificant for all traits. This might indicate that testers were not different under any of plants densities. Significant line x tester mean squares were obtained for all traits, except, ear diameter in both densities and the combined analyses.

The magnitude of mean squares due to lines were higher than of testers for most studied traits, indicating that, lines contributed more to total variation for most studied traits. Also, the magnitude of mean squares due to line x densities were higher than testers x densities for most studied traits, indicating that, lines were more affected by environment.

Significant interaction between lines x testers x plant densities mean squares were obtained for plant height, ear height, ear diameter and ear weight.

Similar results were obtained by El-Hosary and Elgammal (2013); Mostafa (2014); El-Shamarka *et al.* (2015); Abd-El Mottalb (2017) and Mostafa (2018).

2- Proportional contribution

The contribution of lines, testers and their interactions over the two densities to total variances were presented in Table (3). The proportion contribution of lines to total variances was much higher than testers in all traits. Also, lines contribution was higher than lines x testers in all traits, except, ear length, ear diameter, 100-kernel weight and ear weight under the two plant densities and their combined data. Also, the contribution of lines x density to total variances was much higher than testers x density in all studied traits. However, a contribution of lines x density to total variance was less than lines x testers x density in all traits, except, plant height, ear length, number of rows per ear and 100-kernel weight. These results might suggest maximum female parent contributed to total variance. These results are in agreement with obtained by Gamea (2019).

3- Mean performance:-

The mean performance of the 50 top crosses for all studied traits under two plant populations and their combined data were shown in Table (4). Only one top cross (L13 x T1) was the check Giza 176 under high plant density. Under low plant density and the combined data all top crosses did not differ significantly from the short check. Five top crosses i.e., (L8 x T2), (L13 x T1) and (L14 x T1) (L12 x T2) and (L15 x T2) expressed lower ear placement, compared to the check Giza 176 under high and low plant densities, respectively. One top cross (L3 x T2) showed longer ear than the higher check, but the value was insignificant under HD.

All crosses exhibited insignificant ear diameters from the best check under this study but thirteen top crosses gave higher values over the best check Giza 168 under high plant density.

Regarding number of rows per ear, the top cross L13 x T2 under HD had significant values relative to the check Giza 168. Four top crosses (L14 x T1, L16 x T1, L20 x T1 and L24 x T2) showed significant values relative to the highest check under LD. from combined data, eight top crosses gave higher values over the best check.

Table 2: Mean squares from single experiment analysis and combined analysis for the studied traits.

S. O. V	d.f		Mean squares												
			Plant height (CM)			Ear height (CM)			Ear length (CM)			Ear diameter (CM)		
	Density	Comb.	HD	ND	Comb.	HD	ND	Comb.	HD	ND	Comb.	HD	ND	Comb.
D		1			243.00			175.55			14.00**			1.30**
Rep / D	2	4	435.50	2433.50**	1434.50	272.67	1086.00**	679.33	8.94**	1.68	5.31	0.09	0.62	0.36
Crosses	49	49	507.28**	777.21**	667.18**	323.47**	531.94**	545.93**	2.38**	3.15**	5.37**	0.13	0.22	0.15
Lines	24	24	571.29**	958.17**	796.88**	342.01**	650.10**	699.08**	2.29*	3.14**	5.27**	0.11	0.17	0.15
Testers	1	1	140.17	661.50*	705.33	266.67	28.17	60.75	0.05	0.06	0.11	0.01	0.11	0.09
Line X Tester	24	24	458.57**	601.08**	535.89**	307.29**	434.76**	413.01**	2.56**	3.28**	5.69**	0.15*	0.27	0.15
Crosses X D		49			617.32**			309.47**			0.15			0.19
Lines X D		24			732.58**			293.04*			0.17			0.12
Testers X D		1			96.33			234.08			0.00			0.02
Line X Tester X D		24			523.76**			329.05**			0.15			0.27*
Error	98	196	186.18	155.95	171.07	116.20	158.62	137.41	1.10	0.73	0.92	0.08	0.21	0.15
σ^2 GCA			-2.54	5.15	4.01	-0.07	-2.36	0.40	-0.03	-0.04	-0.04	0.00	0.00	0.00
σ^2 SCA			90.80	148.38	2.02	63.70	92.05	13.99	0.48	0.85	0.92	0.02	0.02	-0.02
GCA/SCA			-0.03	0.03	1.98	0.00	-0.03	0.03	-0.07	-0.05	-0.04	-0.10	-0.17	-0.11
σ^2 GCA x D					-2.70			-1.62			0.00			0.00
σ^2 SCA x D					117.57			63.88			-0.26			0.04
C V %			5.81	5.36	5.59	9.08	10.74	9.94	5.99	4.75	5.39	6.65	10.66	8.89
G M			234.90	233.10	234.00	118.67	117.30	117.98	17.55	17.98	17.76	4.31	4.32	4.31

*and** indicate significance at 0.05 and 0.01 levels of probability, respectively.

Table 2: Continued …

S. O. V	d.f		Mean squares											
			No. of rows / ear			No. of kernels / row			No. of ears / plot			100-kernel weight (g)		
	Density	Comb.	HD	ND	Comb.	HD	ND	Comb.	HD	ND	Comb.	HD	ND	Comb.
D		1			4.65			9.40			174.65**			1.08
Rep / D	2	4	2.88	0.11	1.49	60.35**	7.29	33.82	7.71**	1.13	4.42	3.92	4.22	4.07
Crosses	49	49	3.59**	3.70**	3.58**	37.91**	12.64**	46.42**	5.16**	5.97**	9.12**	42.56**	17.71**	56.16**
Lines	24	24	4.75**	4.02**	3.81**	37.91**	14.40**	50.95**	6.13**	6.08**	10.22**	43.33**	15.81**	54.33**
Testers	1	1	6.00	0.67	5.33	0.24	0.33	0.56	2.16	0.17	1.76	5.61	0.33	4.32
Line X Tester	24	24	2.33	3.50**	3.28*	36.68**	11.40**	43.80**	4.33**	6.10**	8.32**	43.33**	20.33**	60.15**
Crosses X D		49			3.71**			4.13			2.01			4.10
Lines X D		24			4.96**			1.35			1.98			4.80
Testers X D		1			1.33			0.00			0.56			1.61
Line X Tester X D		24			2.56			4.28			2.11			3.50
Error	98	196	1.71	1.20	1.46	10.61	4.44	7.53	1.51	1.39	1.45	5.74	5.95	5.85
σ^2 GCA			0.08	-0.03	0.01	-0.40	-0.10	-0.18	0.00	-0.07	-0.02	-0.47	-0.30	-0.38
σ^2 SCA			0.21	0.77	0.12	8.69	2.32	6.59	0.94	1.57	1.04	12.53	4.79	9.44
GCA/SCA			0.36	-0.04	0.07	-0.05	-0.04	-0.03	0.00	-0.05	-0.02	-0.04	-0.06	-0.04
σ^2 GCA x D					0.01			-0.09			-0.02			-0.01
σ^2 SCA x D					0.37			-1.08			0.22			-0.78
C V %			8.86	7.58	8.26	8.36	5.36	7.01	6.67	6.99	6.82	7.82	7.93	7.88
G M			14.76	14.41	14.59	38.93	39.29	39.11	18.41	16.89	17.65	30.62	30.74	30.68

*and** indicate significance at 0.05 and 0.01 levels of probability, respectively.

Table 2: Continued …

S. O. V	d.f		Mean squares					
			Ear weight (g)			Grain yield (ard/fed)		
	Density	Comb.	HD	ND	Comb.	HD	ND	Comb.
D		1			1190.42**			383.75**
Rep / D	2	4	138.07	223.04	180.56	2.57	3.24	2.90
Crosses	49	49	753.92**	463.47**	1036.38**	29.63**	20.40**	49.05**
Lines	24	24	529.45**	445.75**	852.16**	26.86**	21.05**	47.13**
Testers	1	1	170.45	15.49	41.59	0.00	1.14	0.59
Line X Tester	24	24	1002.71**	499.87**	1262.04**	33.63**	20.55**	52.99**
Crosses X D		49			181.02			0.98
Lines X D		24			123.03			0.79
Testers X D		1			144.35			0.55
Line X Tester X D		24			240.54*			1.20
Error	98	196	123.57	122.56	123.07	1.59	1.66	1.63
σ^2 GCA			-16.12	-6.65	-8.74	-0.50	-0.23	-0.35
σ^2 SCA			293.05	125.77	170.25	10.68	6.30	8.63
GCA/SCA			-0.05	-0.05	-0.05	-0.05	-0.04	-0.04
σ^2 GCA x D					-2.64			-0.01
σ^2 SCA x D					39.16			-0.14
C V %			7.29	7.46	7.38	5.99	6.86	6.40
G M			152.39	148.41	150.40	21.07	18.81	19.94

*and** indicate significance at 0.05 and 0.01 levels of probability, respectively.

Table 3: Proportional contribution of lines, testers and their interactions percentage to total variance.

Source	Plant height (CM)			Ear height (CM)			Ear length (CM)			Ear diameter (CM)			No. of rows / ear		
	HD	ND	COM	HD	ND	COM	HD	ND	COM	HD	ND	COM	HD	ND	COM
Due to lines	55.16	60.38	58.50	51.79	59.86	62.72	47.25	48.90	48.05	41.33	37.47	49.30	64.78	53.23	52.11
Due to testers	0.56	1.74	2.16	1.68	0.11	0.23	0.04	0.04	0.04	0.18	1.01	1.26	3.41	0.37	3.04
Due to lines x testers	44.28	37.88	39.34	46.53	40.03	37.05	52.69	51.06	51.91	58.16	61.62	49.62	31.81	46.39	44.85
Due to lines x Densities			58.12			46.38			53.09			30.71			65.51
Due to testers x Densities			0.32			1.54			0.00			0.25			0.73
Due to lines x testers x Densities			41.56			52.08			46.77			68.77			33.76

Table 3: Continued ….

Source	No. of kernels / row			No. of ears / plot			100-kernel weight (g)			Ear weight (g)			Grain yield (ard/fed)		
	HD	ND	COM	HD	ND	COM	HD	ND	COM	HD	ND	COM	HD	ND	COM
Due to lines	52.58	55.78	53.76	58.11	49.90	54.92	49.86	43.73	47.38	34.40	47.11	40.27	44.40	50.54	47.06
Due to testers	0.01	0.05	0.02	0.85	0.06	0.39	0.27	0.04	0.16	0.46	0.07	0.08	0.00	0.11	0.02
Due to lines x testers	47.40	44.16	46.22	41.04	50.05	44.69	49.87	56.23	52.46	65.14	52.83	59.64	55.60	49.34	52.92
Due to lines x Densities			16.05			48.25			57.36			33.29			39.33
Due to testers x Densities			0.00			0.57			0.80			1.63			1.15
Due to lines x testers x Densities			50.82			51.19			41.84			65.08			59.47

Table 4: Mean performance of 50 top crosses for all studied traits under the two plant densities and their combined data.

