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Studies on Heterosis and Combiing Ability for Yield and Quality Attributing Traits in Chilli (*Capsicum Annum L.*)

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Abstract

Seven lines and four testers were crossed in line x tester mating design to evolve twenty-eight hybrids. These hybrids were studied along with their eleven parents for estimation of relative heterosis, heterobeltiosis and standard heterosis for Fruififteen characters. Observations were recorded on fifteen economically important traits viz., days to 50 percent flowering, plant height at maturity, plant spread, fruit length, fruit width, fruit pedicel length, placenta length, number of fruits per plant, fruit weight, number of seeds per fruit, 1000 seed weight, fruit yield per plant, ascorbic acid content, capsaicin content and capsanthin content. The hybrids L_4 x T_3 (LCA 625 × G-4) is the best hybrids followed by L_7 x T_4 (Pant C-1 × LCA 678) and L_7 x T_2 (Pant C-1 × K1) recorded significant standard heterosis for fruit yield per plant. Selection of hybrids for heterosis breeding based on per se performance, sca effects and standard heterosis will be more effective. It may be concluded that based on all the three criteria, the following three hybrids L_4 x T_3 (LCA 625 × G-4) and L_7 x T_4 (Pant C-1 × LCA 678) and L_7 x T_2 (Pant C-1 × K1) were identified as the superior hybrids, among the twenty-eight hybrids evaluated.

Keywords: *Heterosis, Hybrids, Fruits*

1. Introduction

Chilli is one of the important spices and vegetable crops of the Solanaceae family. The species that comes under the Capsicum genus have been widely used in food as well as pharmaceutical industries. Chilli is valued for its pungency and colour aspects in food industries. Pungency is due to crystalline alkaloid called capsaicin present in placenta of fruits. The red colour of fruit is due to capsanthin. The occurrence of high cross pollination and adaptation to micro climatic condition has led do the formation of variants and land races within the species (Kehie *et al*. 2012). It is important to note that chilli peppers are a crop that thrives in warm weather conditions and are extremely vulnerable to frost. (Rodriguez-Rey *et al*. 2000).

Heterosis refers to the phenomenon that the two genetically dissimilar gametes or individuals are crossed, the resulting F1 hybrid may exhibit increased or decreased vigour compared to the better parent or mid-parental values. Shull (1908) referred to this phenomenon as the stimulus of heterozygosis and has interpreted it as increased "vigour", "size", "fruitfulness", "speed of development", and "resistant to disease and insect pests', manifested by the outbreeding organisms as compared with the corresponding inbreds and as specific results of the differences in the constitution of the uniting parental gametes.

2. Materials And Methods

The study entitled "Heterotic Studies in Chilli (Capsicum Annum L.) for Yield and Quality Attributing Traits" was conducted at the experimental fields of the Department of Genetics and Plant Breeding farm, Faculty of Agriculture, Annamalai University, Annamalainagar. This study took place between 2019 and 2021, at an altitude of 5.79m above sea level and at the geographical coordinates of 11º24' N latitude and 79 º 41'E longitude.

Seven genotypes were used as lines (LCA 705-2(L_1), Co-1 (L_2), Arka Lohit (L_3), LCA 625 (L_4), LCA 620 (L_5), Pusa Jwala (L_6) and Pant C1 (L_7) and four genotypes were used as testers LCA 334(T_1), K1

(T_2), G4 (T_3) and LCA 678 (T_4) were crossed in a line x tester mating design resulting in twenty-eight F_1 hybrids.

The observations were recorded for fifteen characters on randomly selected plants viz., days to 50 percent flowering, plant height at maturity, plant spread, fruit length, fruit width, fruit pedicel length, placenta length, number of fruits plant^{-1}, fruit weight, number of seeds fruit^{-1}, 1000 seed weight, fruit yield plant^{-1}, ascorbic acid content, capsaicin content and capsanthin content.

3. Results and Discussion

Days to 50 percent flowering

Eleven out of twenty-eight cross combinations recorded negatively significant relative heterosis for this character. The maximum relative heterosis was recorded with the cross L_4 x T_3 (LCA 625 × G-4) followed by L_6 x T_2 (Pusa Jwala × K1) and L_6 x T_1 (Pusa Jwala × LCA 334). Heterobeltiosis was negative and significant in twenty-eight cross combinations out of thirteen. It was maximum with the cross L_6 x T_1 (Pusa Jwala × LCA 334) followed by L_6 x T_2 (Pusa Jwala × K1) and L_3 x T_3 (Arka Lohit × G-4). Standard heterosis for this character was negative and significant for twelve cross combination for days to 50 per cent flowering. It was maximum with the cross L_7 x T_2 (Pant C- 1 × K1) followed by L_6 x T_3 (Pusa Jwala × G- 4) and L_6 x T_4 (Pusa Jwala × LCA 678). The observed direction and magnitudes of standard heterosis for this character added a scope for inclusion of this character in heterosis breeding programme of chilles. The results were in accord with the earlier findings of Tembhurne and Rao (2012), Kumar *et al*. (2013), Suryakumari *et al.* (2014).

