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Combining ability and heterosis estimates for yield and other attributes traits under water stress conditions in white maize (*Zea mays* L.)

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Abstract

Sixteen parents (13 lines and 3 testers), their thirty-nine top-crosses and two check commercial hybrids were evaluated under two irrigation treatments, i.e., normal and water-stressed at Research Station of the Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. during the two seasons of 2021 and 2022, some traits, *i.e.*, days to 50% silking (DS), ear height (EH), ears /plant (E/P), kernels/ row (K/R), 100-kernel weight (KW) and grain yield /plant (GY/P) were studied. Analysis of variance showed significant ($P \leqslant 0.05$ to $P \leqslant 0.01$) differences of genotypes for all studied traits under both environments as well as combined. Mean squares due to GXE showed significant ($P \leqslant 0.05$ to $P \leqslant 0.01$) differences for all studied traits, except for DS. Mean squares due to lines and tester were significant or highly significant for all traits under both environments except for ears/plant for lines under normal environment and ears/plant, 100-K/w under normal environment and 100-K/w under drought stress for tester which were not significant. The inbred IL-16, IL-15 and IL-11 showed positive and highly significant GCA effects for ears/plant, kernels/row and 100-K/w under the normal environment. While IL-18, IL-16 and IL-7 showed positive and highly significant GCA effects for ears/plant, kernels/row and 100-K/W under the drought environment, inbred linens IL-18, IL-16 and IL-15 had positive and highly significant GCA effects for same traits in combined. Inbred L-5 exhibited positive and highly significant GCA effects for grain yield/plant at both condition and combined. The crosses IL-4 × CML-57, IL-5 × SC-128, IL-21 × CML-57 and IL-23 × CML-57, had the best among the hybrids having the highest desirable specific combining ability effect for grain yield at normal, drought stress and combined for grain yield/plant. The highest value of heterotic effects relative to better and mid-parents for grain yield per plant were obtained by IL-21 × CML-57 it gave 531.04% and 649.53% and 109.81% and 140.85% the cross had the highest positive significant heterotic under both environments. Heritability in broad sense values was higher than narrow sense values because non additive variance was larger than additive variance.

Keywords: general and specific combining ability, heritability, heterosis, maize, drought stress.

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1. Introduction

Maize (*Zea mays* L.) is one of the most important crops in Egypt. The area cultivated by maize is estimated to be about 1,027,057 hectares (about 2.44 million feddan) and produced 7.5 million tons of grains, with an average yield of 7.3ton ha-1 (about 22 ardeb/feddan) (feddan = 4200 m² = 0.420 hectares = 1.037 acres, Ardeb = 5.44 imperial or 5.619 U.S. bushels). Drought is a worldwide phenomenon and is a major production constraint, reducing crop yields. Drought, like many other environmental stresses, has adverse effects on crop yield. Low water availability is one of the major causes for crop yield reductions affecting the majority of the farmed regions around the world. Maize is used as a food grain for human and animals. Maize is a versatile crop with a wide genetic diversity and is able to grow successfully in a wide range of environmental conditions. There is a big gap between production and consumption of maize 48% (FAO, 2021). This gap will be increase with the increasing of population in next years. Abiotic stresses such as drought is the major problems, which reducing the chances of expanding the crop cultivation and significant yield losses of maize (Fischer *et al*., 2020). Thus, drought resistance in crops is probably the most difficult trait to understand (Bruce *et al*. 2002; Ashraf, 2010). The development of drought tolerant lines and new hybrid becomes increasingly more important and requires information on the genetic structure of the parental lines and their offspring. This information can be derived through the use of different mating designs, such as diallel crosses, line × tester mating design and others. A selection index (SI) for standardized variables across environments was used to select the best lines in hybrid combinations across water regimes.SI, illustrated by Smith (1936), gives proper weight to each of two or more characters to be considered for selecting better genotypes. The line × tester mating design was used in various studies, for example, those by Menkir *et al*. (2003), Wali *et al*. (2021) and Hefny (2010) to estimate the effects of the general and specific combining abilities of the studied lines and their crosses. The line × tester analysis also helps in estimating the components of genetic variance and the type of genetic effects. Hussain and Aziz (1998) explained that the parents with high general combining ability for any trait do not have to give the effects of the specific combining ability to be high for the same trait. SCA could be used to predict the hybrid performance (Ibrahim *et al*., 2021). After selecting the more promising high general combiner lines, it is necessary to identify the particular combination that will produce the highest yield through specific combining ability (SCA). Moreover, Abrha *et al*. (2013) and Ganapati Mukri *et al*. (2022) indicated that both additive and non-additive gene actions were important in controlling the behavior of genetic potential of the inbred lines of maize development for yield and related traits. The two most important activities in maize improvement are a development the inbred lines with high estimates of general combining ability (GCA) and specific combining ability (SCA), and b- identification the hybrids with high yield potentials. The main objectives of the current study are to estimate the heritability, heterosis and general and specific combining abilities for grain yield of maize and its components from other traits under drought stress and non-drought stress for improving drought tolerance in maize.

2. Materials and methods

In 2021 growing season, 13 inbred lines were used to form testcrosses with three testers from the complimentary heterotic group (Table 1). All lines were planted at the Agricultural Experiment and Research Station of the Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, at three sowing dates (May 4th, May 11th and May 18th) in order to grant flower matching among males and females. and all possible crosses were made between them according to line × tester design (Kempthorne, 1957). 39 top-crosses and 16 parents were evaluated in 2022 season at the Agricultural Experiment and Research Station of the Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, under well watering (N) irrigation every 15 days, Experiment 1, water stress at flowering (S). The irrigation regime was just like well watering, but the 4th and 5th irrigations were withheld, resulting in 24 days' water stress just before and during flowering stage in a Randomized Complete Block Design (RCBD) with three replications. Experimental plot size was one row, 4 m in length and 70 cm wide and 25 cm between hills within row (2.8 m^2).

2.1 Agricultural practices

All other agricultural practices were followed according to the recommendations of Agricultural Research Center (ARC) Egypt. Seedlings were thinned to one plant/hill before the first irrigation (two weeks after sowing). Nitrogen fertilization at the rate of 120 kg N/feddan was added in two equal doses of Urea 46% before 1st and 2nd irrigations. Weed control was performed chemically with Stomp 330-E herbicide (Pendimethalin 33% w/v), just after sowing and before the planting irrigation. Pest control was performed when required by spraying plants with Lannate (Methomyl) 90% (manufactured by DuPont, USA) against corn borers.

2.3 Data recorded

The data on the individual ten plants were selected at random from each experimental unit for studying the following traits, days to 50% silking (DS), ear height (EH), ears /plant (E/P), kernels/ row (K/R), 100-kernel weight (100-KW) and grain yield /plant (GY/P).

Table (1): Pedigree and origin of 13 inbred lines and three testers used in this study.

SN	Designation	Parental source	Origin
Inbred lines (females)			
1.	IL.1	TWC-310	ARC-Egypt
2.	IL.4	S.C 124	ARC-Egypt
3.	IL.5	S.C 2030	Misr HYTECH
4.	IL.6	S.C 2030	Misr HYTECH
5.	IL.7	S.C 2031	Misr HYTECH
6.	IL.11	EGAS.77	Egaseed Co., Egypt
7.	IL.13	SC30 K8	DuPont Pioneer
8.	IL.14	SC 10	ARC-Egypt
9.	IL.15	FIN 1005	Fine Seeds, Egypt
10.	IL.16	SC30 K9	DuPont Pioneer
11.	IL.18	CML 86	CIMMYT-Mexico
12.	IL.21	CML 208	CIMMYT-Mexico
13.	IL.23	CML 371	CIMMYT-Mexico
Testers (males)			
1.	SC -128 W	(local commercial cultivar) (single cross)	ARC-Egypt
2.	CML-47	CML-314W (inbred)	CIMMYT-Mexico
3.	CML-57	CML-445 W (inbred)	CIMMYT-Mexico

ARC = Agricultural Research Center, SC = Single cross, IL = inbred line, CML= CIMMYT line, W = white grains.

2.3 Statistical analysis

Statistical procedures used in this study were done to the analysis of variance for randomized complete blocks design as outlined by Cochran and Cox (1957). Mean of values were compared at 5% level of probability using least significant difference (LSD). An ordinary analysis of variance was performed for the data collected from top crosses to test the differences and significance of all genotypes. When differences among top crosses were significant, the line × tester analysis according to Kempthorne (1957) and Singh and Chaudhary (1985) was done to estimate variance due to general and specific combining ability of the tested lines and testers interaction as well as various types of the gene effects.

2.3.1 Estimating GCA and SCA variances and effects

The model used to estimate general (GCA) and specific (SCA) combining ability effects of the Xijkth observation is as follows:

Xijk = μ + gi + gj + sij +eijk

Where: μ = overall population mean. gi = GCA effect of the ith lines parent. gj = GCA effect of the jth testers parent. sij = SCA effect of the ij cross combination. eijk = the error associated with the xijk observation. i= number of parents lines = 1,2,3……13. j= number of parent's tester = 1,2,3. k= number of replications =1,2,3.

2.3.2 Estimation of GCA effects for lines [ĝi(l)]

Estimation of GCA effects for lines was calculated according to the following formula:

$$\hat{g}i(l) = \frac{Yi..}{tr} - \frac{Y..}{ltr}$$

Where: Yi..= total of the Lth lines parent across all tester parents and replications, Y..= total of all lines across all tester and replications, r = number of replications, l = number of lines and t = number of tester.

2.3.3 Estimation of GCA effects for tester [ĝj(t)]

Estimation of GCA effects for tester was calculated according to the following formula:

$$\hat{g}i(t) = \frac{Yj..}{lr} - \frac{Y..}{ltr}$$

Where: $Y_{j..}$ = total of the j^{th} tester parent across all lines and replications.

2.3.4 Estimation of SCA effects for crosses [ŝij(lt)]

Estimation of SCA effects for crosses was calculated according to the following formula:

$\hat{s}ij(lt) = Yji./r - Yi../tr - Y.j./lr + Y../ltr$

Where: Yij. = total of i^{th} line and it's interaction with j^{th} tester over all replications.

