

Original Research Article

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## Combining Ability Analysis of Maize Inbred Lines from Line X Tester Mating Design under Two Plant Population Density

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### ABSTRACT

#### Keywords

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A line X tester analysis was carried out in maize with nine lines and five tester under two plant population density (optimum planting density and high planting density) at the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Combining ability analysis revealed significant variances due to GCA and SCA for most of the characters in both the environments, indicating importance of both additive and non-additive genetic variances. The magnitude of SCA variance was greater than GCA variance for all the characters in all the environments showing preponderance of non-additive variance and suitability of material for hybrid breeding. The GCA effects of the parents indicated that parental lines L1, L4, L8, L9 and testers T2 and T3 in optimum plant population density; lines, L1, L2, L4, L8 and L9 and testers T1, T3 and T4 in high plant population density and lines L2, L4, L8 and L9 and tester T1 in pooled environment were the best combiners. Hybrids L2 x T5, L7 x T1, L3 x T5 and L9 x T2 in optimum plant population density, L2 x T5, L3 x T5 and L8 x T1 in high plant population density and L2 x T5, L8 x T1 and L6 x T1 in pooled environment showed higher SCA effects for grain yield and its contributing traits.

### Introduction

Maize (*Zea mays* L.) is cultivated globally being one of the most important cereal crops worldwide. Among cereals, maize is rich in starch, proteins, oil and sucrose, due to which it has assumed significant industrial importance. The utilization of maize as feed in India and world is almost similar. Whereas, the industrial use of maize in world is 22 percent as compared to 16 per cent in India. Further, the continued growth in the poultry

and starch industry will support the highest consumption of maize in India. Because of its wide adaptability, high production potential and now enhanced industrial demand over last decade maize has been emerged as world's leading crop among the cereals with highest production (991.92 MT) (USDA, 2015). In India, its average production is 22.5 MT (USDA, 2015). Owing to burgeoning growth rate of poultry, livestock, fish and wet and dry milling industries, maize demand is expected to increase from current level of 16.72 to 45

million tons by 2030. The projected requirement of maize can only be met by focused research on high yielding single cross hybrids (SCHs) with good quality seeds and its integration with novel molecular tools and techniques like introgression of superior alleles (genes) into best available single cross hybrids (Sai Kumar *et al.*, 2012). This clearly indicates that high yielding superior single cross hybrids are prerequisites. Single cross hybrid (SCH) technology is simple and acceptable.

Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis. It is also important to have information on the nature of combining ability of parents, their behaviour and performance in hybrid combination (Chawla and Gupta, 1984). In the present study, keeping in view the above facts an attempt was made to find out the best combiner out of nine lines and five testers. The objective of the study was identify the promising single cross maize hybrids based on GCA of parents and SCA of hybrids.

### Materials and Methods

The present investigation was carried out at the Norman E. Borlaug Crop Research Centre, at Govind Ballabh Pant University of Agriculture and Technology, during 2013-14 to identify good combiners for yield component in maize. The basic experimental material comprised of nine maize inbred lines and five testers which were initially screened for various desired characters (Table 1). These lines were crossed to testers in a line X tester mating design during Rabi, 2013-14 to generate 45 single cross hybrids. The present

study consists of 59 genotypes, i.e. 9 inbred lines, 5 testers, 45 F<sub>1</sub>s.

All genotypes were evaluated in a randomized complete block design in two-row plots with three replications under two plant population densities i.e., Optimum (53,333 plants/ha) and High planting densities (88,889 plants/ha). To achieve required plant population in case of optimum planting density (E<sub>1</sub>), spacing of 75 cm between rows and 25 cm maintained. Whereas, in case of high planting density (E<sub>2</sub>), spacing of 75 cm between rows and 15 cm between plants was maintained. The total plot area for F<sub>1</sub>s and parents was 6.00 m<sup>2</sup>. Observations were recorded on the whole plot basis in respect of days to 50 per cent tasselling, days to 50 per cent silking, and grain yield (kg/ha). However, plant height, number of kernel, rows/ear and number of kernels/row were recorded on the basis of five randomly selected competitive plants. The average value of these plants for all the characters was calculated and used for the statistical analysis.