Estimation of relative heterosis for fifteen characters

hybrids	**Days to 50per cent flowering**	**Plant height**	**Plant spread**	**Fruit length**	**Fruit width**	**Fruit pedicel length**	**Placenta length**	**No. of fruits per plant**	**Fruit weight**	**No. of seeds per fruit**	**1000 seed weight**	**Fruit yield per plant**	**Ascorbic acidcontent**	**Capsaicin content**	**capsanthincontent**
L_1 x T_1	12.43**	6.14**	11.69**	5.90**	15.87	10.17**	37.68**	3.91**	-8.12**	-1.78	0.82	-11.06**	1.76**	7.43**	0.77
L_1 x T_2	6.73**	-2.77	3.19**	11.31**	9.77	-2.80	-5.13	-5.51**	-14.83**	-11.42**	2.39	-7.44**	0.99	2.64**	1.26
L_1 x T_3	13.86**	0.03	12.45**	8.87**	10.27	-2.38	8.27**	9.78**	0.96	-1.19	10.72**	-2.41**	-1.35*	13.49**	1.15
L_1 x T_4	18.73**	0.89	22.40**	0.69	3.56	-20.33**	-2.58	0.06	-11.77**	-9.34**	-9.13**	-16.78**	-2.30**	13.43**	3.54**
L_2 x T_1	11.54**	14.08**	10.15**	-5.80**	-4.40	1.73	6.82*	4.33**	0.26	-2.28	-7.08**	-0.78	1.29*	6.67**	5.99**
L_2 x T_2	11.16**	20.42**	11.66**	12.12**	28.08 **	6.83*	5.95*	-4.83**	-6.49**	-6.79**	-0.89	-1.14*	-2.22**	10.12**	5.70**
L_2 x T_3	3.11*	5.10**	1.82	3.59**	18.28*	20.29**	5.41*	0.01	-3.40	0.82	-3.20*	-5.59**	-0.29	14.96**	1.0
L_2 x T_4	14.72**	3.21*	8.37**	11.44**	-29.31**	-3.08	-8.09**	-3.61**	-3.79*	-3.88**	0.58	1.66**	-3.06**	8.21**	3.42**
L_3 x T_1	1.94	14.08**	16.17**	14.98**	12.58	-1.85	23.38**	-11.37**	-14.37**	4.59**	-0.63	-0.79	3.49**	8.68**	-2.58**
L_3 x T_2	14.77**	12.93**	7.64**	11.30**	18.81*	-1.13	10.69**	-5.73**	-13.90**	1.58	10.57**	1.68**	-1.26*	11.66**	2.40**
L_3 x T_3	-9.01**	5.02**	-1.55	10.57**	-13.32	17.87**	2.94	-9.94**	8.52**	6.41**	4.13**	-0.77	-2.99**	18.21**	-1.81*
L_3 x T_4	-3.91*	0.81	-10.46**	1.13	36.59**	9.39**	-9.39**	-5.94**	-5.05**	2.36*	2.08	-8.10**	-0.54	11.34**	-1.73*
L_4 x T_1	-1.06	27.10**	7.95**	17.00**	51.53**	11.32**	13.65**	-7.94	16.64**	12.68**	-0.37	1.74**	0.52	7.54**	1.70*

