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Recombination superiority studies for yield and quality traits in bitter gourd (*Momordica charantia* L.)

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Abstract
The present investigation entitled studies on Recombination superiority studies for yield and quality traits in Bitter Gourd (*Momordica charantia* L.) using 10 lines, four testers and 40 hybrids along with one commercial check to investigate the extent of heterosis. The analysis of variance for experimental design revealed the existence of adequate genetic variability in experimental material for all traits under study. Maximum and significant heterosis was observed in cross L10 x T1 (VRBTG-1-1 x CO-1) which is followed by L6 x T2 (Guledgudd Local x Pusa Rasdar) over best parent and commercial check for fruit yield per vine. Maximum significant and desirable heterosis was observed in the cross L10 x T1 (VRBTG-1-1 x CO-1) which is followed by exhibited L3 x T2 (Dharwad local x Pusa Rasdar) for the same trait over better parent.

Keywords: Bitter gourd, Best parent, better parent, commercial check, heterosis

Introduction
Bitter gourd (*Momordica charantia* L.) is one of the important commercial cucurbit vegetable belongs to family cucurbitaceae. It is native to Indo Burma and the regions of Eastern India and Southern China are suggested to be the probable centers of its domestication (Mini Raj *et al.*, 1993) [5]. In India, Karnataka, Maharashtra, Tamil Nadu and Kerala are the major bitter gourd growing states. It ranks first among the cucurbits for its nutritive value. Besides the nutritional superiority, it is known for its medicinal importance. Due to its monoecious sex expression and highly cross pollination nature it can be profitably utilized through commercial exploitation of hybrid vigour for the production of F_1 hybrids. Heterosis is superiority of F1 over its parents. The primary objective of heterosis breeding is to achieve a quantum jump in yield and quality aspects of crop plants.

Material and Methods
The present investigation was undertaken involving 10 lines namely, L_1 (Dharwad local), L_2 (Budihal local), L_3 (Dharwad local), L_4 (Bagalkot local), L_5 (Gadag local), L_6 (Guledgudd local), L_7 (DVBTG-5-6), L_8 (Bagalkot local), L_9 (Laxmeshwar local) and L_{10} (VRBTG-1-1) and four testers namely T_1 (CO -1), T_2 (Pusa Rasdar),T_3 (Preethi) and T_4 (Pusa Aushadhi) and their 40 hybrids of bitter gourd. The material was evaluated in a Randomized Block Design with two replications at Vegetable Science unit, College of Horticulture Bagalkot. Observation were recorded on five randomly selected tagged plants from each treatment for vine length (m), number of branches, days to first male and female flowering, nodes up to first female flowering, days to first and last harvest, sex ratio, days taken from fruit set to maturity, number of fruits per vine, fruit girth, fruit length, average fruit weight and fruit yield per vine. Heterosis over better parents, best parent and commercial check, were computed following standard statistical procedure of Fonseca and Patterson (1968) to calculate heterosis estimates.

Result and Discussion
Analysis of variance due to genotypes was significantly different which indicates presence of sufficient amount of variability in the experimental material. Significant variance was recorded for majority of characters due to crosses depicting presence of sustainable heterosis in hybrids. Values of variance due to parents which includes both line and tester for majority of traits were due to additive and non- additive gene action. Variance due to line x cross interaction were significant for maximum characters, showing different behavior of lines over testers and vice versa (Table 1).
Heterosis was calculated as per cent increase or decrease in F1 over the better parent, best

parent and commercial check. The cross L5 x T1 showed heterosis over better parent, best parent and commercial check for vine length. Significant heterosis was found in hybrid L10 x T1 over best parent and commercial check, L3 x T2 over better parent for number of branches. Similar findings were obtained from Rani *et al.* (2014) and Verma *et al.* (2016) [6, 9].

In bitter gourd, earliness is a useful character for realizing the potential economic yield in a short time. The characters like days to first male and female flower appeared and node number at which first male and female flower appeared are considered as criterion for earliness and in negative direction is desirable. For days to first male flowering, negative significant heterosis over best parent, better parent and commercial check was found in hybrid L6 x T3 and it was found in L5 x T3 for days to first female flowering. The hybrid L4 x T4 exhibited maximum significant and negative heterosis for nodes up to first female flowering and days from fruit set to maturity. Hybrid L5 x T2 exhibited significant heterosis over best parent, L4 x T4 over better parent and L8 x T2 over commercial check for days to first harvest. Desirable direction is negative for sex ratio, lower sex ratio more female flowers. The crosses L5 x T3 and L1 x T3 exhibited maximum heterosis over best parent, better parent and commercial check. Maximum significant and positive heterosis over commercial check was recorded in the cross L3 x T2 for days to last harvest. These results are in agreement with those of Kandaswamy (2015) [3], Verma *et al.* (2016) [9] and Sureshkumara *et al.* (2017) [8].

