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Predicting The Nature of Gene Action for Grain Yield and Its Components in Some Hybrids of Yellow Maize Grown in Different Locations

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ABSTRACT

This study was carried out at Sids Agricultural Research Station, during the 2022 growing season, fifteen new inbred lines of yellow maize were top crossed with four testers (two inbred lines and two single crosses) namely Gz.658, Sd.3118, single cross (SC.) 162 and SC.177. In the growing season 2023, the 60 top crosses and four commercial check hybrids i.e. SC.168, SC.3444, three way cross (TWC.) 360 and TWC.368 were evaluated at three locations, i.e. Sids, Sakha and Gemmeiza Agricultural Research Stations. These results showed that, significant difference of mean squares due to genotypes, crosses and their interaction × locations for all traits under studied. Results showed that, as well as the inbred lines L2 and L3 had good general combiners for number days to 50% silking toward earliness, L1, L14 and L15 were the best general combiners for grain yield. While, the testcross L9 × Gz.658 had a favorable and considerable SCA effects for ear length, ear diameter and 100–kernel weight traits. Sixteen testcrosses i.e. L1 × SC.162, L2 × SC.177, L3 × SC.177, L5 × Gz.658, L6 × Gz.658, L7 × SC.162, L7 × SC.177, L8 × SC.162, L8 × SC.177, L10 × Gz.658, L11 × Gz.658, L11 × Sd.3118, L12 × SC.162, L13 × Sd.3118, L14 × Sd.3118 and L15 × SC.177 exhibited positive and significant SCA effects for grain yield arddab/feddan. These results indicated that the non- additive gene effects were more important than the additive in inheritance for these traits. The magnitude of the interaction variances of K^2SCA × loc. interaction was greater than those of K^2 GCA × loc., indicating that the non-additive gene action interacted more with the environmental conditions than the additive components of gene action for all traits.

Keywords *Zea mays*, Combining ability, Gene action, Genotypes × locations.

1. Introduction

The Poaceae family includes maize (*Zea mays* L.), a crop with greater genetic variety and diversity. It is one of the most significant cereal crops cultivated worldwide, next to wheat and rice, its great genetic yield potential among the cereals, and referred to as the "queen of cereals" on a global scale (Vardhini *et al.*, 2024). In Egypt, is regarded as one of the staple crops, ranking third in importance after rice and wheat. Both human and animal nutrition depend heavily on maize, which is also a common ingredient in industrial goods (Attia *et al.*, 2015). It is an essential component of human diets since their flour is combined with 20% wheat flour to make bread. Additionally, fresh, silage, or grain maize is used as animal feed.

Developing a successful breeding program depends in a major way on the type and nature of gene action. Assessing combining ability is helpful in determining the type of gene action for specific quantitative traits as well as for assessing potential inbred lines (El-Gazzar, 2021). The line × tester method is successful technique for assessing novel inbred lines and testers has therefore been an essential component in the creation of new crosses, common method for assessing the general (GCA)

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and specific (SCA) combining abilities of parental inbred lines for use in hybrid combinations (Arunkumar *et al.*, 2020; El-Hosary, 2020; Mousa *et al.,* 2021).

While strong SCA effects imply that potential single cross combinations may be discovered, the significant GCA suggests that breeders might take advantage of the genetic variety available in order to identify elite materials with desired features. In order to improve new maize genotypes, breeders must understand the kind and relative amount of genetic variation components as well as how they interact with the environment. (Ali *et al.,* 2014; Ram *et al.*, 2015).

The aim of this study was to determine the type of gene action controlling inheritance of grain yield and its components.

2. Materials and Methods

2.1. Plant materials and experimental sites

Fifteen yellow maize inbred lines (L) developed from geographical regions in table (1) were used in this investigation. In 2022 season, the fifteen yellow maize inbred lines were crossed with the four testers (T) in a line × tester mating design at Sids Agricultural Research Station, National Maize Research Program to obtain 60 single and three way crosses. During 2023 growing season, the resulted 60 crosses along with four yellow check hybrid; SC.168, SC.3444, TWC.360 and TWC.368 were evaluated in a yield trial at three locations (loc.); Sids, Sakha and Gemmeiza Agricultural Research Stations.