2.3.5 Estimating standard error (SE) for combining ability effects

Estimating standard error (SE) for combining ability effects was calculated according to the following formula:

SE (GCA) for lines = $(2Me/rt)^{½}$

SE (GCA) for testers = $(2Me/rl)^{½}$

2.4 Heterosis

Estimate of heterosis (%) were calculated as the percent deviation of F_1 performance from the mid-parent or better parent as follows:

Heterosis from the mid-parent % (M.P) = $(F_1 - MP) / MP) \times 100$

Heterosis over the better-parent % (BP) = $(F_1 - BP) / BP) \times 100$

2.5 Heritability

2.5.1 Heritability in broad sense

Heritability in broad sense (Hb) was calculated according to the following formula: $Hb = \sigma 2G / \sigma 2P \times 100$

2.5.2 Heritability in narrow sense

Heritability in narrow sense (Hn) was calculated according to the following formula: $Hn = \sigma 2A / \sigma 2P \times 100$

2.6 The expected genetic advance (GA)

The expected genetic advance (GA) expressed as a percentage of the main value with 10% intensity of selection pressure was computed by the formula given by Johanson *et al.* (1955) and Allard (1960) as follows.

2.6.1 Expected gain from selection (G.S)

The expected gain from selecting was calculated according to Allard (1960):

$$G.S\% = [(K \times \sigma ph \times h2\,n) / \bar{x}] \times 100$$

Where dph = phenotypic standard deviation, k = selection differential (the k value for 10% selection intensity used in this study equals 1.76), $\bar{x}$ = mean of the crosses for the respective trait.

2.7 The contributions of lines, testers and line × tester

The contributions of lines, testers and lines × testers were accounted as following:

$$\text{Contribution of lines} = \frac{\text{S.S of lines}}{\text{S.S of crosses}} \times 100$$

$$\text{Contribution of testers} = \frac{\text{S.S of testers}}{\text{S.S of crosses}} \times 100$$

$$\text{Contribution of lines} \times \text{testers} = \frac{\text{S.S of lines} \times \text{s.s of testers}}{\text{S.S of crosses}} \times 100$$

The greater contributions of line × tester interaction than parents for any trait indicates high estimates of variance due to specific combing ability.

3. Results and Discussion

3.1 Analysis of variance

The analysis of variance for maize genotypes involved 39 top crosses resulting from (13 inbred lines × 3 testers) are presented in Table (2). Genotypes *i.e.* parents and crosses exhibited highly significant variation for all studied traits under normal irrigation and water stress conditions, except ears/plant under normal conditions, indicting differences among these genotypes under investigation. Results presented in Table (2) showed that mean squares of parents *vs*. crosses were found to be significant and highly significant for all studied traits, illustrating the wide range of heterosis values among the hybrids for all studied traits for both normal irrigation and water stress conditions. Partitioning the sum of squares due to crosses into their components by using line × tester analysis showed that mean squares due to lines and tester were significant or highly significant for all traits under both environments except for ears/plant, 100-K/w under normal environment and 100-k/w under water stress conditions for tester which were not significant. The significance of mean squares due to lines and testers revealed that variances due to GCA of both lines and testers played an important role in the inheritance of studied traits. At the same time mean squares due to the line × tester interaction was significant or highly significant for all studied traits except for day to 50% silking and kernel/row under water stress conditions and ear/plant and kernel/row under a normal environment, indicating that the SCA variance played an important role in the inheritance of most studied traits. Combined analysis over the two environments, results showed highly significant differences between the two conditions for all traits. Mean squares due to crosses, lines, testers, and their interaction (L × T) were significant or highly significant for all studied traits, except for 100-kernel/weight and (L × T) for number of kernels/row, indicating that crosses had a wide genetic diversity among themselves for these traits providing opportunity for selection, meaning that great diversity exists among inbred lines and among testers; also indicated that the inbred lines performed differently in their respective crosses depending on the type of testers used for these traits. These results are in agreement with those reported by several authors among of them (Abd El-Moula *et al.*, 2009; Barh *et al.*, 2015; Darshan and Marker, 2019; Mosa, 2003). The interaction of crosses × locations (C × Loc) and their partitions i.e., L × Loc, T × Loc, and L × T × Loc were significant or highly significant for ears/plant, 100-kernel/weight and grain yield/plant, while other traits is not significant., meaning that the lines, testers and crosses differed in their order from location to another.

Table (2): Mean squares analysis of variance for the studied maize traits under normal irrigation and water stress conditions.

S.O.V	df		DS			EH			E/P		
	singl	Combi	N	S	Combi.	N	S	Combi.	N	S	Combi
Rep	2	-----	4.87ns	4.59ns		74.16ns	44.81ns		0.005 NS	0.008ns	
Genotypes (G)	54	54	35.95**	44.11**	74.08**	1681.42**	1804.61**	10178.45**	0.045**	0.157**	0.104**
Parents (P)	15	-----	38.64**	44.88**		744.60**	354.16**		0.10**	0.10**	
P vs. C	1	-----	843.47**	1021.02**		62381.31**	74187.29**		0.05*	0.07**	
Crosses (C)	38	-----	13.63**	18.10**	26.35**	453.85**	472.35**	884.59**	0.023ns	0.181**	0.09**
Lines (L)	12	12	16.31**	16.37*	27.48**	532.33**	465.11**	960.22**	0.018ns	0.143**	0.07**
Testers (T)	2	2	88.88**	90.77**	179.75**	4239.42**	4702.08**	8858.98**	0.002ns	1.385**	0.66**
L × T	24	24	6.03**	12.91ns	12.99**	99.15**	123.49**	182.25**	0.027ns	0.099**	0.058**
Error	108	108	1.65	7.3		27.42	73.21		0.02	0.003	
Env (I)	-----	1			524.41**			1241664.92**			18.45**
Rep/enviro	-----	4			1.94			226.04			0.007
Env × Gen	-----	54			5.980ns			6584.78**			0.097**
Env × cross	-----	38			5.436ns			41.61ns			0.12**
Env × Line	-----	12			5.54ns			37.21ns			0.09**
Env × Tester	-----	2			1.107ns			82.52ns			0.72**
E × L × T	-----	24			5.75ns			40.39ns			0.07**
Error (combi)	-----	216			4.53			356.47			0.012
S.O.V	df		K/R			100-KW			GY/P		
	singl	Combi	N	S	Combi.	N	S	Combi.	N	S	Combi
Rep	2	------	28.858ns	29.446ns		34.697ns	17.10ns		1381.48	14.798ns	
Genotypes (G)	54	54	192.675**	138.408**	291.05**	61.348**	30.715**	64.34**	14249.00**	2833.763**	10178.52**
Parents (P)	15	------	187.44**	165.29**		55.59**	29.36**		8474.55**	2085.20**	
P vs. C	1	------	5995.84**	2799.39**		873.97**	53.55**		571418.63**	24.05ns	
Crosses (C)	38	-------	42.027**	57.770**	74.87**	42.235**	30.651**	49.91**	1866.02**	3203.12**	3692.89**
Lines (L)	12	12	72.219**	86.909**	126.59**	65.818**	62.400**	91.42**	2169.04**	2386.43**	3074.59**
Testers (T)	2	2	164.600**	261.155**	375.49**	29.154ns	2.271ns	21.32ns	1948.09**	22669.69**	18386.23**
L × T	24	24	16.716ns	26.251ns	23.97ns	31.533*	17.142*	31.53**	1707.67**	1989.36**	2777.59**
Error	108	108	13.9	17.76		14.86	9.81		653.4	47.65	
Env. (I)	-----	1			9047.74**			3217.97**			1241664.92**
Rep/enviro	-----	4			25.78			24.17			226.04
Env × Gen	-----	54			40.03**			27.72**			6584.78**
Env. x cross	-----	38			24.92ns			22.97*			1376.31**
Env × Line	-----	12			32.54*			36.79**			1480.87**
Env × Tester	-----	2			50.26ns			10.10ns			6231.54**
E x L xT	-----	24			18.99ns			17.13ns			919.43**
Error(combi)	-----	216			15.83			12.33			350.52

3.2 Mean performance

Data in Table (3) presented mean performance of the 39 crosses and two check for six traits of maize combined over two environments. Mean values of inbred and crosses for days to 50% silking for lines the IL-16 and IL-14 were earlier than the others under normal and water stress conditions with value (60.33) and (60.67) respectively.

Table (3): Means performance of parents (13-lines and 3 testers) and two checks under normal and water stress conditions for day to 50% silking.

