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COMBINING ABILITY ANALYSIS FOR YIELD AND QUALITY TRAITS IN MAIZE (*Zea mays* L.) HYBRIDS

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ABSTRACT

Thirty-nine hybrids of maize were developed by crossing 13 lines with 3 testers. These hybrids along with parents and 3 standard checks were evaluated during kharif-2017 for 14 characters. The mean sum of squares of hybrids, lines and testers, were significant for majority of traits. Among inbred lines, EI-2840 had significant GCA effects for grain yield per plant (27.19) and yield component traits like number of grain rows per ear (1.92), harvest index (2.63), maturity traits like, days to 50 per cent tasseling (1.39), days to 50 per cent silking (1.19) and quality traits like oil content (0.34), protein content (0.87) and starch content (2.97), indicated that best general combiner for these traits, while in male parent, EI-1110-2 was the best general combiner for yield contributing traits viz., grain yield per plant (4.76), harvest index (1.11), number of grain rows per ear (0.81), and quality traits viz., oil content (0.08), protein content (0.21). Hybrid EI-3823 x EI-1110-2 (37.21) followed by hybrid EI-2817 x EI-1175-2 (34.26), EI-2543x EI-1175-2 (33.76) expressed positive significant SCA effects for yield and contributing traits. Hence these hybrids embark to be high promising combination for virtual exploitation.

INTRODUCTION

Maize is amazing crop which is C4 plant and it is an important cereal crop belonging to the grass family, Poaceae and is a native to South America. It is the third most important cereal crop in India after Wheat and Rice also known as "Queen of cereals". It has highest genetic yield potential among the cereal crops and accounts for 9 percent of total food grain in country. Karnataka, Rajasthan, Andhra Pradesh, Maharashtra, and Uttar Pradesh, are the major maize producing states. Maharashtra, and Uttar Pradesh together contribute 60 per cent of area and 70 per cent of maize production in India. In Rajasthan area under cultivation during Kharif is highest among other maize growing states. Globally, maize is cultivated in an area of 195.363mha, with production of 1100.2 million tonnes and a productivity of 5632 kg/ha (Anonymous, 2019). 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). In Rajasthan it occupies 8.7 lakh ha area with an annual production of 16.4 lakh tones with average yield of 1884 kg/ha (Anonymous, 2019).

Heterosis and combining ability is prerequisite for developing good economically viable hybrids of maize. Information on the heterotic patterns and combining ability among maize germplasm is essential in maximizing the effectiveness of hybrid development. In successful hybridization programme, the ability of a parent to combine well and produce segregations in succeeding generations is an important criterion in selecting parents. The combining ability analysis is a powerful tool to determine good as well as poor combiners for selecting appropriate parents to formulate an efficient breeding programme. It also elucidates the nature of gene action involved in the inheritance of various traits. General combining ability is attributed to additive and additive x additive interaction and is fixable in nature, while specific combining ability is attributed to non-additive (*i.e.* dominance, dominance x dominance and additive x dominance interactions) gene action and is non-fixable in nature Comstock *et al.* (1949) The present study therefore, undertaken with a view to estimate general and specific combining ability variances and effects to identify superior maize hybrids for good yield potential and quality traits.

MATERIALS AND METHODS

The present investigation was carried out at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, India during Kharif, 2017. The experimental material consisting of 13 female parents (Lines) and 3 male parents (Tester) presented in Table 1. 13 inbred lines were crossed with three testers viz., EI-1104-1, EI-1175-3 and EI-1110-2 during Rabi 2016-17 to develop a total of 39 hybrids. These 39 F1 hybrids along with 13 parents and 3 checks viz., Pratap Hybrid Maize-3(PHM-3), PMH-3and PM-9 were evaluated in randomized block design (Fisher 1918) with three replications with a single row plot of four 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 50per cent silking and days to 75 per cent brown husk where observations were recorded on plot basis. During Data recorded were subjected to analysis of variance according to Panse and Sukhatme (1985) to determine significant differences among genotypes. Combining ability analysis for line x tester mating design was performed as per method suggested by Kempthorne (1957).]. Estimation of oil content, starch content and protein content were done as per method suggested by Soxhlet's Ether Extraction method (A.O.A.C. 1965), Anthrone Reagent method (Morris D.L. 1948) and Microkjeldahl's method (Lindner 1944), respectively.