Yield is greatly influenced by number of fruits, average fruit weight, fruit length and fruit girth and for these characters expression of heterosis in positive direction are desirable. Maximum positive significant heterosis over best parent and commercial check was observed in the cross L9 x T2 and over better parent it was found in cross L7 x T4. Out of 40 crosses, only seven crosses over better parent and five crosses over commercial check exhibited significant and positive heterosis for average fruit weight and no cross showed desirable heterosis over best parent. Hybrid L4 xT3 and L4 x T2 showed maximum significant heterosis over better parent and commercial check, respectively. For fruit length L9 x T2 exhibited significant heterosis over better parent, none of crosses showed desired heterosis over best and commercial check for this trait. The cross L10 x T4 showed significant heterosis over best parent and L4 x T1 over better parent. These results are comparable with the results from Celine and Sirohi (1996) [1] an Verma *et al.* (2016) [9].

Table 1: Analysis of variance (mean sum of square) of line x tester analysis for various characters in bitter gourd

Sl. No	Character	Replication	Genotypes	Parents	Crosses	Parents Vs. Crosses	Lines	Testers	Line x Testers	Error
	Degree of freedom	**1**	**53**	**13**	**39**	**1**	**9**	**3**	**27**	**53**
	Growth parameters									
1	Vine length at 30 DAP	0.009	0.105**	0.074**	0.117*	0.028	0.067**	0.021	0.291**	0.015
2	Vine length at 60 DAP	0.009	0.109**	0.098**	0.116**	0.023	0.104**	0.010	0.304**	0.007
3	Vine length at 90 DAP	0.009	0.083**	0.054**	0.087**	0.307**	0.054**	0.007	0.197**	0.011
4	Number of branches per vine at 30 DAP	0.004	2.266**	0.770**	2.777**	1.783**	0.330**	2.304**	0.116	0.085
5	Number of branches per vine at 60 DAP	0.017	3.674**	1.499**	4.445	1.855	1.422**	1.751**	1.442**	0.139
6	Number of branches per vine at 90 DAP	0.078	3.991**	1.567**	4.892**	0.361**	1.530**	1.921**	0.836*	0.196
	Flowering and earliness									
1	Days to first male flowering	3.080	12.056**	9.367*	11.870**	54.278**	8.768	14.277*	0.030	4.280
2	Days to first female flowering	2.582	26.887**	24.587**	28.334**	0.385	21.199**	42.734**	0.631	5.073
3	Nodes up to first female flowering	1.613	19.605**	16.906**	19.673**	52.035**	17.669**	20.218**	0.104	0.894
4	Days to first harvest	38.640	96.981**	189.025**	68.409**	14.728	80.787**	343.539**	343.540**	18.342
5	Sex ratio	1.183	40.680**	44.208**	40.494**	2.070	22.943**	44.037**	236.110**	3.979
6	Days from fruit set to maturity	0.133	10.362**	14.646**	8.048**	44.926**	7.869**	25.584**	42.822**	1.066
7	Days to last harvest	50.704	76.815**	134.999**	58.790**	23.367	20.543	304.374**	656.983**	22.664
	Yield parameters									
1	Number of fruits per vine	14.228	40.090**	17.811**	40.910**	297.697**	22.994**	8.090**	0.329**	0.837
2	Fruit length	0.539	19.272**	26.021**	17.049**	18.241**	28.573**	26.458**	1.749	0.585
3	Fruit girth	11.123	73.578	60.574	73.916	229.477	26.989	50.031	394.463	2.345
4	Average fruit weight	0.284	240.236**	486.932**	158.401**	224.743**	68.955*	1132.715**	2311.386**	7.324
5	Fruit yield per vine	0.007	0.296**	0.076**	0.349**	1.096**	0.040**	0.109**	0.301**	0.007
6	Fruit yield per plot	4.083	9.352**	4.264**	10.719**	22.210**	2.078**	6.837**	16.224**	0.160
7	Fruit yield per hectare	3.553	8.016**	3.6 71**	9.171**	19.450**	1.777**	5.820**	14.270**	0.139
	Fruit quality parameters									
1	Ascorbic acid	4.692	902.240**	791.677**	942.119**	784.252**	886.247**	763.757**1	24.308	7.677
2	Rind thickness	0.001	0.0196**	0.019**	0.015**	0.020	0.006**	0.031**	0.014	0.004
3	Total phenol	0.002	0.046**	0.033*	0.051**	0.004*	0.026**	0.047**	0.063**	0.006
4	Protein	0.005	0.269**	0.182**	0.295**	0.400**	0.231**	0.069**	0.087**	0.001

* and ** indicates significance of variance at p=0.05, p=0.01, respectively, DAP = days after planting

Table 2: Heterosis (%) over best parent, better parent and commercial check for yield and yield related parameters in bitter gourd

Sl. No.	Genotypes	Vine length			Number of branches			Sex ratio		
		BTP	BP	CC	BTP	BP	CC	BTP	BP	CC
1	L1 x T1	2.17**	13.71**	18.99**	-11.58**	-6.15**	-12.50**	-17.15**	57.14**	68.51**
2	L1 x T2	17.03**	18.32**	36.29**	-19.47**	-14.53**	-20.31**	-38.22**	17.18**	25.66**
3	L1 x T3	-3.26**	0.38**	12.66**	-35.79**	-31.84**	-36.46**	-54.81**	-46.00**	-8.09**
4	L1 x T4	3.62**	8.33**	20.68**	-8.42**	-8.42**	-9.38**	-28.66**	35.32*	45.11**