No.	Line	Tester	DS			No.	Line	Tester	DS		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	54.67	55.33	55.00	31	IL-18	SC-128	56.00	57.33	56.67
2		CML-47	57.33	61.00	59.17	32		CML-47	62.33	62.33	62.33
3		CML-57	57.33	57.67	57.50	33		CML-57	56.33	62.00	59.17
4	IL-4	SC-128	56.67	57.00	56.83	34	IL-21	SC-128	62.33	63.33	62.83
5		CML-47	58.33	61.00	59.67	35		CML-47	61.67	60.00	60.83
6		CML-57	57.00	59.67	59.17	36		CML-57	58.33	59.33	58.83
7	IL-5	SC-128	55.33	59.67	57.50	37	IL-23	SC-128	55.33	58.33	56.83
8		CML-47	58.67	62.33	60.50	38		CML-47	60.67	59.67	60.17
9		CML-57	58.33	64.33	61.33	39		CML-57	58.33	62.67	60.50
10	IL-6	SC-128	55.00	58.00	56.50	40	mean		58.00	60.42	59.23
11		CML-47	58.00	61.67	59.83	41	1	IL-1	60.67	69.00	64.83
12		CML-57	56.00	57.00	56.50	42	2	IL-4	60.33	64.00	62.17
13	IL-7	SC-128	58.33	59.67	59.00	43	3	IL-5	63.33	69.00	66.17
14		CML-47	60.33	63.67	62.00	44	4	IL-6	60.33	64.67	62.50
15		CML-57	57.33	58.67	58.00	45	5	IL-7	64.00	65.00	64.50
16	IL-11	SC-128	56.67	56.67	56.67	46	6	IL-11	65.00	67.00	66.00
17		CML-47	60.33	65.33	62.83	47	7	IL-13	64.33	69.00	66.67
18		CML-57	56.67	59.33	58.00	48	8	IL -14	60.67	60.67	60.67
19	IL-13	SC-128	57.00	60.67	58.83	49	9	IL -15	63.00	66.33	64.67
20		CML-47	61.00	64.00	62.50	50	10	IL -16	68.00	69.00	68.50
21		CML-57	59.33	61.00	60.17	51	11	IL -18	65.67	68.00	66.83
22	IL-14	SC-128	53.00	59.00	56.00	52	12	IL -21	67.67	68.33	68.00
23		CML-47	58.00	60.00	59.00	53	13	IL -23	62.67	63.67	63.17
24		CML-57	57.33	61.00	59.17	54	mean		63.51	66.44	64.97
25	IL-15	SC-128	57.00	56.67	56.83	55	Tester 1	SC-128	53.00	54.67	59.13
26		CML-47	57.67	60.67	59.17	56	Tester 2	CML-47	65.33	67.33	57.77
27		CML-57	58.67	61.67	60.17	57	Tester 3	CML-57	64.33	68.67	60.79
28	IL-16	SC-128	59.00	64.00	61.50	58	Check	SC-128	53.66	55.00	
29		CML-47	61.00	63.67	62.33	59	Check	TWC-324	60.33	60.33	
30		CML-57	59.33	61.00	60.17	60	L.S.D. 0.05		2.7	7.59133	

Data in Table (4) exhibited that IL-14 with value (77.50, 69.17 and 73.33) was low ear heights than all others line in all environments and combined, respectively.

Table (4): Means performance of parents (13-lines and 3 testers) and two checks under normal and water stress conditions for ear height.

No.	Line	Tester	EH			No.	Line	Tester	EH		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	131.25	126.67	128.96	31	IL-18	SC-128	135.00	140.83	137.92
2		CML-47	149.17	140.00	144.58	32		CML-47	145.00	143.33	144.17
3		CML-57	120.83	116.67	118.75	33		CML-57	126.67	115.00	120.83
4	IL-4	SC-128	121.67	119.17	120.42	34	IL-21	SC-128	149.17	149.17	149.17
5		CML-47	149.17	145.00	147.08	35		CML-47	158.33	152.50	155.42
6		CML-57	130.83	128.33	129.58	36		CML-57	128.33	117.50	122.92
7	IL-5	SC-128	129.17	135.00	132.08	37	IL-23	SC-128	137.50	129.17	133.33
8		CML-47	152.50	144.17	148.33	38		CML-47	141.67	132.50	137.08
9		CML-57	131.67	126.67	129.17	39		CML-57	126.67	117.50	122.08
10	IL-6	SC-128	142.50	136.67	139.58	40	mean		138.57	132.88	135.73
11		CML-47	151.67	149.17	150.42	41	1	IL-1	91.67	89.17	90.42
12		CML-57	138.33	132.50	135.42	42	2	IL-4	89.17	89.17	89.17
13	IL-7	SC-128	127.50	130.83	129.17	43	3	IL-5	87.50	71.67	79.58
14		CML-47	127.50	126.67	127.08	44	4	IL-6	96.67	95.00	95.83
15		CML-57	125.83	117.50	121.67	45	5	IL-7	85.00	79.17	82.08
16	IL-11	SC-128	138.67	131.67	135.17	46	6	IL-11	85.00	82.50	83.75
17		CML-47	150.00	136.67	143.33	47	7	IL-13	100.83	92.50	96.67
18		CML-57	125.00	113.33	119.17	48	8	IL -14	77.50	69.17	73.33
19	IL-13	SC-128	154.17	133.33	143.75	49	9	IL -15	92.50	79.17	85.83
20		CML-47	161.67	157.50	159.58	50	10	IL -16	138.75	87.50	113.13
21		CML-57	139.17	133.33	136.25	51	11	IL -18	100.83	86.67	93.75
22	IL-14	SC-128	135.00	125.83	130.42	52	12	IL -21	110.83	104.17	107.50
23		CML-47	147.50	142.50	145.00	53	13	IL -23	79.17	81.67	80.42
24		CML-57	115.00	110.00	112.50	54	mean		95.03	85.19	90.11
25	IL-15	SC-128	135.83	132.50	134.17	55	Tester 1	SC-128	116.67	109.17	125.03
26		CML-47	145.83	135.00	140.42	56	Tester 2	CML-47	97.50	88.33	135.80
27		CML-57	120.00	115.83	117.92	57	Tester 3	CML-57	82.50	74.17	146.35
28	IL-16	SC-128	150.00	152.50	151.25	58	Check	SC-128	118.33	121.67	
29		CML-47	163.33	156.67	160.00	59	Check	TWC-324	150	155	
30		CML-57	145.00	133.33	139.17	60	L.S.D. 0.05		8.48	25.19	

While the line IL-13 and IL-11 were the best in E/P (1.44 and 0.82) under normal and stress water, respectively. Whereas the line IL-1 and IL-18 displayed the lowest E/P (0.82 and 0.27) under normal and water stress, respectively in Table (5).

Table (5): Means performance of parents (13-lines and 3 testers) and two check under normal and water stress conditions for ears/plant.

No.	Line	Tester	E/P			No.	Line	Tester	E/P		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	0.95	0.75	0.85	31	IL-18	SC-128	1.04	0.49	0.77
2		CML-47	0.92	0.55	0.73	32		CML-47	1.02	0.59	0.80
3		CML-57	1.25	0.37	0.81	33		CML-57	0.99	0.85	0.92
4	IL-4	SC-128	0.91	0.38	0.64	34	IL-21	SC-128	0.98	0.90	0.94
5		CML-47	0.97	0.25	0.61	35		CML-47	1.02	0.13	0.57
6		CML-57	1.00	0.56	0.78	36		CML-57	1.00	0.83	0.91
7	IL-5	SC-128	1.02	0.89	0.95	37	IL-23	SC-128	1.04	0.93	0.98
8		CML-47	0.95	0.30	0.62	38		CML-47	0.98	0.18	0.58
9		CML-57	0.98	0.43	0.70	39		CML-57	0.93	0.65	0.79
10	IL-6	SC-128	1.00	0.81	0.91	40	mean		0.996	0.52	0.76
11		CML-47	1.02	0.46	0.74	41	1	IL-1	0.82	0.61	0.71
12		CML-57	1.00	0.60	0.80	42	2	IL-4	0.83	0.48	0.65
13	IL-7	SC-128	0.95	0.58	0.76	43	3	IL-5	0.93	0.57	0.75
14		CML-47	0.98	0.27	0.63	44	4	IL-6	1.22	0.57	0.90
15		CML-57	1.22	0.63	0.93	45	5	IL-7	1.15	0.58	0.86
16	IL-11	SC-128	1.03	0.90	0.97	46	6	IL-11	1.30	0.82	1.06
17		CML-47	0.98	0.29	0.63	47	7	IL-13	1.44	0.67	1.05
18		CML-57	0.67	0.66	0.67	48	8	IL -14	0.94	0.37	0.66
19	IL-13	SC-128	0.95	0.33	0.64	49	9	IL -15	0.95	0.66	0.81
20		CML-47	1.02	0.12	0.57	50	10	IL -16	0.93	0.36	0.65
21		CML-57	0.95	0.26	0.60	51	11	IL -18	0.93	0.27	0.60
22	IL-14	SC-128	0.97	0.91	0.94	52	12	IL -21	1.28	0.36	0.82
23		CML-47	1.00	0.37	0.69	53	13	IL -23	1.00	0.67	0.83
24		CML-57	0.98	0.32	0.65	54	mean		1.06	0.54	0.80
25	IL-15	SC-128	1.00	0.65	0.83	55	Tester 1	SC-128	1.02	1.00	1.01
26		CML-47	0.97	0.59	0.78	56	Tester 2	CML-47	0.94	0.61	0.77
27		CML-57	1.02	0.51	0.77	57	Tester 3	CML-57	0.90	0.50	0.70
28	IL-16	SC-128	1.03	0.58	0.80	58	Check	SC-128	0.46	1.05	0.76
29		CML-47	1.15	0.12	0.63	59	Check	TWC-324	0.79	0.96	0.88
30		CML-57	1.03	0.29	0.66	60	L.S.D. 0.05		0.094	0.17	

The line IL-5 and IL-1 were the higher values of KP/R (33.93 and 27.53), under normal and stress water, respectively in Table (6). Combined mean performance showed the IL-5 the best in K/R (29.60). line IL-11and IL-7 were the higher values of 100-KW (37.33 and 32.00), under normal and water stress conditions, respectively. Combined mean performance showed the IL-7 the best in 100-KW (34.17) in Table (7). the line IL-6 was the best line of GY/P (106.63 and 63.19) under normal and water stress condition, respectively. Combined mean performance showed the IL-6 the best in GY/P (84.92 g) in Table (8). Mean values of crosses for days to 50% silking ranged from 53.00 days for the top-cross IL14 × SC-128 to 62.33 days for the top-cross IL 21 × SC-128 under normal irrigation and 55.33 days for top-cross IL-1 × SC-128 to 65.33 for top-cross IL-11 × CML47 under water stress condition. Results showed that the top-crosses involving SC-128 had earliness days to 50% silking than those involving CML-47 and CML-47. Concerning, ear height, the cross IL-14 × CML-57 recorded the lowest value (115.00 N), (110.00 S) and (112.50 combined) and had significantly lower ear height than the check hybrid SC-128. For number of ears/plant ranged from 0.67 for IL-11 × CML-57, to 1.25 for IL-1 × CML-57 under normal condition while under water stress condition from 0.12 L-16 × CML-47 to 0.93 IL-16 × CML-47.

Table (6): Means performance of parents (13-lines and 3 testers) and two checks under normal and water stress conditions for of kernels/row.