Table 1: The code number, pedigree, segregation and source of the studied inbred lines and four testers

No. of lines	Code number	Pedigree	Segregation	Source	
1	L1	3-2-2-1-1			
2	L2	4-1-1-1-1			
3	L3	25-1-2-1-1			
4	L4	34-1-1-1-1			
5	L5	35-1-1-1-1		Pop. 45	
6	L6	35-1-1-2-1	S_5	Ev-4	
7	L7	35-2-1-1-1			
8	L8	54-1-1-1-1			
9	L9	59-1-1-1-1			National
10	L10	87-1-2-1-1			Maize
11	L11	34-1-1-1-1		Local	Research
12	L12	40-1-1-1-1-1		Pop.45 Ev-4	Program
13	L13	12-1-1-1-1-1	S_6		
14	L14	9-1-1-2-1-1		Comp.21	
15	L15	14-1-1-1-1-1		Local	
		Testers			
		Gz.658			
		Sd.3118			
		SC.162			
		SC.177			

2.2. Experimental design and its management

A randomized complete blocks design with three replications was used at each location. Plot size was one row, 6 m long and 0.8 m a part. Seeds were planted in hills evenly spaced at 0.25 m along the row at the rate of two kernels hill, which thinned to one plant hill after three weeks from planting date. The field trails were kept clean of weeds throughout the growing season, whereas all cultural practices for maize production were applied as recommended at the proper time.

2.3. Data recorded

The data collected on number of days to 50% silking, ear length (cm), ear diameter (cm), 100–kernel weight (g) and grain yield arddab/feddan (ardab/fed) (one fed = 4200 m^2) adjusted to 15.5% moisture content, one ardab =140 kg.

2.4. Statistical analysis

Data were analyzed using general linear model (GLM) procedures in SAS (2008). Means for all maize combinations adjusted for block effects through sites were analyzed according to Snedecore and Cochran (1980). Combining ability analysis was performed for traits that showed statistical differences among crosses. Kempthorne's (1957) method was employed to determine general and specific combining abilities and their interaction effects with three locations.

3. Results and Discussion

3.1. Analysis of variance

Mean squares of locations and sixty-four crosses and their interaction for all the studied traits; number of days to 50% silking, ear length, ear diameter, 100–kernel weight and grain yield combined across three locations are presented in Table 2. Results revealed that, locations mean squares were highly significant for all the studied traits. These results indicating that, the environmental conditions were differed from location to another. Mean squares of genotypes (G), crosses (C) and their interaction with locations Loc. (G × Loc. and C × Loc.) were highly significant for all the studied traits. These results are agreement with numerous researchers (Alsebaey *et al.,* 2020; Alsebaey, 2021; Alsebaey *et al.,* 2021; Aldulaimy and Hammadi, 2021; Ibrahim *et al.,* 2021; Abd El-Azeem *et al.,* 2023; Abo-Elwafa *et al*., 2023; Mosa *et al.*, 2023).

Table 2: Mean squares of locations and 64 crosses and their interaction for all the studied traits across three locations.

S.O.V	df	Number of days to 50% silking	Ear length (cm)	Ear diameter (cm)	100–kernel weight (g)	Grain yield (*Ardab/fed)
Locations (Loc.)	2	40.14**	185.25**	103.10**	8503.37**	106.05**
Reps/Loc.	6	15.85	0.96	0.18	76.19	17.48
Genotypes (G)	63	17.26**	20.81**	0.23**	17.63**	105.53**
Crosses (C)	59	15.28**	19.24**	0.21**	11.34**	108.67**
Geno × Loc.	126	5.11**	2.27**	0.11**	9.56**	25.43**
C x Loc.	118	4.68**	2.16**	0.11**	9.04**	25.62**
Pooled error	378	1.61	2.05	0.07	5.98	6.41

