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Combining ability for grain yield and yield attributing traits in yellow seeded maize (*Zea mays* L.)

Rakesh Munwal, Amit Dadheech and Narayan Ram Gurjar

Abstract
Thirty six crosses of maize were developed through Line x Tester design using three testers and twelve inbred lines. These 36 crosses along with parents and four standard checks, *viz.*, Vivek Hybrid-43, Pratap Hybrid Maize-3, Pratap Makka-9 and HM-11 were evaluated during *Kharif* 2016. Analysis of variance for means revealed significant differences for majority of the characters studied. The ratio of σ^2_{sca} / σ^2_{gca} was greater than one for all the traits except anthesis silking interval, plant height, grain yield per plant, harvest index, starch content, protein content and oil content. Among female lines EI-2523 was good general combiner for plant height, grain rows per ear, grain yield per plant, ear girth, harvest index, oil content & starch content whereas among males, EI-1118 was found good general combiner for days to 50 per cent silking (-0.80), anthesis silking interval (-0.19), ear length (4.21), grain yield per plant (5.16), harvest index (0.63), oil content (0.14) and starch content (0.36). Hybrid EI-2532 x EI-1118 showed highest positive significant sca effects for grain yield per plant 46.41% followed by EI-2302 x BML-6 (25.94%) and EI-2524x BML-6 (24.11%) showed significant and desirable SCA effect for most of the character studied indicating potential for exploiting hybrid vigour in breeding programme.

Keywords: Combining ability, maize, grain yield, gene action, line x tester

Introduction
Maize (*Zea mays* L.) also called Indian corn or cereal plant of the grass family Poaceae. The domesticated crop is one of the most widely distributed among the world's food crops. Corn is used as livestock feed, as human food, as bio-fuel and as raw material in industry. In the United States, the colourful variegated strains known as Indian corn are traditionally used in autumn harvest decorations. Maize grains contain about 9 per cent protein, 4 per cent oil, 70 per cent starch and 2.7 per cent crude fiber. Maize contains a high percentage of unsaturated fatty acids like oleic acid and linoleic acid and has a very low content of cholesterol. In Rajasthan, area under cultivation during *kharif* is highest among other maize growing states in India. Globally, maize is cultivated in an area of 195.363 mha, with production of 1100.2 million tonnes and a productivity of 5632 kg/ha (Anonymous, 2019) [2]. In India during 2018-19, maize occupied 9.47 mha, area with estimated production of about 28.75 million tonnes and yield of 3032 kg/ha (Anonymous, 2019) [2]. In Rajasthan it occupies 8.7 lakh ha area with an annual production of 16.4 lakh tones and average yield of 1884 kg/ha (Anonymous, 2019) [2]. Combining ability analysis is of special importance in cross-pollinated crops like maize as it helps in identifying potential inbred parents and desirable cross combination that can be used for producing potential hybrids (Vasal 1998). The combining ability provides information about the nature of gene action involved in the inheritance of various traits and hence breeding methodology to be used for their improvement. The nature of gene action would help in predicting the effectiveness of selection in population. A distinct type of gene action, its magnitude and constitution of genetic architecture are of fundamental importance to plant breeder. The present study was, therefore, undertaken with a view to estimate general and specific combining ability variances and effects to identify superior quality protein maize hybrids with good yield potential.

Material and Methods
The present investigation was carried out at the Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *kharif* 2016.To generate experimental material 12 inbred lines were crossed with three testers *viz*; EI-586-2, BML-6 and EI-1118 in the ongoing AICRP Maize Project in line x tester design to develop 36 hybrids. These 36 hybrids along with 15 parents and four checks *viz.*, Vivek Hybrid -43, Pratap Hybrid Maize-3, Pratap Makka-9 and HM-11 were evaluated in a

randomized block design with three replications during *kharif* 2016 (Table 1). The experimental material consisted of a total of 55 entries (36 F_1 hybrids, 15 parents and 4 checks) which were planted in randomized block design with three replications with a single row plot of three meter length, maintaining crop geometry of 60 x 25 cm. Observations for all traits were recorded on five randomly selected competitive plants of each entry in each replication except for days to 50 per cent tasseling, days to 50 per cent silking and days to 75 per cent brown husk where observations were recorded on plot basis. Data recorded were subjected to analysis of variance according to Panse and Sukhatme (1985) [19] to determine significant differences among genotypes. Combining ability analysis for line x tester mating design was performed as per method suggested by Kempthorne (1957) [12]. Estimation of oil content, starch content and protein content were done as per method suggested by Soxhlet's Ether Extraction method developed by A.O.A.C. (1965) [1], Anthrone Reagent method and Micro kjeldahl's method given by Lindner (1944), respectively.

