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Heterosis and combining ability for yield and its attributes in *Rabi* maize (*Zea mays* L.)

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Abstract
Combining ability studies for yield and its attributing traits were carried out in *rabi* maize (*Zea mays* L.) using 30 F_1's, 10 lines, 3 testers and two checks DHM-117 and DKC-9081 and were evaluated for 14 different quantitative characters at Bihar Agricultural University, Sabour, Bhagalpur. The analysis of variance for combining ability showed the presence of both additive and non-additive gene actions. The SCA variance component was found to be higher than the respective GCA variance component for all the traits except for cob length, number of kernels per row and harvest index, indicating the multitude of non-additive gene action for inheritance of most of the traits. Further combining ability estimates revealed L_1, L_2, L7 and T_2 among the lines and testers respectively to be good general combiner for grain yield and its contributing characters. These parental lines could be utilized in improvement of traits directly correlated with grain yield. On the basis of mean performance, SCA effects, standard heterosis for yield and its attributing traits crosses namely L7 x T3, L6 x T2, L2 x T3 and L2 x T2 proves a best combination of these parents in exploitation of heterosis for grain yield and its other attributing traits.

Keywords: General combining ability, specific combining ability, maize, yield

Introduction
Maize (*Zea mays* L.) is one of the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Its chromosomes number is 2n = 20 and is native to central America. Globally, maize is known as queen of cereals due to its photo-thermo insensitive character and highest genetic yield potential among the cereals. Maize is predominately a *Kharif* season crop but in past few years *Rabi* maize is gaining popularity among farmers and multinationals seed companies due to its high yield potential. The success of *Rabi* maize is due to sunny days, long growing season, dry and cool temperatures which are more suitable to the crop and less infestation of pests. With increasing demand in poultry and livestock sectors in the country maize demand in India is being expected to increase. To meet the rising demand, enhancement of maize yield in coming years across all the growing locations in India is the big challenge in the era of climate change (Soni and Khanorkar, 2013; Iqbal *et al.*, 2014; Kumar *et al.*, 2014) [17, 3, 13].

Heterosis and combining ability is a powerful tool for developing economically viable variety. General combining ability refers to the average performance of the genotype in a series of hybrid combinations and is a measure of additive gene action. The knowledge of combining ability effects and the corresponding variances is important in the choice of selecting parents and it can be further used for exploiting heterosis to produce high performing new recombinants. Likewise, specific combining ability is the performance of a parent in a specific cross in relation to general combining ability and is a measure of genes showing non-additive effects. Among different biometrical techniques line x tester analysis is one which is widely used to study combining ability of the parents to be chosen for heterosis breeding (Rajesh *et al.*, 2014; Khan and Dubey, 2015) [7, 6].

The current research is envisage to focus on the determination of general combining ability of the parents and specific combining ability of the crosses and also determination the extent of heterosis with respect to grain yield and other traits.

Materials and methods
The experiment was carried out at maize section of Bihar Agricultural University, Sabour, Bhagalpur, Bihar. Ten lines and three testers (Table 1 and Table 2) were mated using line x tester mating design during *Kharif* 2015. During *Rabi* 2015-16 the resulting 30 F1s along with their parents and checks DHM 117, DKC 9081 were grown in a randomizedcomplete block design with two replications. A compound fertilizer was applied at the rates of 60 kg N, 60 kg P, and 60 kg per hectare at the time of sowing.

An additional 60 kg ha^{-1} N was applied in the form of urea as top dressing after four weeks. The spacing between rows was 60 cm and between plants was 20 cm and one plant per hill was maintained. Data were recorded for 14 different quantitative characteristics. Estimates of combining ability variances and effects were obtained using line x tester method suggested by Kempthorne (1957) [5] and detailed by Singh and Chaudhary (1985) [15].

Results and discussion

Estimates of components of variance

The analysis of variance revealed significant differences among the genotypes for all the characters studied like days to 50% tasseling and silking, anthesis-silking interval, days to 75% brown husk, plant height, ear height, cob length, cob diameter, number of kernel rows per cob, number of kernels per row, 100 grain weight, grain yield at 15 % moisture, harvest index, shelling percentage. Further partitioning of genotypes suggested that significant differences were also observed among the parents as well as hybrids for all the traits under study. It indicates that materials used for present investigation had adequate genetic variability for all traits studied. Proportional contributions of female parents were higher as compared with male parents for all characters investigated (Table 3). The analysis of variance for combining ability revealed that both additive and non-additive gene actions were responsible for the inheritance for all the characters under study. The SCA variance component was observed to be higher than the respective GCA variance component for most of the traits indicating preponderance of non-additive gene action for the inheritance, for cob length, number of kernels per row and harvest index, which indicated the preponderance of additive gene interaction.