RESULTS AND DISCUSSION

The mean sum of square values for fourteen traits are presented in Table 2. The mean sum of squares of hybrids, lines and testers, were significant for all the traits except days to 75 per cent brown husk of lines, days to 50 per cent tasseling, days to 50 per cent silking, days to 75 per cent brown husk, ear length and ear girth of testers. The significant mean squares for lines x testers for all the characters except days to 50 per cent tasseling, days to 50 per cent silking. This revealed presence of appreciable amount of genetic variability in the experimental material of the present investigation.

Table 1: List of Inbred lines, tester and checks used in in present study

S.No.	Inbred Lines (Symbol/Code)	Stage of level of inbred line	Origin
Details of Parents			
1	L1 (EI-2817)	S5	MPUAT , Udaipur
2	L2 (EI-2823)	S5	MPUAT , Udaipur
3	L3 (EI-2826)	S5	MPUAT , Udaipur
4	L4 (EI-2835)	S5	MPUAT , Udaipur
5	L5 (EI-2838)	S5	MPUAT , Udaipur
6	L6 (EI-2840)	S5	MPUAT , Udaipur
7	L7 (EI-2843)	S5	MPUAT , Udaipur
8	L8 (EI-2845)	S5	MPUAT , Udaipur
9	L9 (EI-2851)	S5	MPUAT , Udaipur
10	L10 (EI-2857)	S5	MPUAT , Udaipur
11	L11 (EI-2858)	S5	MPUAT , Udaipur
12	L12 (EI-2862)	S5	MPUAT , Udaipur
13	L13 (EI-2865)	S5	MPUAT , Udaipur
14	T1 (EI-1104-1)	S6	MPUAT , Udaipur
15	T2 (EI-1175-3)	S6	MPUAT , Udaipur
16	T3 (EI-1110-2)	S6	MPUAT , Udaipur
Details of Checks			
1	C1	Pratap Hybrid Maize-3(PHM-3)	MPUAT , Udaipur
2	C2	PMH-3	PAU, Ludhiana
3	C3	PM-9	MPUAT , Udaipur

Where,
PAU- Punjab Agricultural University,MPUAT-Maharana Pratap University of Agriculture and Technology

Combining ability variance of grain yield and its component of maize are presented in Table 3. The analysis of variance for combining ability revealed that variance due to lines was of higher magnitude than that of testers for days to 50 per cent tasseling, days to 50 per cent silking, days to 75per cent brown husk, 100- grain weight, grain yield per plant, oil content, protein content and starch content. This indicated that the contribution of lines for these traits, was greater towards σ^2gca. Variance due to testers was of higher magnitude than that of lines for plant height, ear height, ear girth, number of grain rows per ear and harvest index. This indicated that the contribution of testers for these traits, was greater towards σ^2sca. The estimates of sca variance were of higher magnitude than gca variance for all the traits except days to 75 per cent brown husk and starch content. Besides this the ratio of σ^2sca /σ^2gca was greater than one for all the traits except days to 75 % brown husk, ear girth, 100-grain weight and oil content. This indicated that the preponderance of non-additive gene effects in the expression of these traits. These results are in accordance with the findings of Izhar and Chakraborty (2013), Karupakar *et al*.(2013) Panwar *et al*. (2013), Kambe *et al*. (2013), Tamirat *et al*. (2014), Hayder and Paul (2014), Rastgari *et al*. (2014), Kumar *et al*. (2015), Khan and Dubey (2015), Murtadha *et al*. (2016), and Karim *et al*. (2018)

The combining ability analysis gives information on selection of better parents and crosses for their further use in breeding programme. The estimates of gca effects of the parents and sca effects of the hybrids for different traits are presented in Table 4 and Table 5, respectively.The estimates of gca effects among the lines revealed that inbred lines viz., EI-2826, EI-2438, EI-2838 EI-2840,EI-2858 and EI-2862 are found good general combiner for grain yield per plant. Inbreed line EI-2840 and EI-2862 was found good general combiner for grain yield per plant and yield component traits like number of grain rows per ear, 100-grain weight and harvest index. As

Table 2: Analysis of variance for combining ability for different characters in maize