No.	Line	Tester	K/R			No.	Line	Tester	K/R		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	41.60	34.20	37.90	31	IL-18	SC-128	38.73	25.73	32.23
2		CML-47	42.00	27.53	34.77	32		CML-47	37.93	24.27	31.10
3		CML-57	35.33	23.95	29.64	33		CML-57	38.00	22.60	30.30
4	IL-4	SC-128	39.07	25.63	32.35	34	IL-21	SC-128	43.40	31.53	37.47
5		CML-47	41.07	25.67	33.37	35		CML-47	39.47	23.53	31.50
6		CML-57	40.73	30.13	35.43	36		CML-57	36.27	24.53	30.40
7	IL-5	SC-128	45.60	37.33	41.47	37	IL-23	SC-128	39.87	29.67	34.77
8		CML-47	40.87	31.09	35.98	38		CML-47	36.27	21.00	28.63
9		CML-57	38.93	28.27	33.60	39		CML-57	37.47	26.67	32.07
10	IL-6	SC-128	42.20	29.40	35.80	40	mean		39.19	27.50	33.34
11		CML-47	40.47	23.00	31.73	41	1	IL-1	29.40	27.53	28.47
12		CML-57	41.87	26.67	34.27	42	2	IL-4	27.53	24.80	26.17
13	IL-7	SC-128	42.47	26.47	34.47	43	3	IL-5	33.93	25.27	29.60
14		CML-47	41.00	24.73	32.87	44	4	IL-6	33.87	11.10	22.48
15		CML-57	38.03	23.27	30.65	45	5	IL-7	24.93	14.88	19.91
16	IL-11	SC-128	36.40	31.27	33.83	46	6	IL-11	19.67	15.93	17.80
17		CML-47	36.53	17.93	27.23	47	7	IL-13	24.73	19.07	21.90
18		CML-57	24.07	26.40	25.23	48	8	IL -14	21.67	12.40	17.03
19	IL-13	SC-128	37.53	28.93	33.23	49	9	IL -15	31.87	13.87	22.87
20		CML-47	38.07	22.20	30.13	50	10	IL -16	19.93	24.67	22.30
21		CML-57	37.53	23.27	30.40	51	11	IL -18	14.23	10.40	12.32
22	IL-14	SC-128	40.00	29.33	34.67	52	12	IL -21	14.95	11.00	12.98
23		CML-47	34.87	28.17	31.52	53	13	IL -23	23.47	16.40	19.93
24		CML-57	33.47	21.53	27.50	54	mean		24.63	17.49	21.06
25	IL-15	SC-128	46.00	34.80	40.40	55	Tester 1	SC-128	45.07	36.33	31.68
26		CML-47	42.40	30.81	36.61	56	Tester 2	CML-47	28.73	19.27	35.83
27		CML-57	41.87	32.33	37.10	57	Tester 3	CML-57	20.73	11.93	32.52
28	IL-16	SC-128	42.66667	31.8	37.23333	58	Check	SC-128	46.07	27.2	36.63
29		CML-47	39.86667	34.73333	37.3	59	Check	TWC-324	42.87	29.18	36
30		CML-57	38.6	32	35.3	60	L.S.D. 0.05		6.72	11.73	

Table (7): Means performance of parents (13-lines and 3 testers) and two checks under normal and water stress conditions for 100-kernel/weight.

No.	Line	Tester	100-KW			No.	Line	Tester	100-KW		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	37.00	35.67	36.33	31	IL-18	SC-128	36.33	24.00	30.17
2		CML-47	39.33	34.00	36.67	32		CML-47	34.00	28.00	31.00
3		CML-57	37.33	31.00	34.17	33		CML-57	35.00	27.67	31.33
4	IL-4	SC-128	36.00	27.00	31.50	34	IL-21	SC-128	35.33	24.33	29.83
5		CML-47	38.33	30.33	34.33	35		CML-47	36.33	27.33	31.83
6		CML-57	37.00	30.33	33.67	36		CML-57	38.33	32.33	35.33
7	IL-5	SC-128	40.00	34.00	37.00	37	IL-23	SC-128	37.33	30.00	33.67
8		CML-47	40.33	34.67	37.50	38		CML-47	36.33	29.00	32.67
9		CML-57	41.67	30.33	36.00	39		CML-57	41.00	32.67	36.83
10	IL-6	SC-128	36.33	29.67	33.00	40	mean		37.36	30.00	33.68
11		CML-47	37.67	28.67	33.17	41	1	IL-1	34.00	31.33	32.67
12		CML-57	39.67	25.50	32.58	42	2	IL-4	34.67	27.00	30.83
13	IL-7	SC-128	38.00	36.67	37.33	43	3	IL-5	30.00	30.33	30.17
14		CML-47	43.33	34.00	38.67	44	4	IL-6	33.67	31.33	32.50
15		CML-57	26.33	34.33	30.33	45	5	IL-7	36.33	32.00	34.17
16	IL-11	SC-128	45.00	31.00	38.00	46	6	IL-11	37.33	25.33	31.33
17		CML-47	38.67	27.33	33.00	47	7	IL-13	34.00	32.00	33.00
18		CML-57	39.00	31.67	35.33	48	8	IL -14	33.00	25.67	29.33
19	IL-13	SC-128	43.67	30.67	37.17	49	9	IL -15	26.67	29.67	28.17
20		CML-47	36.67	26.67	31.67	50	10	IL -16	34.00	24.67	29.33
21		CML-57	37.00	28.00	32.50	51	11	IL -18	25.00	24.00	24.50
22	IL-14	SC-128	36.67	31.67	34.17	52	12	IL -21	30.67	26.33	28.50
23		CML-47	34.00	27.67	30.83	53	13	IL -23	28.67	28.67	28.67
24		CML-57	30.00	25.33	27.67	54	mean		32.15	28.33	30.24
25	IL-15	SC-128	33.67	28.33	31.00	55	Tester 1	SC-128	41.33	35.00	38.17
26		CML-47	31.00	26.67	28.83	56	Tester 2	CML-47	30.33	28.67	29.50
27		CML-57	31.67	27.67	29.67	57	Tester 3	CML-57	27.00	28.00	27.50
28	IL-16	SC-128	40.00	30.67	35.33	58	Check	SC-128	40.00	30.33	35.17
29		CML-47	42.33	33.67	38.00	59	Check	TWC-324	36.67	30.33	33.50
30		CML-57	39.33	31.67	35.50	60	L.S.D. 0.05		5.06	8.68	

the F_1 hybrid of IL-15 and IL-5 × SC-128 were the best hybrid in KPR (46 and 37.3) under normal and water stress condition, respectively. While IL-11 × CML-57 and IL-11 × CML-47 (24.07 and 17.93), were the lowest F_1 hybrid under normal and stress water, respectively. Results showed that the top-crosses IL-11 × SC-128 and IL-7 × SC-128 were the best hybrid in 100-KW (45.00 and 36.67) under normal water and water stress respectively, while F1 hybrid IL-2 × CML-47 (38.67) for combined. While L-7 and IL-14 × CML-57 (26.33 and 27.67 was the lowest F_1 hybrid under well water and combined respectively, there were 17 and 15 single crosses exhibited significant number of 100-KW comparing with the check hybrid SC-128 under normal and drought environment conditions respectively. The F_1 hybrid of IL-5, L-23 and IL-5 × SC-128 were the best hybrid in GY/P (260.76, 132.5 and 194.0) under normal water, water stress and other combined respectively. While IL-4 × SC-128 and IL-13 × CML-57 (124.36 and 5.3) were the lowest F_1 hybrid under well water and drought stress respectively, there were 4 and IL-7 × CML-57 single crosses exhibited significant number of GYP comparing with the check hybrid SC-128 under normal and water stress conditions respectively.

Table (8): Means performance of parents (13-lines and 3 testers) and two check under normal and water stress conditions for grain yield /plant (g).

No.	Line	Tester	GY/P			No.	Line	Tester	GY/P		
			N	S	Com.				N	S	Com.
1	IL-1	SC-128	185.67	102.85	144.26	31	IL-18	SC-128	214.83	36.61	125.72
2		CML-47	209.29	28.48	118.89	32		CML-47	188.96	35.65	112.30
3		CML-57	173.93	19.08	96.50	33		CML-57	182.57	25.55	104.06
4	IL-4	SC-128	124.36	23.91	74.13	34	IL-21	SC-128	211.18	27.46	119.32
5		CML-47	209.17	12.84	111.01	35		CML-47	182.77	7.51	95.14
6		CML-57	213.54	45.74	129.64	36		CML-57	235.75	55.13	145.44
7	IL-5	SC-128	260.76	128.01	194.38	37	IL-23	SC-128	219.19	132.50	175.84
8		CML-47	214.43	24.87	119.65	38		CML-47	166.36	9.70	88.03
9		CML-57	221.22	25.67	123.44	39		CML-57	195.88	51.56	123.72
10	IL-6	SC-128	198.83	40.12	119.47	40	mean		191.02	36.76	113.89
11		CML-47	204.37	32.77	118.57	41	1	IL-1	75.91	31.18	53.54
12		CML-57	211.81	27.75	119.78	42	2	IL-4	72.77	31.47	52.12
13	IL-7	SC-128	214.70	90.78	152.74	43	3	IL-5	76.02	45.13	60.58
14		CML-47	214.24	13.91	114.07	44	4	IL-6	106.63	63.21	84.92
15		CML-57	239.07	58.47	148.77	45	5	IL-7	91.69	57.68	74.68
16	IL-11	SC-128	235.62	111.44	173.53	46	6	IL-11	52.55	44.99	48.77
17		CML-47	184.83	25.66	105.25	47	7	IL-13	44.15	27.82	35.99
18		CML-57	213.47	29.33	121.40	48	8	IL -14	60.44	33.32	46.88
19	IL-13	SC-128	214.76	59.35	137.06	49	9	IL -15	78.41	44.83	61.62
20		CML-47	190.19	8.62	99.40	50	10	IL -16	29.21	16.57	22.89
21		CML-57	193.19	5.30	99.25	51	11	IL -18	20.13	14.72	17.42
22	IL-14	SC-128	209.61	30.94	120.27	52	12	IL -21	25.55	19.50	22.53
23		CML-47	171.71	23.59	97.65	53	13	IL -23	61.56	27.94	44.75
24		CML-57	154.03	15.02	84.53	54	mean		61.15	35.26	48.21
25	IL-15	SC-128	208.03	59.84	133.93	55	Tester 1	SC-128	249.29	124.85	187.07
26		CML-47	169.55	38.98	104.26	56	Tester 2	CML-47	70.15	35.81	52.98
27		CML-57	193.94	37.04	115.49	57	Tester 3	CML-57	37.36	26.28	31.82
28	IL-16	SC-128	208.24	23.00	115.62	58	Check	SC-128	137.47	48.20	92.83
29		CML-47	217.26	6.59	111.93	59	Check	TWC-324	217.67	62.54	140.11
30		CML-57	203.50	8.51	106.01	60	L.S.D. 0.05		21.09	19.65	