5	L2 x T1	-2.17**	10.20**	13.92**	-3.16**	15.00**	-4.17**	0.00	0.00	103.40**
6	L2 x T2	12.68**	13.92**	31.22**	2.63**	18.90**	1.56**	-22.59**	-22.59*	57.45**
7	L2 x T3	6.52**	10.53**	24.05**	-15.26**	0.63	-16.15**	-51.46**	-51.46**	-1.28
8	L2 x T4	9.06**	14.02**	27.00**	12.63**	12.63**	11.46*	-34.94**	-34.94**	32.34**
9	L3 x T1	8.70**	22.45**	26.58**	-3.68**	27.97**	-4.69**	0.42	1.91	104.26**
10	L3 x T2	2.54**	3.66**	19.41**	6.84**	23.78**	5.73**	-30.54**	-29.51**	41.28**
11	L3 x T3	6.16**	10.15**	23.63**	-5.26**	13.92*	-6.25**	-3.77	-2.34	95.74**
12	L3 x T4	-11.96**	-7.95**	2.53**	-31.58**	-31.58**	-32.29**	-27.41**	-26.33**	47.66**
13	L4 x T1	6.52**	20.00**	24.05**	-29.47**	-12.99*	-30.21**	-13.39**	5.99*	76.17**
14	L4 x T2	-16.67**	-15.75**	-2.95**	3.16**	19.51**	2.08**	-26.78**	-10.39**	48.94**
15	L4 x T3	6.52**	10.53**	24.05**	-35.79**	-22.78**	-36.46**	-46.44**	-36.00**	8.94**
16	L4 x T4	-36.96**	-34.09**	-26.58**	-37.89**	-37.89**	-38.54**	-1.20	20.91**	100.96**
17	L5 x T1	20.29**	35.51**	40.08**	-21.58**	-1.97**	-22.40**	6.90**	21.09**	117.45**
18	L5 x T2	-15.22**	-14.29**	-1.27**	-13.68**	0.00	-14.58**	-11.03**	0.78	80.98**
19	L5 x T3	2.90**	6.77**	19.83**	-32.11**	-18.35**	-32.81**	-60.67**	-55.45**	-20.00**
20	L5 x T4	-6.52**	-2.27**	8.86**	-18.95**	-18.95**	-19.79**	9.21**	23.70**	122.13**
21	L6 x T1	-18.48**	-8.16**	-5.06**	-8.42**	17.57**	-9.38**	-19.25**	-12.67**	64.26**
22	L6 x T2	-16.67**	-15.75**	-2.95**	1.05*	17.07**	0.00	-8.79**	-1.36	85.53**
23	L6 x T3	-30.07**	-27.44**	-18.57**	-33.68*	-20.25**	-34.38**	-28.24**	-22.40**	45.96**
24	L6 x T4	-19.57**	-15.91**	-6.33**	-12.63**	-12.63**	-13.54**	-20.08**	-13.57**	62.55**
25	L7 x T1	-10.87**	0.41**	3.80**	-3.16**	2.22**	-4.17**	-28.45**	0.00	45.53**
26	L7 x T2	-21.38**	-20.51**	-8.44**	6.84**	12.78**	5.73**	-40.38**	-16.67**	21.28**
27	L7 x T3	-24.64**	-21.80**	-12.24**	-37.89**	-34.44**	-38.54**	-51.46**	-42.00**	-1.28
28	L7 x T4	12.68**	17.80**	31.22**	-24.21**	-24.21**	-25.00**	-48.33**	-27.78**	5.11*
29	L8 x T1	-22.83**	-13.06**	-10.13**	-42.11**	-23.08**	-42.71**	5.44**	33.33**	114.47**
30	L8 x T2	3.62**	4.76**	20.68**	-16.32**	-3.05**	-17.19**	-40.59**	-24.87**	20.85**
1	L8 x T3	-3.62**	0.00	12.24**	-30.53**	-16.46**	-31.25**	-39.54**	-27.75**	22.98**
32	L8 x T4	-35.87**	-32.95**	-25.32**	-35.79**	-35.79**	-36.46**	-24.90**	-5.03*	52.77**
33	L9 x T1	-10.51**	-3.52**	4.22**	1.05*	12.28**	0.00	-17.57**	-5.74**	67.66**
34	L9 x T2	-16.30**	-15.38**	-2.53**	-29.47**	-21.64**	-30.21**	-41.00**	-32.54**	20.00**
35	L9 x T3	-2.90**	0.75**	13.08**	-11.05**	-1.17*	-11.98**	-1.67	12.44**	100.00**
36	L9 x T4	-27.17**	-23.86**	-15.19**	-13.68**	-13.68**	-14.58**	-39.96**	-31.34**	22.13**
37	L10 x T1	5.80**	5.80**	23.21**	22.11**	48.72**	20.83**	4.60*	40.85**	112.77**
38	L10 x T2	8.70**	8.70**	26.58**	-17.89**	-4.88**	-18.75**	-11.30**	19.44**	80.43**
39	L10 x T3	8.33**	8.33**	26.16**	6.84**	28.48**	5.73**	-25.32**	-10.75**	51.91**
40	L10 x T4	-24.28**	-24.28**	-11.81**	-34.74**	-34.74**	-35.42* *	-20.92**	6.48**	60.85**
	C.D.@1%	0.28	0.28	0.28	1.20	1.20	1.20	5.40	5.40	5.40
	C.D.@5%	0.21	0.21	0.21	0.90	0.90	0.90	4.03	4.03	4.03
	S.E.(m)±	0.10	0.10	0.10	0.44	0.44	0.44	1.99	1.99	1.99