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
* Ardab: 140 Kg

3.2. Mean performance of genotypes

The sixty single and three way crosses and the four check hybrids; SC.168, SC.3444, TWC.360 and TWC.368 for all the studied traits across three locations are presented in Table 3. For number of days to 50% silking, data revealed that, twenty three single crosses were significantly earlier than the two checks (SC.168 and SC.3444) with a range from 60.6 days for L2 × Gz.658 to 63.9 days for L12 × Gz.658, as for the two check hybrids, SC. 168 and SC. 3444 were recorded 65.1 and 65.3 days, respectively. With respect to the three way crosses, range from 60.8 days for L3 × SC.162 to 63.8 days for L7 × SC.162, all crosses exhibited significant earlier than the two checks TWC.360 and TWC.368 except for, eight crosses which did not differ significantly than the two checks. Regarding the ear length, when compared with the best checks SC.168 or TWC.360, no hybrids (whether it was single or three way crosses) exhibited significant increase than the check hybrids for these traits. But, sixteen (single and three way crosses) exhibited best values for ear length and did not differ significantly with check hybrids. For ear diameter trait, ranged from 4.1 cm for L10 × SC.177 to 4.8 cm for L11 × Sd.3118, most of crosses did not differ significantly compared with the check hybrids. Concerning, 100–kernel weight revealed that, out of 30 single crosses seven crosses, exhibited the best mean values for this trait and did not differ significant the best check SC.3444. The best mean values for single crosses were observed for L13 × Gz.658 (35.0 g), followed by L3 × Gz.658 (34.3 g) then for L7 × Sd.3118 (33.2 g). While, three way crosses which the best mean value were observed for L13 × SC.162 (34.4 g) but did not reach to significant when compared to the check TWC.368 (37.1 g). Regarding the grain yield, one and four (single and three way crosses), respectively, had significantly out yielding than the best checks SC.168 and TWC. 368. Furthermore, ten and sixteen (single and three way crosses), respectively, did not vary significantly compared with the checks hybrid. The highest yielding crosses was L14 × SC.162 (32.6 ardab/fed) follows L1 × SC.162 (30.4 ardab/fed) then L14 × Sd.3118 (32.6 ardab/fed).

Table 3: Mean performances of the 60 single and three way crosses and four check hybrids for all the studied traits across three locations.