Cross	Mean											
	Plant height (cm)			Ear height (cm)			Ear length (cm)			Ear diameter (cm)		
	HD	LD	Com	HD	LD	Com	HD	LD	Com	HD	LD	Com
L1 x T1	226.67	240.00	233.34	111.67	128.33	120.00	17.07	17.27	17.17	4.33	4.40	4.37
L1 x T2	240.00	240.00	240.00	126.67	130.00	128.34	17.67	18.13	17.90	4.33	4.00	4.17
L2 x T1	251.67	250.00	250.84	145.00	130.00	137.50	17.47	17.80	17.64	4.33	4.20	4.27
L2 x T2	266.67	266.67	266.67	140.00	146.67	143.34	18.20	18.53	18.37	4.27	4.53	4.40
L3 x T1	246.67	255.00	250.84	128.33	145.00	136.67	19.07	19.40	19.24	4.40	4.47	4.44
L3 x T2	246.67	253.33	250.00	125.00	141.67	133.34	19.53	20.13	19.83	4.53	4.47	4.50
L4 x T1	246.67	230.00	238.34	126.67	116.67	121.67	18.33	18.67	18.50	4.40	4.37	4.39
L4 x T2	220.00	203.33	211.67	116.67	106.67	111.67	18.07	18.47	18.27	4.33	4.33	4.33
L5 x T1	233.33	263.33	248.33	116.67	135.00	125.84	18.67	19.20	18.94	4.60	4.47	4.54
L5 x T2	220.00	230.00	225.00	110.00	115.00	112.50	17.13	17.67	17.40	3.95	4.27	4.11
L6 x T1	253.33	210.00	231.67	126.67	103.33	115.00	18.53	19.07	18.80	4.47	4.13	4.30
L6 x T2	230.00	236.67	233.34	110.00	120.00	115.00	17.07	17.20	17.14	4.53	4.67	4.60
L7 x T1	233.33	216.67	225.00	115.00	103.33	109.17	16.47	16.73	16.60	4.08	4.40	4.24
L7 x T2	260.00	203.33	231.67	131.67	116.67	124.17	18.23	18.60	18.42	4.48	4.20	4.34
L8 x T1	233.33	240.00	236.67	123.33	110.00	116.67	17.87	18.33	18.10	4.27	4.20	4.24
L8 x T2	203.33	230.00	216.67	100.00	110.00	105.00	16.07	15.20	15.64	4.13	4.33	4.23
L9 x T1	226.67	235.00	230.84	130.00	108.33	119.17	18.40	18.93	18.67	3.87	4.53	4.20
L9 x T2	236.67	225.00	230.84	113.33	130.00	121.67	17.73	18.13	17.93	4.33	4.33	4.33
L10 x T1	243.33	226.67	235.00	116.67	116.67	116.67	18.67	19.33	19.00	4.27	4.40	4.34
L10 x T2	260.00	226.67	243.34	131.67	123.33	127.50	16.90	17.27	17.09	4.13	4.00	4.07
L11 x T1	236.67	216.67	226.67	118.33	113.33	115.83	17.57	18.00	17.79	4.40	4.07	4.24
L11 x T2	216.67	250.00	233.34	116.67	140.00	128.34	18.53	19.13	18.83	4.40	4.73	4.57
L12 x T1	233.33	243.33	238.33	120.00	125.00	122.50	16.60	17.07	16.84	4.22	4.60	4.41
L12 x T2	230.00	210.00	220.00	123.33	90.00	106.67	18.63	19.13	18.88	4.67	4.33	4.50
L13 x T1	210.00	236.67	223.34	98.33	108.33	103.33	16.73	16.73	16.73	4.13	4.53	4.33
L13 x T2	236.67	233.33	235.00	120.00	110.00	115.00	17.90	18.33	18.12	4.64	4.47	4.56
L14 x T1	223.33	210.00	216.67	98.33	100.00	99.17	18.33	18.93	18.63	4.53	4.47	4.50
L14 x T2	230.00	233.33	231.67	115.00	115.00	115.00	18.67	19.30	18.99	4.48	4.43	4.46
L15 x T1	243.33	233.33	238.33	128.33	106.67	117.50	16.00	16.47	16.24	4.33	3.93	4.13
L15 x T2	230.00	216.67	223.34	110.00	93.33	101.67	18.03	18.40	18.22	4.20	4.53	4.37
L16 x T1	236.67	243.33	240.00	116.67	116.67	116.67	18.13	18.60	18.37	4.53	4.47	4.50
L16 x T2	223.33	240.00	231.67	120.00	113.33	116.67	16.20	17.00	16.60	4.27	4.20	4.24
L17 x T1	225.00	250.00	237.50	108.33	128.33	118.33	17.93	18.40	18.17	4.23	4.53	4.38
L17 x T2	240.00	203.33	221.67	118.33	100.00	109.17	15.53	16.27	15.90	4.53	4.17	4.35
L18 x T1	250.00	220.00	235.00	126.67	100.00	113.34	17.20	17.40	17.30	3.87	4.33	4.10
L18 x T2	250.00	213.33	231.67	125.00	116.67	120.84	17.13	17.53	17.33	4.47	4.40	4.44
L19 x T1	243.33	213.33	228.33	131.67	106.67	119.17	17.47	17.67	17.57	4.60	4.33	4.47
L19 x T2	223.33	220.00	221.67	106.67	106.67	106.67	16.03	15.67	15.85	4.13	3.80	3.97
L20 x T1	230.00	220.00	225.00	125.00	110.00	117.50	17.67	17.93	17.80	4.17	4.67	4.42
L20 x T2	230.00	243.33	236.67	110.00	123.33	116.67	16.93	17.33	17.13	4.33	4.47	4.40
L21 x T1	240.00	240.00	240.00	113.33	116.67	115.00	16.80	17.53	17.17	4.00	3.92	3.96
L21 x T2	223.33	240.00	231.67	103.33	113.33	108.33	17.27	17.73	17.50	4.00	4.53	4.27
L22 x T1	226.67	240.00	233.34	116.67	123.33	120.00	16.57	16.93	16.75	4.00	4.47	4.24
L22 x T2	255.00	250.00	252.50	133.33	136.67	135.00	17.47	17.80	17.64	4.13	4.27	4.20
L23 x T1	243.33	260.00	251.67	113.33	140.00	126.67	17.93	18.27	18.10	4.63	4.33	4.48
L23 x T2	226.67	233.33	230.00	103.33	110.00	106.67	18.07	18.53	18.30	4.27	4.33	4.30
L24 x T1	230.00	230.00	230.00	130.00	120.00	125.00	17.53	17.93	17.73	4.47	4.13	4.30
L24 x T2	220.00	230.00	225.00	106.67	106.67	106.67	18.00	18.40	18.20	4.00	4.60	4.30
L25 x T1	230.00	256.67	243.34	115.00	110.00	112.50	16.13	16.53	16.33	4.32	3.93	4.13
L25 x T2	230.00	243.33	236.67	116.67	128.33	122.50	17.27	17.67	17.47	4.33	4.33	4.33
168	216.67	206.67	211.67	113.33	103.33	108.33	19.13	16.40	17.77	4.40	4.47	4.44
176	236.67	203.33	220.00	103.33	93.33	98.33	17.93	16.80	17.37	4.33	4.20	4.27
L.S.D 5%	22.11	20.24	18.38	17.47	20.41	14.93	1.70	1.38	0.99	0.46	0.74	0.46
L.S.D 1%	29.27	26.79	24.25	23.12	27.01	19.70	2.25	1.83	1.31	0.61	0.98	0.60

Table 4: Continued …

Cross	Mean								
	No. of rows/Ear			No. of kernels/row			No. of ears/plot		
	HD	LD	Com	HD	LD	Com	HD	LD	Com
L1 x T1	14.67	13.33	14.00	36.00	37.67	36.84	18.00	16.00	17.00
L1 x T2	15.33	14.00	14.67	38.67	39.67	39.17	19.00	17.00	18.00
L2 x T1	15.33	15.33	15.33	38.00	39.00	38.50	18.00	16.67	17.34
L2 x T2	15.33	14.67	15.00	41.00	40.33	40.67	18.33	19.00	18.67
L3 x T1	14.67	14.67	14.67	47.33	44.00	45.67	21.00	19.33	20.17
L3 x T2	15.33	15.33	15.33	46.67	44.33	45.50	20.00	19.67	19.84
L4 x T1	15.33	14.67	15.00	42.00	41.00	41.50	20.00	16.67	18.34
L4 x T2	15.33	14.67	15.00	41.00	40.00	40.50	18.00	17.00	17.50
L5 x T1	12.00	13.33	12.67	44.00	42.00	43.00	20.00	19.00	19.50
L5 x T2	12.67	15.33	14.00	36.33	38.33	37.33	18.33	14.00	16.17
L6 x T1	15.33	14.67	15.00	43.67	41.00	42.34	19.67	17.00	18.34
L6 x T2	12.67	13.33	13.00	36.33	37.67	37.00	16.33	16.00	16.17
L7 x T1	14.00	12.67	13.34	35.00	37.00	36.00	17.33	16.00	16.67
L7 x T2	14.00	14.67	14.34	41.00	40.67	40.84	18.33	17.33	17.83
L8 x T1	15.33	13.33	14.33	39.33	39.67	39.50	18.67	17.33	18.00
L8 x T2	15.33	12.67	14.00	34.33	35.00	34.67	17.33	14.00	15.67
L9 x T1	15.33	14.67	15.00	42.67	40.67	41.67	19.00	18.00	18.50
L9 x T2	14.67	15.33	15.00	39.00	39.33	39.17	18.33	17.33	17.83
L10 x T1	15.33	12.67	14.00	44.33	43.67	44.00	20.67	19.67	20.17
L10 x T2	14.67	13.33	14.00	35.67	38.00	36.84	18.67	17.00	17.84
L11 x T1	14.00	14.67	14.34	38.33	39.33	38.83	18.33	16.67	17.50
L11 x T2	15.33	13.33	14.33	43.33	41.67	42.50	19.00	17.33	18.17
L12 x T1	14.67	13.33	14.00	35.00	37.67	36.34	17.00	16.00	16.50
L12 x T2	17.33	14.00	15.67	44.33	41.67	43.00	19.67	18.67	19.17
L13 x T1	15.33	12.67	14.00	35.67	36.67	36.17	17.67	16.33	17.00
L13 x T2	18.00	14.67	16.34	39.33	39.67	39.50	17.00	17.00	17.00
L14 x T1	16.00	16.67	16.34	42.00	41.00	41.50	19.00	18.00	18.50
L14 x T2	16.00	16.00	16.00	45.33	42.33	43.83	22.00	18.00	20.00
L15 x T1	13.33	12.67	13.00	33.67	36.33	35.00	17.67	14.67	16.17
L15 x T2	14.67	15.33	15.00	40.33	39.67	40.00	18.67	17.67	18.17
L16 x T1	13.33	16.67	15.00	41.00	40.33	40.67	19.33	16.33	17.83
L16 x T2	15.33	12.67	14.00	34.67	37.33	36.00	16.67	16.00	16.34
L17 x T1	14.00	14.67	14.34	39.67	39.67	39.67	18.33	16.33	17.33
L17 x T2	14.67	14.67	14.67	34.00	36.33	35.17	16.33	13.67	15.00
L18 x T1	14.00	15.33	14.67	37.33	38.33	37.83	17.33	16.67	17.00
L18 x T2	14.67	15.33	15.00	36.67	38.33	37.50	18.33	16.33	17.33
L19 x T1	14.67	14.67	14.67	38.00	38.33	38.17	18.67	16.00	17.34
L19 x T2	14.00	14.00	14.00	34.00	35.67	34.84	16.00	15.00	15.50
L20 x T1	13.33	16.67	15.00	38.33	39.33	38.83	17.00	18.00	17.50
L20 x T2	13.33	15.33	14.33	35.67	38.33	37.00	17.00	16.00	16.50
L21 x T1	15.33	14.00	14.67	35.67	38.33	37.00	19.00	16.00	17.50
L21 x T2	15.33	13.33	14.33	37.67	39.00	38.34	19.67	16.67	18.17
L22 x T1	14.67	14.67	14.67	35.00	36.67	35.84	17.33	15.00	16.17
L22 x T2	14.67	14.67	14.67	38.00	39.00	38.50	17.67	17.67	17.67
L23 x T1	15.33	14.67	15.00	39.67	39.67	39.67	17.67	17.33	17.50
L23 x T2	14.00	14.00	14.00	40.67	40.33	40.50	20.00	19.67	19.84
L24 x T1	14.67	13.33	14.00	38.33	39.33	38.83	20.00	18.00	19.00
L24 x T2	14.67	16.67	15.67	40.67	39.67	40.17	19.67	16.67	18.17
L25 x T1	14.00	14.67	14.34	34.33	36.67	35.50	16.67	16.00	16.34
L25 x T2	16.67	14.67	15.67	37.67	38.67	38.17	17.00	16.67	16.84
168	15.33	14.67	15.00	38.67	39.00	38.84	19.00	18.33	18.67
176	13.33	12.67	13.00	40.00	38.00	39.00	19.00	17.33	18.17
L.S.D 5%	2.12	1.77	1.57	5.28	3.41	2.98	1.99	1.91	1.42
L.S.D 1%	2.80	2.35	2.07	6.99	4.52	3.93	2.64	2.53	1.88

Table 4: Continued …

Cross	Mean								
	100 kernel weight (g)			Ear weight (g)			Grain yield (ard/fed)		
	HD	LD	Com	HD	LD	Com	HD	LD	Com
L1 x T1	27.67	28.67	28.17	132.95	144.51	138.73	17.92	17.30	17.61
L1 x T2	31.33	31.67	31.50	153.35	150.25	151.80	21.78	19.11	20.45
L2 x T1	29.67	31.00	30.34	154.87	151.50	153.19	20.95	18.89	19.92
L2 x T2	32.67	32.33	32.50	164.90	144.68	154.79	22.71	20.59	21.65
L3 x T1	37.33	34.67	36.00	168.33	165.73	167.03	26.46	24.02	25.24
L3 x T2	38.67	35.67	37.17	174.21	163.80	169.01	26.11	24.16	25.14
L4 x T1	33.33	32.67	33.00	157.67	169.68	163.68	23.59	21.22	22.41
L4 x T2	32.33	32.33	32.33	167.30	160.07	163.69	22.54	20.38	21.46
L5 x T1	36.67	33.67	35.17	170.51	155.97	163.24	25.55	22.17	23.86
L5 x T2	29.00	29.67	29.34	147.38	165.93	156.66	20.24	17.42	18.83
L6 x T1	34.00	32.67	33.34	170.77	170.27	170.52	25.16	21.74	23.45
L6 x T2	28.33	28.33	28.33	148.18	140.70	144.44	18.09	16.89	17.49
L7 x T1	27.33	27.33	27.33	132.03	131.84	131.94	17.00	15.78	16.39
L7 x T2	32.67	32.67	32.67	170.05	161.44	165.75	23.36	21.00	22.18
L8 x T1	31.67	32.00	31.84	159.07	147.55	153.31	21.99	19.19	20.59
L8 x T2	20.00	26.33	23.17	117.06	140.37	128.72	15.16	14.70	14.93
L9 x T1	33.00	32.67	32.84	164.62	158.26	161.44	23.42	21.30	22.36
L9 x T2	31.00	31.67	31.34	158.35	148.18	153.27	21.76	19.16	20.46
L10 x T1	38.33	34.33	36.33	170.42	156.50	163.46	26.34	23.00	24.67
L10 x T2	28.33	28.67	28.50	132.17	131.65	131.91	18.45	16.68	17.57
L11 x T1	30.67	31.67	31.17	157.42	151.81	154.62	21.64	19.01	20.33
L11 x T2	34.00	33.00	33.50	178.12	164.13	171.13	25.35	21.32	23.34
L12 x T1	27.33	28.00	27.67	139.60	134.60	137.10	17.71	16.07	16.89
L12 x T2	35.33	33.00	34.17	173.09	157.72	165.41	25.46	22.05	23.76
L13 x T1	26.67	27.33	27.00	124.16	134.97	129.57	16.41	16.50	16.46
L13 x T2	31.67	32.00	31.84	171.95	151.39	161.67	21.90	19.27	20.59
L14 x T1	33.67	32.67	33.17	168.41	156.82	162.62	23.95	21.13	22.54
L14 x T2	36.33	33.00	34.67	156.76	173.87	165.32	25.90	23.45	24.68
L15 x T1	24.33	27.00	25.67	121.49	129.57	125.53	16.13	14.19	15.16
L15 x T2	32.00	32.00	32.00	160.31	150.57	155.44	22.27	19.88	21.08
L16 x T1	32.67	32.67	32.67	160.68	167.26	163.97	23.31	20.45	21.88
L16 x T2	27.67	28.00	27.84	141.34	126.31	133.83	17.64	15.15	16.40
L17 x T1	32.00	32.00	32.00	160.74	160.89	160.82	22.07	19.62	20.85
L17 x T2	23.33	26.67	25.00	129.30	135.88	132.59	15.82	13.87	14.85
L18 x T1	29.00	29.67	29.34	152.48	141.85	147.17	19.90	17.69	18.80
L18 x T2	29.00	29.67	29.34	145.61	141.21	143.41	20.00	17.33	18.67
L19 x T1	29.00	30.33	29.67	144.93	150.29	147.61	20.26	18.10	19.18
L19 x T2	24.33	25.00	24.67	128.76	130.65	129.71	15.39	14.65	15.02
L20 x T1	30.67	31.33	31.00	165.97	141.10	153.54	21.15	19.05	20.10
L20 x T2	28.67	29.00	28.84	147.59	140.26	143.93	18.84	16.78	17.81
L21 x T1	29.00	29.67	29.34	136.35	138.09	137.22	19.39	16.57	17.98
L21 x T2	29.67	31.00	30.34	142.92	143.59	143.26	20.93	17.86	19.40
L22 x T1	27.33	27.33	27.33	129.79	142.20	136.00	16.82	15.90	16.36
L22 x T2	30.33	31.33	30.83	158.73	141.39	150.06	21.02	18.79	19.91
L23 x T1	31.67	32.00	31.84	165.14	150.61	157.88	21.81	19.51	20.66
L23 x T2	32.67	32.33	32.50	151.15	136.70	143.93	22.65	20.13	21.39
L24 x T1	31.00	31.33	31.17	143.61	140.59	142.10	21.47	18.91	20.19
L24 x T2	32.00	32.00	32.00	153.52	157.91	155.72	22.45	19.62	21.04
L25 x T1	26.33	27.00	26.67	131.05	125.71	128.38	16.36	15.05	15.71
L25 x T2	29.33	30.00	29.67	164.21	143.34	153.78	20.89	17.86	19.38
168	28.33	31.67	30.00	162.16	164.12	163.14	23.07	22.56	22.82
176	29.67	26.33	28.00	148.39	159.87	154.13	21.13	20.77	20.95
L.S.D 5%	3.88	3.95	2.67	18.01	17.94	13.22	2.04	2.09	1.39
L.S.D 1%	5.14	5.23	3.52	23.84	23.74	17.44	2.71	2.76	1.84