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L_4 x T_2	-0.03	9.97	11.66**	9.52**	33.22**	20.69**	7.40**	-21.87**	0.85	3.33**	10.23**	7.99**	-3.30**	-5.11**	3.86**
L_4 x T_3	-9.66**	-1.37**	11.35**	13.47**	39.74**	16.50**	14.02**	10.28**	15.79**	2.47	14.71**	16.48**	-5.57**	19.38**	2.97**
L_4 x T_4	21.34**	-4.64**	-13.54**	-4.30**	7.28	8.30**	7.65**	-11.35**	-3.93*	-9.55**	-1.52	-7.66**	-1.09	4.04**	2.43**
L_5 x T_1	14.45**	19.64**	1.31	12.70**	-4.82	14.52**	23.03**	4.60**	0.60	1.67	0.77	2.46**	0.86	-1.62	2.02**
L_5 x T_2	15.37**	16.37**	-6.54**	16.48**	2.41	8.37**	14.85**	3.75**	7.66**	1.24	10.08**	-2.76**	-3.71**	-2.55**	3.81**
L_5 x T_3	0.77	-1.30	24.25**	9.38**	28.72**	4.51	9.60**	6.43**	10.96**	11.00**	7.11**	7.49**	2.14**	11.55**	-1.53*
L_5 x T_4	-5.76**	-9.82**	25.89**	6.58**	28.03**	6.09*	1.27	-1.07*	12.85**	4.48**	7.25**	1.33**	-4.42**	6.73**	3.19**
L_6 x T1	-9.09**	14.32**	8.07**	8.27**	43.65**	4.92*	16.95**	-0.87*	12.17**	-3.73**	-4.56**	7.10**	-8.09**	8.64**	8.98**
L_6 x T_2	-9.34**	10.22**	10.74**	14.73**	10.37	21.09**	12.49**	-5.51**	7.95**	1.23	-3.28*	8.54**	-0.49	-0.74	13.50**
L_6 x T_3	-5.70**	-4.02**	13.33**	8.18**	0.80	15.32**	15.29**	3.90**	6.96**	2.96*	4.15**	-2.74**	-1.55*	2.36*	4.87**
L_6 x T_4	-5.52**	-4.52**	7.92**	-8.84**	26.16**	7.65**	18.33**	-11.49**	4.45	-2.18	-9.85**	-3.29**	1.55*	4.10**	-1.24
L_7 x T_1	13.78**	25.06**	11.99**	7.38**	20.15*	-2.08	26.06**	-1.69**	16.47**	11.79**	-15.58**	-10.89**	0.66	3.17**	1.29
L_7 x T_2	-6.22**	20.43 **	-5.25**	22.34**	25.25**	22.45**	11.48**	8.92**	-2.85	-3.07*	19.76**	10.20**	-9.76**	7.24**	15.25**
L_7 x T_3	-6.34**	17.30 **	12.83**	19.93**	21.45*	15.52**	17.32**	7.46**	6.88**	3.24*	6.69**	6.46**	-5.53**	6.70**	12.81**
L_7 x T_4	-4.35**	-1.67 ns	10.52**	13.65**	34.65**	10.39**	10.52**	11.18**	3.28	4.47**	13.99**	4.74**	-8.34	11.01**	14.52**

Plant height at maturity

The relative heterosis was positively significant in sixteen cross combinations. It was maximum with the cross L_4 x T_1 (LCA 625 × LCA 334) followed by L_7 x T_1 (Pant C- 1 × LCA 334) and L_7 x T_2 (Pant C-1 × K1). Heterobeltiosis exhibited positive and significant in eleven cross combinations. It was maximum with the cross L_2 x T_2 (CO -1 × K1) followed by L_7 x T_3 (Pant C-1 × G- 4) and L_2 x T_1 (CO-1 × LCA 334). Standard heterosis was positive and significant in twenty-seven cross-combinations. It was registered maximum with the cross L_4 x T_1 (LCA 625 × LCA 334) followed by L_7 x T_3 (Pant C-1 × G-4) and L_7 x T_1 (Pant C-1 × LCA 334). These results of heterosis for plant height confirm the earlier findings of Tembhurne and Rao (2012), Kumar *et al*. (2013), Savitha *et al*. (2015).

Estimation of heterobeltiosis for fifteen characters

hybrids	**Days to 50 per cent flowering**	**Plant height**	**Plant spread**	**Fruit length**	**Fruit width**	**Fruit pedicel length**	**Placenta length**	**No. of fruits per plant**	**Fruit weight**	**No. of seeds per fruit**	**1000 seed weight**	**Fruit yield per plant**	**Ascorbic acidcontent**	**Capsaicin content**	**capsanthincontent**
L_1 x T_1	1.90	4.72*	9.16**	2.11	11.11	7.77**	34.28**	0.07	-8.53**	-4.44**	-5.92**	-14.20**	1.35	-1.75	-0.38
L_1 x T_2	0.98	-3.56	-1.69	9.37 **	-9.28	-5.53	-14.42**	-10.65*	-22.80*	-17.60*	2.32	-11.96*	0.27	-6.14**	0.76