Crosses		Number of days to 50% silking	Ear length (cm)	Ear diameter (cm)	100 – kernel weight (g)	Grain yield (*Ardab/fed)
1	L1 × Gz.658	61.2	18.2	4.3	32.9	22.2
2	L1 × Sd.3118	62.8	16.4	4.2	30.5	24.9
3	L1 × SC.162	63.9	19.0	4.5	33.4	30.4
4	L1 × SC.177	63.2	19.4	4.4	32.5	25.5
5	L2 × Gz.658	60.6	17.7	4.3	31.1	20.0
6	L2 × Sd.3118	62.7	17.7	4.4	31.4	23.5
7	L2 × SC.162	62.3	20.3	4.5	33.3	25.0
8	L2 × SC.177	61.9	20.0	4.5	32.5	27.8
9	L3 × Gz.658	60.7	19.1	4.6	34.3	26.1
10	L3 × Sd.3118	61.9	17.9	4.3	31.6	20.0
11	L3 × SC.162	60.8	19.7	4.6	32.9	24.9
12	L3 × SC.177	60.9	18.4	4.5	32.4	26.2
13	L4 × Gz.658	64.1	20.4	4.5	30.9	22.8
14	L4 × Sd.3118	62.3	17.3	4.2	33.3	21.0
15	L4 × SC.162	64.6	21.4	4.6	33.0	27.4
16	L4 × SC.177	63.9	20.3	4.6	33.5	24.0
17	L5 × Gz.658	63.3	20.3	4.6	30.6	27.0
18	L5 × Sd.3118	62.8	17.5	4.4	32.8	20.4
19	L5 × SC.162	65.0	21.1	4.6	32.1	27.1
20	L5 × SC.177	64.0	20.9	4.6	33.3	25.7
21	L6 × Gz.658	64.3	20.5	4.7	30.2	25.8
22	L6 × Sd.3118	64.7	19.4	4.4	32.4	19.6
23	L6 × SC.162	64.3	21.1	4.6	31.2	24.5
24	L6 × SC.177	61.7	18.2	4.4	32.5	20.1
25	L7 × Gz.658	61.6	17.4	4.3	31.7	20.4
26	L7 × Sd.3118	61.4	17.6	4.4	33.2	20.5
27	L7 × SC.162	63.7	21.1	4.5	30.7	29.1
28	L7 × SC.177	62.3	20.7	4.4	32.1	26.3
29	L8 × Gz.658	62.0	17.6	4.2	31.4	20.7
30	L8 × Sd.3118	62.1	16.6	4.2	32.5	23.3
31	L8 × SC.162	62.7	19.8	4.5	32.3	29.4
32	L8 × SC.177	62.2	18.8	4.4	32.6	27.2
33	L9 × Gz.658	64.2	19.4	4.6	32.9	20.4
34	L9 × Sd.3118	62.7	15.8	4.1	30.6	18.8
35	L9 × SC.162	61.7	17.7	4.3	30.5	21.5
36	L9 × SC.177	60.9	17.5	4.2	31.8	19.7
58	L15 × Sd.3118	62.2	19.2	4.5	33.2	24.3
59	L15 × SC.162	63.4	18.8	4.3	31.4	23.6
60	L15 × SC.177	62.9	19.5	4.4	33.7	28.1
61	SC.168	65.1	20.8	4.8	33.3	27.8
62	SC.3444	65.3	21.5	4.6	35.9	27.5
63	TWC.360	65.3	21.8	4.6	36.1	25.0
64	TWC.368	65.0	20.6	4.6	37.1	26.7
LSD	0.05	1.18	1.33	0.24	2.27	2.35
	0.01	1.55	1.75	0.31	2.98	3.09

* Ardab: 140 Kg

3.3. General combining ability effects

General combining ability (GCA) effects for all studied traits in the three locations for fifteen inbred lines and four testers are presented in Table 4. For number of days to 50% silking raveled that, the inbred lines L2, L3, L7, L8 and L9 had a negative and highly significant (favorable) attitude towards

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earliness. For ear length trait, the inbred lines L4, L5, L6 and L14 had a positive and highly significant for this trait. Concerning ear diameter, the inbred lines L5, L11 and L14 showed positive and significant or highly significant GCA effects. For 100 – kernel weight, only inbred line L13 showed positive and highly significant. For grain yield, the highest general combiners were L1, L14 and L15 which resulted in positive and highly significant GCA effects. The findings indicated that T4 (SC.177) has good combiner GCA affects for days to 5o% silking and 100–kernel weight, while T3 (SC.162) has a good combiner for ear length, ear diameter and grain yield (ardab/fed). These results are agreement with those obtained by Dar *et al.* (2017), Hundera, (2017); Abd El-Latif *et al.* (2023).

Table 4: General combining ability effects of 15 inbred lines of maize and four testers for all the studied traits across the three locations