Table 3: Heterosis (%) over best parent, better parent and commercial check for yield and yield related parameters in bitter gourd

Sl. No.	Genotypes	Days to first male flowering			Days to first female flowering			Nodes up to first female flowering			Days from fruit set to maturity		
		BTP	BP	CC	BTP	BP	CC	BTP	BP	CC	BTP	BP	CC
1	L1 x T1	-1.53	-1.53	3.58	-10.15**	-7.61**	4.55	-9.30**	-6.02**	7.59**	-21.92**	-17.14 **	11.42**
2	L1 x T2	0.77	0.77	6.00**	-13.64**	-11.20**	0.49	42.44**	46.71**	68.97**	-16.67**	-1.07	1.09
3	L1 x T3	-4.23*	-4.23*	0.74	-7.82**	-5.22*	7.26**	-0.58	0.59	17.93**	-2.88**	-13.49**	-9.09**
4	L1 x T4	-0.23	-0.23	4.94*	-4.02	-4.02	11.69**	3.78**	7.53**	23.10**	-3.85**	-16.13**	-24.36 **
5	L2 x T1	1.29	2.13	6.54**	-7.82**	-3.11	7.26**	-34.30**	-34.30**	-22.07**	-6.73**	-11.56**	-5.45**
6	L2 x T2	-4.58*	-3.44	0.37	-17.65**	-9.63**	-4.18	13.08**	13.08**	34.14**	-35.26**	-26.01 **	-21.71 **
7	L2 x T3	-8.45**	-7.36**	-3.70	-14.16**	3.05	-0.12	-18.60**	-18.60**	-3.45**	-18.17**	-1.27	4.47**
8	L2 x T4	-10.33**	-9.26**	-5.68**	-7.19**	-7.19**	8.00**	-36.05**	-36.05**	-24.14**	-6.73**	-28.18 **	-24.00 **
9	L3 x T1	4.93*	5.80**	10.37**	-8.25**	-3.56	6.77**	-13.95**	8.82**	2.07*	-17.95**	-2.57**	10.18**
10	L3 x T2	-2.46	1.59	2.59	-11.21**	-2.55	3.32	7.56**	10.78**	27.59**	-29.17**	-27.14 **	-17.60 *
11	L3 x T3	-14.32**	-12.57*	-9.88**	-6.55**	8.60**	8.73**	-10.17**	-9.12**	6.55**	-10.90**	-11.25**	0.36
12	L3 x T4	0.47	4.65*	5.68**	-8.67**	-8.67**	6.27**	-10.76**	20.87**	5.86**	-30.99**	-32.15 **	-23.27 **
13	L4 x T1	-3.29	-2.49	1.73	-12.47**	-8.00**	1.85	-14.53**	8.09**	1.38	-27.37**	2.04	9.09**
14	L4 x T2	-3.52	0.98	1.48	-15.54**	-7.31**	-1.72	-19.19**	-16.77**	-4.14**	-48.30**	-42.60 **	-41.35 **
15	L4 x T3	-10.21**	-8.38**	-5.56*	-19.13**	-11.25**	-5.90*	-2.62**	-1.47	15.52**	-21.47**	-0.14	4.95**
16	L4 x T4	-0.94	3.69	4.20*	-22.20**	-22.20**	-9.47**	-66.28**	-43.14**	-60.00**	-33.01**	-27.99 **	-28.25 **
17	L5 x T1	-3.29	-2.49	1.73	-12.26**	-10.85**	2.09	28.49**	30.00**	52.41**	-10.26**	-1.02	5.82**
18	L5 x T2	3.05	14.47**	8.40**	-13.53**	-12.14**	0.62	4.94**	6.18**	24.48**	-19.04**	-12.81**	-10.91**
19	L5 x T3	-17.14**	-15.45**	-12.84*	-25.37**	-24.17**	-13.16**	0.87	2.06**	19.66**	-20.83**	4.50**	9.82**
20	L5 x T4	-3.64	7.04**	1.36	-9.94**	-9.94**	4.80*	13.95**	15.29**	35.17**	-33.14**	-10.87**	-14.44**
21	L6 x T1	-7.39**	-6.63**	-2.59	-10.78**	-6.22**	3.81	4.07**	7.19**	23.45**	-19.87**	-35.26 **	-26.55 **
22	L6 x T2	-2.23	-0.12	2.84	-3.17	6.26**	12.67**	-13.37**	-10.78**	2.76**	-7.95**	-33.01 **	-24.00 **
23	L6 x T3	-20.66**	-19.04**	-16.54**	-13.11**	6.61**	1.11	-15.70**	-14.71*	0.00	-11.54**	-18.17 **	-7.16**
24	L6 x T4	-1.53	0.60	3.58	-18.60**	-18.60**	-5.29*	-6.40**	-3.59**	11.03**	-7.50**	-24.36 **	-14.18**