Considering number of kernels per row, three top crosses (L3 x T1, L3 x T2 and L14 x T2), two top crosses (L3 x T1 and L3 x T2) and seven top crosses (L3 x T1, L3 x T2, L5 x T1, L10 x T1, L11 x T2, L12 x T2 and L14 x T2) possessed significant values over the best commercial check under HD, LD and their combined data, respectively. These results are in harmony with those obtained by El-Shamarka *et al.*, (2015); Mostafa (2014)andAbd El-Mottalb (2017).

Regarding 100 kernels weight, twelve top crosses under HD (L2 x T2, L3 x T1, L3 x T2, L4 x T1, L5 x T1, L6 x T1, L9 x T1, L10 x T1, L11 x T2, L12 x T2, L14 x T1 and L14 x T2) only one top crosses (L3 x T2) under LD and ten top crosses in combined (L3 x T1, L3 x T2, L4 x T1, L5 x T1, L6 x T1, L10 x T1, L11 x T2, L12 x T2, L14 x T1 and L14 x T2) showed higher significant values over the best check.

For ear weight, sixteen top crosses, six top crosses and seven top crosses showed higher values over the highest check (Giza 168) under high, low plant densities and their combined data, respectively.

Concerning grain yield (ard/fad) under high plant density values ranged from 15.16 ard/fad. for the top cross (L8 x T2) to 26.46 ard/fad for the top cross (L3 x T1). While, twelve top crosses gave higher grain yield compared to higher check Giza 168 (23.07 ard/fad), under low plant density grain yields ranged from 15.05 ard/fed for the top cross L3 x T2, while, four top crosses gave higher values compared with the highest check Giza 168. Moreover, combined data grain yields ranged from 14.93 ard/fed for the cross L8 x T2 to 25.24 ard/fed for the cross L3 x T1, while, eight top crosses surpassed check Giza 168 (22.82 ard/fad). These results were similar to what reported by Sedhom *et al.* (2007); El-Hosary and Elgammal (2013); and Gamea (2019).

4- Combining ability effects:

The estimation of variance due to general combining ability (σ^2 GCA) and specific combining ability (σ^2 SCA) along with their interaction with densities were presented in Table (2). Results indicated that σ^2 SCA was more important than σ^2 GCA for all studied traits in each density as well as the combined analysis except, plant height. These results might indicate that, the largest part of the total genetic variability associated with those traits was the result of additive type of gene action.

The magnitude of the interaction between specific combining ability and densities was much higher than general combining ability. These results might led to the conclusion that non-additive gene action was more biased by the interaction with environments than the additive effects. Results are in agreement with those reported by Barakat and Balbaa (2013) and Fromme *et al.* (2019).

For other traits, the magnitude of GCA x density was higher than that σ^2 SCA x density revealing that, additive and additive x additive gene action interacted more with the environment than the non-additive component. Similar results were reported by Al-Naggar *et al.* (2014); Mostafa (2018) and Darshan and Marker (2019).

4.1- General combining ability effects (GCA):

Estimates of the general combining ability effects (GCA) for the twenty-five parental inbred lines and the two testers for the ten studied traits under each of the two plant densities (HD and LD) and their combined data were given in Table (5). Values of general combining ability effects for grain yield and its components revealed both negative and positive GCA values, indicating that, there were good and poor general combiners for studied traits. Inbreds L3, L4, L5, L14 and L23 exhibited good general combining ability effects and would be useful in maize breeding programmes for grain yield improvement. as those lines have agenetic potential to transfer desirable traits to their progenies. In this study, the magnitude of GCA effects of the two testers was equal but opposite in sign. Tester (1) showed positive GCA effects for plant and ear height. Tester (2) showed negative GCA effects for grain yield traits. The current investigation is in agreement with the findings of several authors who reported both negative and positive combining ability effects for grain yield, Mhike *et al.* (2011); Mostafa (2014); Ejigu *etal.* (2017) and Abd El-Mottalb (2017).

As for plant height, negative significant GCA effects were obtained for the inbred lines 4, 7, 14, 18 and 19 under low plant density, whereas, lines 8 and 13 gave similar response under high plant density only lines 14 under their combined gave similar response. Significant and negative GCA effects for ear height were detected for inbred lines 13 and 14 for HD and combined analysis, line 15 for LD and combined analysis, line 19 for LD and inbred lines 21 and 23 for HD analysis. So that, those lines might be have additive genes for short plant and low ear placement.

Table 5: General combining ability effects (GCA) of the 25 parental inbred lines and the two testers (Giza 168 and Giza 176) for all studied traits over the two plant densities (HD and LD) and their combined data.

Lines	Plant height (CM)			Ear height (CM)			Ear length (CM)			Ear diameter (CM)			No. of rows/ear		
	HD	LD	Com	D1	D2	Com	D1	D2	Com	D1	D2	Com	D1	D2	Com
1	-1.57	6.90	2.67	0.50	11.87*	6.18	-0.18	-0.15	-0.16	0.02	-0.15	-0.06	0.24	-0.75	-0.25
2	24.27**	25.23**	24.75**	23.83**	21.03**	22.43**	0.29	0.19	0.24	-0.01	0.01	0.00	0.57	0.59	0.58
3	11.77*	21.07**	16.42**	8.00	26.03**	17.02**	1.75**	1.85**	1.80**	0.16	0.01	0.09	0.24	0.59	0.41
4	-1.57	-16.43**	-9.00	3.00	-5.63	-1.32	0.65	0.69*	0.67**	0.06	-0.15	-0.05	0.57	0.25	0.41
5	-8.23	13.57**	2.67	-5.33	7.70	1.18	0.35	0.52	0.44	-0.03	0.01	-0.01	-2.43**	-0.08	-1.25**
6	6.77	-9.77	-1.50	-0.33	-5.63	-2.98	0.25	0.02	0.14	0.19	0.18	0.19	-0.76	-0.41	-0.59
7	11.77*	-23.10**	-5.67	4.67	-7.30	-1.32	-0.20	-0.15	-0.17	-0.01	-0.15	-0.08	-0.76	-0.75	-0.75
8	-16.57**	1.90	-7.33	-7.00	-7.30	-7.15	-0.58	-1.15**	-0.86**	-0.11	-0.32	-0.21	0.57	-1.41**	-0.42
9	-3.23	-3.10	-3.17	3.00	1.87	2.43	0.52	0.52	0.52*	-0.21	0.18	-0.01	0.24	0.59	0.41
10	16.77**	-6.43	5.17	5.50	2.70	4.10	0.24	0.35	0.29	-0.11	-0.15	-0.13	0.24	-1.41**	-0.59
11	-8.23	0.23	-4.00	-1.17	9.37	4.10	0.50	0.69*	0.59*	0.09	0.01	0.05	-0.09	-0.41	-0.25
12	-3.23	-6.43	-4.83	3.00	-9.80	-3.40	0.07	0.02	0.04	0.14	0.18	0.16	1.24*	-0.75	0.25
13	-11.57*	1.90	-4.83	-9.50*	-8.13	-8.82*	-0.23	-0.48	-0.36	0.07	0.18	0.13	1.91**	-0.75	0.58
14	-8.23	-11.43*	-9.83*	-12.00**	-9.80	-10.90**	0.95*	1.19**	1.07**	0.21	0.18	0.19	1.24*	1.92**	1.58**
15	1.77	-8.10	-3.17	0.50	-17.30**	-8.40*	-0.53	-0.48	-0.51*	-0.04	0.01	-0.01	-0.76	-0.41	-0.59
16	-4.90	8.57	1.83	-0.33	-2.30	-1.32	-0.38	-0.15	-0.26	0.09	-0.15	-0.03	-0.43	0.25	-0.09
17	-2.40	-6.43	-4.42	-5.33	-3.13	-4.23	-0.81	-0.48	-0.65*	0.07	0.18	0.13	-0.43	0.25	-0.09
18	15.10**	-16.43**	-0.67	7.17	-8.97	-0.90	-0.38	-0.48	-0.43	-0.14	0.01	-0.06	-0.43	0.92*	0.25
19	-1.57	-16.43**	-9.00	0.50	-10.63*	-5.07	-0.80	-1.48**	-1.14**	0.06	-0.32	-0.13	-0.43	-0.08	-0.25
20	-4.90	-1.43	-3.17	-1.17	-0.63	-0.90	-0.25	-0.31	-0.28	-0.06	0.35	0.14	-1.43**	1.59	0.08
21	-3.23	6.90	1.83	-10.33*	-2.30	-6.32	-0.51	-0.31	-0.41	-0.31*	0.01	-0.15	0.57	-0.75	-0.09
22	5.93	11.90*	8.92	6.33	12.70*	9.52*	-0.53	-0.48	-0.51*	-0.24*	0.01	-0.11	-0.09	0.25	0.08
23	0.10	13.57**	6.83	-10.33*	7.70	-1.32	0.45	0.69*	0.57*	0.14	0.01	0.08	-0.09	-0.08	-0.09
24	-9.90	-3.10	-6.50	-0.33	-3.97	-2.15	0.22	0.19	0.20	-0.08	0.01	-0.03	-0.09	0.59	0.25
25	-4.90	16.90**	6.00	-2.83	1.87	-0.48	-0.85*	-0.81*	-0.83**	0.02	-0.15	-0.06	0.57	0.25	0.41
L.S.D.gi 5%	11.05	10.12	9.18	8.73	10.20	7.46	0.85	0.69	0.50	0.23	0.37	0.22	1.06	0.89	0.79
L.S.D (gi-gj)5%	15.63	14.31	12.99	12.35	14.43	10.55	0.24	0.98	0.70	0.33	0.53	0.32	1.50	1.25	1.11
T1	0.97	2.10	1.53	1.33	-0.43	0.45	0.02	0.02	0.02	-0.01	-0.03	-0.02	-0.20	-0.07	-0.13
T2	-0.97	-2.10	-1.53	-1.33	0.43	-0.45	-0.02	-0.02	-0.02	0.01	0.03	0.02	0.20	0.07	0.13
L.S.D.gi 5%	3.13	2.86	2.60	2.47	2.89	2.11	1.20	0.20	0.14	0.07	0.11	0.06	0.30	0.25	0.22
L.S.D (gi-gj)5%	4.42	4.05	3.67	3.49	4.08	2.98	0.34	0.28	0.20	0.09	0.15	0.09	0.42	0.35	0.31