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L_1 x T_3	11.16**	-8.63**	6.98**	-0.28	-8.36	-6.31*	-1.04	7.28**	-3.75	-2.47	9.36**	-6.94**	-2.88**	9.31**	0.09
L_1 x T_4	15.92**	-12.17**	13.62**	-9.33**	-13.94	-20.75**	-15.77**	-6.78**	-17.03**	-18.84**	-14.69**	-25.44**	-3.04**	7.04**	2.97**
L_2 x T_1	10.76**	11.61**	2.42*	-9.22**	-18.43	1.22	0.42	2.92**	-6.43*	-2.57	-13.85**	-1.97**	0.64	-5.26**	1.86*
L_2 x T_2	6.91**	18.42**	11.36**	6.07**	27.65**	6.67*	3.87	-5.33**	-8.99**	-11.25**	-1.64	-3.74**	-3.91**	-2.19*	3.22**
L_2 x T_3	-3.85*	-3.23*	1.69	1.85	17.06	18.56**	4.87	-2.80**	-5.95*	-0.34	-3.74*	-7.82**	-0.82	7.35**	-2.77**
L_2 x T_4	6.97**	-9.48**	5.72**	7.56**	-30.03**	-6.15*	-13.99**	-5.62**	-4.99*	-12.03**	-6.18**	-6.91**	-4.78**	-0.94	-0.03
L_3 x T_1	-3.07	-1.03	5.87**	5.22**	3.66	-5.62	15.21**	-13.36**	-22.07**	-1.05	-1.89	-2.05**	3.08**	-3.95**	-4.51**
L_3 x T_2	14.19**	-1.60	5.04**	0.09	9.62	-5.53	9.30**	-9.54**	-13.90**	0.60	4.49**	1.49**	-2.74**	-1.32	2.02*
L_3 x T_3	-11.46**	0.46	-3.78**	6.50**	-19.51	11.25**	2.73	-10.64**	2.91	-0.70	-2.79*	-0.85	-3.74**	9.80**	-3.67**
L_3 x T_4	-6.51**	-0.12	-10.73**	-0.77	26.83**	8.06**	-14.63**	-11.09**	-8.72**	-0.89	1.44	-13.88**	-2.08**	1.41	-3.11**
L_4 x T_1	-6.62**	7.27**	-3.71**	4.81**	25.24**	-2.01	0.59	-13.32**	5.26*	11.46**	-4.16**	-3.79**	0.48	-3.07**	1.23
L_4 x T_2	-1.30	-6.78**	6.46**	-3.55**	27.76**	5.64*	2.61	-27.73**	-0.09	-0.30	-0.71	3.57**	-4.40**	14.47**	2.63**
L_4 x T_3	-11.42**	-8.53**	6.32**	6.85**	33.12**	0.85	7.41**	5.33**	8.82**	-0.09	2.13	11.42**	-6.67**	13.24**	2.60**
L_4 x T_4	18.96**	-6.84**	-15.33**	-8.24**	2.21	-2.32*	7.43**	-19.18**	-8.47**	-16.16**	-5.85**	-9.70**	-2.27**	-3.29**	2.28**
L_5 x T_1	8.20**	6.07**	-2.49	0.81	-18.56	8.77**	6.83**	4.29**	-8.14**	-1.84	0.12	-5.13**	0.55	-7.02**	1.65
L_5 x T_2	14.11**	3.64*	-15.91**	2.44 *	2.41	2.28	7.44**	1.51**	7.27**	0.08	3.42*	-8.71**	-5.07**	-7.89**	2.49**
L_5 x T_3	-1.37	-3.24*	11.65**	2.85*	27.84**	-2.56	1.14	5.15**	5.58*	5.67**	-0.60	0.65	1.25	11.27**	-1.79*
L_5 x T_4	-7.76**	-12.84**	10.54**	2.03	27.15**	3.47	-0.74	-4.70**	8.87**	-0.88	7.25**	1.33**	-5.81**	4.23**	2.94**
L_6 x T1	-18.56**	7.03**	-3.79**	2.78	16.07	-1.77	-1.58	-3.08**	10.14**	-10.20**	-10.24**	5.37**	-8.20**	-3.51**	8.54**
L_6	-	3.7	5.3	6.9	2.9	12.	1.66	-	-	-	-	8.3	-	-	12.11**

x T_2	15.27**	0*	7**	4**	8	67**		9.31**	0.09	1.23	4.03*	6**	1.70**	11.84**	
L_6 x T_3	-9.09**	-7.74**	7.99**	8.03**	-6.55	6.02*	2.84	3.10**	4.26	-5.25**	2.01	-3.16**	-2.58**	-4.41**	4.54**
L_6 x T_4	-8.91**	-12.78**	5.48**	-10.67**	16.96	3.45	11.85**	-16.33**	0.39	-3.87**	-14.69**	-9.07**	0.26	-4.69**	-1.43
L_7 x T_1	4.12**	10.99**	0.60	0.63	-0.94	-4.53	4.94*	-7.42**	2.80	10.04**	-17.19**	-18.39**	0.45	0.01	-1.05
L_7 x T_2	-10.37**	7.37**	-8.96**	12.61**	19.75*	18.61**	-0.43	0.77	-6.10**	-6.03**	9.85**	2.30**	-10.95**	3.95**	14.43**
L_7 x T_3	-7.59**	15.13**	8.56**	18.47**	15.36	10.51**	3.44	2.66**	-1.86	0.18	-3.30*	-1.42**	-6.43**	4.21**	10.30**
L_7 x T_4	-5.62**	-5.08**	9.10**	12.89**	27.90**	10.18**	3.16	1.38**	-3.90	-2.72*	11.10**	3.48**	-9.59**	10.75**	12.54**