25	L7 x T1	-0.94	-0.12	4.20*	10.99**	16.67**	29.15**	-1.74	-1.74	16.55**	-3.21**	-13.16**	-7.16**
26	L7 x T2	2.23	15.82**	7.53**	-5.07*	4.18	10.46**	-6.69**	-6.69**	10.69**	-18.14**	-0.36	1.82
27	L7 x T3	-6.57**	-4.67*	-1.73	-10.47**	11.15**	4.18	7.85**	7.85**	27.93**	-28.01**	-22.28 **	-18.33 **
28	L7 x T4	-2.23	10.04	2.84	-16.70**	-16.70**	-3.08	-26.74**	-26.74**	-13.10**	-38.65**	4.84**	-5.45**
29	L8 x T1	1.76	2.60	7.04**	-5.50*	-0.67	9.96**	5.23**	33.09**	24.83**	-13.65**	-1.02	5.82**
30	L8 x T2	-3.76	10.81**	1.23	-20.93**	-13.53*	-8.00**	5.81**	8.98**	25.52**	-6.73**	-10.11**	-8.15**
31	L8 x T3	1.76	3.83	7.04	-4.23	4.74*	11.44**	-14.53**	-13.53**	1.38	-33.33**	-33.81 **	-30.44 **
32	L8 x T4	-3.99	8.06**	0.99	-1.90	-1.90	14.15**	-24.42**	25.00**	-10.34**	-33.01**	-1.61	-11.27**
33	L9 x T1	4.58*	5.44*	10.00**	-4.55	0.33	11.07**	5.23**	33.09**	24.83**	-32.37**	-12.93**	-6.91**
34	L9 x T2	4.46*	16.80**	9.88**	-10.15**	-5.13*	4.55	-14.53**	-11.98**	1.38	-36.73**	-12.1**	-10.18**
35	L9 x T3	-6.46**	-4.55*	-1.60	-7.19**	-2.01	8.00**	-13.95**	-12.94**	2.07*	-24.55**	-6.82**	-2.07
36	L9 x T4	0.00	11.81**	5.19*	-10.78**	-10.78**	3.81	-23.55**	9.13**	-9.31**	-24.36**	-15.73**	-24.00 **
37	L10 x T1	1.17	2.01	6.42**	-5.29*	-2.82	10.21**	-16.28**	5.88**	-0.69	-16.67**	-24.83 **	-19.64 **
38	L10 x T2	4.93*	13.89**	10.37**	-2.96	-0.43	12.92**	-13.37**	-10.78**	2.76**	-21.79**	-25.77 **	-24.15 **
39	L10 x T3	-1.64	0.36	3.46	-2.96	-0.43	12.92**	-8.72**	-7.65**	8.28**	-33.01**	0.69	5.82**
40	L10 x T4	-0.23	8.28**	4.94*	17.65**	17.65**	36.90**	-18.02**	12.35**	-2.76**	-27.88**	-9.27**	-18.18 **
	C.D.@1%	5.60	5.60	5.60	6.10	6.10	6.10	2.56	2.56	2.56	2.84	2.84	2.84
	C.D.@5%	4.18	4.18	4.18	4.56	4.56	4.56	1.91	1.91	1.91	2.13	2.13	2.13
	S.E.(m)±	2.07	2.07	2.07	2.25	2.25	2.25	0.95	0.95	0.95	1.05	1.05	1.05

Table 4: Heterosis (%) over best parent, better parent and commercial check for yield and yield related parameters in bitter gourd