S.No.	Mean sum of Square Characters source d.f.	Replication 257	Genotype 15	Parents 1	P Vs C 38	Crosses 114	Error
1	Days to 50% Tasseling	0.36	3.87	5.64**	0.01	3.31*	2.15
2	Days to 50%silking	0.74	3.56	4.97**	0.15	3.20*	2.07
3	Days to 75% Brown Husk	2.22	10.82	8.22	16.57	11.61**	6.35
4	Plant Height (cm)	164.86	2275.39	1258.15**	90574.71**	417.61**	58.22
5	Ear Height (cm)	27.31	470.71	355.64**	17951.92**	86.48**	15.02
6	Ear Length (cm)	1.53	4.15	3.33**	6.49**	4.68**	0.79
7	Ear Girth (cm)	0.01	3.09	2.68**	56.85**	2.01**	0.52
8	No of Grain Rows per Ear	0.28	8.28*	5.11**	86.11**	7.70**	0.61
9	100- Grains weight (g)	2.9	88.65**	63.93**	1355.83**	71.27**	2.3
10	Grain Yield per Plant (g)	122.38	2386.08	263.14*	54347.79**	1916.14**	131.88
11	Harvesting Index (%)	10.01	34.55	22.96**	393.69**	31.89**	4.43
12	Oil Content (%)	0.04	1.52	1.31**	0.35**	1.69**	0.01
13	Starch Content (%)	5.45	10.46	7.12*	0.02	12.68**	3.51
14	Protein Content (%)	0.05	1.57**	1.36**	0.85**	1.71**	0.06

*, ** Significant at 5 % and 1 % level of significance, respectively

Table 3: Analysis of variance for fourteen traits in maize

Source of variation	Days to 50 % tasseling	Days to 50 % silking	Days to 75 % brown husk	Plant height	Ear height	Ear length	Ear girth	Grain rows	100- grain per ear	Grain yield/ weight	Harvest index plant	Oil content	Starch content	Protein content
σ^2L	0.31	0.18	-0.09	8.65	1	0.32	-0.08	0.26	0.43	108.7	0.75	0.01	0.27	0.17
σ^2t	-0.06	-0.07	-0.23	18.35	11.61	-0.09	-0.05	0.43	-0.62	-22.23	1.9	-0.02	0.27	0
σ^2GCA	0.04	0.02	-0.04	3.63	1.56	0.04	-0.02	0.1	0	15.37	0.35	0	0.08	0.03
σ^2SCA	0.14	0.26	1.99	99.04	14.93	1.06	0.65	1.82	23.01	506.99	7.15	0.56	2.61	0.38
σ^2SCA/GCA	3.5	13	-49.75	27.28	9.57	26.5	-30.5	18	-"	32.98	20.42	-"	32.62	12.66

σ^2sca, σ^2gca Significant at 5 % and 1 % level of significance, respectively

Table 4: GCA and SCA effects for Days to 50 % tasseling, Days to 50%, silking, Days to 75 % brown husk, Plant height(cm), Ear height(cm), Ear length (cm) and Ear girth