Table 1: Details of the Inbred lines used as Parents, testers and checks

S. No.	Inbred line (Symbol/Code)	Source
1.	L1 (EI-2302)	AICRP on Maize, Udaipur
2.	L2 (EI-2309)	AICRP on Maize, Udaipur
3.	L3 (EI-2620)	AICRP on Maize, Udaipur
4.	L4 (EI-2630)	AICRP on Maize, Udaipur
5.	L5 (EI-2641)	AICRP on Maize, Udaipur
6.	L6 (EI-2649)	AICRP on Maize, Udaipur
7.	L7 (EI-2650)	AICRP on Maize, Udaipur
8.	L8 (EI-2502)	AICRP on Maize, Udaipur
9.	L9 (EI-2512)	AICRP on Maize, Udaipur
10.	L10 (EI-2523)	AICRP on Maize, Udaipur
11.	L11 (EI-2524)	AICRP on Maize, Udaipur
12.	L12 (EI-2532)	AICRP on Maize, Udaipur
13.	T_1 (EI-586-2)	AICRP on Maize, Udaipur
14.	T_2 (BML-6)	ANGRAU, Hyderabad
15.	T_3 (EI-1118) Details of checks	AICRP on Maize, Udaipur
1.	C1 Vivek Hybrid-43	VPKAS, Almora
2.	C2 Pratap Hybrid Maize-3	AICRP on Maize, Udaipur
3.	C3 Pratap Makka-9	AICRP on Maize, Udaipur
4.	C4 HM-11	CCSHAU, Haryana

Where,
AICRP- All India Coordinated Research Project
VPKAS- Vivekanand Parvatiya krishi Anusandhan Shala
CCSHAU- Choudhary Charan Singh Haryana Agricultural University
ANGRAU- Acharya N. G.Ranga Agricultural University

Result and Discussion

The analysis of variance for combining ability using Line x Tester design in respect of 36 crosses for all 15 traits are presented in Table 2. The analysis of variance for combining ability (Table 3, 4, 5) indicated that the mean sum of squares due to lines and testers were significant for all the traits except for days to 75 per cent brown husk due to lines and for days to 75 per cent brown husk, plant height, ear girth, number of grain rows per ear due to testers. This indicate significant contribution of lines and testers towards GCA variance. The mean squares due to line x tester interaction were significant for all the traits except days to 75 per cent brown husk thereby indicating significant contribution of line x tester towards SCA variance.

Estimation of General Combining Ability and Specific Combining Ability variance: Combining ability variance for grain yield and yield attributing traits of maize are presented in Table 3. The analysis of variance for combining ability indicated that the mean sum of squares due to lines and testers were significant for all the traits except for days to 75 per cent brown husk due to lines and for days to 75 per cent brown husk, plant height, ear girth, number of grain rows per ear due to testers. There by indicating significant contribution of lines and testers towards gca variance. The mean squares due to line x tester interaction were significant for all the traits except days to 75 per cent brown husk thereby indicating significant contribution of line x tester towards sca Variance due to lines was of higher magnitude than that of testers for days to 50 per cent tasseling, days to 75 per cent brown husk, plant height, ear girth, grain rows per ear, harvest index, oil content, starch content and protein content. This indicated that the contribution of lines for these traits was greater towards σ^2_{gca}. Variance due to testers was of higher magnitude than that of lines for days to 50 per cent silking, anthesis silking interval ear height, ear length, 100-grain weight and grain yield per plant. This indicated that the contribution of testers for these traits was greater toward σ^2_{sca}.