Estimation of standard heterosis for fifteen characters

hybrids	**Days to 50per cent flowering**	**Plant height**	**Plant spread**	**Fruit length**	**Fruit width**	**Fruit pedicel length**	**Placenta length**	**No. of fruits per plant**	**Fruit weight**	**No. of seeds per fruit**	**1000 seed weight**	**Fruit yield per plant**	**Ascorbic acidcontent**	**Capsaicin content**	**capsanthincontent**
L_1 x T_1	11.88**	6.47**	-1.17	-20.96*	-20.96*	14.20**	13.57**	-3.68**	-24.98**	-13.07**	8.46**	-16.71**	-0.10	-1.75	2.97*
L_1 x T_2	0.99	-1.95	-1.69	-9.28	-9.28	0.10	-14.42**	-10.65**	-22.80**	-17.60**	2.32	-11.96**	0.27	-6.14**	1.76*
L_1 x T_3	4.12*	12.34**	7.30**	-9.62	-9.62	-0.72	-3.92	0.18	-13.71**	-13.84**	9.21**	-7.44**	-4.28**	-2.19*	3.25**
L_1 x T_4	8.56**	20.48**	20.11**	-15.12	-15.12	-15.12**	-7.14*	-3.75**	-23.43**	-11.63**	-2.93	-15.05**	-2.95**	0.00	5.16**
L_2 x T_1	21.61**	15.45**	2.99*	-17.87	-17.87	2.57	-3.52	1.83**	-11.44**	-11.37**	-0.68	-4.84**	-1.59*	-5.26**	5.28**
L_2 x T_2	15.75**	22.49**	11.97**	28.52**	28.52**	7.00*	3.87	-5.33**	-8.99**	-11.25**	-1.64	-3.74**	-3.91**	-2.19*	3.22**
L_2 x T_3	4.11*	18.97**	2.25	17.87	17.87	18.93**	1.81	-3.82**	-10.99**	-9.88**	-5.18**	-8.33**	-4.25**	-3.95**	0.31
L_2 x T_4	15.82**	24.17**	11.76**	-29.55**	-29.55**	0.51	-5.18	-2.56**	-10.08**	-4.21**	6.75**	6.07**	-4.69**	-7.46**	2.09*
L_3 x T_1	6.42**	33.23**	11.24**	-12.37	-12.37	3.60	12.31**	-16.61**	-22.07**	0.89	13.10**	-2.43**	0.80	-3.95**	-1.30
L_3 x T_2	14.19**	32.48**	10.37**	9.62	9.62	3.70	9.30**	-9.54**	-13.90**	2.57	17.39**	1.49**	-2.74**	-1.32	2.02*

L_3 x T_3	-12.35**	35.25**	1.10	-20.62**	-20.62**	22.12**	0.15	-16.56**	2.91	1.25	9.21**	-1.23	-6.62**	-1.75	-0.62
L_3 x T_4	-7.45**	37.01**	-5.63**	25.09**	25.09**	18.62**	-5.88*	-8.21**	-8.72**	7.91**	15.42**	-1.88**	-1.98*	-5.26**	-1.05
L_4 x T_1	2.53	54.29**	6.17**	36.43**	36.43**	30.56**	10.45**	-16.57**	7.27**	3.63*	19.58**	4.79**	-1.74*	-3.07**	4.64**
L_4 x T_2	-1.30	34.07**	17.38**	39.18**	39.18**	40.74**	12.66**	-27.73**	1.82	-0.30	23.87**	12.81**	-4.40**	-14.47**	5.12**
L_4 x T_3	-13.67**	31.55**	17.23**	45.02**	45.02**	34.36**	17.94**	1.51**	10.90**	-7.11**	27.42**	21.36**	-8.77**	1.32	5.84**
L_4 x T_4	15.94**	33.99**	-6.64**	11.34	11.34	30.14**	18.44**	-16.56**	-6.72**	-8.71**	17.46**	2.89**	-2.17*	-9.65**	4.76**
L_5 x T_1	18.80**	35.75**	15.72**	-18.56	-18.56	22.53**	22.66**	0.38	-8.81**	-4.09**	15.42**	8.10**	-1.67*	-7.02**	5.07**
L_5 x T_2	14.11**	32.65**	15.91**	2.41	2.41	15.23**	23.37**	-1.64**	7.27**	0.08	17.67**	4.02**	-5.07**	-7.89**	5.17**
L_5 x T_3	-3.53*	23.84**	11.98**	27.84**	27.84**	9.77**	16.13**	0.61	4.81*	3.26*	13.10**	14.69**	-1.59	-0.44	1.31
L_5 x T_4	-9.78**	19.56**	16.86**	27.15**	27.15**	16.56**	13.97**	-1.60**	8.08**	7.92**	22.03**	15.46**	-5.71**	-2.63**	5.64**
L_6 x T1	-10.58**	21.40**	6.54**	34.02**	34.02**	14.09**	21.86**	-6.72**	-6.27**	-5.62**	3.48*	5.71**	-10.23**	-3.51**	12.18**
L_6 x T_2	-10.37**	17.63**	16.69**	18.90	18.90	30.86**	25.88**	-9.31**	-0.09	3.82**	-2.52	8.71**	-1.70*	-11.84**	14.93**
L_6 x T_3	-14.85**	13.43**	19.59**	7.90	7.90	23.15**	27.34**	-3.72**	-6.54**	-0.41	3.62*	-2.85**	-4.96**	-14.47**	7.85**
L_6 x T_4	-14.70**	19.64**	16.80**	35.05**	35.05**	20.16**	38.49**	-13.62**	-7.36**	4.66**	-2.93	3.61**	0.36	-10.96**	1.06
L_7 x T_1	14.32**	41.71**	9.15**	8.59	8.59	1.85	33.47**	-10.89**	10.17**	3.32*	-0.75	-4.73**	-1.77*	0.01	2.28*
L_7 x T_2	-15.27**	37.09**	-1.22	31.27**	31.27**	26.54**	26.63**	0.77	0.64	-6.03**	31.65**	19.42**	-10.95**	3.95**	14.43**
L_7 x T_3	-13.45**	46.99**	17.79**	26.46**	26.46**	17.90**	31.56**	-4.14**	5.18*	-5.94**	15.89**	15.08**	-8.89**	-2.19*	13.79**
L_7 x T_4	-11.61**	30.21**	18.37**	40.21**	40.21**	18.00**	31.21**	4.67**	3.00	5.92**	33.15**	20.80**	-9.50**	3.95**	14.93**