Sl. No.	Genotypes	Days to first harvest			Days to last harvest			Number of fruits			Average fruit weight		
		BTP	BP	CC	BTP	BP	CC	BTP	BP	CC	BTP	BP	CC
1	L1 x T1	-8.21**	-8.14	0.50	-4.26	-4.26	18.60**	4.04**	4.04**	36.45**	-45.62**	-38.40 **	-14.73**
2	L1 x T2	-5.10*	-4.06	0.62	-3.01	-3.01	20.14**	9.03**	9.03**	42.99**	-46.67**	13.12**	-16.38**
3	L1 x T3	-1.94	-1.36	3.01	-8.47	-8.47*	13.38**	-38.95**	-38.95**	-19.94**	-53.62**	0.00	-27.26**
4	L1 x T4	-5.43*	-6.32	2.48	-1.16	-1.16	22.43**	-43.71**	-43.71**	-26.17**	-49.53**	-49.53 **	-20.86**
5	L2 x T1	-5.99*	-5.02	3.90	-3.49	-3.30	19.54**	-2.38*	41.24**	28.04**	-42.01*	-34.30 **	-9.06**
6	L2 x T2	-10.77**	-3.04	1.68	-6.54	-6.36	15.76**	-43.94**	-18.90**	-26.48**	-58.58**	-12.13**	-35.04**
7	L2 x T3	5.10*	1.81	1.00	-0.44	-0.24	23.32**	-34.92**	-6.80**	-14.64**	-51.34**	4.91	-23.70**
8	L2 x T4	-0.81	-8.67	-0.09	-4.01	-3.82	18.90**	-24.94**	8.59**	-1.56*	-55.31**	-55.31 **	-29.92**
9	L3 x T1	-2.91	-1.86	7.36**	-1.73	0.29	21.73**	-30.64**	8.15**	-9.03**	-41.42**	-33.64 **	-8.14**
10	L3 x T2	-6.32*	-6.46	-1.90	-0.04	4.53	23.82**	-28.50**	11.07**	-6.23**	-63.65**	-32.43 **	-43.00**
11	L3 x T3	-8.10*	3.00	6.38**	-1.57	1.74	21.93**	-25.18**	7.14**	-1.87*	-29.99**	30.15**	9.79**
12	L3 x T4	-7.13*	-9.64 *	-1.15	-15.30**	-11.42**	4.92	-13.30**	46.00**	13.71**	-50.76**	-50.76 **	-22.78**
13	L4 x T1	-10.40**	-5.35	3.55	-1.36	-1.25	22.18**	-42.28**	-10.00**	-24.30**	-63.36**	-58.49 **	-42.54**
14	L4 x T2	-11.30**	-7.41	-2.90	-8.99	-8.88*	12.73*	-27.08**	13.28**	-4.36**	-28.65**	51.36**	11.89**
15	L4 x T3	-10.69**	-7.01	-3.05	-5.26	-5.14	17.35**	-33.02**	-4.08**	-12.15**	-29.70**	51.57**	10.25**
16	L4 x T4	-5.67*	-13.02 **	-4.85	-8.43	-8.32*	13.43**	-15.44**	77.11**	10.90**	-55.66**	-55.66 **	-30.47**
17	L5 x T1	-1.38	-5.99	2.93	-6.30	-4.38	16.06**	-5.70**	30.59**	23.68**	-72.70**	-69.07 **	-57.18**
18	L5 x T2	-15.74**	-10.69 *	-2.22	-7.31	-3.47	14.82**	0.71	39.47**	32.09**	-40.61**	25.99**	-6.86*
19	L5 x T3	-7.94**	-10.28 *	-1.77	-6.50	-3.36	15.81**	-7.36**	28.29**	21.50**	-62.19**	-18.49 **	-40.71**
20	L5 x T4	-5.54*	-8.72 *	-0.06	-1.16	2.93	22.43**	-12.11**	21.71**	15.26**	-49.12**	-49.12 **	-20.22**
21	L6 x T1	-5.91*	-10.70 *	-2.30	-6.86	-4.96	15.37**	-48.46**	-20.22**	-32.40**	-44.87**	-37.54 **	-13.54**
22	L6 x T2	-7.74**	-1.52	3.28	-6.30	-2.67	16.06**	14.25**	76.84**	49.84**	-47.49**	11.39**	-17.66**
23	L6 x T3	-2.83	-0.51	-0.95	-6.46	-3.32	15.86**	-33.73**	-5.10**	-13.08**	-58.17**	-9.81**	-34.40**
24	L6 x T4	-11.45**	-7.21	1.51	-3.65	0.08	19.34**	-45.61**	-15.81**	-28.66**	-51.93**	-51.93 **	-24.61**
25	L7 x T1	-10.28**	5.19	15.07 **	-3.77	-3.50	19.19**	-38.72**	-4.44**	-19.63**	-70.25**	-66.29 **	-53.34**
26	L7 x T2	-9.52**	2.96	7.98**	-11.72*	-11.47**	9.35	-1.66	52.77**	28.97**	-53.21**	-0.74	-26.62**
27	L7 x T3	-9.99**	4.87	-1.45	-14.09**	-13.85**	6.41	-40.14**	-14.29**	-21.50**	-50.99**	5.26	-23.15**
28	L7 x T4	-7.90**	-11.83 **	-3.55	-3.89	-3.62	19.05**	-1.66	105.97**	28.97**	-58.23**	-58.23 **	-34.49**
29	L8 x T1	-3.85	-0.73	8.60**	-9.71	-7.87	11.83*	-42.28**	-10.00**	-24.30**	-47.49**	-40.52 **	-17.66**
30	L8 x T2	1.13	-12.04 *	-7.75**	-13.85**	-9.41**	6.71	22.09**	89.67**	60.12**	-53.21**	-0.74	-26.62**
31	L8 x T3	-6.40*	2.37	0.82**	-15.54**	-12.70**	4.62	-41.81**	-16.67**	-23.68**	-63.01**	-20.25 **	-41.99**
32	L8 x T4	-8.74**	-1.78	7.45**	-2.13	2.91	21.23**	-31.59**	34.58**	-10.28**	-58.23**	-58.23 **	-34.49**
33	L9 x T1	-9.72**	-2.84	6.29*	-2.17	-0.16	21.18**	-34.20**	2.59**	-13.71**	-44.22**	-36.81 **	-12.53**
34	L9 x T2	-13.09**	-3.89	0.80	-14.37**	-7.70	6.07	30.64**	102.95**	71.34**	-55.78**	-26.97 **	-30.65**
35	L9 x T3	-8.71**	2.00	5.26	-6.86	-3.73	15.37**	4.75**	50.00**	37.38**	-37.81**	2.70	-2.47
36	L9 x T4	-7.29**	-11.43 *	-3.10	-2.33	5.28	20.98**	-20.43**	37.30**	4.36**	-51.58**	-51.58 **	-24.06**
37	L10 x T1	-11.90**	-6.24	2.57	-5.58	-4.62	16.96**	18.29**	84.44**	55.14**	-43.41**	-35.89 **	-11.25*
38	L10 x T2	-1.86	-3.27	3.42	-7.63	-6.69	14.42**	-44.42**	-13.65**	-27.10**	-52.28**	-10.60**	-25.16**
39	L10 x T3	-11.50**	3.57	10.73 **	-2.25	-1.26	21.08**	-25.42**	6.80**	-2.189	-41.37**	9.84**	-8.05**
40	L10 x T4	11.58**	11.67 **	22.16 **	-1.20	-0.20	22.38**	-10.93**	42.05**	16.82**	-32.21**	-32.21 **	6.31*
	C.D.@1%	7.17	7.17	7.17	12.89	12.89	12.89	2.48	2.48	2.48	7.33	7.33	7.33
	C.D.@5%	5.36	5.36	5.36	9.63	9.63	9.63	1.85	1.85	1.85	5.47	5.47	5.47
	S.E.(m)±	2.65	2.65	2.65	4.76	4.76	4.76	0.92	0.92	0.92	2.71	2.71	2.71