Table 5: Continued …

Lines	No. of kernels/row			No. of ears/plot			100-kernel weight (g)			Ear weight (g)			Grain yield (ard/fed)		
	D1	D2	Com	D1	D2	Com	D1	D2	Com	D1	D2	Com	D1	D2	Com
1	-1.60	-0.62	-1.11	0.09	-0.39	-0.15	-1.12	-0.57	-0.85	-9.24*	-1.01	-5.12	-1.20*	-0.61	-0.91*
2	0.57	0.38	0.47	-0.25	0.95	0.35	0.55	0.93	0.74	7.49	-0.34	3.58	0.75	0.91	0.83*
3	8.07**	4.88**	6.47**	2.09**	2.61**	2.35**	7.38**	4.43	5.90**	18.88**	16.36**	17.62**	5.21**	5.28**	5.25**
4	2.57	1.21	1.89*	0.59	-0.05	0.27	2.21*	1.76	1.99**	10.09*	16.49**	13.29**	2.00**	1.99**	2.00**
5	1.23	0.88	1.06	0.75	-0.39	0.18	2.21*	0.93	1.57*	6.53	12.53**	9.53**	1.85**	0.99	1.42**
6	1.07	0.05	0.56	-0.41	-0.39	-0.40	0.55	-0.24	0.15	7.09	7.08	7.09*	0.56	0.51	0.54
7	-0.93	-0.45	-0.69	-0.58	-0.22	-0.40	-0.62	-0.74	-0.68	-1.34	-1.77	-1.56	-0.90	-0.41	-0.66
8	-2.10	-1.95	-2.03**	-0.41	-1.22*	-0.82*	-4.79**	-1.57	-3.18**	-14.32**	-4.44	-9.38**	-2.49**	-1.87**	-2.18**
9	1.90	0.71	1.31	0.25	0.78	0.52	1.38	1.43	1.40*	9.09*	4.81	6.95*	1.50**	1.41**	1.45**
10	1.07	1.55	1.31	1.25*	1.45**	1.35**	2.71**	0.76	1.74*	-1.11	-4.34	-2.72	1.31*	1.03	1.17**
11	1.90	1.21	1.56*	0.25	0.11	0.18	1.71	1.59	1.65*	15.38**	9.58*	12.48**	2.43**	1.36*	1.90**
12	0.73	0.38	0.56	-0.08	0.45	0.18	0.71	-0.24	0.24	3.96	-2.26	0.85	0.51	0.24	0.38
13	-1.43	-1.12	-1.28	-1.08*	-0.22	-0.65	-1.45	-1.07	-1.26	-4.32	-5.22	-4.77	-1.92**	-0.91	-1.41**
14	4.73**	2.38**	3.56**	2.09**	1.11*	1.60**	4.38**	2.09*	3.24**	10.21*	16.96**	13.59**	3.85**	3.51**	3.68**
15	-1.93	-1.29	-1.61*	-0.25	-0.72	-0.48	-2.45*	-1.24	-1.85**	-11.47*	-8.34	-9.91**	-1.89**	-1.77**	-1.83**
16	-1.10	-0.45	-0.78	-0.41	-0.72	-0.57	-0.45	-0.41	-0.43	-1.37	-1.62	-1.50	-0.59	-1.01	-0.80*
17	-2.10	-1.29	-1.69*	-1.08*	-1.89**	-1.48**	-2.95**	-1.41	-2.18**	-7.36	-0.01	-3.68	-2.12**	-2.06**	-2.09**
18	-1.93	-0.95	-1.44	-0.58	-0.39	-0.48	-1.62	-1.07	-1.35*	-3.34	-6.87	-5.11	-1.14*	-1.29*	-1.21**
19	-2.93	-2.29	-2.61**	-1.08*	-1.39**	-1.23**	-3.95**	-3.07**	-3.51**	-15.54**	-7.94	-11.74**	-3.24**	-2.44**	-2.84**
20	-1.93	-0.45	-1.19	-1.41**	0.11	-0.65	-0.95	-0.57	-0.76	4.38	-7.74	-1.68	-1.09*	-0.89	-0.99**
21	-2.27	-0.62	-1.44	0.92	-0.55	0.18	-1.29	-0.41	-0.85	-12.76**	-7.54	-10.15**	-0.90	-1.61**	-1.26**
22	-2.43	-1.45	-1.94*	-0.91	-0.55	-0.73*	-1.79	-1.41	-1.60*	-8.14	-6.59	-7.36*	-2.15**	-1.44**	-1.80**
23	1.23	0.71	0.97	0.42	1.61**	1.02**	1.55	1.43	1.49*	5.78	-4.77	0.50	1.18*	0.99	1.09**
24	0.57	0.21	0.39	1.42**	0.45	0.93*	0.88	0.93	0.90	-3.82	0.84	-1.49	0.90	0.44	0.67
25	-2.93*	-1.62	-2.28**	-1.58**	-0.55	-1.07**	-2.79**	-2.24*	-2.51**	-4.77	-13.87**	-9.32**	-2.44**	-2.36**	-2.40**
L.S.D.gi 5%	2.64	1.71	1.49	1.00	0.96	0.71	1.94	1.98	1.33	9.01	8.97	6.61	1.02	1.05	0.70
L.S.D (gi-gj)5%	3.73	2.41	2.11	1.41	1.35	1.01	2.74	2.79	1.89	12.74	12.68	9.34	1.45	1.48	0.99
T1	0.04	0.05	0.04	0.12	0.03	0.08	0.19	0.05	0.12	-1.07	0.32	-0.37	0.00	0.09	0.04
T2	-0.04	-0.05	-0.04	-0.12	-0.03	-0.08	-0.19	-0.05	-0.12	1.07	-0.32	0.37	-0.00	-0.09	-0.04
L.S.D.gi 5%	0.75	0.48	0.42	0.28	0.27	0.20	0.55	0.56	0.38	2.55	2.54	1.87	0.29	0.30	0.20
L.S.D (gi-gj)5%	1.06	0.68	0.60	0.40	0.38	0.28	0.78	0.79	0.53	3.60	3.59	2.64	0.41	0.42	0.28

On the other hand, inbred lines 2, 3, 5, 22 and 25 exhibited significant positive GCA effects towards tall-plant and high ear placement. Several researchers have reported both negative and positive GCA estimates for these traits (Aguiar *et al.*(2003); Legesses *et al.*(2009); Abraha *et al.*(2013); Hosana *et al.*(2015); Ejigu *et al.*(2017); Mostafa and Mostafa (2017)and Abd El-Mottalb (2017)).

Regarding ear length, inbred lines 3 and 14 exhibited desirable significant GCA effects under the two plant populations and combined analysis Meanwhile, lines 4, 11 and 23 had significant effects for LD and combined analysis. While, inbred lines 9 showed desirable significant GCA effect for combined analysis.

Inbred lives, showed insignificant positive GCA affects for ear diameter.

Concerning number of rows per ear, two inbred lines (12 and 13) manifested significant GCA effects for high plant density analysis. Also, inbred line 14 showed significant GCA effects for the two plant densities and combined analysis, whereas, line 18 was significant only under low plant density.

For number of kernelsper row, the two inbred lines 3 and 14 showed significant GCA effects for high and low plant densities and combined analysis. Considering number of ear per plot, the inbred lines 3, 10 and 14 showed significant GCA effects for the two plant densities and combined analysis. While, significant effects of L23 was shown for LD and combined analysis, while L24 showed similar effect for HD and combined analysis.

Concerning 100-kernel weight, inbred lines L3, L4 and L10 showed significant GCA effects for high plant density and combined analysis. While, lines L9, L12 and L23 for combined analysis and inbred lines L14 for the two plant densities and combined analysis, showed similar effects.

For ear weight, the inbred lines L3, L4, and L14 showed highly significant GCA effects for the two plant densities and combined analysis, while, line 9 gave similar response for HD and combined analysis.

Positive GCA estimates are desirable for the improvement of grain yield while negative GCA effects for the same trait are undesirable in a maize breeding programme. This result is in accordance with the findings of Divan *et al.* (2013), Al-Falahy (2015), Hosana *et al.* (2015), Pavan *et al.* (2016) and Ejigu *etal.* (2017).

For grain yield, significant and positive GCA effects were obtained by L3, L5, L4, L9, L10, L11, L14 and L23 for the two densities and combined analysis, indicating that, those lines have favorable additive genes for grain yield which might be utilized in the hybrid breeding program.

4.2- Specific combining ability effects (SCA):-

Estimates of specific combining ability effects (SCA) of the top crosses for all traits under two plant populations and their combined data were presented in Tables (6).

SCA estimates detected both negative and positive values varied with characters. This might be due to the effect of the tester, which showed equal combining abilities but with opposite sing.

For plant height, the top crosses L5 x T2, L6 x T1, L11 x T1, L12 x T2 and L17 x T2 exhibited desirable significant SCA effects only for low plant density. Considering ear height, the top crosses L12 x T2, L17 x T2 and L23 x T2 showed significant negative SCA effects for low plant density. The negative SCA values indicate the possibility to have short plant and ear height which might help to reduce stem lodging and facilitate mechanized harvesting. The current finding are similar to the previous study of Mhike *et al.* (2011) and Ejigu *et al.* (2017).

Estimate of SCA effect for ear length revealed both negative and positive SCA estimates. The top crosses L6 x T1, L8 x T1, L10 x T1, L12 x T2, L15 x T2 and L19 x T1 for LD and combined date gave a desirable significant SCA effects.

For ear diameter, all top crosses showed insignificant differences, except, top cross L5 x T1 for HD. Regarding number of rows per ear the top cross L6 x T1 expressed desirable significant SCA effects for HD and combined data. The top crosses L15 x T2, L16 x T1 and L24 x T2 showed desirable significant SCA effects for low plant density. For number of kernels per row, top cross L10 x T1 showed positive significant SCA effects under HD, LD and combined data. The top crosses L5 x T1 and L12 x T2 for HD and the combined analysis and the top crosses L6 x T1, L7 x T2, L8 x T1, L15 x T2, L16 x T1 and L17 x T1 for combined data, expressed desirable significant SCA effects. Concerning number of ears per plot, the top cross L12 x T2 showed significant SCA effects for the two plant populations and combined analysis. The top crosses L5 x T1, L8 x T1 and L15 x T2 for LD and combined data and the top crosses L6 x T1, L10 x T1, L17 x T1 and L23 x T2 in combined data, showed, positive significant SCA effects. Regarding 100 kernel weight, under the two plant populations and combined data, two top crosses (L8 x T1 and L10 x T1) exhibited positive significant SCA effects as well as the five top crosses (L5 x T1, L7 x T2, L12 x T2, L15 x T2 and L17 x T1) for HD and combined data and the three top crosses (L6 x T1, L13 x TT and L19 x T1) for the combined data, expressed positive significant SCA effects.

For ear weight, the top cross L7 × T2 showed positive significant SCA effects under the HD, LD and their combined. The top crosses L8 × T1, L10 × T1, L12 × T2, L13 × T2, L15 × T2, L17 × T1 and L25 × T2 under HD and combined data and the two top crosses L6 × T1 and L16 × T1 under LD and the combined data expressed highly significant for SCA effects.

For grain yield, thirteen top crosses (L5 × T1, L6 × T1, L6 × T1, L7 × T2, L8 × T1, L10 × T1, L12 × T2, L13 × T2, L15 × T2, L16 × T1, L17 × T1, L19 × T1, L22 × T2 and L25 × T2) under the two plant populations and their combined data showed significant positive SCA effects.

Table 6: specific combining ability effects (SCA) of the 50 top crosses for all studied traits under the two plant densities (HD and LD) and their combined data.