Combining ability analysis in line × tester was done following the method given by Kempthorne (1957).

The following model of Kempthorne (1957) was used for estimating the GCA and SCA effect in combining ability analysis.

$$X_{ijk} = \mu + g_i + g_j + S_{ij} + e_{ijk}$$

where,

$\mu$  = general mean

$g_i$  = GCA effect of  $i$ th line;  $i = 1, 2, 3, \dots, l$

$g_j$  = GCA effect of  $j$ th tester;  $j = 1, 2, 3, \dots, t$

$S_{ij}$  = SCA effect of  $ij$ th combination and

$e_{ijk}$  = error associated with the observation  $X_{ijk}$ ;  $k = 1, 2, 3, \dots, r$

The evaluation of crosses were done under two plant population density (optimum plant population density and high plant population

density) and pooled analysis for both the environment has also done.

## Results and Discussion

### Analysis of variance

The analysis of variance for all the traits showed highly significant differences between parents and crosses in both the environments. The analysis of variance indicated that sufficient genetic variability present among parents and crosses for all the characters. All the characters showed significant differences in E<sub>1</sub>, E<sub>2</sub> and pooled environments for line × tester component. These results were in connivance with those of Kambeet *al.* (2013), Aminuet *al.* (2014) and Ram *et al.* (2015).

### Estimates of genetic components and other genetic parameters

Variance component of general combining ability (GCA) and Specific combining ability (SCA) are shown in Table 2. It was observed

that SCA variance was higher than GCA variance for all the characters in both E<sub>1</sub> and E<sub>2</sub> environment. Maximum variance for GCA was observed plant height in E1 and days to 50 per cent silking in E2. The non-additive (dominance) variance ( $s^2D$ ) was higher than the additive variance ( $s^2A$ ) at both inbreeding coefficients (F=0 and F=1). Therefore, as the dominance variance is predominant, transgressive (recombinant) breeding may not be useful. Heterosis breeding is a better choice for these conditions. Pavanet *al.* (2011), Haddadiet *al.* (2012), Kambeet *al.* (2013) and Aminuet *al.* (2014) also reported similar findings.

### Estimates of combining ability effects

The estimate of general combining ability of parents and Specific combining ability of crosses for different traits under two plant population density as well as pooled over environment are given in Table 3 and 4, respectively.

**Table.1** Maize inbred lines selected for study

S.No.	Coded Pedigree	Lines
1.	L1	YHPA ⊗ 85-4-3-2-3-3-1-1-1-⊗-1-1⊗2
2.	L2	Pob 446-12-3-2-B-B-B
3.	L3	Pop 31 ⊗ 23-1-1-1-1-2-1/2 # ⊗ 2-2 to 6#
4.	L4	YHP-B⊗ 45-1-2-3-1-6-2-4 ⊗ 4
5.	L5	Pob 446-74-2-2-BBB
6.	L6	POB-45-C8 -86-1-3-7-4-2-⊗-1-⊗-1-⊗A
7.	L7	Tarun⊗ 83-1-3-2-1-3-2-1
8.	L8	POB. 45 C8 – 149-1-1-2-2-1-2-⊗-8
9.	L9	Pop 31⊗ 18-2-1-1-1-1-3-1 to 6# ⊗ 1-1 to 5
10.	T1	CM-129
11.	T2	CML-421
12.	T3	CM 137
13.	T4	V 357
14.	T5	CM 211

**Table.2** Component of variance of combining ability in terms of full sibs and half sibs under optimum (E<sub>1</sub>) and high plant population density (E<sub>2</sub>) environments in maize