General combining ability effect

For significant negative GCA (Table 4), L4 (-3.93), L9 (-3.93) and L3 (-3.27) for days to 50% tasseling, L3 (-4.77), L4 (-3.93) and T1 for days to 50% silking, L3 (-1.50) for anthesis-silking interval, L8 (-20.25) for plant height, L8 (-17.25), L4 (-11.91) and T3 (-5.96) for ear height were found to be good general combiners. None of the parent was found to be significant for days to 75% brown husk. For significant positive GCA effect L1 (1.79) and L2 (2.13) for cob length, L1 (0.92), L2 (0.82) and L7 (0.45) T2 (0.35) for cob diameter, L1 (1.37) for number of kernel rows per cob, L2 (4.35) and T2 (2.08) for number of kernels per row, L1 (2.73), L2 (3.74) and L7 (2.65) for 100 grain weight, L7 (1392.60), L2 (1250.77), L1 (1241.77), L6 (702.27) and T2 (634.867) for grain yield, L2 (2.98) for harvest index and L2 (5.04`) and L1 (4.47) T2 for shelling percentage were found to be good general combiners. L7 was also good general combiner for cob diameter, number of kernels per row and 100 seed weight. Whereas, line L2 appeared to be good combiner for cob length, cob diameter, number of kernels per row and 100 seed weight, harvest index and shelling percentage. Thus, these two parents can be useful in future breeding programme.

Specific combining ability effects of crosses

For significant negative SCA (Table 5), L1 x T3 (-4.75), L8 x T1 (-4.47) and L3 x T1 (-3.13) for days to 50% tasseling, L1 x T3 (-5.25), L5 x T3 (-4.75) and L3 x T1 for days to 50% silking, L7 x T1 (-2.53), L5 x T3 (-1.83) and L9 x T2 (-1.63) for anthesis-silking interval, L6 x T2 (-6.58 for days to 75% brown husk, L8 (-20.25) for plant height, L8 (-17.25), L4 (-11.91) and L2 x T2 (42.27), L1 x T3 (21.80) and L8 x T1 (22.60) for ear height were found to be good specific combiners. L7 x T1 (-27.88), L8 x T3 (-25.65) and L1 x T2 (-23.63) were average performers for plant height. For significant positive SCA effect L1 (1.79) and L2 (2.13) for cob length, L5 x T1 (0.79) and L2 x T3 (0.75) for cob diameter, L1 (2.73), L7 x T3 (3.78) and L5 x T1 (2.93) for 100 grain weight, L7 x T3 (2093.90), L5 x T1 (1517.30) and L6 x T2 (1446.63) for grain Yield, L2 (2.98) and L2 (5.04`) and L1 (4.47) T2 for shelling percentage were found to be good specific combiners. L5 x T1 (2.42), L7 x T3 (2.23) and L2 x T3 (1.47) for cob length, L5 x T1 (1.57) and L9 x T3 (1.37) for number of kernel rows per cob, L7 x T3 (4.63) and L5 x T1 (4.12) for number of kernels per row, all thirty crosses for harvest Index were average performers. The SCA effect ranged from -6.23 (L8 x T3) to 5.03 (L8 x T1) for shelling percentage. Fifteen crosses showed negative non-significant SCA effect and fifteen crosses exhibited positive non-significant SCA effect were average specific combiner for shelling percentage.

Standard heterosis

Standard heterosis ranged from positive to negative value for most of the characters (Table 6). Crosses L7 x T3, L6 x T2, L2 x T3 and L2 x T2 exhibited significant and positive heterosis for grain yield over mid parent, better parent and best check DHM 117.