3.3 General combining ability (GCA) effects

GCA estimates of the 13 lines and 3 testers under normal and water stress conditions for the previously mentioned characters are given in Table (9). showed that lines namely: IL-14 and IL-6 had negative and highly significant GCA effects for DS under normal, drought and IL-1 at both conditions and combined, indicating that these inbred could be considered as good general combiners for earliness. Ear height (cm) of results show that lines IL-7 and tester CML-57 under both water conditions and their combined had negative and highly significant GCA effects, suggesting that these inbred lines are the best general combiners for ear height (shortness).

Table (9): General combining ability (GCA) effects of the 13 lines and 3 testers for maize yield, and other traits under normal, water stress conditions and over combined.

Line	DS			EH			E/P		
	N	S	COM.	N	S	Com.	N	S	Com.
IL-1	-1.56*	-2.42*	-2.01*	-4.82	-5.11	-4.96	0.05*	0.04	0.04
IL-4	-0.67	-1.2	-0.06	-4.68	-2.05	-3.36	-0.04	-0.13*	-0.08*
IL-5	-0.56	1.69*	1.27*	-0.79	2.39	0.8	-0.01	0.02	0.00
IL-6	-1.67*	-1.53*	-1.18*	5.6	6.56	6.08	0.01	0.1	0.06
IL-7	0.67	0.25	-0.51	-11.62*	-7.88*	-9.75*	0.05*	-0.03	0.01
IL-11	-0.11	0.03	2.1	-0.68	-5.66	-3.17	-0.11*	0.1	0.00
IL-13	1.11	1.47*	0.16	13.10*	8.50*	10.80*	-0.02	-0.28*	-0.15*
IL-14	-1.89*	-0.42	1.60*	-6.07	-6.77	-6.42	-0.01	0.01	0.0
IL-15	-0.22	-0.75	-0.06	-4.68	-5.11	-4.89	0.0	0.07	0.03
IL-16	1.78*	2.47*	-0.68	14.21*	14.62*	14.41*	0.07*	-0.19*	-0.06*
IL-18	0.22	0.14	0.55	-3.01	0.17	-1.42	0.02	0.13*	0.07*
IL-21	2.78*	0.47	-1.62*	6.71	6.84	6.77	0	0.1	0.05
IL-23	0.11	-0.2	0.44	-3.29	-6.5	-4.89	-0.01	0.07	0.03
S.E.Lines 0.05	1.31	1.3	1.17	7.39	6.91	7.02	0.04	0.12	0.06
Tester									
SC-128	-1.36*	-1.52*	-1.46*	-1.07	1.22	0.07	-0.01*	0.18*	0.09*
CML-47	1.64*	1.53*	1.56*	10.92*	10.32*	10.62*	0	-0.20*	-0.10*
CML-57	-0.28	-0.01	-0.1	-9.85*	-11.54*	-10.69*	0.01*	0.02	0.01
S.E.Testers 0.05	1.24	1.25	1.23	8.51	8.97	8.7	0.01	0.15	0.08
Line	K/R			100-KW			GY/P		
	N	S	Com.	N	S	COM.	N	S	COM.
IL-1	0.45	1.06	0.76	0.53	3.55*	2.04	-11.93	10.65	-0.64
IL-4	1.1	-0.35	0.37	-0.25	-0.78	-0.51	-19.20*	-11.99	-15.60*
IL-5	2.61	4.73*	3.67*	3.31*	3.00*	3.15*	30.58*	20.02*	25.30*
IL-6	2.32	-1.14	0.59	0.53	-2.06	-0.76	3.45	-5.95	-1.25
IL-7	1.31	-2.67	-0.68	-1.47	5.00*	1.76	21.11*	14.89	18.00*
IL-11	-6.86*	-2.3	-4.58*	3.53*	0	1.76	9.75	15.99*	12.87*
IL-13	-1.48	-2.7	-2.09	1.75	-1.56	0.1	-2.18	-15.07	-8.62
IL-14	-3.08*	-1.15	-2.12	-3.80*	-1.78	-2.79*	-23.11*	-16.31*	-19.71*
IL-15	4.23*	5.15*	4.69*	-5.25*	-2.45	-3.85*	-11.05	5.8	-2.63
IL-16	1.19	5.35*	3.27*	3.20*	2.00	2.60*	8.11	-26.79*	-9.34
IL-18	-0.97	-3.3	-2.13	-2.25*	-3.45*	-2.85*	-6.11	-6.89	-6.5
IL-21	0.52	-0.96	-0.22	-0.69	-2	-1.35	8.34	-9.46	-0.56
IL-23	-1.33	-1.72	-1.52	0.86	0.55	0.71	-7.75	25.10*	8.67
S.E.Lines 0.05	2.72	2.99	2.55	2.6	2.53	2.17	14.92	15.64	12.56
Tester									
SC-128	2.00*	2.97*	2.49*	0.74*	0.28*	0.51*	6.58*	27.19*	16.88*
CML-47	0.1	-1.75	-0.83	0.21*	-0.16	0.02	-7.47*	-18.78	-13.13*
CML-57	-2.10*	-1.22	-1.66	-0.95*	-0.12	-0.53	0.9	-8.4	-3.75
S.E.Testers 0.05	1.68	2.11	1.79	0.71	0.2	0.43	5.77	19.69	12.54

Also, the inbred IL-16, IL-15 and IL-11 showed positive and highly significant GCA effects for ear/plant, kernel/row and 100-K/w under the normal environment. While L-18, IL-16 and IL-7 showed positive and highly significant GCA effects for ears/plant, kernels/row and 100-K/W under water stress conditions, inbred linens IL-18, IL-16 and IL-15 had positive and highly significant GCA effects for same traits in combined. Inbred IL-5 exhibited positive and highly significant GCA effects for grain yield/plant at both condition and combined. Results show that testers namely: T1 (S.C.128) and tester T3 CML- 57 under both conditions and combined had negative and highly significant GCA effects indicating that these testers could be considered as good general combiners for earliness and shortness ear. Also, tester (S.C.128) under both conditions and combined had positive and highly significant GCA effects for E/P, K/R, 100-K/W and GY/P. indicating that these testers could be considered as the best general combiners for increasing yield and yield component under both conditions. High GCA effects are related to additive components for genetic variation; parents with higher positive significant GCA effects are considered to be good combiners, while those with negative GCA effects are poor general combiners. Similar results were obtained by Menkir *et al*. (2003) and Rahman *et al*. (2010).

3.3.1 Specific combining ability (SCA) effects

Table (10a,b) showed estimates of specific combining ability (SCA) effects of the 39 test crosses for all the studied traits. The results revealed that the desirable cross for SCA effects were IL-7 × CML-57, IL-18 × SC-128 and L-21 × CML-47 under water stress conditions and combined. for earliness, the IL-4 × SC-128, IL-21 × CML-57 and IL-7 × CML-47 had negative and significant SCA under normal and water stress conditions and their combined for ear height indicating that these crosses are the best combinations between lines and testers for earliness and shortness. Also, the top crosses IL-5 × SC-128, IL-14 × SC-128, IL- 23 × SC-128 and IL-21 × CML-57 had positive and significant at drought stress and combined for ear/plant. The best hybrids for kernels/row were IL-4 × CML-57 and IL-11 × SC-128 had positive and significant SCA under normal and over all environments.

Table (10a): Estimates of specific combining ability effects of line × tester for different traits in maize under normal and water stress conditions.