S.No.	Env	Component of variance		Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Kernel rows/ ear	Kernels/ row	Grain yield (quintal)
1	E <sub>1</sub>	Cov H.S. (s <sup>2</sup> GCA)		0.006	0.05	0.8873	-0.006	-0.026	-0.685
		Cov F.S.		0.623	2.56	154.4650	0.440	3.367	80.271
		Cov (F.S.) - 2 (Cov H.S.)= s <sup>2</sup> SCA		0.617	2.51	153.5777	0.446	3.393	80.956
		s <sup>2</sup> GCA/s <sup>2</sup> SCA		0.010	0.02	0.0058	-0.013	-0.008	-0.008
2	E <sub>2</sub>	Cov H.S. (s <sup>2</sup> GCA)		0.009	0.04	-0.0454	0.000	0.001	-0.214
		Cov F.S.		0.765	2.43	103.7450	0.321	6.358	67.762
		Cov (F.S.) - 2 (Cov H.S.)= s <sup>2</sup> SCA		0.756	2.39	103.7904	0.321	6.357	67.976
		s <sup>2</sup> GCA/s <sup>2</sup> SCA		0.012	0.02	-0.0004	0.001	0.000	-0.003
3	E <sub>1</sub>	s <sup>2</sup> A	F=1	0.012	0.09	4.580	-0.011	-0.052	-1.370
			F=0	0.025	0.19	9.161	-0.023	-0.104	-2.740
		s <sup>2</sup> D	F=1	0.450	0.72	55.783	0.687	5.010	120.170
			F=0	1.798	2.88	223.132	2.747	20.038	480.681
4	E <sub>2</sub>	s <sup>2</sup> A	F=1	0.019	0.08	0.193	0.001	0.002	-0.427
			F=0	0.037	0.17	0.387	0.002	0.005	-0.855
		s <sup>2</sup> D	F=1	0.478	0.96	105.029	0.339	5.546	78.629
			F=0	1.911	3.85	420.116	1.355	22.182	314.515

**Table.3** Estimates of general combining ability effects of lines and testers for important economic characters under optimum (E<sub>1</sub>) and high plant population density (E<sub>2</sub>) environment in maize.

S. No.	Lines	Days to 50% tasselling			Days to 50% silking			Plant height (cm)		
		E <sub>1</sub>	E <sub>2</sub>	Pooled	E <sub>1</sub>	E <sub>2</sub>	Pooled	E <sub>1</sub>	E <sub>2</sub>	Pooled
1	L1	-0.58	0.13	-0.23	-1.19 *	0.30	-0.44	-6.73***	-11.83***	-9.28***
2	L2	0.82*	0.99**	0.91***	0.94*	0.97*	0.96***	4.98**	7.20*	6.09***
3	L3	-0.44	0.06	-0.19	-1.73 ***	0.50	-0.61 *	-9.25***	-7.36*	-8.30***
4	L4	-0.11	-0.61	-0.36	-0.93*	-1.36***	-1.14***	-0.09	4.84	2.37
5	L5	-0.58	-0.21	-0.39	0.27	0.10	0.19	1.82	5.99	3.90*
6	L6	0.02	-0.41	-0.19	0.61	-0.90*	-0.14	-7.09***	2.60	-2.25
7	L7	0.62	0.39	0.51 *	1.21*	-0.50	0.36	-2.47	2.52	0.03
8	L8	-0.64	-1.07 ***	-0.86 ***	-0.59	-1.30 **	-0.94**	7.44***	-4.07	1.69
9	L9	0.89*	0.73 *	0.81***	1.41 **	2.17 ***	1.79***	11.38***	0.12	5.75**
10	S.E.(gi)	0.3667	0.3072	0.2235	0.4597	0.3859	0.2835	1.5896	3.0152	1.7625
11	Gi- Gj(Line)	0.5185	0.4345	0.3161	0.6501	0.5457	0.4009	2.2481	4.2642	2.4925
12	T1	-0.40	0.24	-0.08	-0.76 *	-0.42	-0.59**	-4.96***	-3.41	-4.19**
13	T2	-0.10	-0.27	-0.19	-0.13	-0.42	-0.27	-1.48	-1.55	-1.51
14	T3	0.45	0.32	0.39*	0.76 *	0.47	0.61 **	4.70***	-0.63	2.03
15	T4	0.01	-0.01	0.00	-0.20	0.32	0.06	-0.29	3.66	1.68
16	T5	0.04	-0.27	-0.11	0.32	0.06	0.19	2.03	1.93	1.98
17	S.E.(gj)	0.2733	0.2290	0.1666	0.3426	0.2876	0.2113	1.1848	2.2474	1.3137
18	Gi - Gj(Tester)	0.3865	0.3239	0.2356	0.4846	0.4068	0.2988	1.6756	3.1783	1.8578