Plant spread

Significant positive relative heterosis was registered for this trait in twenty-one out of twenty-eight cross combinations. It was maximum with the cross L_5 x T_4 (LCA 620 × LCA 678) followed by L_5 x T_3 (LCA 620 × G-4) and L_1 x T_4 (LCA 705-2 × LCA 678). Better parent heterosis was maximum and significant with seventeen cross combinations namely, L_1 x T_4 (LCA 705-2 × LCA 678) followed by L_5 x T_3 (LCA 620 × G-4) and L_2 x T_2 (CO -1 × K1). Seventeen cross combinations recorded positively significant heterobeltiosis for this character. Commercial heterosis was significant and positive in nineteen cross combinations. It was maximum with the cross L_1 x T_4 (LCA 705-2 × LCA 678) followed by L_6 x T_3 (Pusa Jwala × G- 4) and L_7 x T_4 (Pant C-1 × LCA 678). Similar findings were putforth by Ganesh Reddy *et al.* (2008), Surya Kumari *et al.* (2014).

Fruit length

Relative heterosis for fruit length was found to be positive and significant in twenty-three cross combinations. The cross L_7 x T_2 (Pant C-1 × K1) followed by L_7 x T_3 (Pant C-1 × G-4) and L_4 x T_1 (LCA 625 × LCA 334) attains maximum relative heterosis when compared to other cross combinations. Thirteen cross combinations recorded positively significant heterobeltiosis for this character. The crosses L_7 x T_3 (Pant C-1 × G-4) followed by L_7 x T_4 (Pant C-1 × LCA 678) and L_7 x T_2 (Pant C-1 × K1) recorded maximum better parent value for this trait. When it comes to standard heterosis twenty-seven cross combinations shows positively significant and it registered maximum with the cross L_7 x T_3 (Pant C-1 × G-4) followed by L_4 x T_3 (LCA 625 × G-4) and L_4 x T_1 (LCA 625 × LCA 334). There exists scope for inclusion of this character in heterosis breeding programme of chillies Payakhapaab *et al.* (2012), Suryakumari *et al.* (2014).

Fruit width

Significant and positive relative heterosis was observed in fifteen cross combinations, with the highest value observed in the cross L4 x T1 (LCA 625 × LCA 334) followed by the cross L6 x T1 (Pusa Jwala × LCA 334) and L4 x T3 (LCA 625 × G-4). For this trait, heterobeltiosis was positive and significant in nine cross combinations. The cross L4 x T3 (LCA 625 G-4) was showed maximum heterobeltiosis followed by L7 x T4 (Pant C-1 LCA 678) and L5 x T3 (LCA 620 G-4). Twelve cross combinations exhibited significant and positive standard heterosis. The highest standard heterosis was observed in the cross L4 x T3 (LCA 625 × G-4) followed by L7 x T4 (Pant C-1 × LCA678) and L4 x T2 (LCA 625 × K1). This information was reported by Payakhapaab et al. (2012) and Khalil and Hatem (2014). **Fruit pedicel length**

Nineteen out of twenty-eight cross combinations registered positively significant relative heterosis for this character. It was maximum with the cross L_7 x T_2 (Pant C-1 × K1) followed by L_6 x T_2 (Pusa Jwala × K1) and L_4 x T_2 (LCA 625 × K1). Twelve cross combinations exhibited better parent heterosis for this character. It was maximum with the cross L_7 x T_2 (Pant C-1 × K1) followed by L_2 x T_3 (CO -1 × G-4) and L_6 x T_2 (Pusa Jwala × K1). Standard heterosis was positive and significant in twenty cross combinations. It was maximum with the cross L_4 x T_2 (LCA 625 × K1) followed by L_4 x T_3 (LCA 625 × G-4) and L_6 x T_2 (Pusa Jwala × K1). There exists a good scope for inclusion of this character in heterosis breeding programme of chillies.