Crosses		DS			EH			E/P		
line	Tester	N	S	Com.	N	S	com.	N	S	Com.
I.L-1	SC-128	-0.42	-1.15	-0.76	-1.43	-2.33	-1.88	-0.08*	0.01	-0.03
	CML-47	-0.75	1.47	0.38	4.5	1.90	3.20	-0.12	0.19*	0.03
	CML-57	1.17*	-0.32	0.38	-3.07	0.43	-1.32	0.21	-0.2	0.00
I.L-4	SC-128	0.69	-0.7	-0.26	-11.15*	-12.88	-12.02*	-0.04	-0.2	-0.12
	CML-47	-0.64	0.25	-0.45	4.36	3.85	4.10	0.01	0.05	0.03
	CML-57	-0.05	0.45	0.71	6.79*	9.04*	7.92*	0.03	0.15*	0.09
I.L-5	SC-128	-0.75	-0.92	-0.82	-7.54*	-1.50	-4.52*	0.04	0.17*	0.11*
	CML-47	-0.42	-1.31	-0.84	3.8	-1.43	1.18	-0.04	-0.04	-0.04
	CML-57	1.17*	2.23*	1.66*	3.74	2.93	3.33	-0.01	-0.12	-0.07
I.L-6	SC-128	0.03	0.63	0.35	-0.59	-4.00	-2.29	0.00	0.01	0.00
	CML-47	0.03	1.25	0.66	-3.42	-0.6	-2.01	0.01	0.03	0.02
	CML-57	-0.05	-1.88*	-1.01	4.01	4.59	4.30	-0.01	-0.04	-0.03
I.L-7	SC-128	1.03	0.52	0.79	1.63	4.62	3.12	-0.09*	-0.09	-0.09*
	CML-47	0.03	1.47	0.77	-10.37*	-8.65*	-9.51*	-0.07	-0.03	-0.05
	CML-57	-1.05	-1.99*	-1.56*	8.74*	4.04	6.39*	0.16*	0.12	0.14*
I.L-11	SC-128	0.14	-2.26	-1.04	1.85	3.23	2.54	0.14*	0.1	0.12*
	CML-47	0.8	3.36*	2.10*	1.19	-0.88	0.16	0.09	-0.14*	-0.02
	CML-57	-0.94	-1.1	-1.06	-3.04	-2.35	-2.70	-0.23*	0.03	-0.10*
I.L-13	SC-128	-0.75	0.3	-0.21	3.57	-9.27*	-2.85	-0.01	-0.08	-0.05
	CML-47	0.25	0.58	0.44	-0.92	5.79*	2.43	0.04	0.08	0.06
	CML-57	0.5	-0.88	-0.23	-2.65	3.48	0.42	-0.03	0.00	-0.01
I.L-14	SC-128	-1.75*	0.52	-0.59	3.57	-1.50	1.04	-0.01	0.19*	0.09*
	CML-47	0.25	-1.53	-0.62	4.08	6.07*	5.07*	0.02	0.04	0.03
	CML-57	1.50*	1.01	1.21*	-7.65*	-4.57	-6.11	-0.01	-0.23*	-0.12*
I.L-15	SC-128	0.58	-1.48	-0.43	3.02	3.50	3.26	0.01	-0.11	-0.05
	CML-47	-1.75*	-0.53	-1.12	1.02	-3.10	-1.04	-0.03	0.2	0.09*
	CML-57	1.17*	2.01*	1.55*	-4.04	-0.41	-2.22	0.02	-0.09	-0.03
I.L-16	SC-128	0.58	2.63*	1.63*	-1.71	3.78	1.04	-0.04	0.07	0.02
	CML-47	-0.42	-0.75	-0.56	-0.37	-1.15	-0.76	0.08*	-0.01	0.03
	CML-57	-0.16	-1.88*	-1.06	2.07	-2.63	-0.28	-0.04	-0.05	-0.05
I.L-18	SC-128	-0.86	-1.70*	-1.26*	0.52	6.56	3.54	0.03	-0.33*	-0.15*
	CML-47	2.47*	0.25	1.38*	-1.48	-0.04	-0.76	0.00	0.14*	0.07
	CML-57	-1.61*	1.45	-0.12	0.96	-6.52	-2.78	-0.03	0.19*	0.08*
I.L-21	SC-128	2.91*	3.97*	3.46*	4.96	8.23	6.59*	-0.01	0.1	0.04
	CML-47	-0.75	-2.42*	-1.56*	2.13	2.46	2.30	0.02	-0.29*	-0.14*
	CML-57	-2.16*	-1.55	-1.90*	-7.10*	-10.68*	-8.89*	0.00	0.19*	0.09*
I.L-23	SC-128	-1.42*	-0.37	-0.87	3.29	1.56	2.43	0.06	0.17*	0.11*
	CML-47	0.91	-2.09	-0.56	-4.53*	-4.21	-4.37*	0	-0.21*	-0.11*
	CML-57	0.5	2.45	1.44*	1.24	2.65	1.94	-0.06	0.05	0.00
S.E. SCA		1.09	1.63	1.16	4.51	5.03	4.32	0.07	0.14	0.08

Table (10b): Estimates of specific combining ability effects of line × tester for different traits in maize under normal and water stress conditions.

Crosses		K/R			100-KW			GY/P		
Line	Tester	N	S	Com.	N	S	Com.	N	S	Com.
I.L-1	SC-128	-0.05	2.67*	1.31	-1.63	1.83	0.1	-10.54	25.53*	7.5
	CML-47	2.26*	0.73	1.49	1.24	0.72	0.92	27.13*	-2.87	12.13
	CML-57	-2.21	-3.39*	-2.80*	0.39	1.94*	-1.02	-16.59*	-22.66*	-19.63*
I.L-4	SC-128	-3.22	-4.48*	-3.85	-1.85	3.17*	-2.18*	-64.58*	-30.78*	-47.68
	CML-47	0.68	0.28	0.48	1.02	0.5	1.14	34.29*	4.13	19.21*
	CML-57	2.55*	4.21*	3.38*	0.84	-1.61	1.03	30.29*	26.65*	28.47*
I.L-5	SC-128	1.8	2.13	1.96*	-1.41	-2.83*	-0.34	22.04*	41.31*	31.68*
	CML-47	-1.03	0.61	-0.21	-0.54	-3.94*	0.64	-10.23	-15.86	-13.05
	CML-57	-0.76	-2.74*	-1.75*	1.95	-0.83	-0.3	-11.81	-25.45*	-18.63*
I.L-6	SC-128	-1.31	0.07	-0.62	-2.3	-2.50*	-0.43	-12.75	-20.62*	-16.68
	CML-47	-1.14	-1.6	-1.37	-0.43	0.72	0.23	6.84	18.01	12.42
	CML-57	2.46*	1.53	1.99*	2.73*	1.44	0.2	5.91	2.61	4.26
I.L-7	SC-128	-0.04	-1.33	-0.68	1.37	1.39	1.38	-14.54	9.2	-2.67
	CML-47	0.4	1.66	1.03	7.24*	0.6	3.20*	-0.96	-21.69*	-11.33
	CML-57	-0.36	-0.34	-0.35	-8.61*	-2.51	-4.58*	15.5	12.49	14
I.L-11	SC-128	2.06*	3.09*	2.58*	3.37*	-1.62	2.04*	17.73	28.77*	23.25*
	CML-47	4.10*	-5.51*	-0.71	-2.43	-0.4	-2.47*	-19.00*	-11.03	-15.02
	CML-57	-6.16*	2.42*	-1.87*	-0.94	-0.73	0.42	1.27	-17.74	-8.24
I.L-13	SC-128	-2.18*	1.16	-0.51	3.81*	1.82	2.88*	8.81	7.74	8.27
	CML-47	0.26	-0.85	-0.3	-2.65	1.6	-2.13*	-1.72	2.98	0.63
	CML-57	1.92*	-0.31	0.81	-1.16	-0.51	-0.74	-7.09	-10.72	-8.9
I.L-14	SC-128	1.89	0.02	0.95	2.37	-1.4	2.77*	24.58*	-19.43	2.57
	CML-47	-1.34	3.58*	1.12	0.24	1.27	-0.08	0.73	19.19	9.96
	CML-57	-0.54	-3.59*	-2.07*	-2.61*	1.82	-2.69*	-25.31	0.24	-12.54
I.L-15	SC-128	0.58	-0.82	-0.12	0.81	0.88	0.66	10.95	-12.64	-0.85
	CML-47	-1.12	-0.08	-0.6	-1.32	-0.84	-1.02	-13.49	12.48	-0.5
	CML-57	0.55	0.9	0.73	0.5	-2.44*	0.37	2.54	0.16	1.35
I.L-16	SC-128	0.29	-4.02*	-1.87*	-1.3	1.79	-1.46	-8.01	-16.89	-12.45
	CML-47	-0.61	3.64*	1.52	1.57	-0.32	1.7	15.07	12.68	13.87
	CML-57	0.32	0.37	0.35	-0.27	-2.77*	-0.24	-7.06	4.21	-1.42
I.L-18	SC-128	-1.49	-1.44	-1.47	0.48	0.23	-1.18	12.8	-23.18*	-5.19
	CML-47	-0.39	1.82	0.72	-1.32	-0.21	0.14	0.98	21.83*	11.41
	CML-57	1.88*	-0.38	0.75	0.84	1.23	1.03	-13.78	1.35	-6.22
I.L-21	SC-128	1.69	2.03	1.86*	-2.08	4.45*	-3.01*	-5.3	-29.76*	-17.53*
	CML-47	-0.34	-1.25	-0.8	-0.54	2.23*	-0.52	-19.66*	-3.74	-11.7
	CML-57	-1.34	-0.78	-1.06	2.62*	1.23	3.53*	24.96*	33.50*	29.23*
I.L-23	SC-128	0	0.92	0.46	-1.63	-2.55*	-1.23	18.80*	40.73*	29.76*
	CML-47	-1.7	-3.02*	-2.36*	-2.09	-2.32*	-1.75	-19.98*	-36.10*	-28.04*
	CML-57	1.7	2.11	1.91*	3.73*	-0.55	2.98*	1.18	-4.62	-1.72
S.E. SCA		1.85	2.32	1.57	2.54	1.88	1.8	18.72	20.2	16.88

For 100-kernel weight the cross IL-7 × CML-47, (IL-11, IL13 × SC-128) and (IL-21, IL-23 × CML-57) had the highest positive values of SCA effects under normal water and combined, While the cross IL-1 × CML-57, IL-4 × SC-128, IL-21 × SC-128 and CML-47 were positive and significant under water stress conditions. While the best top crosses depending on SCA effects were IL-4 × CML-57, IL-5 × SC-128, IL-21 × CML-57 and IL-23 × CML-57 crosses had positive and significant at normal, water stress conditions and combined for grain yield/plant. Similar results of GCA and SCA effects as additive and non-additive gene effects which played an important role in the inheritance for different traits of maize were reported by El-Hosary *et al.* (1990), El-Itriby *et al.* (1990), Mosa (2010), Khatab *et al.* (2011), Kanagarasu *et al.* (2010), Shams *et al.* (2010), Lal *et al.* (2011) and Abuali *et al.* (2012). GCA mean squares for inbred lines were highly significant for all the traits, except number of rows/ear while, GCA due to testers was only significant for 100- kernels weight. Moreover, variances due to SCA were higher in magnitude than GCA for the yield and yield components.

3.4 Heterosis

Results given in Table (11a,b), revealed that the cross combinations viz., IL-21 × CML-57 it gave 531.04% ** and 649.53%

** at both conditions recorded the highest positive significant heterosis over mid and better-parents for grain yield/plant. The lowest negative and significant heterosis over mid and better-parent for days to 50% silking percentage were recorded by IL-18 × SC-128 and IL-14 × SC-128 at normal irrigation and IL-1 × SC-128 at stress water.