**Table 3 Conti...**

S. No.	Lines	Number of kernel rows/ ear			Number of kernels/ row			Grain yield (quintal)		
		E <sub>1</sub>	E <sub>2</sub>	Pooled	E <sub>1</sub>	E <sub>2</sub>	Pooled	E <sub>1</sub>	E <sub>2</sub>	Pooled
1	L1	-0.10	0.02	-0.04	-0.22	-0.03	-0.13	0.93	6.09**	3.51
2	L2	-0.06	0.44***	0.19**	0.64	1.88***	1.26***	8.67***	5.30***	6.99
3	L3	0.10	0.60***	0.35***	0.28	0.44	0.36	-0.25	-3.17***	-1.71
4	L4	0.46***	-0.04	0.21***	-0.43	0.39	-0.02	-1.62	-3.95***	-2.79
5	L5	0.01	-0.13	-0.06	-2.46***	0.07	-1.19***	-7.38***	-1.61*	-4.50
6	L6	-0.22*	-0.35***	-0.29***	0.30	-1.43***	-0.56	0.35	0.46	0.40
7	L7	-0.22*	-0.16*	-0.19**	0.42	-0.47	-0.03	2.86	0.62	1.74
8	L8	0.11	-0.31***	-0.10	1.00*	-0.30	0.35	0.63	-3.69***	-1.53
9	L9	-0.07	-0.07	-0.07	0.48	-0.55	-0.04	-4.19**	-0.06	-2.12
10	S.E.(gi)	0.1054	0.0805	0.0614	0.4365	0.3769	0.2876	1.4505	0.7856	0.8652
11	Gi- Gj(Line)	0.1491	0.1138	0.0869	0.6173	0.5331	0.4067	2.0514	1.1110	1.2236
12	T1	-0.22**	-0.03	-0.13**	0.06	1.80***	0.93***	0.71	-2.96***	-1.12
13	T2	-0.26v	-0.13*	-0.20***	0.53	0.31	0.42	2.98**	2.02***	2.50
14	T3	0.16*	-0.13*	0.02	-0.64	-0.59*	-0.62**	-2.46*	3.27***	0.41
15	T4	0.07	0.09	0.08	0.13	-0.83**	-0.35	-0.73	-1.95**	-1.34
16	T5	0.25**	0.20**	0.22***	-0.08	-0.69*	-0.38	-0.51	-0.38	-0.45
17	S.E.(gj)	0.0786	0.0600	0.0458	0.3254	0.2810	0.2143	1.0812	0.5856	0.6449
18	Gi - Gj(Tester)	0.1111	0.0848	0.0648	0.4601	0.3973	0.3031	1.5290	0.8281	0.912

**Table.4** Estimates of Specific combining ability effects of lines and testers for important economic characters under optimum (E<sub>1</sub>) and high plant population density (E<sub>2</sub>) environment in maize