Table 1: Pedigree of parents (Lines and Tester), checks and their codes

S. No.	Pedigree	Codes	Origin
	Lines		
1	G18SQCSF76-2-2-1-1-2BBB	L1	CIMMYT
2	CML433B*4	L2	CIMMYT
3	(CLQ-6601xCL-20843)-BB-26-1-1-BB-1-BBB	L3	CIMMYT
4	EC611064	L4	DMR
5	POB45C9F22-18-3-1-B*4-1-B*5	L5	CIMMYT
6	CLQRCY028xP390Aml(CMLC4F218-B)-B-43-1-BB-2-BB	L6	CIMMYT
7	CL-RCY08(CC-03618*CML287)-BB-1-1-BB	L7	CIMMYT
8	CLA18-B-1-1-B	L8	CIMMYT
9	CML162-B*8	L9	CIMMYT
10	S99TTYQ-HGAB*4-2-BBB	L10	CIMMYT
	Tester		
11	CML 500CM 5 CM 500	T1	DHOLI
12	SUWAN	T2	DHOLI
13	LAPOSTASQC7-F64-1-1-2-1-182-1	T3	CIMMYT

Table 2: Pedigree of crosses and their codes

S. No.	Pedigree of crosses	Code
1	G18SQCSF76-2-2-1-1-2BBB* CM 500	L1 x T1
2	G18SQCSF76-2-2-1-1-2BBB* SUWAN	L1 x T2
3	G18SQCSF76-2-2-1-1-2BBB*LAPOSTASQC7-F64-1-1-2-1-182-1	L1 x T3
4	CML433B*4* CM 500	L2 x T1
5	CML433B*4* SUWAN	L2 x T2
6	CML433B*4* LAPOSTASQC7-F64-1-1-2-1-182-1	L2 x T3
7	(CLQ-6601xCL-20843)-BB-26-1-1-BB-1-BBB* CM 500	L3 x T1
8	(CLQ-6601xCL-20843)-BB-26-1-1-BB-1-BBB* SUWAN	L3 x T2
9	(CLQ-6601xCL-20843)-BB-26-1-1-BB-1-BBB* LAPOSTASQC7-F64-1-1-2-1-182-1	L3 x T3
10	EC611064* CM 500	L4 x T1
11	EC611064* SUWAN	L4 x T2
12	EC611064* LAPOSTASQC7-F64-1-1-2-1-182-1	L4 x T3
13	POB45C9F22-18-3-1-B*4-1-B*5* CM 500	L5 x T1
14	POB45C9F22-18-3-1-B*4-1-B*5* SUWAN	L5 x T2
158	POB45C9F22-18-3-1-B*4-1-B*5* LAPOSTASQC7-F64-1-1-2-1-182-1	L5 x T3
16	CLQRCY028xP390Aml(CMLC4F218-B)-B-43-1-BB-2-BB* CM 500	L6 x T1
17	CLQRCY028xP390Aml(CMLC4F218-B)-B-43-1-BB-2-BB* SUWAN	L6 x T2
18	CLQRCY028xP390Aml(CMLC4F218-B)-B-43-1-BB-2-BB* LAPOSTASQC7-F64-1-1-2-1-182-1	L6 x T3
19	CL-RCY08(CC-03618*CML287)-BB-1-1-BB* CM 500	L7 x T1
20	CL-RCY08(CC-03618*CML287)-BB-1-1-BB* SUWAN	L7 x T2
21	CL-RCY08(CC-03618*CML287)-BB-1-1-BB* LAPOSTASQC7-F64-1-1-2-1-182-1	L7 x T3
22	CLA18-B-1-1-B* CM 500	L8 x T1
23	CLA18-B-1-1-B* SUWAN	L8 x T2
24	CLA18-B-1-1-B* LAPOSTASQC7-F64-1-1-2-1-182-1	L8 x T3
25	CML162-B*8* CM 500	L9 x T1
26	CML162-B*8* SUWAN	L9 x T2
27	CML162-B*8* LAPOSTASQC7-F64-1-1-2-1-182-1	L9 x T3
28	S99TTYQ-HGAB*4-2-BBB* CM 500	L10 x T1
29	S99TTYQ-HGAB*4-2-BBB* SUWAN	L10 x T2
30	S99TTYQ-HGAB*4-2-BBB*LAPOSTASQC7-F64-1-1-2-1-182-1	L10 x T3

Table 3: Proportional contributions of lines, testers and their interaction.