Table 5: Heterosis (%) over best parent, better parent and commercial check for yield and yield related parameters in bitter gourd

Sl. No.	Genotypes	Fruit length			Fruit girth			Fruit yield per vine		
		BTP	BP	CC	BTP	BP	CC	BTP	BP	CC
1	L1 x T1	-25.61**	-19.34**	-42.70 **	-24.62**	-4.92**	-43.49 **	0.00	0.00	22.09**
2	L1 x T2	-28.59**	-22.57**	-45.00 **	-22.10**	6.17**	-31.79 **	-9.57**	23.53*	9.88**
3	L1 x T3	-25.61**	-19.34**	-42.70 **	-19.58**	15.95**	-30.87 **	-51.67**	-33.99**	-41.28**
4	L1 x T4	-22.99**	-16.50**	-40.69 **	-17.07**	-39.59**	-54.72 **	-54.07**	-37.25**	-44.19**
5	L2 x T1	-28.89**	15.89**	-45.24 **	-14.55**	18.35**	-37.92 **	3.35**	3.35**	25.58**
6	L2 x T2	-24.10**	12.75**	-41.55 **	-12.03**	-10.43**	-42.45 **	-64.11**	-28.57**	-56.40**
7	L2 x T3	-52.05**	-21.84**	-63.07 **	-9.51**	20.57**	-28.11 **	-44.98**	-0.86**	-33.14**
8	L2 x T4	-21.82**	-13.23**	-39.79 **	-7.00**	-41.86**	-56.42 **	-44.02**	-22.52**	-31.98**
9	L3 x T1	-22.10**	6.31**	-40.00 **	-4.48**	31.29**	-31.13 **	-29.67**	-29.67**	-14.53**
10	L3 x T2	-3.82**	31.25**	-25.92 **	-1.96	-24.08**	-51.23 **	49.76**	49.76**	81.98**
11	L3 x T3	-55.81**	-39.70**	-65.97 **	0.55	-32.91**	-60.00 **	-13.88**	55.17**	4.65**
12	L3 x T4	-17.36**	-8.29**	-36.35 **	3.07	-37.08**	-52.83 **	-21.05**	9.27**	-4.07**
13	L4 x T1	-56.92**	-11.00**	-66.82 **	5.59**	46.76**	-23.02 **	-64.59**	-64.59**	-56.98**
14	L4 x T2	-46.50**	-20.53**	-58.80 **	8.10**	16.89**	-24.91 **	-13.88**	71.43**	4.65**
15	L4 x T3	-60.60**	-15.63**	-69.66 **	10.62**	-24.48**	-54.97 **	-33.97**	18.97**	-19.77**
16	L4 x T4	-38.01**	-31.20**	-52.25 **	13.14**	-47.65**	-60.75 **	-32.54**	-6.62**	-18.02**
17	L5 x T1	-53.75**	-4.43**	-64.38 **	15.66**	24.10**	-34.91 **	-30.48**	-30.14**	-15.17**
18	L5 x T2	-46.39**	-20.36**	-58.71 **	18.17**	-12.48**	-43.77 **	19.62**	138.10**	45.35**
19	L5 x T3	-53.58**	-0.60	-64.25 **	20.69**	-18.67**	-51.51 **	-47.37**	-5.17**	-36.05**
20	L5 x T4	-11.20**	-1.45	-31.61 **	23.21**	-23.99**	-43.02 **	-27.75**	0.00	-12.21**
21	L6 x T1	-40.71**	22.51**	-54.33 **	25.72**	15.16**	-33.58 **	-55.02**	-55.02**	-45.35**
22	L6 x T2	-60.82**	-41.80**	-69.83 **	28.24**	4.41**.	-32.92 **	39.71**	178.10**	69.77**
23	L6 x T3	-27.39**	55.49**	-44.08 **	30.76**	-26.42**	-56.13 **	-55.50**	-19.83**	-45.93**
24	L6 x T4	-16.13**	-6.93**	-35.41 **	33.27**	-37.20**	-52.92 **	-63.64**	-49.67**	-55.81**
25	L7 x T1	-31.29**	-9.87**	-47.08 **	35.79**	-0.90	-48.02 **	-70.33**	-70.33**	-63.95**
26	L7 x T2	-14.02**	12.79**	-33.78 **	38.31**	6.02**	-31.89 **	-15.31**	68.57**	2.91**
27	L7 x T3	-20.23**	4.64**	-38.56 **	40.83**	-17.09**	-50.57 **	-52.63**	-14.66**	-42.44**
28	L7 x T4	-28.11**	-20.22**	-44.64 **	43.34**	-46.14**	-59.62 **	-24.88**	3.97**	-8.72**
29	L8 x T1	-43.27**	-25.31**	-56.31 **	45.86**	15.70**	-39.31 **	-53.11**	-53.11**	-43.02**
30	L8 x T2	-22.79**	1.65*	-40.54 **	48.38**	12.09**	-27.99 **	2.39**	103.81**	24.42**
31	L8 x T3	-23.71**	0.44	-41.24 **	50.89**	23.42**	-26.42 **	-62.68**	-32.76**	-54.65**
32	L8 x T4	-8.44**	1.61*	-29.48 **	53.41**	-37.83**	-53.40 **	-51.20**	-32.45**	-40.70**
33	L9 x T1	-19.59**	37.23**	-38.07 **	55.93**	12.95**	-40.75 **	-43.06**	-43.06**	-30.81**
34	L9 x T2	-0.53	47.76**	-23.39 **	58.44**	-28.34**	-53.96 **	2.87**	79.17**	25.00**
35	L9 x T3	-20.59**	35.52**	-38.84 **	60.96**	15.19**	-31.32 **	0.00	74.17**	21.51**
36	L9 x T4	-28.95**	-21.15**	-45.28 **	63.48**	-35.31**	-51.51 **	-33.49**	-7.95**	-19.19**
37	L10 x T1	-19.48**	-19.48**	-37.98 **	66.00**	40.76**	-26.17 **	144.02**	142.86**	196.51**
38	L10 x T2	-35.36**	-35.36**	-50.21 **	68.51**	6.46**	-31.60 **	-57.42**	-28.80**	-48.26**
39	L10 x T3	-8.33**	-8.33**	-29.40 **	71.03**	11.71**	-33.40 **	10.53**	84.80**	34.30**
40	L10 x T4	-12.23**	-12.23**	-32.40 **	73.55**	-26.25**	-44.72 **	-19.14**	11.92**	-1.16**
	C.D.@1%	2.07	2.07	2.07	4.15	4.15	4.15	0.23	0.23	0.23
	C.D.@5%	1.55	1.55	1.55	3.10	3.10	3.10	0.17	0.17	0.17
	S.E.(m)±	0.76	0.76	0.76	1.53	1.53	1.53	0.09	0.09	0.09