S. No.	Crosses	Days to 50% tasselling			Days to 50% silking			Plant height (cm)		
		E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
1	L1×T1	-0.87	-0.64	-0.76	-0.84	-0.38	-0.61	-0.35	-15.10 *	-7.72
2	L1×T2	1.17	-0.46	0.36	0.19	-1.38	-0.59	7.05	13.09	10.07*
3	L1×T3	-0.39	0.28	-0.05	-0.03	0.40	0.19	-7.23 *	-0.02	-3.62
4	L1×T4	-1.61	-0.05	-0.83	-1.73	0.21	-0.76	-0.24	2.29	1.02
5	L1×T5	1.69*	0.87	1.28*	2.41*	1.14	1.78	0.77	-0.26	0.25
6	L2×T1	0.07	1.82**	0.94	2.02	2.96***	2.49**	-7.84 *	-18.28 **	-13.06**
7	L2×T2	1.10	0.67	0.89	1.06	0.62	0.84	14.12 ***	-4.92	4.60
8	L2×T3	0.88	-0.25	0.31	-0.16	-0.60	-0.38	-2.50	4.30	0.90
9	L2×T4	-0.34	-0.92	-0.63	-0.53	-0.45	-0.49	-14.73 ***	8.34	-3.20
10	L2×T5	-1.71*	-1.33	-1.52**	-2.39*	-2.53**	-2.46***	10.95**	10.56	10.76**
11	L3×T1	0.00	-0.58	-0.29	0.36	-1.24	-0.44	-1.95	4.95	1.50
12	L3×T2	-0.63	-0.73	-0.68	0.06	0.09	0.07	-21.99***	-25.83 ***	-23.91***
13	L3×T3	-0.85	-1.32	-1.09*	-0.83	-1.47	-1.15	15.73***	12.47	14.10***
14	L3×T4	1.26	1.01	1.14*	0.80	1.01	0.91	-1.40	-3.04	-2.22
15	L3×T5	0.22	1.61*	0.91	-0.39	1.61	0.61	9.62**	11.45	10.53**
16	L4×T1	1.00	0.42	0.71	-0.11	-0.71	-0.41	11.34**	-6.61	2.36
17	L4×T2	1.37	0.94	1.16	1.93	1.62	1.77**	15.30***	9.65	12.47**
18	L4×T3	0.15	0.01	0.08	0.37	1.07	0.72	-7.21	2.38	-2.41
19	L4×T4	-2.07*	-0.99	-1.53**	-1.33	-1.45	-1.39*	-11.33**	6.02	-2.65
20	L4×T5	-0.44	-0.39	-0.42	-0.85	-0.53	-0.69	-8.10*	-11.44	-9.77*
21	L5×T1	-0.53	-0.31	-0.42	-1.31	-1.18	-1.24	5.76	2.24	4.00
22	L5×T2	-1.50	-0.46	-0.98	-1.94	-1.18	-1.56	-6.06	-0.14	-3.10
23	L5×T3	1.28	0.28	0.78	0.84	-0.07	0.39	4.77	1.01	2.89
24	L5×T4	0.06	0.95	0.50	0.80	1.41	1.11	6.65	-5.31	0.67
25	L5×T5	0.69	-0.46	0.11	1.61	1.01	1.31	-11.12**	2.20	-4.46