Lines and Testers	**Number of days to 50% silking**	**Ear length (cm)**	**Ear diameter (cm)**	**100-kernel weight (g)**	**Grain yield (*Ardab/fed)**
L1	-0.13	-0.71**	-0.09*	0.03	1.38**
L2	-1.04**	-0.02	-0.01	-0.22	-0.27
L3	-1.85**	-0.16	0.05	0.52	-0.06
L4	0.82**	0.91**	0.06	0.37	-0.57
L5	0.87**	1.02**	0.09*	-0.11	0.67
L6	0.84**	0.86**	0.06	-0.72	-1.88**
L7	-0.66**	0.26	-0.02	-0.37	-0.27
L8	-0.66**	-0.77**	-0.11**	-0.10	0.76
L9	-0.54*	-1.33**	-0.13**	-0.84*	-4.26**
L10	-0.38	-0.64**	0.01	0.72	-0.54
L11	0.26	-0.45	0.11**	-0.12	-0.38
L12	0.54*	-0.41	-0.09*	-1.19**	-1.77**
L13	-0.04	-0.33	-0.03	1.44**	0.63
L14	1.87**	1.45**	0.12*	0.35	4.96**
L15	0.09	0.33	0.01	0.24	1.59**
LSD (gi) 0.05	0.42	0.46	0.08	0.78	0.82
0.01	0.56	0.60	0.11	1.02	1.08
T1 (Gz.658)	0.25*	0.20	0.06**	-0.30	0.21
T2 (Sd.3118)	-0.32**	-1.25**	-0.07**	-0.23	-1.70**
T3 (SC.162)	0.48**	1.05**	0.06**	0.06	2.02**
T4 (SC.177)	-0.41**	0.01	-0.05*	0.46*	-0.54*
LSD (gi) 0.05	0.22	0.24	0.04	0.40	0.43
0.01	0.29	0.31	0.06	0.53	0.57

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
* Ardab: 140 Kg

3.4. Specific combining ability effects

Specific combining ability (SCA) effects of 60 crossings for all traits under study combined across three locations illustrated in Table 5. Results showed that, eleven testcrosses i.e. L1 × Gz.658, L2 × Gz.658, L4 × Sd.3118, L6 × SC.177, L7 × Gz.658, L9 × SC.162, L9 × SC.177, L11 × SC.162, L11 × SC.177, L13 × Sd.3118 and L14 × Sd.3118 exhibited negative (desirable) and significant or highly significant SCA effects for days to 50% silking. Regarding the ear length, nine testcrosses i.e. L1 × SC.177, L2 × SC.177, L5 × SC.177, L7 × SC.177, L9 × Gz.658, L10 × SC.162, L11 × Sd.3118, L13 × Gz.658 and L15 × Sd.3118 exhibited positive and significant or highly significant SCA effects for ear length. For ear diameter, two testcrosses i.e. L9 × Gz.658 and L11 × Sd.3118 exhibited positive and highly significant SCA effects for this trait. Regarding to 100–kernel weight, two testcrosses i.e. L3 × Gz.658 and L9 × Gz.658 exhibited positive and significant SCA effects for this trait. In addition, results showed that, sixteen testcrosses i.e. L1 × SC.162, L2 × SC.177, L3 × SC.177, L5 × Gz.658, L6 × Gz.658, L7 × SC.162, L7 × SC.177, L8 × SC.162, L8 × SC.177, L10 × Gz.658, L11 × Gz.658, L11 × Sd.3118, L12 × SC.162, L13 × Sd.3118, L14 × Sd.3118 and L15 × SC.177 exhibited positive and significant or highly significant SCA effects for grain yield (ardab/fed). These findings are comparable with those obtained by Larièpe *et al.* (2017), Bisen *et al.* (2020); Zeleke *et al,* (2020); El Sayed *et al.* (2022).

Table 5: Specific combining ability effects of 60 top crosses of maize for all the studied traits across the three locations