S. No	Characters	Contribution of females (%)	Contribution of males (%)	Contribution offemales x males (%)	Components of Variance		
					s^2 GCA	s^2 SCA	s^2GCA/s^2 SCA
1	Days to 50% tasseling	57	3.5	39.49	2.35	6.69	0.35
2	Days to 50% silking	51.33	5.72	42.93	2.67	8.11	0.33
3	Anthesis-silking interval	40.88	3.39	55.72	0.16	1.05	0.16
4	Days to 75% brown husk	27.3	24.09	48.6	4.31	5.54	0.78
5	Plant height	26.28	11.19	62.52	47.35	226.81	0.21
6	Ear height	30.31	7.27	62.4	50.43	323.99	0.16
7	Cob length	49.18	13.3	37.51	0.81	0.37	2.21
8	Cob diameter	55.17	11.66	33.15	0.15	0.24	0.62
9	Number of kernel rows/ cob	34.9	3.09	62	0.06	0.7	0.09
10	Number of kernel per row	54.34	14.58	31.06	4.13	2.55	1.62
11	100 grain weight	52.15	13.19	34.65	2.69	2.94	0.91
12	Grain yield	49.11	10.68	40.19	544076.1	1369205	0.4
13	Harvest index	53.78	9	37.2	1.49	0.97	1.53
14	Shelling percentage	53.81	8.49	37.68	3.58	3.85	0.93

Table 4: Estimates of general combining ability (GCA) effect of parents

Liners and Tester	Days to 50% tasseling	Days to 50% silking	Anthesis-silking Interval (days)	Days to 75% brown husk	Plant height (cm)	Ear height (cm)	Cob length (cm)	Cob diameter (cm)
L1	-0.6	-0.6	-	-0.6	10.08	12.75**	1.79*	0.92**
L2	1.73	1.73	-	1.9	-0.92	10.08*	2.13*	0.82**
L3	-3.27*	4.77**	-1.50*	-0.1	2.92	-5.08	-1.61	-0.56*
L4	-3.93*	-3.93*	-	0.4	-12.58	11.92**	-0.98	-0.50*
L5	0.07	0.4	0.33	0.23	3.42	-2.58	0.18	0.13
L6	2.40*	1.73	-0.67	4.73*	14.08*	17.08**	0.58	0.17
L7	4.73**	5.07**	0.33	-0.93	-0.42	-1.75	1.68	0.45*
L8	-0.93	-0.43	0.5	-0.27	-20.25*	17.25**	-1.51	-0.59*
L9	-3.93*	-2.1	1.83**	-3.1	0.08	0.42	1.77*	-0.75**
L10	3.73*	2.90*	-0.83	-2.27	3.58	-1.75	-0.48	-0.09
T1	-1.03	-1.33*	-0.3	2.65*	8.72*	6.23*	-0.88	-0.28*

T2	0.62	0.92	0.3	0.75	-3.53	-0.27	0.93	0.35**
T3	0.42	0.42	-	1.90*	-5.18	-5.97*	-0.05	-0.07

Contd.

Liners and Testers	Kernel rows per cob	Kernels per row	100 grain weight (g)	Grain yield at 15 % moisture	Harvest index (%)	Shelling percentage (%)
L1	1.37*	3.68*	2.73*	1241.77**	2.17	4.47*
L2	0.7	4.35*	3.74*	1250.77**	2.98*	5.048
L3	-0.3	-4.15*	-2.48*	1082.90**	-2.99*	-4.06*
L4	-0.3	-2.65	-1.98	-844.07**	-1.74	-3.87*
L5	0.03	0.68	0.27	227.1	1.31	0.17
L6	0.37	1.85	1.53	702.27*	1.14	2.42
L7	0.37	3.02*	2.65*	1392.60**	2.12	3.14
L8	-0.97	-2.82	-2.88*	-1290.90**	-2.70*	-2.49
L9	-0.97	-3.32	-3.12*	-1425.40**	-2.89*	-3.98*
L10	-0.3	-0.65	-0.45	-171.23	0.59	-0.84
T1	-0.23	-1.62*	-1.39*	-569.13**	-1.17	-1.32
T2	0.27	2.08*	1.59*	634.87**	1.04	1.85
T3	-0.03	-0.47	-0.19	-65.73	0.13	-0.54