26	L6×T1	0.87	0.89	0.88	1.02	0.16	0.59	3.67	21.85**	12.76**
27	L6×T2	-0.76	-0.59	-0.68	-0.94	0.49	-0.23	-1.36	-3.82	-2.59
28	L6×T3	0.35	0.15	0.25	0.84	0.27	0.55	8.57*	1.07	4.82
29	L6×T4	0.13	0.48	0.30	0.47	0.41	0.44	1.78	-4.34	-1.28
30	L6×T5	-0.58	-0.93	-0.75	-1.39	-1.33	-1.36	-12.66***	-14.77*	-13.71***
31	L7×T1	-1.07	-1.91**	-1.49**	-2.58*	-1.58	-2.08	-5.40	-7.30	-6.35
32	L7×T2	-0.03	0.61	0.29	0.46	0.76	0.61	-8.22*	9.96	0.87
33	L7×T3	-0.59	1.35	0.38	0.24	0.87	0.55	-14.72***	0.99	-6.86
34	L7×T4	1.19	-0.32	0.44	1.20	-0.65	0.27	16.60***	-7.73	4.44
35	L7×T5	0.49	0.27	0.38	0.68	0.61	0.64	11.73**	4.08	7.91*
36	L8×T1	0.53	0.56	0.54	1.22	1.22	1.22	3.47	33.11***	18.29***
37	L8×T2	-0.43	-0.93	-0.68	-0.07	-1.78*	-0.93	-5.35	-8.03	-6.69
38	L8×T3	0.01	-0.19	-0.09	-0.63	-0.33	-0.48	16.93***	-17.90**	-0.48
39	L8×T4	0.79	0.81	0.80	0.33	0.81	0.57	-0.20	-8.91	-4.55
40	L8×T5	-0.91	-0.26	-0.59	-0.85	0.07	-0.39	-14.85***	1.72	-6.56
41	L9×T1		-0.24	-0.12	0.22	0.76	0.49	-8.69*	-14.87*	-11.78**
42	L9×T2	-0.30	0.94	0.32	-0.74	0.76	0.01	6.50	10.02	8.26*
43	L9×T3	-0.85	-0.32	-0.59	-0.63	-0.13	-0.38	-14.34	-4.31	-9.32*
44	L9×T4	0.59	-0.99	-0.20		-1.32	-0.66	2.87	12.69	7.78*
45	L9×T5	0.56	0.61	0.58	1.15	-0.06	0.54	13.66	-3.54	5.06
46	CD 95% SCA	1.63	1.37	0.99	2.04	1.71	1.25	7.06	13.40	7.78
47	Stand. Error	0.8199	0.6870	0.4998	1.0279	0.8629	0.6339	3.5545	6.7423	3.941
48	Sij – Skl	1.1595	0.9716	0.7068	1.4537	1.2203	0.8964	5.0269	9.5350	5.5734