Placenta length

For this particular trait, there were twenty-two cross combinations that showed significant and positive relative heterosis. The highest relative heterosis was observed in the cross between L1 x T1 (LCA 705-2 × LCA 334). This was followed by L7 x T1 (Pant C-1 x LCA 334), and L3 x T1 (Arka Lohit x LCA 334). In better parent heterosis nine crosses were significant for this trait. It was maximum with the cross L_1 x T_1 (LCA 705-2 × LCA 334) followed by L_3 x T_1(Arka Lohit × LCA 334) and L_6 x T_4 (Pusa Jwala × LCA 678). Nineteen out of twenty-eight cross combinations registered positively significant standard heterosis for this character. It was maximum with the cross L_6 x T_4 (Pusa Jwala × LCA 678) followed by L_7 x T_1 (Pant C-1 × LCA 334) and L_7 x T_3 (Pant C-1 × G-4) respectively. Incorporating this character in heterosis breeding programme may be beneficial, as it exhibited a higher number of crosses with significant positive standard heterosis. The direction and magnitude of standard heterosis in these crosses further supports its inclusion.

Number of fruits per plant

Positive and significant relative heterosis for this trait was observed in eleven cross combinations. The highest positive heterosis was detected in L7 x T4 (Pant C-1 × LCA 678), followed by L4 x T3 (LCA 625 × G-4) and L1 x T3 (LCA 705-2 × G- 4). Better parent heterosis was significant for nine cross combinations. The highest heterosis was observed in the cross L1 x T3 (LCA 705-2 × G-4), followed by L4 x T3 (LCA 625 × G-4) and L5 x T3 (LCA 620 × G-4). Three crosses out of twenty-eight cross combinations registered positive and significant standard heterosis for this character. It was maximum with the cross L_7 x T_4 (Pant C-1 × LCA 678) followed by L_2 x T_1 (CO -1 × LCA 334) and L_4 x T_3 (LCA 625 × G-4) respectively. Supporting evidences for results of the current study were available from the earlier studies of Ganesh Reddy *et al.* (2008), Kumar *et al*. (2013), Savitha *et al.* (2015).

Fruit weight

Eleven different crosses showed significant relative heterosis for this particular trait. The highest level of heterosis was observed in the L4 x T1 cross (LCA 625 × LCA 334). This was followed by the L7 x T1 cross (Pant C-1 × LCA 334) and the L4 x T3 cross (LCA 625 × G-4). Only six crosses out of twenty-eight cross combinations exhibited heterobeltiosis for this character. It was maximum with the cross L_6 x T_1 (Pusa Jwala × LCA 334), L_5 x T_4 (LCA 620 × LCA 678) and L_4 x T_3 (LCA 625 × G- 4). Seven cross combinations evinced standard heterosis for this character. It was maximum with the cross L_4 x T_3 (LCA 625 × G-4) followed by L_7 x T_1 (Pant C-1 × LCA 334) and L_5 x T_4 (LCA 620 × LCA 678).

Number of seed fruit $^{-1}$

Relative heterosis for this trait was observed in eleven different cross combinations. The highest level of heterosis was observed in L4 x T1 cross (LCA 625 × LCA 334), followed by Pant C-1 x T1 (LCA 334 × L7) and G-4 x L5 (G-4 × LCA 620). Three cross combinations showed heterobeltiosis for number of seeds per fruit. The highest value was achieved with the cross L4 x T1 (LCA 625 × LCA 334). After that, the next best cross combinations were L7 x T1 (Pant C-1 × LCA 334) and L5 x T3 (LCA 620 × G-4). Commercial heterosis was positive and significant with eight cross combinations. It was maximum with the cross L_5 x T_4 (LCA 620 × LCA 678) followed by L_3x T_4 (Arka Lohit × LCA 678) and L_7 x T_4 (Pant C-1 × LCA 678). The outcome agrees with the findings of Tembhurne and Rao (2012), Kumar *et al*. (2013), Surya Kumari *et al.* (2014).