Table 5: Estimates of specific combining ability (SCA) effect of crosses

Crosses	Days to 50% Tasseling	Days to 50% Silking	Anthesis-Silking Interval (days)	Brown Husk 75%	Plant Height cm	Ear Height (cm)	Cob Length (cm)	Cob Diameter (cm)	Kernel Rows per Cob
L1 x T1	1.7	2	0.3	-3.85	-3.38	-9.9	0.69	0.12	0.23
L1 x T2	3.05	3.25	0.2	2.75	-23.63*	-11.90*	-0.42	-0.08	-0.27
L1 x T3	-4.75*	-5.25*	-0.5	1.1	27.02*	21.80**	-0.27	-0.04	0.03
L2 x T1	4.37*	4.17*	-0.2	1.15	-19.88	-22.23**	-1.84	-0.64*	-1.1
L2 x T2	-2.78	-1.58	1.2	-1.75	28.37*	42.27**	0.37	-0.11	0.4
L2 x T3	-1.58	-2.58	-1	0.6	-8.48	-20.03*	1.47	0.75*	0.7
L3 x T1	-3.13	-4.33*	-1.2	-1.35	12.28	10.43	1.1	0.43	0.9
L3 x T2	-0.78	-0.08	0.7	0.75	-18.97	-13.07*	-1.74	-0.90*	-1.6
L3 x T3	3.92*	4.42	0.5	0.6	6.68	2.63	0.64	0.47	0.7
L4 x T1	-0.97	-1.17	-0.2	-3.35	2.78	2.27	0.19	0.14	0.9
L4 x T2	-1.12	-0.92	0.2	2.75	0.03	-7.73	-0.48	0.06	-0.6
L4 x T3	2.08	2.08	`-	0.6	-2.82	5.47	0.28	-0.2	-0.3
L5 x T1	2.53	4.00*	1.47	1.32	-9.22	-12.07*	2.42	0.79*	1.57
L5 x T2	0.38	0.75	0.37	1.42	10.53	5.43	-1.45	-0.52	-0.93
L5 x T3	-2.92	-4.75*	-1.83*	-2.73	-1.32	6.63	-0.97	-0.27	-0.63
L6 x T1	1.7	2.17	0.47	8.32*	2.62	16.77	-0.46	0.01	0.23
L6 x T2	-0.95	-1.08	-0.13	-6.58*	-2.63	-18.73*	2.25	0.27	0.73
L6 x T3	-0.75	-1.08	-0.33	-1.73	0.02	1.97	-1.79	-0.28	-0.97
L7 x T1	2.37	-0.17	-2.53*	1.98	-27.88*	-11.40*	-2.03	-0.54	-1.77*
L7 x T2	0.22	0.58	0.37	-0.42	19.37	9.6	-0.2	0.18	0.73
L7 x T3	-2.58	-0.42	2.17	-1.57	8.52	1.8	2.23	0.36	1.03
L8 x T1	-4.47*	-4.17*	0.3	0.82	20.45	22.60**	1.09	0.29	0.57
L8 x T2	2.88	2.08	-0.8	0.42	5.2	1.6	1.05	0.68*	1.07
L8 x T3	1.58	2.08	0.5	-1.23	-25.65*	-24.20**	-2.14	-0.96*	-1.63
L9 x T1	-1.47	-1	0.47	-3.85	19.12	6.43	-0.88	-0.56	-1.43
L9 x T2	-0.12	-1.75	-1.63*	-0.75	-7.13	2.93	0.42	0.45	0.07
L9 x T3	1.58	2.75	1.17	4.6	-11.98	-9.37	0.46	0.11	1.37
L10 x T1	-2.63	-1.5	1.13	-1.18	3.12	-2.9	-0.29	-0.03	-0.1
L10 x T2	-0.78	-1.25	-0.47	1.42	-11.13	-10.4	0.2	-0.02	0.4
L10 x T3	3.42	2.75	-0.67	-0.23	8.02	13.3	0.09	0.06	-0.3

Contd.