**Table 4 Conti...**

S.No.	Crosses	Number of kernel rows/ ear			Kernels/ Row			Grain Yield (quintal)		
		E1	E2	Pooled	E1	E2	Pooled	E1	E2	Pooled
1	L1×T1	-1.02***	-0.43*	-0.72	-1.02	-2.13*	-1.57*	-10.89**	2.05	-4.42
2	L1×T2	-1.39***	-0.53**	-0.96	1.58	-4.21***	-1.31*	6.25	-3.93*	1.16
3	L1×T3	0.23	-0.07	0.08	-0.72	0.03	-0.34	-3.65	-1.43	-2.54
4	L1×T4	1.75***	0.93***	1.34	1.1	3.27***	2.18***	11.7***	4.58*	8.14
5	L1×T5	0.44	0.09	0.26	-0.94	3.04	1.05	-3.4	-1.27	-2.33
6	L2×T1	-0.53*	0.18	-0.18	-3.29**	-0.72	-2**	-7.85*	-3.87*	-5.86
7	L2×T2	-0.26	0.31	0.03	-0.76	1.15	0.2	-0.83	-5.23**	-3.03
8	L2×T3	-0.48*	-1.15***	-0.81	-3.04**	-4.01***	-3.52***	-0.9	-0.51	-0.7
9	L2×T4	0.08	-0.4*	-0.16	0.38	1.96*	1.17	-1.12	3.15	1.02
10	L2×T5	1.2***	1.06***	1.13	6.7***	1.62	4.16***	10.69**	6.46***	8.58
11	L3×T1	-0.56*	-1.19***	-0.88	-0.39	0.56	0.09	12.13***	-3.68	4.22
12	L3×T2	0.65**	-0.49**	0.08	1.61	1.41	1.51*	-7*	-15.43***	-11.22
13	L3×T3	-0.28	0.9***	0.31	-1.02	1.82*	0.4	-7.71*	10.5***	1.39
14	L3×T4	-0.78**	0.22	-0.28	-1.52	0.5	-0.51	-5.61	-3.81*	-4.71
15	L3×T5	0.97***	0.56**	0.76	1.31	-4.3***	-1.5*	8.2*	12.43***	10.32
16	L4×T1	1.04***	0.37*	0.7	2.02*	-0.05	0.98	-21.09***	-6.17***	-13.63
17	L4×T2	0.18	0.11	0.14	-1.88	-0.65	-1.27	11.19***	10.96***	11.08
18	L4×T3	-0.78**	-0.25	-0.52	-0.38	-0.45	-0.41	1.39	7.85***	4.62
19	L4×T4	0.35	-0.1	0.13	1.97*	1.05	1.51*	-2.76	-9.21***	-5.98
20	L4×T5	-0.79**	-0.12	-0.46	-1.73	0.1	-0.82	11.27***	-3.44	3.91
21	L5×T1	0.61*	-0.37*	0.12	0.89	0.33	0.61	-1.6	-2	-1.8
22	L5×T2	0.4	0.07	0.24	0.88	-1.05	-0.08	-2.29	7.3***	2.5
23	L5×T3	0.11	0.31	0.21	-0.41	0.8	0.19	21.8***	7.06***	14.43
24	L5×T4	-0.23	0.1	-0.06	-0.68	1.03	0.18	-18.96***	-7.39***	-13.18***
25	L5×T5	-0.89***	-0.11	-0.5***	-0.68	-1.12	-0.9	1.05	-4.97**	-1.96
26	L6×T1	1.3***	0.42*	0.86***	-0.51	1.51	0.5	-0.34	10.67***	5.17**
27	L6×T2	-1.03***	0.07	-0.48***	-1.88	-1.78*	-1.83**	-1.59	-1.74	-1.66

28	L6×T3	-0.24	-0.92***	-0.58***	2.38*	-0.21	1.08	-12.77***	-15.75***	-14.26***
29	L6×T4	-0.42	0.19	-0.11	2.76**	0.12	1.44*	11.34****	6.81**	9.07***
30	L6×T5	0.39	0.24	0.32*	-2.74**	0.35	-1.19	3.36	0.01	1.68
31	L7×T1	-0.88***	0.1	-0.39**	-1.59	-1.64	-1.62*	-4.72	-8.12***	-6.42**
32	L7×T2	0.23	0.33	0.28*	1.45	2.03*	1.74**	-11.13***	7.61***	-1.76
33	L7×T3	1.3***	0.33	0.82***	2.25*	3.6***	2.92***	5.28	-12.88***	-3.8
34	L7×T4	0.14	0.2	0.17	-1.72	-2.57**	-2.15**	12.97***	4.47*	8.72***
35	L7×T5	-0.79**	-0.96***	-0.87***	-0.38	-1.42	-0.9	-2.4	8.92***	3.26
36	L8×T1	0.25	0.5**	0.37**	-1.47	-0.2	-0.83	13.93***	16.11***	15.02***
37	L8×T2	-0.1	0	-0.05	1.46	0.91	1.18	5.53	-0.58	2.48
38	L8×T3	-0.04	0.8***	0.38**	2.94**	3.09***	3.01***	1.36	3.37	2.37
39	L8×T4	-0.36	-0.68***	-0.52***	-1.57	-2.33**	-1.95**	-6.61*	-8.59***	-7.6***
40	L8×T5	0.26	-0.62***	-0.18	-1.36	-1.47	-1.41*	-14.21***	-10.31***	-12.26***
41	L9×T1	-0.21	0.43*	0.11	5.36***	2.33**	3.85***	20.43***	-4.99**	7.72***
42	L9×T2	1.32***	0.13	0.73	-2.46*	2.18*	-0.14	-0.12	1.04	0.46
43	L9×T3	0.19	0.04	0.11	-2.01*	-4.67***	-3.34***	-4.8	1.79	-1.51
44	L9×T4	-0.52*	-0.48**	-0.5	-0.72	-3.04***	-1.88**	-0.95	9.99***	4.52*
45	L9×T5	-0.78**	-0.13	-0.45**	-0.18	3.19***	1.51*	-14.55***	-7.83***	-11.19***
46	CD 95% SCA	0.47	0.36	0.27	1.94	1.68	1.27	6.45	3.49	3.82
47	Stand. Error	0.2357	0.1799	0.1374	0.9761	0.8429	0.643	3.2435	1.7567	1.9347
48	Sij – Skl	0.3333	0.2545	0.1943	1.3804	1.192	0.9094	4.587	2.4843	2.7361