The ratio of $\sigma^2_{sca}/\sigma^2_{gca}$ was greater than one for all the traits except anthesis silking interval, plant height, grain yield per plant, harvest index, starch content, oil content and protein content. This indicated the preponderance of additive gene effects in the expression of these traits while preponderance of non-additive gene effects for rest of the characters. These results are in accordance with the findings of Dar *et al.* (2007) [8], Lata *et al.* (2008) [14], Arbha *et al.* (2013), Panwar *et al.* (2013) [18], Hemalatha *et al.* (2014) [10], Verma *et al.* (2014) [21] and Anupam *et al.* (2016) [3].

Table 2: Analysis of variance for fifteen traits in maize

Source of variation	df	Mean squares														
		Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	A.S.I	Plant height	Ear height	Ear length	Grain rows per ear	Ear girth	100-grain weight	Grain yield/ plant	Harvest index	Starch content	Oil content	Protein content
Replication	2	18.12**	14.89*	8.95	0.13	5117.16**	26.89	5.51*	11.52**	11.12**	4.95	32.68	0.68	0.09	0.01*	0.16*
Genotype	54	19.44	21.74	12.03	1.25*	995.34	339.08**	4.98	3.22	3.58	8.39*	1261.80**	27.98**	14.60**	0.95**	1.75**
Parent	14	20.47**	22.99**	14.61	1.34**	597.63*	122.04**	6.30**	4.65**	7.83**	7.80**	1058.44**	19.12**	13.56**	0.09	1.88**
Crosses	35	10.60**	14.74**	11.47	1.25**	240.82	141.53**	4.51**	2.60*	2.07*	9.22**	1149.30**	28.97**	15.82**	1.03**	1.72**
Parent v/s Crosses	1	363.21**	308.18**	16.06	3.19**	34926.45**	9688.45**	6.92*	0.41	0.07	3.45	11947.21**	180.43**	22.18**	0.29**	1.87**
Error	108	3.44	3.87	19.29	0.15	278.73	27.41	1.18	1.51	1.28	1.66	26.43	1.60	0.49	0.01	0.05

*,** Significant at 5 per cent and 1 per cent level of significance, respectively.

Table 3: Analysis of variance for combining ability for fifteen traits in maize

Source of variation	Days to 50 per cent tasseling	Days to 50 per cent silking	Days to 75 per cent brown husk	A.S.I.	Plant height	Ear height	Ear length	Grain rows per Ear	Ear girth	100-grain weight	Grain yield per plant		Harvest index	Starch content	Oil content	Protein content
$\sum^2_L$	1.39	1.78	-0.92	-0.02	55.63	15.56	0.35	0.22	0.10	0.37		-94.35	-1.96	-0.73	-0.04	0.02
$\sum^2_t$	0.26	0.69	-0.35	0.04	-0.71	11.69	0.40	-0.04	-0.02	0.45		-14.99	-0.63	-0.32	-0.01	-0.04
$\sum^2_{GCA}$	0.28	0.41	-0.21	-0.01	9.82	4.29	0.11	0.03	0.02	0.13		-18.75	-0.43	-0.17	-0.01	-0.01
$\sum^2_{SCA}$	0.89	1.47	-1.50	0.36	-64.60	15.35	0.51	0.18	0.18	1.86		473.53	11.40	6.02	0.39	0.57
$\sum^2_{SCA/GCA}$	3.17	3.58	7.14	-36	-6.57	3.57	4.63	6	9	14.3		-25.25	-26.51	-35.41	-39	-57

*, ** Significant at 5 per cent and 1 per cent level of significance, respectively.