S.N.	Genotype	Days to 50% tasseling	Days to 50 % silking	Days to 75 % brown husk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth
1	EI-1104-1	0.03	0.05	-0.12	-1.54	-1.68*	0.05	-0.05
2	EI-1175-3	-0.02	-0.05	-0.22	-4.30**	-2.49**	0.08	-0.04
3	EI-1110-2	-0.02	0	0.34	5.84**	4.16**	-0.12	0.09
4	EI-2817	0.62	0.53	0.91	-0.51	0.22	-0.81*	0.27
5	EI-2823	0.62	0.64	1.35	-4.75	-0.87	-0.15	0.34
6	EI-2826	-1.27*	-1.14*	0.02	-0.53	-3.25*	-0.24	0.19
7	EI-2835	-0.16	-0.25	-0.54	11.61**	-0.27	-0.31	-0.2
8	EI-2838	-0.61	-0.36	0.13	4.87	-0.43	0.3	-0.47
9	EI-2840	1.39**	1.09*	-0.65	-4.05	-3.83**	2.12**	0.68**
10	EI-2843	0.62	0.53	-1.76*	6.12*	2.86*	0.43	0.19
11	EI-2845	-0.5	-0.58	-0.43	-1.54	-0.76	-0.19	0.01
12	EI-2851	0.5	0.53	-1.98*	-3.42	-4.49**	-1.19**	-0.06
13	EI-2857	0.62	0.75	1.02	3.03	3.15*	-0.46	-0.57*
14	EI-2858	-0.83	-0.69	0.24	1.07	3.44*	1.25**	0.41
15	EI-2862	-0.61	-0.69	-0.21	5.17	3.82**	-0.39	0
16	EI-2865	-0.38	-0.36	1.91*	-17.06**	0.4	-0.37	- 0.80**
17	EI-2817× EI-1104-1	-0.92	-1.27	0.79	-5.26	-0.48	-1.1	-0.15
18	EI-2823×EI-1104-1	0.74	0.95	-1.99	6.85	-4.26	-1.06	0.38
19	EI-2826×EI-1104-1	0.3	0.06	1.68	0.43	-4.35	-2.14**	-0.04
20	EI-2835×EI-1104-1	0.19	0.17	-1.44	8.75	3.41	0.41	0.05
21	EI-2838×EI-1104-1	-0.37	-0.72	2.23	9.69	6.76*	-0.5	- 1.81**
22	EI-2840×EI-1104-1	-0.7	-0.83	0.01	4.68	0.16	-0.26	-0.66
23	EI-2843×EI-1104-1	1.41	1.39	-2.88	-2.82	4.74	1.33*	0.23
24	EI-2845×EI-1104-1	-0.81	-0.83	2.45	-5.5	-1.77	0.18	0.47
25	EI-2851×EI-1104-1	0.85	1.06	-0.99	-5.02	-1.57	0.02	-0.12
26	EI-2857×EI-1104-1	0.08	0.17	0.34	2.6	-2.01	0.42	1.09*
27	EI-2858×EI-1104-1	-0.48	-0.38	2.45	-17.57**	-7.10**	-0.4	0.24
28	EI-2862×EI-1104-1	0.63	0.62	-2.1	0.2	0.79	0.82	-0.15

regard quality traits, seven inbred lines viz., EI-2817, EI-2826, EI-2835, EI-2838, EI-2840, EI-2843and EI-2857 were found good general combiners for oil content, while inbred lines EI-2840 and EI-2843, were found good general combiners for starch content. Similarly four inbred lines EI-2826, EI-2840, EI-2858, and EI-2862 were good general combiners for protein content. Among the testers, EI-1175-3 was considered good general combiner for grain yield per plant, ear height and tester EI-1110-2 was considered good general combiner for number of grain rows per ear, 100 grain weight , grain yield per plant, harvest index, oil content and protein content. The tester EI-1104-1 was considered good general combiner for ear height. High general combining ability effects (gca) observed were due to additive and additive x additive gene effects (Griffing, 1956 and Sprague, 1942). Among the hybrids, positive significant sca effects for grain yield per plant was recorded in seven hybrids viz., EI-2838 x EI-1104-1, EI-2845 x EI-1104-1, EI-2857 x EI-1104-1, EI-2817 x EI-1175-3, EI-2843 x EI-1175-3,EI-2823 x EI-1110-2 and EI-2851 x EI-1110-2. Hybrid EI-2843 x EI-1175-3 showed highest significant SCA effects in positive direction for grain yield per plant. This was a cross between good x poor gca effect parents for grain yield per plant. Another hybrid EI-2843 x EI-1175-3, EI-2823 x EI-1110-2 and EI-2851 x EI-1110-2 also showed positive significant sca effects for harvest index. Among the 39 hybrids, five best hybrids exhibiting highest magnitude of positive significant sca effects for oil content are viz., EI-2858 x EI-1175-3followed by EI-2851 x EI-1110-2, EI-2835x EI-1110-2, EI-2840 x EI-1175-3 and EI-2862 xEI-1104-1. The maximum positive significant sca effect for this trait was expressed by hybrid EI-2858x EI-1175-3(1.29) and per se performance for grain yield per plant (139.53g/ plant). This hybrid also showed significant positive sca effects 100-grain weight. This was a