A close observation of data on top hybrids showing higher SCA effects for grain yield and other quantitative traits indicated that the cross, L2 × T5 appeared as best Specific combiner for days to 50 per cent tasselling, silking and number of kernel rows/ear, whereas, cross L9 × T1 for number of kernels/row and grain yield in E1, however, in E2, cross having best SCA effect was L2 × T5 for days to 50 per cent tasselling, silking and number of kernel/row whereas, cross, L8 × T1 for grain yield. Results of pooled analysis indicated that cross, L7 × T1 appeared as best Specific combiner for days to 50 per cent tasselling, L2 × T5 for number of kernel rows/ear and number of kernels/row and L8 × T1 for grain yield.

Overall results revealed that different crosses exhibited differential response for SCA effects in different environments for all the quantitative characters studied. This means that there were very little or no reproducibility for SCA effects of the crosses in both the environments. It reflects effect of environment on the performance of the crosses. Similar results were earlier reported by Ramneeket *al.* (2005), Singhalet *al.* (2006), Dar *et al.* (2007), Gurunget *al.* (2009), Choukan (2011), Haddadiet *al.* (2012) and Guerrero *et al.* (2014).

However, best parents and superior hybrids were selected in E<sub>1</sub>, E<sub>2</sub> and pooled environments based on *per se* performance, GCA of parents and SCA of hybrids. Parents selected as good general combiner for yield and other important characters were L1, L9, L8, L4 and L2 in E<sub>1</sub>, while, in E<sub>2</sub>, L1, L2, and L4 and parents L1, L2, L3, L4, L7 and L8 in pooled environment. Cross combinations, L2 × T5 and L9 × T1 in E<sub>1</sub>; L2 × T5 and L8 × T1 in E<sub>2</sub> and L7 × T1, L3 × T5, L2 × T5 and L8 × T1 in pooled environment were selected as superior hybrids

In conclusion, the GCA effects of the parents in the E1 indicated parental lines L1, L4, L8, L9 and testers T2 and T3 to be the best general combiners. In the E2, the significant GCA effects were observed in respect of lines, L1, L2, L4, L8 and L9 and testers T1, T3 and T4 exhibited maximum significant GCA effects. On the basis of pooled analysis, lines L2, L4, L8 and L9 and tester T1 were the best combiners.

Results revealed that hybrids showing higher SCA effects for grain yield and other quantitative traits indicated that the crosses, L2 x T5, L7 x T1, L3 x T5 and L9 x T2 in E1, L2 x T5, L3 x T5 and L8 x T1 in E2 and L2 x T5, L8 x T1 and L6 x T1 in pooled environment appeared as best specific combiners for grain yield and its contributing traits. Different crosses exhibited differential responses for SCA effect in different environments for all the characters studied. This means that there were very little or no reproducibility for SCA effects of the crosses in both the environments. It reflected the effect of environment on the performance of the crosses.

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