Table 4: GCA and SCA effects for days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, days to 75 per cent brown husk, plant height, ear height, ear length and ear girth

S.N	Genotype	Days to 50 per cent tasseling	Days to 50 per cent silking	Anthesis silking interval	Days to 75 per cent brown husk	Plant height	Ear height	Ear length	Ear girth
1	T1	-0.05	-0.27	-0.11	0.03	-0.55	-2.79**	-0.79**	0.09
2	T2	0.68	1.06**	0.31**	-0.25	-0.91	-1.42	0.31	-0.19
3	T3	-0.63	-0.80*	-0.19**	0.22	1.47	4.21**	0.48*	0.10
4	L1	0.31	-0.02	-0.36**	-0.56	-5.47	-5.59**	-0.24	-0.19
5	L2	0.87	1.20	0.08	1.33	14.75*	4.48*	1.13**	-0.13
6	L3	-0.13	0.31	0.42**	0.89	-5.29	-4.26*	-1.11**	-0.35
7	L4	-1.13	-1.57*	-0.36**	0.22	-6.40	-3.43	-0.96*	-0.26
8	L5	-0.91	-1.13	-0.14	-1.00	0.55	-2.28	0.00	-0.57
9	L6	-1.57*	-1.46*	0.08	-1.11	-9.14	-6.41**	-1.18**	-0.33
10	L7	-2.02**	-2.57**	-0.58**	1.00	1.75	4.68*	-0.09	-0.10
11	L8	-0.57	-0.35	0.19	-0.33	8.86	-1.97	1.18**	-0.65
12	L9	2.54**	2.76**	0.19	0.22	6.29	3.70*	0.58	0.49
13	L10	2.20**	2.09**	0.19	0.78	-11.54*	-0.17	0.24	1.30**
14	L11	1.09	1.65*	0.53**	-0.78	-1.94	1.70	0.64	0.52
15	L12	-0.69	-0.91	-0.25	-0.67	7.57	9.55**	-0.20	0.27
16	L1 x T1	-2.40	-1.73	0.56*	-0.69	1.78	-0.08	-1.32	-1.18
17	L2 x T1	-0.29	-1.29	-0.89**	-0.25	-2.18	0.59	0.17	0.62
18	L3 x T1	1.71	0.94	-0.89**	0.19	6.80	9.59**	-0.12	-0.16
19	L4 x T1	1.05	1.49	0.56*	2.19	2.98	1.30	-1.28	-0.78
20	L5 x T1	-0.84	-1.29	-0.33	1.75	-6.71	-7.25*	0.77	-0.74
21	L6 x T1	0.49	1.05	0.44	1.19	0.24	1.21	-1.19	0.59
22	L7 x T1	0.60	0.82	0.11	-0.25	-1.31	1.99	0.59	0.30
23	L8 x T1	-0.51	-0.73	-0.33	-0.25	2.44	0.16	0.19	0.91
24	L9 x T1	-1.29	-0.51	0.67*	-3.47	5.22	-0.43	0.19	0.88
25	L10 x T1	1.71	1.49	0.33	-1.36	-5.09	-0.70	0.72	-0.00
26	L11 x T1	-0.51	-0.40	0.00	1.19	-2.36	-3.90	0.06	-0.22
27	L12 x T1	0.27	0.16	-0.22	-0.25	-1.80	-2.48	1.23	-0.21
28	L1 x T2	2.21	2.27	0.14	2.58	-1.40	-1.58	1.24	-0.40
29	L2 x T2	-0.01	1.38	1.03**	0.69	0.05	2.68	-0.47	-0.30
30	L3 x T2	-2.01	-2.40	-0.31	-1.19	-4.51	0.62	-0.22	-0.04
31	L4 x T2	-1.34	-1.84	-0.53*	-1.19	-0.86	-0.34	1.22	0.64
32	L5 x T2	0.44	0.71	0.25	1.03	9.31	7.04	0.33	0.08
33	L6 x T2	-0.56	-0.95	-0.31	0.47	-8.86	-7.89*	0.64	-0.10
34	L7 x T2	-0.45	-0.84	-0.31	1.36	-2.09	-4.52	-1.11	-0.52
35	L8 x T2	-0.23	-0.40	-0.08	-2.64	-0.20	3.06	0.16	0.23
36	L9 x T2	2.66*	2.49	-0.08	1.47	-6.35	0.79	-1.24	-0.91
37	L10 x T2	-2.01	-2.51	-0.75**	2.58	7.54	-0.01	-0.78	-0.19
38	L11 x T2	1.44	1.94	0.58*	-2.86	2.87	-1.27	0.42	0.59
39	L12 x T2	-0.12	0.16	0.36	-2.31	4.49	1.42	-0.20	0.90
40	L1 x T3	0.19	-0.54	-0.69*	-1.89	-0.38	1.66	0.08	1.58*
41	L2 x T3	0.30	-0.09	-0.14	-0.44	2.13	-3.27	0.30	-0.32
42	L3 x T3	0.30	1.46	1.19**	1.00	-2.29	-10.21**	0.34	0.20
43	L4 x T3	0.30	0.35	-0.03	-1.00	-2.11	-0.96	0.06	0.14
44	L5 x T3	0.41	0.57	0.08	-2.78	-2.60	0.22	-1.10	0.65
45	L6 x T3	0.07	-0.09	-0.14	-1.67	8.62	6.68	0.54	-0.49
46	L7 x T3	-0.15	0.02	0.19	-1.11	3.40	2.53	0.52	0.22
47	L8 x T3	0.74	1.13	0.42	2.89	-2.25	-3.23	-0.34	-1.14
48	L9 x T3	-1.37	-1.98	-0.58*	2.00	1.13	-0.36	1.06	0.03
49	L10 x T3	0.30	1.02	0.42	-1.22	-2.45	0.70	0.06	0.19
50	L11 x T3	-0.93	-1.54	-0.58*	1.67	-0.51	5.17	-0.48	-0.37
51	L12 x T3	-0.15	-0.31	-0.14	2.56	-2.69	1.06	-1.03	-0.69
	Standard error								
	Ti	0.36	0.38	0.07	0.85	3.21	1.01	0.21	0.22
	Lj	0.64	0.68	0.13	1.52	5.79	1.82	0.38	0.39
	Sij	1.29	1.36	0.26	3.05	11.58	3.63	0.75	0.79
	Ti-j	0.44	0.46	0.09	1.04	3.94	1.23	0.26	0.27