Table 4 : Continued

S.N.	Genotype	Days to 50% tasseling	Days to 50 % silking	Days to 75 % brown	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear girth
29	EI-2865×EI-1104-1	-0.92	-0.38	-0.55	2.96	5.68*	2.27**	0.48
30	EI-2817×EI-1175-3	1.13	0.83	-2.11	16.57**	0.13	1.19	0.61
31	EI-2823×EI-1175-3	-1.16	0.44	-0.12	-4.18	-0.42	-0.29	
32	EI-2826×EI-1175-3	0.02	0.5	-0.56	-0.14	1.46	0.93	-0.65
33	EI-2835×EI-1175-3	0.91	0.94	2.33	2.52	1.22	-0.06	0.04
34	EI-2838×EI-1175-3	-0.65	-0.28	-2.33	-6.81	-2.16	-0.4	0.19
35	EI-2840×EI-1175-3	0.68	0.94	0.11	0.01	3.91	0.48	0.53
36	EI-2843×EI-1175-3	-1.87	-1.84	3.22	-9.72	-3.11	0.53	1.59**
37	EI-2845×EI-1175-3	0.57	0.94	-3.44	-5.94	0.37	-0.34	-0.67
38	EI-2851×EI-1175-3	-0.43	-0.5	1.44	-16.46**	-2.03	0.39	-0.82
39	EI-2857×EI-1175-3	0.79	0.61	0.44	8.77	3.26	-0.31	-0.41
40	EI-2858×EI-1175-3	-0.43	-0.62	-1.78	9.46	2.97	-0.65	-0.1
41	EI-2862×EI-1175-3	-0.65	-0.95	2.33	0.83	-0.07	-0.41	0.14
42	EI-2865×EI-1175-3	0.46	0.05	-0.11	1.06	-1.78	-0.94	-0.16
43	EI-2817×EI-1110-2	-0.21	0.44	1.32	-11.30*	0.35	-0.09	-0.46
44	EI-2823×EI-1110-2	-0.21	-0.33	1.55	-6.73	8.44**	1.48*	-0.09
45	EI-2826×EI-1110-2	-0.32	-0.56	-1.12	-0.28	2.88	1.2	0.69
46	EI-2835×EI-1110-2	-1.09	-1.11	-0.9	-11.27*	-4.63	-0.35	-0.09
47	EI-2838×EI-1110-2	1.02	1	0.1	-2.88	-4.61	0.9	1.62**
48	EI-2840×EI-1110-2	0.02	-0.11	-0.12	-4.69	-4.07	-0.22	0.13
49	EI-2843×EI-1110-2	0.46	0.44	-0.34	12.54*	-1.63	-1.86**	-1.81**
50	EI-2845×EI-1110-2	0.24	-0.11	0.99	11.43*	1.39	0.16	0.2
51	EI-2851×EI-1110-2	-0.43	-0.56	-0.45	21.47**	3.59	-0.41	0.94
52	EI-2857×EI-1110-2	-0.87	-0.78	-0.79	-11.37*	-1.25	-0.11	-0.68
53	EI-2858×EI-1110-2	0.91	1	-0.68	8.12	4.13	1.05	-0.14
54	EI-2862×EI-1110-2	0.02	0.33	-0.23	-1.03	-0.72	-0.41	0.01
55	EI-2865×EI-1110-2	0.46	0.33	0.66	-4.02	-3.89	-1.33*	-0.32
	Standard error							
	Ti	0.27	0.27	0.47	1.41	0.72	0.16	0.13
	Lj	0.51	0.5	0.87	2.64	1.34	0.31	0.25
	Sij	1.01	1	1.74	5.28	2.68	0.62	0.5
	Ti-j	0.33	0.33	0.57	1.73	0.88	0.2	0.16
	Li-j	0.69	0.68	1.19	3.6	1.83	0.42	0.34
	Ti-Lj	0.54	0.53	0.93	2.82	1.43	0.33	0.27
	STi-Tj	1.24	1.22	2.14	6.47	3.28	0.75	0.61
	SiL-Jl	1.38	1.36	2.38	7.19	3.65	0.84	0.68
	Sij-kl	1.42	1.4	2.44	7.4	3.76	0.86	0.7

Table 5 : GCA and SCA effects for Number of grain rows per ear, 100- grain weight (g),Grain yield per Plant (g), Harvest index (%), Oil content (%), Starch content (%), Protein Content (%)