1000 seed weight

Twelve cross combinations demonstrated relative heterosis for this character. It was maximum with the cross combination L_7 x T_2 (Pant C-1 × K1) followed by L_4 x T_3 (LCA 625 × G-4) and L_7 x T_4 (Pant C-1 × LCA 678). Six cross combinations showed heterobeltiosis for grain yield per plant. It was maximum with the cross L_7 x T_4 (Pant C-1 × LCA 678) followed by L_7 x T_2 (Pant C-1 × K1) and L_1 x T_3 (LCA 705-2 × G-4). Commercial heterosis was positive and significant with twenty cross combinations. It was maximum with the cross L_7 x T_4 (Pant C-1 × LCA 678) followed by L_7 x T_2(Pant C-1 × K1) and L_4 x T_3(LCA 625 × G-4). The result is in agreement with the findings of Tembhurne and Rao (2012), Kumar *et al*. (2013), Surya Kumari *et al.* (2014).

Fruit yield plant^{-1}

Thirteen cross combinations demonstrated relative heterosis for fruit yield per plant. It was maximum with the cross combination L_4 x T_3 (LCA 25 × G-4) followed by L_7 x T_2 (Pant C-1 × K1) and L_6 x T_2 (Pusa Jwala × K1). Eight cross combinations showed heterobeltiosis for fruit yield per plant. It was maximum with the cross L_4 x T_3 (LCA 25 × G-4) followed by L_6 x T_2 (Pusa Jwala × K1) and L_6 x T_1 (Pusa Jwala × LCA 334). Commercial heterosis was positive and significant with sixteen cross combinations. It was maximum with the cross L_4 x T_3 (LCA 625 × G-4) followed by L_7 x T_4 (Pant C-1 × LCA 678) and L_7 x T_2 (Pant C-1 × K1). The result is in agreement with the findings of Prajapati and Agalodia (2011), Payakhapaab *et al*. (2012).

Ascorbic acid content

Fourteen cross combinations demonstrated negative relative heterosis for this character. It was maximum with the cross combination L_7 x T_2 (Pant C-1 × K1) followed by L_7 x T_4 (Pant C-1 × LCA 678) and L_6 x T_1 (Pusa Jwala × LCA 334). Eigtheen cross combinations showed heterobeltiosis for Ascorbic acid content(mg/100gm). It was maximum with the cross L_7 x T_2 (Pant C-1 × K1) followed by L_7 x T_4 (Pant C-1 × LCA 678) and L_6 x T_1 (Pusa Jwala × LCA 334). Commercial heterosis was negative and significant with twenty-three cross combinations. It was maximum with the cross L_7 x T_2 (Pant C-1 × K1) followed by L_6 x T_1 (Pusa Jwala × LCA 334) and L_7 x T_4 (Pant C-1 × LCA 678). The result is in agreement with the findings of Patel *et al.* (2010), Asish and Pugalendi (2012).

Capsaicin content

Relative heterosis for this trait was shown by twenty-four cross combinations. The highest relative heterosis was observed in the cross combination of L4 x T3 (LCA 625 ×G-4), followed by L3 x T3 (Arka Lohit × G-4) and L2 x T3 (CO -1 x G-4). Nine cross combinations showed heterobeltiosis for capsaicin content. It was maximum with the cross L_4 x T_3 (LCA 625 × G-4) followed by L_5 x T_3 (LCA 620 × G-4) and L_7 x T_4 (Pant C1 x LCA 678) Commercial heterosis was positive and significant with two cross combinations. It was maximum with the cross L_7 x T_2 (Pant C-1 × K1) and L_7 x T_4 (Pant C-1 × LCA 678). The result is in agreement with the findings of Patel *et al.* (2010), Prasath and Ponnuswami (2008), Suryakumari *et al.* (2014).

Capsanthin content

For this character, eighteen cross combinations showed relative heterosis. The cross combination L7 x T2 (Pant C-1 K1), L7 x T4 (Pant C-1 LCA 678) and L6 x T2 (Pusa Jwala K1) were the highest. Fifteen cross combinations showed heterobeltiosis for grain yield per plant. It was maximum with the cross L_7 x T_2 (Pant C1 x K1) followed by L_7 x T_4 (Pant C - 1 × LCA 678) and L_6 x T_2 (Pusa Jwala × K1). Twenty-two cross combinations showed positive and significant standard heterosis. L7 x T4 (Pant C-1 × LCA 678) and L6 x T2 (Pusa Jwala × K1) reached its maximum, followed by L7 x T2 (Pant C-1 × K - 1) and L7 x T3 (Pant C-1 × G-4). The result is in agreement with the findings of Rekha (2015).

4. Conclusion

In the present study, the hybrids L4 x T3 (LCA 625 × G-4) is the best hybrids followed by L7 x T4 (Pant C-1 × LCA 678) and L7 x T2 (Pant C-1 × K1) recorded significant standard heterosis for fruit yield per plant. It would be more effective to choose hybrids for heterosis breeding based on *per se* performance, specific combining ability effects, and standard heterosis. Overall, the three best hybrids identified from among the twenty-eight evaluated are L4 x T3 (LCA 625 × G-4), L7 x T4 (Pant C-1 × LCA 678), and L7 x T2 (Pant C-1 × K1), based on all three criteria.

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