	Li-j	0.87	0.93	0.18	2.07	7.87	2.47	0.51	0.53
	Ti-Lj	0.69	0.73	0.14	1.64	6.22	1.95	0.40	0.42
	STi-Tj	1.58	1.67	0.32	3.73	14.19	4.45	0.92	0.96
	SiL-jL	1.75	1.85	0.36	4.14	15.74	4.94	1.02	1.07
	Sij-kl	1.80	1.91	0.37	4.27	16.22	5.09	1.05	1.10

Table 5: GCA and SCA effects for number of grain rows per ear, 100-grain weight, grain yield per plant, harvest index, oil content, protein content and starch content

SN	Genotype	Number of grain rows per ear	100-Grain weight	Grain yield per plant	Harvest index	Oil content	Protein content	Starch content
1	T1	0.05	-0.76**	-4.86**	-0.58*	-0.01	-0.05	-0.49**
2	T2	-0.13	0.85**	-0.30	-0.06	-0.13**	0.09*	0.13
3	T3	0.08	-0.09	5.16**	0.63*	0.14**	-0.04	0.36**
4	L1	-0.31	-0.87	-4.95**	-0.45	0.08**	-0.26**	-0.95**
5	L2	-0.26	1.13*	8.40**	2.11**	-0.62**	0.57**	2.50**
6	L3	-0.40	-0.43	-9.40**	-1.52**	0.24**	-0.30**	-0.63*
7	L4	-0.31	-0.54	-3.64*	-0.29	0.05*	-0.31**	0.22
8	L5	-0.64	0.91*	-5.22**	-0.89*	0.28**	-0.06	-0.29
9	L6	-0.31	-2.54**	-8.44**	-1.72**	0.07**	-0.60**	-0.34
10	L7	-0.31	-0.54	-11.04**	-1.72**	0.30**	0.49**	-0.86**
11	L8	-0.73	1.35**	6.49**	0.86	-0.20**	-0.04	1.45**
12	L9	1.00*	-0.20	10.49**	1.79**	0.16**	-0.54**	0.45
13	L10	1.20**	0.69	5.14**	1.15*	0.24**	-0.20**	0.70**
14	L11	0.98*	0.57	11.60**	1.55**	-0.12**	0.79**	-1.75**
15	L12	0.09	0.46	0.58	-0.87*	-0.47**	0.47**	-0.51*
16	L1 x T1	-0.94	-0.91	-22.29**	-2.82**	0.29**	0.05	-1.98**
17	L2 x T1	0.55	-0.91	13.69**	1.76*	0.06	-1.03**	-2.97**
18	L3 x T1	-0.12	0.98	15.09**	2.31**	-0.68**	-0.86**	0.28
19	L4 x T1	-0.74	-1.57	-16.34**	-3.04**	-0.63**	-0.55**	0.56
20	L5 x T1	-0.61	2.98**	16.04**	2.69**	0.61**	-0.08	-0.27
21	L6 x T1	0.53	-1.57	15.06**	2.38**	0.49**	0.30*	1.54**
22	L7 x T1	0.59	-0.57	24.60**	4.24**	0.23**	0.29	0.02
23	L8 x T1	1.08	0.54	2.86	0.67	-0.46**	0.81**	1.12*
24	L9 x T1	0.41	0.43	1.66	0.60	0.56**	0.38*	3.23**
25	L10 x T1	0.01	0.54	-15.38**	-2.96**	-0.06	-0.05	-0.81