Cross	Plant height (CM)			Ear height (CM)			Ear length (CM)			Ear diameter (CM)		
	HD	**LD**	**Com**	**HD**	**LD**	**Com**	**HD**	**LD**	**Com**	**HD**	**LD**	**Com**
L1 x T1	-7.63	-2.10	-4.87	-8.83	-0.40	-4.62	-0.32	-0.52	0.42	0.01	0.19	0.10
L1 x T2	7.63	2.10	4.87	8.83	0.40	4.62	0.32	0.52	0.42	-0.01	-0.19	-0.10
L2 x T1	-8.47	-10.43	-9.45	1.17	-7.90	-3.37	-0.38	-0.52	-0.45	0.04	-0.31	-0.13
L2 x T2	8.47	10.43	9.45	-1.17	7.90	3.37	0.38	0.52	0.45	-0.04	0.31	0.13
L3 x T1	-0.97	-1.27	-1.12	0.33	2.10	1.22	-0.25	-0.19	-0.22	-0.06	0.03	-0.02
L3 x T2	0.97	1.27	1.12	-0.33	-2.10	-1.22	0.25	0.19	0.22	0.06	-0.03	0.02
L4 x T1	12.37	11.23	11.80	3.67	5.43	4.55	0.12	0.31	0.21	0.04	0.19	0.12
L4 x T2	-12.37	-11.23	-11.80	-3.67	-5.43	-4.55	-0.12	-0.31	-0.21	-0.04	-0.19	-0.12
L5 x T1	5.70	14.57*	10.13	2.00	10.43	6.22	0.75	0.48	0.61	0.33*	0.03	0.18
L5 x T2	-5.70	-14.57*	-10.13	-2.00	-10.43	-6.22	-0.75	-0.48	-0.61	-0.33*	-0.03	-0.18
L6 x T1	10.70	-15.43*	-2.37	7.00	-7.90	-0.45	0.72	0.98*	0.85*	-0.02	-0.47	-0.25
L6 x T2	-10.70	15.43*	2.37	-7.00	7.90	0.45	-0.72	-0.98*	-0.85*	0.02	0.47	0.25
L7 x T1	-14.30	4.57	-4.87	-9.67	-6.23	-7.95	-0.90	-0.85	-0.88*	-0.19	0.19	0.00
L7 x T2	14.30	-4.57	4.87	9.67	6.23	7.95	0.90	0.85	0.88*	0.19	-0.19	0.00
L8 x T1	14.03	2.90	8.47	10.33	0.43	5.38	0.88	1.48**	1.18**	0.08	0.03	0.05
L8 x T2	-14.03	-2.90	-8.47	-10.33	-0.43	-5.38	-0.88	-1.48**	-1.18**	-0.08	-0.03	-0.05
L9 x T1	-5.97	2.90	-1.53	7.00	-10.40	-1.70	0.32	0.48	0.40	-0.22	0.19	-0.02
L9 x T2	5.97	-2.90	1.53	-7.00	10.40	1.70	-0.32	-0.48	-0.40	0.22	-0.19	0.02
L10 x T1	-9.30	-2.10	-5.70	-8.83	-2.90	-5.87	0.87	0.98*	0.92*	0.08	0.19	0.13
L10 x T2	9.30	2.10	5.70	8.83	2.90	5.87	-0.87	-0.98*	-0.92*	-0.08	-0.19	-0.13
L11 x T1	9.03	-18.77*	-4.87	-0.50	-12.90	-6.70	-0.50	-0.69	-0.59	0.01	-0.31	-0.15
L11 x T2	-9.03	18.77*	4.87	0.50	12.90	6.70	0.50	0.69	0.59	-0.01	0.31	0.15
L12 x T1	0.70	14.57*	7.63	-3.00	17.93*	7.47	-1.03	-1.02*	-1.03**	-0.21	0.19	-0.01
L12 x T2	-0.70	-14.57*	-7.63	3.00	-17.93*	-7.47	1.03	1.02*	1.03**	0.21	-0.19	0.01
L13 x T1	-14.30	-0.43	-7.37	-12.17	-0.40	-6.28	-0.60	-0.85	-0.73*	-0.24	0.19	-0.02
L13 x T2	14.30	0.43	7.37	12.17	0.40	6.28	0.60	0.85	0.73*	0.24	-0.19	0.02
L14 x T1	-4.30	-13.77	-9.03	-9.67	-7.07	-8.37	-0.18	-0.19	-0.19	0.03	0.19	0.11
L14 x T2	4.30	13.77	9.03	9.67	7.07	8.37	0.18	0.19	0.19	-0.03	-0.19	-0.11
L15 x T1	5.70	6.23	5.97	7.83	7.10	7.47	-1.03	-1.19*	-1.11**	0.08	-0.31	-0.12
L15 x T2	-5.70	-6.23	-5.97	-7.83	-7.10	-7.47	1.03	1.19*	1.11**	-0.08	0.31	0.12
L16 x T1	5.70	-0.43	2.63	-3.00	2.10	-0.45	0.95	0.81	0.88*	0.14	0.19	0.17
L16 x T2	-5.70	0.43	-2.63	3.00	-2.10	0.45	-0.95	-0.81	-0.88*	-0.14	-0.19	-0.17
L17 x T1	-8.47	21.23**	6.38	-6.33	14.60*	4.13	1.18	0.81	1.00**	-0.14	0.19	0.03
L17 x T2	8.47	-21.23**	-6.38	6.33	-14.60*	-4.13	-1.18	-0.81	-1.00**	0.14	-0.19	-0.03
L18 x T1	-0.97	1.23	0.13	-0.50	-7.90	-4.20	0.02	-0.19	-0.09	-0.29	0.03	-0.13
L18 x T2	0.97	-1.23	-0.13	0.50	7.90	4.20	-0.02	0.19	0.09	0.29	-0.03	0.13
L19 x T1	9.03	-5.43	1.80	11.17	0.43	5.80	0.70	1.15*	0.92*	0.24	0.03	0.13
L19 x T2	-9.03	5.43	-1.80	-11.17	-0.43	-5.80	-0.70	-1.15*	-0.92*	-0.24	-0.03	-0.13
L20 x T1	-0.97	-13.77	-7.37	6.17	-6.23	-0.03	0.35	0.31	0.33	-0.07	0.03	-0.02
L20 x T2	0.97	13.77	7.37	-6.17	6.23	0.03	-0.35	-0.31	-0.33	0.07	-0.03	0.02
L21 x T1	7.37	-2.10	2.63	3.67	2.10	2.88	-0.25	-0.35	-0.30	0.01	-0.31	-0.15
L21 x T2	-7.37	2.10	-2.63	-3.67	-2.10	-2.88	0.25	0.35	0.30	-0.01	0.31	0.15
L22 x T1	-15.13	-7.10	-11.12	-9.67	-6.23	-7.95	-0.47	-0.52	-0.49	-0.06	0.03	-0.02
L22 x T2	15.13	7.10	11.12	9.67	6.23	7.95	0.47	0.52	0.49	0.06	-0.03	0.02
L23 x T1	7.37	11.23	9.30	3.67	15.43*	9.55	-0.08	-0.02	-0.05	0.19	0.03	0.11
L23 x T2	-7.37	-11.23	-9.30	-3.67	-15.43*	-9.55	0.08	0.02	0.05	-0.19	-0.03	-0.11
L24 x T1	4.03	-2.10	0.97	10.33	7.10	8.72	-0.25	-0.19	-0.22	0.24	-0.31	-0.03
L24 x T2	-4.03	2.10	-0.97	-10.33	-7.10	-8.72	0.25	0.19	0.22	-0.24	0.31	0.03
L25 x T1	-0.97	4.57	1.80	-2.17	-8.73	-5.45	-0.58	-0.52	-0.55	0.01	-0.14	-0.07
L25 x T2	0.97	-4.57	-1.80	2.17	8.73	5.45	0.58	0.52	0.55	-0.01	0.14	0.07
L.S.D.Sij 5%	15.63	14.31	12.99	12.35	14.43	10.55	1.20	0.98	0.70	0.33	0.53	0.32
L.S.D (Sij-Skl-gj)5%	22.11	20.23	18.37	17.47	20.41	14.92	1.70	1.38	0.99	0.46	0.75	0.45

Table 6: Continued …

Cross	No. of rows/ear			No. of kernels/row			No. of ears/plot		
	HD	LD	Com	HD	LD	Com	HD	LD	Com
L1 x T1	-0.13	-0.27	-0.20	-1.37	-1.05	-1.21	-0.62	-0.53	-0.58
L1 x T2	0.13	0.27	0.20	1.37	1.05	1.21	0.62	0.53	0.58
L2 x T1	0.20	0.40	0.30	-1.54	-0.71	-1.13	-0.29	-1.20	-0.74
L2 x T2	-0.20	-0.40	-0.30	1.54	0.71	1.13	0.29	1.20	0.74
L3 x T1	-0.13	-0.27	-0.20	0.29	-0.21	0.04	0.38	-0.20	0.09
L3 x T2	0.13	0.27	0.20	-0.29	0.21	-0.04	-0.38	0.20	-0.09
L4 x T1	0.20	0.07	0.13	0.46	0.45	0.46	0.88	-0.20	0.34
L4 x T2	-0.20	-0.07	-0.13	-0.46	-0.45	-0.46	-0.88	0.20	-0.34
L5 x T1	-0.13	-0.93	-0.53	3.79*	1.79	2.79**	0.71	2.47**	1.59**
L5 x T2	0.13	0.93	0.53	-3.79*	-1.79	-2.79**	-0.71	-2.47**	-1.59**
L6 x T1	1.53*	0.73	1.13*	3.63	1.62	2.62*	1.55*	0.47	1.01*
L6 x T2	-1.53*	-0.73	-1.13*	-3.63	-1.62	-2.62*	-1.55*	-0.47	-1.01*
L7 x T1	0.20	-0.93	-0.37	-3.04	-1.88	-2.46*	-0.62	-0.70	-0.66
L7 x T2	-0.20	0.93	0.37	3.04	1.88	2.46*	0.62	0.70	0.66
L8 x T1	0.20	0.40	0.30	2.46	2.29	2.37*	0.55	1.63*	1.09*
L8 x T2	-0.20	-0.40	-0.30	-2.46	-2.29	-2.37*	-0.55	-1.63*	-1.09*
L9 x T1	0.53	-0.27	0.13	1.79	0.62	1.21	0.21	0.30	0.26
L9 x T2	-0.53	0.27	-0.13	-1.79	-0.62	-1.21	-0.21	-0.30	-0.26
L10 x T1	0.53	-0.27	0.13	4.29*	2.79*	3.54**	0.88	1.30	1.09*
L10 x T2	-0.53	0.27	-0.13	-4.29*	-2.79*	-3.54**	-0.88	-1.30	-1.09*
L11 x T1	-0.47	0.73	0.13	-2.54	-1.21	-1.88	-0.45	-0.37	-0.41
L11 x T2	0.47	-0.73	-0.13	2.54	1.21	1.88	0.45	0.37	0.41
L12 x T1	-1.13	-0.27	-0.70	-4.71*	-2.05	-3.38**	-1.45*	-1.37*	-1.41**
L12 x T2	1.13	0.27	0.70	4.71*	2.05	3.38**	1.45*	1.37*	1.41**
L13 x T1	-1.13	-0.93	-1.03	-1.87	-1.55	-1.71	0.21	-0.37	-0.08
L13 x T2	1.13	0.93	1.03	1.87	1.55	1.71	-0.21	0.37	0.08
L14 x T1	0.20	0.40	0.30	-1.71	-0.71	-1.21	-1.62*	-0.03	-0.83
L14 x T2	-0.20	-0.40	-0.30	1.71	0.71	1.21	1.62*	0.03	0.83
L15 x T1	-0.47	-1.27*	-0.87	-3.37	-1.71	-2.54*	-0.62	-1.53*	-1.08*
L15 x T2	0.47	1.27*	0.87	3.37	1.71	2.54*	0.62	1.53*	1.08*
L16 x T1	-0.80	2.07**	0.63	3.13	1.45	2.29*	1.21	0.13	0.67
L16 x T2	0.80	-2.07**	-0.63	-3.13	-1.45	-2.29*	-1.21	-0.13	-0.67
L17 x T1	-0.13	0.07	-0.03	2.79	1.62	2.21*	0.88	1.30	1.09*
L17 x T2	0.13	-0.07	0.03	-2.79	-1.62	-2.21*	-0.88	-1.30	-1.09*
L18 x T1	-0.13	0.07	-0.03	0.29	-0.05	0.12	-0.62	0.13	-0.24
L18 x T2	0.13	-0.07	0.03	-0.29	0.05	-0.12	0.62	-0.13	0.24
L19 x T1	0.53	0.40	0.47	1.96	1.29	1.62	1.21	0.47	0.84
L19 x T2	-0.53	-0.40	-0.47	-1.96	-1.29	-1.62	-1.21	-0.47	-0.84
L20 x T1	0.20	0.73	0.47	1.29	0.45	0.87	-0.12	0.97	0.42
L20 x T2	-0.20	-0.73	-0.47	-1.29	-0.45	-0.87	0.12	-0.97	-0.42
L21 x T1	0.20	0.40	0.30	-1.04	-0.38	-0.71	-0.45	-0.37	-0.41
L21 x T2	-0.20	-0.40	-0.30	1.04	0.38	0.71	0.45	0.37	0.41
L22 x T1	0.20	0.07	0.13	-1.54	-1.21	-1.38	-0.29	-1.37*	-0.83
L22 x T2	-0.20	-0.07	-0.13	1.54	1.21	1.38	0.29	1.37*	0.83
L23 x T1	0.87	0.40	0.63	-0.54	-0.38	-0.46	-1.29	-1.20	-1.24*
L23 x T2	-0.87	-0.40	-0.63	0.54	0.38	0.46	1.29	1.20	1.24*
L24 x T1	0.20	-1.60*	-0.70	-1.21	-0.21	-0.71	0.05	0.63	0.34
L24 x T2	-0.20	1.60*	0.70	1.21	0.21	0.71	-0.05	-0.63	-0.34
L25 x T1	-1.13	0.07	-0.53	-1.71	-1.05	-1.38	-0.29	-0.37	-0.33
L25 x T2	1.13	-0.07	0.53	1.71	1.05	1.38	0.29	0.37	0.33
L.S.D.Sij 5%	1.50	1.25	1.11	3.73	2.41	2.11	1.41	1.35	1.01
L.S.D (Sij-Skl-gj)5%	2.12	1.77	1.57	5.28	3.41	2.98	1.99	1.91	1.42