Crosses		Number of days to 50% silking	Ear length (cm)	Ear Diameter (cm)	100 – kernel weight (g)	Grain Yield (*Ardab/fed)
1	**L1 × Gz.658**	-1.81**	-0.26	-0.10	0.84	-3.74**
2	**L1 × Sd.3118**	0.32	-0.56	-0.04	-1.56*	0.87
3	**L1 × SC.162**	0.63	-0.33	0.08	0.98	2.62**
4	**L1 × SC.177**	0.85*	1.15*	0.07	-0.26	0.25
5	**L2 × Gz.658**	-1.56**	-1.43*	-0.19*	-0.66	-4.29**
6	**L2 × Sd.3118**	1.13**	0.06	0.02	-0.45	1.14
7	**L2 × SC.162**	-0.01	0.30	0.04	1.12	-1.13
8	**L2 × SC.177**	0.44	1.07*	0.14	-0.01	4.28**
9	**L3 × Gz.658**	-0.64	0.15	0.01	1.79*	1.55
10	**L3 × Sd.3118**	1.15**	0.36	-0.08	-0.95	-2.58**
11	**L3 × SC.162**	-0.76	-0.17	0.06	0.04	-1.42
12	**L3 × SC.177**	0.24	-0.35	0.02	-0.88	2.46**
13	**L4 × Gz.658**	0.14	0.37	-0.02	-1.46	-1.21
14	**L4 × Sd.3118**	-1.07*	-1.27**	-0.19*	0.82	-1.09
15	**L4 × SC.162**	0.35	0.50	0.09	0.24	1.62
16	**L4 × SC.177**	0.58	0.40	0.13	0.40	0.69
17	**L5 × Gz.658**	-0.69	0.10	-0.03	-1.31	1.69*
18	**L5 × Sd.3118**	-0.68	-1.18*	-0.11	0.81	-2.93**
19	**L5 × SC.162**	0.74	0.12	0.01	-0.16	0.05
20	**L5 × SC.177**	0.63	0.96*	0.13	0.66	1.19
21	**L6 × Gz.658**	0.33	0.51	0.09	-1.06	3.06**
22	**L6 × Sd.3118**	1.24**	0.88	-0.06	1.01	-1.21
23	**L6 × SC.162**	0.10	0.21	0.01	-0.44	-0.04
24	**L6 × SC.177**	-1.67**	-1.61**	-0.04	0.49	-1.81*
25	**L7 × Gz.658**	-0.94*	-1.98**	-0.17*	0.11	-3.87**
26	**L7 × Sd.3118**	-0.49	-0.38	0.07	1.48	-1.88*
27	**L7 × SC.162**	0.94*	0.88	0.06	-1.26	2.97**
28	**L7 × SC.177**	0.49	1.48**	0.03	-0.33	2.78**
29	**L8 × Gz.658**	-0.50	-0.79	-0.17*	-0.55	-4.69**
30	**L8 × Sd.3118**	0.18	-0.34	-0.02	0.54	-0.16
31	**L8 × SC.162**	-0.06	0.53	0.06	0.04	2.26**
32	**L8 × SC.177**	0.38	0.60	0.13	-0.04	2.58**
33	**L9 × Gz.658**	1.61**	1.63**	0.24**	1.75*	0.08
34	**L9 × Sd.3118**	0.63	-0.52	-0.13	-0.61	0.43
35	**L9 × SC.162**	-1.17**	-0.95*	-0.05	-1.06	-0.65
36	**L9 × SC.177**	-1.06*	-0.16	-0.06	-0.08	0.13

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
* Ardab: 140 Kg

Table 5: Cont.

Crosses		Number of days to 50% silking	Ear length (cm)	Ear diameter (cm)	100 – kernel weight (g)	Grain yield (*Ardab/fed)
37	**L10 × Gz.658**	0.01	0.43	0.16	0.23	5.05**
38	**L10 × Sd.3118**	-0.43	-1.10*	0.06	-0.51	-0.28
39	**L10 × SC.162**	0.21	1.93**	0.05	0.93	-1.00
40	**L10 × SC.177**	0.21	-1.27**	-0.27**	-0.65	-3.77**
41	**L11 × Gz.658**	0.58	0.89	0.08	-0.39	5.09**
42	**L11 × Sd.3118**	1.60**	1.79**	0.34**	-0.72	2.83**
43	**L11 × SC.162**	-0.87*	-2.16**	-0.28**	0.29	-5.21**
44	**L11 × SC.177**	-1.31**	-0.52	-0.13	0.82	-2.71**
45	**L12 × Gz.658**	0.19	-0.31	0.04	-0.33	-0.05
46	**L12 × Sd.3118**	-0.46	0.76	-0.06	1.40	-1.33
47	**L12 × SC.162**	-0.26	0.86	0.12	-0.27	2.93**
48	**L12 × SC.177**	0.52	-1.32**	-0.10	-0.80	-1.55
49	**L13 × Gz.658**	0.67	0.99*	0.11	1.54	0.21
50	**L13 × Sd.3118**	-0.87*	0.29	0.04	-0.95	3.71**
51	**L13 × SC.162**	0.55	-0.33	-0.06	0.56	0.12
52	**L13 × SC.177**	-0.34	-0.95*	-0.10	-1.16	-4.04**
53	**L14 × Gz.658**	2.42**	-0.42	-0.08	-0.13	-0.54
54	**L14 × Sd.3118**	-1.79**	0.01	0.06	-1.20	2.46**
55	**L14 × SC.162**	-0.37	0.11	0.01	0.20	1.21
56	**L14 × SC.177**	-0.26	0.30	0.02	1.12	-3.14**
57	**L15 × Gz.658**	0.19	0.09	0.07	-0.38	1.63
58	**L15 × Sd.3118**	-0.46	1.20*	0.11	0.89	0.04
59	**L15 × SC.162**	-0.04	-1.50**	-0.19*	-1.21	-4.33**
60	**L15 × SC.177**	0.30	0.21	0.01	0.71	2.66**
LSD (Sij)	**0.05**	0.85	0.92	0.17	1.56	1.66
	0.01	1.13	1.22	0.22	2.07	2.19