26	L11 x T1	-0.63	0.31	-12.45**	-2.56**	-0.38**	-0.08	1.27*
27	L12 x T1	-0.14	-0.24	-22.56**	-3.27**	-0.03	0.81**	-1.99**
28	L1 x T2	-0.49	-0.52	25.94**	4.46**	-0.61**	-0.95**	-0.11
29	L2 x T2	-0.20	-0.52	-8.28*	-1.70	-0.09*	0.29	1.59**
30	L3 x T2	-0.00	-1.63	-18.21**	-2.68**	0.32**	0.66**	2.74**
31	L4 x T2	0.64	1.48	21.50**	3.90**	0.73**	0.36*	-1.03*
32	L5 x T2	0.04	-2.30*	-1.99	-0.37	0.40**	-0.10	-2.99**
33	L6 x T2	-0.09	0.15	-3.70	-0.94	0.34**	-0.76**	0.55
34	L7 x T2	-0.36	1.48	-11.90**	-2.21*	0.54**	0.42**	1.97**
35	L8 x T2	0.33	0.26	16.76**	2.81**	-0.19**	0.59**	2.45**
36	L9 x T2	-1.40	1.48	-20.64**	-3.92**	-0.74**	0.14	-1.69**
37	L10 x T2	-0.00	-1.74	-0.21	0.19	-0.33**	-0.76**	-2.16**
38	L11 x T2	0.55	0.70	24.59**	3.39**	-0.44**	0.05	-1.08*
39	L12 x T2	0.98	1.15	-23.86**	-2.92**	0.08*	0.07	-0.23
40	L1 x T3	1.43	1.43	-3.65	-1.63	0.32**	0.90**	2.09**
41	L2 x T3	-0.35	1.43	-5.41	-0.06	0.04	0.74**	1.39**
42	L3 x T3	0.12	0.65	3.13	0.37	0.37**	0.21	-3.02**
43	L4 x T3	0.10	0.09	-5.16	-0.86	-0.10*	0.19	0.47
44	L5 x T3	0.56	-0.69	-14.05**	-2.32**	-1.01**	0.18	3.26**
45	L6 x T3	-0.44	1.43	-11.36**	-1.43	-0.83**	0.46**	-2.09**
46	L7 x T3	-0.24	-0.91	-12.70**	-2.03*	-0.77**	-0.71**	-1.99**
47	L8 x T3	-1.41	-0.80	-19.63**	-3.48**	0.65**	-1.40**	-3.57**
48	L9 x T3	0.99	-1.91*	18.97**	3.32**	0.17**	-0.52**	-1.54**
49	L10 x T3	-0.01	1.20	15.59**	2.77**	0.40**	0.81**	2.97**
50	L11 x T3	0.08	-1.02	-12.14**	-0.83	0.82**	0.03	-0.19
51	L12 x T3	-0.84	-0.91	46.41**	6.19**	-0.05	-0.88**	2.22**
				Standard error				
	Ti	0.24	0.25	0.99	0.24	0.01	0.04	0.13
	Lj	0.43	0.45	1.78	0.44	0.02	0.08	0.24
	Sij	0.85	0.89	3.57	0.88	0.04	0.15	0.48
	Ti-j	0.29	0.30	1.21	0.30	0.01	0.05	0.16
	Li-j	0.58	0.61	2.42	0.60	0.03	0.10	0.33
	Ti-Lj	0.46	0.48	1.92	0.47	0.02	0.08	0.26
	STi-Tj	1.05	1.09	4.37	1.08	0.05	0.18	0.59
	SiL-jL	1.16	1.21	4.85	1.19	0.05	0.20	0.66
	Sij-kl	1.20	1.25	5.00	1.23	0.06	0.21	0.68