Crosses	Kernels per Row	100 Grain Weight (g)	Grain Yield at 15 % Moisture	Harvest Index (%)	Shelling (%)
L1 x T1	0.62	0.85	374.63	0.85	1.81
L1 x T2	-0.58	-0.57	-322.87*	-0.56	-1.14
L1 x T3	-0.03	-0.28	-51.77	-0.29	-0.67
L2 x T1	-3.55	-2.87	-967.87*	-1.29	-5.55
L2 x T2	0.25	0.4	68.13	0.08	1.54
L2 x T3	3.3	2.48	899.73*	1.21	4.01
L3 x T1	2.95	1.81	812.8	2.41	2.1
L3 x T2	-2.75	-3.2	-1470.20**	-4.50*	-4.25
L3 x T3	-0.2	1.39	657.4	2.09	2.14
L4 x T1	0.45	0.27	327.97	0.04	0.48

L4 x T2	0.25	-0.13	-35.53	0.74	0.72
L4 x T3	-0.7	-0.13	-292.43	-0.78	-1.2
L5 x T1	4.12	2.93	1517.30**	1.87	3.8
L5 x T2	-2.58	-1.96	-954.70*	-1.93	-2.52
L5 x T3	-1.53	-0.97	-562.6	0.07	-1.28
L6 x T1	-0.55	-0.84	-409.87	-0.3	0.49
L6 x T2	3.25	3.09	1446.63*	2.26	1.63
L6 x T3	-2.7	-2.25	-1036.77*	-1.96	-2.11
L7 x T1	-3.72	-2.85	-1557.20**	-2.1	-4.72
L7 x T2	-0.92	-0.93	-536.7	-0.26	-0.03
L7 x T3	4.63	3.78	2093.90**	2.35	4.75
L8 x T1	2.12	1.98	978.80*	1.71	5.03
L8 x T2	1.92	2.44	1097.30*	2.38	1.2
L8 x T3	-4.03	-4.42*	-2076.10**	-4.09	-6.23
L9 x T1	-1.88	-1.5	-1011.70*	-2.26	-2.88
L9 x T2	1.42	1.53	706.3	2.38	3.05
L9 x T3	0.47	-0.03	305.4	-0.12	-0.17
L10 x T1	-0.55	0.23	-64.87	-0.94	-0.56
L10 x T2	-0.25	-0.67	1.63	-0.59	-0.19
L10 x T3	0.8	0.44	63.23	1.52	0.75

Table 6: Estimates of standard heterosis

Crosses	Days to 50% Tasseling	Days to 50% Silking	Anthesis-SilkingInterval (days)	Brown Husk 75%	Plant Height cm	Ear Height (cm)	Cob Length (cm)	Cob Diameter (cm)
L1 x T1	1.7	2	0.3	-3.85	-3.38	-9.9	0.69	0.12
L1 x T2	3.05	3.25	0.2	2.75	-23.63*	-11.90*	-0.42	-0.08
L1 x T3	-4.75*	-5.25*	-0.5	1.1	27.02*	21.80**	-0.27	-0.04
L2 x T1	4.37*	4.17*	-0.2	1.15	-19.88	-22.23**	-1.84	-0.64*
L2 x T2	-2.78	-1.58	1.2	-1.75	28.37*	42.27**	0.37	-0.11
L2 x T3	-1.58	-2.58	-1	0.6	-8.48	-20.03*	1.47	0.75*
L3 x T1	-3.13	-4.33*	-1.2	-1.35	12.28	10.43	1.1	0.43
L3 x T2	-0.78	-0.08	0.7	0.75	-18.97	-13.07*	-1.74	-0.90*
L3 x T3	3.92*	4.42	0.5	0.6	6.68	2.63	0.64	0.47
L4 x T1	-0.97	-1.17	-0.2	-3.35	2.78	2.27	0.19	0.14
L4 x T2	-1.12	-0.92	0.2	2.75	0.03	-7.73	-0.48	0.06
L4 x T3	2.08	2.08	`-	0.6	-2.82	5.47	0.28	-0.2
L5 x T1	2.53	4.00*	1.47	1.32	-9.22	-12.07*	2.42	0.79*
L5 x T2	0.38	0.75	0.37	1.42	10.53	5.43	-1.45	-0.52
L5 x T3	-2.92	-4.75*	-1.83*	-2.73	-1.32	6.63	-0.97	-0.27
L6 x T1	1.7	2.17	0.47	8.32*	2.62	16.77	-0.46	0.01
L6 x T2	-0.95	-1.08	-0.13	-6.58*	-2.63	-18.73*	2.25	0.27
L6 x T3	-0.75	-1.08	-0.33	-1.73	0.02	1.97	-1.79	-0.28
L7 x T1	2.37	-0.17	-2.53*	1.98	-27.88*	-11.40*	-2.03	-0.54
L7 x T2	0.22	0.58	0.37	-0.42	19.37	9.6	-0.2	0.18
L7 x T3	-2.58	-0.42	2.17	-1.57	8.52	1.8	2.23	0.36
L8 x T1	-4.47*	-4.17*	0.3	0.82	20.45	22.60**	1.09	0.29
L8 x T2	2.88	2.08	-0.8	0.42	5.2	1.6	1.05	0.68*
L8 x T3	1.58	2.08	0.5	-1.23	-25.65*	-24.20**	-2.14	-0.96*
L9 x T1	-1.47	-1	0.47	-3.85	19.12	6.43	-0.88	-0.56
L9 x T2	-0.12	-1.75	-1.63*	-0.75	-7.13	2.93	0.42	0.45
L9 x T3	1.58	2.75	1.17	4.6	-11.98	-9.37	0.46	0.11
L10 x T1	-2.63	-1.5	1.13	-1.18	3.12	-2.9	-0.29	-0.03
L10 x T2	-0.78	-1.25	-0.47	1.42	-11.13	-10.4	0.2	-0.02
L10 x T3	3.42	2.75	-0.67	-0.23	8.02	13.3	0.09	0.06