Table (11a): Percentage of heterosis over mid (M.P) and better-parent (B.P) for F1 crosses of studied maize traits under normal and water stress conditions.

Line	Tester	DS				EH				E/P			
		N		S		N		S		N		S	
		B	M	B	M	B	M	B	M	B	M	B	M
I.L-1	SC-128	-9.89**	-13.23**	-17.82**	-18.83	43.18**	38.77**	43.40**	42.72**	-6.18**	3.68**	-24.65**	-6.31
	CML-47	-5.49**	-8.27**	-11.17**	-11.38**	80.81**	71.29**	88.76**	71.43**	-2.30**	4.24**	-9.33**	-9.3
	CML-57	8.18**	0.88	5.49**	-6.74**	31.82**	16.00**	30.84**	17.65**	39.43**	45.55**	-38.68**	-32.5
I.L-4	SC-128	-6.08**	-9.81**	-10.94**	-13.20**	36.45**	30.36**	34.91**	34.27**	-10.47**	-1.18**	-62.35**	-49.11
	CML-47	-3.31**	-6.42**	-4.69**	-8.04**	80.81**	73.79**	95.51**	77.55**	2.92**	9.67**	-59.19**	-54.34
	CML-57	7.55**	0.59	9.15**	0.56	46.73**	27.13**	43.93**	29.41**	11.11**	15.82**	12.98**	15.01
I.L-5	SC-128	-12.63**	-13.99**	-11.39**	-12.47**	47.62**	39.64**	88.37**	68.75**	0.26**	4.42**	-11.07**	13.02
	CML-47	-7.37**	-8.09**	-9.22**	-9.44**	84.85**	79.41**	101.16**	97.71**	0.63**	0.95**	-50.34**	-48.86
	CML-57	10.06**	0.29	17.68**	4.04**	50.48**	28.98**	76.74**	40.09**	4.73**	6.83**	-24.80**	-19.42
I.L-6	SC-128	-8.84**	-12.47	-10.31**	-12.12**	47.41**	46.78**	54.72**	49.09**	-18.16**	-10.63**	-18.20**	4.03
	CML-47	-3.87**	-6.95**	-4.64**	-7.50**	83.84**	69.30**	101.12**	76.35**	-16.73**	-5.90**	-23.66**	-21.31
	CML-57	5.66**	-1.18	4.27**	-4.47**	43.10**	29.69**	39.47**	29.80**	-17.83**	-5.28**	4.61**	11.99
I.L-7	SC-128	-8.85**	-9.79**	-8.21**	-9.82**	50.00**	39.73**	65.26**	56.22**	-17.36**	-12.37**	-41.76**	-26.15
	CML-47	-5.73**	-5.97**	-2.05	-4.74**	54.55**	52.24**	70.79**	65.22**	-14.38**	-5.95**	-55.65**	-54.46
	CML-57	8.18**	-1.99*	7.32**	-1.95	48.04**	24.79**	48.42**	24.78**	6.26**	19.17**	10.14**	18.35
I.L-11	SC-128	-12.82**	-13.04**	-15.42**	-15.63**	63.14**	51.96**	59.60**	54.15**	-20.79**	-11.10**	-9.43**	-0.55
	CML-47	-6.22**	-6.70**	-2.49	-3.69**	81.82**	79.10**	84.27**	74.47**	-24.73**	-12.69**	-65.01**	-59.81
	CML-57	6.92**	-3.95**	8.54**	-2.47	47.06**	23.97**	37.37**	18.26**	-48.68**	-39.32**	-18.86**	1.09
I.L-13	SC-128	-11.40**	-12.08**	-9.90**	-11.00**	58.12**	55.46**	50.94**	47.47**	-33.80**	-22.32**	-66.55**	-59.92
	CML-47	-5.18**	-5.18**	-6.80**	-7.02**	95.96**	76.36**	112.36**	89.00**	-29.29**	-14.41**	-81.67**	-80.8
	CML-57	11.95**	1.14	11.59**	-1.35	38.02**	27.97**	44.14**	32.23**	-34.06**	-18.74**	-61.57**	-55.91
I.L-14	SC-128	-12.64**	-15.87**	-2.75	-7.81**	74.19**	54.29**	81.93**	59.79**	-4.55**	-1.05**	-8.63**	33.52
	CML-47	-4.40**	-7.20**	-1.1	-7.22**	90.32**	84.38**	106.02**	98.84**	5.92**	6.11**	-38.20**	-23.01
	CML-57	8.18**	0.88	11.59**	5.78**	48.39**	18.45**	59.04**	23.36**	3.84**	6.43**	-35.24**	-25.63
I.L-15	SC-128	-9.52**	-11.17**	-14.57**	-15.21**	46.85**	42.98**	67.37**	58.21**	-1.56**	1.69**	-34.47**	-21.4
	CML-47	-8.47**	-9.42**	-8.54**	-10.12**	76.77**	66.67**	82.02**	76.09**	1.84**	2.37**	-10.98**	-6.91
	CML-57	10.69**	1.15	12.80**	1.93	29.73**	14.74**	46.32**	23.01**	7.37**	10.42**	-22.58**	-11.26
I.L-16	SC-128	-9.69**	-11.50**	-4.95**	-6.11**	53.85**	26.98**	74.29**	73.46**	1.20**	5.61**	-42.27**	-15.24
	CML-47	-5.18**	-7.81**	-7.28**	-7.51**	97.98**	47.65**	111.24**	93.81**	22.04**	22.68**	-80.78**	-75.89
	CML-57	11.95**	-1.93*	11.59**	-1.35	24.29**	13.54**	52.38**	35.59**	11.08**	13.08**	-41.53**	-32.33
I.L-18	SC-128	-14.29**	-14.50**	-14.85**	-15.27**	38.46**	36.13**	62.50**	60.95**	2.08**	6.67**	-50.31**	-21.75
	CML-47	-3.11**	-4.10**	-8.33**	-8.78**	75.76**	58.18**	93.26**	78.24**	8.16**	8.87**	-2.92**	34.51
	CML-57	6.29**	-5.06**	13.41**	1.09	25.62**	16.48**	32.69**	17.45**	6.38**	8.15**	72.23**	123.21
I.L-21	SC-128	-4.59**	-6.27**	-5.94**	-6.63**	52.99**	43.20**	68.87**	54.98**	-23.56**	-14.78**	-9.64**	32.67
	CML-47	-4.15**	-6.57**	-12.20**	-12.41**	91.92**	63.79**	105.62**	71.03**	-20.48**	-8.35**	-78.31**	-72.8
	CML-57	10.06**	-3.31**	8.54**	-3.52	15.79**	12.82**	12.80**	10.16	-21.85**	-8.16**	67.18**	93.45**
I.L-23	SC-128	-11.70**	-13.54**	-8.38**	-10.94**	73.68**	55.66**	58.16**	51.96**	1.99**	3.02**	-6.29**	12.07**
	CML-47	-3.19**	-4.46**	-6.28**	-9.82**	78.95**	75.26**	78.65**	70.05**	-1.14**	1.65**	-73.59**	-72.28**
	CML-57	10.06**	0.86	14.63**	5.92**	60.00**	29.36**	43.88**	23.14**	-6.42**	-1.61**	-2.62**	11.96**
L.S.D	0.05	1.47	1.8	3.09	3.78	5.99	7.33	9.78	11.98	0.16	0.2	0.06	0.08
	0.01	1.94	2.38	4.08	5	7.91	9.69	12.93	15.83	0.21	0.26	0.08	0.1

For ear height, all crosses showed undesirable heterosis values with positive highly significant values under both environments. For ears/plant percentage, the highest positive significant heterosis over mid and better-parents was recorded by IL-1 × CML-57 at normal condition and IL-18 × CML-57 at stress condition. The highest positive significant heterosis over mid and better-parents for kernels/row recorded by IL-16 × CML-57 and IL-18 × CML-57 at normal and IL-6 × CML-57 at stress condition. The highest significant positive heterosis over mid and better-parent for 100-kerenl/weight was recorded by IL-23 × CML-57 at normal condition and IL-16 × CML-47 at stress condition. Ali *et al.* (2009), found that heterosis for GY/h ranged from 40.50% to 68.33 for mid parent, 10.08 to 60.99 for high parent Rajitha *et al.* (2014) found that significant positive heterosis over both mid and better parents for grain yield per plant (Ganapati Mukri *et al.,* 2022; Hussain *et al.*, 2021; Khakwani *et al.*, 2020; Sedhom *et al.*, 2023). The genetic variance component and dominance degree calculated for yield and 100-kernel/weight traits are present in Table 12. The resulted developed that the non-additive (σ2 D) was higher than additive variance for number of kernels /row, 100-kernel weight and grain yield plant. This result denoted that dominance variance effects played a major role in the genetic expression for these traits, while additive effect had a minor role this indicated that the hybridization program would be effective improvement most studied characters.

Table (11b): Percentage of heterosis over mid (M.P) and better-parent (B.P) for F1 crosses of studied maize traits under normal and water stress conditions.