*, ** significant at 0.05 and 0.01 levels of probability, respectively.
* Ardab: 140 Kg

3.5. Genetic parameters

Genetic parameters and their interactions with locations, proportional contribution of lines, testers, and their interaction to the overall variance in maize combined across three locations for all the studied traits. The findings showed that the K^2 SCA values were greater than the K^2 GCA values for all the studied traits, indicating that the non- additive gene effects were more important than the additive in inheritance of all traits. While, the magnitudes of the interaction variances of K^2SCA × loc. interaction was greater than those of K^2 GCA × loc. for all traits, indicating that the non-additive gene action interacted more with the environmental conditions than the additive components of gene action for all traits. These results are in agreement with the findings of several investigations and they found that the variance in specific combining ability was more susceptible to changes in the environment than the variance in general combining ability. These findings harmony agreed with those obtained by Mousa and Abd El-Azeem, (2009); Ibrahim *et al.* (2012); Gamea, (2015); Darshan and Marker*,* (2019); Mohamed, 2020).

With respect to Contribution of lines, testers, L×T interaction, the proportional contribution of L × T to total variances was much higher than line and tester for all traits except for, days to 50% silking, suggesting that the line × tester was essential for contributing to improve these traits. These findings agreed with those obtained by Akula *et al.* (2016); Ejigu *et al*. (2017); Abd El-Latif *et al*. (2020); Abd El-Latif *et al.* (2023).

Table 6: Genetic parameters and contribution of line, tester and line × tester interaction for all the studied traits across the three locations

Genetic Parameters	Number of days to 50% silking	Ear length (cm)	Ear diameter (cm)	100 – kernel weight (g)	Grain yield (*Ardab/fed)
K^2GCA	0.31	0.82	0.004	0.12	2.68
K^2SCA	0.87	0.99	0.012	0.44	8.31
K^2GCA×Loc.	0.23	0.09	0.01	0.14	1.23
K^2SCA×Loc.	0.56	0.14	0.02	0.62	6.01
Contribution of Lines	47.31	26.55	26.41	32.37	31.53
Contribution of Testers	8.43	26.99	15.36	7.31	15.32
Contribution of L×T	44.26	46.45	58.24	60.32	53.15

* Ardab: 140 Kg

4. Conclusion

In general, the current study's findings showed that inbred line L1, L14 and L15 have significant GCA effects for grain yield, inbred lines L2 and L3 has the best combiner for earliness. The best crosses L2 × SC.177, L10 × Gz.658, L11 × Gz.658 and L13 × Sd.3118 combinations that result in the desired SCA effects for grain yield under study. This suggests that crop breeders may be able to develop suitable cross combinations by recombination or crossing inbred lines with desirable traits. Breeders aiming at developing maize crops with high yields may find the data and information from this study helpful.

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