Contd.

Crosses	Kernel Rows per Cob	Kernels per Row	100 Grain Weight (g)	Grain Yield at 15 % Moisture	Harvest Index (%)	Shelling (%)
L1 x T1	0.23	0.62	0.85	374.63	0.85	1.81
L1 x T2	-0.27	-0.58	-0.57	-322.87*	-0.56	-1.14
L1 x T3	0.03	-0.03	-0.28	-51.77	-0.29	-0.67
L2 x T1	-1.1	-3.55	-2.87	-967.87*	-1.29	-5.55
L2 x T2	0.4	0.25	0.4	68.13	0.08	1.54
L2 x T3	0.7	3.3	2.48	899.73*	1.21	4.01
L3 x T1	0.9	2.95	1.81	812.8	2.41	2.1
L3 x T2	-1.6	-2.75	-3.2	-1470.20**	-4.50*	-4.25
L3 x T3	0.7	-0.2	1.39	657.4	2.09	2.14

L4 x T1	0.9	0.45	0.27	327.97	0.04	0.48
L4 x T2	-0.6	0.25	-0.13	-35.53	0.74	0.72
L4 x T3	-0.3	-0.7	-0.13	-292.43	-0.78	-1.2
L5 x T1	1.57	4.12	2.93	1517.30**	1.87	3.8
L5 x T2	-0.93	-2.58	-1.96	-954.70*	-1.93	-2.52
L5 x T3	-0.63	-1.53	-0.97	-562.6	0.07	-1.28
L6 x T1	0.23	-0.55	-0.84	-409.87	-0.3	0.49
L6 x T2	0.73	3.25	3.09	1446.63*	2.26	1.63
L6 x T3	-0.97	-2.7	-2.25	-1036.77*	-1.96	-2.11
L7 x T1	-1.77*	-3.72	-2.85	-1557.20**	-2.1	-4.72
L7 x T2	0.73	-0.92	-0.93	-536.7	-0.26	-0.03
L7 x T3	1.03	4.63	3.78	2093.90**	2.35	4.75
L8 x T1	0.57	2.12	1.98	978.80*	1.71	5.03
L8 x T2	1.07	1.92	2.44	1097.30*	2.38	1.2
L8 x T3	-1.63	-4.03	-4.42*	-2076.10**	-4.09	-6.23
L9 x T1	-1.43	-1.88	-1.5	-1011.70*	-2.26	-2.88
L9 x T2	0.07	1.42	1.53	706.3	2.38	3.05
L9 x T3	1.37	0.47	-0.03	305.4	-0.12	-0.17
L10 x T1	-0.1	-0.55	0.23	-64.87	-0.94	-0.56
L10 x T2	0.4	-0.25	-0.67	1.63	-0.59	-0.19
L10 x T3	-0.3	0.8	0.44	63.23	1.52	0.75

Conclusion

Three lines namely L1, L2 and L7 and one tester T2 were identified as good parents on the basis of GCA effects of grain yield and its other contributing characters further these can be used in multiple hybridization programmes in order to pool all favourable alleles distributed among different parents for isolation of improved inbred lines. On the basis of mean performance, SCA effects, standard heterosis for yield and its attributing traits crosses namely L7 x T3, L6 x T2, L2 x T3 and L2 x T2 were identified as high grain yielder.

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