Line	Tester	K/R				100-KW				GY/P			
		N		S		N		S		N		S	
		B	M	B	M	B	M	B	M	B	M	B	M
I.L-1	SC-128	-7.69**	11.73**	-5.87*	7.10*	-10.48**	-1.77	1.9	7.54**	-25.52	14.19	-17.62**	31.84**
	CML-47	42.86**	44.50**	0	17. **	15.69**	22.28**	8.51**	13.33**	175.72**	186.58**	-20.47**	-14.97**
	CML-57	20.18**	40.96**	-13.01**	21.37**	9.80**	22.40**	-1.06	4.49*	129.13**	207.11**	-38.82**	-33.60**
I.L-4	SC-128	-13.31**	7.62**	-29.45**	-16.14	-12.90**	-5.26	-22.86**	-12.90**	-50.12	-22.77	-80.85**	-69.41**
	CML-47	42.92**	45.97**	3.49	16.49**	10.58**	17.95**	5.81**	8.98**	187.43**	192.70**	-64.13**	-61.82**
	CML-57	47.94**	68.78**	21.51**	64.07**	6.73**	20.00**	8.33**	10.30**	193.44**	287.79**	45.37**	58.43**
I.L-5	SC-128	1.18	15.44**	2.75	21.21**	-3.23	12.15**	-2.86	4.08	4.6	60.31**	2.54	50.62**
	CML-47	20.43**	30.43**	23.04**	39.62**	32.97**	33.70**	14.29**	17.51**	182.07**	193.39**	-44.90**	-38.55**
	CML-57	14.73**	42.44**	11.87**	51.97**	38.89**	46.20**	0.00	4.00	191.01**	290.23**	-43.14**	-28.12**
I.L-6	SC-128	-6.36**	6.93**	-19.08**	23.96**	-12.10**	-3.11	-15.24**	-10.55**	-20.24	11.73	-67.87**	-57.34**
	CML-47	19.49**	29.29**	19.38**	51.48**	11.88**	17.71**	-8.51**	-4.44*	91.66**	131.21**	-48.16**	-33.82**
	CML-57	23.62**	53.36**	123.46**	131.55**	17.82**	30.77**	-18.62**	-14.04**	98.63**	194.19**	-56.10**	-37.98**
I.L-7	SC-128	-5.77**	21.33**	-27.16**	3.35	-8.06**	-2.15	4.76**	9.45**	-13.88	25.93	-27.29**	-0.53
	CML-47	42.69**	52.80**	28.37**	44.85**	19.27**	30.00**	6.25**	12.09**	133.65**	164.74**	-75.88**	-70.24**
	CML-57	52.54**	66.57**	56.33**	73.52**	-27.52**	-16.84**	7.29**	14.44**	160.73**	270.51**	1.38	39.29**
I.L-11	SC-128	-19.23**	12.46**	-13.94**	19.64**	8.87**	14.41**	-11.43**	2.76	-5.49	56.12**	-10.74**	31.23**
	CML-47	27.15**	50.96**	-6.92**	1.89	3.57	14.29**	-4.65*	1.23	163.47**	201.26**	-42.95**	-36.47**
	CML-57	16.08**	19.14**	65.69**	89.47**	4.46*	21.24**	13.10**	18.75**	306.21**	374.84**	-34.80**	-17.68**
I.L-13	SC-128	-16.72**	7.55**	-20.37**	4.45	5.65**	15.93**	-12.38**	-8.46**	-13.85	46.38	-52.46**	-22.25**
	CML-47	32.48**	42.39**	15.22**	15.83**	7.84**	13.99**	-16.67**	-12.09**	171.11**	232.79**	-75.93**	-72.91**
	CML-57	51.75**	65.10**	22.03**	50.11**	8.82**	21.31**	-12.50**	-6.67**	337.62**	374.06**	-80.95**	-80.41**
I.L-14	SC-128	-11.24**	19.88**	-19.27**	20.38**	-11.29**	-1.35	-9.52**	4.40*	-15.92	35.35	-75.22**	-60.88**
	CML-47	21.35**	38.36**	46.21**	77.92**	3.03	7.37**	-3.49	1.84	144.77**	162.98**	-34.13**	-31.76**
	CML-57	54.46**	57.86**	73.66**	76.99**	-9.09**	0.00	-9.52**	-5.59	154.87**	215.01**	-54.92**	-49.59**
I.L-15	SC-128	2.07	19.58**	-4.22	38.65**	-18.55**	-0.98	-19.05**	-12.37**	-16.55	26.96	-52.07**	-29.47**
	CML-47	33.05**	39.93**	59.93**	86.00**	2.2	8.77**	-10.11**	-8.57**	116.24**	128.25**	-13.05**	-3.33
	CML-57	31.38**	59.19**	133.17**	150.65**	17.28**	18.01**	-6.74**	-4.05	147.36**	235.06**	-17.37**	4.19**
I.L-16	SC-128	-5.33*	31.28**	-12.48**	4.26	-3.23	6.19*	-12.38**	2.79	-16.47	49.54**	-81.58**	-67.47**
	CML-47	38.75**	63.84**	40.81**	58.12**	24.51**	31.61**	17.44**	26.25**	209.69**	337.31**	-81.59**	-74.82**
	CML-57	86.17**	89.84**	29.73**	74.86**	15.69**	28.96**	13.10**	20.25**	444.71**	511.40**	-67.60**	-60.26**
I.L-18	SC-128	-14.05	30.64**	-29.17**	10.13**	-12.10**	9.55**	-31.43**	-18.64**	-13.83	59.47**	-70.67**	-47.53**
	CML-47	32.02**	76.57**	25.95**	63.60**	12.09**	22.89**	-2.33	6.33**	169.35**	318.61**	-0.45	41.11**
	CML-57	83.28**	117.35**	89.39**	102.39**	29.63**	34.62**	-1.19	6.41**	388.67**	535.17**	-2.77	24.64**
I.L-21	SC-128	-3.7	44.63**	-13.21**	33.24**	-14.52**	-1.85	-30.48**	-20.65**	-15.29	53.68**	-78.00**	-61.95**
	CML-47	37.35**	80.69**	22.15**	55.51**	18.48**	19.13**	-4.65*	-0.61	160.53**	281.97**	-79.02**	-72.84**
	CML-57	74.92**	103.27**	105.59**	113.95**	25.00**	32.95**	15.48**	19.02**	531.04**	649.53**	109.81**	140.85**
I.L-23	SC-128	-11.54	16.34**	-18.35**	12.52**	-9.68**	6.67*	-14.29**	-5.76	-12.08	41.02	6.13*	73.44**
	CML-47	26.22**	38.95**	9.00**	17.76**	19.78**	23.16**	1.16	1.16	137.13**	152.60**	-72.91	-69.56**
	CML-57	59.66**	69.53**	62.60**	88.24**	43.02**	47.31**	13.95**	15.29**	218.19**	296.04**	84.54	90.20**
L.S.D	0.05	4.26	5.22	4.82	5.9	4.41	5.4	3.58	4.38	29.22	35.79	7.89	9.66
	0.01	5.63	6.9	6.37	7.8	5.82	7.13	4.73	5.79	38.62	47.3	10.43	12.77

Estimates of heritability in broad and narrow senses for yield and yield component traits are present in Table (12). The result displayed that brood senses posed high values which ranged from 55.38% for ear/plant to 99.34 for grain yield/feddan under normal condition. Under stress condition, it was observed high values which ranged from 68.08% for 100-KW to 98.32% for grain yield/plant. These resulted that heritability in broad sense values was higher than narrow sense values because non additive variance was larger than additive variance indicated the preponderance of non-additive gene action in controlling the traits. Genetic advance as a percent of mean for ears/plant (0.50–11.38%), kernels/row (1.32–2.88%), 100-kernel weight (1.59–2.46%), grain yield/plant (0.79–18.65%) exhibited low genetic advance as a percent of mean under two conditions, respectively. except ears /plant, grain yield/pant and grain yield/fad had moderate genetic advance as a percent of mean under drought stress, low genetic advance as a percent of mean indicates that the expression of the trait is under the control of non-additive type of gene action. These finding were harmony with that obtained by Abrha *et al.* (2013), Dinesh *et al.* (2016) and Ganapati Mukri *et al.* (2022) found low GCA variance to SCA variance ratio revealed a preponderance of non-additive gene action, indicating the non-additive gene action in the inheritance of grain yield and its related traits in maize.

Table (12): Genetic parameters for all traits under two conditions.

Trait	Environment	σ^2GCA	σ^2SCA	σ^2A	σ^2D	GCA/SCA	Hb	Hn	GA%
Ear/Plant	N	0.0001	0.002	0.0003	0.002	0.00	55.38	1.97	0.5
	S	0.002	0.032	0.01	0.032	0.06	97.94	12.91	11.38
Kernel/Row	N	0.45	0.94	1.81	.0.94	0.48	92.78	2.82	1.32
	S	0.59	2.83	2.36	2.83	0.21	87.17	5.12	2.88
100-Kernel Weight	N	0.31	5.56	1.25	5.56	0.06	75.78	6.13	1.59
	S	0.28	2.45	1.13	2.45	0.12	68.08	11.05	2.46
Grain Yield/Plant	N	10.84	470.9	43.34	470.9	0.02	97.93	0.91	0.79
	S	27.64	647.24	110.58	647.24	0.04	98.32	11.71	18.65

3.5 Proportion contribution

Relative percentage of contributions of the lines, testers and their interaction for all the studied traits are presented in Table (13). The lines contributed played the major role in the inheritance of kernel/row and 100-Kerenl/weight traits under both conditions, indicates higher estimates of variance due to general combining ability and predominant of lines influence for traits. Moreover, the testers contributed played the major role in the inheritance of ear height at both environments for days to 50% silking and ear/plant at normal and drought condition respectively. While the lines × testers interaction contributed with the large percentage and played the major role in the inheritance of grain yield/plant at two environments, day to 50% silking and ear/plant at normal and drought condition respectively indicates higher estimates of variance due to specific combining ability for traits.

Table (13): Proportion contribution of lines, testers and their interaction for all studied traits under two conditions.

Trait	Environment	Lines	Testers	Lines × Testers
Days to 50% tasseling	N	37.77	34.31	27.92
	S	28.57	26.40	45.04
Ear height	N	37.04	49.16	13.8
	S	31.09	52.39	16.51
Ear/Plant	N	25.16	0.36	74.48
	S	25.02	40.34	34.63
Kernel/Row	N	54.27	20.61	25.12
	S	47.51	23.79	28.7
100-Kernel weight	N	49.21	3.63	47.16
	S	64.29	0.39	35.32
Grain yield/Plant	N	36.71	5.49	57.8
	S	23.53	37.25	39.22

These results are supported with the findings by El-Itriby *et al*. (1990), Abd El-Aziz *et al.* (1994), Soliman and Sadek (1999), Todkar and Naval (2006), Shams *et al.* (2010), and Meseka *et al.* (2012).

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