Table 6: Continued …

Cross	100-kernel weight (g)			Ear weight (g)			Grain yield (ard/fed)		
	HD	LD	Com	HD	LD	Com	HD	LD	Com
L1 x T1	-2.03	-1.55	-1.79	-9.12	-3.19	-6.15	-1.93**	-1.02	-1.48**
L1 x T2	2.03	1.55	1.79	9.12	3.19	6.15	1.93**	1.02	1.48**
L2 x T1	-1.69	-0.71	-1.20	-3.95	3.08	-0.44	-0.88	-0.94	-0.91
L2 x T2	1.69	0.71	1.20	3.95	-3.08	0.44	0.88	0.94	0.91
L3 x T1	-0.86	-0.55	-0.70	-1.87	0.65	-0.61	0.18	-0.17	0.01
L3 x T2	0.86	0.55	0.70	1.87	-0.65	0.61	-0.18	0.17	-0.01
L4 x T1	0.31	0.12	0.21	-3.75	4.48	0.36	0.53	0.35	0.44
L4 x T2	-0.31	-0.12	-0.21	3.75	-4.48	-0.36	-0.53	-0.35	-0.44
L5 x T1	3.64**	1.95	2.80**	12.62	-5.29	3.66	2.65**	2.28**	2.46**
L5 x T2	-3.64**	-1.95	-2.80**	-12.62	5.29	-3.66	-2.65**	-2.28**	-2.46**
L6 x T1	2.64	2.12	2.38*	12.35	14.46*	13.41**	3.53**	2.33**	2.93**
L6 x T2	-2.64	-2.12	-2.38*	-12.35	-14.46*	-13.41**	-3.53**	-2.33**	-2.93**
L7 x T1	-2.86*	-2.71	-2.79**	-17.95**	-15.12*	-16.54**	-3.17**	-2.69**	-2.93**
L7 x T2	2.86*	2.71	2.79**	17.95**	15.12*	16.54**	3.17**	2.69**	2.93**
L8 x T1	5.64**	2.79*	4.21**	22.07**	3.28	12.67**	3.42**	2.18**	2.80**
L8 x T2	-5.64**	-2.79*	-4.21**	-22.07**	-3.28	-12.67**	-3.42**	-2.18**	-2.80**
L9 x T1	0.81	0.45	0.63	4.18	4.70	4.44	0.83	1.00	0.91
L9 x T2	-0.81	-0.45	-0.63	-4.18	-4.70	-4.44	-0.83	-1.00	-0.91
L10 x T1	4.81**	2.79*	3.80**	20.18**	12.11	16.15**	3.95**	3.08**	3.51**
L10 x T2	-4.81**	-2.79*	-3.80**	-20.18**	-12.11	-16.15**	-3.95**	-3.08**	-3.51**
L11 x T1	-1.86	-0.71	-1.29	-9.27	-6.47	-7.87	-1.83*	-1.25	-1.54**
L11 x T2	1.86	0.71	1.29	9.27	6.47	7.87	1.83*	1.25	1.54**
L12 x T1	-4.19**	-2.55	-3.37**	-15.68*	-11.87	-13.78**	-3.88**	-3.07**	-3.48**
L12 x T2	4.19**	2.55	3.37**	15.68*	11.87	13.78**	3.88**	3.07**	3.48**
L13 x T1	-2.69	-2.38	-2.54**	-22.83**	-8.54	-15.69**	-2.75**	-1.49*	-2.12**
L13 x T2	2.69	2.38	2.54**	22.83**	8.54	15.69**	2.75**	1.49*	2.12**
L14 x T1	-1.53	-0.21	-0.87	6.90	-8.85	-0.98	-0.98	-1.24	-1.11*
L14 x T2	1.53	0.21	0.87	-6.90	8.85	0.98	0.98	1.24	1.11*
L15 x T1	-4.03**	-2.55	-3.29**	-18.35**	-10.82	-14.59**	-3.08**	-2.92**	-3.00**
L15 x T2	4.03**	2.55	3.29**	18.35**	10.82	14.59**	3.08**	2.92**	3.00**
L16 x T1	2.31	2.29	2.30*	10.75	20.16**	15.46**	2.85**	2.58**	2.71**
L16 x T2	-2.31	-2.29	-2.30*	-10.75	-20.16**	-15.46**	-2.85**	-2.58**	-2.71**
L17 x T1	4.14**	2.62	3.38**	16.80*	12.18	14.49**	3.12**	2.80**	2.96**
L17 x T2	-4.14**	-2.62	-3.38**	-16.80*	-12.18	-14.49**	-3.12*	-2.80**	-2.96**
L18 x T1	-0.19	-0.05	-0.12	4.48	-0.02	2.23	-0.03	0.10	0.03
L18 x T2	0.19	0.05	0.12	-4.48	0.02	-2.23	0.03	-0.10	-0.03
L19 x T1	2.14	2.62	2.38*	9.15	9.51	9.33	2.43**	1.65*	2.04**
L19 x T2	-2.14	-2.62	-2.38*	-9.15	-9.51	-9.33	-2.43**	-1.65*	-2.04**
L20 x T1	0.81	1.12	0.96	10.23	0.11	5.17	1.15	1.06	1.11*
L20 x T2	-0.81	-1.12	-0.96	-10.23	-0.11	-5.17	-1.15	-1.06	-1.11*
L21 x T1	-0.53	-0.71	-0.62	-2.20	-3.09	-2.64	-0.77	-0.75	-0.76
L21 x T2	0.53	0.71	0.62	2.20	3.09	2.64	0.77	0.75	0.76
L22 x T1	-1.69	-2.05	-1.87	-13.38*	0.06	-6.66	-2.12**	-1.52*	-1.82**
L22 x T2	1.69	2.05	1.87	13.38*	-0.06	6.66	2.12**	1.52*	1.82**
L23 x T1	-0.69	-0.21	-0.45	8.07	6.61	7.34	-0.42	-0.39	-0.40
L23 x T2	0.69	0.21	0.45	-8.07	-6.61	-7.34	0.42	0.39	0.40
L24 x T1	-0.69	-0.38	-0.54	-3.90	-8.97	-6.44	-0.50	-0.44	-0.47
L24 x T2	0.69	0.38	0.54	3.90	8.97	6.44	0.50	0.44	0.47
L25 x T1	-1.69	-1.55	-1.62	-15.52*	-9.15	-12.34**	-2.27**	-1.50*	-1.89**
L25 x T2	1.69	1.55	1.62	15.52*	9.15	12.34**	2.27**	1.50*	1.89**
L.S.D.Sij 5%	2.74	2.79	1.89	12.74	12.68	9.34	1.45	1.48	0.99
L.S.D (Sij-Skl-gj)5%	3.88	3.95	2.67	18.01	17.94	13.21	2.04	2.09	1.39

Table 7: Percentage of Heterosis H% for top crosses over two check varieties (Giza 168 and Giza 176) for all studied traits under two plant densities (HD (20 cm) and LD (25cm)).

Traits	Plant height (CM)				Ear height(CM)			
Crosses	H% relative to Giza 168		H% relative to Giza 176		H% relative to Giza 168		H% relative to Giza 176	
	HD	LD	HD	LD	HD	LD	HD	LD
T1&L1	4.62	16.13**	-4.23	18.03**	-1.47	24.19*	8.06	37.50**
T2&L1	10.77*	16.13**	1.41	18.03**	11.76	25.81*	22.58**	39.29**
T1&L2	16.15**	20.97**	6.34	22.95**	27.94**	25.81*	40.32**	39.29**
T2&L2	23.08**	29.03**	12.68**	31.15**	23.53**	41.94**	35.48**	57.14**
T1&L3	13.85**	23.39**	4.23	25.41**	13.24	40.32**	24.19**	55.36**
T2&L3	13.85**	22.58**	4.23	24.59**	10.29	37.10**	20.97*	51.79**
T1&L4	13.85**	11.29*	4.23	13.11*	11.76	12.90	22.58**	25.00*
T2&L4	1.54	-1.61	-7.04	0.00	2.94	3.23	12.90	14.29
T1&L5	7.69	27.42**	-1.41	29.51**	2.94	30.65**	12.90	44.64**
T2&L5	1.54	11.29*	-7.04	13.11*	-2.94	11.29	6.45	23.21*
T1&L6	16.92**	1.61	7.04	3.28	11.76	0.00	22.58**	10.71
T2&L6	6.15	14.52**	-2.82	16.39**	-2.94	16.13	6.45	28.57*
T1&L7	7.69	4.84	-1.41	6.56	1.47	0.00	11.29	10.71
T2&L7	20.00**	-1.61	9.86*	0.00	16.18*	12.90	27.42**	25.00*
T1&L8	7.69	16.13**	-1.41	18.03**	8.82	6.45	19.35*	17.86
T2&L8	-6.15	11.29*	-14.08**	13.11*	-11.76	6.45	-3.23	17.86
T1&L9	4.62	13.71**	-4.23	15.57**	14.71	4.84	25.81**	16.07
T2&L9	9.23	8.87	0.00	10.66*	0.00	25.81*	9.68	39.29**
T1&L10	12.31*	9.68	2.82	11.48*	2.94	12.90	12.90	25.00*
T2&L10	20.00**	9.68	9.86*	11.48*	16.18*	19.35	27.42**	32.14**
T1&L11	9.23	4.84	0.00	6.56	4.41	9.68	14.52	21.43
T2&L11	0.00	20.97**	-8.45	22.95**	2.94	35.48**	12.90	50.00**
T1&L12	7.69	17.74**	-1.41	19.67**	5.88	20.97*	16.13	33.93**
T2&L12	6.15	1.61	-2.82	3.28	8.82	-12.90	19.35*	-3.57
T1&L13	-3.08	14.52**	-11.27*	16.39**	-13.24	4.84	-4.84	16.07
T2&L13	9.23	12.90*	0.00	14.75**	5.88	6.45	16.13	17.86
T1&L14	3.08	1.61	-5.63	3.28	-13.24	-3.23	-4.84	7.14
T2&L14	6.15	12.90*	-2.82	14.75**	1.47	11.29	11.29	23.21*
T1&L15	12.31*	12.90*	2.82	14.75**	13.24	3.23	24.19**	14.29
T2&L15	6.15	4.84	-2.82	6.56	-2.94	-9.68	6.45	0.00
T1&L16	9.23	17.74**	0.00	19.67**	2.94	12.90	12.90	25.00*
T2&L16	3.08	16.13**	-5.63	18.03**	5.88	9.68	16.13	21.43
T1&L17	3.85	20.97**	-4.93	22.95**	-4.41	24.19*	4.84	37.50**
T2&L17	10.77*	-1.61	1.41	0.00	4.41	-3.23	14.52	7.14
T1&L18	15.38**	6.45	5.63	8.20	11.76	-3.23	22.58**	7.14
T2&L18	15.38**	3.23	5.63	4.92	10.29	12.90	20.97*	25.00*
T1&L19	12.31*	3.23	2.82	4.92	16.18*	3.23	27.42**	14.29
T2&L19	3.08	6.45	-5.63	8.20	-5.88	3.23	3.23	14.29
T1&L20	6.15	6.45	-2.82	8.20	10.29	6.45	20.97*	17.86
T2&L20	6.15	17.74**	-2.82	19.67**	-2.94	19.35	6.45	32.14**
T1&L21	10.77*	16.13**	1.41	18.03**	0.00	12.90	9.68	25.00*
T2&L21	3.08	16.13**	-5.63	18.03**	-8.82	9.68	0.00	21.43
T1&L22	4.62	16.13**	-4.23	18.03**	2.94	19.35	12.90	32.14**
T2&L22	17.69**	20.97**	7.75	22.95**	17.65*	32.26**	29.03**	46.43**
T1&L23	12.31*	25.81**	2.82	27.87**	0.00	35.48**	9.68	50.00**
T2&L23	4.62	12.90*	-4.23	14.75**	-8.82	6.45	0.00	17.86
T1&L24	6.15	11.29*	-2.82	13.11*	14.71	16.13	25.81**	28.57*
T2&L24	1.54	11.29*	-7.04	13.11*	-5.88	3.23	3.23	14.29
T1&L25	6.15	24.19**	-2.82	26.23**	1.47	6.45	11.29	17.86
T2&L25	6.15	17.74**	-2.82	19.67**	2.94	24.19*	12.90	37.50**

Table 7: Continued…

Traits	Ear length(CM)				Ear diameter(CM)			
Crosses	H% relative to Giza 168		H% relative to Giza 176		H% relative to Giza 168		H% relative to Giza 176	
	HD	LD	HD	LD	HD	LD	HD	LD
T1&L1	-10.80*	5.28	-4.83	2.78	-1.52	-1.49	0.00	4.76
T2&L1	-7.67	10.57*	-1.49	7.94	-1.52	-10.45	0.00	-4.76
T1&L2	-8.71	8.54*	-2.60	5.95	-1.52	-5.97	0.00	0.00
T2&L2	-4.88	13.01**	1.49	10.32*	-3.03	1.49	-1.54	7.94
T1&L3	-0.35	18.29**	6.32	15.48**	0.00	0.00	1.54	6.35
T2&L3	2.09	22.76**	8.92	19.84**	3.03	0.00	4.62	6.35
T1&L4	-4.18	13.82**	2.23	11.11**	0.00	-2.24	1.54	3.97
T2&L4	-5.57	12.60**	0.74	9.92*	-1.52	-2.99	0.00	3.17
T1&L5	-2.44	17.07**	4.09	14.29**	4.55	0.00	6.15	6.35
T2&L5	-10.45*	7.72	-4.46	5.16	-10.15	-4.48	-8.77	1.59
T1&L6	-3.14	16.26**	3.35	13.49**	1.52	-7.46	3.08	-1.59
T2&L6	-10.80*	4.88	-4.83	2.38	3.03	4.48	4.62	11.11
T1&L7	-13.94**	2.03	-8.18	-0.40	-7.20	-1.49	-5.77	4.76
T2&L7	-4.70	13.41**	1.67	10.71*	1.89	-5.97	3.46	0.00
T1&L8	-6.62	11.79**	-0.37	9.13*	-3.03	-5.97	-1.54	0.00
T2&L8	-16.03**	-7.32	-10.41*	-9.52*	-6.06	-2.99	-4.62	3.17
T1&L9	-3.83	15.45**	2.60	12.70**	-12.12	1.49	-10.77*	7.94
T2&L9	-7.32	10.57*	-1.12	7.94	-1.52	-2.99	0.00	3.17
T1&L10	-2.44	17.89**	4.09	15.08**	-3.03	-1.49	-1.54	4.76
T2&L10	-11.67*	5.28	-5.76	2.78	-6.06	-10.45	-4.62	-4.76
T1&L11	-8.19	9.76*	-2.04	7.14	0.00	-8.96	1.54	-3.17
T2&L11	-3.14	16.67**	3.35	13.89**	0.00	5.97	1.54	12.70
T1&L12	-13.24**	4.07	-7.43	1.59	-4.17	2.99	-2.69	9.52
T2&L12	-2.61	16.67**	3.90	13.89**	6.06	-2.99	7.69	3.17
T1&L13	-12.54**	2.03	-6.69	-0.40	-6.06	1.49	-4.62	7.94
T2&L13	-6.45	11.79**	-0.19	9.13*	5.53	0.00	7.15	6.35
T1&L14	-4.18	15.45**	2.23	12.70**	3.03	0.00	4.62	6.35
T2&L14	-2.44	17.68**	4.09	14.88**	1.89	-0.75	3.46	5.56
T1&L15	-16.38**	0.41	-10.78*	-1.98	-1.52	-11.94	0.00	-6.35
T2&L15	-5.75	12.20**	0.56	9.52*	-4.55	1.49	-3.08	7.94
T1&L16	-5.23	13.41**	1.12	10.71*	3.03	0.00	4.62	6.35
T2&L16	-15.33**	3.66	-9.67*	1.19	-3.03	-5.97	-1.54	0.00
T1&L17	-6.27	12.20**	0.00	9.52*	-3.79	1.49	-2.31	7.94
T2&L17	-18.82**	-0.81	-13.38**	-3.17	3.03	-6.72	4.62	-0.79
T1&L18	-10.10*	6.10	-4.09	3.57	-12.12*	-2.99	-10.77*	3.17
T2&L18	-10.45*	6.91	-4.46	4.37	1.52	-1.49	3.08	4.76
T1&L19	-8.71	7.72	-2.60	5.16	4.55	-2.99	6.15	3.17
T2&L19	-16.20**	-4.47	-10.59*	-6.75	-6.06	-14.93	-4.62	-9.52
T1&L20	-7.67	9.35*	-1.49	6.75	-5.30	4.48	-3.85	11.11
T2&L20	-11.50*	5.69	-5.58	3.17	-1.52	0.00	0.00	6.35
T1&L21	-12.20**	6.91	-6.32	4.37	-9.09	-12.31	-7.69	-6.75
T2&L21	-9.76*	8.13	-3.72	5.56	-9.09	1.49	-7.69	7.94
T1&L22	-13.41**	3.25	-7.62	0.79	-9.09	0.00	-7.69	6.35
T2&L22	-8.71	8.54*	-2.60	5.95	-6.06	-4.48	-4.62	1.59
T1&L23	-6.27	11.38**	0.00	8.73*	5.30	-2.99	6.92	3.17
T2&L23	-5.57	13.01**	0.74	10.32*	-3.03	-2.99	-1.54	3.17
T1&L24	-8.36	9.35*	-2.23	6.75	1.52	-7.46	3.08	-1.59
T2&L24	-5.92	12.20**	0.37	9.52*	-9.09	2.99	-7.69	9.52
T1&L25	-15.68**	0.81	-10.04*	-1.59	-1.89	-11.94	-0.38	-6.35
T2&L25	-9.76*	7.72	-3.72	5.16	-1.52	-2.99	0.00	3.17