Estimation of General Combining Ability and Specific Combining Ability effects

The combining ability analysis was carried out for found information on selection of better inbred lines and their crosses for further use in breeding programme. The estimates of GCA effect of the parents and SCA effect of crosses for different character presented in Table 4 and 5, respectively. The estimates of gca effects revealed that good general combiner inbred lines for grain yield per plant were L_2, L_8, L_9, L_{10}, and L_{11}. These lines were also good general combiners for majority of the yield and yield contributing traits *viz*., ear length, grain rows per ear, ear girth, 100-grain weight and harvest index. With respect to quality traits, inbred lines L_3, L_4, L_5, L_6, L_7, L_9 and L_{10} were found good general combiners for oil content, while inbred lines L_2, L_8 and L_{10} were good general combiners for starch content. Inbred lines $L_{2,}$ L_6, $L_{7,}$ L_{11} and L_{12} were good general combiners for protein content.

In case of plant type traits, inbred line L_{10} was good general combiner for plant height, grain rows per ear, grain yield per plant, ear girth and harvest index, oil content & starch content. whereas, inbred lines L_1, L_3, and L_6 were good general combiner for ear height. Inbred line L_7 has been found good general combiner for majority of traits *viz*., days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, oil content and protein content followed by inbred line L_6 for traits *viz.*, days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, ear height, oil content and protein content.

Among the testers, the tester T_1 was found good general combiner for ear height and T_2 was found good general combiner for 100 grain weight and protein content. The tester T_3 was found good general combiner for days to 50 per cent silking, anthesis silking interval, ear length, grain yield per plant, harvest index, oil content and starch content. High general combining ability effects (gca) observed were due to additive and additive x additive gene effects (Griffing, 1956 and Sprague, 1942) [9].

A perusal of sca effects revealed that positive significant sca effects for grain yield per plant were recorded in twelve hybrids (s) (Table 5.2). out of them, hybrid L_{12} x T_3 showed highest positive significant sca effects (46.41%) along with good *per se* performance (148.93 g/plant) and positive significant economic heterosis (27.58%) for grain yield per plant. This hybrid also exhibited positive significant sca effects for harvest index and starch content. Another hybrid L_{11} x T_2 showed good sca effects along with high economic heterosis (13.65%) and *per se* performance (132.67 g/ plant) for grain yield per plant (Table 5.1 and 5.4). Similar finding for identification of superior inbred lines and hybrids based on gca and sca effects for grain yield and its components in maize were also reported by Dar *et al.* (2007) [8], Lata *et al.* (2008) [14], Amiruzzaman *et al.*(2010) [6], Kanagarasu *et al*. (2010) [11], Reddy *et al*. (2011) [20], Mural and Chikkalingaiah (2012) [17], Panwar *et al*. (2013) [18], Hemalatha *et al*. (2014) [10], Motamedi *et al*. (2014) [16], Lahane *et al*.(2015) [13] and Chandana and Deshpande (2016) [7].

Out of the 36 hybrids, five best hybrids which exhibited higher significant positive sca effects for grain yield per plant were L_7 x T_1, L_1 x T_2, L_4 x T_2, L_{11} x T_2 and L_{12} x T_3. The hybrid L_{12} x T_3 also exhibited maximum positive significant sca effects for harvest index. Similarly hybrid L_5 x T_1 also exhibited highest positive significant sca effects for 100-grain weight.

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