* and ** indicate significance of values at p=0.05 and p= 0.01, respectively.
BTP = Heterosis over best parent BP = Heterosis over best parent CC = Heterosis over commercial check

Conclusion

Among the 40 hybrids, only eight hybrids over best parent and 17 hybrids over better parent and 14 hybrids over commercial check exhibited positive and significant heterosis for fruit yield per vine. The cross L10 X T1 which is followed by the cross L3 x T2. Maximum positive significant heterosis over better parent was observed in the cross L6 x T2 which is followed by the cross L10 x T1. Maximum positive significant heterosis over commercial check were observed in the crosses L10 x T1 and L3 x T2. These results are in close proximity with results obtained by Singh *et al.* (2000) and Mallikarjunarao *et al.* (2018) [7, 4].

Reference

1. Celine VA, Sirohi PS. Heterosis in bitter gourd (*Momordica charantia* L.). Vegetable Science 1996;2(2):180-185.
2. Fonseca S, Patterson PL. Hybrid vigour in seven parent diallel cross in common winter wheat (*Triticum aestivum* L.). Crop Science 1968;8:85-88.
3. Kandasamy R. Heterosis in bitter gourd (*Momordica charantia* L.). The Asian Journal of Horticulture 2015;10(1):158-160.
4. Mallikarjunarao K, Das AK, Nandi A, Baisakh B, Tripathy P, Sahu GS. Heterosis and combining ability of quality and yield of bitter gourd (*Momordica charantia* L.). Journal of Pharmacognosy and Phytochemistry 2018;7(3):05-09.
5. Mini Raj N, Prasanna KP, Peter KV. Bitter gourd (*Momordica* spp.). *In:* Genetic improvement of vegetable crops. Kalloo, G. and Berg, B.O. (eds.). New York, Pergamon Press 1993,239-246p.
6. Rani S, Kumar S, Singh BK, Singh SP. Heterosis and combining ability studies in cucumber (*Cucumis sativus* L.). Indian Journal of Scientific Research and Technology 2014;48(3):49-52.

7. Singh AK, Pandey UB, Mamta S. Studies on heterosis in bitter gourd (*Momordica charantia* L.). Vegetable Science 2000;27(2):158-161.
8. Sureshkumara B, Puttaraju TB, Pavithr HB. Evaluation of bitter gourd (*Momordica charantia* L.) hybrids under eastern dry zone of Karnataka, India. International Journal of Current Microbiology and Applied Sciences 2017;6(11):1931-1939.
9. Verma NRS, Pratap, Shekhar RP, Singh R, Vishnoi RK. Exploitation of heterosis for yield and its components in bitter gourd (*Momordica charantia* L.). Plant Archives 2016;16(1):403-412.