SN	Genotype	No of grain rows per ear	100-grain weight (g)	Grain yield/ plant (g)	Harvest index (%)	Oil content (%)	Starch content (%)	Protein content (%)
1	EI-1104-1	-0.70**	-0.94**	-4.16	-1.83**	0.10**	-0.84*	-0.12*
2	EI-1175-3	-0.11	-0.27	-0.6	0.72	-0.17**	0.61	-0.09
3	EI-1110-2	0.81**	1.21**	4.76*	1.11**	0.08**	0.23	0.21**
4	EI-2817	1.06**	-0.46	-8.28*	0.01	0.55**	0.76	-0.22*
5	EI-2823	-1.05**	-1.63**	-19.93**	-0.52	-0.59**	0.12	-0.02
6	EI-2826	-0.43	0.26	10.00*	-0.75	0.27**	-0.02	0.58**
7	EI-2835	0.11	-3.46**	2.93	0.03	0.17**	-1	-0.30**
8	EI-2838	-0.25	2.99**	12.79**	1.90*	0.23**	0.33	-0.30**
9	EI-2840	1.92**	6.21**	27.19**	2.63**	0.34**	2.97**	0.87**
10	EI-2843	0.27	0.46	0.65	1.87*	0.58**	1.38*	-0.97**
11	EI-2845	-0.67*	-0.9	-9.69*	-2.68**	-0.25**	0.19	-0.62**
12	EI-2851	0.64*	-1.13*	-0.17	-0.94	-0.39**	-1.88**	-0.30**
13	EI-2857	-1.47**	-3.69**	-11.71**	-0.89	0.46**	-0.85	-0.07
14	EI-2858	0.08	1.81**	16.33**	1.17	-0.48**	-0.99	0.64**
15	EI-2862	0.88**	2.81**	15.74**	1.98**	-0.29**	-0.82	0.73**
16	EI-2865	-1.09**	-3.27**	-35.85**	-3.80**	-0.61**	-0.19	-0.03
17	EI-2817× EI-1104-1	-0.1	-2.23*	-41.39**	-1.35	-0.25**	0.17	0.62**
18	EI-2823× EI-1104-1	-1.32*	-1.73	-24.81**	-0.1	0.41**	-0.19	0.35
19	EI-2826× EI-1104-1	-0.47	-1.95	0.02	-1.59	-0.25**	-0.32	-0.24