Table 7: Continued………

Traits	No. of rows / ear				No. of kernels / row			
Crosses	H% relative to Giza 168		H% relative to Giza 176		H% relative to Giza 168		H% relative to Giza 176	
	HD	LD	HD	LD	HD	LD	HD	LD
T1&L1	-4.35	-9.09	10.00	5.26	-6.90	-3.42	-10.00	-0.88
T2&L1	0.00	-4.55	15.00	10.53	0.00	1.71	-3.33	4.39
T1&L2	0.00	4.55	15.00	21.05**	-1.72	0.00	-5.00	2.63
T2&L2	0.00	0.00	15.00	15.79*	6.03	3.42	2.50	6.14
T1&L3	-4.35	0.00	10.00	15.79*	22.41**	12.82**	18.33**	15.79**
T2&L3	0.00	4.55	15.00	21.05**	20.69**	13.68**	16.67*	16.67**
T1&L4	0.00	0.00	15.00	15.79*	8.62	5.13	5.00	7.89
T2&L4	0.00	0.00	15.00	15.79*	6.03	2.56	2.50	5.26
T1&L5	-21.74**	-9.09	-10.00	5.26	13.79*	7.69	10.00	10.53*
T2&L5	-17.39*	4.55	-5.00	21.05**	-6.03	-1.71	-9.17	0.88
T1&L6	0.00	0.00	15.00	15.79*	12.93	5.13	9.17	7.89
T2&L6	-17.39*	-9.09	-5.00	5.26	-6.03	-3.42	-9.17	-0.88
T1&L7	-8.70	-13.64*	5.00	0.00	-9.48	-5.13	-12.50	-2.63
T2&L7	-8.70	0.00	5.00	15.79*	6.03	4.27	2.50	7.02
T1&L8	0.00	-9.09	15.00	5.26	1.72	1.71	-1.67	4.39
T2&L8	0.00	-13.64*	15.00	0.00	-11.21	-10.26*	-14.17*	-7.89
T1&L9	0.00	0.00	15.00	15.79*	10.34	4.27	6.67	7.02
T2&L9	-4.35	4.55	10.00	21.05**	0.86	0.85	-2.50	3.51
T1&L10	0.00	-13.64*	15.00	0.00	14.66*	11.97**	10.83	14.91**
T2&L10	-4.35	-9.09	10.00	5.26	-7.76	-2.56	-10.83	0.00
T1&L11	-8.70	0.00	5.00	15.79*	-0.86	0.85	-4.17	3.51
T2&L11	0.00	-9.09	15.00	5.26	12.07	6.84	8.33	9.65
T1&L12	-4.35	-9.09	10.00	5.26	-9.48	-3.42	-12.50	-0.88
T2&L12	13.04	-4.55	30.00**	10.53	14.66*	6.84	10.83	9.65
T1&L13	0.00	-13.64*	15.00	0.00	-7.76	-5.98	-10.83	-3.51
T2&L13	17.39*	0.00	35.00**	15.79*	1.72	1.71	-1.67	4.39
T1&L14	4.35	13.64*	20.00*	31.58**	8.62	5.13	5.00	7.89
T2&L14	4.35	9.09	20.00*	26.32**	17.24*	8.55	13.33*	11.40*
T1&L15	-13.04	-13.64*	0.00	0.00	-12.93	-6.84	-15.83*	-4.39
T2&L15	-4.35	4.55	10.00	21.05**	4.31	1.71	0.83	4.39
T1&L16	-13.04	13.64*	0.00	31.58**	6.03	3.42	2.50	6.14
T2&L16	0.00	-13.64*	15.00	0.00	-10.34	-4.27	-13.33*	-1.75
T1&L17	-8.70	0.00	5.00	15.79*	2.59	1.71	-0.83	4.39
T2&L17	-4.35	0.00	10.00	15.79*	-12.07	-6.84	-15.00*	-4.39
T1&L18	-8.70	4.55	5.00	21.05**	-3.45	-1.71	-6.67	0.88
T2&L18	-4.35	4.55	10.00	21.05**	-5.17	-1.71	-8.33	0.88
T1&L19	-4.35	0.00	10.00	15.79*	-1.72	-1.71	-5.00	0.88
T2&L19	-8.70	-4.55	5.00	10.53	-12.07	-8.55	-15.00*	-6.14
T1&L20	-13.04	13.64*	0.00	31.58**	-0.86	0.85	-4.17	3.51
T2&L20	-13.04	4.55	0.00	21.05**	-7.76	-1.71	-10.83	0.88
T1&L21	0.00	-4.55	15.00	10.53	-7.76	-1.71	-10.83	0.88
T2&L21	0.00	-9.09	15.00	5.26	-2.59	0.00	-5.83	2.63
T1&L22	-4.35	0.00	10.00	15.79*	-9.48	-5.98	-12.50	-3.51
T2&L22	-4.35	0.00	10.00	15.79*	-1.72	0.00	-5.00	2.63
T1&L23	0.00	0.00	15.00	15.79*	2.59	1.71	-0.83	4.39
T2&L23	-8.70	-4.55	5.00	10.53	5.17	3.42	1.67	6.14
T1&L24	-4.35	-9.09	10.00	5.26	-0.86	0.85	-4.17	3.51
T2&L24	-4.35	13.64*	10.00	31.58*	5.17	1.71	1.67	4.39
T1&L25	-8.70	0.00	5.00	15.79*	-11.21	-5.98	-14.17*	-3.51
T2&L25	8.70	0.00	25.00**	15.79*	-2.59	-0.85	-5.83	1.75

Table 7: Continued…

Traits	No. of ears / plot				100-kernel weight (g)			
Crosses	H% relative to Giza 168		H% relative to Giza 176		H% relative to Giza 168		H% relative to Giza 176	
	HD	LD	HD	LD	HD	LD	HD	LD
T1&L1	-5.26	-12.73*	-5.26	-7.69	-2.35	-9.47	-6.74	8.86
T2&L1	0.00	-7.27	0.00	-1.92	10.59	0.00	5.62	20.25**
T1&L2	-5.26	-9.09	-5.26	-3.85	4.71	-2.11	0.00	17.72*
T2&L2	-3.51	3.64	-3.51	9.62	15.29*	2.11	10.11	22.78**
T1&L3	10.53*	5.45	10.53*	11.54*	31.76**	9.47	25.84**	31.65**
T2&L3	5.26	7.27	5.26	13.46*	36.47**	12.63*	30.34**	35.44**
T1&L4	5.26	-9.09	5.26	-3.85	17.65*	3.16	12.36	24.05**
T2&L4	-5.26	-7.27	-5.26	-1.92	14.12*	2.11	8.99	22.78**
T1&L5	5.26	3.64	5.26	9.62	29.41**	6.32	23.60**	27.85**
T2&L5	-3.51	-23.64**	-3.51	-19.23**	2.35	-6.32	-2.25	12.66
T1&L6	3.51	-7.27	3.51	-1.92	20.00**	3.16	14.61*	24.05**
T2&L6	-14.04**	-12.73*	-14.04**	-7.69	0.00	-10.53	-4.49	7.59
T1&L7	-8.77	-12.73*	-8.77	-7.69	-3.53	-13.68*	-7.87	3.80
T2&L7	-3.51	-5.45	-3.51	0.00	15.29*	3.16	10.11	24.05**
T1&L8	-1.75	-5.45	-1.75	0.00	11.76	1.05	6.74	21.52**
T2&L8	-8.77	-23.64**	-8.77	-19.23**	-29.41**	-16.84**	-32.58**	0.00
T1&L9	0.00	-1.82	0.00	3.85	16.47*	3.16	11.24	24.05**
T2&L9	-3.51	-5.45	-3.51	0.00	9.41	0.00	4.49	20.25**
T1&L10	8.77	7.27	8.77	13.46*	35.29**	8.42	29.21**	30.38**
T2&L10	-1.75	-7.27	-1.75	-1.92	0.00	-9.47	-4.49	8.86
T1&L11	-3.51	-9.09	-3.51	-3.85	8.24	0.00	3.37	20.25**
T2&L11	0.00	-5.45	0.00	0.00	20.00**	4.21	14.61*	25.32**
T1&L12	-10.53*	-12.73*	-10.53*	-7.69	-3.53	-11.58	-7.87	6.33
T2&L12	3.51	1.82	3.51	7.69	24.71**	4.21	19.10**	25.32**
T1&L13	-7.02	-10.91*	-7.02	-5.77	-5.88	-13.68*	-10.11	3.80
T2&L13	-10.53*	-7.27	-10.53*	-1.92	11.76	1.05	6.74	21.52**
T1&L14	0.00	-1.82	0.00	3.85	18.82**	3.16	13.48*	24.05**
T2&L14	15.79**	-1.82	15.79**	3.85	28.24**	4.21	22.47**	25.32**
T1&L15	-7.02	-20.00**	-7.02	-15.38**	-14.12*	-14.74*	-17.98**	2.53
T2&L15	-1.75	-3.64	-1.75	1.92	12.94	1.05	7.87	21.52**
T1&L16	1.75	-10.91*	1.75	-5.77	15.29*	3.16	10.11	24.05**
T2&L16	-12.28*	-12.73*	-12.28*	-7.69	-2.35	-11.58	-6.74	6.33
T1&L17	-3.51	-10.91*	-3.51	-5.77	12.94	1.05	7.87	21.52**
T2&L17	-14.04**	-25.45**	-14.04**	-21.15**	-17.65*	-15.79*	-21.35**	1.27
T1&L18	-8.77	-9.09	-8.77	-3.85	2.35	-6.32	-2.25	12.66
T2&L18	-3.51	-10.91*	-3.51	-5.77	2.35	-6.32	-2.25	12.66
T1&L19	-1.75	-12.73*	-1.75	-7.69	2.35	-4.21	-2.25	15.19*
T2&L19	-15.79**	-18.18**	-15.79**	-13.46*	-14.12*	-21.05**	-17.98**	-5.06
T1&L20	-10.53*	-1.82	-10.53*	3.85	8.24	-1.05	3.37	18.99*
T2&L20	-10.53*	-12.73*	-10.53*	-7.69	1.18	-8.42	-3.37	10.13
T1&L21	0.00	-12.73*	0.00	-7.69	2.35	-6.32	-2.25	12.66
T2&L21	3.51	-9.09	3.51	-3.85	4.71	-2.11	0.00	17.72*
T1&L22	-8.77	-18.18**	-8.77	-13.46*	-3.53	-13.68*	-7.87	3.80
T2&L22	-7.02	-3.64	-7.02	1.92	7.06	-1.05	2.25	18.99*
T1&L23	-7.02	-5.45	-7.02	0.00	11.76	1.05	6.74	21.52**
T2&L23	5.26	7.27	5.26	13.46*	15.29*	2.11	10.11	22.78**
T1&L24	5.26	-1.82	5.26	3.85	9.41	-1.05	4.49	18.99*
T2&L24	3.51	-9.09	3.51	-3.85	12.94*	1.05	7.87	21.52**
T1&L25	-12.28*	-12.73*	-12.28*	-7.69	-7.06	-14.74*	-11.24	2.53
T2&L25	-10.53*	-9.09	-10.53*	-3.85	3.53	-5.26	-1.12	13.92

Table 7: Continued…

Traits	Ear weight (g)				Grain yield (ard/fed)			
Crosses	H% relative to Giza 168		H% relative to Giza 176		H% relative to Giza 168		H% relative to Giza 176	
	HD	LD	HD	LD	HD	LD	HD	LD
T1&L1	-18.01**	-11.95*	-10.40	-9.61	-22.32**	-23.29**	-15.18**	-16.69**
T2&L1	-5.43	-8.45	3.34	-6.02	-5.58	-15.29**	3.10	-8.01
T1&L2	-4.49	-7.69	4.37	-5.23	-9.21*	-16.26**	-0.86	-9.06
T2&L2	1.69	-11.84*	11.13	-9.50	-1.55	-8.73	7.50	-0.88
T1&L3	3.81	0.98	13.44*	3.66	14.67**	6.49	25.21**	15.64**
T2&L3	7.43	-0.20	17.41**	2.46	13.16**	7.12	23.56**	16.33**
T1&L4	-2.77	3.38	6.26	6.13	2.24	-5.92	11.64*	2.17
T2&L4	3.17	-2.47	12.75*	0.13	-2.31	-9.67*	6.67	-1.91
T1&L5	5.15	-4.97	14.91*	-2.44	10.74**	-1.73	20.92**	6.72
T2&L5	-9.11	1.10	-0.68	3.79	-12.27**	-22.79**	-4.20	-16.16**
T1&L6	5.31	3.74	15.08*	6.50	9.04*	-3.62	19.07**	4.67
T2&L6	-8.62	-14.27*	-0.14	-11.99*	-21.59**	-25.14**	-14.39**	-18.71**
T1&L7	-18.58**	-19.67**	-11.02	-17.53**	-26.31**	-30.05**	-19.54**	-24.03**
T2&L7	4.87	-1.64	14.60*	0.98	1.24	-6.92	10.55*	1.08
T1&L8	-1.90	-10.10	7.20	-7.71	-4.67	-14.93**	4.09	-7.62
T2&L8	-27.81**	-14.47**	-21.11**	-12.20*	-34.29**	-34.83**	-28.25**	-29.23**
T1&L9	1.52	-3.57	10.94	-1.01	1.50	-5.58	10.83*	2.54
T2&L9	-2.35	-9.72	6.72	-7.31	-5.69	-15.04**	2.98	-7.74
T1&L10	5.09	-4.64	14.85*	-2.11	14.18**	1.96	24.67**	10.72*
T2&L10	-18.49**	-19.79**	-10.93	-17.65*	-20.04**	-26.05**	-12.69*	-19.69**
T1&L11	-2.92	-7.50	6.09	-5.04	-6.21	-15.71**	2.42	-8.47
T2&L11	9.84	0.00	20.04**	2.66	9.88*	-5.48	19.98**	2.65
T1&L12	-13.91*	-17.99**	-5.92	-15.80**	-23.26**	-28.74**	-16.20**	-22.62**
T2&L12	6.74	-3.90	16.65**	-1.34	10.37*	-2.26	20.51**	6.14
T1&L13	-23.43**	-17.76**	-16.33**	-15.58**	-28.88**	-26.87**	-22.34**	-20.58**
T2&L13	6.04	-7.76	15.88*	-5.31	-5.08	-14.55**	3.64	-7.21
T1&L14	3.85	-4.45	13.49*	-1.91	3.81	-6.31	13.35**	1.74
T2&L14	-3.33	5.94	5.65	8.76	12.25**	3.94	22.57**	12.88*
T1&L15	-25.08**	-21.06**	-18.13**	-18.96**	-30.11**	-37.10**	-23.68**	-31.69**
T2&L15	-1.14	-8.26	8.03	-5.82	-3.47	-11.86*	5.40	-4.28
T1&L16	-0.91	1.91	8.29	4.62	1.04	-9.35*	10.33*	-1.56
T2&L16	-12.84*	-23.04**	-4.75	-20.99**	-23.54**	-32.85**	-16.52**	-27.08**
T1&L17	-0.87	-1.97	8.33	0.64	-4.32	-13.03**	4.47	-5.55
T2&L17	-20.26**	-17.21**	-12.86*	-15.00**	-31.44**	-38.50**	-25.13**	-33.22**
T1&L18	-5.97	-13.57*	2.76	-11.27*	-13.75**	-21.59**	-5.82	-14.85**
T2&L18	-10.21	-13.96*	-1.87	-11.67*	-13.32**	-23.18**	-5.36	-16.58**
T1&L19	-10.62	-8.43	-2.33	-5.99	-12.19**	-19.78**	-4.12	-12.88*
T2&L19	-20.60**	-20.39**	-13.23*	-18.28**	-33.30**	-35.06**	-27.16**	-29.47**
T1&L20	2.35	-14.03*	11.85	-11.74*	-8.34	-15.55**	0.09	-8.29
T2&L20	-8.98	-14.54*	-0.53	-12.27*	-18.32**	-25.61**	-10.82*	-19.22**
T1&L21	-15.91*	-15.86**	-8.11	-13.62*	-15.96**	-26.54**	-8.23	-20.22**
T2&L21	-11.86*	-12.51*	-3.68	-10.18	-9.26*	-20.80**	-0.92	-13.99**
T1&L22	-19.96**	-13.36*	-12.53*	-11.05	-27.11**	-29.51**	-20.41**	-23.46**
T2&L22	-2.12	-13.85*	6.97	-11.56*	-8.88*	-16.72**	-0.51	-9.56*
T1&L23	1.84	-8.23	11.29	-5.79	-5.45	-13.52**	3.24	-6.08
T2&L23	-6.79	-16.71**	1.86	-14.49*	-1.84	-10.77*	7.19	-3.10
T1&L24	-11.44	-14.34*	-3.22	-12.06*	-6.92	-16.17**	1.63	-8.97
T2&L24	-5.32	-3.78	3.46	-1.22	-2.69	-13.02**	6.25	-5.55
T1&L25	-19.19**	-23.40**	-11.69	-21.36**	-29.09**	-33.28**	-22.58**	-27.55**
T2&L25	1.27	-12.66*	10.66	-10.34	-9.46*	-20.82**	-1.14	-14.02**

The two top crosses (L1 × T2 and L11 × T2) under HD and the combined data and the two top crosses (L14 × T2 and L20 × T1) under the combined analysis only, showed significant positive specific combining ability effects for this trait. The current finding is similar with the previous investigation by Barakat and Balbaa (2013); El-Koomy (2015); Ejigu et al. (2017) and Mbuvi et al. (2018).

5- Heterosis

Economic heterosis expressed by superiority F1 over the check varieties (Giza 168 and Giza 176) for all studied traits under two plant populations were presented in Table (7). Regarding plant height, economic heterosis relative to Giza 168 ranged from -6.15% to 23.08% and -1.6% to 29.03% under high plant density and low plant density, respectively. The respective heterotic values for the check Giza 176 ranged from -14.04% to 12.68% and 0.00% to 31.15%. However, the top cross L8 x T2 exhibited the best heterotic values under high plant density relative to both check varieties. For ear height, heterotic effects relative to Giza 168 ranged from -13.24% to 27.94% and -12.90% to 41.94% under HD and LD, respectively. The heterotic values relative to Giza 176 ranged from -4.84% to 40.32% and -3.57%to 57.14% for the respective cases. Negative heterosis for plant and ear height which helps for developing short plants with less lodging. These results are in agreement with those reported by Abd El-Moneam *et al.,* (2009) and Sedhom *et al.,* (2016).

Concerning ear length, forteen top crosses exhibited the highest values relative to check Giza 176 under high plant density. Under low plant density, twenty two top crosses (L2 x T2, L3 x T1, L3 x T2, L4 x T1, L4 x T2, L5 x T1, L6 x T1, L7 x T2, L8 x T1, L9 x T1, L10 x T1, L11 x T2, L12 x T2, L13 x T2, L14 x T1, L14 x T2, L15 x T2, L16 x T1, L17 x T1, L23 x T1, L23 x T2 and L24 x T2) exhibited the highly significant values relative to two check varieties. Regarding ear diameter, the top crosses (L3 x T2, L5 x T1, L6 x T1, L6 x T2, L7 x T2, L12 x T2, L13 x T2, L14 x T1, L14 x T2, L16 x T1, L17 x T2, L18 x T2, L19 x T1, L23 x T1 and L24 x T1) showed the highest values of heterosis relative to two checks under high plant density. The top crosses (L2 x T2, L6 x T2, L9 x T1, L11 x T2, L12 x T1, L13 x T1, L15 x T2, L17 x T1, L20 x T1 and L21 x T2) were the best crosses, also for this trait under low plant density. For number of rows per ear, the top crosses (L12 x T2, L14 x T1, L14 x T2 and L25 x T2) exhibited significantly superior over the check Giza 176. The top cross L13 x T2 was significant heterotic effect relative to two check varieties under high plant density. Meanwhile, under low plant density, thirty top crosses exhibited significant heterotic effects only relative to the check Giza 176. The top crosses (L14 x T1, L16 x T1, L20 x T1 and L24 x T2) showed significant superiority relative to two check varieties. Concerning number of kernels per row, significant and positive standard heterosis relative to two check were detected for two top crosses (L3 x T1 and L3 x T2) under two plant populations. Moreover, the best heterotic effect for this trait was recorded by the top crosses (L5 x T1 and L10 x T1) relative to Giza 168, top crosses (L14 x T2) relative to two checks and the top crosses (L5 x T1 and L14 x T2) relative to Giza 176, and top cross (L10 x T1) relative to two check varieties under high and low plant densities, respectively. Number of ears per plot, two top crosses, (L3 x T1 and L14 x T2) exhibited positive and significant heterotic effects relative to the checks (Giza 168 and Giza 176) under high plant density. Four top crosses (L3 x T1, L3 x T2, L10 x T1 and L23 x T2) expressed desirable heterotic effects relative to Giza 176 under low plant density. Regarding 100-kernel weight, the top cross (L3 x T2) was the highest heterosis relative to two checks over two plant populations. Under (HD), nine top crosses were highly significant heterosis relative to Giza 168 and Giza 176, while, eight top crosses were superiority effects relative to Giza 168 only. Under (LD), thirty top crosses expressed significant superiority relative to Giza 176 only. Similar results were reported by Akntar *et al.,* (2003); Mohanraj and Goplan (2005); El-Shamarka *et al.,* (2015) and Sedhom *et al.,* (2016). For ear weight, eleven top crosses (L3 x T1, L3 x T2, L4 x T2, L5 x T1, L6 x T1, L7 x T2, L10 x T1, L11 x T2, L12 x T2, L13 x T2 and L14 x T1) exhibited significantly superior over the check Giza 176 under high plant density.

Economic heterosis effects for grain yield (ard/fad) relative to Giza 168 and Giza 176 in two plant populations. Results indicate that eight top crosses expressed significant and positive standard heterosis relative to two checks under high plant density. Moreover, the top cross L3 x T1 ranked the first for heterosis relative to Giza 168(14.67%) and Giza 176 (25.21%). Low plant density, four top crosses (L3 x T1, L3 x T2, L10 x T1 and L14 x T2) showed significantly superior over Giza 176 recording (15.64%, 16.33%, 10.72% and 12.88%0, respectively. These results are in agreement with those obtained by El-Hosary and El-gammal (2013); El-shamarka *et al.,* (2015); Sedhom *et al.,* (2016); Darshan and Marker (2019).

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الملخص العربى

القدرة علي التآلف للمحصول ومكوناتة من خلال تحليل سلالة في كشاف في الذرة الشامية تحت كثافتين نباتيتين مختلفتين

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أجريت هذه الدراسة بالمزرعة البحثية بكلية الزراعة بجامعة المنوفية بالراهب بمصر خلال موسمي الزراعة ٢٠١٤، ٢٠١٥ بهدف تقييم مجموعة من سلالات الذرة الشامية الصفراء، وأشتملت هذه الدراسة علي ٢٥ سلالة صفراء منتخبة من الجيل الثالث المعزولة من الصنف التركيبي ٢١ لقدرتها الإنتاجية العالية وصفاتها المرغوبة.

في الموسم الصيفي ٢٠١٤م، تم زراعة ٢٥ سلالة والكشافان وتم إجراء كل التهجينات الممكنة بين ٢٥ سلالة والكشافان بواسطة اليد للحصول علي ٥٠ هجين قمي. وفي الموسم الصيفي ٢٠١٥م، تم تقييم جميع الهجن القمية (٥٠ هجين) بالإضافة إلي الهجينين الفرديين (جيزة١٦٨، جيزة١٧٦) للمقارنة تحت كثافتين نباتيتين هما ٢٤ الف نبات/فدان، ٣٠ الف نبات/فدان، في تجربتين متجاورتين نفذ كل منهما في تصميم قطاعات عشوائية كاملة بثلاث مكررات، القدرة الخاصة علي التآلف كانت أكثر أهمية من القدرة العامة وذلك لكل الصفات عدا التحليل التجميعي لصفة طول النبات. سجلت السلالات L3, L4, L5, L14, L23 قدرة عامة عالية علي التآلف لصفة المحصول ومكوناته ولذلك ينصح بإدخالهم في انتاج هجن عالية المحصول. كان الهجينين القميين L12 x T2, L17 x T2 لهم تأثير معنوي ومرغوب للقدرة الخاصة على التآلف نحو صفتي قصر النبات وانخفاض موقع الكوز تحت الكثافة المنخفضة فقط. وجد ١٣ هجين قمي في كلا الكثافتين والتحليل المشترك ذات تأثير معنوي للقدرة الخاصة على التآلف لصفة المحصول، كما أن الهجينين L1 x T2, L11 x T2 كانا ذا تأثير معنوي مرغوب للقدرة الخاصة للمحصول تحت الكثافة العالية. الهجينين L3 x T1, L14 x T2 سجلا قوة هجين معنوي مقارنة بصنفي المقارنة تحت الكثافة العالية بالنسبة لصفة عدد الكيزان في القطعة التجريبية. أعطي الهجين القمي L3 x T2 أعلي قيمة للتفوق الهجيني بالنسبة لصفة وزن المائة حبة. سجل الهجين القمي L3 x T1 أعلي قيمة لقوة الهجين بالنسبة لصفتي وزن الكوز والمحصول مقارنة بصفتي المقارنة، كما وجد ٨ هجن قمية أخري أعطت قوة هجين عالية بالنسبة لصفة المحصول.