Table 5 : Continued

SN	Genotype	No of grain rows per ear	100-grain weight (g)	Grain yield/ plant (g)	Harvest index (%)	Oil content (%)	Starch content (%)	Protein content (%)
20	EI-2835× EI-1104-1	-1.27*	0.77	5.4	-0.64	-0.49**	0.53	-0.54**
21	EI-2838× EI-1104-1	0.81	3.65**	17.09*	1.99	0.42**	1.25	-1.06**
22	EI-2840× EI-1104-1	-0.24	1.45	4.73	-3.22*	0.45**	0.44	0
23	EI-2843× EI-1104-1	3.23**	-0.82	10.75	2.88	0.46**	4.09**	0.43*
24	EI-2845× EI-1104-1	0.1 2.84**	21.94**	2.25	0.25**	-0.01	0.2	
25	EI-2851× EI-1104-1	-1.21*	-2.56*	-19.07*	-1.32	-0.67**	-1.05	0.70**
26	EI-2857× EI-1104-1	-0.3	3.16**	21.33**	-0.22	-0.16*	-0.7	-0.55**
27	EI-2858× EI-1104-1	-1.45**	-5.51**	-11.27	-3.62*	-0.68**	-3.68**	0.02
28	EI-2862× EI-1104-1	1.28*	0.49	3.86	2.58	0.88**	-1.06	-0.34
29	EI-2865 ×EI-1104-1	0.93	2.42*	11.41	2.38	-0.37**	0.53	0.42*
30	EI-2817 ×EI-1175-3	0.84	6.60**	34.26**	2.84	0.49**	0.95	0.1
31	EI-2823 ×EI-1175-3	0.15	-3.40**	-12.4	-3.26*	-0.05	1.43	0.18
32	EI-2826 ×EI-1175-3	-1.47**	-3.29**	-14.7	-0.9	-0.34**	-1.96	0.2
33	EI-2835 ×EI-1175-3	0.53	4.77**	-0.55	1.7	-0.57**	1.14	-0.23
34	EI-2838 ×EI-1175-3	-1.84**	-5.82**	-22.82**	-2.12	-0.74**	-1.11	1.03**
35	EI-2840 ×EI-1175-3	0.25	0.26	1.85	2.18	0.88**	0.21	-0.02
36	EI-2843 ×EI-1175-3	-1.10*	7.85**	33.76**	3.24*	-0.41**	-2.45	0.28
37	EI-2845 ×EI-1175-3	0.64	-2.80**	-6.74	-0.33	0.06	-0.35	-0.27
38	EI-2851 ×EI-1175-3	0.46	-2.73*	-4.05	-1.79	-0.57**	-1.88	-1.41**
39	EI-2857 ×EI-1175-3	0.71	-6.51**	-24.75**	-1.49	0.24**	-0.3	0.23
40	EI-2858 ×EI-1175-3	0.55	3.16**	5.51	1.2	1.29**	1.82	-0.34
41	EI-2862 ×EI-1175-3	0.62	2.99**	8.24	0.85	-0.17*	1.73	0.15
42	EI-2865 ×EI-1175-3	-0.34	-1.09	2.39	-2.1	-0.12	0.77	0.11
43	EI-2817 ×EI-1110-2	-0.74	-4.37**	7.13	-1.49	-0.24**	-1.13	-0.72**
44	EI-2823 ×EI-1110-2	1.17*	5.13**	37.21**	3.36*	-0.36**	-1.24	-0.52**
45	EI-2826 ×EI-1110-2	1.94**	5.24**	14.67	2.5	0.60**	2.28	0.04
46	EI-2835 ×EI-1110-2	0.74	-5.54**	-4.85	-1.06	1.06**	-1.67	0.77**
47	EI-2838 ×EI-1110-2	1.03	2.17*	5.73	0.13	0.32**	-0.14	0.03
48	EI-2840 ×EI-1110-2	-0.01	-1.71	-6.59	1.05	-1.34**	-0.65	0.02
49	EI-2843 ×EI-1110-2	-2.13**	-7.03**	-44.50**	-6.11**	-0.05	-1.63	-0.70**
50	EI-2845× EI-1110-2	-0.74	-0.04	-15.2	-1.92	-0.31**	0.36	0.08
51	EI-2851 ×EI-1110-2	0.74	5.29**	23.12**	3.12*	1.24**	2.93*	0.71**
52	EI-2857 × EI-1110-2	-0.41	3.35**	3.42	1.72	-0.08	1	0.33
53	EI-2858 × EI-1110-2	0.9 2.35*	5.75	2.41	-0.61**	1.86	0.32	
54	EI-2862 × EI-1110-2	-1.90**	-3.49**	-12.09	-3.42*	-0.71**	-0.67	0.18
55	EI-2865 × EI-1110-2	-1.33	-13.79	-0.28	0.49**	-1.31	-0.54**	
	Standard error							
	Ti	0.14	0.28	2.12	0.39	0.02	0.35	0.05
	Lj	0.27	0.52	3.97	0.73	0.04	0.65	0.09
	Sij	0.54	1.05	7.95	1.46	0.08	1.3	0.18
	Ti-j	0.18	0.34	2.6	0.48	0.03	0.42	0.06
	Li-j	0.37	0.72	5.41	0.99	0.05	0.88	0.12
	Ti-Lj	0.29	0.56	4.25	0.78	0.04	0.69	0.09
	STi-Tj	0.66	1.29	9.73	1.78	0.09	1.59	0.22
	SiL-jL	0.74	1.43	10.83	1.98	0.11	1.77	0.24
	Sij-kl	0.76	1.47	11.14	2.04	0.11	1.82	0.25

cross between good x good gca effect parents for oil content. Similar findings for identification of superior inbred lines and hybrids based on gca and sca effects for grain yield and its component traits in maize were also reported by Rastgari *et al*. (2014), Kumar *et al*. (2015) Murtadha *et al*. (2016) and Devi *et al*. (2016). The five best hybrids exhibiting highest magnitude of sca effects for number of grain yield per plant are viz., EI-2823 x EI-1110-2, EI-2817 x EI-1175-3, EI-2843 x EI-1175-3, EI-2851 x EI-1110-2 and EI-2845 x EI-1104-1 reported by Dadheech and Joshi (2007).

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